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Municipal Solid Waste Management in Mahabad Town, Iran

[1]Soran Erami, [2]Behzad Shahmoradi and [2]Afshin Maleki
[1]Students Research Committee, Kurdistan University of Medical Sciences, Sanandaj, Iran
[2]Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran

Corresponding Author: Behzad Shahmoradi, Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran Tel: +98-87-31827426, +98-918-7705355 Fax: +98-87-33625131

ABSTRACT

Being one of the global issues, waste management is a crucial aspect of the environment. To identify this type of management, one should identify its components in order to obtain a feasible alternative for meeting the existing problems. The present study was conducted to determine the quality and quantity of waste generated within Mahabad Town, Iran and to present possible recommendations for improving the waste management. This was a descriptive-analytical research in which data required was collected through field observation and questionnaire. The findings show that daily waste generation rate is 130 t in Mahabad, consisting of 75.17% putrescible and 24.83% non-putrescible materials; out of the later, 18.32 could be recycled. Hence, only 6.51% is left for disposing of at landfill. While, at the present the waste generated is dumped of under an unsanitary conditions at a nearby village, creating many environmental problems. Therefore, an inappropriate waste management is practiced in the Town and it requires authority consideration in this regard. Moreover, the study involved the analysis of the economic benefits of the source separation process and construction of the compost plant, which its implementation may induce changes in the municipal waste management system. In this paper, recommendations for improving urban waste management system is also explained.

Key words: MSW, management, Mahabad, generation, recycling, compost plant, economic benefits, potential analysis

INTRODUCTION

Rapid population growth, developing technology and human affinity to more usage of consumable materials have brought about increasing of solid waste generation rate, which has become one of the most important environmental issues recently in human societies (Tchobanoglous *et al*., 1990; Raghimi *et al*., 2006). Fighting such a pollution requires an integrated method including engineering principals and finance for waste disposal (Tanskanen, 2010).

Municipal waste management is a multifaceted process comprised of different components. These components include source reduction, production, storage, processing, collection, transportation, recycling, disposal and treatment of rejection (Moghadam *et al*., 2009). Therefore, the aim of Municipal Solid Waste Management (MSWM) is to protect public health, to prevent waste accumulation, to control unpleasant odors and to eliminate ugly city's capes of solid waste from its source to final disposal (Zhang *et al*., 2010). Municipal waste as a major challenge in urban communities derives a significant impact because of environmental concerns and legal and political conditions (Xu *et al*., 2009).

The National MWS Act was adopted on May 29, 2009 in Iran (Islamic Parliament, 2004), Article IV of this Act implies that all province centers and cities having a population over one million should have both plans-source separation and recycling to reduce the size-until May 20, 2012 and for other cities until March 20, 2014. Moreover, according to Article XII, manufactures are required to recycle their wastes.

Being ranked one, the waste generated at residential houses is the main principal source of MSW. Hence, determining the quantity and quality of MSW is the main part of MSWM. Physical analysis is one of the most important steps in determining the quality of MSW in any city. Physical analysis is not only important for evaluating and selecting collection and transportation systems, but also for managing and planning waste collection layout (Nabegu, 2010). In developing countries, mismanagement of finance and lack of sufficient investment in the region remain the main impediments to improve solid waste infrastructure (Kanat, 2010).

Dangi *et al*. (2011) found that the waste generation rate was 330 g per capita per day in Kathmandu, Nepal. Having 48% organic waste, they suggested composting as a suitable approach to reduce the landfilling volume (Dangi *et al*., 2011). Gidarakos *et al*. (2006) observed a significant reduction for organic wastes over past decade in Greece because of increased change in food consumption patterns. They recommended source separation as a suitable strategy to avoid expending $9,000 per day at landfill.

Assessing quality and quantity of waste in Isfahan, Iran showed that the rate of waste generation is 1090 t, out of which 65% were organic materials, 25% recycled materials and 5-10% other materials. His cost-benefit analysis revealed that waste incineration could be recommended as a suitable approach for improving waste management through energy recovery (Abdoli *et al*., 2013).

In another study, it was found that perishable materials are at the highest level comparing with other gradients in household waste. It was suggested construction of composting factory as a suitable alternative for solving this problem in the northern cities of Iran (Mehdi Nejad, 2009).

No study has been carried out on characterization of MSW in Mahabad Town. Therefore, the objectives of this study were to characterize the quantity and composition of waste generated in Mahabad Town and to present a suitable alternative for MSW management in this Town.

MATERIALS AND METHODS

Study area: Mahabad is located in the Southern district of West Azarbaijan, Iran, with an area of 2591 km, 9.6% of the total area of the province (45°43´ N, 36°46´ E) (Fig. 1). The population was 148230 consisting of 7,4361 males and 73,869 females in 2013. Approximately 31% of the population is under 20 years old. No waste separation is carried out in this Town and the whole waste generated is non-hygienically dumped and disposed of at a nearby village, Sayyed Abad.

Data collection: This was an analytical-descriptive study in which data collection was carried out through literature review, field observation and attending. The Town was divided to five districts and the garbage of each district was individually collected using dumper trucks designed solely to carry the garbage to dumping station. Each dumper truck was randomly selected from each district. The garbage samples of several districts were mixed and sample garbage weighing 1000 kg was separated. Then the final sample was subdivided into four equal parts. The ingredients were separated using covered hands and weighed using a digital scale and the percentage of each of the ingredients was calculated.

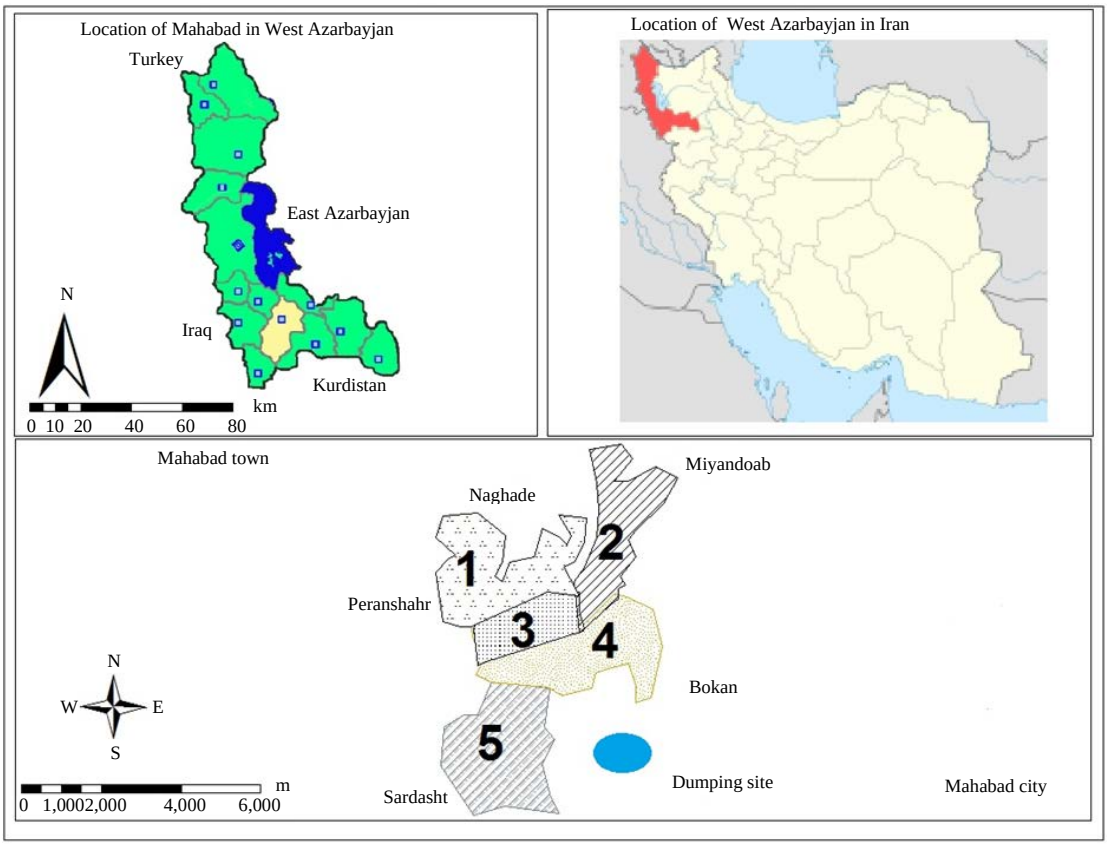

Fig. 1: Geographical location of the study area (Mahabad, Iran)

To estimate the humidity percentage (according to wet weight) inside the laboratory, 1 kg of food portions and crumbs were collected and analyzed. All of the analysis were conducted during two stages in 2013-2014.

RESULTS AND DISCUSSION

Municipal solid waste generation and composition: Waste components analysis has a direct impact on the collection and maintenance of machines, allowing use of separated materials, planning and development of the MSW management. The main effective elements of MSW compositions are, usually, production facilities, socioeconomic status and seasonal variation (Ahmed and Ali, 2004). In order to evaluate the waste generation rate, all waste samples were collected and weighed during the analysis period and an average of all wastes generated in a two-phase periods were estimated as 130 t. The average waste generation and physical analysis of waste and comparison of waste ingredients in other studies are shown in Table 1 and 2, respectively. As shown in Table 1, the waste generation rate in this study was 0.878 g per capita, which is higher than the average amount reported for Iran (0.646).

This discrepancy among the waste generation rates in different parts of the world could be contributed to climate, economic and cultural conditions. According to Table 1 in this study, 75.17% of waste generation is decayed and biodegradable materials and 24.83% is consisted of other materials, while 18.32% of these materials is recyclable, in which plastics have the highest rate of recyclability and the least is for metals.

Table 1: Average composition and weight percentage of MSW in Mahabad Town in 2013-2014

	Weight percentage		Weight percentage			
Components	Stage I (%)	Ton/day	Stage II (%)	Ton/day	Average (%)	Ton/day
Organic waste	75.34	97.57	75.00	98.07	75.17	97.72
Paper	3.91	5.06	3.68	4.82	3.79	4.93
Plastic	9.82	12.72	9.75	12.74	9.78	12.72
Metal	0.75	0.97	0.91	1.19	0.83	1.08
Textile fiber	1.84	2.38	2.03	2.65	1.93	2.50
Other	8.34	10.80	8.63	11.28	8.50	11.05
Total	100.00	129.50	100.00	130.75	100.00	130.00
Generation rate (kg/cap-day)	0.875		0.883		0.878	

Table 2: Comparison of solid waste generation rates of the studied with the other reported researches

References	Generation rate (kg/cap-day)	Organic waste	Paper	Plastic	Metal	Textile fiber	Other
Present study	0.878	75.17	3.79	9.78	0.83	1.93	8.50
Tehran, Iran (Hassanvand *et al*., 2008)	0.84	69.66	9.37	6.82	1.53	1.89	10.73
Isfahan, Iran (Mehdi Nejad, 2009)	0.69	68.97	4.10	17.80	1.38	2.90	4.85
Rasht, Iran (Moghadam *et al*., 2009)	0.80	70.25	7.70	13.90	0.80	1.20	6.15
Sistan and Baluchestann, Iran (Omrani *et al*., 2007)	0.748	65.42	10.50	10.80	4.90	2.20	6.18
Veles, Macedonia (Hristovski *et al*., 2007)	1.56	52.18	8.00	24.50	3.80	7.20	4.32
Bangkok, Thailand (Chiemchaisri *et al*., 2007)	1.50	43.00	12.10	10.90	3.50	4.70	25.80
Crete, Greece (Gidarakos *et al*., 2006)	1.045	48.25	19.90	5.30	4.90	5.30	16.35
Average of USA (Chang and Davila, 2008)	2.038	11.00	37.00	11.00	8.00	6.50	26.50
Average of Iran (Hassanvand *et al*., 2008)	0.64	72.63	8.92	4.50	2.24	2.52	9.19

There are significant differences among the aforementioned studies. For example in Table 2, the amount of dumping materials in our study equals 75.17% but it was 65.42% in Zahedan, Iran (Omrani *et al*., 2007). It can be deducted that in hot climate areas the percentage of dumping is reduced. Moreover, this research found that the amount of metals was 0.83% but it was 7.77, 4.9, 36.5 and 8% for Iranian cities, Crete in Greece, Bangkok in Thailand and U.S., respectively (Hassanvand *et al*., 2008; Gidarakos *et al*., 2006; Chiemchaisri *et al*., 2007; Chang and Davila, 2008). In addition, the amount of paper was found to be 3.79%, whereas, it was 6.43, 24.5 and 37% in Iranian cities, Macedonia and the United States of America (Hristovski *et al*., 2007).

Another important factor in the physical composition of the waste is moisture presenting in waste that is depended on several parameters including waste composition, moisture in the air and season of the year (Iran has four distinct seasons in a year). The research found that the moisture content of waste was 24-34%, which is far higher than the waste moisture content in European and American countries (Mehdi Nejad, 2009).

Waste storage at home: Storage duration and method of storing waste at home is very important. There are various ways to store waste at home. We found that most of households store their wastes in dustbins containing plastic cover (65%), followed by plastic dustbins without cover, tin dustbins and other methods (30, 4 and 1%, respectively).

MSW collection and transportation system: Collection is the most costly part of MSW management. In Mahabad, more than 95% of the waste is collected by the municipality and the other 5% is collected by informal sector. The waste generated is collected door to door by municipal crews every morning at 5-10 am. Different systems are practiced for waste collection and transportation in Mahabad Town. Since the landfill location is very close to the Town, there is no

transfer station in this Town. Hence, the collection and transportation vehicles are the same (direct hauling). The research indicated that 82% of the waste is collected and transported using semi-mechanical trucks; 15% using mechanized trucks and the rest 3% is carried out manually loading trucks.

Municipal solid waste disposal: In Mahabad, the landfill used for disposal of waste is not covered by soil even every six months once. The wastes transported are simply dumped into the place without providing liner or capping system. As a result, the unsanitary dumping could be suitable place for breeding and reproduction of rats, flies, etc.

Future prospects for treatment system

Municipal solid waste source separation: As the heading indicates, this process aimed at preventing valuable material disposal of and recycling them before their conversion into waste; this would result in returning an important part of the discarded wealth back to the production and consumption cycle (Abduli and Azimi, 2010).

As, it was abovementioned, the highest proportion of household waste (75.17%) consists of food waste and putrescible material. Out of 24.83% remaining, however, 18.32% are recyclable, which could be used as raw material or for generating energy. Figure 2 shows the recycling flow diagram proposed based on the data we collected.

Based on field studies carried out in the city, about 37% of the households separate their recyclable waste from discarded wastes before delivering to the waste collection crew and sell it to the itinerant and informal sectors. There are several converting workshops, especially for paper and plastics, around Mahabad Town and nearby cities, which are some potential recovery and processing centers in the area. Therefore, the use of recycled materials and reducing the cost of collection and transportation of the MSW generated in Mahabad is indispensable and unavoidable programmes for this Town.

Waste separation at source is considered as one of the economics pillars of the MSW recovery plan. Based on the physical analysis of the waste, Table 3 estimates the price per kilogram of dry residues.

Accordingly, source separation of only 10% of the recyclable materials in the waste of Mahabad could avoid landfilling of more than 42 million rials of national wealth per day. In addition to the above income calculated, the profits from reduced transportation costs and saving land for the

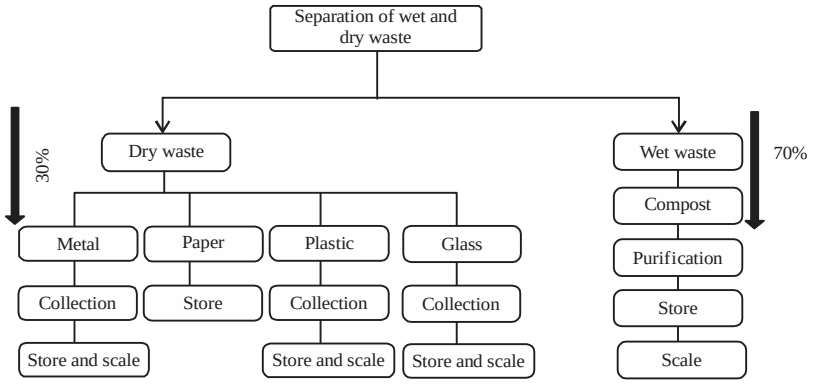

Fig. 2: Proposed recycling flow diagram for mahabad municipal solid waste management

Table 3: Price per kilogram of dry residue existing in Municipal solid waste generated in Mahabad Town

Type of waste	Average waste composition (kg day^{-1})	Purchase price (kg Rls^{-1})	Daily purchase price (kg Rls^{-1})
Paper	4930	400	1972000
Plastic	12720	2500	31800000
Metal	1080	7000	7560000
Textile fiber	2500	250	625000
Total	21230	-	41957000

US $ ≈ 26,000 Iran Rls

Table 4: Economic benefits/potential analysis for compost plant (million rials)

	Year							
Description	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Cost								
Yearly payment	-2772	-5544	-5544	-5544	-5544	-2772	0	0
Maintenance	-260	-266	-273	-280	-287	-295	-303	-310
Wage	-1288	-1481	-1703	-1985	-2252	-2590	-2980	-3426
Total cost	-1825	-7291	-7530	-7782	-8083	-5657	-3283	-3736
Income								
Annual sale of fertilizer	+7300	+8176	+9157	+10256	+11486	+12864	+14408	+16137
Gross income	5475	885	1627	2474	3403	7207	9581	12401
Depreciation	-975	-1121	-1289	-1482	-1705	-1961	-2255	-2592
Net income	4500	239	338	992	1698	5246	7326	9809

[3]US $ ≈ 26,000 Iran Rls

disposal of solid waste could be achieved. Waste source separation and recycling programs results in reduced non-putrescible materials, hence a suitable option for producing compost because the impurities in compost prepared from municipal waste could be reduced. On the other hand, it can decrease the large volume of incoming waste to the disposal areas. Thus, the cost of MSWM could remarkably eliminated and a significant profit could be granted to municipalities, along with job opportunity creation. Considering the size of the study area and the volume of waste generated, incineration plant for energy recovery cannot be a cost-effective method. Moreover, there is no compost plant in and around the study area; therefore, building a compost plant could not only convert a major part of the waste discarded but also can reduce the amount of the waste transported to the landfill for final disposal. Hence, this study analyses the economic benefits for the construction of a compost plant.

Composting: In general, composting is the controlled decomposition of organic material at the appropriate temperature and humidity by suitable aerobic and anaerobic microorganisms. This fertilizer has the capability to be used in parks and even agricultural desertification projects (Gidarakos *et al*., 2006; NEERI., 2005). According to estimates given, the compost required will vary from 5-8 kg per person per year (PDSID., 2008). Based on the analysis carried out, about 130 t of waste are produced daily, which consists of 97.5 t of organic waste. Thus, constructing a composting plant with a potential capacity of receiving 200 t of organic waste is recommended for Mahabad. According to the economic analysis, initial investment for construction composting plant is estimated to be 31,000 million rials (Table 4).

Table 5 shows the total income resulted from and expenses for the construction of composting plant in Mahabad Town. The values given are based on predicted selling price of 2000 Rls per kg of compost produced. As the data calculated in Table 5 indicates, the payback period is four years (34899 million rials income), which covers the initial capital investment and the revenue is predicted to be about 89,784 million rials after eight years. Hence, a reasonable benefit could be expected from constructing a composting plant, a suitable method of waste management in developing countries such as Iran.

Table 5: Economic benefits/potential analysis for compost plant (million rials)

	Year							
Description	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
Annual sales	7300	8176	9157	10256	11486	12864	14408	16137
Initial investment	31000							
Cumulative annual sales	7300	15476	24633	34889	46375	59239	73647	89784
Total income	89784							

[3]US $ ≈ 26,000 Iran Rls

It is noteworthy that one of the most efficient and economical way for processing the waste generated is to supply the feed of the proposed compost plant from the surrounding villages and neighborhood Towns. In other words, the plant proposed for the area has the capacity to cover other cities organic wastes.

Karak *et al*. (2012) reported that recycling paper, plastics, glass and metal could reduce the cost of measurement and emission control from industries by US$ 2 million and up to US$ 2.1 for not extracting raw materials. In another research work, Dehghani *et al*. (2009) noticed that recycling of these materials could reduce the transportation costs, increased landfill capacity and conservation of the environment.

Conducting a dissertation work in Khomain, Iran, Salehi (2008) emphasized that establishing and constructing a composting plant should be considered as priority because of its socioeconomic aspects. He justified that composting can result in reducing the costs of waste landfilling.

In contrary, Renknow and Rubin (1998) mentioned that the community interested in composting as an integrated part of municipal solid waste management should accept this fact that composting has much higher costs than landfilling. However, applying measures such as source separation and segregating dry from wet wastes can reduce composting costs.

Moreover Hurst *et al*. (2005) observed that in some areas the soil used for covering is much more valuable than compost. In such cases, marketing compost may not be economic but it is suggested to use compost instead of covering soil for landfilling.

CONCLUSION

We assessed the characteristics of the MSW generated in Mahabad Town and found that the daily waste generation rate was 130 t out of which 75% was putrescible waste and organic materials making up, totally, about 97.5 t of the waste generated daily. The high percentage of the putrescible materials was attributed to the lack of diversity in consumption and waste source reduction programs. Thus, cultural policies and programs can reduce the amount of waste produced at source. Hence, the main priority of municipal waste could be concentrated on the source reduction programs and projects as well as waste composting projects. Not only the public participation in the MSWM was found to be very weak in Mahabad Town, but also the services provided by the municipality was not so significant. Therefore, holding up workshops and panels may stimulate public participation in waste management. Moreover, economic analysis revealed that constructing composting plant could play a crucial role in creating job opportunity and in reducing the amount of wastes dumped in landfills.

Not only the public participation in the MSWM was found to be very weak in Mahabad Town, but also the services provided by the municipality was not so significant. Therefore, holding up workshops and panels may stimulate public participation in waste management. Moreover, economical analysis revealed that constructing composting plant could play a crucial role in creating job opportunity and also in reducing the amount of wastes dumped in landfills.

RECOMMENDATIONS

- Raising awareness and changing attitude of people towards proper waste management through educational programs, radio and television announcements and billboards
- Raising awareness of officials through organizing periodic training on waste collection and transportation
- Changes in consumption patterns and culture through education and legislation requirements including purchase and use of durable goods, recycling and reuse
- City officials are suggested to have plan to upgrade integrated solid waste management and source reduction
- Use the capacity of private sector in waste recycling
- Involving stakeholders in MSWM programs and related decision-making plans
- Providing equipment and machinery required for the implementation of automated systems for collection and disposal of municipal waste
- Constructing a small composting plant would create job opportunity and also reduces the amount of waste sent to landfill

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