Int. J. of Sustainable Water and Environmental System
Volume 2, No. 2 (2011) 103-110

Evaluation of Current Municipal Solid Waste Practice and Management for Al-Ahsa, Saudi Arabia

Emhaidy S. Gharaibeh*, No'man M. Haimour, and Bilal A. Akash

College of Engineering, King Faisal University, Al-Ahsa, 31982, Saudi Arabia

Abstract

This paper presents an overview of the municipal solid waste (MSW) management in selected locations at Al-Ahsa . MSW generation rate, quantities, and composition are presented in this paper. Al-Ahsa is considered the oasis region in eastern Saudi Arabia. It has a population of about 1,200,000 inhabitants. Its weather is considered hot arid climate. The municipality of Al-Ahsa is responsible for the supervising of the solid waste management in the provenance. The amount of MSW generated in the province is about 3,800 m^3/day. Therefore, the average MSW generation rate is 0.95kg/capita/day. Paper and cardboard waste comprised 17.09%, followed by food at 14.73%, plastics at 13.81%, wood at 13.51%, metals at 11.41%, and glass at 10.82%. Currently all MSW is sent to a landfill site without any treatment. A small percentage, mainly cardboard, is recycled from large stores. Based on the collected data, it is important that recycling of MSW in Al-Ahsa is to be considered in order to reduce landfills and environmental problems.

Keywords: *Municipal solid waste management, Al-Ahsa, Saudi Arabia*

1. Introduction

Al- Ahsa is the main city of the eastern in Saudi Arabia with a population of 1,200,000 in 2009 census [1]. Al-Ahsa city is located at coordinates 25.383 degrees North, 49.6 degrees East, in the eastern in Saudi Arabia as shown in Fig. 1. and encompasses an area of 534,000 km^2 [2].The Municipality of Al Hofuf is located in the central part of Al-Ahsa , approximately 350 km south east of Riyadh (the capital of Saudi Arabia). The municipality is characterized by both urban and non-urban areas.

Al-Ahsa is characterized by a hot climate, the average mean summer temperature (May through September) is 36 °C. with a peaking average of 38 °C in July, while the average winter temperature (November –March) is 18 °C. The mean temperature over the period 1989-2009 is shown in Fig. 2. The precipitation in 2010 was 20.9 mm [3]. The majority of the land is desert and characterized by date palm trees covering part of the area with water springs used for irrigation.

There is a large university in Al-Ahsa, Most of the industries are of small to medium size for packaging dates and dairy products plants. The largest fraction of the economy of the municipality, almost 85.6%, is comprised of commercial and noncommercial establishments, small businesses, and institutions such as trade and retail companies, transport and communication, public administration and schools, lodging and restaurants etc. Most of the people work for the governmental institutions, the university and with oil producing companies (Saudi ARAMCO).

Solid waste management is a multidimensional challenge faced by urban authorities especially in developing countries. Municipal authorities are usually the responsible agencies for solid waste collection and disposal. The volume of municipal solid waste (MSW) produced annually is increasing rapidly as a result of population growth, global urbanization, rapid industrialization and economic development [4].

Waste disposal in developing countries is still largely random and uncontrolled. In the Kingdom of Saudi Arabia context, the MSW collection services are facing an increasing number of problems such increasing population growth, changes in habits and lack of awareness of the impact of solid waste on the environment. Therefore, it is the aim of this paper to evaluate the current MSW practice in Al-Ahsa and to recommend proper management procedures to improve MSW management, which in its turn will ultimately step up environmental protection.

The subject of treating solid wastes is one the most important issues that were adopted by the League of Arabian Countries in its programs for the year 2008. The league urges researchers to prepare project proposals for solid waste management at a country level for the Arab region. Furthermore, an integrated strategy for the management of hazardous materials and waste should be implemented. Improper management of municipal solid waste (MSW) causes hazards to inhabitants for its crucial role on environment pollution [1-8]. Proper solid waste management (i.e., storage, collection, disposal, and recycling)

* Corresponding author. Tel.: +966-3-5895419
E-mail: mgharaiba@kfu.edu.sa

DOI: 10.5383/swes.02.02.006

requires accurate information regarding waste-generation rates, and quantities, composition, sources, and locations of waste [9]. This type of information is not available for the cities in Al-Ahsa of Saudi Arabia. There are a number of successful case studies of community and private sector participation in Solid Waste management in developing countries [10-13], but these did not address waste-generation rate or waste composition. Other studies presented more cases regarding MSW managements in various countries [14-23]. Unfortunately, such case studies are not implemented in Al-Ahsa. Furthermore, the present method of solid waste collection and storage in Al-Ahsa is traditional and inefficient because different sources of waste are mixed together. Moreover, there are no sound records indicating the amount of various types of waste collected and the volumes of waste generated per capita.

Fig.1. Kingdom of Saudi Arabia map and Hofuf (Al-Ahsa) location

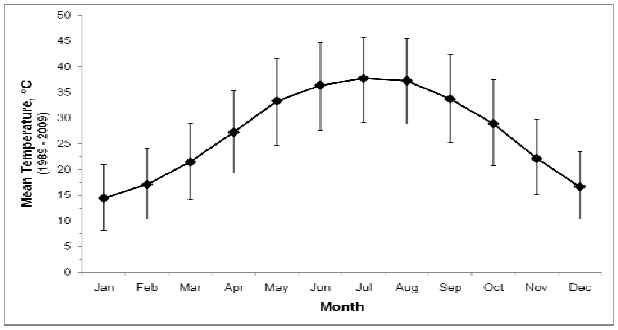

Fig. 2. Al-Ahsa Mean Tempreature for the period 1989-2009.

In this study, an attempt will be made to provide a comprehensive review of the characteristics, generation, collection and transportation, disposal and treatment technologies of MSW practiced in Al-Ahsa . Based on the results, a solid waste management plan will be proposed.

2. Solid Waste Services

The public works services in the municipality are performed by private contractors under the supervision of the municipality. The entire municipal solid waste, including the collected litter, is collected in a variety of containers. The types and sizes of containers used for onsite storage of the solid waste range from approximately 0.25 m^3 small residence containers (barrels) to 5 m^3 curbside containers. The most commonly used containers are 0.25 m^3 containers. The waste is frequently bagged in old shopping plastic bags before storing/disposing into the containers, and sometimes is disposed as bulk or bagged in trash bags. This type of disposal significantly contributes to mixing of the waste in the onsite storage containers.

During the period of the study, solid waste was collected daily by a fleet of solid waste collection vehicles composed of 26 vehicle of 10 m^3 capacity and 16 vehicles of 5 m^3 capacity (shown in Fig. 3). The solid waste is sent to two transfer stations (Fig. 4) to decrease operational cost. The type of the transfer stations is direct-load. New and well designed transfer stations were being under construction during the period of the study (Fig. 5). The waste that is collected by the collection vehicles is discharged into an open top bin then transferred with compaction to a 75 m^3 trailer (Fig. 6). In terms of sanitation, these transfer stations are well managed and maintained. Then the MSW is transferred to the landfill site operated by a private contractor under the supervision of Al-Ahsa municipality. The landfill is located approximately 30 km east of the city of Al-Ahsa.

Fig. 3. Solid Waste Collection Vehicles

Fig. 4. Al-Mubaraz Transfer Station

Fig. 5. New Transfer Station under Construction

Fig. 6. A main hall truck (75 m^3 capacity)

The application of the Daily Route method of waste collection allows the municipal solid waste generated in a seven day period to be collected once during these seven working days.

Hazardous wastes are generated from hospitals, university, technical colleges, and maintenance shops in Al-Ahsa. The hazardous wastes are collected separately and disposed of at a national industrial waste dump on a paid basis in Al-Jubail industrial city located about 300 km north east of Al-Ahsa .

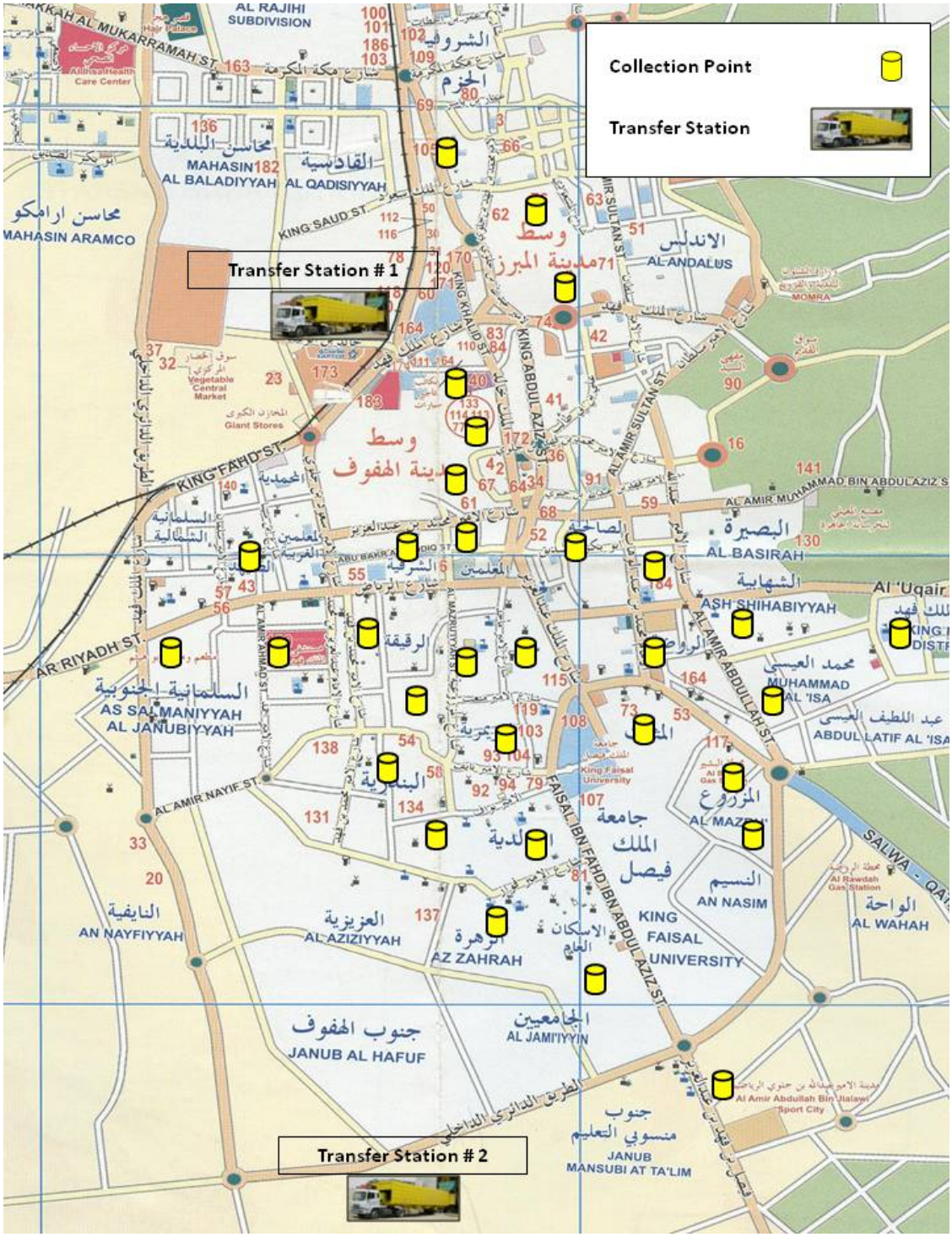

Fig. 7. Location of selected collection points and transfer stations of Al-Ahsa region

3. Methodology

In the study several important parameters of the municipal solid waste stream in Al-Ahsa were assessed: solid waste generation rate, quantity of daily generated municipal solid waste expressed per capita, and composition of the municipal solid waste. The municipal solid waste generation rate was estimated from calculating the number of collecting waste vehicles, number of collection routes and the capacity of each vehicle. The generated solid waste per capita was calculated by calculating the mass generating rate assuming the specific gravity of the solid waste is 300 kg/m^3 then dividing it by population. The composition of the municipal solid waste was estimated by taking samples randomly over two months period (March, April 2010) from 34 locations in Al-Ahsa as shown in Fig. 7.

The selected areas represent: high income areas, low income areas and commercial areas. Then the samples were segregated into the following categories and each category was weighed:

- Food waste.
- Paper & cardboard.
- Glass.
- Plastic.
- Aluminum.
- Scrap metal excluding the aluminum.
- Rubber.
- Wood.
- Agricultural waste.
- Hazardous waste.
- Others including electronic devices, used furniture, electrical appliances, etc.

4. Results and Discussion

The generation rate of uncompacted MSW of Al-Ahsa was calculated to be 3,800 m^3/day which is equivalent to 1140 t/day. Therefore, the average daily generation rate per capita, based on Al-Ahsa population of 1,200,000 and MSW density of 300 kg/m^3 [28], is 0.95 kg/cap/day which is lower than the average value for Saudi Arabia[7]. The corresponding values for the Arab Gulf countries is shown in Fig. 8. The average values of MSW generation rate for USA, European Union and Developing Countries are 2.08, 1.51, and 0.50 respectively [29]. This may be due to the relatively high standard of living and income in Saudi Arabia. The people in Saudi Arabia (including high percentage of foreign labor) use packed food and bottled drinks and other materials extensively.

The results for MSW analysis are shown in Fig. 9. Paper and cardboard waste comprised 17.09%, followed by food at 14.73%, plastics at 13.81%, wood at 13.51%, metals at 11.41%, and glass at 10.82%, aluminum 7.87%, rubber 3.13% and agricultural waste 6.81%. Hazardous waste was found in measurable small amounts (0.63%). The results for the different areas in Al-Ahsa could be divided into five different zones; these zones are A, B, C, D, and E (Fig. 10). Each zone represents an area of dwellings with similar standard of living. For example zone A is close to the shopping center area and MSW may contain large amounts of paper and cardboard wastes. On the other hand zone D is a newly built area. Therefore, it may contain large amounts of metals as a result of waste by the construction companies. This is evident by Fig. 11. Zones C and E have high percentage of food in their MSW.

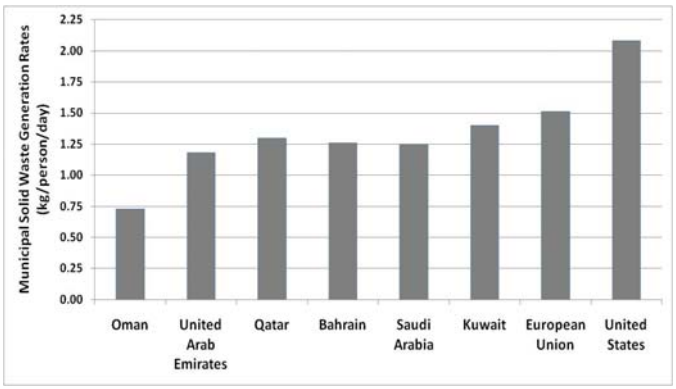

Fig. 8 Municipal solid waste generation in the Gulf Arab countries.

During this study it was observed that:

- Small containers are not sufficient and many of them disappear frequently and have been used by people for other purposes. Therefore most of the onsite small collection containers are new.
- The large containers are open and located near restaurants where they dispose food remnants directly which produces bad smell under high temperature.
- Garbage bins are common for both decomposable and non-decomposable wastes (although no separation is performed).
- Most of the construction/demolition waste is disposed in special containers and collected by a paid contractor.
- A number of large stores collect and recycle cardboard independently.
- Some residential houses and gardens dispose trees remnants in the collection containers.
- Empty bottles and cans are frequently littered by people in the streets.
- Crashing empty glass bottles is practiced by some teenagers.
- Some samples contain hazardous waste in collection containers nearby some private oil change workshops.
- Some hospitals, illegally, dump some diapers, sheets, syringes, veins etc., with the MSW.

The waste analysis of Al-Ahsa showed that the percentage of organic waste in the MSW represents 14.7% which is very low compared with developing countries which is about 55% [29] this could be mainly due to:

- the use of processed foods in the daily diet of inhabitants .
- using bottled and canned products
- a large percentage of foreign labors who depend on canned food in their daily diet.
- local people depends mainly on rice, fish, date and meat in their diet which produce low organic waste.

The present challenges of solid waste management in Al-Ahsa are:

a. Expansion of the city and increasing quantity of wastes: The solid waste quantities generated have been increasing due to a rise in population and in waste generation rate.

b. Problems with hazardous solid waste (HSW): Unfortunately, HSW, including used batteries, and pesticide containers, are not collected separately in Al-Ahsa.

c. Problems with plastic waste: Plastic wastes, especially thin plastics used as packaging materials and PET bottles, have become a nuisance in MSW management in almost all Saudi cities.

At present, landfill is the only method practiced in Al-Ahsa for final disposal. Establishing proper collection and disposal methods appear to be the primary concerns of the municipality of Al-Ahsa. Developing strategies to increase recycling is also of significant concern. In the late 20th century, landfill was recommended as the only option for waste management. Nowadays because of the change in the characteristics of waste, recycling, composting and incineration are common and more suitable management practices [30].

For the Gulf Arab Countries landfill, is considered the most appropriate waste disposal technique. Landfill is dominantly used by all of the GCC member states, and all landfill sites in the GCC region are government owned. Although some of the GCC member states have placed recycling at the top of their waste management priorities, the low cost of landfill and the availability of land, usually old quarries or deserted areas make recycling programs infeasible, uneconomical and unachievable[7].

According to the EPA's integrated waste management hierarchy includes the following four components, listed in order of preference. The waste management hierarchy emphasizes the importance of reducing the amount of waste created, reusing whenever possible, and then recycling whatever is left.

Examples of source reduction activities are:

- Designing products or packaging to reduce the quantity or the toxicity of the materials used or make them easy to reuse.
- Reusing existing products or packaging, such as refillable bottles, reusable pallets, and reconditioned barrels and drums.
- Lengthening the lives of products such as tires so fewer need to be produced and therefore fewer need to be disposed of.

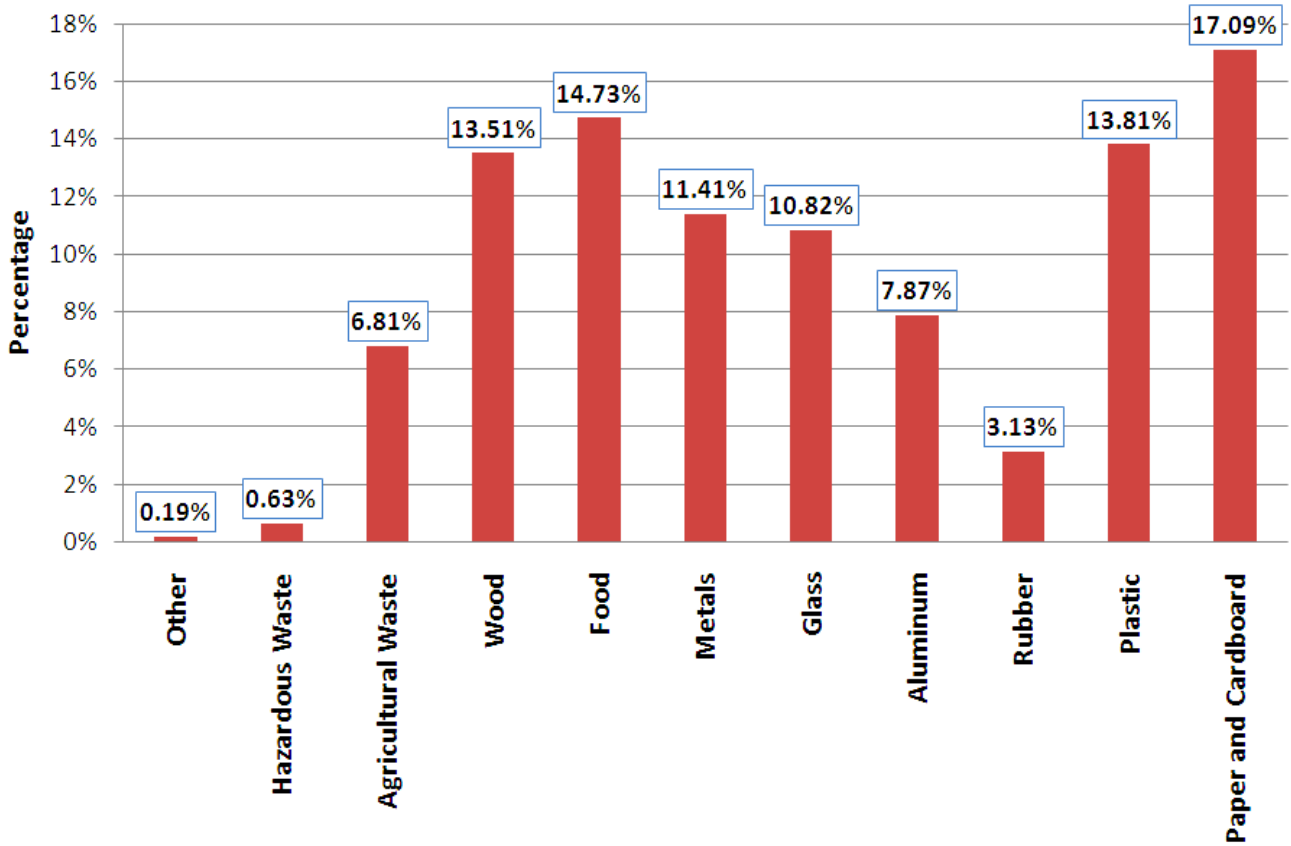

Fig. 9. MSW percentage of material contents

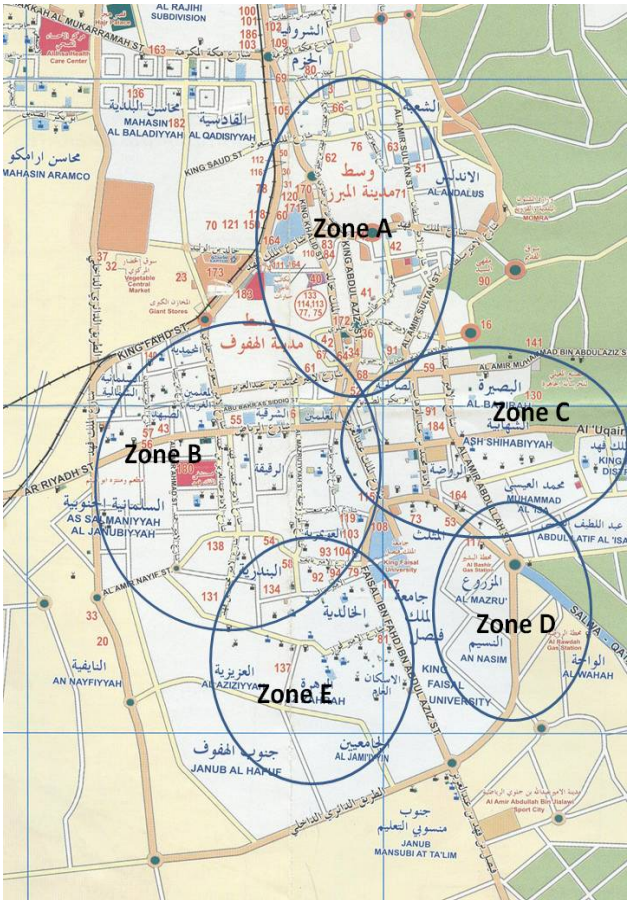

Fig. 10. Collected samples at various locations of Al-Ahsa

The second component of waste management hierarchy is recycling. Materials like glass, metal, plastics, paper, are collected, separated, and sent to facilities that can process them into new materials or products. Recycling has environmental benefits recycling also reduces air and water pollution associated with making new products from raw materials. The main benefits of recycling are prolonging the life of the local landfill sites due to reduction of waste amounts arriving at the landfills and expansion and development in the waste utilization industries and minimizing the use of virgin materials. Before recyclable materials can be processed and recycled into new products, they must be collected. Most residential recycling involves curbside recyclables collection, drop-off programs, buy-back operations, and/or container deposit systems. Collection of recyclables from commercial establishments is usually separate from residential recyclables collection programs.

MSW for Al-Ahsa contains appreciable amounts of recyclable materials such as paper and cardboard, plastics, metals, glass and aluminum. Therefore source separation functions as sorting out individual waste types into separate storage containers at the point of generation is recommended which will be helpful to future waste recycling . The third component is combustion with energy recovery MSW combustion with energy recovery increased substantially between 1980 and 1990 in USA. Since 1990, the quantity of MSW combusted with energy recovery has only increased slightly. Most of the municipal solid waste combustion currently practiced in USA incorporates recovery of an energy product (generally steam or electricity). The resulting energy reduces the amount needed from other sources, and the sale of the energy helps to offset the cost of operating the facility. In past years, it was common to burn municipal solid waste in incinerators solely as a volume reduction practice; energy recovery became more prevalent in the 1980s. Combustion with energy recovery is not recommended for Saudi Arabia and nearby Arab Gulf countries. It has negative effects on air pollution, global warming and ozone layer depletion.

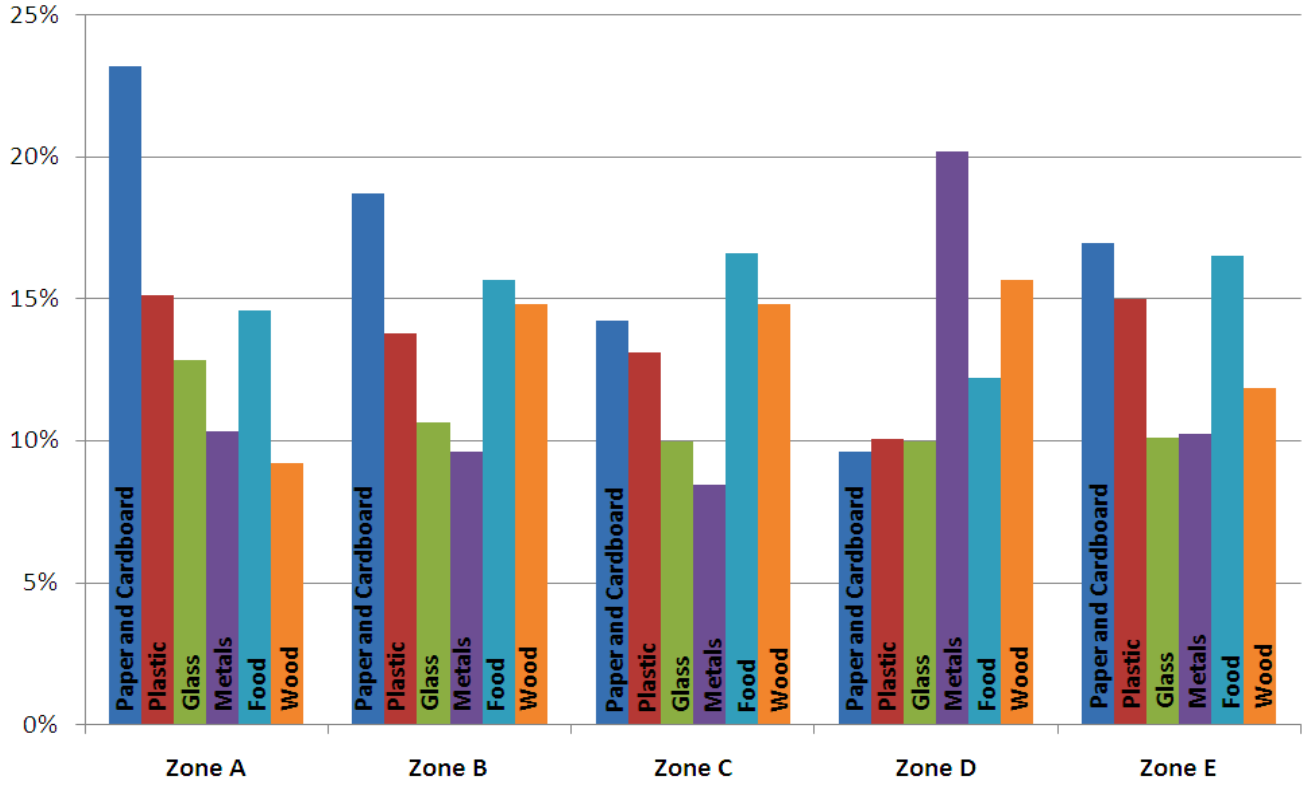

Fig. 11. Percentages of materials at various zones of Al-Ahsa

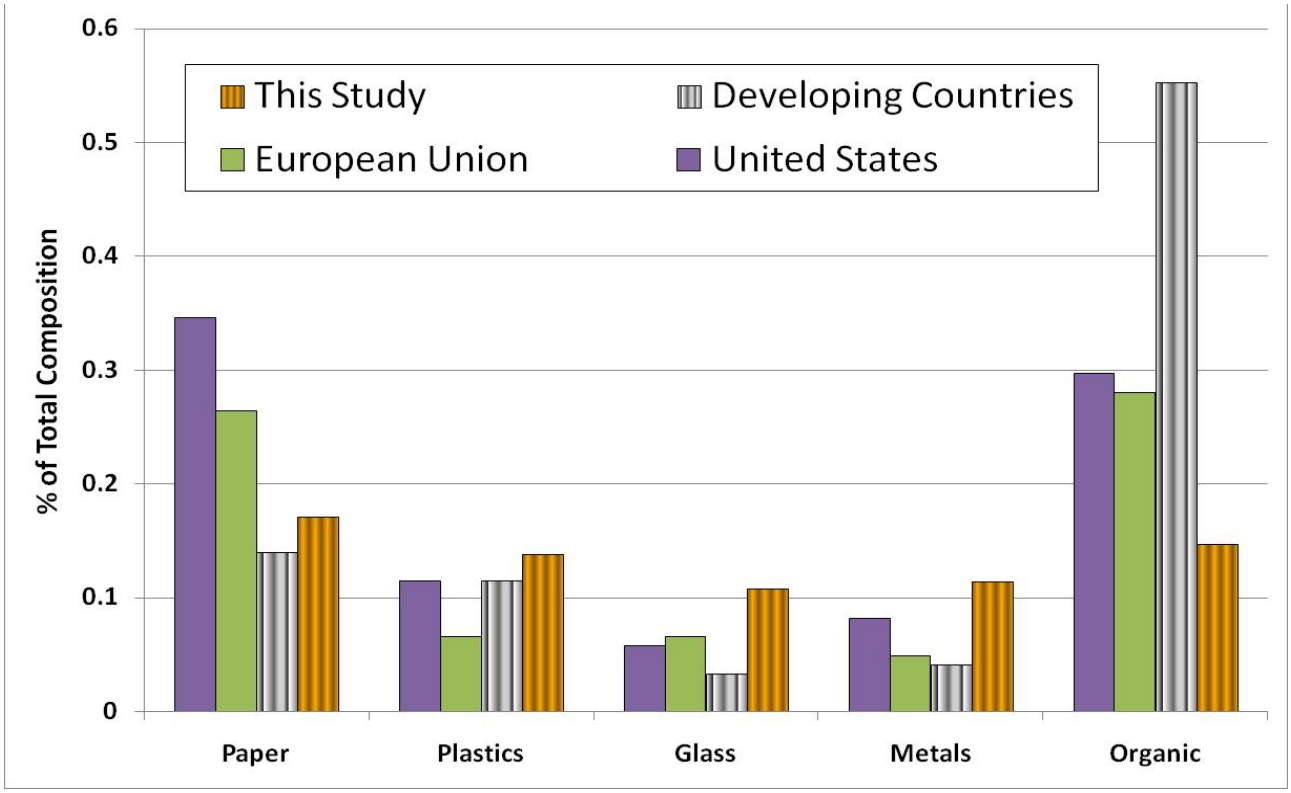

Fig. 12. compare the results of this work with the results for USA, European countries and the average composition of MSW for developing countries

The main challenge for the solid waste management system of Al-Ahsa city is the public awareness. Efforts should be made by both the government and local authorities to increase public awareness and participation regarding solid waste management issues through an organized program using the media, advertisement, direct contact with public through the university, schools and local societies. Activation of laws that control unethical disposal of SW and protecting the small SW containers, dumping of food from restaurants directly to the large containers without bagging.

There are certain principles of general applications, which are basic to proper waste management:

- Disposal plans must be reviewed periodically in the light of changing conditions, changing processes and technology. A method of disposal once considered appropriate, safe and economical may no longer be so.
- Site contingency plans should be available, designed to cope with emergencies and accidents and these should also be reviewed in the light of any changes made in the handling of waste and the appropriate authorities advised.

4. Conclusions

- MSWM is of a primary concern for the municipality of Al-Ahsa.
- Al-Ahsa province generates 1140 metric tons of municipal solid waste per day.
- The average MSW generation rate in Al-Ahsa is 0.95 kg/capita/day.
- New collection and hauling trucks are used to collect MSW from residential areas to the transfer stations and to the final landfill site.
- Small containers are not sufficient and many of them disappear frequently and have been used by people for other purposes. Therefore most of the onsite small collection containers are new.
- A number of large stores collect and recycle cardboard independently.
- Source separation functions as sorting out individual waste types into separate storage containers at the point of generation is recommended which will be helpful to future waste recycling .
- The percentage of the organic materials in the MSW is low, therefore composting of MSW is not recommended
- Strict regulations and control should be implemented to prevent disposal of hazardous waste with the MSW.
- It is recommended that Al-Ahsa Municipality held public awareness programs on the municipal solid waste management and recycling.

Acknowledgments

The authors would like to acknowledge the financial funds to support their research project provided by King Faisal University through KFU Deanship of Scientific Research. The authors also would like to thank all responsible people in the Municipality of Al-Ahsa for their kind cooperation in this research.

References

[1] Obtained from: http://en.wikipedia.org/wiki/Hofuf

[2] Obtained from: http://en.wikipedia.org/wiki/Al-Ahsa_Governorate

[3] Obtained from: http://weather.ie.msn.com/local.aspx?wealocations=wc:6907691&q=Al+Mubarraz%2c+SAU

[4] Suocheng, D., Tong, K.W., Yuping, Y., 2001. Municipal solid waste management in China: using commercial management to solve a growing problem. Utilities Policy 10, 7–11.A.

[5] Bdour, B. Altrabsheh, N. Hadadin, M. Al-Shareif, 2008. Assessment of medical wastes management practice: A case study of the northern part of Jordan, *Waste Management*, 28, 746–759.

[6] A. Damghani, G. Savarypour, E. Zand, R. Deihimfard, 2008. Municipal solid waste management in Tehran: Current practices, opportunities and challenges, *Waste Management*, 28, 929–934.

[7] J. Alhumoud 2005. Municipal solid waste recycling in the Gulf Co-operation Council states, *Resources, Conservation and Recycling*, 45, 142–158.

[8] J.M. Alhumoud, I. Al-Ghusain, H. Al-Hasawi, 2004. Management of recycling in the Gulf Co-operation Council states, *Waste Management*, 24, 551–562.

[9] A. Agarwal, A. Singhmar, M. Kulshrestha, A.K. Mittal, 2005. Municipal solid waste recycling and associated markets in Delhi, India, *Resources, Conservation and Recycling*, 44, 73–90.

[10] Bartone, C., Leite, L., Triche, T., Schertenleib, R., 1991. Private sector participation in municipal solid waste service: experiences in Latin America. *Waste Management and Research* 9, 495–509.

[11] Boadi, K.O., Kuitunen, M., 2003. Municipal solid waste management in Accra Metropolitan Area Ghana. *The Environmentalist* 23 (3), 211–218.

[12] Chandana K. Vidanaarachchi, Samuel T.S. Yuen, Sumith Pilapitiya, 2006. Municipal solid waste management in the Southern of Sri Lanka: Problems, issues and challenges, *Waste Management*, 26 920–930.

[13] H.U. Khan, T. Husain, and S.M. Khan, 1987. Solid Waste Management Practices in the Eastern of Saudi Arabia, *Environmental Management*, 11(6), 729-734.

[14] J.C. Agunwamba, 1998. Solid waste management in Nigeria; problems and issues, *Environmental Management* 22(6), 849–856.

[15] J.M. Alhumoud, 2002. Solid waste management in Kuwait. *Journal of Solid Waste Technology and Management* 28(2), 97–105.

[16] A.M. El-Hamouz, 2008. Logistical management and private sector involvement in reducing the cost of municipal solid waste collection service in Tubas of the West Bank, *Waste Management*, 28, 260–271.

[17] CWG 2006. Solid Waste, Health and the Millennium Development Goals, A Report of the CWG International Workshop, Compiled by Adrian Coad, Kolkata, India.

[18] G.V. Patil, K. Pokhrel, 2005. Biomedical solid waste management in an Indian hospital: a case study, *Waste Management*, 25, 592–599.

[19] Gbenga Matthew Ayininuola , Musa Adekunle Muibi, 2008. An engineering approach to solid waste collection system: Ibadan North as case study, *Waste Management*, 28, 1681–1687.

[20] G. Vego, S. Kuc˘ar-Dragic˘evic´, N. Koprivanac, 2008. Application of multi-criteria decision-making on strategic municipal solid waste management in Dalmatia, Croatia, *Waste Management*, 28, 2192 – 2201.

[21] H.A. Abu Qdais, 2007. Techno-economic assessment of municipal solid waste management in Jordan, *Waste Management*, 27,1666–1672.

[22] Isa, M.H., Asaari, F.A.H., Ramli, N.A., Ahmad, S., Siew, T.S., 2005. Solid waste collection and recycling in Nibong Tebal, Penang, Malaysia: a case study. *Waste Management and Research* 23(6), 565–570.

[23] J. Jin, Z. Wang, S. Ran, 2006. Solid waste management in Macao: Practices and challenges, *Waste Management*, 26,1045–1051.

[24] Kgathi, D.L., 2001. Instrument for sustainable solid waste management in Botswana. *Waste Management and Research* 19 (4), 342– 353.

[25] M.A. Sufian, B.K. Bala, 2007. Modeling of urban solid waste management system: The case of Dhaka city, *Waste Management*, 27, 858–868.

[26] M.F. Badran, S.M. El-Haggar, 2006. Optimization of municipal solid waste management in Port Said – Egypt, *Waste Management*, 26, 534–545.

[27] L. Sefouhi, M. Kalla, L. Aouragh, 2010. Trends and problems of municipal waste management in Banta city and prospects for a sustainable development, *International Journal of Sustainable Water and Environmental Systems*, 1, 15-20.

[28] T. Ch. Ogwueleka**,** 2009. Municipal solid waste characteristics and management in Nigeria, *Iran. J. Environ. Health. Sci. Eng*., 6(3), 173-180.

[29] Alexis M. Troschinetz , James R. Mihelcic, 2009. Sustainable recycling of municipal solid waste in developing countries, *Waste Management* 29, 915–923.

[30] Tinmaz, E., Demir, I., 2006. Research on solid waste management system: to improve existing situation in Corlu Town of Turkey, *Waste Management* 26, 307–314.