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ESTIMATING GENERATION RATE AND COMPOSITION OF SOLID WASTES FOR MANAGEMENT IMPROVEMENT IN ALMUTHANNA, IRAQ

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ABSTRACT

Under the influence of deterioration in solid waste management in Iraq, this paper describes the work conducted to improve the solid waste management practices in Al-Muthanna Governorate. Numbers of students and volunteers at the College of Engineering at Al-Muthanna University have developed a methodology to test solid waste characteristics at their homes, selected institutional locations, and various dumpsites in the two major cities in the governorate. The average of solid waste generation in the governorate was 0.78 ±0.23 kg/person/day, and it is applied to employees and students which are representing around 37.5% of the governorate's population. However, other classes of the population such as farmers, merchants, or workers are not expected to show significant differences. Municipalities of Al-Muthanna Governorate need to establish a solid waste management strategy that includes composting and recycling programs. Among the commingled waste, materials that can be composted (food waste, paper, cardboard, yard wastes, wood, and other organics), represent 56.2% of waste. Municipalities can easily find a market for paper and cardboard, so if they decided not to use them for composting, the remaining percentage is (40%) which is still significant.

Keywords: generation rate and composition estimation, solid waste management, Iraq.

INTRODUCTION

Most of anthropogenic activities consequence in generating solid waste (Laurent *et al.*, 2014a, b). Inappropriate solid waste management (SWM) contribute to spreading of diseases and infirmity in human and other species, deprivation of ecosystems, depletion in natural resources, decrease in real estate values, and may cause blocking drainage systems and damaging infrastructures. Capricious solid waste dumping may lead to the formation of a high amount of toxic leachate to the soil, rivers, and groundwater (Aziz *et al,* 2011). In addition, solid waste is one of the important contributors to climate change and global warming (e.g. from emissions of greenhouse gases from landfills or from open burning) (Laurent *et al.*, 2014a).

Due to an increase in solid waste generation and the lack of proper SWM strategies, some developing countries need to put high efforts to build the basic required infrastructures for an efficient SWM. Improper SWM is severe in countries suffered crises such as Iraq. Solid wastes in Iraq represent one of the big problems facing the country where the inefficient management is related to the lack of implementing the basics of the integrated solid waste management (ISWM) practices. The basic waste collection systems are missing in most of the country's cities (Knowles, 2009). Besides the need for a planned strategy to recover from the environmental impacts due to the improper practices during the last decades, continuous poor management of all types of waste streams has caused a high requirement for urgent and effective waste management infrastructure (Knowles, 2009).

Recently, most of the Iraqi cities are suffering from incompetent solid waste collection systems, and disposing wastes to unregulated dumpsites. According to Hauer (2011), an estimated 31,000 tons of solid wastes produced every day in the country, where only 4,000 tons are collected and moved to dumpsites. These dumpsites have grown without careful deliberation for pollution prevention measures, and they appear to dearth minimal pollution prevention practices or structures such as liner systems, compaction and daily cover, and leachate/gas collection systems (Knowles, 2009). Cities in Al-Muthanna Governorate are no exception. Tons of solid wastes are accumulated in streets, parking lots, and driveways changing cities in Al-Muthanna Governorate into highly polluted cities (Alyaseri, 2016). Al-Muthanna Governorate is one of the southern governorates in Iraq. With a total area of 51740 km2, a population of 780000, and a poverty rate of 52.5% (Statistics Directorate in Al-Muthanna, 2014), the governorate is suffering the lack of essential infrastructures including solid waste management essentials. The projected Iraqi landfill requirement to the year 2027 for Al-Muthanna Governorate is 13 Mm3 (Knowles, 2009).

Every single day in the governorate, tons of solid wastes are either open burned by citizens in their yards, broken down into small pieces and leached to rivers or streams, consumed by cattle, or accumulated in the soil around homes and schools. Even the small portions of solid wastes collected by the municipalities are usually taken away to dump sites that lack any pollution prevention practice. No clear collection system used now in the cities of the governorate. There are some hauled and stationary containers in some areas for in-place storage while no containers in other areas. No designated locations for the placement of containers. In most cases, the placement of these containers in a specific location is only a response for residences' formal requests. The collection is daily for some areas while it is absent for the most.

Numbers of available packers are not suitable for the amount of waste generated. The frequency of collection is not regular and clear routing for packers are usually missing.

Besides the lack of an efficient collection system in the urban regions, rural regions are not served now with any collection or treatment system. Rural regions represent important demographic areas in the governorate. Statistics Directorate in the Governorate in the year 2014 indicated that the population in the governorate was 770476 of which 55.5% of them are living in rural areas.

Extensive and collaborative works are required for establishing an efficient and integrated solid waste management system in the governorate. Data for generation rate and composition are essential for any efficient SWM system. Studies to obtain these data in Iraq are still limited. Aziz *et al.* (2011) estimated waste generation in Erbil City as 0.654 kg/capita/day. Hadi (2014) estimated that the rate of solid waste generation in Hilla City is 0.93 kg/capita/day in the year 2012, and this rate was expected to increase at a rate of 4% per year. Other studies estimated that the rate of solid waste generation in Iraq varies from 0.8 to 1.4 kg/capita/day (RTI International, 2008). However, the rate of generation and other waste properties are not identified clearly due to changes in population and lack of studies in many cities in the country. In Al-Muthanna Governorate, no studies have been conducted to estimate the generation rate or composition properties.

However, in order to design an efficient solid waste collection and disposal system, a number of questions regarding waste characteristics must be answered (Tchobanoglous, 1993). The data related to estimating generation rate and other properties of wastes will help in designing a collection and treatment system for the governorate' cities. For example, Number and volume of trucks required, the total number of residents served per week, collection frequency, number of residents that can be served per truck every day, number of workdays per week, labor requirements, etc require a clear understanding of waste characteristics (Elagroudy *et al.*, 2011).

Objectives of this project are: 1) to estimate generation rate, composition, and other properties of solid wastes based on hands-on approach learning, and 2) to prepare a set of recommendations for the best management practices for solid wastes management in the governorate.

MATERIALS AND METHODS

Beigl *et al.* (2008) reviewed 45 studies on waste generation estimation across the world. they referred to four characteristic classification criteria; regional scale, type of modeled waste stream, type of independent variables, and modeling method. For every case, it is essential to carefully decide the approach to be used for waste characterization. Focusing on household may be the most effective approach in Iraq. In addition to simplicity, it facilitates analyzing relationships between waste characteristics and individual characteristics or habits of either the household itself or the household's representative (Beigl *et al.*, 2008).

Regarding the waste streams modeled, it may be classified into three concepts; material streams, collection streams, and fractions of household waste (Beigl *et al.*, 2008). The first concept which is the most appropriate for this experiment is to address all wastes originating from the final consumer. College students can achieve this methodology in their households. A hands-on assignment for students in two semesters (spring and fall 2018) was used in the Civil Engineering Department in the College of Engineering at Al-Muthanna University for examining generation rate and composition of solid waste at their homes. Testing solid waste characteristics from institutional and dumping areas was conducted by a number of volunteers. The work includes testing the composition of solid waste in various samples from dumpsites in the two major cities in the Governorate (Al-Samawah and Al-Rumaitha).

On October 10th, 2017, a number of institutional locations were selected for sampling. Sixteen students and volunteers were arranged in two groups: one for visiting institutes, and another for going with packers for sorting and classifying solid waste from residential and commercial areas at Al-Samawah and Al-Rumaitha dumpsites.

An engineering course was started at the beginning of February 2018 to teach students concepts and methodologies of SWM. Household characteristics are usually gained by personal interviews and surveys. Before the starting of the hands-on assignment, students were asked to fill a form that describes some of their information such as location, number of household members, average level of education, and average stay hours at home. One of the main issues related to deciding the appropriate sample sizes is representativeness, which is highly dependent on the experiment's temporal and spatial conditions, household income (Abu Qdais *et al.*, 1997), and education level (Pladerer, 1999). Aziz *et al.* (2011) collected 72 samples of solid waste materials from different types of households in the four quarters of Erbil, Iraq (population around 700,000). Yasir (2012) used samples ranged from 100 to 115 for selected cities in three governorates in southern Iraq. Sampling in the former two pieces of research weren't continuous. 48 students participated in this assignment in spring 2018 and 45 in fall 2018. The average number of households in their families was 7 ±2.4 person/home. The number of samples in this research were limited to the number of students (93) but was continued to a period between April 18th and May 24th, and between November and December 15th, 2018. Students during this period were following various patterns ranging from daily to weekly examining. The period was selected to ensure considering fluctuations in the composition of the waste stream. This number of samples was verified statistically for a confidence level of 95%.

Iraq's per capita gross domestic product for the year 2018 was $5,878. According to data collected from students, their average income was $2,160/person/year

(±$1,776 SD). Household income was expected to be the main factor affecting the rate of generation and waste composition. Homes were classified according to their income into above and below the poverty line. Among the 93 students, a significant number of them are living below the poverty line (31 students if consider $3.2/person/day as the poverty line, and 58 students if consider $5.5). Data collected from students included the average years of education for students' families sampled. The average was 10 years (±3.4 years SD and range from 2 to 17 years).

For all generation rate and solid waste composition sampling activities, every student was given instructions to follow during his/her analysis. Data collected from students included: number of persons per household, district, duration or storage time, composition after sorting, special events if any, types and quantities of hazardous materials, and any other remarks. Although Aziz *et al*., (2011) estimated solid waste generation in (Erbil, Iraq) without assessing time spent by household members at their homes, the average time spent at home by individuals participated in the experiment may affect the generation rate, hence such data was collected.

The average generation rate in (kg. capita^{-1} day^{-1}) was determined by every student. Figure-1 shows images of students conducting the experiment at home and at the dumpsite.

Figure-1. The right image shows a student conducting the experiment at his home while the one to the left shows the sorting process at the dumpsite in Al-Samawah city.

For institutional locations, the number of schools, and offices for direct sampling was randomly selected. Besides solid waste characteristics data, numbers of students or employees in the institution or an average number of people who visit the location per day were collected. The teamwork on the institutional sites includes four students and four volunteers. A total of 28 visits to selected locations in Al-Samawah City were made by the team. Al-Muthanna University, number of elementary and high schools, and the Departments of Education, Environment Protection, Agriculture, and Urban Planning were selected for sampling. A work plan was developed for sampling at these sites. The objectives are to estimate the generation rate and waste composition in these locations. In addition to testing composition and weights, information related to the number of students or employees, estimated visitors to each institute or department, and the time of the last collection was gathered during every visit.

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Volunteers arranged a plan for sampling the dumpsites in both Al-Samawah and Al-Rumaitha Cities to test solid waste composition. It was hard to calculate the number of homes served by packers -that collect wastes from various locations- to estimate the generation rates; hence the objective was limited to testing waste composition only. A total of 47 sampling events at two phases have occurred. The first phase included 24 sampling events between April 22nd and May 23rd 2018, while the second included 23 sampling events that occurred in the period between October 5th and October 27th 2018. For selection, sorting, and examining the comingled waste stream composition, the Standard Method D 5231 - 92 (Reapproved 2003) was used. The random track loads were examined for composition from the typical weekday collection route in different residential areas. Every load was first quartered, and one part is then selected for additional quartering until a sample size of about 200 Ib (91 kg) is obtained (Tchobanoglous, 1993). Collected solid wastes, from homes or from trucks were sorted into the following components: food waste, plastic, paper, cardboard, textiles, rubber, leather, wood, yard waste, glass, tin cans, aluminum, other metals, dirt and ash, electronic waste, medical waste, and batteries. The samples were manually sorted on a secure sorting area into the waste groups shown in Table-1. Data collected was arranged and classified percentages of waste categories will help in assessing the recycling possibilities.

Table-1. Descriptions of solid waste sorting groups.

Component	Items
Food waste	Food remains and cooked and uncooked food wastes including bones.
Paper	All types of paper such as office paper, magazines, newspaper, and brown paper
Cardboard	High-grade paper, packing board, carton boxes, and corrugated paper.
Plastics	All plastics, for example, bags, packaging, solid plastic items, pens, bottles, and toys.
Textiles	All types of textiles
Rubber	Rubber and tires
leather	Leather cloth parts, shoes, and others.
Yard wastes	Garden waste, grass, leaves, trimmings, and plant parts.
Wood	Construction wood, furniture, trees, etc.
misc. organic	Other organics
Glass	All types of glasses include clear and brown, pieces and/or bottles (without metal or plastic lids).
Tin cans	Tin cans and other kinds.
Aluminum	Soda cans, aluminum doors, aluminum foil, etc.
Other metal	Waste from auto shops, bi-metal cans, etc.
Dirt, ash, etc.	Dirt and ash and anything which doesn’t fit into the categories above
E. Waste	Computers, TVs, cell phones, etc.
Medical waste	Wastes from hospitals, clinics, pharmaceutical centers, etc.
Batteries	Batteries from different types.

RESULTS AND DISCUSSIONS

Experiment at Homes

The class assignment shows that the average generation rate of solid waste in students’ homes was 0.62 kg person^{-1} day^{-1} (±0.26 SD and range from 0.15 to 1.21 kg person^{-1} day^{-1}). This rate is higher than rates from other cities in the country where it shows (0.42 kg person^{-1} day^{-1}) in Najaf Governorate (Hamoud, 2005), (0.44 kg person^{-1} day^{-1}) in Kirkuk City (Al-Najar, 1998), and (0.496 kg person^{-1} day^{-1}) in Mousel city (Suleiman, 2008). But the rate obtained by this experiment is close to rates reported around the region. Manaf et al. (2009) estimated the solid waste generation in Malaysia within the range of 0.5 to 0.8 kg person^{-1} day^{-1}. Other studies from different places in the world are 0.59 kg person^{-1} day^{-1} in Puducherry, India (Bernardo 2008), 0.50 kg person^{-1} day^{-1} in Manila, Philippines (Pattnaik& Reddy 2010), and 0.85 kg person^{-1} day^{-1} in Beijing, China (Zhenshan *et al.* 2009). However, this average generation rate is not for the whole day. Generation rate calculation is not limited to testing rates at homes only. It has to include the rates of generation at public places such as commercial and shopping centers, offices, institutes, and schools. Due to the actuality that commercial stores are not located separate from residential places in the governorates’ cities, it was difficult to estimate generation rate from commercial activities and the focus was to estimate the generation rate in

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institutional places. The average time spent by household members is 65% of the whole day hours (±14.3% SD and range from 7% to 85%) which was around 16 hours of the day.

To test the effects of monthly income on the rate of solid waste generation, data were split into two groups. $5.5/person/day was taken as the threshold for the poverty line. Average solid waste generation in a home for families above this threshold was 0.78 kg person^{-1} day^{-1} (35 homes), while the average for families under was 0.51 kg person^{-1} day^{-1} (58 homes).

Institutional Waste Estimation

The team estimated the generation rate from institutes to be an average of 0.16 kg/person/8 hours (±0.12 kg/person SD). By combining averages from sampling in homes and in institutes, estimation to the overall average of solid waste generation in the governorate was made. This average is 0.78 kg person^{-1}day^{-1}(±0.23 kg person^{-1} day^{-1} the relative SD), and it is applied on employees and students which are representing around 37.5% of the population (Statistics Directorate in Al-Muthanna, 2014). However, other classes of the population such as farmers, merchants, or workers are not expected to show significant differences than students and government departments employees.

Composition Analysis from Dump Sites

As indicated in Table-2 and Figure-2, the composition test reveals that 59% of the solid waste generated in samples from homes was food wastes. If Al-Muthanna' Municipalities want to conduct a source separation program for the collection of solid waste, they have to consider an adequate number of containers for food residuals waste. The high percentage is not unexpected since governorate's residents are still using the old culture of food preparation. Consuming packed and/or processed food is not common in the governorate.

Table-2. Solid waste classification according to sampling in homes (48 homes for 35 days in spring 2018 and45 homes for 30 days in fall 2018), dumpsites (54 sampling events), and institutional sites (28 sampling events).

	Samples from homes, %		Samples from dump sites, %		Samples from institutions, %	
Component	**Average**	**SD***	**Average**	**SD***	**Average**	**SD***
Food waste	59.4	19.1	28.6	14.0	10.8	10.4
Paper	4.4	4.3	5.3	3.4	8.7	9.5
Cardboard	2.6	2.1	10.7	7.8	10.4	4.1
Plastics	6.1	4.7	8.6	5.6	11.7	8.4
Textiles	1.7	2.3	4.5	3.9	0.0	0.1
Rubber	0.9	1.8	4.7	7.8	0.0	0.0
leather	1.5	7.0	3.0	3.9	0.6	2.1
Yard wastes	3.9	5.0	5.0	4.7	13.0	17.1
Wood	2.1	3.1	5.3	4.9	4.2	9.0
misc. organic	1.1	2.2	0.7	1.3	0.7	2.5
Glass	2.9	3.3	4.9	4.1	28.2	12.0
Tin cans	1.9	3.0	3.9	2.8	2.7	6.0
Aluminum	1.5	1.6	2.6	3.3	6.8	4.6
Other metal	1.9	5.5	3.4	4.2	0.0	0.0
Dirt, ash, etc.	6.6	9.2	4.6	7.6	1.5	1.6
E. Waste	0.9	2.3	2.6	3.0	0.6	1.5
Medical waste	0.6	2.5	0.9	1.2	0.0	0.0
Batteries	0.0	0.0	0.6	3.2	0.0	0.0

* Standard deviation

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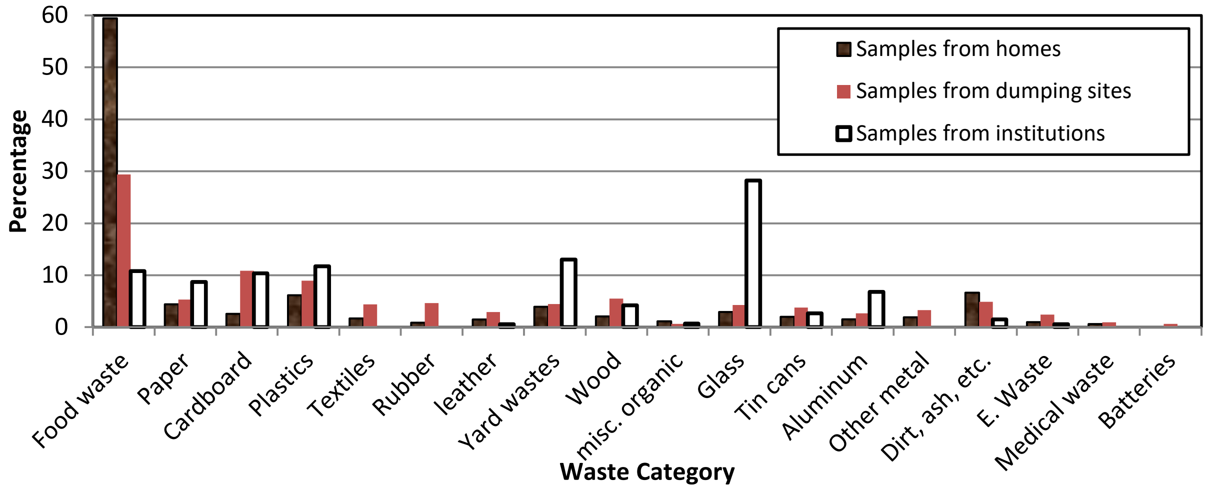

Figure-2. Solid waste classification according to sampling from the three categories.

In general, the composition observed from homes is consistent with composition from other experiments around the world. In more developed cities such as Kuala Lumpur, Malaysia, Saeed *et al.* (2009), observed the following compositions: food waste (57%), mixedpaper (17%), mixed plastic (15 %), and other waste materials (11%). Pokhrel and Viraraghavan (2005) reported that the food waste fraction in municipal solid waste was 70% in Nepal, while Zhen-shan *et al* (2009) showed it was 63% in China.

Reasonably, the percentage of food waste was decreased in the dumpsites to 29% as packers are usually collected from various locations including commercial and institutional sites. Also, not all wastes are collected by municipalities. High percentages of waste are either open burned, accumulated on soil, leached to rivers or streams, or recycled. However, the 29% still indicating promising future for the composting industry if Al-Muthanna' Municipalities implement such methodology for waste treatment. Among the commingled waste, materials that can be composted are food waste, paper, cardboard, yard wastes, wood, and other organics, and they represent around 56% of waste. Municipalities can easily find a market for paper and cardboard, so if they decided not to use them for composting, the remaining percentage is (40%) which is still significant. Renkow and Rubin (1998) showed that composting may be competitive with land disposal where the cost of landfilling is high. It is an effective contamination prevention methodology, and it can provide a good source of revenue to the governorate. Although composting is a simple treatment method that can be implemented by Municipalities with small capital costs comparing to other treatment methodologies, the treatment has to be designed carefully. Several developing countries had established large-scale composting plants that eventually failed mainly due to the lack of application of simple scientific methods to select the material to be composted (e.g. presence of non-compostable materials such as plastic) (Narayana, 2009).

In general, the percentages of paper, cardboard, plastic, textiles, rubbers, leathers, and glasses were increased compared to the percentages from homes due to collection from workshops, commercial, and institutional sites. As can be seen in Table-2, high percentages of recyclable materials can be found which increases the success of any recycling program initiated by the municipalities. The generation rate experiment was included students in both urban and rural areas. With a population of 780,000 capita in the governorate, the monthly generation of solid waste is about 18,000 tons. Although the municipalities have no efficient collection system in urban areas recently, and are not collecting solid wastes from rural areas at all, but even with this limited current collection of waste, a recycling program can be started and then expanded in future.

The data collected by volunteer students are essential for municipalities if these municipalities' representatives are planning to conduct a recycling program for cities in the governorate, or planning to adopt new methodologies for treatment and disposal.

CONCLUSIONS AND RECOMMENDATIONS

Testing solid waste characteristics can be made by university students if municipalities in some developing countries do not have the capabilities to do so. Solid waste generation in Al-Muthanna Governorate was 0.78 kg capita^{-1}day^{-1}. In general, residential solid waste consisted of materials that are compostable (73.4%), combustible (24.7%), recyclable (21.4%), and disposable only (6.6%). The study found that large amounts of food waste are generated on a regular basis. This may be addressed by constructing composting facilities in proper and accessible locations.

Municipalities need to develop a comprehensive strategy to deal with the environmental problem related to solid waste management. This may be implemented through cooperation with the University. Such a strategy should focus recently on increasing collection and encourage recycling. The municipalities should undertake the establishment of a recycling infrastructure and leave the reliance on investments from the private sector. Solid wastes in the Governorate include a significant percentage of materials that can be composted; hence municipalities can start isolating waste that can be decomposed in each dumpsite. Such a site will need a material recycling facility on the same site.

In the future, Al-Muthanna Governorate needs to consider establishing a solid waste management strategy that focuses on recycling programs. Municipalities need to create a marketing department to find external and internal markets of recycled materials to start recycling operations since there is an enormous percentage of recyclable materials that can be found in the waste.

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REFERENCES

Abu Qdais H.A., Hamoda M.F., Newham J., 1997. Analysis of Residential Waste at Generation Sites. Waste Management and Research. 15(4): 395-406.

Alnajjar A. Y. 2015. Solid Waste Management in Iraq. http://www.ecomena.org/swm-iraq/ (October 7, 2016).

Al-Najar W.M.S. 1998. A Study of Collection and Treatment of Solid Waste for Kurkuk City and Its Environmental Impact. Thesis, Master of Science in Environment Engineering, College of Engineering, University of Baghdad, Iraq.

Al-Yaseri I. 2016.Environmental Condition Assessment for Al-MuthannaGovernorate, Iraq: Surface Water Management, Wastewater Treatment, Drinking Water Treatment, and Solid Waste Management in the Governorate.Technical Report for The Local Government in Al-MuthannaGovernorate, Iraq. March, 2016 (in Arabic).

Aziz S. Q., Aziz H. A., Bashir M. J.&Yusoff M. S. 2011. Appraisal of Domestic Solid Waste Generation, Components, and the Feasibility of Recycling in Erbil, Iraq. Waste Management & Research. 29(8): 880-887.

Beigl P., Lebersorger S.&bSalhofer S. 2008. Modeling Municipal Solid Waste Generation: A Review. Waste Management. 28(1): 200-214.

Bernardo EC. 2008. Solid Waste Management Practices of Households in Manila, Philippines. Journal of Annals of the New York Academy of Sciences. 1140: 420-424.

Elagroudy S., Elkady T. and Ghobrial F. 2011.Comparative Cost Benefit Analysis of Different Solid Waste Management Scenarios in Basrah, Iraq.Journal of Environmental Protection. 2(05): 555.

Hadi N. S. 2014. Estimation of Municipal Solid Waste Generation Rate (Case Study of Hilla City).Journal of Kerbala University, Vol. 12 No.1 Scientific. 2014.

Hamoud H.A. 2005. Assessment and Development of Municipal Solid Waste Management in Najaf City. M.Sc, Environmental Department, University of Baghdad, Iraq.

Hauer Walter. 2011. My Knowledge concerning Iraq: Country Program Document 2009-2011).http://www.iswa.org/fileadmin/galleries/Projects/UNHABITAT%20Training%202011/Presentations/6%20Requirements%20for%20Efficient%20Waste%20Management.pdf . (11/10/2016).

Knowles J. A. 2009. National Solid Waste Management Plan for Iraq.Waste Management& Research. 2009: 27: 322-327. DOI: 10.1177/0734242X09104129.

Laurent A., Bakas I., Clavreul J., Bernstad A., Niero M., Gentil E., Hauschild M. Z., Christensen T. H. 2014a. Review of LCA Studies of Solid Waste Management Systems – Part I: Lessons learned and perspectives.Waste Management 34(2014): 573-588. http://dx.doi.org/10.1016/j.wasman.2013.10.045

Laurent A., Clavreul J., Bernstad A., BakasI., Niero M., Gentil E., Hauschild M. Z., Christensen T. H. 2014b.Review of LCA Studies of Solid Waste Management Systems – Part II:Methodological Guidance for a Better Practice.Waste Management 34(2014): 589-606. http://dx.doi.org/10.1016/j.wasman.2013.12.004.

Manaf LA., Abu Samah MA. and MohdZukki NI. 2009. Municipal Solid Waste Management in Malaysia: Practices and Challenges. Waste Management. 29: 2902-2906.

Narayana T. 2009. Municipal Solid Waste Management in India: From waste disposal to recovery of resources?. Waste management. 29(3): 1163-1166.

Pattnaik S. and Reddy MV. 2010. Assessment of Municipal Solid Waste Management in Puducherry (Pondicherry), India. Resources, Conservation and Recycling. 54: 512-520.

Pladerer C. 1999. Disposal Habits of Households Taking Vienna as Example. Master of Science Thesis, BOKU – University of Natural Resources and Applied Life Sciences, Vienna, Austria.

Pokhrel D. and Viraraghavan T. 2005. Municipal Solid Waste Management in Nepal: Practices and Challenges. Waste Management. 25:555-562.

Renkow M.& Rubin A. R. 1998. Does Municipal Solid Waste Composting Make Economic Sense?. Journal of Environmental Management. 53(4): 339-347.

RTI International. 2008. Iraq Strengthening Local Governance Project. Environmental Impact Assessment Workshop, Erbil, Iraq. Erbil, Iraq: Chrakhan Hall.

Statistics Directorate in Al-Muthanna Governorate. 2014. Statistical Data for Al-MuthannaGovernorate. Census 2014, Statistics Directorate, Al-Muthanna, Alsamawah, Iraq.

Suleiman F.A. 2008. Municipal Solid Waste Management in the City of Mosul. Master Thesis, Faculty of Engineering, University of Mosul, Iraq.

Tchobanoglous G., Theisen H. and Vigil S.A. 1993. Solid Waste Management: Engineering Principles and Management. McGraw-Hill International Editions, Civil Engineering Series, ISBN 0-07-112865-4.

Yasir R. A., Hussein T. E., Khalaf. H. A., Selman, M. D., Hadi, F. K. and Semir A. H. 2012. Survey on Solid Waste Management in the Southern Governorates of Iraq.Marshland Research Centre, Marsh Bulletin. 7(1): 69-101.

Zhen-shan L., Lei Y., Xiao-Yan Q. and Yu-mei S. 2009. Municipal Solid Waste Management in Beijing City. Waste Management. 29: 2596-2599.