International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 8, Issue 1 [January 2019] PP: 57-62

Recyclable Solid Waste Materials Management in Erbil City-Iraq

Shuokr Qarani Aziz [1], Srwa Othman Ismail [1], Imad Ali Omar [1,2 *]
1 Department of Civil Engineering, College of Engineering, Salahaddin University-Erbil, Iraq;
2 Ministry of Municipality and tourism, General Directorate of Water and Sewerage-Erbil, Iraq
Corresponding Author: Imad Ali Omar

ABSTRACT: *This paper presents a study on recyclable solid waste materials in Erbil City-Iraq. The data collected from Directorate of Services and Environmental Protection. Collected samples were tabulated and separated to their components: plastic, corrugated & paper, glass, aluminum, and ferrous. In addition, the percentage ratios of recyclable materials were determined for the collected samples. The amount of daily residential solid waste generation in Erbil City was found to be about 1.27 kg/capita for the population of 1,118,187. Average percentage ratios of recyclable materials such as plastic, corrugated & paper, glass, aluminum, and ferrous were 34.87%, 13.39%, 1.84%, 0.5%, and 1.74%, respectively. It is also found that food (organic) waste is the major non-recyclable component (> 50 %) followed by mix plastics and mix paper as recyclable materials. In 2016, the predicted income from the recyclable solid waste in Erbil City was334,488.85 $/day. Along with estimated population growth and their business activities, it has been observed that the city is still lacking in terms of efficient waste treatment technology, sufficient fund, public awareness, maintaining the established norms of industrial waste treatment etc.*
KEYWORDS:*Municipal solid waste; recyclable materials; economic; Erbil City.*

Date of Submission: 28-03-2019 Date of acceptance:08-04-2019

I. INTRODUCTION

Due to economic development and increasing population, problems related to the expanded consumption and depletion of resources and the increased output of wide-ranging types of waste are becoming more serious than ever. Clearly, the way to limit the impact on the environment is by reducing the amount of waste that is generated. Failing this, waste must be either be recycled. Recycling is the best approach to address the issue since it reduces the waste to be directly disposed of in a landfill (Connet and Sheehan, 2001). Additionally, recycling has the potential to reduce disposal costs, waste transport costs and to prolong the lifespan of landfills site (Folz, 1991; Bolaane, 2006). Studies have shown can create a new product from the source materials that indirectly benefit the environment and the economy (Akil et al., 2015). However, the success of the recycling program is depending on the active public participation in the separation of recyclable waste (Akil et al., 2015).For this purpose of this analysis, recycling is defined as the recovery of useful materials such as: paper, glass, plastic, metals, and construction and demolition materials. There are numerous studies related to recycling behavior. In Erbil City, an author studied quality and quantity of household solid waste contents (Shekha, 2011). Recycling of waste engine oils by using a new washing agent (Hamawand, 2013). In the developed country most studies on waste recycling focused on technical applications such as models and tools (Akil et al., 2015). They also involved policy analysis and to measures to improve recycling practices. Turan et al. (2009) presented a brief history of the legislative trends in Turkey for municipal solid waste management (MSWM) and present situation of generation, composition, recycling, and treatment. A study by Wilson et al. (2009) highlighted the role of the informal sector in waste minimization through recycling.

The municipal solid waste (MSW) is the most heterogeneous since they consist of the residues of nearly all materials used by human: food and other organic wastes, papers, plastics, fabrics, leather, metals, glass, and miscellaneous other materials. There are four principal methods for disposal of MSW: 1-Recovery of materials: as paper, metal, plastic, and glass; 2-Recovery of energy: by combustion of organic materials; 3-Bioconversion: the natural organic components of MSW can be oxidized aerobically under controlled condition. The compost product can be used as a soil conditioner. Anaerobic digestion or fermentation produces methane or alcohol and compost product; 4-Landfilling the unrecoverable material have to be disposed of in properly designed landfills (Shekha, 2011). The goal of this study was to determine the percentage composition of each recyclable solid waste materials such as plastic, bottles, glasses, paper, metals, fabric, etc. in Erbil City-Iraq. Estimation of income from the disposed recyclable materials was

another objective for the current work. This study aimed to create a material-recycled society that generates as little waste as possible and recycles and reuses wastes as resources and achievement may assist to preserve the environment and recycle resources on a global level.Also to estimate the economic activity attributable to recycling, it is necessary to associate recyclable materials and recycling flows with the physical processes involved in transforming recyclable materials into useful products.

II. MATERIALS AND METHODS

2.1 Erbil Landfill Site (ELS)

The situation of ELS in Iraq is investigated to determine the effects of disposed MSW in non-scientific landfill on the groundwater and soil characteristics. ELS is situated on the left side of the Erbil-Mosul main road (near Kani-Qrzhala Sub-district) in Erbil City, Iraq and is approximately 15 km from Erbil City center. The landfill, which opened in 2001, has a total site area of 37 ha. Most of the landfill have already been used. The site receives more than 2000 ton of MSW daily (based on data obtained from the ELS administration staff). Disposed MSW is mixed without appropriate separation of components Figs. 2 and3. A small fraction of recyclable materials, such as plastic, glass, and metals, are separated by scavengers on-site (Aziz and Maulood, 2015).

Figure 1. Satellite image of Erbil landfill site at center.

Figure 2. Erbil landfill site.

Figure 3. Recyclable materials from landfill site.

2-2 Types of Solid waste

The common materials of solid waste can be classified in several different ways. The point of origin is important in some cases, so classifications as domestic, institutional, commercial, industrial, street, demolition, or construction may be useful. The nature of the material may be important, so classification may be made on the basis of organic, inorganic, combustible, noncombustible, putrescible, and non-putrescible fractions. But one of the most useful classification is based on types of materials such as rubbish, ashes, street, refuse, dead animals, abandoned vehicles, industrial wastes, demolition wastes, construction generated solid wastes, special wastes, and sewage treatment residue (Davis and Cornwell, 2008).In this study, the classification of the nature of the materials has been depended.

2-3 Percentage Ratio of Recyclable Materials

Percentage ratio of recyclable materials in Erbil city was collected in 2016 from Director of Service and-Environment Protection. For example: plastic, glass, aluminum, ferrous, corrugated & paper; the percentage ratios calculated as follows: Total weight of municipal solid waste in Erbil city for example = 1559460 kg/day

Plastic % = (543783.702*100)/1559460 = 34.87 %
Glass % = (28694.064*100)/1559460 = 1.84 %
Aluminum %= (7797.3*100)/1559460 = 0.50 %
Ferrous %= (27134.604*100)/1559460 = 1.74 %
Corrugated & paper % = (208811.694*100)/1559460 = 13.39 %

These materials can be used as raw materials for manufacturers.

The average percentage ratio of the recyclable materials = 34.87+1.84+0.50+1.74+13.39 = 52.34 % Generation rate of recyclable materials = 0.5234*1.27*1000 = 664.718 g/cap/day. Average daily recyclable materials from solid waste in Erbil city = 664.718*1118187/10^6 = 743.3 tons/day (Ojeda-Benitez et al., 2000).

III. RESULTS AND DISCUSSIONS

Due to increase in population MSW increased in Erbil city, and population in this place approximately about 1118187, and waste generation of 1.27 kg/capita/day. Manycompanies in Erbil city collect the MSW such as Glass Stuttgart, Qadar, BaghiPrgul, Artush, Zug, Nrkh, Halmat, Governmental Trucks, and Private SectorTrucks. Average daily collected of MSW for all companies are 1559.460 tones. The variation is due to different consumer style, per capita waste production, and population composition,

social, economic and cultural status (Ojeda- Benitez et al., 2000). In Erbil City the recyclable material in year 2016 is shown in Fig. 4. The datawere collected from Directorate of Service and-Environment Protection shows that plastic 34.87 %, corrugated & paper 13.39 %, glass 1.84 %, aluminum 0.5 %, ferrous 1.74 %, food waste 27.735%, yard & wood 5.57 %, diapers 5.42 %, other organics 7.01 %, and other inorganics 1.92 %. Another classification of solid waste in Erbil City is given in Fig. 5 (Shekha, 2011).It is important to known that waste from household in Erbil was mainly organic, most of which was food scraps 79%, followed by papers 5% and yard trimmings 3%, while, inorganic composition represented by plastic and nylon; glass and porcelain; metals with 5%, 4% and 3% respectively. Aziz(2009) revealed that the recyclable materials such as plastic, paper, metal, glass, and cloths were 6.28%, 5.9%, 3.61%, 3.42%, and 1.45% respectively. According to the collected data plastic in recyclable material more than any of

metal, paper, glass, etc. The same result was obtained in Nigeria in which organic component reached 75.4% (Afon and Okewole, 2007).

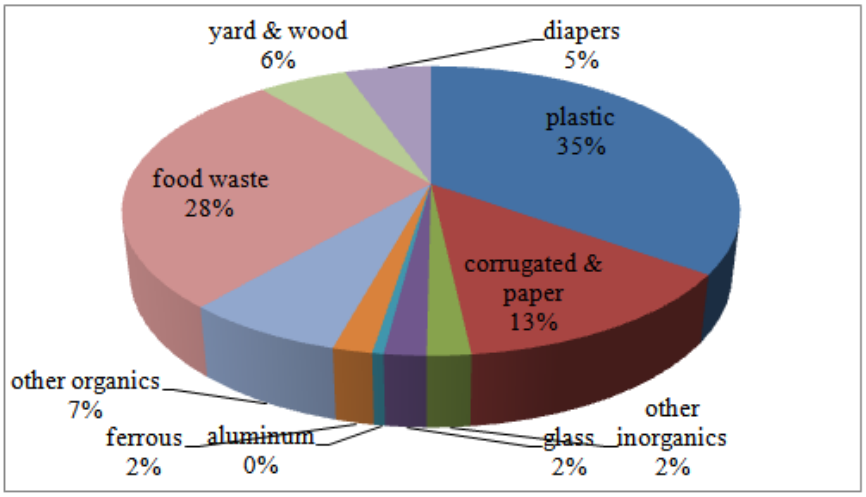

Figure 4. Municipal Solid Waste in Erbil City 2016.

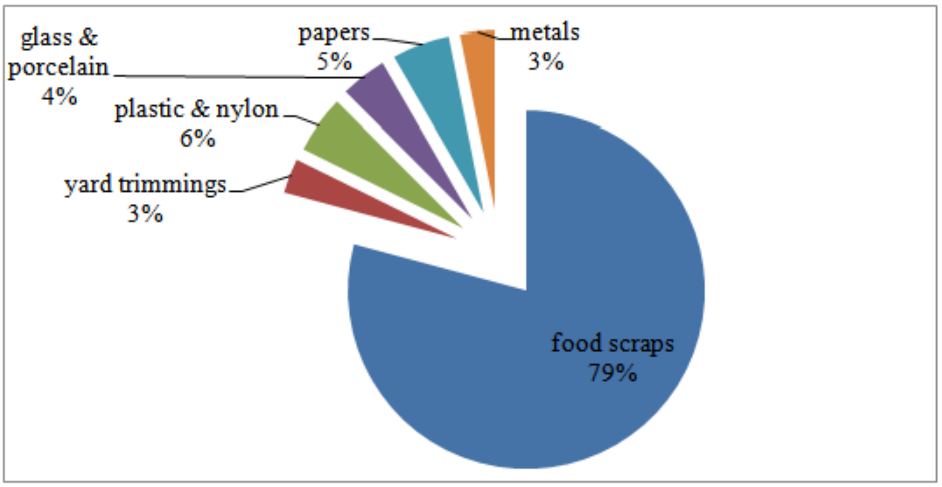

Figure5. Percentage for different solid waste component of Erbil city in 2009.

Fernandez (1996) observed that the largest portion of household waste in developing countries was organic component. From Fig. 6, it is evident that the large part of the refuse produced by the families under study can be recycled or it is potentially recyclable (13.79% can be recycled, 85.87% is potentially recyclable and 0.34% cannot be recycled). Food remains represent the largest amount of potentially recyclable and smallest amount of inert waste for non-recyclable. With regard to organic waste, which forms the greatest part of domestic waste, there is the possibility of creating compost programmed for local nurseries (Skourides et al., 2008). Compost is biological degradation or breakdown of organic matter under aerobic conditions. The organic compost resulting from this process makes a nutrient-rich soil amendment that aids water retention, slows soil erosion, and improves crop yields (Aziz et al., 2018). Donnini et al. (2007) found no significant differences between low- and medium-income level for solid waste generation in Gaborone city, Botswana and return the reason to lifestyle pattern and the type of food consumed in this area. On the other hand, increase in some solid waste component such as glass, paper, metals, plastics and nylon bags with increasing income were observed. Also, they noticed increasesin packaging waste (papers and plastics) with increasing income level in Indaiatuba city, Brazil. In Kuala Lumpur Malaysia the recyclable material plastic and paper more than any of glass, ferrous, etc. The Malaysian´s attitude towards recycling is higher, but only a few practices it (Mamat, 2007). Since 1993 a major effect of recycling waslaunched by the Ministry of Housing and Local Government, but unfortunately limited recycling activities taken place (Agamuthu, 2001). In Kuala Lumpur, by 2005 the recycling of the waste generated planned to reach 16% and 22% by 2020 (Saeed, 2009).

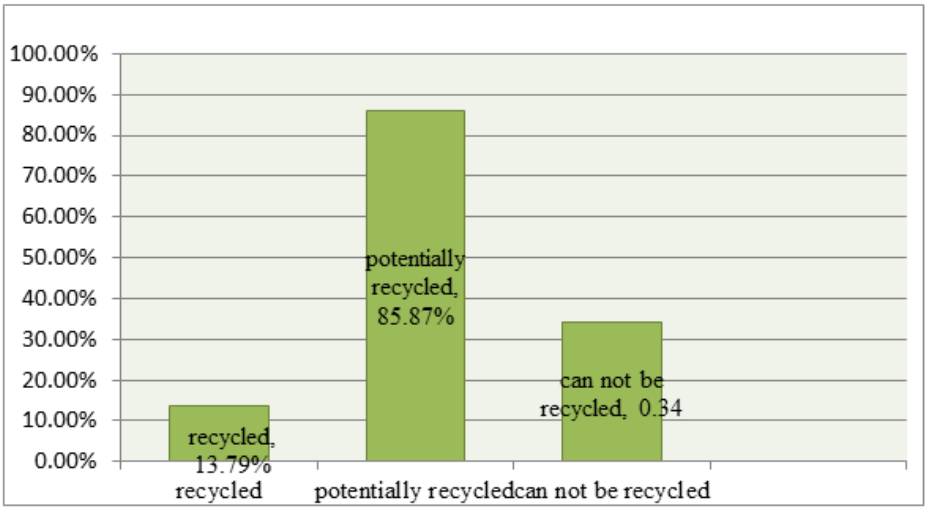

Figure 6. Recyclable, potentially recyclable and non-recyclable refuse as percentage of total refuse.

As the average weights present an unbiased result for the mean by minimizing the sampling error (Bolaane and Ali, 2004). In order to forecast the quantity of waste generation using per capita figure and population number, the simple equation below was used (Gardner, 1988):

Qd=pi Cd

Where Qd is the daily quantity of waste production; Cd is the daily per capita waste generation, and Pi is the population number for a certain year i.

Shekha (2011) provides the average national population growth rate of 3.03% for Iraq, it has been estimated that Erbil city dwellers will reach 939517 inhabitants in 2009. As shown in the Tab. 1, it is estimated that the daily waste production in 2009 will be 400 tones, while the production per month and year expected to reach 12002 and 144028 ton respectively.

Table 1. Expected daily solid waste generation (kg) for Erbil city in the year 2009.

Waste component	**Cd**	**Qd = (Pi Cd)**
Food scraps	0.2867	320.42
Yard trimmings	0.0126	14.1914
Plastic & nylon	0.0144	20.05284
Glass & porcelain	0.01223	16.22228
Papers	0.02262	22.00004
Metals	0.01197	11.8848
Rubber	0.00006	0.048852
Textile & leather	0.00695	7.81484
Inert	0.00110	1.39606
Miscellaneous waste	0.00646	6.49924
Kg/capita/day	0.420	
Kg/capita/year	153.3	
Tones/city/month	120,02.33	
Tones/city/year	144,027.95	

Recyclable materials more useful if we made them to money by selling them for example if tone of recyclable materials Tab. 2, such as plastics are about (300-600) $/ton, and weight of plastic are 543.784 ton/day, 543.784ton*500$ = 271,891.851 $/day it is more useful for developing in economic.

Table 2. Weight and price of recyclable materials in Erbil City

Recyclable materials (R.M)	**Weight of (R.M) Tone/day**	**Price of (R.M) $/tone**	**Weight*price $/day**
Plastic	543.784	500	271,892
Glass	28.7	75	2152.1
Aluminum	7.8	1700	13,255.41
Ferrous	27.135	200	5427
Corrugated and paper	208.8	200	41,762.34
Total			**334,488.85**

The total result shows that the price of these recyclable materials is 334,488.85 $/day it is a high value of cost for profit.

IV. CONCLUSIONS

In recent years, reducing and recycling household waste has become increasingly imperative because a waste generation has been increasing due to an increase in population and economic development. Although there is widespread public support for reducing and recycling of household waste, this is not reflected in participation levels in Erbil City.The amount of daily residential solid waste generation in Erbil City was found to be about 1.27 kg/capita for the population of 1,118,187. Average percentage ratios of recyclable materials such as plastic, corrugated & paper, glass, aluminum, and ferrous were 34.87%, 13.39%, 1.84%, 0.5%, and 1.74%, respectively. It is also found that food (organic) waste was > 50 %. In 2016, the predicted income from the recyclable solid waste in Erbil City was334,488.85 $/day. Finally, private sectors and authority should put a very good plan to enhance awareness of population, reducing disposed waste (particularly food waste), increasing recyclable materials, and increasing income and energy from the disposed MSW.

REFERENCES

[1]. AFON, A. O. & OKEWOLE, A. 2007. Estimating the quantity of solid waste generation in Oyo, Nigeria. Waste management & research, 25, 371-379.

[2]. AGAMUTHU, P. 2001. Solid waste: Principles and management: with Malaysian case studies, Insitute of Biological Sciences, University of Malaya.

[3]. Akil, A. M., et al. (2015). The effects of socio-economic influences on households recycling behavior in Iskandar Malaysia. Procedia-Social and Behavioral Sciences 202: 124-134.

[4]. AZIZ, S. Q. & MAULOOD, Y. I. 2015. Contamination valuation of soil and groundwater source at anaerobic municipal solid waste landfill site. Environmental monitoring and assessment, 187, 755.

[5]. AZIZ, S. Q., OMAR, I. A. & MUSTAFA, J. S. 2018. Design And Study For Composting Process Site. International Journal of Engineering Inventions 7, 09-18.

[6]. BOLAANE, B. & ALI, M. 2004. Sampling household waste at source: lessons learnt in Gaborone. Waste management & research, 22, 142-148.

[7]. Bolaane, B. (2006). Constraints to promoting people centered approach in recycling. Habitat International, 30(4),731-740.

[8]. Che Mamat, R. and T. Chong (2007). Public's Role in Solid Waste Management: In IMPAK, quarterly DOE update on environment, development and sustainability. Issue (4): 5-7.

[9]. Connett, p., & Sheehan, B. (2001). A citizen's agenda for zero waste. Grassroots Recycling Network.

[10]. Davis, M. L., & Cornwell, D. A. (2008). Introduction to environmental engineering: McGraw-Hill Companies.

[11]. Directorate, E. S. (2009). Erbil governorate population according to food card. Archive.

[12]. Directorate, E. S. (2016). Erbil governorate population according to food card. Archive.

[13]. Donnini Mancini, S., Rodrigues Nogueira, A., Akira Kagohara, D., Saide Schwartzman, J. A., & de Mattos, T. (2007). Recycling potential of urban solid waste destined for sanitary landfills: the case of Indaiatuba, SP, Brazil. Waste Management & Research, 25(6), 517-523.

[14]. FERNANDEZ, A. 1996. Introduction in UNCRD, Recycling in Asia: Partnerships for Responsive Solid Waste Management. UNCRD Research Report.

[15]. Folz, D. H. (1991). Recycling program design, management, and participation: a national survey of municipal experience. Public Administration Review, 222-231.

[16]. GARDNER, H. S. 1988. Comparative economic system, Dryden Press.

[17]. Hamawand, I., T. Yusaf and S. Rafat (2013). Recycling of waste engine oils using a new washing agent. Energies 6(2): 1023-1049.

[18]. Mancini, S.D., Nogueiria, A.R.; Kagohara, D.A.; Schwartzman, J.A.S and Mattos, T. (2007). Recycling potential of urban solid waste destined for sanitary landfills: the case of Indaiatuba, SP, Brazil. Waste Management & Research 25(6): 517-523

[19]. OJEDA-BENITEZ, S., DE VEGA, C. A. & RAMÍREZ-BARRETO, M. E. 2000. The potential for recycling household waste: a case study from Mexicali, Mexico. Environment and Urbanization, 12, 163-173.

[20]. Saeed, M. O., Hassan, M. N., & Abdul Mujeebu, M. (2009). Development of Municipal Solid Waste Generation and Recyclable Components Rate of Kuala Lumpur: Perspective Study.

[21]. Shekha, Y. A. (2011). Household Solid Waste Content in Erbil City, Iraq Kurdistan Region, Iraq. Zanco Journal of Pure and Applied Science 23(3): 1-8.

[22]. Skourides, I., and Smith, S. R. (2008). Sources and factors controlling the disposal of biodegradable municipal solid waste in urban and rural areas of Cyprus. Waste Management & Research 26(2): 188-195.

[23]. Turan, N. G., S. Çoruh, A. Akdemir and O. N. Ergun (2009). Municipal solid waste management strategies in Turkey. Waste Management 29(1): 465-469.

[24]. Wilson, D. C., A. O. Araba, K. Chinwah and C. R. Cheeseman (2009). Building recycling rates through the informal sector. Waste management 29(2): 629-635.

Imad Ali Omar" Recyclable Solid Waste Materials Management in Erbil City-Iraq" International Journal of Engineering Inventions, Vol. 08, No. 1, 2019, pp. 57-62