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## Waste Management

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# Solid waste composition analysis and recycling evaluation: Zaatari Syrian Refugees Camp, Jordan

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## ABSTRACT

There is a need for Municipal Solid Waste (MSW) stream characterization and composition analysis to allow for an accurate estimation of its recycling potential and for effective management of the entire system. Recycling provides employment and a livelihood for vulnerable social groups such as refugees. The aim of this paper is to determine the composition of MSW in Zaatari Syrian Refugee Camp, where approximately 430,000 Syrian refugees have passed through the camp. The representative waste samples and analysis included household waste and commercial waste produced by the refugees in the selected districts in Zaatari. The waste sampling was performed in 2015 over two seasons to ensure that the seasonal fluctuations in the composition of the waste stream are taken into consideration. Hand sorting was used for classifying the collected wastes into the categories and subcategories. The organic waste represents the main waste category with 53% of the total MSW, while plastics, textile, and paper and cardboard are 12.85%, 10.22% and 9%, respectively. Moreover, the MSW composition percentage in Zaatari Camp is similar to that in municipalities in Jordan with slight disparity. The potential recyclable materials market has been investigated in this study. Plastics and paper and cardboard have significant potential to be separated and collected for recycling purposes. Financial revenues of potential recyclables have been analyzed based on local prices. Recycling model in the camp is also proposed based on the present study findings. Consequently, these results should be taken as a baseline for all Syrian refugees camps in the Middle East, as well as, in Europe.

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## 1. Introduction

Municipal solid waste (MSW) is a growing social and environmental concern nowadays. Most of the MSW generated in different countries is disposed of in dumping sites, causing severe pollution in the ecosystem and overload of waste in the environment." (Rathi, 2006; Nemerow, 2009; Thanh and Matsui, 2011; Vergara and Tchobanoglous, 2012; Dai et al., 2015; Kawai and Tasaki, 2016).

Accurate and reliable data on waste composition are crucial for both planning and environmental assessment of waste management. Because waste streams vary, the composition of solid waste is different across the rural-suburban-urban communities (Hoornweg and Bhada-Tata, 2013; Ilic and Nikolic, 2016).

There has been a steady increase in the volume of municipal solid waste in Jordan, especially in the last three decades due to various factors such as steady population growth, current modern living standards and the resulting cultural, social and economic developments and massive influx of refugees caused by the numerous and severe conflicts in the neighboring countries (UNDP, 2014).

In mid-September 2013, more than 2 million Syrian people had registered, or were awaiting registration with the United Nations High Commissioner for Refugees (UNHCR) in Jordan, Lebanon, Turkey, Iraq and Egypt. Of these, approximately 600,000 (52.2% females and 47.8% males) have crossed the border into Jordan, distributed mainly among the age group (18–35) representing 28% of the Syrian refugee population in Jordan, and the age group (5–11) representing 20.76%. The number of refugees in Jordan could have surpassed 650,000 in the end of 2013, constituting more than 10 percent of the population in Jordan (UNHCR, 2013; UNDP, 2014).

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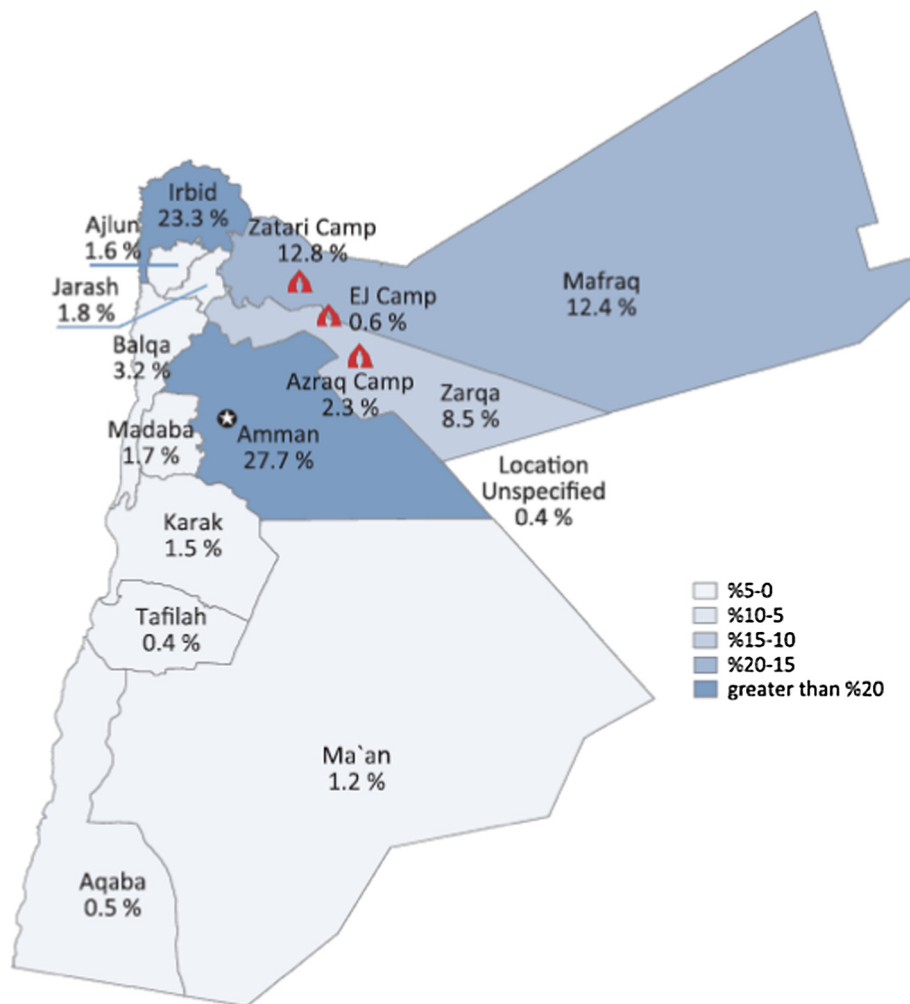


Fig. 1. Distribution of Syrian Refugees in Jordan per governorates and camps in 2014 (JRPSC, 2015).

As shown in Fig. 1, based on the distribution of Syrian refugees in the year 2014, the largest concentration of Syrian refugees is in the northern part of Jordan in the cities of Irbid and Mafraq, with 23.3% and 12.4%, respectively (JRPSC, 2015).

Refugees who are settled in camps precipitate environmental problems and biosphere impacts (Jacobsen; 1997: 23–26; Kalpers, 2001). Some of the Syrians (20%) are living in camps, however, the majority – as much as 70 percent – are staying in urban centers, where they share space, resources and services with their Jordanian hosts. This has however placed a critical pressure on Jordan's social, economic and institutional systems. Consequently this contributes to the growing solid waste management (SWM) problem in low-income urban areas (Boadi et al., 2005; Konteh, 2009; Marshall and Farahbakhsh, 2013).

There is no literature or previous studies or records relating to either solid waste composition or waste generation rate per capita at Zaatari refugees camp so far. Therefore, there is a need for MSW stream characterization and composition analysis to allow for an accurate estimation of its recycling potential and for effective management of the entire system (Mor et al., 2006; Ezeah et al., 2013).

The objective of the present work is to examine the solid waste generation and composition within the target districts at Zaatari Syrian Refugee Camp, located in the Mafraq Governorate, based on the data gathered through the waste composition analysis performed in Zaatari in 2015. In addition, the present work aims to assess the potential market of waste categories recycling, and

propose a preliminary recycling model with the intention that it be initiated in Zaatari, with the long term vision that it be extended to the Mafraq region.

### 1.1. Background of SWM in Jordan

About 2.7 million tons of municipal solid waste was generated and collected by the relevant authorities in Jordan in 2014 (Al-Hamamre et al., 2017; MoMA, 2015a), produced by a population of 6.7 million inhabitants consisting of around 1 million Syrian refugees living in refugee camps and urban areas (UNHCR Jordan, 2014). In comparison, in 2009, the annual generated solid waste was 1.9 million tons for a population of 5.8 million inhabitants (MoMA, 2010). These figures indicate a very rapid rise of the municipal solid waste generation rate in Jordan, which has been estimated to continue increasing by 3% annually (Al-Hamamre et al., 2017). In Addition to the influx of refugees that is estimated to have added an additional 10% to the population (UNDP, 2014), which has increased the annually projected amounts of generated MSW by 0.5 million tons.

Studies show that in 2012, of the total solid waste generated in Jordan around 50% was organic, 16% plastic, 15% paper and cardboard, and the remainder included glass, metal and other miscellaneous types of waste (SWEETNET, 2014). The per capita waste generation in Jordan is estimated at 0.6 and 0.9 kg per day, in rural

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