



Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district – Palestine

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ABSTRACT

Solid waste management (SWM) is one of the most challenging issues faced by developing countries that suffer from serious pollution problems caused by the generation of large waste quantities. This paper presents the case study of SWM in the Nablus district – Palestine. Surveys for household residents' and SWM program operators, field investigations, on-site waste measurements and characterizations were conducted. Per capita waste generation rates varied between different localities although trends were similar. Overall, the majority of waste was organic (65.1% by weight), suggesting a strong resource recovery potential in terms of animal feed or compost. Recyclable waste (plastic, paper and card) made up 16.7% by weight the waste composition suggesting an incentive to introduce source separation. Household attitudes complemented the waste characterization study, revealing the main problems faced. SWM operators quoted on the current status, highlighting problems with disposing in unsanitary landfills, ineffective solid waste fees system, increasing solid waste quantities and lacking equipment and experienced personnel. To enhance sustainable SWM, public awareness, funding, expertise, equipment and facilities and other provisions currently lacking or inappropriate must be provided.

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1. Introduction

Rapidly growing populations, rapid economic growth and rise in community living standards have accelerated the generation rate of municipal solid waste (MSW) causing its management to be a major worldwide challenge (Seo et al., 2004). Particularly in urban cities of developing countries, MSW management (MSWM) is a highly neglected area (Zhen-shan et al., 2009; Batool and Ch, 2009; Chung and Carlos Lo, 2008; Imam et al., 2008; Berkun et al., 2005; Metin et al., 2003; Ahmeda and Alib, 2004). The awareness that improper handling of MSW leads to contamination of water, soil and atmosphere and is a major impact on public health has caused developing nations to address this issue with increasing urgency (Batool and Ch, 2009; Sharholly et al., 2008). In particular, the collection of MSW has been identified as a major problem since in many areas municipal authorities are either unable or unwilling to provide waste collection services to all residents in their jurisdiction. On average, up to 50% of residents lack collection services in urban areas of low and middle

income countries (Parizeau et al., 2006). There are limited opportunities for the development of a sustainable SWM systems as government budgets are limited and more than often, collection is overlooked; only the proper disposal of solid waste is perceived as representing a cost (McBean et al., 2005).

Aside from being a technical issue, MSWM is also strongly influenced by political, legal, socio-cultural, environmental, economic factors and available resources. These factors have interrelationships that are usually complex in waste management systems (Abu Qdais, 2007; Kum et al., 2005). All these issues need to be addressed to reach a sustainable MSWM solution. It is usually not the environmental legislation itself that is at the heart of the problem; some developing countries have more refined legislation than developed countries. Rather, it is the lack of enforcement and/or the availability of viable alternatives (Fourie, 2006).

The current paper examines one case study of a developing country dealing with serious pollution problems due to the ineffective management of the large solid waste generated; the city of Nablus in Palestine. The aim of this paper was to estimate the quantity of waste produced that requires collection and the different waste constituents, to assess the level of services, to analyze the current practices of SWM, to evaluate the citizens'

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satisfaction with the level of service provided and to propose an environmentally sound and economically feasible integrated management system for dealing with solid waste. Information was obtained via a thorough investigation of local attitudes and waste management behaviors by means of a survey for household residents' and SWM program operators and a waste characterization study in the Nablus district.

2. Current situation in the Nablus district

There are 72 localities in the Nablus district and a total population of approx. 336,380 inhabitants in 2006 (projection based on figures from [Palestinian Central Bureau of Statistics \(PCBS\), 1999](#)). Joint Councils for Services, Planning and Development (JCSPD) were formed to create a stronger institutional framework in Nablus, reduce waste management costs, support sustainable development of communities, improve environmental and health conditions and raise the quality and efficiency of services in rural areas ([Ministry of Local Government, 2004](#)). One important improvement was the allocation of collection services to most localities and improvement of the existing ones. Moreover, major obstacles to proper MSWM such as, lack of reliable data and research, shortage of trained manpower, inadequate legal and regulatory cover, poor institutional and administrative arrangements, shortage of equipment, financial and technical difficulties and a serious shortage of competent private operators were improved.

Regarding solid waste treatment and reuse, the Environmental Quality Authority (EQA) of Palestine suggested that separation and composting of organic waste, incineration, separation and recycling of certain waste streams were considered alternatives that depend on the effectiveness of the proposed collection and landfill measures. The characterization of solid waste streams and the estimation of solid waste generation rates are critical data required to propose any sustainable management system and to find the most appropriate and viable alternative solutions to MSWM. It is one of the greatest challenges that organizations face today; how to diversify the treatment options, increase the reliability of infrastructure systems, and leverage the redistribution of waste streams among incineration, composting, recycling, and other facilities to their competitive advantage region-wide. Although the main constituents of domestic solid waste are similar worldwide, the generated quantity, the density and the proportion of constituents vary widely, even within a country according to the level of economic development, geographic location, weather and social conditions ([Sufian and Bala, 2007](#)).

3. Methodology

3.1. Household survey

The target population of the study area consisted of approx. 56,092 households located in Nablus district in 2006 (projection from [PCBS, 1999](#)). A survey was designed and administered to a sample of 1068 households to give a 95% confidence level with a confidence interval of 3% in the study area. A simple and structured questionnaire was prepared and pre-tested. The questionnaire aimed to collect information about residents' socio-economic characteristics, attitudes towards waste, waste management behaviors (disposal and waste separation), how much they are able to afford for collection services and their problems faced with the current management system. Due to anticipated variances of waste behaviors and incomes influenced by the type of locality, the surveys were conducted in households in villages (50.1%), refugee camps (9.3%) and Nablus city (40.6%), where the percentages are representative of the proportionate population of people in the three localities.

The surveys took place as follows; after a random start at each location, every third house within the stratum was approached for inclusion in the sample. If there was no answer at the selected household, this was substituted with the next household. A door-to-door interview, conducted from June to August 2006, targeted questions to the head of the household or the spouse. In cases where neither were present, either the oldest child or a relative (over 15 years) were interviewed. Descriptive statistics such as means and ranges was computed by the use of the Statistical Package for Social Science (SPSS version 11) computer program.

3.2. Solid waste management program operators' survey

A second questionnaire was designed that targeted solid waste program operators. The MSW referred to in this study includes residential and commercial waste collected by the Palestinian municipalities. In a few areas, municipalities also collect industrial waste. Construction and demolition (C&D) waste is generally not collected by the municipalities, this is the responsibility of the West Bank citizens'.

The questionnaire aimed to obtain information on the locality type, MSW quantities collected, collection service availability, collection equipment and vehicles, collection fees, methods of collecting the fees, final disposal methods, location/type of dumping sites and other relevant issues. Face-to-face interviews were held with personnel in charge of MSW management in the city, village or refugee camp councils. In the larger cities, this refers to the head of the Health and Environment Department and in the smaller areas, the head of the city or village council. Field observations related to MSW and its management in all the localities were also conducted alongside the interviews from July to September 2006.

3.3. Waste characterization study

Due to the heterogeneous nature of solid waste, determination of the composition is not an easy task. For this reason, more generalized field procedures based on common sense and random sampling techniques have evolved for determining composition ([Tchobanoglous et al., 1993](#)). In the literature, there is no specific method used for specifying the number of samples for solid waste characterization. According to the methodology recommended for solid waste characterization by [Sharma and McBean \(2007\)](#), thirty samples are adequate. Based on this, thirty samples chosen to represent the whole district were analyzed in July 2006; 14 samples were obtained from a site managing waste from Nablus city and refugee camps, 8 samples from a site managing the Western localities (Beit Imrin) and 8 samples from a site managing the Eastern localities (Beita). The number of samples obtained from each site is representative of the respective populations in each area. An explanatory sampling locations' can be seen in [Fig. 1](#).

The World Health Organization (WHO) method for sampling solid waste and qualitatively and quantitatively analyzing the samples followed ([WHO, 1988](#)). A tank filled with solid waste, capacity 0.5 m³, was shaken three times without applying any additional force. Random sampling was used in selecting the solid waste sample. The tank contents were then disposed of on screening equipment (1.5 × 3) m with a (10 × 10) mm mesh surface size, specifically designed and fabricated for dealing with the heterogeneity of the solid waste. The waste not passing through the mesh surface was then manually separated. The "potential use" categorization was used to sort the waste rather than the traditional material-based categorization as this method was preferable for examining the feasibility of waste separation for composting and recycling ([Bernache-Perez et al., 2001](#); [Fehr et al., 2000](#); [Ojeda-Benitez et al., 2003](#)). Based on this method, each sample was sorted into the following

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