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A review on technologies and their usage in solid waste monitoring and management systems: Issues and challenges

M.A. Hannan [a,*], Md. Abdulla Al Mamun [a], Aini Hussain [a], Hassan Basri [b], R.A. Begum [c]

[a] Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor DE, Malaysia
[b] Department of Civil and Structural Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor DE, Malaysia
[c] Institute of Climate Change, Universiti Kebangsaan Malaysia, Bangi, Selangor DE, Malaysia

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ABSTRACT

In the backdrop of prompt advancement, information and communication technology (ICT) has become an inevitable part to plan and design of modern solid waste management (SWM) systems. This study presents a critical review of the existing ICTs and their usage in SWM systems to unfold the issues and challenges towards using integrated technologies based system. To plan, monitor, collect and manage solid waste, the ICTs are divided into four categories such as spatial technologies, identification technologies, data acquisition technologies and data communication technologies. The ICT based SWM systems classified in this paper are based on the first three technologies while the forth one is employed by almost every systems. This review may guide the reader about the basics of available ICTs and their application in SWM to facilitate the search for planning and design of a sustainable new system.

Contents

* Corresponding author. Tel.: +60 193380693.
E-mail addresses: hannan@eng.ukm.my (M.A. Hannan), md.abdulla@siswa.ukm.edu.my (Md. Abdulla Al Mamun), aini@eng.ukm.my (A. Hussain), drhb@ukm.my (H. Basri), rawshan@ukm.edu.my (R.A. Begum).

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1. Introduction

With the rapid footsteps toward urban future by the modern world, the volume of municipal solid waste (MSW), major by-products of urban lifestyle, is mounting even faster than the degree of urbanization. The global production of MSW is about 1.3 billion tonnes/year i.e. 1.2 kg/capita/day. Ten years ago, waste generation rate was about 0.64 kg/capita/day i.e. 0.68 billion tonnes/year. The solid waste generation will be 1.42 kg/capita/day i.e. 2.2 billion tonnes/year from 4.3 billion of urban residents by the year 2025 (The World Bank, 2012). Table 1 shows the urban population and MSW generation rate for the year 2012 and 2025 (estimated data) of 161 countries of different 7 regions in the world (The World Bank, 2012).

Solid waste management (SWM), is the one thing just about each municipality delivers for its habitants which is perhaps the most significant municipal service and a prerequisite for other complicated municipal services like health, transportation or education (Rajendran et al., 2013). For the municipalities, the difficulties as well as challenges of SWM are continuously increasing due to this urbanization (Cheng and Hu, 2010). Now it becomes an urgent priority for the authorities responsible for SWM to improve their services, particularly in low and middle income countries (The World Bank, 2012). The overall target of SWM is to monitor, collect, treat, and dispose solid wastes generated by the population groups, in a cost effectively, environmentally and socially satisfactory manner. Municipalities are facing problem with solid waste route optimization for collection that has various effects on collection efficiency, cost and pollutant emissions. There are many researches on optimization problems such as vehicle routing problem, capacitated vehicle routing problem and vehicle routing problem with time windows have been studied to reduce cost, less emission, serve customers and depot through optimized route (Johansson, 2006; Nuortio et al., 2006; Faccio et al., 2011). However, most of the researches considered static data rather than real time dynamic data for optimization. To address the above problems, local governments are usually authorized to manage MSW and their laws give them exclusive rights over waste once it has been placed outside. To handle the increasing problems in SWM, ICTs are becoming more significant due to the growing necessities for automated data acquisition, identification, communication, storage and analysis in connection with swift and parallel computing. But, systems that are not using ICTs pose various limitations in terms of site selection, collection monitoring, intelligent recycling, inefficient waste disposal etc. ICTs can help to overcome these challenges to make a sound SWM system (Johansson, 2006; Mcleod et al., 2013; The World Bank, 2012).

Information and communication technologies (ICT) are generally known as technologies that facilitate capturing, processing and communication of information (OECD, 2003). ICTs provide an innovative way to address SWM issues because of their unrivalled capacity to offer the access to information instantly from remote location at a comparatively low cost (Lu et al., 2013). An obvious motivation on using ICTs in accomplishment of comprehensive SWM goals could allow municipalities to attain more sustainable cities. To encounter the aims of automated and intelligent SWM system, ICTs are becoming more vital due to the growing requirements of acquiring, transmission as well as analysis of huge data along with speedy computational capability. Advancement in MEMS technologies boost the development of modern ICTs during the last few decades (Lyshevski, 2013), that contributes to design and establishment of more and more efficient system for SWM. Though ICTs can face with various environmental problems by combining hardware and software applications (Vassilas et al., 2001), there are some challenges that the developing world is facing and these make the 'Digital Divide' continue. The barriers of adopting ICT based systems are mainly the lack of financial resources, poor access to the internet, shortage of skilled human capital and lack of proper policy (Aleke et al., 2011; Ndou, 2004).

So far, various researches have been showed that ICTs can help handle different types of SWM related issues with a more efficient manner in terms of cost, time, risk and environment (Lu et al. 2013). In the past, the overall SWM system was manual, hence there was no exact information about waste generation and collection which led to an unplanned management. As a result site selection for trash bins, collection point, disposal point or recycling station were accomplished without proper planning. In addition, waste collection was conducted without perceiving or analyzing demand and the drivers were responsible to construct travelling routes for waste collection (Beliën et al., 2012). It cause inefficient collection as trash bins may be empty or overflow. Sometimes the resulting disturbed waste become apparent as more costly in terms

Table 1
Urban population and MSW generation rate of different regions of the globe for 2012 and 2025 (estimated).

Region	No. of countries included	2012		2025 (Projections)	
		Urban population (millions)	Urban MSW generation (kg/capita/day)	Urban population (millions)	Urban MSW generation (kg/capita/day)
Africa	42	261	0.65	518	0.85
East Asia and Pacific	17	777	0.95	1,230	1.52
Europe and Central Asia	19	227	1.12	240	1.48
Latin America and the Caribbean	33	400	1.09	466	1.56
Middle East and North Africa	16	162	1.07	257	1.43
Organization for Economic Co-operation and Development (OECD)	27	729	2.15	842	2.07
South Asia	7	426	0.45	734	0.77

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