WASTE MANAGEMENT SYSTEMS' IMPACT ON HEALTH AND ENVIRONMENT IN DEVELOPING COUNTRIES

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ABSTRACT

There is a large body of literature produced in developed countries on the potential adverse health effects of different waste management options but hardly studied in developing countries. On the contrary, the relations between economic issues and the impact of waste management systems on the environment have been studied by different scholars from developing countries. This paper aims to explain associations between some parameters that describe waste management systems at a city level and country parameters in relation to public health and environmental pollution in developing countries. This work reviews waste management systems from more than thirty urban areas in 22 developing countries in 4 continents It describes partly their waste management as answers to 122 questions that include information of public sources and general country characteristics. A combination of methods was used in order to assess the impact of waste management system on health and the environment. Collected data was analyzed using descriptive and inferential statistic methods in order to draw conclusions. The outcomes were unable to provide convincing evidence of an association of waste management and the impact on health. On the contrary, the results show that some of the waste management practices have a negative influence in the environment. The study didn't consider epidemiological evidences concerning public health, economy and pollution of the studied cities due to nonexistence or unreliable reliable information. Instead, data on country performance indicators for public health (perinatal mortality, adult mortality, life expectancy at birth and healthy life expectancy, an economic indicator (Gross Domestic Product/capita) and environmental indicators (ecological footprint / capita and CO2-emission/capita were used. In addition, some other country characterization parameters were chosen (persons/km^2, % urban population).

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KEYWORDS

Waste management, health, developing countries, economy, environment, pollution

1 INTRODUCTION

Urban cities in developing countries face the challenge of an increasing amount of solid waste, due to urbanization, population growth and increased wealth[1]. Municipalities are usually responsible for the waste management system of the cities and often they lack information about its efficiency and effectiveness. Solid waste management in developing countries contrasts with the management in developed ones. In the last case, environmental concerns (pollution, energy use, climate change, resource management) are the main driving forces for the improvement of the systems; while in developing countries the protection of public health (infections, accidents) remains as the key driver nowadays[2].

There is a large body of literature produced in developed countries on the potential adverse health effects of different waste management options[3] but hardly studied in developing countries. On the contrary, the relations between waste management systems and the impact on the environment[4] have been studied by scholars from developing countries. The aim of this study is to find associations between some variables that describe waste management systems at a city level and country variables in relation to public health and environmental pollution in developing countries.

2 RESEACH METHODOLOGY

This study is based on desk research, on site visits, interviews with relevant professionals, cities' stakeholders and a survey.

Data on country performance indicators for public health (perinatal mortality, adult mortality, life expectancy at birth and healthy life expectancy at birth[5,6,7,8,9], economy (Gross Domestic Product/capita)[10], and environment (ecological footprint/capita)[11], CO_2-emission/capita[12] (were collected. In addition, some other country characterization parameters were chosen (persons / km^2, % urban population) [13].

This work reviews waste management systems from more than thirty urban areas in 22 developing countries in 4 continents It describes partly their waste management as answers to 122 questions that include information of public sources and general country characteristics.

In the time period 1985-2011, the first author visited and collected information from more than 30 urban areas in 22 developing countries in 4 continents (Table 1). Waste generation was followed in on-site visits of households, hospitals, offices and schools, construction sites, health care centers, agricultural and commercial areas. The following characteristics were noted: collection and transportation systems, waste treatment procedures used, final disposal facilities and identification of materials for reuse and recycle. Information on public health aspects was not collected at the municipality level.

Structured interviews were also carried out with relevant professionals in which the findings of the visits were analyzed. Other information was collected by means of exercises provided to different stakeholders during workshops with questions about the state of the solid waste

management system in the city in relation to the elements, the aspects and the problems associated with it.

The collected information was used to prepare a questionnaire of 122 questions which helped to structure the previous collected information and it allowed gathering extra data during 2010-2011.

A limitation of the study is that it did not consider epidemiological evidences concerning public health, and pollution of the studied cities due to nonexistence or unreliable reliable information. Instead, data on country performance indicators for public health (perinatal mortality, adult mortality, life expectancy at birth and healthy life expectancy, an economic indicator (Gross Domestic Product/capita) and environmental indicators (ecological footprint / capita and CO_2-emission /capita were used. In addition, some other country characterization parameters were chosen (persons / km^2, % urban population).

3 DATA PREPARATION

Answers to the questions were coded as values of actual measurements (5 questions), as binary scale (Yes/No) (22 questions) [14], 74 are measured on a five-point Likert-type scale with anchors ranging from never, none, very bad (1) to always, all, excellent (5) [15] and general information (21 questions).

Completed questionnaires were checked, edited and entered for the coding process. The information was analyzed using the Statistical Package for Social Sciences (SPSS) Version 17 (2009)[16]. The results were initially explored using a Kolmogorov-Smirov test indicating that the data were not normally distributed. Consequently, a non standard parametric test was used in the subsequent statistical analysis[17]. With the purpose of determining relationships between health and environmental country parameters and waste management city parameters, the Spearman's correlation coefficient measure was used. The values obtained are at significant levels of $p<0.01$** (2-tailed); and $0.05>p>0.01$* (2-tailed). A bi-variate analysis was performed between variables related to health issues (perinatal mortality, adults' mortality and life expectancy) and environmental issues (ecological footprint).

4 RESULTS AND DISCUSSION

The studied cities in developing countries are very diverse and heterogeneous. They range in sizes, geographic position, climate, health, social and economic conditions. This diversity is also reflected in the waste management systems serving the cities.

The analyses of the data show large variations among the studied countries. Life expectancy at birth in the different country-year combinations ranges from 45 to 79 years, perinatal mortality from 7 to 70 deaths/1000 births, adult mortality from 68 to 220 deaths/million persons, Gross Domestic Product/capita from 344 to 47917 US$, while the ecological footprint sees a variation of 0.6 to 3.5 ha/person.

Table 1 also shows great disparities of wastes arriving to the different disposal sites and waste generation rates in the studied cities (see *Table 1*). Lilongwe in Malawi receive only household waste while Nakuru (Kenya) and Managua (Nicaragua) receive also waste from businesses (offices and schools), construction and demolition activities, health care centers,

agriculture, industries and commercial shops. The waste generation rates in the different cities also show variations between 0.25 to 1.50 kg/capita/day.

Continent	Country	Year of study	City	Waste origin at the disposal site	Waste generation rate (kg/capita/day)
Africa	Ethiopia	2009	Addis Ababa	1,2,4,6,7	0.32
	Kenya	2009	Nakuru	1,2,3,4,5,6,7	0.50
	Malawi	2009	Lilongwe	1	0.50
	South-Africa	2009	Pretoria	1,2,3,4,7	0.65
		2009	Langeberg	1,3,4,5,6,7	0.65
		2009	Emfuleni	1,3,6	0.60
	Tanzania	2010	Dar es Salam	1,2,4,5,6,7	0.50
	Zambia	2010	Lusaka	1,2,3,4,6,7	0.37
Asia	Bangladesh	2007, 2008, 2009	Gazipur	1,4	0.25
	Bhutan	2010	Thimphu	1,2,3,7	0.54
	China	2010	Beijing	1,3,4,7	0.80
	India	2010	Doddaballapur	1,2,3,6,7	0.28
	Indonesia	2009, 2010	Banda Aceh	1,4	0.90
		2009, 2010	Ambon	1,4	0,90
		2010	Jogjakarta	1,2,5,7	0.90
	Nepal	2007	Kathmandu	1,2,6,7	0.35
	Pakistan	1995	Lahore	1,2,6,7	0.84
	Philippines	2009	Quezon City	1,2,3,4,7	0.67
	Sri Lanka	2010	Balangoda	1,2,3,4,6,7	0.83
		2010	Hambantota	1,2,3,4,7	0.81
	Thailand	2009, 2010	Bangkok	1,2,3,4,6,7	1.10
	Turkey	2010	Kutahya	1,2,4,6,7	0.60
		2010	Bitlis	1,2,3,4,5,6,7	0.90
		2010	Amasya	1,2,4,7	1.20
Central & South America	Costa Rica	1985, 1995	Cartago	1,2,3,4,5,7	0.7-0.8
		2011	San José	1, 2, 3, 4, 6, 7	1.10
		1991	Talamanca	1,7	0.30
		1992, 1995	Tarcoles	1,7	0.30-0.50
		2001	Tuis	1,7	0.30
	Ecuador	1995	Pillaro	1,7	0.50
		1995	El Carmen de los Colorados	1,7	0.50
	Nicaragua	2008, 2009, 2010	Managua	1,2,3,4,5,6,7	0.48
		2009, 2010	Masaya	1,2,4,7	0.40
	Peru	2008, 2009, 2010	Cañete	1,2,3,4,5,6,7	0.47
	Suriname	2008, 2009	Paramaribo	1,7	0.47
		2008	Asidonhopo	1, 2, 4, 7	0.28

Table 1. Site characteristics of case cities and solid waste origin arriving at official disposal site; 1=household; 2=offices, schools; 3=construction; 4=health care ; 5=agriculture; 6=industry; 7=shops

		Country							City			
		% Urban population	Perinatal mortality	Adult mortality (15-65 yrs old)	Life expectancy at birth	Gross Domestic Product / capita	Ecological footprint / capita	CO_2-emission / capita	Priority for solid waste management	Sophistication of waste collection system	Household waste burned on site	Illegal dumping sites in the city
City	Priority for solid waste management	.17	-.10	-.04	-.03	.48**	-.20	.44**	1.00			
	Sophistication of waste collection systems	.29*	-.15	-.09	-.09	.39**	.18	.43**	.07	1.00		
	Household waste burned on site	-.31*	-.09	.35*	-.25*	-.26	-.28	-.24	.03	-.13	1.00	
	Illegal dumping sites in the city	-.11	.39**	.09	-.03	.06	.13	-.01	-.10	.07	-.46**	1.00

*Table 2. Spearman correlation matrix of country parameters and correlated city waste management parameters at ; **=p<0.01 (2-tailed); *=0.05>p>0.01 (2-tailed); Likert scale 1-5; confidence level =0.05, n=50*

The results show that health represented by parameters such as adult mortality and perinatal mortality decreases in more urbanized countries, which have in general a better Gross Domestic Product and larger ecological footprint. Open air burning of household waste and illegal dumping of solid waste in cities seem to have a negative health effect at the country level (see *Table 2*).

The Gross Domestic Product (GDP) has been used as an indicator for the economy of the country. The analysis of the data suggests that countries with higher GDP have higher CO_2 emissions. The outcomes also suggest that politicians tend to have more interest in solid waste management issues providing better waste collection systems in those countries with higher incomes.

On the contrary, the Factor Analysis results (see *Table 3*) showed that the variables related to waste management systems do not seem to be related to the country's indicators for health, indicating that other influential factors are of higher importance. In contrast, those variables seem to be influenced by the other two factors: economy and environment.

Characteristic	**Component**		
Component	1-Health	2-Economy	3-Environment
Variance explained	31%	23%	17%
Parameter	**Loadings**		
Priority for solid waste management	-0.11	**0.66**	-0.26
Waste collection systems	0.04	**0.67**	0.15
Household waste burning frequency	0.17	-0.15	**-0.75**
Illegal dumping sites in the city	0.25	0.05	**0.83**

Tabel 3. Factor analysis of country parameters and their related city parameters after Varimax rotation with Kaiser normalization converged in 5 iterations; Only components explaining at least 10% of total variance are included; Loadings over 0.50 are considered relevant and are printed in bold; n=50

As already mentioned, it is commonly written in literature that health is affected by the solid waste management in the city (e.g. Rushton 2003) [3]. The data collected and analyzed in this research was unable to provide convincing evidence of an association between waste management and their impact on health. This result is on agreement with Pheby et al. (2002)[18], Saffron et al. and Rushton (2003) [19] and Giusti (2009) [20] in which they concluded that the existing epidemiological evidence linking waste management and human health is quite controversial. Confounding factors have not been adequately controlled in many studies, especially social deprivation, age, ethnicity, gender, smoking, access to health care and occupational history.

Waste is a mixture of a diverse amount of substances and materials, and some of them might be hazardous to health. In order to establish a cause-effect relationships, epidemiological studies must be done with data that is complete and reliable, containing good exposure information and confounding by other unrelated factors that also explain the results[20].

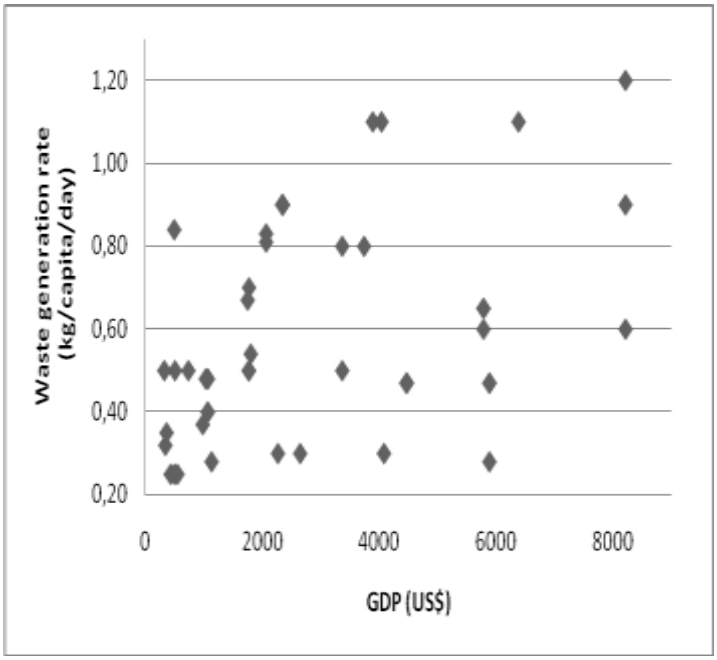

Figure 1. Country GDP (US$) and city waste generation rate (kg/capita/day)

Waste generation rates were also analyzed in relation to GDP. Figure 1 shows the relation between waste generation rate at the studied city level and the National Gross Domestic Product. Contrary to what often is written in literature[21], the data does not show an increase on waste generation with the increase of GDP. This situation can be explained by the fact that literature reports country's waste generation rates and GDP. In the case of this study the presented waste generation rates are related to the investigated cities.

Table 4 show results of country characteristics influencing phenomena in cities. Burning of waste is commonly practiced in developing countries. The analysis of the data shows that, in general terms, the level of burning of waste at the household level is less in municipalities where the authorities give priority to waste management issues. This can be as a result of the provision of diverse waste collection systems. It is also found that in the developing countries, cities with higher ecological footprint have more illegal dumping and less burning of the waste.

Migration from rural areas to more urban areas due to better economic possibilities has given as a result bigger amounts of waste that the municipalities are often unable to manage. This situation affects the environment by the waste practices of the population of disposing the waste in illegal places, attitude that can potentially pollute the air and water sources.

	Environmental interest of leaders	Waste management interest of municipality authorities	Knowledge local waste situation by municipality authorities	Stakeholder participation	Priority for solid waste management	Collection time fitting users' needs	Environmental awareness campaigns	Citizens participating in decision making	Efficiency on collection systems	Sophistication of waste transportation	Cost recovery	Illegal dumping sites in the city	Legal framework in place	Household waste burning level	Willingness to pay for service
Environmental interest of leaders	1.00														
Waste management interest of municipality authorities	.77**	1.00													
Knowledge local waste situation by municipality authorities	.70**	.55**	1.00												
Stakeholder participation	.55**	.52**	.55**	1.00											
Priority for solid waste management	.26	.39**	.18	.26	1.00										
Collection time fitting users' needs	.39**	.48**	.17	.30*	.28	1.00									
Environmental awareness campaigns	.56**	.58**	.64**	.44**	.36**	.09	1.00								
Citizens participating in decision making	.76**	.64**	.73**	.46**	.28	.26	.78**	1.00							
Efficiency on collection systems	.68**	.49**	.57**	.47**	.30*	.54**	.49**	.62**	1.00						
Sophistication of waste transportation	-.15	-.10	-.09	-.09	.06	.02	-.31*	-.14	-.07	1.00					
Cost recovery	.38**	.30*	.33*	.33*	-.13	.08	.51**	.18	.38**	-.33*	1.00				
Illegal dumping sites in the city	.21	.37**	.00	-.02	-.10	.35*	-.06	.11	.17	.08	.20	1.00			
Legal framework in place	.20	.20	.23	.12	.18	.43	.20	.63**	.65**	-.15	.23	-.24	1.00		
Household waste burning level	-.28	-.33*	-.06	-.04	.03	-.45**	-.09	-.12	-.24	-.16	-.17	-.46**	-.34*	1.00	
Willingness to pay for service	.57**	.42**	.52**	.33*	.04	.30*	.27	.41**	.66**	.16	.36**	.36**	.52**	-.45**	1.00

*Table 4. Spearman correlation matrix of overall city parameters that are correlated with at least one other city parameter; **=p<0.01 (2 tailed); Likert scale 1-5; confidence level =0.05, n=50*

The outcomes show other city phenomena. The analysis of the data indicated that awareness campaigns in the cities were positively correlated with municipal leaders having knowledge on the city's waste situation. The result suggests that when leaders become interested in environmental issues they give priority to activities related to solid waste which often is of low concern in the municipalities.

Users of the waste management services are willing to pay and contribute in the solutions of the cleanliness of the city, if they actively participate in the decision making process about the type of system provided, the efficiency and time of waste collection and the existence of laws and regulations, specifically for waste management. This result is also in agreement with some of the findings of Vidanaarachchi et al. (2006) [23]. Furthermore, environmental awareness campaigns promote the users to pay for the service helping the municipalities to recuperate the costs invested in the system.

It was also found that awareness programs and community participation provide information to the general public and decision makers helping to improve waste management systems. Similar conclusions were given by Vicente and Reis (2008) [22] in which they concluded that communication campaigns change the perception of "indifferent" citizens.

As a conclusion, the studied cities in developing countries are very diverse and heterogeneous; therefore generalizations could not be made but common associations were found. The cities have the challenge and the opportunity to improve the systems in an integral way by means of adapting technologies, creating capacities and providing human and financial resources to the institutions in charge of waste management issues. Efforts are necessary to create awareness on the population about their responsibility on solid waste management issues and policies and legal frameworks should support the efforts for cleaner cities.

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