

A Successful Case in Waste Management in Developing Countries

Lorena De Medina-Salas¹, Eduardo Castillo-González², Mario Rafael Giraldi-Díaz¹, Víctor Fernández-Rosales¹, Carlos Manuel Welsh Rodríguez³

Oluleye and Joseph Sunday Ojo

¹Universidad Veracruzana, Facultad de Ciencias Químicas. Circuito Gonzalo Aguirre Beltrán s/n, Zona Universitaria, Xalapa, Veracruz, Mexico

²Universidad Veracruzana. Facultad de Ingeniería Civil. Circuito Gonzalo Aguirre Beltrán s/n Zona Universitaria, Xalapa, Veracruz, Mexico

³Universidad Veracruzana. Centro de Ciencias de la Tierra. Francisco J. Moreno, Xalapa, Veracruz, Mexico

Abstract

Although most of the developing countries have serious problems with the issue of waste management, there have been some success stories including the development of environmental public policies, which had led to better life quality. In most developing countries, waste management considers only two stages: collection and final disposal. The collection system does not include a differentiated collection of the municipal solid waste (MSW), this implies that the valorization of the different waste fractions becomes more difficult to separate and most of them are dumped on uncontrolled sites. Meanwhile, the landfilled sites are limited and usually are about to exceed their capacity. In certain rural and semi-urban localities is common the practice of burning their waste, polluting the air, soil and even water. Local authorities are making some efforts to prevent this type of pollution, but it does not always work properly. However, there are certain successful cases like Teocelo, Veracruz in Mexico. This is a semi-urban locality where the inhabitants have been contributing to waste management in different ways since the year 2000. All the people separate their waste in organic and inorganic. Only the inorganic fraction is managed to the collection system, while a part of the organic fraction is usually composted in homes and the rest is treated in a composting plant. Until now, people of the locality keep this way of living and consider that the care of the environment is important for this generation as well as the new ones.

Keywords: Municipal solid waste (MSW); Developing countries; Waste management; Collection; Final disposal

Introduction

Developing countries are those nations that have low living standards, undeveloped industrial base and low human development index; economically and socially trying towards betterment by economic and social maintenances and proper policy implementation and have an annual per capita income between US\$875 and US\$10,725 [1].

Around the world there are about 145 developing countries facing similar problems due to urbanization, economic activity and quality of life that have caused an increase in the

consumption of products and services in the population, accelerating the waste generation [2].

In 2016, the world generated 2.01 billion tons of waste, but global waste is expected to grow to 3.40 billion tons by 2050. The Latin American and the Caribbean region generated 231 million tons of waste and the municipal solid waste (MSW); East Asia and Pacific 468 and Middle East and North Africa 129 million tons of waste. In addition, generation per capita was 0.99, 081 and 0.56 kg per inhabitant a day, respectively. The main categories of the average waste composition for the three region included: food and green 52-58 %, paper and cardboard 13-15 % and plastic 12 % [3]. Table 1 shows some examples of cities from different parts of the world including the MSW generation per capita.

In developing countries, most of the MSW generated is disposed in landfills and open-air sites causing serious risks to public health and environment. In addition, in highly populated countries such as China, India, Turkey, Mexico, and Brazil, almost 90% of the solid waste (major part is organic), considered as the principal source for producing methane is usually destined to landfills and dumps generously liberating huge quantities of carbon dioxide and methane to the atmosphere [4].

Table 1: MSW generation per capita.

Developing countries	MSW Generation per capita (kg per inhabitant per day)
Buenos Aires, Argentina	1.15
CDMX, Mexico	1.38
Puerto Cabezas, Nicaragua	0.5
Hanoi, Vietnam	1.06
Tehran, Iran	0.88
Alexandria city, Egypt	1.2
Tashkent, Uzbekistan	0.55
Doula, Cameroon	0.54
Nairobi, Kenya	0.72
Rabat, Morocco	0.76

WB[3], Brenes et al., [5]; Gobierno de Argentina [6]; SEDEMA [7]; Kawai and Tasak [8]; Asian Development Bank [9]; El Gazzar and Gomaa [10]; Mbue et al., [11]; German Corporation [12].

Due to the poor infrastructure and inefficient or non-existent organizational structures to manage waste, vulnerability to water contamination and water logging is very high in many cities of developing countries [2].

In Mexico, according to the General Law for the Prevention

and Integrated Waste Management "...MSW are generated in households, resulting from the elimination of materials used from domestic activities, of products consumed and their bottles, packaging or containers; waste from any other activity within establishments or in public areas that generates waste with the characteristics similar to that from households, as well as what are generated from cleaning streets and public areas..." and this General Law also defines the integrated waste management as a "set of actions that are articulated and interrelated with the operational, financial, planning, administrative, social, educational, monitoring, supervision and evaluation for waste management from generation to landfill. The purpose is to achieve environmental benefits, economic optimization of management and social acceptance in response to the needs and circumstances of each locality or region..." [13].

Therefore, considering this conceptualization, the objective of this work is to know more information about the waste management in developing countries using a successful case study of Mexico.

Waste Management (Collection and Final Disposal)

Most of the developing countries have serious problems with the waste management. The limited financial resources are the critical point at all governmental levels. However, waste management is different for urban and rural localities (Table 2).

In most developing countries, waste management considers only two stages: collection and final disposal (and usually in uncontrolled dumps). The collection system does not include a differentiated collection of the MSW. In Latin American and the Caribbean region, at the urban level, about 85% of waste is collected, but in rural communities, waste collection coverage is about 30%; meanwhile in East Asia and Pacific is 77 % (urban) and 45 % (rural); in Middle East and North Africa 90 % (urban) and 74 % (rural) [3]. Most of the waste collection systems are on a door-to-door basis [14-16].

The disposal methods in Latin American and the Caribbean region include 68.5 % of the generated waste are landfilled, 26.8 % are

dumped into uncontrolled sites, 4.5 % are recycled, less than 1 % are composted or are anaerobically digested. The Middle East and North Africa 34 % landfill, 52.7 % open dumps, recycling 9%, 4 % composting and less than 1 % incineration; East Asia and Pacific 46 % landfill, 18 % open dump, 24 % incineration, 9 % recycling, 2 % composting [3].

It is relevant to say that in rural localities, the practice of burning some waste fractions is common [17]. The leachates generated in open dumps and landfills, although highly heterogeneous, are characterized by containing high concentrations of organic and inorganic contaminants. Unfortunately, they are not treated adequately, causing soil, water and air pollution [18].

The limited resources are always the critical point to improve

the waste management system in developing countries, however, to overcome the principal issues about this subject it is necessary to look for institutional set up, human awareness and capacities, proper standards, laws, guidelines and norms, and proper infrastructure to contribute about enabling waste management to mitigate adverse impacts to the environment, natural resources and public health [19].

Teocelo, Veracruz, Mexico. A Successful Case Study

In Mexico, especially in the state of Veracruz, there is a little urban municipality named Teocelo, surrounded by a rural context with a population of 16,327 inhabitants [20]. Due to its context, this locality is a great generator of biodegradable organic waste. Teocelo has received different awards and recognitions for several years in Mexico (Table 3). Thus, it is a national reference in waste management.

This municipality has also received recognition for the Agenda Program from the Local Authorities; Recognition of the World Association for the Protection of Animals; First municipality in Veracruz to present its Waste Separation Plan to 2025; First municipality in Mexico to prepare a Climate Change Plan and First municipality in the state of Veracruz to declare free of transgenic crops [21].

The MSW generation per capita is 0.24 kg per inhabitant a day and its waste management program started in 2001. It is important to highlight the importance of the citizen involvement and caring of the environment in this municipality. All people separate their waste in organic and inorganic. Only the inorganic fraction is managed to the collection system, while a part of the organic fraction is usually composted at home and the rest is treated in a vermicomposting plant.

The attitude of Teocelo's people had been analyzed by several authors and the results showed that the "environment" and "consciousness and share responsibility" (28%) are the most important categories to continue with the policy of waste management (Figure 1) (Source: Based on Wojtarovksy-Leal et al.) [22]. About the relevance of waste separation, the most important aspects are improving the environment (40.75%) and use of organic waste for fertilizer production (35.19%) (Figure 2) (Source: Based on Wojtarovksy-Leal et al.) [22].

It is interesting to know that 90% of the people feel proud of waste separation due principally to three factors: social collaboration (32.60%), environment care (27.90%), and moral obligation (20.93%) (Figure 3) (Source: Based on Wojtarovksy-Leal et al.) [22].

The Teocelo Vermicomposting Plant is considered a municipal achievement of high social, economic and environmental impact. It has green areas, an educational module and large spaces for family recreation. Within these facilities, awareness-raising processes are carried out with the community in general, so that they know the social, economic and environmental value that is represented by this eco-technology. This has been done since 2010 through courses, talks and workshops to strengthen community participation in

programs led by the municipal authority. One of its main functions is the treatment of organic solid waste produced in the same municipality to obtain compost, a useful by-product, marketable and suitable for agricultural activities. This fertilizer is currently used in the green areas of the municipality, but it has also

Table 2: Differences between urban and rural localities in waste management.

Urban Localities	Rural Localities
• High amount of waste.	• Small amount of waste (moderately biodegradable organic waste).
• Relevant investment by the authorities.	• Lower investments to improve the collection system.
• Optimization of the collection.	• The collection system is not differentiated.
• Selective collection systems in some localities.	• Easier involvement of the population.
• Difficulties in control and monitoring environmental variables.	• Abundance of space.
• Lack of space for introducing new waste management plants, facilities and landfilling sites.	• Rare construction of controlled dumping sites.
• Data available are mostly incomplete.	• Lack of public investment.
	• Limited capacities for introducing new technological facilities and for its maintenance.
	• Lack of reliable data.

Source: Ferronato et al., [23]; Castillo-Gonzalez & De Medina-Salas, [24].

development of environmental public policies had led to better life quality.

Conclusions

Waste management in developing countries requires integrated holistic approaches for its solution. Although the limited financial resources are the critical point for the waste management system in the developing countries, there is a good chance to improve them, as the successful case of Teocelo, through the citizen involvement, conscientization of the importance of caring the environment and adequate community participation policies in solving problems. In addition, developing countries must start improving the waste management system using a differentiated collection, and strengthen actions of recycling to contribute the circular economy.

Table 3: Teocelo's awards since 2002 to 2016.

Awards	Institutions	Year
National Government and Management Award	Economic Research and Teaching Center (CIDE)	2002
Prize for the Environment (State level)	Versacar State Government	2002
'Let's Clean Our Mexico' Award	TV-Azteca	2009
Sustainability Award	ICLEI- Local Governments for sustainability	2013
Ecological Merit Award, with a special mention in the category of Formal Environmental Education to the Center for Multiple Attention of Special Education María Enriqueta Camarillo	Mexico Government	2016

Source: De la Cruz, et al.,[25]; Garcia & Luna, [21]; Wojtarowsky-Leal et al., [22]; González, [26].

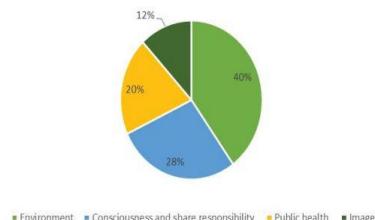


Figure 1: The attitude of Teocelo's people.

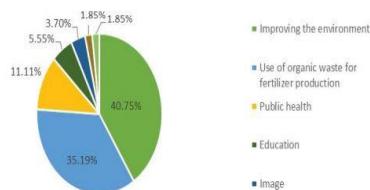


Figure 2: Relevance of waste separation.

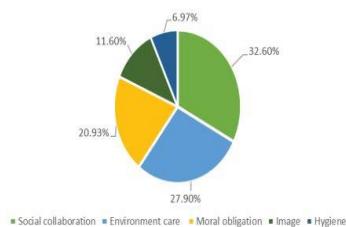


Figure 3: Aspects for being proud of the waste separation.

been shared with coffee producers to fertilize their agroecosystems, with housewives for their backyard crops and with schools for the establishment of school gardens [25].

Nowadays, the people of the locality keep this way of living and considers that the care of the environment is important for this and new generations. In this successful story the