

EVALUATION OF WASTE DIVERSION EFFECTS THROUGH A LOW-COST, GRAVITY-DRIVEN WASTE SORTING PLANT IN SAN CARLOS CITY, PHILIPPINES

K. Hanuschke^{1*}, A.R.D. Romallosa², J. G. Paul³, L.C. Sanchez⁴, A. Batomalaque⁴

1 Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, c/o Central Philippine University, Iloilo City, Philippines

2 Central Philippine University, Iloilo City, Philippines

3 AHT GROUP AG, GIZ SWM4LGUs Project Office, Parola Street, 5000 Iloilo City, Philippines

4 Local Government Unit, SWM Office, San Carlos City, Neg. Occ., Philippines

** Corresponding author. Tel: +63 999 460 3441, E-mail: klaus.hanuschke@giz.de*

ABSTRACT. Solid Waste Management (SWM) is a serious and rapidly growing problem not only in the Philippines but in many developing countries. Waste generation and the variety of the waste material mix are increasing especially in fast growing urban centres. To answer this, the Philippines passed a new waste management law, the Republic Act 9003, in January 2001. However, many municipalities in the Philippines still struggle to upgrade their SWM system accordingly stating budget and expertise constraints as main reasons. San Carlos City, Negros Occidental together with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH established a new SWM system using low-cost technology. The system includes among others a gravity-driven facility to sort and recover the collected waste materials. The study demonstrates that in the context of a developing country the approach to establish low-cost technologies to increase waste diversion rates to more than 60% proved successful and could be replicated under certain conditions.

Keywords: *MSWM, Waste diversion, Low-cost approach, Gravity-driven sorting facility*

1. Introduction

Compliance with Republic Act (RA) 9003 or the Ecological Solid Waste Management Act of the Philippines remains poor throughout the country. Most of the local government units (LGUs) until now still fail to meet the legally prescribed waste diversion rate of 25% [4]. The main reasons for this are lack of expertise within the LGUs and limited budget. Uncontrolled dumping remains common practice without proper waste segregation, lack of management, monitoring and environmental protection measures resulting in release of greenhouse gases, pollution of air and water resources and threats to public health and the environment. On the other hand, highly technical solutions designed to improve segregation and processing of Municipal Solid Waste (MSW) were also introduced, mostly without success, primarily due to high operation and maintenance costs, such as electric consumption or procurement rate and the long delivery time of spare parts. Therefore, many successfully implemented new SWM systems later on failed and could not be sustained. Some LGUs even returned to uncontrolled open dumping.

2. Material and Methods

San Carlos City, is a medium-sized city with 133,000 residents in the Province of Negros Occidental in the Visayas region [6]. The LGU of San Carlos started in 2002 to enhance their SWM System mainly with awareness building and information-education and communication (IEC) campaigns contracting a local non-government organization (NGO). In July 2003 the LGU entered into cooperation with GIZ to jointly plan and implement a new comprehensive SWM Program for the City. Its outcomes, the newly established SWM Office, the reorganized segregated waste collection and the environmentally sound integrated SWM facilities have been eventually completed, with the launching of the Eco-Center in September 2007.

The Eco-Center mainly integrates a sorting plant, a composting site and a clay-lined sanitary landfill site (SLF) with leachate treatment facility [2]. All components were developed according to the required standards of RA 9003 and by utilizing appropriate, low-cost technologies. The Materials Recovery Facility (MRF), also called “Gravity-MRF” was designed as in-house unit whereby incoming waste can be segregated during down-passage along several slides by utilizing gravity force. All incoming wastes at the Eco-Center are screened and further sorted in the MRF respectively processed and recorded on a daily basis. Wastewater generated in the MRF is treated in the leachate treatment facility.

The Gravity MRF was designed to substantially increase materials recovery and further increase the waste diversion. The law mandates at least 25% waste diversion by the year 2006 with increasing values every three years thereafter. “Waste diversion” refers to activities that reduce the amount of solid wastes from disposal facilities [4]. Diversion activities include the processing, composting, recovery and recycling of collected materials from the municipal waste stream, which is done partly in the Gravity-MRF. It is situated at a sloping hill side of the Eco-Center and has two main delivery ramps at the upper part, one for the biodegradable collection and one for the non-bio collection. The whole upper portion of the MRF including the delivery area, sorting area and temporary storage, where mixed wastes are handled, is restricted for authorized personnel only. After sorting the recyclable materials are packed and stored in the lower portion of the MRF where buyers can enter without passing by the delivery area. In this way no untrained person could come in contact with hazardous materials, sharps, infectious waste, etc.

The waste delivered to the Eco-Center comes mainly from the city’s segregated collection, which was established even prior to the launching of the Eco-Center. Waste is only being collected from households, establishments, schools, etc. if it is segregated into a biodegradable and a non-organic fraction. However, both collected waste fractions still have impurities, which require a final sorting in the MRF before further processing respectively final disposal. Whereas the bio-collection has only 2-3% of foreign substances the non-organic fraction still contains 10% recyclables, 2% special wastes and 88% residuals, including some organics, which will be sorted out and transferred to the biodegradable section without being especially recorded. Prior to the operation of the Eco-Center, materials recovery was mainly conducted by waste pickers at the dumpsite who had chosen to recover waste as their livelihood. During this time, more than 5,000 tons of solid wastes were disposed at the former dumpsite every year. With the operation of segregation and waste processing technologies at the Eco-Center, the amount of residual waste disposed could be reduced to < 3,000 tons per annum, while the collection of waste increased. Table 1 summarizes the input/output data of the baseline situation 2005 and the Eco-Center operation since September 2007.

Table 1. Waste collection, segregation and disposal data Eco-Center San Carlos (in tons)

| Year (in tons) ^a | Total collected waste (tons/year) [tons/day] | Segregated organic waste (tons) [%] | Recyclables (tons) [%] | Residual waste disposed at SLF (tons/year) [%] | Total operation cost (US-\$) ^e |
|--------------------------------|--|---|---------------------------|--|--|
| 2005 ^b | 5,475 [15.0] | - | 345 [6.3] | 5,130 [93.7] | 134,884 |
| 2007 | 7,157 [19.6] | 2,460 ^c [34.4] | 717 [10.0] | 3,980 ^d [55.6] | 269,767 |
| 2008 | 7,038 [19.3] | 2,837 [40.3] | 1,195 [17.0] | 3,006 [42.7] | 286,046 |
| 2009 | 7,177 [19.6] | 4,418 [61.6] | 428 [5.9] | 2,331 [32.5] | 239,535 |
| 2010 | 6,586 [18.0] | 4,316 [65.5] | 329 [5.0] | 1,941 [29.5] | 355,814 |
| 2011 | 6,148 [16.9] | 3,870 [62.9] | 61 [1.0] | 2,222 [36.1] | 354,767 |
| Total 07-10 | 34,106 | 17,896 [52.5] | 2,730 [8.0] | 13,480 [39.5] | 1,496,929 |
| Average/ton | - | - | - | - | 43.89 |

a- Calculation of tonnage derived from m³ measurements of LGU waste collection with average density of 0.3 tons/ m³

b- 2005 was chosen as baseline with dumpsite operation and low material recovery, mainly performed by waste pickers (data excluded in total sum)

c- Start of Eco-Center operation in September 2007, the calculation includes 4 month compost production at the Eco-Center in 2007

d- From that around 2,800 tons were disposed at the former dumpsite

e- Based on exchange rate PHP43 for US\$1; total costs include waste collection and Eco-Center operation with employment of 24 workers

As shown in Table 1, the rate of materials recovery at the Eco-Center always surpassed 60% of waste input since the year 2009. The total amount of delivered waste as well as the amount of non-organic recyclable materials has been decreasing lately. This indicates that the intense IEC program of the LGU resulted in enhanced waste segregation and materials recovery at source. According to the data displayed in Table 1, the average total cost for the management of 1 ton solid waste in San Carlos are estimated with 43.89 US\$ per ton. Based on the average waste generation of 0.44 kg/capita, each of the 41,250 served residents would have to pay annual SWM fees in the amount of US\$7.05 for a 100% cost recovery. This fee does not include investment cost for constructing the Eco-Center.

3. Results and Discussion

3.1 Performance of the Gravity -MRF

Like many other LGUs, San Carlos City was confronted with the complex problem of increasing waste generation due to rapid urban development. To enhance the performance of its municipal SWM system the LGU established a “*new way*” of SWM implementation. The approach includes segregation at source, segregated collection and management of all kinds of municipal solid waste (MSW) in an Eco-Center and centralized gravity-driven MRF with a material recovery efficiency >60%. The new system reduces waste disposal to a significantly lower level if compared with the baseline scenario in 2005 [1,6]. At that time all collected wastes were still disposed at a local dumpsite and material recovery were merely conducted by waste pickers. Since the start of operation of the Eco-Center in 2007, a total of around 18,000 tons of organic waste and 2,700 tons of recyclable materials were recovered. The value of the recovered materials alone is estimated with US\$1.5 million, whereas, the cost for disposing these materials would have been around US\$0.74 million. Considering an average waste disposal height of 8m the maintained diversion rate of >60% almost doubles the lifespan of the 2007 established first SLF cell (6,600 m²) from initially estimated 5 years to 9.5 years. This all means substantially cost savings for the LGU.

The worker efficiency has also considerably increased through the use of the Gravity-MRF. The total delivered waste of 6,586 tons in 2010 were segregated and processed in 300 working days and 6 hours/day operation of the MRF. With segregation efficiency of 80% the 10 workers assigned at the non-organic section segregated and prepared for final treatment and sales about 1.6 ton/hour respectively 160 kg/man-hour, whereas during the same time 14 workers further segregated and processed the biodegradables with an efficiency of 215 kg/man-hour. Similar estimations in other SLF or MRF systems in the country led to segregator efficiencies of only 25 kg/man-hour for non-organics. The clear numerical difference between San Carlos City and other MRFs is also due to the performance of segregated collection, which is also shown in the difference in efficiency of bio and non-bio processing in San Carlos City alone, where the organic fraction delivered to the Eco-Center is already 95-98% pure organics, hence efficiency of final sorting is higher.

Aside from manpower and gravity, no machines, conveyer belts, etc. are used for final sorting of about 540 tons of pre-segregated waste monthly delivered to the Eco-Center. This keeps electricity costs for the whole Eco-Center as low as US\$40 per month. Additional operational costs only result from fuel for the operation of shredder for organics, compactor for the disposal area and truck for transferring materials from MRF to SLF and labor costs. By establishing a new SWM system, the LGU was able to provide the needed facilities to ensure that the various waste generators are served and supported in their SWM needs. The established SWM system is considered as very cost-efficient since an environmentally sound SW management can be conducted for only US\$43.89 per ton collected waste including all municipal SWM activities. This would translate to a SWM fee of only 7.05 US\$/cap/year, an amount that could easily be refinanced by users if compared with costs claimed by other public services such as energy or water supply.

3.2 Further benefits

Recovery of bio-waste and compost production is one further benefit [1]. Based on conducted laboratory analyses of compost samples, the produced compost (ca. 5,600 tons by 2011) is a valuable organic fertilizer that contains in total around 45 tons of Nitrogen (N), 60 tons of Phosphates (P) and 75 tons of Potassium (K) and a bulk of humic substances and micro-elements that largely contribute to increase soil fertility, soil

structure and water retention capacity, substitution of chemical fertilizers and others [8]. Besides, harmful impacts of bio-waste disposal such as leachate or methane emissions are by far reduced since the disposed residual waste at the Eco-Center hardly contains any organic substances.

Based on the results of a greenhouse gas (GHG) emission assessment applying a GHG Calculator that was developed by GIZ and the German Bank for Reconstruction (KfW) significant emission reductions were already achieved with the new SWM system [1, 3]. Whereas 7,340 tons CO₂-eq/year net emissions were calculated for the baseline scenario 2005, the new established SWM system with 60% material recovery reduces GHG emissions with 7,600 tons CO₂-eq/year resulting even in GHG benefits of 260 tons CO₂-eq/year. With that, San Carlos City demonstrates that in the context of a developing country, the enhancement of municipal SWM including climate mitigation aspects is feasible and can be sustained, even with restricted budgets. The fact that the municipality has managed to sustain the newly established SWM system over a time period of five years supports this statement.

To date, this unique MRF design is gaining attention in the whole region as it contributes to provide a safe and environmentally-sound processing facility. Consequently it was already replicated several times by other LGU's due to its low maintenance requirements yet successful performance in terms of operation that was practically designed for local conditions.

4. Conclusions

San Carlos City is one of the few LGUs that has successfully implemented the provisions of the new waste management law with innovative approaches and low-cost technologies that can be sustained by an LGU in the context of a developing country. The developed Gravity-MRF proved effective and contributed significantly to enhance waste diversion rates since available manpower and equipment could easily be adjusted to the local conditions and operation requirements of the new Eco-Center. However, the latter has to be embedded in a whole integrated SWM System, including community participation, environmental awareness building and education, segregation at source and segregated collection for achieving maximum success. From a development perspective it will now be crucial to study conditions and constraints in order to upscale and further distribute the made positive experiences to other LGUs.

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