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Analysis and Characterization of Wastes in a Closed Dumpsite of an Urbanized City

M. A. N. Tanchuling[1], B. A. Requejo[2], and M. B. L. D. Diola[3]

[1]Professor, University of the Philippines Diliman, Quezon City, Philippines, email: mntanchuling@up.edu.ph

[2]Design Engineer, AMH Philippines Inc., email: benedict.requejo@amhphil.com

[3]Assistant Professor, University of the Philippines Diliman, Quezon City, Philippines, email: mddiola@up.edu.ph

ABSTRACT

Wastes from a closed 4.6-ha dumpsite in a 1st Class Urbanized City in Mindanao Island in the Philippines were characterized to evaluate its feasibility as feed of a proposed Waste-to-Energy (WtE) plant. The closed dumpsite was visually sectioned into five (5) strips with one strip being sampled per day for a total of five days. The excavated wastes were then weighed and then screened using a trommel with a 2"x2" square mesh. The coarse and fine fractions of the screening were manually sorted into general categories: metal, soft plastic, hard plastic, wood, leather, rubber, textile, e-waste, rocks and stones, ceramics, glass, and fine residuals. Each of these waste categories were then weighed after sorting. The dumpsite is found to be comprised of 61% fines and 39% coarse wastes. Around 90% of the coarse fraction consisted of combustibles, with 74% of these consisting of soft plastics. Meanwhile, rocks and stones at 9% compose majority of the remaining non-combustible wastes in the coarse fraction. On the other hand, 80% of the fine fraction consisted of non-combustibles, with 78% of the total consisting of fine residuals. Meanwhile, soft plastics at 18% compose majority of the combustible wastes in the fine fraction. The significant amount of combustible matter and the heavy contamination of the sorted waste fractions in general make the wastes in the dumpsite a viable feed for WtE.

Keywords: landfill mining, solid waste management, dumpsite

1 INTRODUCTION

Solid waste management is a major concern the Philippines. Open dumping has been the prevalent waste disposal method in the country before and even after the enactment of Republic Act No. 9003, or the Ecological Solid Waste Management Act of 2000, which mandates permanent closure to open dumpsites and the establishment of sanitary landfills (DENR, 2001). Open dumpsites are a health and environment hazard because these are mostly undocumented, uncontrolled, and have no safeguards to protect the environment and human health. Around 335 open dumpsites have been closed only in recent years by the government in an effort to enforce the law (DENR, 2021). With the concerns of rapid urbanization in the country, however, landfilling may not be enough to sufficiently address the waste generation of the country.

Landfill mining is an emerging approach to circular economy by taking advantage of the materials that have been previously deposited in disposal sites for material and energy recovery, landfill area reduction, soil cover, and other purposes (Krook et al., 2012). The economic feasibility of landfill mining was shown to yield positive return under varying scenarios (Zhou et al., 2015). Simple excavation and screening equipment can be used are shown to demonstrate moderate performance in obtaining marketable recyclables from landfills (Krook et al., 2012).

Although numerous studies exist on the feasibility of landfill mining in other countries (van Vossen & Prent, 2011; Faitli, et al., 2019), studies on the feasibility of landfill mining in the Philippines, however, are almost non-existent in recent literature. The objective of the study is to quantify the composition of various waste fractions that are deposited in a closed dumpsite in the country for a potential waste-to-energy (WtE) project.

2 METHODOLOGY

2.1 Study Site

The closed dumpsite, with an area of 4.6 ha, is located in a 1st class urbanized city in Mindanao Island in the Philippines. It served as the disposal site of municipal solid wastes (MSW) of the city until its mandated closure in 2015 to give way to a sanitary landfill. The estimated waste volume based a combination of unmanned aerial vehicle (UAV) and global navigation satellite system (GNSS) technologies is 430,000 m^3. The dumpsite is mostly covered with top soil and vegetation (Figure 1).

Figure 1. *3D representation of the closed dumpsite based on orthophotos and digital surface model*

2.2 Sampling

Sampling and sorting of wastes was done in June of 2019 in coordination with the environmental office of the city government. The closed dumpsite was visually sectioned into five strips with one strip being sampled per day for a total of five days (Figure 2). Three sampling points were identified and distributed in different sections of every strip, except for Strip 1 which only had one sampling point but sampled thrice, to have a more representative sample per strip. Flag markers where physically placed at the dumpsite mound to assist local personnel on the location of sampling points. An excavator was used to collect roughly 0.5 tons of wastes per sampling point or 1.5 tons of wastes per strip at a depth of at least 1 m below the surface (Figure 3).

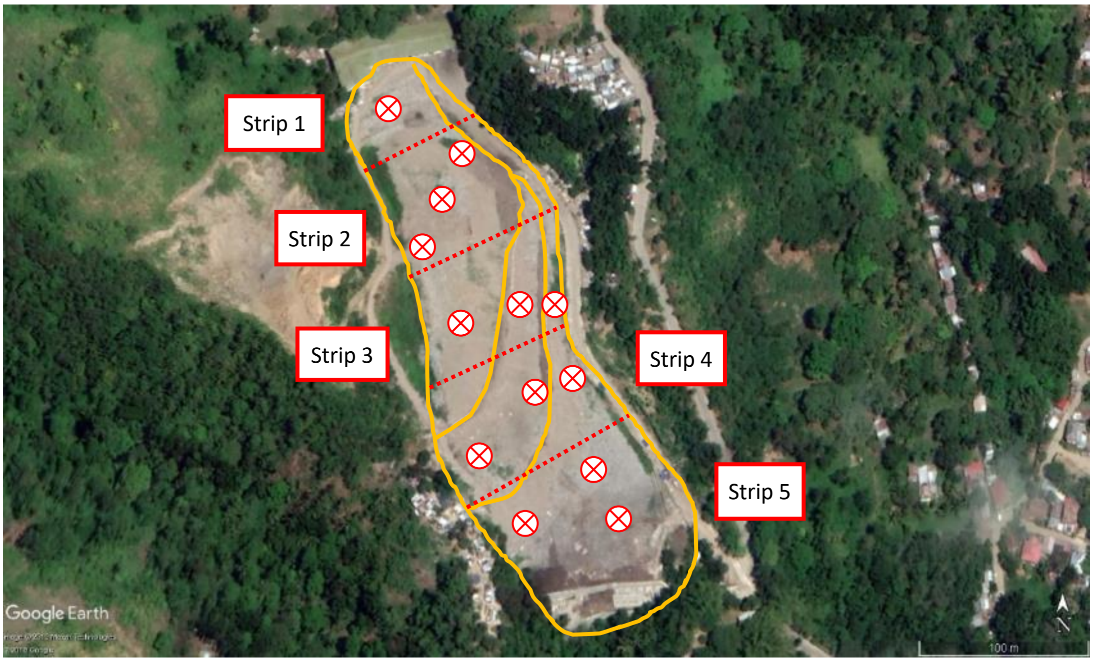

Figure 2. *Sectioning of the closed dumpsite and identification of sampling points*

Figure 3. *Placement of flag markers at a sampling point (left). Excavation of waste samples at a marked sampling point (right).*

2.3 Screening and Sorting of Waste

The excavated wastes were brought to a sorting area designated by the city government and were initially weighed using truck weighing pads. Each waste samples were then screened through a trommel with 2”x2” square mesh that was available at the sorting area. Wastes that fit and pass through the 2”x2” screen drop down the hopper, were collected through a container, and then weighed immediately to limit losses of material during the screening; these wastes are labelled as the fine fraction for this study. Meanwhile, wastes that were larger than the 2”x2” screen exit at the opposite end and were likewise collected and immediately weighed; these wastes are labelled as coarse fraction (Figure 4).

Figure 4. *Trommel used to separate the fine fraction from the coarse fraction (left). Fine and coarse fractions after separation by the trommel (right).*

Both fractions were manually sorted by the city-designated sorters into general categories: metal, soft plastic, hard plastic, wood, leather, rubber, textile, e-waste, rocks and stones, ceramics, glass. And Loose dirt, particles, and wastes that were too degraded or small to be identified were classified into fine residuals. Each of these waste categories were then weighed after sorting (Figure 5). Weights per category in each fine and coarse fraction per strip were recorded. The weights of the materials are on a wet basis since no drying was done.

Figure 5. *Sorting of coarse fraction (left). Weighing of soft plastics sorted from coarse fraction (right).*

3 RESULTS AND DISCUSSION

The resulting composition of each strip show that all strips have similar ratios, with fines ranging from 59% to 65% and coarse wastes ranging from 35% to 41% (Figure 6). The average composition of the whole dumpsite was then computed by assuming that each strip had equal weights to the overall composition of the dumpsite. Thus, the dumpsite is computed to be comprised of 61% fines and 39% coarse wastes.

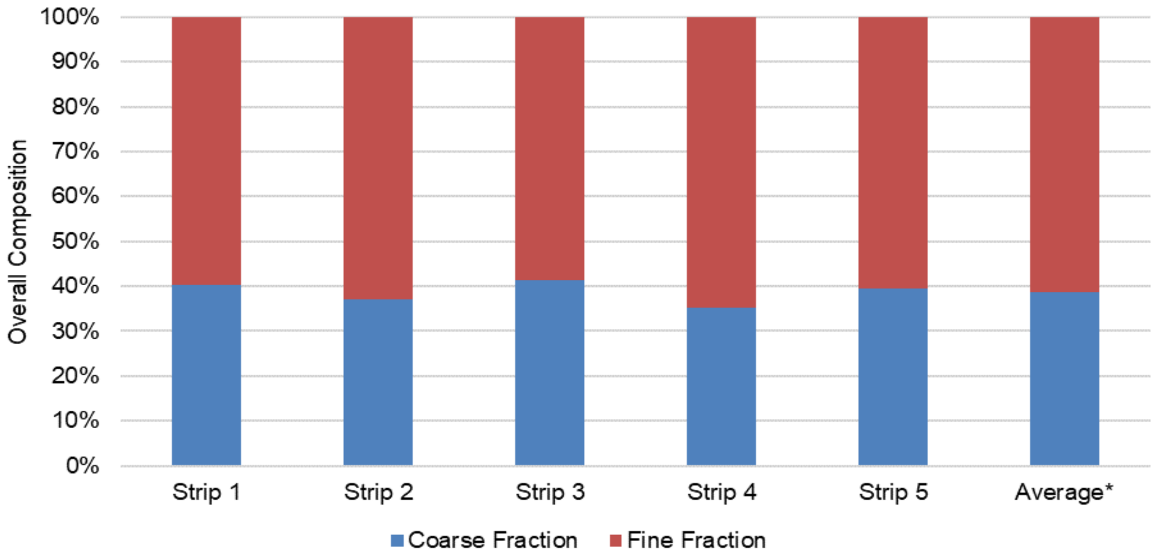

Figure 6. *Overall Composition per Strip*

The result of the sorting of the coarse fraction of each strip show that soft plastics had the greatest percentage in all strips, ranging from at least 65% for Strip 3 and up to 76% for Strip 4 (Figure 7). Other combustible wastes such as textiles, rubber, and wood, are also present but in lesser amounts. Meanwhile, rocks and stones are also present in the strips, especially in Strip 3 where these amounted to 24% of the total composition. Other non-combustible wastes such as glass, fine residuals, e-wastes, and ceramics are also found but in minimal amounts. The coarse fraction compositions of each strip are used to compute an average composition of the coarse wastes of the dumpsite.

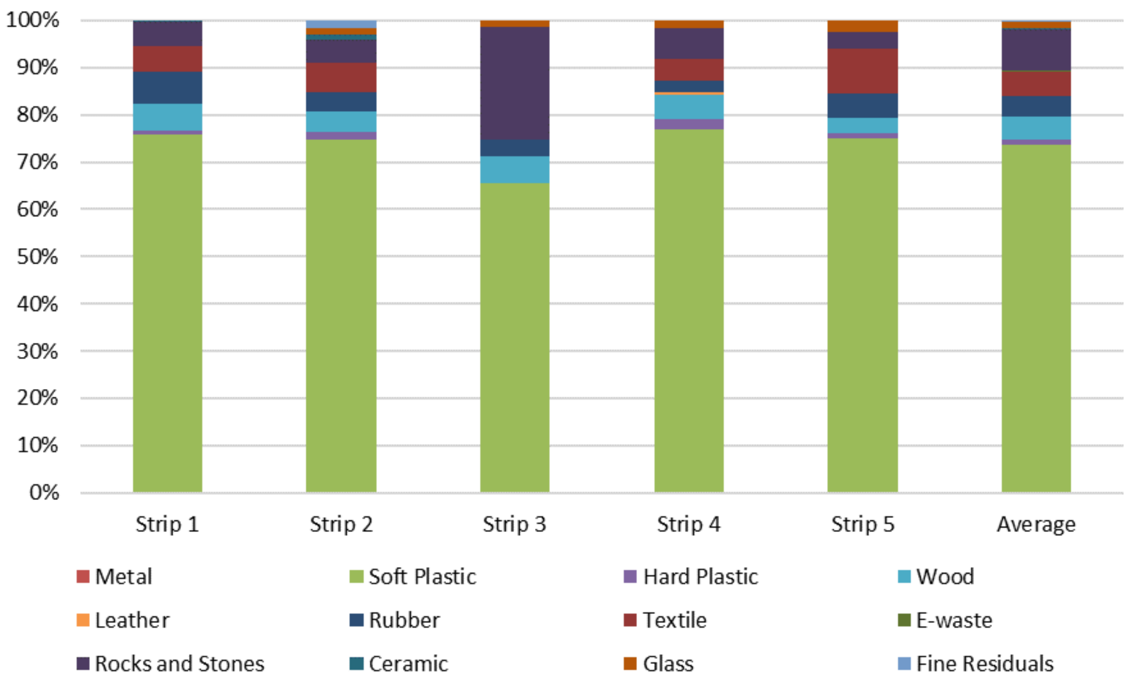

Figure 7. *Composition of the Coarse Fraction per Strip*

The waste categories of the coarse and fine fractions were grouped into combustible and non-combustible fractions. Combustible materials are carbon-containing materials that can react with oxygen with the presence of enough heat through an exothermic reaction (Lebelo, 2016). The combustible fractions were composed of soft plastic, hard plastic, wood, leather, rubber, and textile. The non-combustible fractions, meanwhile, were composed of rocks and stones, glass, ceramic, metal, e-waste, and fine residuals.

Computations show that 90% of the coarse wastes consist of combustibles, with 74% of these consisting of soft plastics (Figure 8). Textile, rubber, and wood were also found at 5% each, hard plastics at 1%, and leather at less than 1%. Meanwhile, rocks and stones at 9% compose majority of the remaining non-combustible wastes. Glass was found at 1%, and ceramic, fines, metals, and e-wastes were found in minute percentages.

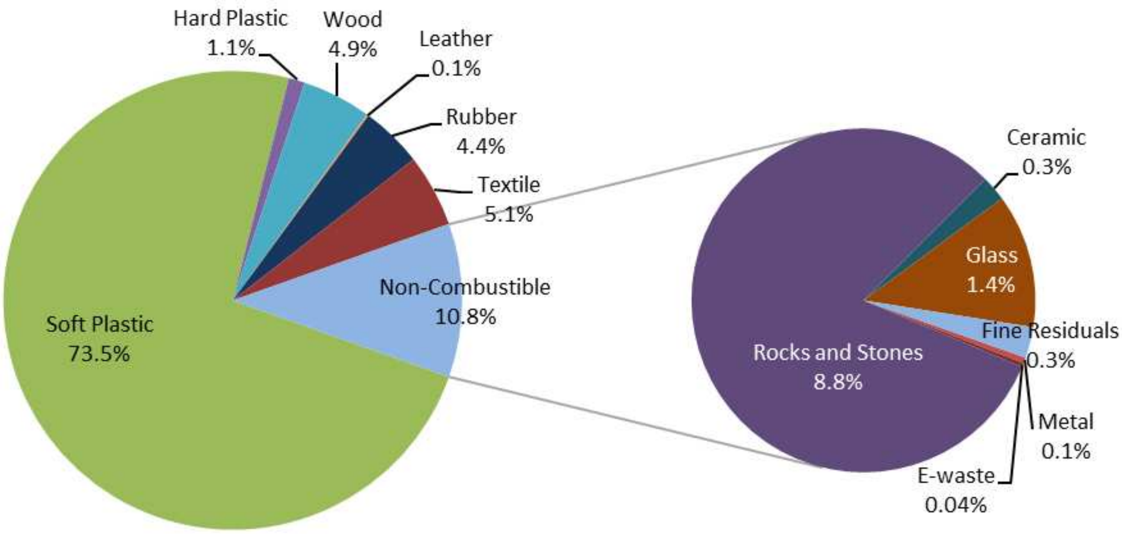

Figure 8. *Average Composition of the Coarse Fraction*

The result of the sorting of the fine fraction of each strip reveal that fine residuals ranged from 69% for Strip 2 to as much as 83% for Strip 3 (Figure 9). Other non-combustible wastes such as glass, ceramics, rocks, and stones are also present but in insignificant amounts. Meanwhile, soft plastics are still present in all fines in at least 10% in Strip 3 and as much as 29% in Strip 2. Other combustible wastes are found in minute percentages. The fine fraction compositions of each strip are likewise used to compute an average composition of the fine fraction of the entire dumpsite.

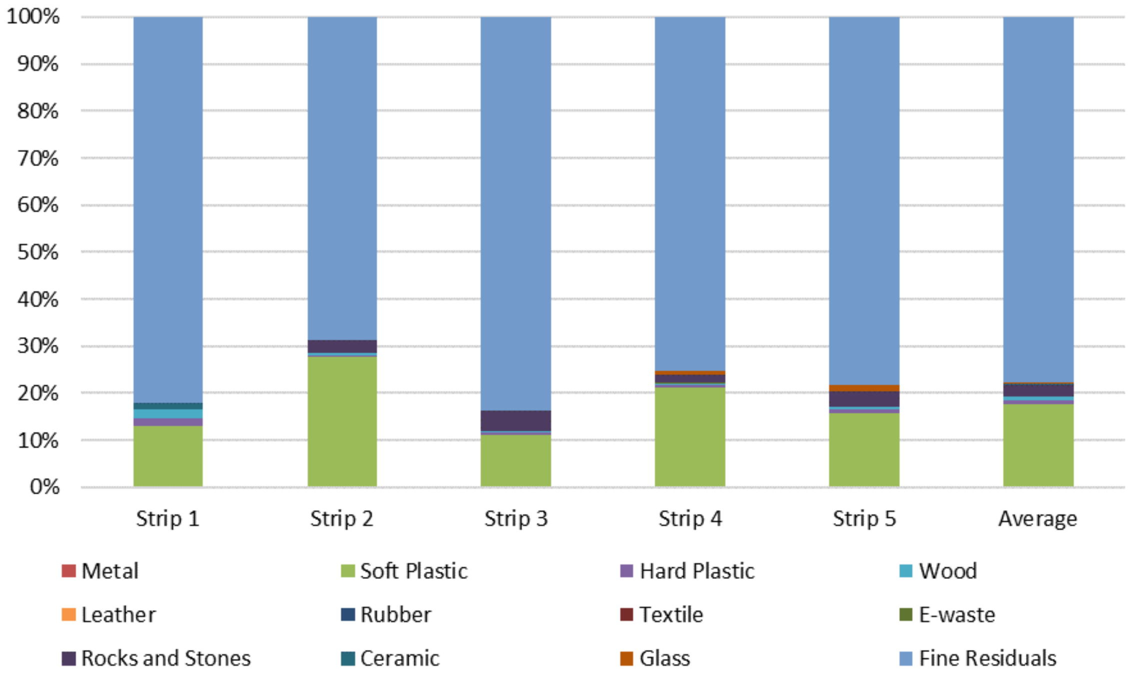

Figure 9. *Composition of the Fine Fraction per Strip*

Computations show that 80% of the fines component of the dumpsite wastes consist of non-combustibles, with 78% of the total consisting of fine residuals (Figure 10). Rocks and stones were found at 2% each, and glass, and ceramics found at less than 1%. Meanwhile, soft plastics at 18% compose majority of the combustible wastes, with wood and hard plastics also found at 1% each.

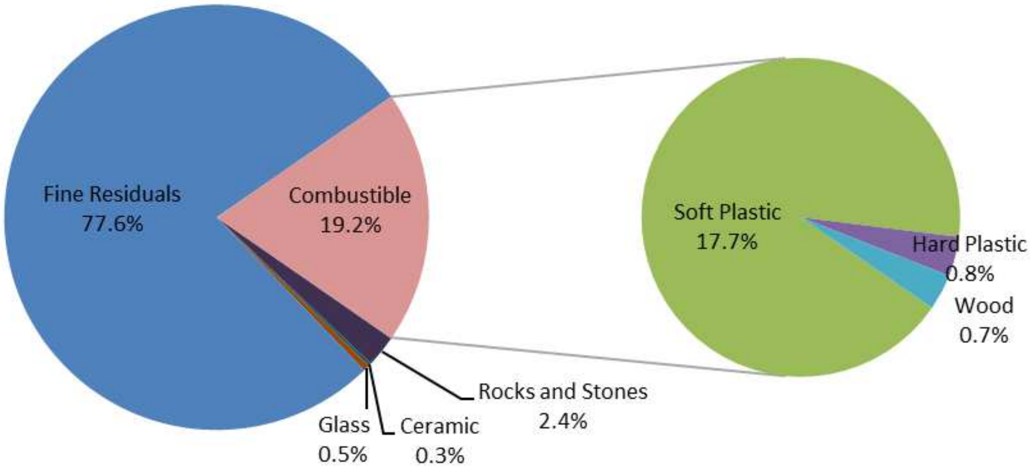

Figure 10. *Average Composition of the Fine Fraction*

The average compositions of the coarse and fine fractions were applied to estimate the overall composition of wastes in the dumpsite and were compared to European landfills studied by Van Vossen and Prent (2011) for reference (Table 1). The amount of the plastics in the dumpsite, with a total of 40.3%, are significantly larger than in the European landfills, which only have 4.7%. Construction and demolition waste, organic wastes, paper and cardboard were not identified in the dumpsite, presumably because of the age of the dumpsite during the conduct of the study that which may have evidenced degradation of these waste types. The percentage of other waste types are similar. The significant presence of combustible fractions suggests that WtE rather than material recovery is the ideal valorisation route in this dumpsite (Parrodi et al., 2018).

Table 1. *Overall Composition of the Dumpsite compared to those studies by Van Vossen & Prent (2011)*

Material	This Study	Van Vossen & Prent (2011)
Fine Residuals	47.6%	54.8%
Metals	0.0%	2.0%
Plastics	39.4% (Soft) 0.9% (Hard)	4.7%
Wood	2.3%	3.5%
Leather	0.1%	1.6%
Textile	2.0%	1.6%
Rocks and Stones	4.9%	2.5% (stones)
Glass	0.8%	1.1%
Others	1.7% (rubber) 0.3% (ceramic) 0.0% (e-waste)	2.6% (no description)
Construction & Demolition	-	9.0%
Organic	-	5.3%
Paper & Cardboard	-	5.3%
Inert	-	5.8%
Non-MSW	-	0.3%
Total	100.0%	100.0%

4 CONCLUSIONS

The feasibility of landfill mining at a closed dumpsite in the Philippines for a potential WtE project was done. Samples were retrieved at the closed dumpsite and were sorted through a trommel with a 2"x 2" mesh to identify the amount of combustible wastes that are contained in the closed dumpsite. About 39% by mass of the wastes that did not pass through the 2"x 2" screen are considered as the coarse fraction and were found to be further comprised by around 89.2% combustible materials and 10.8% non-combustible materials. The remaining 61% by mass of wastes that passed through the 2"x 2" screen were considered as fine fraction; these were found to be further comprised by roughly 19.2% combustible materials and 80.8% by mass non-combustible materials. Soft plastics have the largest presence in the combustible in both coarse and fine fractions. The significant amount of combustible matter and the heavy contamination of the sorted waste fractions in general make the dumpsite a viable candidate for WtE. To further explore the potential of a WtE facility that will utilize waste from this dumpsite, analysis of the physical and chemical properties of select waste fractions and cost-benefit of putting up the facility can be done.

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