The Republic of Indonesia

German-Indonesian Chamber of Industry and Commerce (EKONID), on site study report

"Technology-based Concept Development and EKONID Workshop in Indonesia 2018 – Waste Management in Tasikmalaya"

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Abstract

The Ciangir landfill site, located in Tasikmalaya, will run out of deposit capacities in foreseeable time. The German-Indonesian Chamber of Industry and Commerce (EKONID), BlackForest Solutions GmbH (BFS) and the University of Siliwangi studied the site and the local waste management infrastructures to find solutions which will reduce landfill amounts at the collection, sorting and disposal level.

Despite several challenges regarding available equipment, staff capacity, processes and specialized know how on site, the current management and administration achieved a constant operational mode to ensure a reliable collection and safe disposal of municipal solid waste from local waste generators.

To ensure and expand the scope of services and capacities with a sustainable long-term perspective for all involved and possibly new share and stakeholders, EKONID, the University of Siliwangi and BFS assessed the Ciangir landfill in July 2018.

To reach the long-term target of providing waste management optimization support for the local government, EKONID developed a four phases action plan which includes introducing safety measures and sampling of waste on-site (Phase 1), conducting quantitative and qualitative waste analysis (Phase 2), providing different suitable waste treatment method for a reduction of landfilled waste amounts (Phase 3) and assessing the feasibility of each German technology cooperating with potential investors (Phase 4).

During phases 1 and 2, more than 10 tons of municipal solid waste (MSW) from household, market and commercial sources were separated from the frequent delivery to the landfill and hand sorted to different fractions, as well as analyzed concerning fraction quantities and qualities. The main condition hereby was to maximize the level of representation of samples and followed a stringent sampling plan, developed in coordination with the landfill operators. The waste quantity and quality analysis based on primary data will be the foundation of any strategic optimization approach (regulatory or technical).

The municipal solid waste in Tasikmalaya is dominated by the organic fraction with more than 50% weight proportion, followed by plastics (16,5%) and mixed textiles (15-17%). Leachate water analysis indicate that the parameter concentrations are still below the threshold. However, since the open leachate water treatment ponds are frequently emitting gases, it is advisable to upgrade the leachate water treatment system.

Within this report, the results of phases 1 and 2 will be summarized. Furthermore, EKONID and BFS present 3 main options for an optimization of the waste management system in Tasikmalaya with a focus on the reduction of landfill inputs. Hereby, not only technology solutions in different budget levels will be suggested, but also structural optimization measures (source segregation) reflecting socio-economic aspects of the local population.

Content

List of abbreviations

BFS	BlackForest Solutions GmbH
CAPEX	Capital Expenditures
CW	Commercial Waste
EKONID	German-Indonesian Chamber of Industry and Commerce
FE	Ferrous Metals
GRDP	Gross regional domestic product
HDPE	High Density Polyethylene
HW	Hazardous Waste
HoW	Household Waste
LDPE	Low Density Polyethylene
NFE	Non-ferrous metals
MBR	Membrane Bioreactor
MSW	Municipal Solid Waste
MW	Market Waste
OPEX	Operational Expenditures
PET	Polyethylene Terephthalate
PMMA	Polymethylmethacrylate
PP	Polypropylene
PPE	Personal protective equipment
PS	Polystyrene
RO	Reverse Osmosis
Unsil	Siliwangi University
WEEE	Waste Electrical and Electronic Equipment

List of units

[IDR]	Indonesian Rupiah
[KG]	Kilogram
[MG/L]	Miligram per liter
[MM]	Milimeter
[MT]	Metric ton
[UMHOS/CM]	umhos per centimeter
[°C]	Degree Celcius
[%]	Percent

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1. Introduction

As the result of an assessment study for the waste management of six medium-sized Indonesian cities (Bandar Lampung, Banjarmasin, Manado, Samarinda, Surakarta and Tasikmalaya), conducted by the German-Indonesian Chamber of Industry and Commerce (EKONID) in 2016, Tasikmalaya was selected for further project implementations due to the city's strong interest and need for modern waste management solutions.

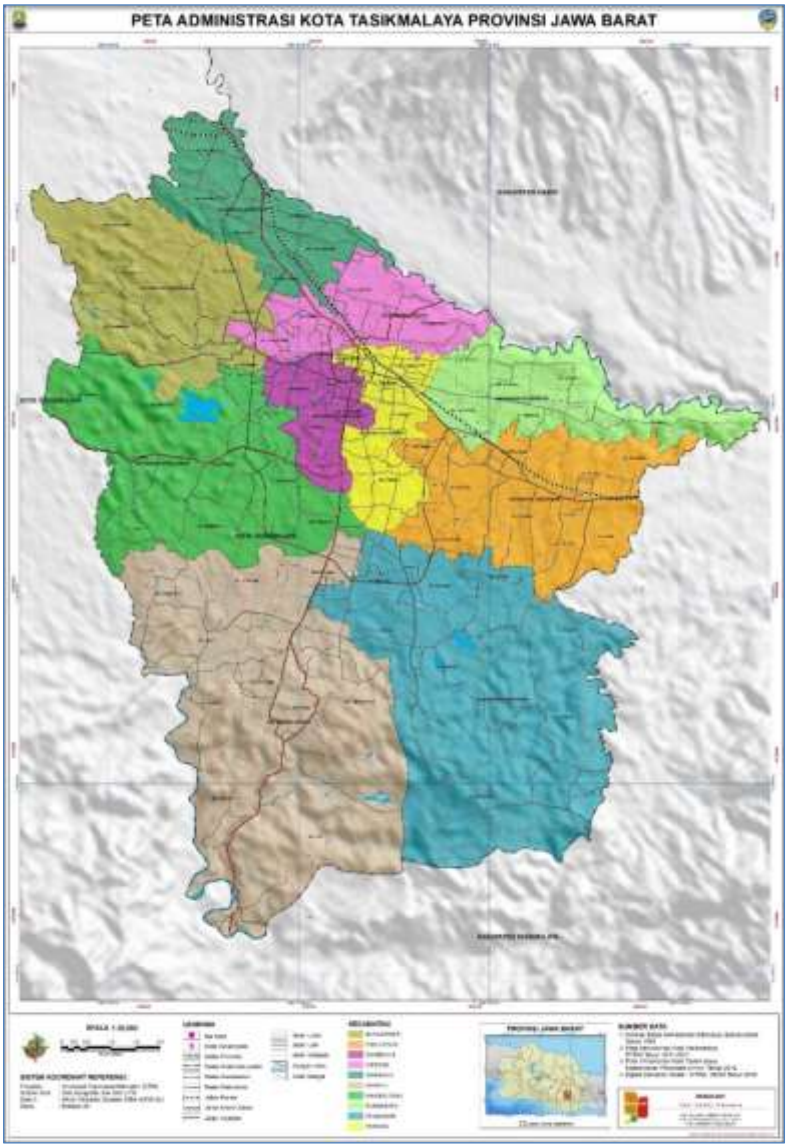

Figure 1: Map of Tasikmalaya (Source: petatematikindo.wordpess.com)

Tasikmalaya is located 120 km southeast from Bandung. Since 2005, the total number of inhabitants in Tasikmalaya increased by approximately 40%. As this unexpected rise of population also affects the total amounts of generated waste, a responding update of waste management infrastructure is urgently needed. Moreover, since waste contains valuable resources such as paper and plastics, promoting circular economy to improve the local economy can be supported through the upgrade of waste treatment facilities.

1.1. Project Goals

The EKONID assessment study (2016) concerning the waste management of six medium-sized urban areas in Indonesia has led to the identification of the most significant obstacles for an appropriate waste management system in Tasikmalaya. Based on this study, BFS analyzed the current situation in Tasikmalaya and produced the current report, which shall support as a decision-making overview for the local government. The overall project goals can be summarized as following:

- Reduction of the overall landfill input and the introduction of a waste type segregation at the producer level (source segregation)
- Improvement of waste management data availability and their visualization
- Upgrading the local waste management system by implementing suitable technical solutions
- Enforcing the local environmental economy and creation of waste management business cases

1.2. Targets of the site Assessment

The project aims to provide guidance for the government of Tasikmalaya city in a result-oriented manner. Hereby, the current site assessment report shall provide an extended view of the current situation in Ciangir landfill site. For this, the report includes the identification of suitable technology solutions for the local MSW management, development of concrete approaches for waste recycling as well as presenting and discussing the feasibility of a commercial project involving potential investors (project overview, see figure 2).

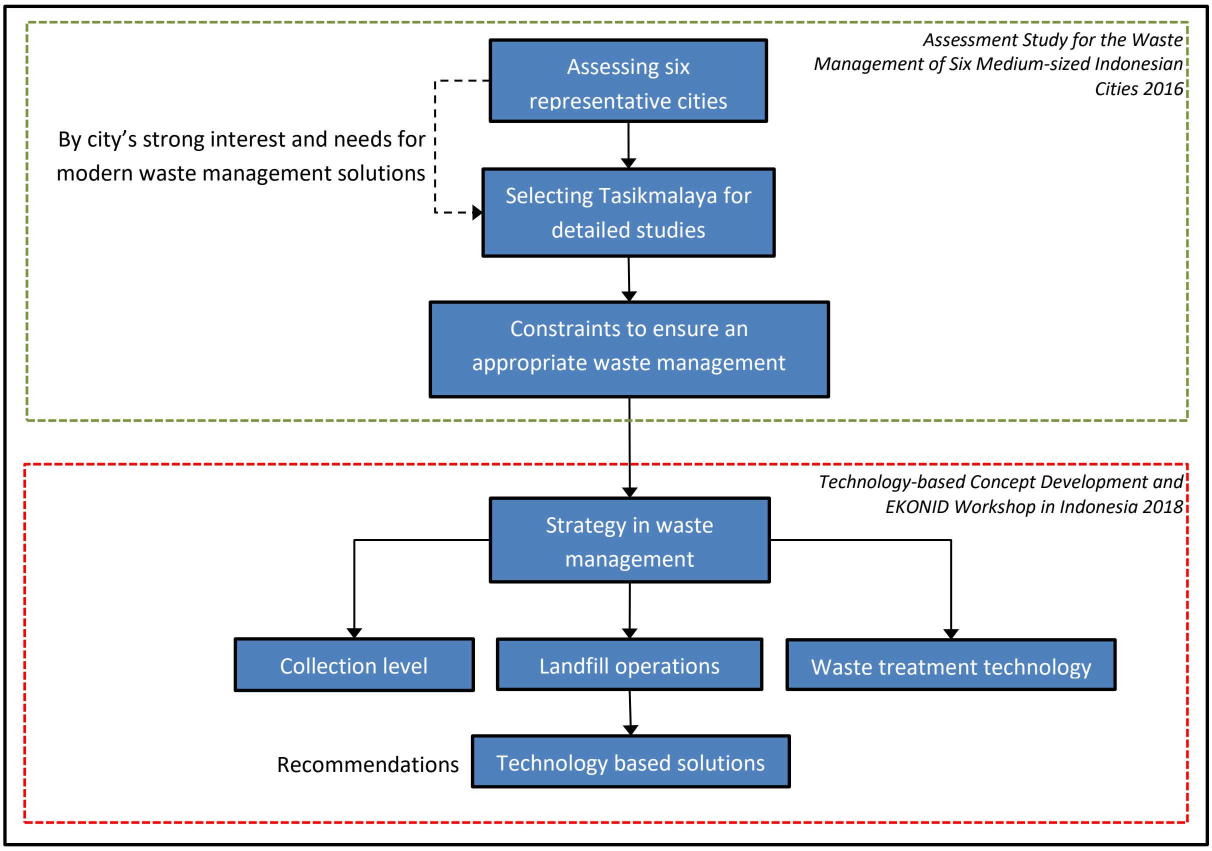

Figure 2: Scheme of approaches for a sustainable waste management in Tasikmalaya (Source: BFS)

1.3. Solution method and structure

EKONID developed 4 modules that consist of detailed primary data analysis and the development of technology-based concepts for Tasikmalaya, presentations of the proposed concepts in Tasikmalaya, intensive seminars on waste separation at the household level, and workshops on the realization of a waste-related business case for Tasikmalaya.

The focus of the mentioned modules lays on the preparation of a decision-making basis for the local administration and possible investors. EKONID and BFS hereby respect local framework conditions, socio-economic aspects and available budget lines. Therefore, the current report and proposed technologies contain options with different technology levels and CAPEX/OPEX requirements.

EKONID and BFS are available to conduct detailed technical and financial feasibility studies, including detailed technical concepts and procurement management solutions, as soon as local decision makers or investors decided to approach one (or several) of the presented upgrade options for the MSW management system in Tasikmalaya.

2. Assessment of the waste management system in Tasikmalaya

To assess the status quo of the existing waste management system in Tasikmalaya, customized questionnaires and sampling procedures have been developed by EKONID and BFS. Questionnaires, as well as the qualitative and quantitative on-site waste analysis were required to receive a valid and up-to-date information basis, describing the current situation of Ciangir landfill and the surrounding waste management infrastructure. The following aspects were respected during the on-site data collection phase:

1) Existing infrastructure: Understanding the current waste management infrastructure in Tasikmalaya (via questionnaires and primary data gathering on-site)
2) Current framework data: General numbers and data for correlation calculations (machinery types and quantities, engaged workers and waste pickers on site, delivery frequencies etc.)
3) Socio-Economic factors: Interviews with waste bank staff, landfill staff and informal waste pickers on site, to understand the needs and requirements of all mainly involved persons

After the conduction of personal interviews and questionnaires on both the workers and the decision-making level, the on-site physical examination of existing infrastructure and the landfill itself was performed. Based on all data and information, EKONID and BFS elaborated technical solutions which could fit to the existing system and optimize the current situation, with a focus on reducing landfill amounts and increasing the recycling rate locally, without negative socio-economic impacts on the informal sector and respecting possible budget restrictions.

Figure 3: Interview sessions with waste bank workers, landfill staff and waste pickers

Local conditions

Tasikmalaya consists of 10 subdistricts: Kawalu, Tamansari, Cibeureum, Purbaratu, Tawang, Cihideung, Mangkubumi, Indihiang, Bungursari and Cipedes (Table 2-1). Tasikmalaya is inhabited by approximately 660,000 people. The city experienced a population increase of 4% between 2010 and 2015. Considering its weather condition, the annual precipitation is 3,432 mm/year, while the average temperature lays around 25.2°C (Figure 4).

Table 2-1: Population in Tasikmalaya and its subdistricts

#	Subdistrict	Population		
		2010	2014	2015
1.	Kawalu	84,930	87,607	87,973
2.	Tamansari	63,073	65,303	65,604
3.	Cibeureum	61,238	62,959	63,171
4.	Purbaratu	38,130	39,134	39,243
5.	Tawang	62,641	64,764	65,082
6.	Cihideung	71,507	73,631	73,934
7.	Mangkubumi	85,193	87,995	88,346
8.	Indihiang	47,554	49,034	49,238
9.	Bungursari	45.733	47,217	47,432
10.	Cipedes	74,949	77,150	77,454
		634,948	**654,794**	**657,477**

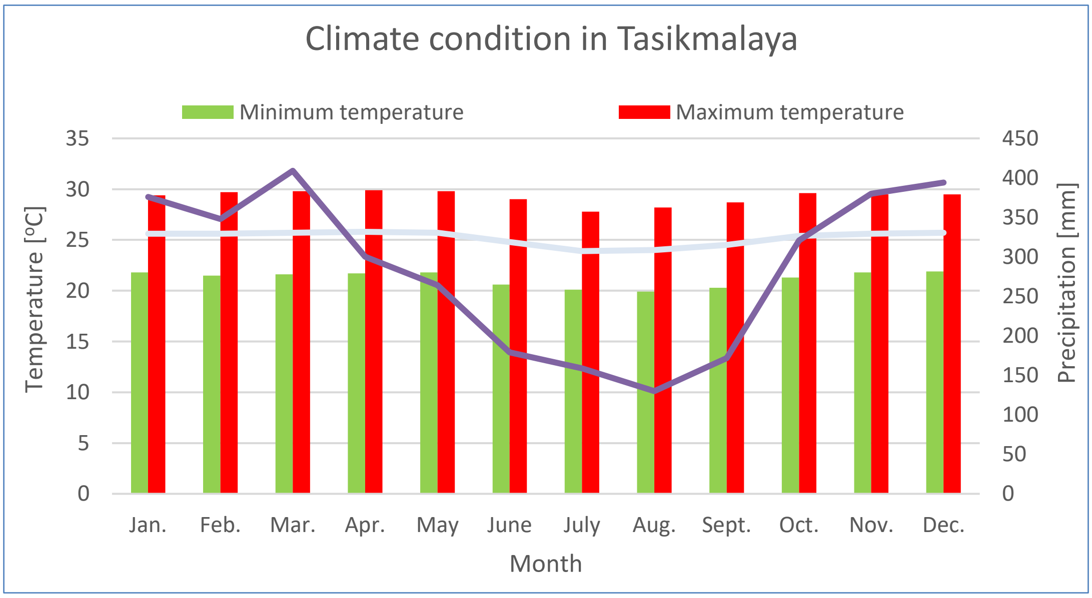

Figure 4: Climate conditions in Tasikmalaya

3. Methodology

3.1. Municipal solid waste sampling

In general, there are four main levels at which MSW sampling may take place:

1. Inside the household/business (sampling directly from the internal waste bin)
2. Outside the household/business (sampling from an external waste bin/container)
3. After collection (sampling from the collection vehicle)
4. After disposal (sampling from disposed/dumped amounts)

Considering the project timeframe, local conditions and the study targets, sample level #3 (sampling after collection) was chosen.

Disadvantages: Often, waste collection vehicles compact the waste, making it harder to identify the materials that arrive at the landfill. Also, the cooperation of landfill operators is obligatory and non-conform disposal of waste (open dumping) will not be detected.

Advantages: Considering the current report type, systematically collected waste arriving at the landfill represents an average of each waste source (market, household, commercial) instead of being regionally divided per neighborhood, for example. Sampling level #1 or #2 could bring scattered results (due to residential structure, bin sizes, holiday locations etc.) in case no surrounding GIS and detailed source documentation and selection is involved.

The sampling shall produce a representative database for all waste types and amounts which arrive at the landfill per day. Therefore, all incoming trucks per day were weighted and documented (origin of their waste, arrival time, amount of waste). The total size of separated sample lots (number of single samples and sample amounts) and selection hand-sorting parameters depend on:

1. Variation (heterogeneity) of the waste, expressed by a variation coefficient. This variation coefficient is usually unknown and should be estimated based on results from past waste analyses or on-site visual assessment of delivered waste
2. Desired general accuracy of the results
3. Desired level of correlation accuracy and needed output data/conclusions

3.1.1. Sampling process description

In case local circumstances prevent the application of internationally acknowledged sampling standards (such as German PN98), sampling procedures must be defined locally with appropriate scales. In this project, the selected sample lot size was 10% (weight) of all delivered materials which arrived at the landfill during one working day. Before the 10% sampling of each delivery, the material was unloaded and homogenized/mixed in a separate area “A”.

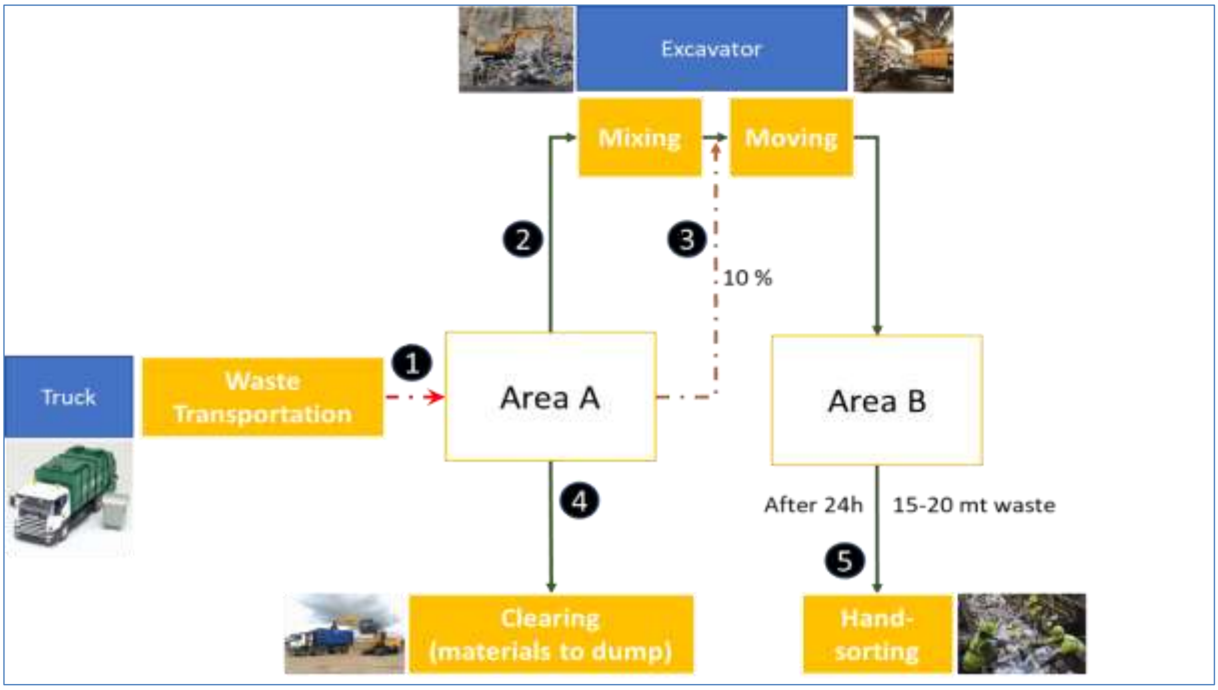

Figure 5: Scheme of the waste sampling procedure (Source: BFS)

The sampling team conducted the following defined sampling steps for one working day (figure 5):

1. Each incoming truck was weighted and unloaded in a defined free area on the landfill yard (area A). Hereby the three main collection origins were considered and separated: Households, commercial entities and markets
2. An excavator mixed truck loads to produce a homogenous sample mass
3. A visual inspection of the flattened heap was conducted to identify irregular bulky items, electronic devices, possible medical and/or hazardous waste contaminations
4. From the mixed, homogenous sample mass, the excavator loaded approx. 10% on a pick-up truck, which transported the separated final samples to a second free area (area B). The remaining amounts were moved aside
5. Steps 1-4 were repeated for one working day for all incoming waste amounts. In area B, the final samples were again separated depending on their origin (household, commercial, market waste)
6. After the sampling finalization, handsorting of the waste in area B began.

After one day, more than 10 metric tons of reduced mixed samples were shifted to area B. These amounts can be considered as daily average for the respective waste origins. Besides the following hand-sorting, a parallel water content analysis and leachate water analysis was conducted by the university.

Figure 6: Mixing and moving waste from area A to area B

3.1.2. Dry matter analysis

At area B, the sampling team separated and weighted approximately 20 kg of material from each origin. Transferred to the Siliwangi Universities laboratory, the samples were dried and weighted again. The percental weight delta is considered as water content.

The water content in mixed waste samples gives an indication of the approximate portion of the organic fraction, such as food waste (wet waste). In case the water content is conducted with separated samples without organic fractions, the analysis gives indications on the contamination level of recyclables (e.g. contamination of paper with organic materials). In general, the water content is an important planning parameter when composting, recycling, digestion or incineration processes are considered.

3.1.3. Leachate water analysis

Landfill leachate water is considered as one of the most contaminated waste waters at all. Rainfall and MSW water content both pass all vertical levels of the landfill, thus binding and concentrating partly hazardous substances, bacteria and other toxic compounds. Leachate water is in general a serious danger for local groundwater qualities and all surrounding lakes, rivers and agricultural activities.

On Ciangir landfill, a bottom liner and a drainage system (downstream leachate and upstream methane) are installed. The leachate water is directed to an open structure pond system with overflow mechanisms. After the final pond, a wet land is connected to the treatment ponds outflow.

Leachate water samples were taken at the inflow of the pond system, at the outflow of the pond system and at the outflow of the wetland.

The analysis of leachate water was carried out by a certified external laboratory to determine several parameters, such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), total solid matter, concentration of ammonium, total nitrogen, total phosphate, and more (see table B-8).

Figure 7: Leachate water treatment system in Ciangir landfill site

3.2. Hand-sorting and category selection

Figure 8: Three different heaps of household, market and commercial waste

To analyze the waste composition per origin and in average, the separated sample heaps for market, commercial and household waste were hand-sorted. First, the organic fraction was separated (positive selection). After the organic fraction was separated from the heaps, the non-organic and mostly recyclable waste streams were hand-sorted in defined primary and secondary fractions.

Table 3-1: Chosen sorting fractions

#	MAIN WASTE CATEGORY	SECONDARY CATEGORY
1		Mixed Paper
2	**Paper / Paperboards**	Cardboard
3		Multi-layer material
4		PET
5		HDPE
6		LDPE
7	**Plastics**	PS
8		PP
9		PMMA
11		Others
12	**Organics**	Putrescible
14	**Textiles**	Mixed textiles
15		FE
16	**Metals**	NFE (aluminum cans)
17		NFE (excluding aluminum cans)
19	**Glass**	Mixed glass (not clear)
20	**Rubber**	Tires, rubber products
21		Liquid or solid hazardous waste
23	**Potentially hazardous waste**	WEEE
24		Medical waste
25	**Inerts**	Stones, concrete, soil/clay

Table 3-1 shows all waste fractions which were detected and separated on-site. Some waste types require a higher separation grade (e.g. organic waste vs. plastics) due to different treatment/recycling processes and different disposal efforts/market values.

4. Results

The obtained results are based on the findings of the survey and interviews conducted on site, the hand-sorting records and the leachate water analysis.

4.1. On-site survey

Before the onsite project kick-off, general data based on literature review, waste sampling and truck statistics were evaluated by the team. Before the first on-site visit, the sampling team (delegation of Siliwangi University) was trained and instructed about the following topics:

- Possible hazards on an MSW landfill (fire, gas emissions, bacteria)
- How to prepare samples in a statistical sound manner
- How to technically take samples (tools, procedures, spot selection etc.)
- Which personal protection equipment shall be worn when and where
- How to document the planned sampling and hand-sorting process

The on-site survey and analysis started on 2 July 2018 and ended on 7 July 2018. The temperature during that week was between 25 and 27°C. Other findings are summarized in the following subchapters as addition to the waste sorting results.

Waste collection logistics

- Each truck team either has allocated waste collection points or defined waste banks to take over waste amounts. Yet, the truck teams do not use any routing optimization tools (offline/online). Each truck team consists of 2-3 workers
- During the survey day, 64 trucks delivered waste to Ciangir landfill
- Waste handover manifests or tracking tools are not implemented
- It was noted that the landfill is accessible without controls

Hazardous waste contaminations

After the unloading of the respective truck loads in area A, the team manually opened bags and searched for bulky items, for electronic scrap and hazardous materials. The following was found:

- Small amounts of pharmaceutical waste (e.g. expired pills in blisters)
- 4 CRT monitors without housing
- Some CCFL tubes

The low entry rate of electronic scrap to the landfill indicates a well-functioning network of waste bank separators and/or the informal sector. Reflecting the quality and safety level of electronic scrap recycling in Indonesia, a separate project, which aims at a material channeling to professional recycling options via positive incentives for the informal sector, might make sense.

Figure 9: Bag opening and searching for contaminations after each truck unloading

Metal contents in delivered waste amounts

As expected, the metal contents in the delivered waste amounts were found at almost zero. This finding is an indication that the informal sector is already well connected and settled concerning the pro-active collection of valuable metals directly from the respective sources.

Waste picker involvement

The informal sector is not only involved in the source level collection of valuable materials, but also active on the landfill itself. Typically on the landfill, a group of waste pickers wait for the next truck arriving to unload its material. As soon as material is unloaded, each waste picker searches for valuable plastic materials, preferably PET. The following findings were summarized from the interview of two waste pickers on site and the observations during the site assessment:

- The waste pickers are not organized as group and mostly work alone. No site access restriction or registration is needed for waste pickers. Consequently, they are neither employed nor insured
- According to the waste pickers and landfill staff, in high seasons, more than 200 waste pickers are active within the landfill area
- In case of a full-time involvement, a waste picker can earn between 1 million and 2 million IDR per month

- The waste pickers sell their collected and consolidated amounts to a third private party, which collects the material at the entrance of the landfill and transports it to the respective facility or trader
- The waste pickers are not aware of the final market value of the materials which they collect
- One main concern of the waste pickers is the contamination of recyclables with organic waste (harder to separate, less value)
- The waste pickers are sceptic towards the suggested professionalization of their tasks by giving them proper trainings, tools, machinery and probably a working contract with the landfill
- The waste pickers only have a limited timeframe between the unloading of a truck and the dispersal on the landfill area by heavy machinery. Consequently, the recovery rate is limited to the outer surface of a heap and the given timeframe to detect valuable materials. Second consequence is that clearly valuable material which is covered by other waste amounts are only not recovered, because the waste pickers respectively the landfill operators do not have enough time to shift the unloaded materials, before the next truck arrives

Figure 10: On-site interview with waste pickers

4.2. Waste analysis from on-site manual sorting

The following figure summarizes the results of the hand-sorting activities on-site. The 4 diagrams show the waste composition of household, commercial and market waste with the respective organic fraction included. The diagram “Urban waste” is representing the weighted average of all delivered waste amounts (approx. 60% from household origin, 30% from commercial origin, 10% from market origins).

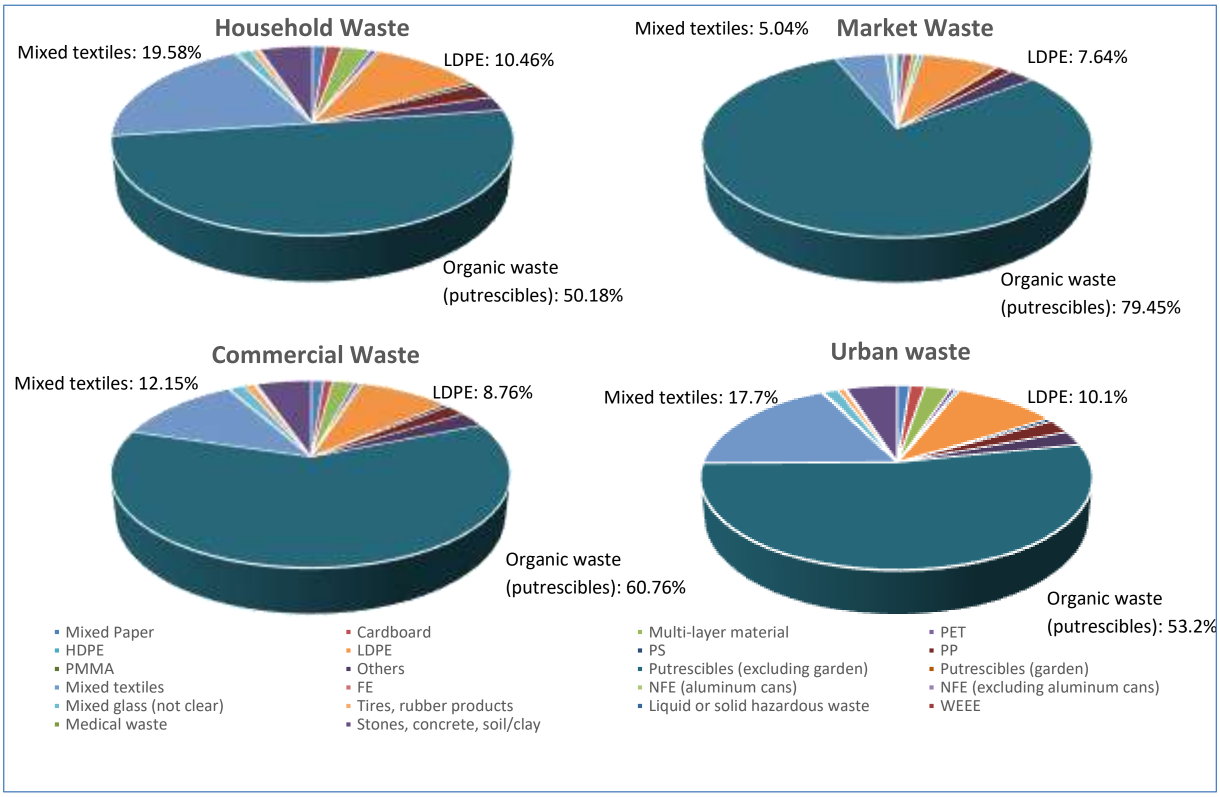

Figure 11: Comparison of waste compositions by their origin (Source: BFS)

As expected, organic waste dominates the municipal waste in Tasikmalaya with a portion of more than 50%. Figure 12 elaborates the waste composition of household, market and commercial waste after separation of the organic matters.

Besides a composting pilot project, there are no initiated approaches yet to separate the organic fraction (approx. half of all amounts arriving at Ciangir landfill). This measure could optimize the recovery rate of recyclables for the landfill operators or the waste pickers. Furthermore, this measure could prevent approx. 50% of all waste amounts entering the landfill, reduce the landfill gas emissions and be another source of income in case a biogas, animal feed or composting unit would be installed and operated.

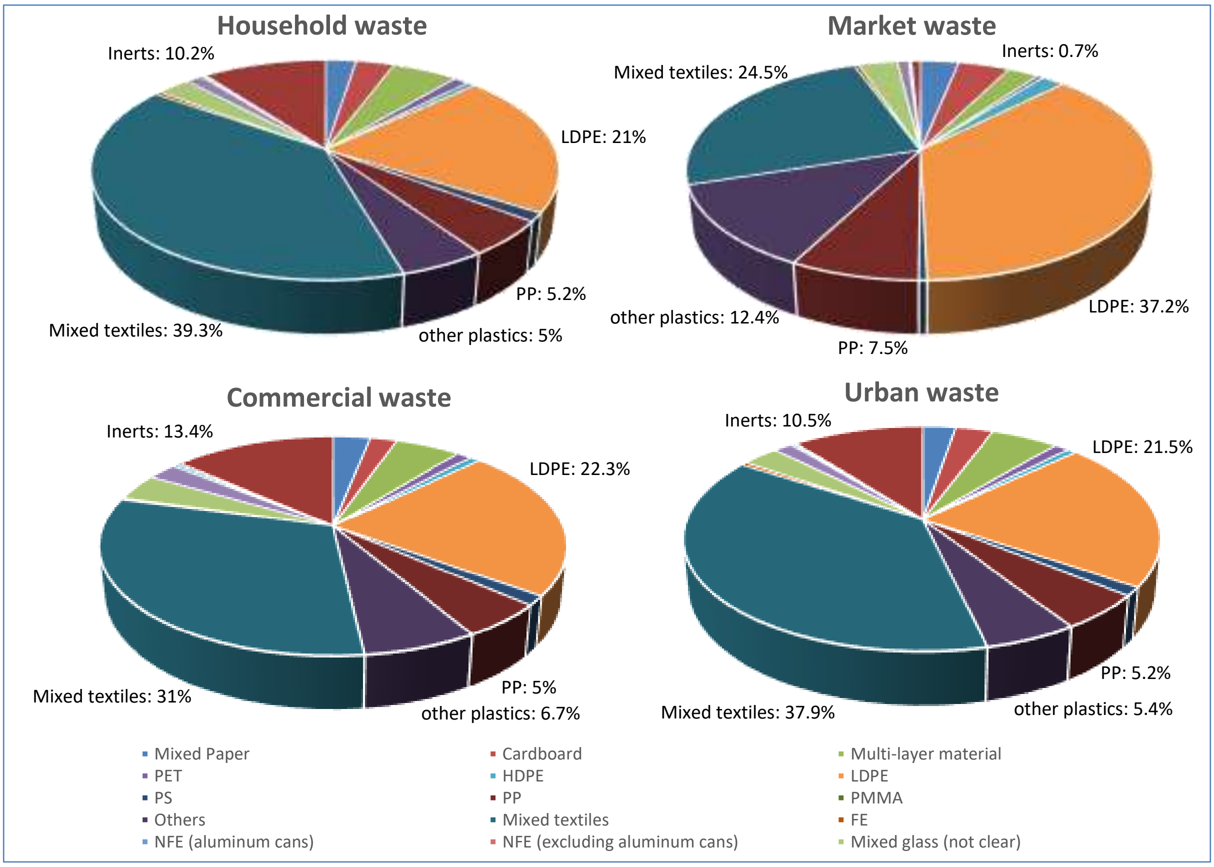

Figure 12: Comparison of different inorganic fractions by their origin (Source: BFS)

The results in figure 11 indicate that the total amounts of household, market and commercial waste contain approximately 12-18% plastics, which would mostly be suitable for sales and recycling. Within the range of plastics, LDPE dominates with a total portion of 8-11% from each waste origin. Another component which could probably be recovered with a total portion of 5-20%, are textiles.

For textile re-usage (as industrial wipes etc.), a treatment line could be set up – in case source segregation can one day be implemented in Tasikmalaya. Apart from the usage as second hand industrial wipes in case of source segregated materials, old contaminated textile can be used as RDF additive for cement kilns or power plants.

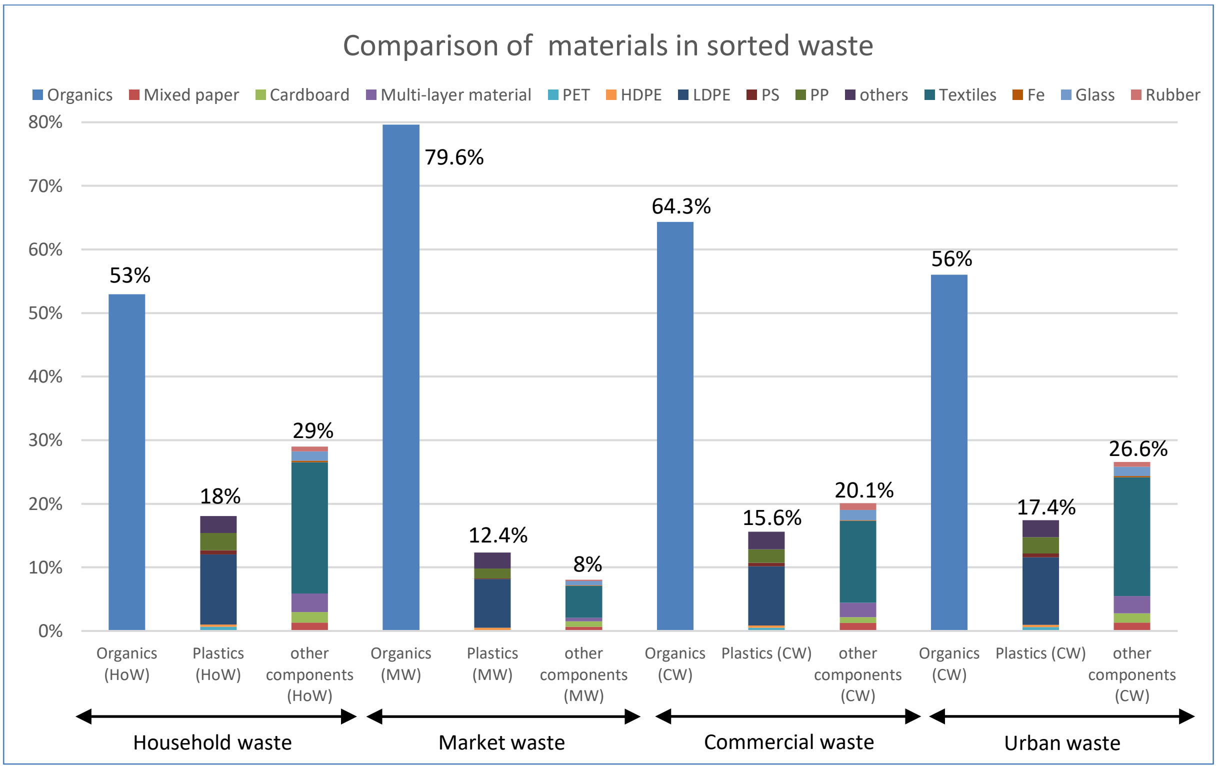

Figure 13: Comparison of potentially recovered materials in different type of waste (Source: BFS)

As paper material (mixed paper (0.7-1.3%), cardboard (0.9-1.7%), multi-layer material (0.5-3%)) represents a minor portion of the total waste composition, a detailed analysis of recycling possibilities does not make sense. The same case was observed for metals, glass and rubber. The mentioned material streams achieve their highest value when collected uncontaminated directly at the source. This collection is organized and conducted by the informal sector outside of the landfill and can be considered as solved case – until initiatives plan to professionalize the complete informal sector in Indonesia.

Further qualitative analysis shows that market and commercial waste both hold approximately 50% moisture content, mostly in the respective organic fraction. Also, household waste contains a significant water amount of 62%. Calculating the overall average water content for the urban waste mixture, the water content adds up to approximately 57%. More detailed compositions for each waste type are shown in the attached tables B-1 to B-3.

4.3. Leachate Water Analysis

The laboratory analysis of the leachate water at Ciangir landfill shows that the assessment parameters for landfill leachate water analysis, which are defined by the regulation of the Ministry of Environment and Forestry Republic of Indonesia Number P.59/Menlhk/Setjen/Kum.1/7/2016, are stated to fulfill the given thresholds.

Table 4-1: Parameters concentration in leachate water of Ciangir landfill site

Parameter	Units	Concentration	
		Leachate water	Threshold
pH	[-]	8	6-9
BOD	[mg/L]	63.4	< 150
COD	[mg/L]	211	< 300
N-total	[mg/L]	10.79	< 100

This regulation was made to provide details of threshold in leachate water of landfill sites in Indonesia. The analysis show that the leachate water treatment system does not require a modification or construction of a new facility. However as described before, the pond emits strong odor. It might be helpful to build a special facility to collect and handle gas from ponds treating leachate water.

Furthermore, a soil analysis and liner test for the wetland behind the pond system is suggested to exclude the possibility of groundwater contamination here.

5. Conclusions and recommendations

5.1. Situation summary

Currently the recycling rate, as well as the landfill rate in Tasikmalaya are not satisfying and impose an economic and environmental disadvantage to the city. While valuable material is contaminated with organic streams and landfilled without recovery, the landfilled biological fraction emits unused harmful landfill gases and toxic leachate water concentrates.

Nevertheless, the waste management system in Tasikmalaya shows potentials to support the local economy by professionalization and employment of people (informal sector, students etc.), as well as potential to generate more income/less costs for the municipality respecitivelly an investor. Urban waste in Tasikmalaya does not only contain 56% organics that can be processed and used in the agricultural sector, as biogas feed-in, or as raw material for a fertilizer or an animal feed process. It also contains about 27% recyclable materials, which are partly valuable and could be professionally separated and be sold to recycling companies.

As obligatory basis for an upgrade of the local waste management system and the reduction of landfill amounts, the following conditions can be set:

1. Waste separation at the source – at least with a 2 bins system (wet & dry)
2. Waste separation at the landfill

Condition number 1 is the cheapest and most effective measure, but also difficult to implement due to local mentalities and collection infrastructure. Furthermore, a source segregation would allow an animal feed production line. Condition number 2 can use the existing collection infrastructure but requires technology which will not be able to separate wet and dry waste with high effectiveness and low contamination rates in comparison with a source segregation.

All following suggestions and technology options are based on at least one of these basic conditions.

5.2. Introduction of a separated waste collection scheme

To successfully divert the organic wastes from a landfill, a separated waste collection scheme option should be considered a "priority option", as it presents a more efficient and cost-effective method than post-collection sorting.

Additionally, the separate collection could reduce the amount of chemical contamination in the organic fraction which could later be used for composting or animal feed production. Mixed textiles make up approximately 1/3 of the total Urban waste, primarily from market sources, therefore introducing a separate collection scheme (e.g. donation containers) of textile waste at the source level could significantly increase the chance for a profitable business case. The wet and dry waste can be separated at the household by using bags made of plastic to collect the dry fraction and bins with putrescible paper bags to collect the wet fraction which can be collected by standard trucks.

5.3. Inclusion of the local informal sector

Concerning the above described source segregation plan and the following technical options to upgrade the onsite processes (lower landfill rate, higher recovery rate), one condition must always be fulfilled: The local informal sector must be included and be requested for cooperation on a positive incentive base.

BFS and other organizations made the experience in many other emerging markets, that if the informal sector is excluded (planned or accidentally) or fears any disadvantages from a newly developed system or implemented technology, the failure of a project or business case respectively open conflicts with new technology operators are never far away. Respecting this fact, BFS began to hold “informal sector FAQ-sessions and workshops” in Buenos Aires in 2017. An official invitation of the leaders of the informal sector and a comprehensive and respectful presentation of the advantages for all involved parties are usually very helpful.

For Tasikmalaya, therefore BFS recommends beginning with technical upgrades which impose benefits for both the landfill operator (or investor) and the informal sector. The following technical concepts and solution approaches reflect this approach with different strategies, which are described in the next subchapters.

5.4. Technical option A: Automatic separation of organic waste amounts and composting

Note: Option A was built on the assumption, that a source segregation of MSW amounts cannot be implemented in Tasikmalaya in short- and mid-term time frames.

Target of option A

The main goal of option A is the post-collection separation of valuable organics from recyclable material and possible contamination for further composting. Compost is useful for farmers, landscaping companies and tree nurseries as a soil conditioner (structural stability) or a fertilizer, as well as natural pesticide for the soil. Depending on the local market conditions, compost and fertilizer can be sold with profits.

Process of option A

1) The mixed MSW input is unloaded to a free area directly from collection trucks. A team shortly checks the lot for irregular bulky items and electronic scrap or any other larger metal pieces. Other, non-contaminated materials (e.g. packs of cardboard) can be separated here and bypass the process
2) The waste will be fed into the feeding hopper of an automatic (yet simple) bag opener. The automatic bag opener decreases the chance for accidents (workers try to open bags with hand tools next to the moving excavator), opens all bags reliably, therefore increases the possible

separation and recovery rate for recyclables. Also, a bag opener, connected to a conveyor system, will provide an evenly distributed waste stream with low stack heights, easy to pick out recyclables.

3) After the bag opener, the material will be conveyed to a screen or trommel sieve to separate the waste according to different grain sizes (fine, medium and oversized) removing small inert and refuse materials (for landfill), the midsize mostly organic fraction (still contaminated) and the large sized plastics, as well as packaging materials.

Figure 14: Example of an automated Bag opener (Source: www.coparm.net)

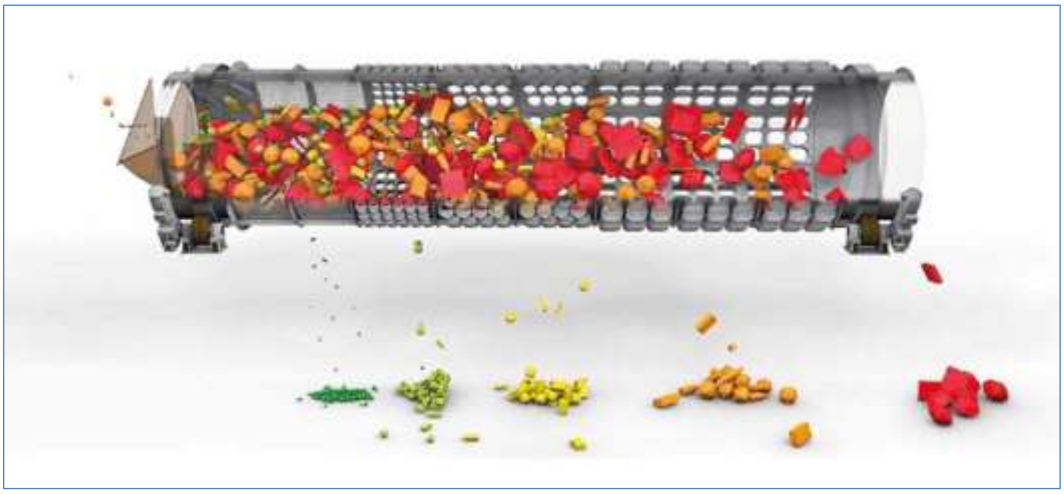

Figure 15: Example: trommel screen (Source: www.w-stadler.de)

4. The most efficient final separation after the diameter screening is a manual sorting process. The following streams will be processed further:
    a. Fines and refuse material: Mostly inert material, will be landfilled

b. Medium grain: Mostly biological and wet material, will be sorted manually (positive extraction of non-putrescible materials). The putrescible fraction will be shredded and processed in a composting unit
c. Over-grain: Mostly packaging material, will be either manually sorted and sold by the landfill operator or handed over to the informal sector

The following section will describe the next steps for the putrescible fraction (see above step 4.b):

After the decontamination, the purified organic fraction will be shredded by e.g. a shear shredder. The size reduction after the separation processes is a requirement to increase the surface area for the needed aerobic bacterial reaction. Typically, for MSW, a size reduction to a particle size between 1.2-5 cm diameter is the optimum to increase the composting rate but at the same time maintain the pores required for the oxygen storage. The resulting fraction should be mixed and placed in aeriated piles.

After the pretreatment process, the rotting process is initiated which required oxygen and constant removal of heat by mixing. The curing phase follows, which requires less heat draining and less addition of oxygen by mechanical mixing and forced aeration. Open composting systems can be done outdoor or simply under a roof. This approach to composting has lower investment costs and energy consumption (for the extraction and treatment of exhaust gases from reactors).

Since the compost might be not sufficiently bulky due to the lack of woody fractions in Tasikmalaya, it might be advisable to periodically completely turn the mixture to provide fresh air to the mixture instead of forced ventilation mechanisms.

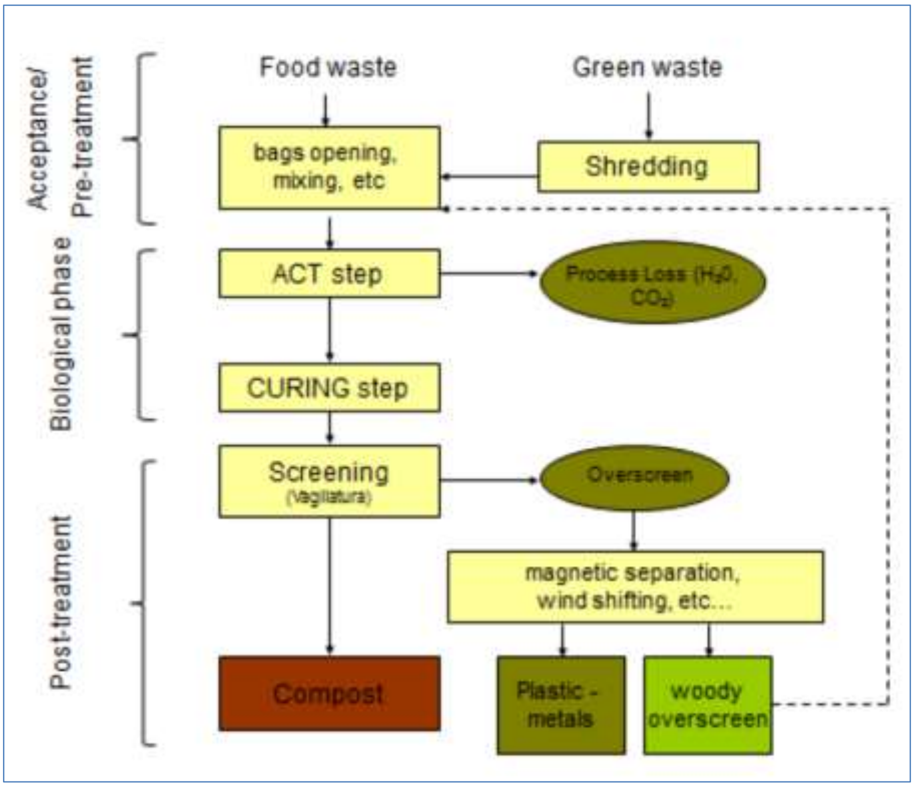

Figure 16: Material flow of a standard composting process (Source: www.ccacoalition.org)

Used machinery/facilities for option A

- Automatic bag opener
- Conveyor belt to the trommel screen
- Trommel screen
- Conveyor for the medium grain, sorting belt to extract any non-putrescible waste types
- Conveyor for the over-grain materials:
  - Either into a truck which brings the waste to the active landfill site, where waste pickers can now recover a far better concentrated amount of valuable recyclables
  - Or onto a connected sorting belt, where waste pickers can be trained and work in a much safer and more efficient surrounding (material will be evenly distributed on a working height, instead of one heap on the ground)
- Composting equipment:
  - Radial ventilation system
  - Hoses and piping
  - Temperature and gas emission sensors
  - Heap turning equipment

Cost estimate for option A

Assuming the usage of used machinery in good shape and local production (metal works, installation etc.), BFS estimates a budget between 1.8 billion IDR (approx. 110,000 EUR) and 2,5 billion IDR (approx. 150,000 EUR) for a low-budget but working solution as basis for further improvement.

For a high-quality setup with new machinery and higher efficiency, approximately 14.7 billion IDR (approx. 900,000 EUR) should be planned in.

Stakeholder benefits of option A

- Landfill operator/investor:
  - Approx. 50% less landfill amounts = longer lifecycle of the landfill
  - Production of valuable compost
  - Optional: sales of recyclable materials
- Waste pickers:
  - The organic fraction which hinders the waste pickers to be more efficient, will be separated before the waste pickers start their work
  - The waste pickers can be fully integrated, as hired staff or as freelancers at the sorting belts, in case they are interested in this model. Working at the belt instead of scavenging heaps on the ground will be much more efficient
- The public/environment:
  - Less methane gas emissions
  - Less new landfill area will be needed
  - Less generation of toxic leachate water

5.5. Technical option B: In case of separated waste sources – Processing of organic waste amounts to animal feed and fertilizer

Note: Option B was built on the assumption, that a source segregation of MSW amounts will be implemented in Tasikmalaya, at the beginning with a diversion of wet and dry waste amounts, with the aim of collecting pure kitchen waste and green cuttings.

Target of option B

The main goal of option B is the processing of separated and uncontaminated kitchen waste and green cuttings. The end product will be a valuable food resource and could provide a sustainable food supply chain based on a circular economy, where the livestock may play a key role in nutrients recycling and food waste disposal on a profitable level

Process of option B

The separated waste amounts either come as kitchen waste and green cuttings, or as "dry" MSW. The dry MSW amounts can be processed like described in option A or C. Alternatively, the dry MSW can be transported to the active landfill site and handed over to the informal sector, similar to the current process.

The separated kitchen waste and green cuttings will be directly processed in an animal feed production line.

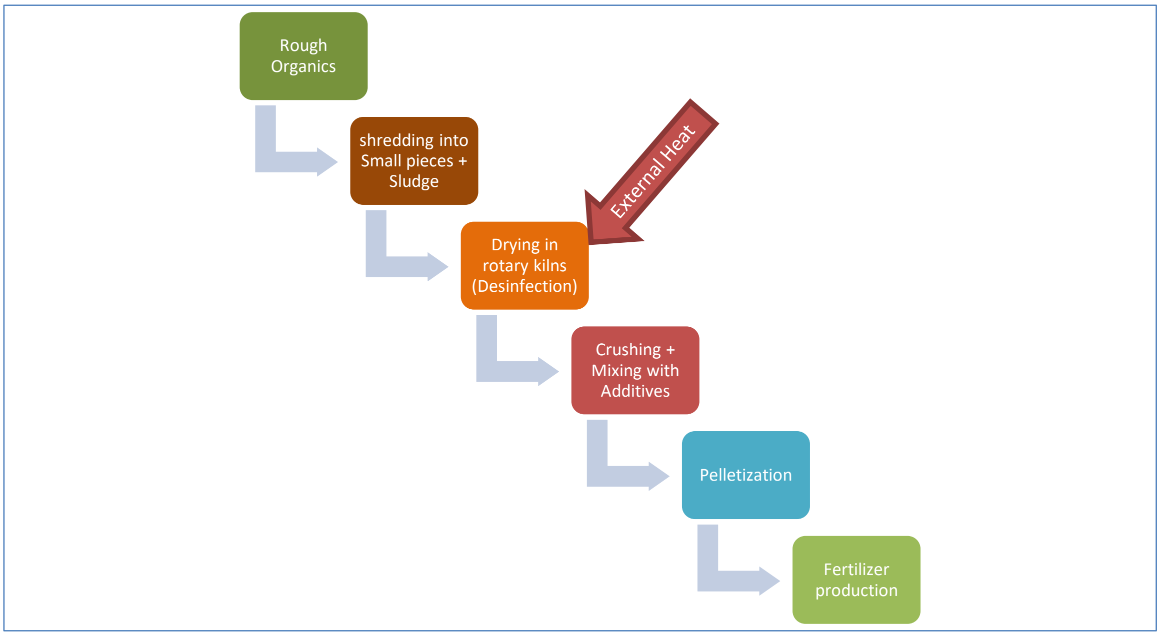

Figure 17: Animal feed production process (Source: BFS)

1. The mixed organics are being discharged onto a separation belt, where staff extracts any contamination and impurities
2. The separation belt leads to a food waste grinder and de-watering unit
3. The grinded food waste and green cuttings are fed into a rotary drier. The rotary drier is important to reduce the water content and to disinfect the input material
4. The heated and dry material is fed into a cyclone which extracts last impurities
5. After the cyclone, the material is conveyed into a cooling line (belt or rotary cooler)
6. From the cooling line, the material is grinded and mixed with additives, vitamins and other additional nutrients
7. The last step is the pelletizing unit. After this step, the animal feed is ready to be packed and sold

Figure 18: Animal Feed process

Used machinery/facilities for option B

- Separation belt
- Grinder and de-watering unit
- Drying unit (rotary)
- Cyclone separator
- Cooling unit (rotary or belt)
- Mixing/blending unit
- Pelletizer

Cost estimate for option B

For option B, it is not recommended to plan with second hand machinery. A complete animal feed line without MEP and construction works can be set up for an estimated amount between 13.9 billion IDR (approx. 850,000 EUR) and 36 billion IDR (approx. 2,2 million EUR).

Stakeholder benefits of option B

- Landfill operator/investor:
    - Approx. 50% less landfill amounts = longer lifecycle of the landfill
    - Production of valuable animal feed (higher value than compost materials)
    - Optional: sales of recyclable materials
    - Building a local supply chain of high-quality animal feed, new business model
- Waste pickers:
    - The organic fraction which hinders the waste pickers to be more efficient, will be separated before the waste pickers start their work
    - The waste pickers can be fully integrated, as hired staff or as freelancers at the sorting belts, in case they are interested in this model. Working at the belt instead of scavenging heaps on the ground will be much more efficient
- The public/environment:
    - Less methane gas emissions
    - Less new landfill area will be needed
    - Less generation of toxic leachate water
    - Better control on local animal feed supply chains

5.6. Technical option C: Biological drying system and RDF production unit for organics and refuse material

Note: Option C was built on the assumption, that a source segregation of MSW amounts will not be implemented in Tasikmalaya. Furthermore, option C requires long-term cooperations between the landfill operator/investor, PLN and/or a nearby cement factory as client base.

Target of option C

The main goal of option C is the processing of mixed MSW into a valuable product (energy). The main target is to convert an inhomogeneous waste stream with a high water content into a homogenous, saleable alternative fuel for common solid fuel combustion processes.

These processes can be found at external sites (cement kilns, coal power plants) or being built up locally (small-scale incineration with electricity generation), in case electricity can be fed in profitably or electricity costs onsite can be reduced significantly.

Process of option C

At the beginning of each RDF process, the mixed material will be dried. In general, there are two different procedures implemented: Mechanical-physical drying (e.g. in rotary driers, MPS process) or mechanical-biological drying (MBT process). Option C concentrates on the MBT process due to its significantly lower CAPEX figures.

1. Mixed MSW will be directly unloaded into heaps. These heaps are either constructed with a secondary bottom including aeration channels and other equipment, or just improvised with aeration pipes and discharged waste amounts
2. The heaps will either be roofed (expansive/industrial solution) or covered with a semipermeable cover (cost-effective solution). This measure will accelerate the bio-drying process of the heap
3. The bacteria contained in water and putrescible amounts within the heap activate an aerobe digestion process. During this process, the heap heats up until 70-80°C. The roof respectively cover prevents rainfall to enter the heap and odors to leave the heap uncontrolled
4. After 1-2 weeks, the heap needs to be turned (after uncovering)
5. After 3-4 weeks, a heap is done, and dry, fluffy material can be discharged. The output material can be considered as low heat value material and could be directly fed into a local incineration and energy recovery unit
6. In case of an industrial long-term buyer, it is recommendable to sort the dried material to generate a high calorific value alternative fuel, which is required in cement kilns and power plants

Used machinery/facilities for option C

- Budget-line 1:
    - Semipermeable covers and frame material
    - Pipelines
    - Radial ventilation system
    - Moisture and gas emission sensors
    - Shredder
    - Fluff handling equipment and loading station (baler)
- Budget-line 2:
    - All items listed in Budget-line 1, plus:
    - Separation belt, to sort out recyclables (waste picker)
    - Containerized WTE unit with a grate oven and external heated, electricity generating turbine (input: approx. 15 tons waste per day, output: approx. 300kW)
- Budget-line 3:
    - A complete EPC-constructed MBT unit for industrial usage in case of long-term agreements with RDF clients

Cost estimate for option C

- Budget-line 1: Assuming a needed capacity of 150 tons per day, a budget between 10.6 billion IDR (approx. 650,000 EUR) and 19.6 billion IDR (approx. 1,2 million EUR) should be planned in
- Budget-line 2: Approximately 19.6 billion IDR (approx. 1,2 million EUR) should be planned in for the equipment and machinery of Budget-line 1. Furthermore, the containerized waste-to-energy unit will cost approximately 31 billion IDR (approx. 1,9 million EUR). The package would cost approximately 55.6 billion IDR (approx. 3,1 million EUR)
- Budget-line 3: For a complete EPC-constructed MBT facility, which covers all waste amounts from Tasikmalaya, a budget of between 114 billion IDR (approx. 7 million EUR) and 196 billion IDR (approx. 12 million EUR) should be planned in

Stakeholder benefits of option C

- Landfill operator/investor:
  - High technology level and either quality product output in suitable amounts (to cover all waste amounts from Tasikmalaya)
  - Long-term sales agreements and new business models
  - Optional: Electricity generation. Sales of electricity or usage for own purposes
- Waste pickers:
  - Budget-line 1: Waste pickers will have access to dried materials, easy to separate (disadvantage for the operator: high calorific value materials will dissolve)
  - Other budget-lines: Waste pickers can be employed as employed workers within the facilities
- The public/environment:
  - Unique waste management project approach in Java
  - Own alternative fuel production = less landfill amounts, less methane gas emissions, less leachate water
  - Optional: Own electricity generation in the region, less CO2 emissions due to the usage of alternative fuel

Examples:

Figure 19: Budget-line 1, mobile Bio-Dry™ unit (Source: Convaero)

Figure 20: Budget-line 2: Additional externally fired gas turbine (EFGT), (Source: www.bergundkiessling.com)

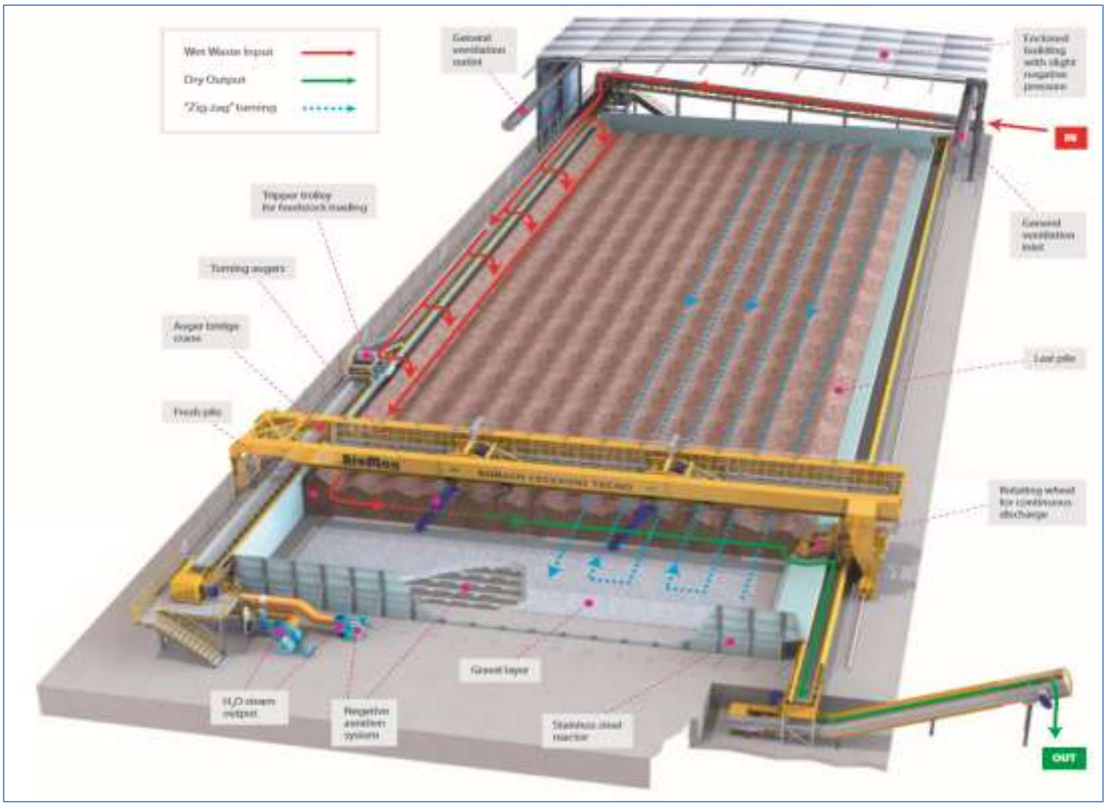

Figure 21: Budget-line 3: SCT complete RDF drying unit (Source: www.sctecno.com)

5.7. Excursus - Technical option D: Upgrading the leachate water treatment system and usage of the freed space for other purposes

In case the landfill operator considers an upgrade of the existing leachate water treatment solution due to odor emissions or expected new outflow thresholds defined by the national authorities, this section shall shortly describe two different possibilities:

The first low budget (low capital cost) option for the upgrade of the existing pond treatment system, is a reverse osmosis system, which is very effective in separation/concentration of pollutants into very clean water stream and a highly polluted stream, as the pollutants are simply concentrated.

The amount of the pollutant does not decrease, but rather the total volume decreases with higher concentrations. This smaller, heavily polluted stream must then either be disposed of externally (disposal costs) or it is returned to the landfill. After about 2-3 years, the plant operator will need to take care of the concentrate, since the highly contaminated liquids find their way to the leachate again, thereby drastically deteriorating the yield of the plant, energy costs rise and the increase of chemicals consumption. This method is preferable when there is a suitable disposal channel for the highly polluted stream. On the other hand, this solution has very simple setup and low operational costs.

Figure 22: Reverse osmosis system (Source: WEHRLE Case Study)

Figure 23: Membrane bioreactor system (Source: WEHRLE Case Study)

The second option is a High-Performance Membrane Bioreactor (MBR). Here, the pollutants are not concentrated, but eliminated by biological processes. Typically produced effluent quality suffices for the indirect discharge and the system can be simply combined with other treatment steps due to having a defined interface (Membrane). The system has low operational costs and works with predictable results.

The upgrading measure could in general provide more free space for other purposes (e.g. closure of the wetland), as well as the reduction of health risks on- site.

5.8. Summary and recommendations

The current waste management situation in Tasikmalaya cannot be classified as optimal. A mixed MSW stream with high organic contents is mostly dumped. The methane gas emissions are at least channeled, but not collected. Local waste pickers work under dangerous conditions to extract a small portion of valuable recyclables. The maximum landfill capacity will soon be reached, the leachate water discharge caused several complaints by the local farmers.

On the other side, Tasikmalaya has a proactive administration and a professional landfill operations team, which is open for new solutions and trials. The Ciangir landfill is engineered and fulfills minimum safety standards. With the pilot composting unit and a roofed trial areal, furthermore with moderate waste inputs of approx. 150 – 200 mt/d, Ciangir landfill can already be upgraded with rather simple solutions and cost-effective approaches.

BFS recommends considering the detailed planning and implementation of options A or B. In case the landfill operator or an investor is interested in the waste-to-energy case described in option C, BFS recommends beginning with the budget-line 2 (own incineration unit) – unless long-term contracts with clients can be realized before any investments.

EKONID and BFS are available and keen to support the upgrade of Ciangir landfill further with detailed consultancy services, technical detailed conception, conduction of pilot trials, conduction of a procurement and tendering process and supervision of an installation and commissioning phase of any technology.

ANNEX A: General Population Information and Waste Management Information

Table A-1: Gross regional domestic product (GRDP) of Tasikmalaya regency

	Details	Years		
		2014	2015	2016
	GRDP of Tasikmalaya regency based on various business fields		[IDR]	
1	Agriculture, forestry and fishery	7096013,37	7073799,38	7395906,32
2	Mining and excavation	59782,36	60013,12	59689,34
3	Manufacturing industry	1370692,42	1457770,82	1553066,57
4	Gas and electricity supply	14250,39	14820,41	15577,7
5	Water supply, waste and wastewater management, and recycle	3511,16	3630,71	3837,07
6	Construction	1590598,33	1684504,57	1778411,79
7	Large and small scales trade, reparation of car and motorcycle	3881503,5	4095235,2	4334846,47
8	Transportation and warehouse	586910,06	644518,84	683913,98
9	Accommodation	265367,7	277805,79	288256,77
10	Information and communication	685996,637	802475,21	918454,11
11	Financial service and insurance	562928,23	610395,24	655216,34
12	Real estate	274629,08	286055,91	293890,55
13	Company service	76376,91	83067,11	90692,12
14	Administration in governments, defense and obliged social insurance	909266,25	931914,76	953458,17
15	Educational service	1065396,45	1188088,48	1316201,81
16	Health service and social activity	113069,9	126134,21	140232,54
17	Other services	293419,3	322337,06	343145,17
	Total	**18.849.712**	**19.662.566,8**	**20.824.796,8**
	GRDP of Tasikmalaya regency based on annual outcome			
1	Outcome of household consumption	20567545,8	22743471,8	24742245,5
2	Outcome of household consumption handled by non-profit organization (LNPRT)	321248,61	303654,95	333798,38
3	Outcome of governmental consumption	1971511,71	2347148,99	2596063,79
4	Gross domestic fixed capital investment	5036327,25	5576323,56	5921192,04
5	Inventory amendment	1390605,79	1436150,02	1411223,48
6	Net export (Export-Import)	6048806,07	6731576,07	6986352,8

Table A-2: General data prior to survey

#	Checklist	Comment / Response		Description
	General Data: START			
1	Who is the responsible person (Team leader)?	Vita Meylani		Who is leading the onsite survey team
2	Who is the responsible person (Documenter)?	Riki Malikul Mulki		Who is documenting the complete survey
3	What is the team composition?	Vita Meylani Dedi Natawijaya Ade Komarudin Adhitya Amarulloh Karsiwulan Aditya Rachman DS Tina Komalasari Ahmad Nana Permana Wuranto EKONID	Ai Usman Sutoyon Junjun Aep Dedi Iyan Rosid Unus Riki Malikul Mulki Ramadhan Abdul Rahman Nazrul Maulana	List of the on-site team members names
4	How is the team condition, is everybody healthy and uninjured?	yes		The team leader is responsible for the health pre-check before any onsite operations
5	Is every team member wearing: Safety shoes (steel caps), working pants, safety gloves (cut-proven), particle filter mask (minimum) or ABEK mask (optimum)?	yes		The team leader is responsible for the PPE pre-check before any onsite operations
6	Date and time of the survey start?	02-07-2018+07.00 a.m.		Date of the selected day for a full shift waste detection (all trucks of one day pass by the first sampling stage) and starting time of the survey (e.g. first truck arrival)
7	Date and time of the sample preparation end?	11-07-2018+04.00 p.m.		After receiving and mixing 10% of all truck loads from one selected survey day, when was the sampling preparation done (before sorting)?
8	How were the weather conditions during the sample preparation and sorting?	During sample preparation process and sorting is good weather. The temperature is about 25-27 degrees and there is no rainfall.		State temperature and possible rainfall
9	Size of the unloading & sample preparation area (Area A)	(20x20 m^2)		State the size of area A in square meters (roughly)

10	Size of the waste separation area (Area B)	(40x40 m^2)	State the size of area B in square meters (roughly)
	General data - Truck statistics		
1	Number of trucks, collecting **HOUSEHOLD** waste	39 trucks	Total number of trucks, which collected waste from households / collection points
2	Number of trucks, collecting **COMMERCIAL** waste	13 trucks	Total number of trucks, which collected waste from commercial entities
3	Number of trucks, collecting **STREET/PUBLIC** waste	12 trucks	Total number of trucks, which collected waste from the street / public bins
4	Do the truck drivers track the collection (route or pickup points)?	All drivers have a route or pick up point to collect waste, but they have not software or paper manifest.	Does the driver use any software or paper manifest?

Table A-3: Weight of raw waste and waste for sampling

TRUCK NUMBER	WEIGHT [kg]					
	HOUSEHOLD WASTE		MARKET WASTE		COMMERCIAL WASTE	
	Net loading	Reduced sample	Net loading	Reduced sample	Net loading	Reduced sample
1	1320	490	3140	440	2940	560
2	2920	155	3210	278	2590	240
3	2790	155	2890	276	1980	270
4	1300	155	2620	276	3450	290
5	1920	155	3100	130	1800	360
6	2590	223	2680	130	1930	420
7	2250	224	2700	830	3570	300
8	2830	224	2400		660	300
9	3470	500	2850		2920	
10	1430	500	2770		4180	
11	4070	500	2570		2730	
12	3630	550	2360		2740	
13	2310	285			1100	
14	2650	285				
15	2090	500				
16	3190	335				
17	4220	335				
18	3320	640				
19	2730	640				
20	3560					
21	4970					
22	840					
23	3890					
24	2540					

25	4070
26	2020
27	2410
28	3870
29	4140
30	3440
31	3550
32	3910
33	2334
34	2790
35	4020
36	2720
37	2960
38	2800
39	1410

ANNEX B: Survey form and analysis of sample

Table B-1: Survey form of household waste management

#	Checklist	Comment / Response		Description	
Truck arrival					
1	Do the truck drivers tracks the collection (route or pickup points)?	All drivers have a route or pick up point to collect waste, but they have not software or paper manifest.		Does the driver use any software or paper manifest?	
2	Net loading weight in kilogram?	Truck 1: 1320	Truck 11: 4070	Truck 21: 4970	Truck 31: 3550
		Truck 2: 2920	Truck 12: 3630	Truck 22: 840	Truck 32: 3910
		Truck 3: 2790	Truck 13: 2310	Truck 23: 3890	Truck 33: 2334
		Truck 4: 1300	Truck 14: 2650	Truck 24: 2540	Truck 34: 2790
		Truck 5: 1920	Truck 15: 2090	Truck 25: 4070	Truck 35: 4020
		Truck 6: 2590	Truck 16: 3190	Truck 26: 2020	Truck 36: 2720
		Truck 7: 2250	Truck 17: 4220	Truck 27: 2410	Truck 37: 2960
		Truck 8: 2830	Truck 18: 3320	Truck 28: 3870	Truck 38: 2800
		Truck 9: 3470	Truck 19: 2730	Truck 29: 4140	Truck 39: 1410
		Truck 10: 1430	Truck 20: 3560	Truck 30: 3440	Truck 40:
Material arrival - Waste visual inspection (after mixing, before 10% sampling)					
1	Duration of the homogenization process in average?	Time to homogenization process is about 20 minutes to get mixed		How long / how many times did the waste heap get mixed?	
2	Any larger amounts of **household and industrial hazardous waste** were included in truck batches (batteries, WEEE, spray cans, chemicals etc.)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
3	Any **medical hazardous waste** was included in the complete truck batch (infectious medical waste, cytotoxic waste, general hospital waste)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
4	Describe any other irregularities for the actual batch	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found:	

			separation, documentation and weighing			
Material arrival - Waste sorting analysis preparation						
1	Reduced sample: Net weight in kilograms?	Truck 1: 490	Truck 11: 500	Truck 21:	Truck 31:	
		Truck 2: 155	Truck 12: 550	Truck 22:	Truck 32:	
		Truck 3: 155	Truck 13: 285	Truck 23:	Truck 33:	
		Truck 4: 155	Truck 14: 285	Truck 24:	Truck 34:	
		Truck 5: 155	Truck 15: 500	Truck 25:	Truck 35:	
		Truck 6: 223	Truck 16: 335	Truck 26:	Truck 36:	
		Truck 7: 224	Truck 17: 335	Truck 27:	Truck 37:	
		Truck 8: 224	Truck 18: 640	Truck 28:	Truck 38:	
		Truck 9: 500	Truck 19: 640	Truck 29:	Truck 39:	
		Truck 10: 500	Truck 20:	Truck 30:	Truck 40:	

Table B-2: Survey form of market waste management

#	Checklist	Comment / Response		Description	
Truck arrival					
1	Do the truck drivers tracks the collection (route or pickup points)?	All drivers have a route or pick up point to collect waste, but they have not software or paper manifest.		Does the driver use any software or paper manifest?	
2	Net loading weight in kilograms?	Truck 1: 3140	Truck 11: 2570	Truck 21:	Truck 31:
		Truck 2: 3210	Truck 12: 2360	Truck 22:	Truck 32:
		Truck 3: 2890	Truck 13:	Truck 23:	Truck 33:
		Truck 4: 2620	Truck 14:	Truck 24:	Truck 34:
		Truck 5: 3100	Truck 15:	Truck 25:	Truck 35:
		Truck 6: 2680	Truck 16:	Truck 26:	Truck 36:
		Truck 7: 2700	Truck 17:	Truck 27:	Truck 37:
		Truck 8: 2400	Truck 18:	Truck 28:	Truck 38:
		Truck 9: 2850	Truck 19:	Truck 29:	Truck 39:
		Truck 10: 2770	Truck 20:	Truck 30:	Truck 40:
Material arrival - Waste visual inspection (after mixing, before 10% sampling)					
1	Duration of the homogenization process in average?	Time to homogenization process is about 20 minutes to get mixed		How long / how many times did the waste heap get mixed?	

2	Any larger amounts of **household and industrial hazardous waste** were included in truck batches (batteries, WEEE, spray cans, chemicals etc.)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
3	Any **medical hazardous waste** was included in the complete truck batch (infectious medical waste, cytotoxic waste, general hospital waste)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
4	Describe any other irregularities for the actual batch	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
Material arrival - Waste sorting analysis preparation					
1	Reduced sample: Net weight in kilograms?	Truck 1: 440	Truck 11:	Truck 21:	Truck 31:
		Truck 2: 278	Truck 12:	Truck 22:	Truck 32:
		Truck 3: 276	Truck 13:	Truck 23:	Truck 33:
		Truck 4: 276	Truck 14:	Truck 24:	Truck 34:
		Truck 5: 130	Truck 15:	Truck 25:	Truck 35:
		Truck 6: 130	Truck 16:	Truck 26:	Truck 36:
		Truck 7: 830	Truck 17:	Truck 27:	Truck 37:
		Truck 8:	Truck 18:	Truck 28:	Truck 38:
		Truck 9:	Truck 19:	Truck 29:	Truck 39:
		Truck 10:	Truck 20:	Truck 30:	Truck 40:

Table B-3: Survey form of commercial waste management

#	Checklist	Comment / Response		Description	
Truck arrival					
1	Do the truck drivers tracks the collection (route or pickup points)?	All drivers have a route or pick up point to collect waste, but they have not software or paper manifest.		Does the driver use any software or paper manifest?	
2	Net loading weight in kilograms?	Truck 1: 2940	Truck 11: 2730	Truck 21:	Truck 31:
		Truck 2: 2590	Truck 12: 2740	Truck 22:	Truck 32:
		Truck 3: 1980	Truck 13: 1100	Truck 23:	Truck 33:
		Truck 4: 3450	Truck 14:	Truck 24:	Truck 34:
		Truck 5: 1800	Truck 15:	Truck 25:	Truck 35:

		Truck 6: 1930	Truck 16:	Truck 26:	Truck 36:
		Truck 7: 3570	Truck 17:	Truck 27:	Truck 37:
		Truck 8: 660	Truck 18:	Truck 28:	Truck 38:
		Truck 9: 2920	Truck 19:	Truck 29:	Truck 39:
		Truck 10: 4180	Truck 20:	Truck 30:	Truck 40:
Material arrival - Waste visual inspection (after mixing, before 10% sampling)					
1	Duration of the homogenization process in average?	Time to homogenization process is about 20 minutes to get mixed		How long / how many times did the waste heap get mixed?	
2	Any larger amounts of **household and industrial hazardous waste** were included in truck batches (batteries, WEEE, spray cans, chemicals etc.)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
3	Any **medical hazardous waste** was included in the complete truck batch (infectious medical waste, cytotoxic waste, general hospital waste)?	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
4	Describe any other irregularities for the actual batch	Based on visual inspection we didn't find those things		Visual inspection after flattening of the mixed batch per truck, before sampling of 10% of the contents. If anything is found: separation, documentation and weighing	
Material arrival - Waste sorting analysis preparation					
1	Reduced sample: Net weight in kilograms?	Truck 1: 560	Truck 11:	Truck 21:	Truck 31:
		Truck 2: 240	Truck 12:	Truck 22:	Truck 32:
		Truck 3: 270	Truck 13:	Truck 23:	Truck 33:
		Truck 4: 290	Truck 14:	Truck 24:	Truck 34:
		Truck 5: 360	Truck 15:	Truck 25:	Truck 35:
		Truck 6: 420	Truck 16:	Truck 26:	Truck 36:
		Truck 7: 300	Truck 17:	Truck 27:	Truck 37:
		Truck 8: 300	Truck 18:	Truck 28:	Truck 38:
		Truck 9:	Truck 19:	Truck 29:	Truck 39:
		Truck 10:	Truck 20:	Truck 30:	Truck 40:

Table B-4: Result of household waste sorting analysis

WASTE CATEGORY			HOUSEHOLD WASTE		
MAIN	**SECONDARY**	**EXAMPLES**	**Sample weight [kg]**	**Weight fraction [%]**	
Paper / Paperboards	Mixed Paper	any loose	70.58	1.3	5.6
	Cardboard	cardboard	87.96	1.6	
	Multi-layer material	drinking packages	153.32	2.7	
Plastics	PET	bottles	33.83	0.6	17.1
	HDPE	buckets, detergent packages	19.07	0.3	
	LDPE	flexible foils	586.82	10.5	
	PS		34.85	0.6	
	PP	static foils, covers	143.97	2.6	
	PMMA	any acrylglas	0	0	
	Others		140.68	2.5	
Organics	Putrescible (ex. garden waste)	any biowaste	2814.42	50.2	50.2
	Putrescible (garden waste)	green cuttings	0	0	
Textiles	Mixed textiles	any textile	1098.4	19.6	19.6
Mixed metals	FE	any FE	13.37	0.2	0.2
	NFE (aluminum cans)	any Aluminum	0	0	
	NFE (ex. aluminum cans)	any NFE excl. Al	0	0	
Glass	Mixed glass (not clear)	any glass	78.25	1.4	1.4
Rubber	Tires, rubber products	any rubber	38.47	0.7	0.7
Potentially hazardous waste	HW	any potentially HW, such as oil cans, batteries etc.	7.42	0.1	0.2
	WEEE	any electronic scrap	0	0	
	Medical waste	any medical and pharmaceutical waste	3.08	0.1	
Inerts	Stones, concrete, soil/clay	any inerts	284.67	5.1	5.1
Total			5,609		

Table B-5: Result of market waste sorting analysis

WASTE CATEGORY			MARKET WASTE		
MAIN	SECONDARY	EXAMPLES	Sample weight [kg]	Weight fraction [%]	
Paper / Paperboards	Mixed Paper	any loose	11.58	0.7	2.1
	Cardboard	cardboard	15.54	0.9	
	Multi-layer material	drinking packages	9.46	0.5	
Plastics	PET	bottles	2.87	0.1	12.3
	HDPE	buckets, detergent packages	6.98	0.4	
	LDPE	flexible foils	135.64	7.6	
	PS		1.74	0.1	
	PP	static foils, covers	27.41	1.5	
	PMMA	any acrylglas	0	0	
	Others		45.2	2.5	
Organics	Putrescible (ex. garden waste)	any biowaste	1410.49	79.4	79.4
	Putrescible (garden waste)	green cuttings	0	0	
Textiles	Mixed textiles	any textile	89.41	5	5
Mixed metals	FE	any FE	1.48	0.1	0.1
	NFE (aluminum cans)	any Aluminum	0	0	
	NFE (ex. aluminum cans)	any NFE excl. Al	0	0	
Glass	Mixed glass (not clear)	any glass	11.66	0.7	0.7
Rubber	Tires, rubber products	any rubber	3.37	0.2	0.2
Potentially hazardous waste	HW	any potentially HW, such as oil cans, batteries etc.	0.64	0.04	0.05
	WEEE	any electronic scrap	0	0	
	Medical waste	any medical and pharmaceutical waste	0.23	0.01	
Inerts	Stones, concrete, soil/clay	any inerts	2.73	0.2	0.2
Total			1,775		

Table B-6: Result of commercial waste sorting analysis

WASTE CATEGORY			COMMERCIAL WASTE		
MAIN	SECONDARY	EXAMPLES	Sample weight [kg]	Weight fraction [%]	
Paper / Paperboards	Mixed Paper	any loose	28.42	1.2	4.2
	Cardboard	cardboard	20.24	0.9	
	Multi-layer material	drinking packages	49.99	2.1	
Plastics	PET	bottles	11.65	0.5	14.7
	HDPE	buckets, detergent packages	7.81	0.3	
	LDPE	flexible foils	206.49	8.8	
	PS		12.71	0.5	
	PP	static foils, covers	46.68	2	
	PMMA	any acrylglas	0	0	
	Others		61.79	2.6	
Organics	Putrescible (ex. garden waste)	any biowaste	1431.9	60.8	60.8
	Putrescible (garden waste)	green cuttings	0	0	
Textiles	Mixed textiles	any textile	286.23	12.1	12.1
Mixed metals	FE	any FE	2.55	0.1	0.1
	NFE (aluminum cans)	any Aluminum	0	0	
	NFE (ex. aluminum cans)	any NFE excl. Al	0	0	
Glass	Mixed glass (not clear)	any glass	36.28	1.5	1.5
Rubber	Tires, rubber products	any rubber	22.78	1	1
Potentially hazardous waste	HW	any potentially HW, such as oil cans, batteries etc.	3.81	0.2	0.3
	WEEE	any electronic scrap	0	0	
	Medical waste	any medical and pharmaceutical waste	2.93	0.1	
Inerts	Stones, concrete, soil/clay	any inerts	124.37	5.3	5.3
Total			2,357		

Table B-7: Moisture content of different type of waste

Analysis of the moisture content	Units	Type of waste		
		Household	Market	Commercial
Weight of sample (before drying)	[kg]	24.29	19.58	21.63
Weight of sample (after drying)	[kg]	9.36	9.76	11.08
Moisture	[kg]	14.93	29.34	10.55
Moisture content	[%]	61.4	50.2	48.8

Table B-8: Result of leachate water analysis at different output

Parameter	Units	Concentration of leachate water		
		First pond	Last pond	River stream
Temperature on site	[°C]	24.6	24.7	24.8
COD by K_2Cr_2O7	[mg/L]	602	455	211
BOD_{5d} at 20°C	[mg/L]	241	137	63.4
Total solid	[mg/L]	5,900	4,712	2,196
Ammonium	[mg/L]	8.11	8.14	7.77
Total Nitrogen	[mg/L]	7.25	7.97	10.79
Total Phosphate	[mg/L]	1.84	2.01	1.41
Sulfate	[mg/L]	261	231	232
Chloride	[mg/L]	1,104	985	485
Oil & Grease	[mg/L]	6.67	< 2	< 2
pH at lab	[-]	7.74	8.33	8.09
Electrical conductivity	[umhos/cm]	12,590	8,810	4,350
Alkalinity	[mg/L]	201	50.26	20.11
Chromium	[mg/L]	0.19	0.15	0.09
Arsenic	[mg/L]	< 0.002	< 0.002	< 0.002
Cadmium	[mg/L]	< 0.003	< 0.003	< 0.003
Mercury	[mg/L]	< 0.0008	< 0.0008	< 0.0008
Lead	[mg/L]	< 0.02	< 0.02	< 0.02