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Municipal Solid Waste Information System (SWIS) Model

USER'S MANUAL

2016.

ASSOCIATION "AQUASAN Network in B&H"

NALAS

SeSWA Serbian Solid Waste Association

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1. Introduction

European Union (EU) waste management policy deals with rational use of natural resources and prevention of harmful effects of poor waste management on human health and environment in general. EU waste directives represent a framework for regulation of waste management in EU member countries, as well as a recommended approach to legislative regulation of waste management in countries aspiring to join the EU. Although implementation of EU regulations and requirements is still not compulsory for most SEE countries, national legislation in countries striving towards EU membership is for the most part harmonised with the relevant EU directives on waste management.

According to the EU Council Resolution, the key European principles of waste management are the following:

- *Prevention of waste generation* - in order to conserve the environment and natural resources waste generation must be reduced to a minimum and prevented wherever possible;
- *Waste recycling and reuse* - if generation of waste cannot be prevented, waste should be reused, recycled or used for energy recovery purposes;
- *Improved final disposal and monitoring* - in cases where waste cannot be recycled or reused it must be adequately treated and safely disposed or incinerated, which requires monitoring due to potentially harmful and hazardous effects on the environment.

National waste management laws in SEE countries define the priorities for waste handling and management activities. However, waste management legislation does not regulate this area in detail but leaves it to local self-government units (LSGUs) to adopt their own regulations (municipal decisions).

Key aspects and priorities in waste management are also contained in the relevant strategic and planning documents, as these documents are executive legal acts linked to national (and lower level) waste management laws.

According to the generally accepted waste management hierarchy, there are two boundary priorities in waste management. The first priority in waste management refers to prevention of waste generation, while the other refers to reducing the amount of waste disposed of in landfills. Realistic solutions should be sought somewhere between these two priorities through minimisation of waste generation, waste recycling and processing. These priorities should represent the foundation for an integrated waste management system in the territory of individual LSGUs. In this regard, efforts aimed at reducing the amount of waste for final disposal indicate the need to increase the proportion of recycled and biologically processed waste in the total amount of generated waste.

Main principles of waste management

However, from strategic and planning documents it can be concluded that very few SEE countries have an organised system for separation of usable components of municipal waste. Primary recycling of municipal waste, although prescribed in all waste management laws, usually does not happen in practice. Institutional organisation of waste management is at a very low level, especially at the LSGU level. A common characteristic of strategic and planning documents is that they organise and plan waste management activities in a generalised manner and then it is up to LSGUs to plan and organise all municipal waste management activities through their detailed local waste management plans.

One of the strategic goals mentioned in almost all strategic and planning documents is the establishment of an information system for the purpose of collecting data on composition, quantity and flows of municipal waste.

However, one of the key issues in municipal waste management noted in most strategic and planning documents is the absence of accurate and up-to-date databases on quantities and composition of municipal waste, which is the main reason why such planning documents are mainly based on estimates and unreliable data. For this very reason, in cases where waste management information systems exist, their reliability and accuracy of entered data may be questionable. To this we should add the fact that waste management legislation mainly fails to adequately define and regulate the procedure for determining the composition and quantity of municipal waste and leaves this matter to LSGUs directly responsible for public utility services.

This situation directly impacts the organisation of operations at the municipal level, efficiency of waste management operators (WMOs), setting and application of inadequate tariffs, which ultimately results in a low quality of utility services and inability to develop adequate medium- and long-term planning of waste management.

1.1. Importance of data in waste management

Planning of all activities within an integrated waste management system primarily requires accurate and reliable databases on the composition and quantity of municipal waste. On the other hand, certain municipal waste disposal activities such as: separation of useful components of municipal waste, waste recycling and reuse, waste processing prior to final disposal, etc. facilitate the collection of data on composition and quantity of municipal waste and also allow for better accuracy and reliability of collected waste composition and quantity data for municipal waste streams.

Data collection and database administration activities concerning the composition and quantity of municipal waste should not be seen and treated as being separate from other municipal waste disposal activities, as databases on composition and quantity of municipal waste are necessary for proper functioning of all other municipal waste management activities.

The primary role of the database on composition and quantity of municipal waste (in addition to tracking waste generation and quantities of individual components of waste) is to support planning of waste management activities and development of the municipal system for management of municipal waste. On the other hand, the quality of data on composition and quantity of municipal waste largely depends on the method of organising and performing waste management operations in the territory of the LSGU where such data is collected. This primarily reflects on establishment and optimal functioning of individual municipal waste management activities within an integrated waste management system.

Considering the long history of neglect in monitoring the status of waste management, municipal waste composition and quantity data used as initial indicators in medium- and long-term planning and projections of waste quantities are mainly based on estimates. Such baseline indicators negatively affect planning efforts aimed at overall development of the area of waste management, and particularly the efficiency of actual disposal of municipal waste. Accurate and reliable data on quantity and composition of municipal waste are now necessary because, if not now than in the near future, it will be the basis for the entire business policy of WMOs. Regular data collection and updating needs to become a part of daily waste disposal activities and this will enable proper monitoring of waste quantity, composition and streams, which is the foundation for planning waste management activities at LSGU and higher levels.

1.2. Municipal Solid Waste Information System Model (SWIS)

Waste management is important for local administrations because this public utility service has a sensitive political and social component. Adequate waste management is significant for reasons of public health, environment, economy and politics, which is why it deserves the attention of local administrations. It is an acknowledged fact that LSGU administrations and WMO managements face numerous problems in the domain of waste management. Starting from an absence of a comprehensive legislative and planning framework as well as tools for improved efficiency and sustainability, the most frequent challenges and problems faced by companies are related to: a) lack of and/or obsolete equipment and buildings; b) lack of financing; c) inadequate personnel policy in WMOs; d) discrepancy between income and expenditure due to rising costs and inadequate tariffs; e) uneconomical tariffs for utility services; f) large number of illegal waste dumps; g) equipment theft and damage; etc.

Due to the unsustainability of the present situation and the need to improve existing waste management practices in the SEE region, the **Municipal Solid Waste Information System Model (SWIS)**

The main purpose of the SWIS model is to assist LSGUs and WMOs in collecting, processing and interpreting information related to waste management, and to provide insights into the state of affairs on the territory of a given LSGU.

Moreover, the SWIS model can also help to improve the organisational framework for municipal waste management and serve as the baseline for consideration and planning of steps needed to improve waste management at the local as well as regional level.

Since introduction of organised (integrated) municipal waste management systems represents a major challenge for LSGUs in the region of South East Europe, the SWIS model can assist the LSGUs to quickly and practically collect and process data on the most significant issues in municipal waste management.

- How much waste is generated in total, and how much of the generated waste is collected?
- What is the structure of municipal waste?

- What is the amount of separation achieved?
- Is the waste treated and how is it disposed of?
- What are the costs and what is the level of efficiency of the present system?

The SWIS model is very useful in practice from a number of aspects. Firstly, the SWIS model offers a standardised format for collection of information and can be modified to suit specific needs of individual LSGUs. Also, the SWIS model may contribute to better understanding of the roles of different stakeholders at various levels in the waste management system.

When the SWIS model is used jointly by the LSGU and the WMO and information is regularly updated, this greatly facilitates exchange of information between the LSGU and the WMO. The SWIS model thereby becomes the means of networking between the LSGU and the WMO, which allows for identification of challenges and provides a solid foundation for joint planning of improvements in the waste management system.

At the operational management level in WMOs the SWIS model provides information that can be used to determine company capacities, human resources, budget allocation potentials and needs. Also, calculated indicators give clear signals to decision-makers in the LSGU and the WMO, which can be used for better organisation of operations as well as for identification of areas where employees may need additional training.

If we look at the use value of the SWIS model, there is an added dimension in that it allows comparison of service levels and performance on the local, national and regional level, as well as comparison with international operating indicators and standards.

And finally, if the SWIS model is continually updated with accurate and objective indicators it becomes a reliable support tool for reporting from the local level to higher levels of government.

Operational use of the SWIS model at the LSGU level provides many possibilities. At the operational and organisation level, data entered in the SWIS model provides an overview of the current status of waste management at the LSGU level with regard to:

- Organised waste management service coverage;
- Quantity of collected municipal waste;
- Structure of municipal waste;
- Municipal waste management system;

- Proportion of controlled vs. uncontrolled disposal of generated municipal waste;
- Effectiveness of municipal waste collection and transport;
- Waste disposal system and waste processing technology;
- Current costs of municipal waste collection and transport;
- Efficiency of the municipal utility company/operator;
- Monitoring of the life span of the waste disposal facility;
- Comparison of efficiency, service levels and quality with other LSGUs/countries/regions.

In terms of planning of waste management, SWIS model offers useful information required for:

- Forecasting future waste quantities for collection and transport;
- Monitoring and planning waste separation options;
- Financial investment planning (equipment, vehicles and buildings in the waste management system);
- Monitoring management of municipal waste generation and illegal waste dumping;
- Defining the tariff system to ensure full coverage of WMO's operating costs;
- Defining elements required for waste management planning;
- Monitoring implementation of waste management plans;
- Preparation and publishing of annual waste statistics.

Potentials for use of SWIS model in South East European countries are multiple and are based on standardisation of key information forms for countries in the region which can be modified to suit individual LSGUs requirements. Furthermore, the SWIS model opens up possibilities for improved yet simplified reporting from the local level towards other levels of government.

SWIS model was designed to provide LSGU administrations and WMO managements with a set of waste management tools tailored to the LSGU level. It provides a general overview of the current situation in waste management and the present challenges. The ability to see the situation clearly is very important because many of the flaws in the existing waste management system are linked with inadequate analyses which often result in inadequate decisions, especially in crisis situations.

Adequate and regular entry of municipal waste quantity and morphology data into the SWIS model is a key to successful planning. The present situation in waste management is better than it was before, however the majority of LSGUs (particularly smaller ones) still does not have a practice of identifying and analysing the characteristics of generated waste, or even of weighing collected/disposed municipal waste. Therefore, the basic assumption for appropriate use of the SWIS model is the need to start measuring the quantity and composition of municipal waste in order to ensure full utilisation of all functionalities offered by the SWIS model.

From the perspective of LSGUs, the SWIS model can generally be used for the following purposes: monitoring of the existing waste management system, estimation of quantities of generated and collected waste, estimation of the composition of mixed municipal waste and proportions of individual components, assessment of existing waste treatment and final disposal methods, estimation of cost and efficiency levels of the existing system. All these functionalities could help LSGUs and WMOs in the planning of future waste management systems and in implementing sustainable future investments.

This manual contains guidelines for use of the SWIS model in practice, planning and implementation of waste management. Use of the SWIS model approach and collection of essential data opens up possibilities for analysis of various elements of the waste management system, such as: waste collection, transport, treatment, disposal, cost of waste handling, etc. It also opens up possibilities for improvements of the existing waste management system (waste management planning, reporting to national institutions, etc.), and particularly for planning of systems for reuse and recycling of waste in SEE countries.

2. Data Entry Operating Manual

2.1. General info on the model data entry – usage

The SWIS model, in Excel, is based on the concept that **relevant data** on the individual elements of municipal waste management **is entered only once**, in the designed cell in one worksheet table (**cells coloured white**).

Some cells are marked with a red triangle in the top right corner. If the mouse is pointed to that cell, a pop-up explanatory text will appear, guiding the user toward proper and complete data entry.

The entered data is then calculated in the original worksheet table. Data entered once, and calculated in one worksheet, is afterwards automatically copied to other relevant worksheets and tables. This previously entered data is then combined with other newly entered data generating results and different waste management indicators.

The cells in tables-worksheets where **data is not entered** are the (**blue coloured cells**) which are calculative and are write-protected to avoid accidental data loss and calculative mistakes. Some calculative cells have a built-in logical control and warn (TRUE, FALSE) if entered information is illogical in comparison to previously entered data, or change colour if data is incomplete or irregular (for example if the total percentage is less or more than 100%). Worksheets (1-6) also contain graphs to help visualize the calculative result of data entered.

Since SWIS excel workbook contains macros which enable easier and more comfortable use of the model it is necessary to enable them before first data entry.

It is important to remember that the originally received model in Excel should always be saved under its original name (using option Excel Macro-Enabled Workbook), and that all the other workbooks that result from working with various data entries can and should be saved on the computer disc under different file names.

Also, when experimenting with different data options, if the user is uncertain about the data entries, or does not want to save the entered data, the "no" option under "save changes" option should be chosen when exiting the workbook and the original municipal data will be restored next time the workbook is opened.

To move through the workbook, and jump to and from worksheets, a menu containing all data entry worksheets and the result worksheet is offered on the HOME page; there is a HOME BUTTON AT THE END OF EACH WORKSHEET, OR THE SHEET BUTTONS AT THE BOTTOM OF EACH PAGE.

IN ORDER TO COMPARE VARIOUS MODELS WITH DIFFERENT MUNICIPAL DATA, THE WORKSHEET MUST BE COPIED AND NEW DATA ENTERED WITH REFERENCE TO OPTIONS, VARIANTS OR MODELS.

PLEASE NOTE:

IN ORDER FOR SWIS TO WORK PROPERLY IT IS NECESSARY TO ENABLE MACROS BEFORE YOU START ENTERING DATA!

PLEASE NOTE:

WHEN SAVING FILE USE OPTION EXCEL MACRO-ENABLED WORKBOOK!

2.2. Worksheet 1 – Summary of waste management indicators

Figure 1. Summary of waste management indicators

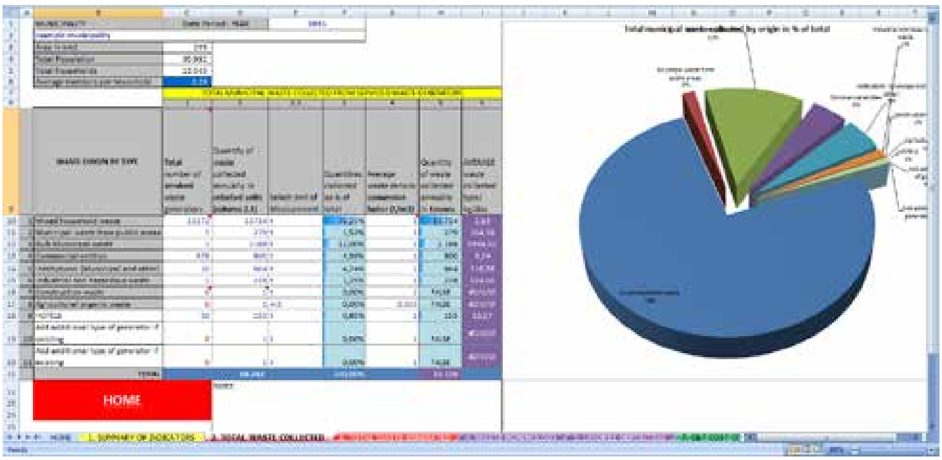
	A	B	C	D	E	F
1		Data for year	2015			
2		Example municipality				
3		Area in km2	235			
4		Total Population	30.992			
5		Total households	13.545			
6		SUMMARY OF MUNICIPAL WASTE MANAGEMENT INDICATORS		Indicator Range	from	to
7	I	MUNICIPAL WASTE COLLECTION AND TRANSPORT				
8	1	Total households served	98%	> 70%	70%	100%
9	2	Service coverage urban areas	100%	> 90%	90%	100%
10	3	Service coverage rural areas	93%	> 60%	60%	100%
11	4	AVERAGE waste collected household/kg/day	2,83	1,05 - 3,6kg	1,05	3,60
12	5	Average waste generation per capita/kg/day	1,64	0,35 - 1,2kg	0,35	1,20
13	6	Quantity of waste collected annually per SWM employee/tons	829	> 650 ton/Empl.	650	1600
14	7	Population served per SWM Employee	603	> 1300 PE / Empl.	1.300	7.000
15	8	Employees in SWM per 1000 population served	1,66	1 - 2 Empl/1000 PE	1,00	2,00
16	9	Employment ratio administrative to operative employees 1:	3,40		14,00	25,00
17	10	SUM Collection Volume provided in m3	106,00		37,60	38,37
18	11	Service Volume required in m³ under current collection rate	37,60			
19	12	Service Volume required in m³ under 100% collection rate	38,37			
20	13	Ratio between provision and requirement under current collection rate	0,35	0,00	1,00	1,00
21	14	Ratio between provision and requirement under 100% collection rate	0,36		1,00	1,00
22	II	MUNICIPAL WASTE QUANTITIES				
23	15	Estimated total waste generated in tonnes/year	18.520			
24	16	Quantity of waste collected annually in tonnes	18.238			
25	17	Ratio between waste collected in Urban and Rural areas	2,64			
26	18	Estimated uncontrolled waste disposal in tonnes/year	282			
27	19	Uncontrolled waste disposal in % of total generated	2%			

This worksheet is write-protected and contains the summary of municipal waste indicators in 41 rows. **Data is not entered directly into this worksheet.**

In the Model it is located and marked as Worksheet 1, as it is intended to be used as an executive summary of all data entered in the Model in Worksheets 2 – 8. This Worksheet compiles the calculative results of data from Worksheets 2 – 8 in summary form. Any changes in the data in any of the Worksheets 2 – 8, will automatically be recorded in this Worksheet.

2.3. Worksheet 2 - Total waste collected

Figure 2. Total waste collected



Basic information about the municipality are entered in the white cells of this worksheet, such as:

- the time period of data collection (the calculative elements of the model are adjusted to a calendar year),
- the name of the municipality

MUNICIPALITY	Data Period - YEAR	**2015**
ENTER the name of the municipality		

- municipal area in km^2,
- total population,
- total households.

Area in km^2	235
Total Population	30.000
Total households	8.000
Average members per household	3,75

In the blue coloured cell, the average number of members per household is calculated based on the total population and number of households.

		1
	TYPE OF WASTE ORIGIN	**Total** number of **serviced** waste ge-nerators
1	Mixed household waste	13272
2	Municipal waste from public areas	1
3	Bulk Municipal waste	1
4	Commercial entities	676
5	Institutions (Municipal and other)	20
6	Industrial non-hazardous waste	1
7	Construction waste	0
8	Agricultural organic waste	0
9	HOTELS	32
10	Add additional type of gen-erator if exists	0
11	Add additional type of gen-erator if exists	0
	TOTAL	

After entering data in these fields, they will be copied into all other worksheets.

The table TOTAL MUNICIPAL WASTE COLLECTED FROM SERVICED WASTE GENERATORS gives an overview of waste origin according to type, such as:

This column contains data on the type of municipal waste origin.

The labelling of rows 1-8 cannot be changed due to specific calculative reasons. However rows 9, 10 and 11 are open for entering any additional waste generator type.

Numeric values entered in **column 1**, should represent the number of serviced waste generators that the municipality is actually servicing through organized waste collection.

This numeric value entered in row 1. (Mixed household waste) should represent the number of serviced households. This number is usually smaller than the total number of households entered in the table above, unless service coverage is 100%.

If the entered numerical value is higher than the previously entered number of households, the cell will change colour to red, indicating an irregular data entry.

If 0 is entered in column 1 but quantities are entered in column 2, the number 0 will change colour to red, and the logical control in column 5 will indicate that such an entry is FALSE. At the same time column 6 will show #DIV/0!

2
Quantity of waste collected annually in **selected units (column 2.1)**
13724
279
2188
800
864
228
1
1
155
1
1
18,242

If a value higher than 0 is entered in column 1, indicating the number of serviced waste generators, a numeric value higher than 0 indicating quantities of waste also has to be entered in column 2. If not, the model will indicate through the built-in logical control that such an entry is FALSE in column 5.

Numeric values entered in **column 2** represent measured or as closely as possible estimated quantities of municipal waste collected **in selected units (column 2.1)**. In the column 2.1 the user must choose from drop list either **t** or **m^3,** and the model will automatically calculate quantities of waste collected annually in tonnes in column 5. Due to different waste collecting systems some municipalities have means of waste measuring, while other are estimating waste quantity upon volume of equipment for collecting.

If a local self-government **gathers data** on collected waste **in tonnes**, numeric data should be entered in column 2, measurement unit **(t)** in column 2.1 should be chosen and model will automatically assign 1 in column 4 for density conversion factor.

Also, **if** local a self-government **gathers data** on collected waste **in m^3,** after entering numeric value in column 2 and choosing **(m^3)** from drop list in column 2.1, the model will show density conversion factor of 0,333 in column 4.

If a value higher than 0 is entered in column 1, indicating the number of serviced waste generators, a numeric value higher than 0 indicating quantities of waste also has to be entered in column 2. If not, the model will indicate through the built-in logical control that such an entry is FALSE in column 5.

Column 3 is automatically calculated in the model and represents weight percentage of specific type of waste origin compared to the total amount of waste collected.

2.1	3	4
Select Unit of Measurement	Quantities collected as % of total	Average waste density **conversion factor (t/m³)**
t	75.25%	1
t	1.53%	1
t	12.00%	1
t	4.39%	1
t	4.74%	1
t	1.25%	1
t	0.00%	1
m^3	0.00%	0.333
t	0.85%	1
t	0.00%	1
t	0.00%	1
	100.00%	

Column 4 is intended for ***Average waste density conversion factor***. The Model automatically selects values in column 4 after selecting measurement unit in column 2.1.; 1 if values are entered in tonnes and 0.333 if values are entered in m^3. This is because most common m^3 to tonnes density conversion factor for mixed household waste is 0.333. However, column 4 is not locked for entry. Users are welcome to insert conversion factors for specific waste types if available.

For example, depending on specific municipal data, average conversion factor for different types of waste can be: 0.032-0.080 for paper, 0.32 – 0.128 for plastics, 0.168 – 0.501 for organic waste, 0,048 – 1.100 for metals.

This data will differ between municipalities in each country, depending on the composition of municipal waste, for example, whether it is an urban or rural area, and it may also differ between countries in the region.

From this point on, all the waste quantities in this and all other worksheets are expressed in weight units **(tonnes or kilograms).**

By entering this data the computation result of total quantities of collected waste in tonnes (calculated in column 5), and average daily waste collected, per waste type in kilograms (calculated in column 6), will become available to the municipality in the calculative cells of the table.

For internal use, a text box for notes is also provided below the worksheet.

This worksheet also contains a graph of the calculative result, visualizing all data entered.

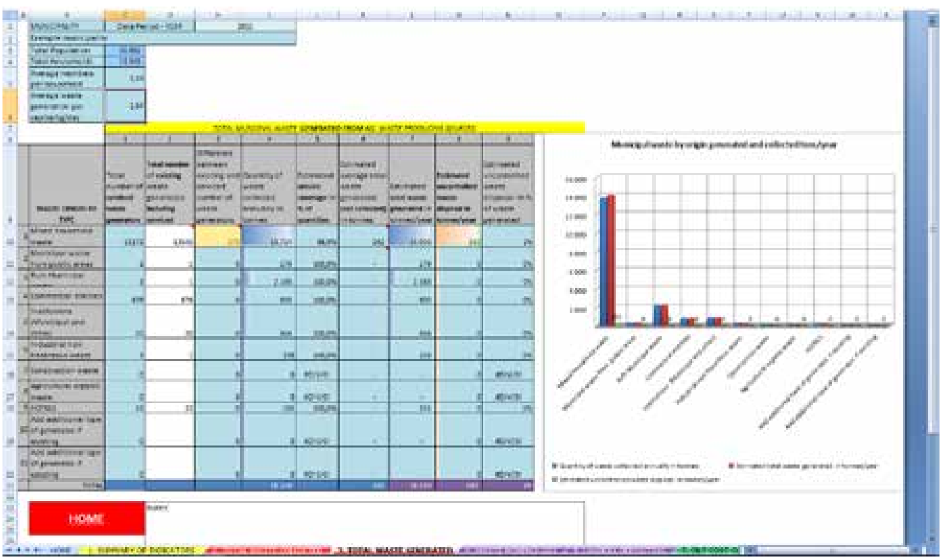
This is the basic worksheet from where information on quantities in tonnes is used in other worksheets, so it is important for it to be as exact as possible or estimated precisely in line with the local conditions.

When data is entered in Worksheet 2 (TOTAL WASTE COLLECTED), press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to Worksheet 3 – TOTAL WASTE GENERATED. The same can be done by pressing the TOTAL WASTE GENERATED worksheet tab at the bottom of the page.

2.4. Worksheet 3 - Total waste generated

TOTAL MUNCIPIAL WASTE GENERATED FROM ALL WASTE PRODUCING SOURCES

Figure 3. Total waste generated



Municipal data is copied automatically from Worksheet 2.

Column 1, with data on the number of serviced waste generators is automatically copied from worksheet 2.

In this worksheet **data is entered only in column 2,** all the other columns (3, 4, 5, 6, 7, 8 and 9) are self-calculative.

2	3
Total number of **existing** waste generators **including serviced ones**	Difference between existing and serviced number of waste generators
13545	273
1	0
1	0
676	0
20	0
1	0
	0
	0
32	0
	0
	0

In column 2, an exact or approximated number of all waste generators, including those not covered by organized waste collection, is entered. The numeric value in column 2 can be equal to cells in column 1 which means that service coverage is 100%, so there should be no difference between waste collected and waste generated.

For waste from households, the numeric value representing the total number of households from the table containing municipal information above should be entered. If the value of cells in column 2 is less than column 1 (negative value), the cells will change colour to red, indicating an irregular or illogical data entry, that needs to be clarified.

If however, the numeric value in the column 2 cells is higher than in column 1, meaning that not all waste generators are covered by collection, their number is automatically detected as a difference in column 3 coloured in yellow, indicating that there are some generators not covered by service and waste that is not collected.

Column 3, is self-calculative, and indicates the difference between the entered number of serviced and the number of existing waste generators, or the number of waste generators that are not covered by organized municipal waste collection.

Column 4 shows quantities of waste collected per generator type annually in tonnes.

Column 5 is self-calculative indicating service coverage in percentage for each waste generator, while column 6 is calculating quantity of waste generated, but not collected in tonnes.

Column 7 calculates total waste generated annually, both collected and not collected; while illegally disposed waste is shown in quantity (tonnes) in column 8 and in percentage in column 9. It is assumed that all waste generated but not collected end up on illegal deposit sites, therefore values in columns 6 and 8 are the same.

6
Estimated average total waste generated **(not collected)** in tonnes
282
-
-
-
-
-
-
-
-
-
-
282

The total self-calculated quantities of municipal waste in column 8 indicate an estimation of how much waste out of total is not collected, representing the measured or estimated uncontrolled waste disposal in tonnes, at sites outside of municipal control.

Column 9 calculates the average structure and the total percentage of uncontrolled waste disposal in comparison to the total generated waste quantities.

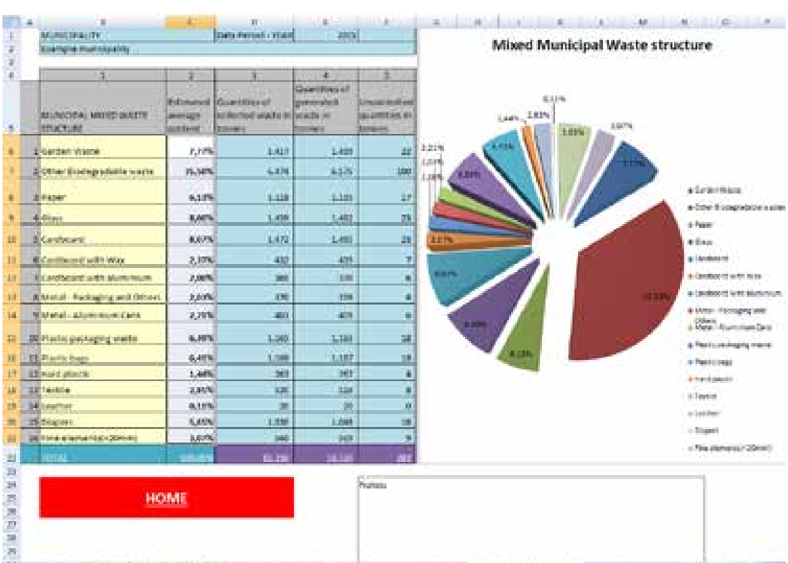
This worksheet also contains a graph of the calculative result, visualizing all changes of data entered.

For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the next Worksheet. The same can be done by pressing the next worksheet tab at the bottom of the page.

2.5. Worksheet 4 – Waste morphology

Figure 4. Waste morphology



	1 MUNICIPAL MIXED WASTE STUCTURE	2 Estimated average content
1	Garden waste	**7.77%**
2	Other biodegradable waste	**35.50%**
3	Paper	**6.13%**
4	Glass	**8.00%**
5	Cardboard	**8.07%**
6	Cardboard with Wax	**2.37%**
7	Cardboard with alu-minium	**2.00%**
8	Metal - Packaging and Others	**2.03%**
9	Metal - Aluminium Cans	**2.21%**
10	Plastic packaging waste	**6.39%**
11	Plastic bags	**6.41%**
12	Hard plastic	**1.44%**
13	Textile	**2.85%**
14	Leather	**0.11%**
15	Diapers	**5.65%**
16	Fine elements(<20mm)	**3.07%**
	TOTAL	100.00%

This worksheet gives us an overview of mixed municipal waste structure and is based on the Methodology developed by the Faculty of Technical Sciences in Novi Sad, in cooperation and with the support of GIZ. In this worksheet numeric data is entered in only one column – **column 2** containing data on the measured or estimated average content of collected mixed municipal waste. The Methodology and the model record data on 16 different morphological waste types: Garden Waste; Other Biodegradable Waste; Paper; Glass; Cardboard; Cardboard with Wax; Cardboard with Aluminium; Metal-Packaging and Other; Metal-Aluminium Cans; Plastic Packaging Waste; Plastic Bags; Hard Plastic; Textile; Leather; Diapers; and Fine Elements.

The numeric data entered in this column can be a round number, for example 10 which will automatically be shown as 10.00%, or a number with a decimal point using comma, and not dot for separation. If dot is used for separation #VALUE! will appear in the self-calculative columns 3, 4 and 5.

If the total of the entered structure in percentages is lower or higher than 100%, the total cell will change colour to red indicating that data should be clarified.

Based on the entered structure, the self-calculative columns 3, 4 and 5, will show the total tonnage of the collected and generated municipal waste. This will enable the municipality to understand what type of material is deposited or available for further recovery and processing management.

The quality of data on the composition of mixed municipal waste is one of the most important and valuable pieces of information for waste management and planning. It is important because it is used for determining the structure of waste deposited, as well as for the possibilities of waste management in the process of separation and recycling of collected waste. Activities for the collection of separate waste fractions are usually planned on the basis of this information so they should be carefully prepared or elaborated for the municipalities or regions where such activities may start.

The accurate determination of the composition of mixed municipal waste can be, technically and statistically, a difficult and expensive task, but if properly performed represents valuable data.

This worksheet also contains a graph of the calculative result, visualizing all changes of data entered.

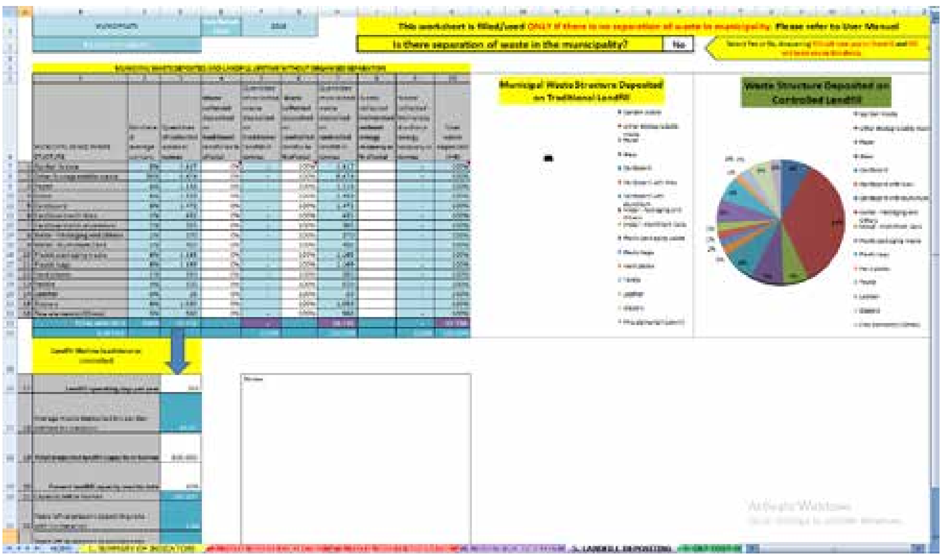
For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the next Worksheet. The same can be done by pressing the next worksheet tab at the bottom of the page.

2.6. Worksheet 5 – Landfill depositing

MUNICIPAL WASTE DEPOSITED AND LANDFILL LIFETIME WITHOUT ORGANISED SEPARATION

Figure 5. Landfill depositing



Data in this Worksheet is entered if there is no separation.

Worksheets 5 - Landfill Depositing and Worksheet 6 - Waste Recovery exclude one another. First one is used when there is no separation and all the collected waste is being deposited on the landfill while the other worksheet is used in cases where the waste separation and recovery system is introduced. For this reason a *macro* has been integrated in these two worksheets allowing users to select the yes/no option from the dropdown menu when answering the question "Is there separation of waste in the municipality?" as shown in the picture.

After selecting YES or NO option, the model will automatically lock one or the other worksheet. Choosing option NO will lock Worksheet 6 - Waste Recovery and selecting option YES will lock Worksheets 5 - Landfill Depositing.

4	6	8	10
Waste collected and de-posited on **traditional** landfill as **% of total**	**Waste collected and de-**posited on **controlled** landfill **as % of total**	**Waste collected and in-cinerated without energy recovery as % of total**	Total waste deposited (4+6)
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
0%	100%	0%	100%
			18,238
			100.00%

In Worksheet 5 data is entered in two out of three writable columns, in **column 4 or column 6** depending on whether the municipal waste is deposited on a traditional or controlled landfill, and in **column 8** if a portion of municipal waste is incinerated without energy recovery.

The estimated average content and quantities in columns 2 and 3, are automatically copied from the previous table where they are calculated from data entered in waste morphology.

Numeric values, as percentages entered in **column 4** should represent the quantities collected and deposited on a traditional landfill, if there is no separation or incineration. In most cases where **traditional landfills** are in use and where separation is non-existent and if there is no incineration, an entry of 100 is correct.

Numeric values, as percentages, entered in **column 6** represent the quantities collected and deposited on a **controlled landfill**, if there is no separation or incineration (without energy recovery).

If a traditional landfill exists, the quantities on a controlled landfill will be 0%, and vice versa. Cases where both are used are rare and represent a temporary exception to the rule.

The quantities of waste are automatically copied from the previous table where they are calculated from data entered in percentages, based on the existing waste morphology.

Data entered in **Column 8**, represents the percentages of municipal waste being incinerated without energy recovery.

Column 10 represents the total municipal waste deposited or incinerated in percentages, which should add up to 100% for each category, or the cells will change colour to red, indicating that data should be clarified.

This worksheet table also contains information on the structure of municipal waste and the quantities of recyclable materials that can be used for other purposes, but are deposited on a traditional or controlled landfill because there is no organized selection.

2.6.1. Landfill lifetime calculation

Numeric values entered in **row 17** of the table**,** represent the number of working days of the landfill per year.

Numeric values entered in **row 19** of the table represent the projected or estimated total capacity of the currently used landfill in tonnes, according to the best estimate. If the municipality is participating in a regional landfill scheme, the entered value should be the capacity of the controlled landfill belonging or assigned to that municipality.

Numeric values entered in **row 20** of the table represent the estimated landfill capacity used to date, meaning for example that the total landfill capacity is 80% filled, up to the end of the reporting period, usually a calendar year. When the municipality is participating in a regional landfill scheme, the entered value should be the ***used*** capacity of the controlled landfill belonging or assigned to that municipality.

Depending on the previously entered data on used landfill capacity and the daily amounts of municipal waste deposited, this worksheet calculation result in **row 22** of the table is the remaining landfill lifetime left for use if municipal waste is continually deposited at a given rate with or without incineration.

Due to the circumstance that in some cases traditional sites are still in operation in parallel with sanitary (controlled) landfills which have been constructed, the results split into traditional (dumpsite) disposal and sanitary controlled (sanitary landfill) disposal. The results depend on the percentage of traditional and controlled (sanitary) disposal stated in column 4 and 6. This can only be an exception to the rule, as the intention is to close traditional landfills.

If the traditional landfill is to be closed and replaced with a sanitary landfill, the remaining capacity has to be signified with 0. Aftercare periods are not part of this calculation.

This data can be used by the municipality to estimate the time at disposal before the traditional landfill is used up, and at what stage it will have to be ready to organize new facilities or plan a different type of waste management.

This worksheet also contains a graph of the calculative result, visualizing all changes of data entered.

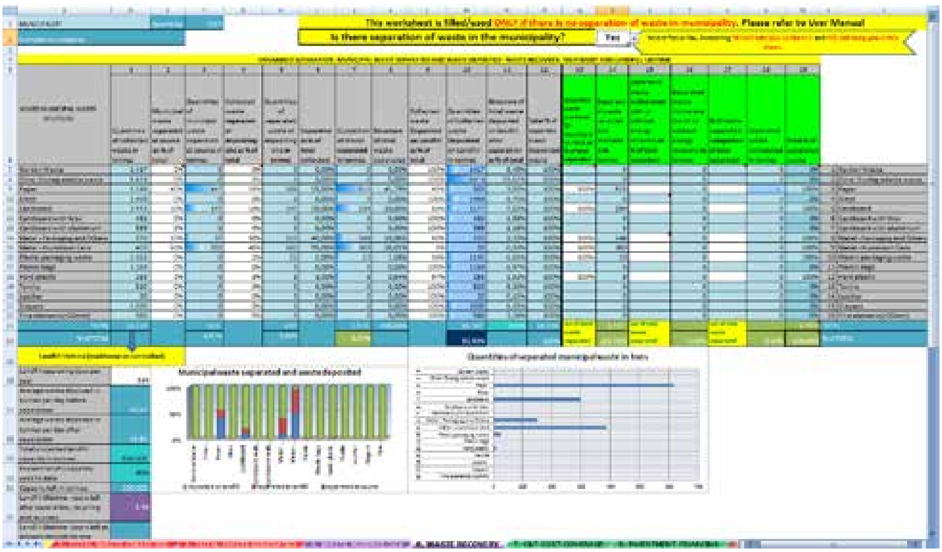
For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the next Worksheet. The same can be done by pressing the next worksheet tab at the bottom of the page.

2.7. Worksheet 6 – Waste recovery

ORGANISED SEPARATION - MUNICIPAL WASTE SEPARATED AND WASTE DEPOSITED - WASTE RECOVERY, TREATMENT AND LANDFILL LIFETIME

Figure 6. Waste recovery



Similar to the previous one Worksheet 6 is intended for use only if there is a system of waste separation or recovery in place in the municipality.

As already mentioned Worksheets 5 - Landfill Depositing and Worksheet 6 - Waste Recovery are excluding one another. First one is used when there is no separation and all the collected waste is being deposited on the landfill and the other in cases where the waste separation and recovery system is introduced. For this reason a *macro* has been integrated in these two worksheets allowing users to select the yes/no option from the dropdown menu when answering the question "Is there separation of waste in the municipality?" as shown in the picture.

If on the Worksheet 5 option YES was selected from dropdown menu, the model automatically switches to Worksheet 6 so data relevant for the separation and recovery of waste could be entered. In that case Worksheet 5 stays locked/invisible for further use.

2	4	9
Municipal waste **separated at source** as % of total	Collected waste **separated at depositing site as % of total**	Collected waste **deposited on Landfill as % of total**
0%	0%	100%
0%	0%	100%
40%	15%	45%
0%	0%	100%
10%	10%	80%
0%	0%	100%
0%	0%	100%
10%	30%	60%
50%	45%	5%
0%	2%	98%
0%	0%	100%
0%	3%	97%
0%	0%	100%
0%	0%	100%
0%	0%	100%
0%	0%	100%

Numeric values, as percentages, entered in **column 2** and **column 4** of the worksheet table should represent data on waste separated at source or/and at the depositing site, which are then automatically calculated into tonnes, based on the entered waste structure in worksheet 4 and copied as tonnes in column 1.

Based on the data entries in column 2 and 4, this operation enables the calculation of quantities totally separated in tonnes and the structure of the municipal waste separated in columns 7 and 8.

If any cells in column 2 or 4 have a value higher than 0, respective numeric values must also be entered in columns 13, 15 or 17 of the same table, where data is entered on what the nature of treatment of separated waste is. These columns are locked for entry if 100% of the waste fraction is deposited.

Numeric values, as percentages, entered in **column 9**, represent the structure and quantities of waste in tonnes that is left after separation, and deposited on landfills, as a % of total municipal waste collected. This operation enables the computation result of quantities totally deposited (land filled) in tonnes as well as the structure of the municipal waste deposited on the landfill in column 10 and 11.

Column 12, automatically adds up the percentages of separated and deposited municipal waste entered in columns 2, 4 and 9 and should be equal to 100%. If not, the respective cells in Column 12 will change colour, indicating a wrong data entry or that data should be clarified.

On the right side of the worksheet table **data is entered in columns 13, 15 and 17.**

13	15	17
Separated waste marketed for recycling or on stock **as % of total separated**	Separated waste **incinerated** with or without energy recovery **as % of total separated**	**% of waste** separated and **composted as % of total separated**
100%		
100%		
100%		
100%		
100%		
100%		
out of total waste separated	**out of total waste separated**	**out of total waste separated**

If any cells in column 2 and 4 have value, the respective numeric values MUST also be entered in columns 13, 15 or 17. This means that if only 20% is separated, but 100% of this is marketed, the entry in the cells in this column should be 100%. This can be checked through quantities that should match in total.

Numeric values, as percentages **out of** total waste separated, entered in **column 13**, represent the structure and quantities of the separated waste that has been marketed for recycling or is on stock for those purposes.

Numeric values, as percentages **out of** total waste separated, entered in **column 15**, represent the structure and quantities of the separated waste that has been incinerated with energy recovery.

Numeric values, as percentages **out of** total waste separated, entered in **column 17**, represent the structure and quantities of the separated waste that has been used for composting. Note that only Garden Waste and Other Biodegradable Waste can be composted, therefore entry of values in U9-22 will result in those cells turning red indicating that the specific waste fraction is not suitable for composting.

Column 19 is self-calculative and calculates the entered totals of separated waste (or data on the "destiny" of the waste that has been separated), so if any cells in column 2 and 4 have value (quantities of waste separated), the respective numeric values MUST also be entered in columns 13, 15 or 17, (out of total waste separated) or the total in column 19 will be >< 100% and the respective cells will change colour to red, indicating a wrong data entry or that data should be clarified. In this case, if data is verified, if the sum in a cell is < 100% this can mean that the separation resulted in expenses that are not justified, or if > 100% that the entered data has to be checked again. This also means that the total quantities in column 19 should be equal to the total sum of Quantities of Waste separated in tonnes in column 7.

By entering data, this worksheet table enables the municipality to take a "snapshot" picture of what quantities by type of materials are or can potentially be recycled, or used for biological or energy recovery and how much municipal waste in tonnes is being land filled, including the structure of the waste going into the ground.

2.7.1. Landfill lifetime calculation

Similar to Worksheet 5 numeric values entered in **row 17** of the table**,** represent the number of working days of the landfill per year.

Numeric values entered in **row 20** of the table represent the projected or estimated total capacity of the presently used landfill in tonnes, according to the best estimate. If the municipality is participating in a regional landfill scheme, the entered value should be the capacity of the controlled landfill belonging or assigned to that municipality.

Numeric values entered in **row 21** of the table represent the estimated landfill capacity used to date, meaning for example that the total landfill capacity is 80% filled, up to the end of the reporting period, usually a calendar year. When the municipality is participating in a regional landfill scheme, the entered value should be the ***used*** capacity of the controlled landfill belonging or assigned to that municipality.

Depending on the previously entered data on used landfill capacity and the daily amounts of municipal waste deposited, **row 23** of this worksheet automatically calculates the remaining landfill lifetime left for use if municipal waste is continually deposited but waste separation is carried out, in comparison to landfill lifetime without separation in **row 24**.

This may be valuable information for the municipality as it estimates the prolonged landfill lifetime if separation is an option in waste management.

In addition, the computation result of this worksheet shown in the totals of columns 7 (quantities of separated waste) and column 10 (quantities of land filled waste) represents valuable information to the local government as it may be used to point out to the municipality the potential savings (as a result of difference in quantities of deposited waste) in tipping or depositing fee charges usually charged at the gate of a controlled landfill.

This worksheet also contains 4 graphs of the calculative result, visualizing all changes of data entered.

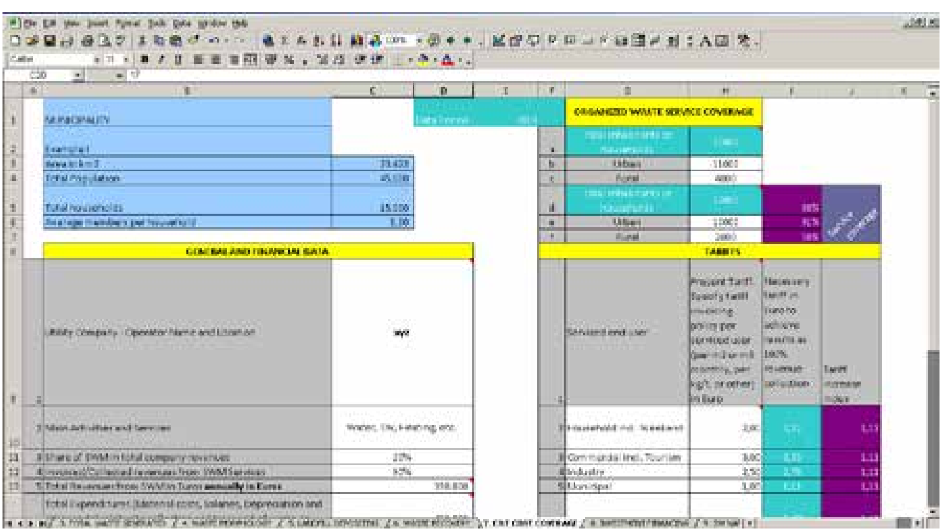
For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the next Worksheet. The same can be accomplished by pressing the next worksheet tab at the bottom of the page.

2.8. Worksheet 7. - Collection and transport cost coverage

ORGANIZED WASTE SERVICE COVERAGE

Figure 7. C&T Cost coverage



In this table the total number of households (row a) is copied from previously entered data. What needs to be entered in the white cells of rows b and c of the Organised Waste Service Coverage Table is the number of urban and rural households, whose sum should equal the total households, in the table to the left, automatically generated from worksheet 2. If this sum is different, the cell (in row a) and the related message will change colour to red, indicating a data discrepancy that should be verified.

Rows e and f of the Organised Waste Service Coverage Table, in the white cells, should contain data on the number of households covered by organized waste collection services. The sum of these two rows is calculated in row d (the numeric value in this cell can be equal to total households in case of 100% service coverage, but cannot be higher. This value should be equal to the value entered in the cell C10 of Worksheet 2). If this sum is different, the cell (in row d) and related message will change colour to red, indicating a data discrepancy that should be verified.

From this point on, the model calculates the percentage of organized waste service coverage.

2.8.1. General and financial data

This worksheet can be used for assessing the cost of collection and transport of municipal waste.

In **rows 1 and 2** basic information such as the name and location of the PUC, general information on main activities and services, indicating if it is a specialized or mixed communal services company.

Row 3 should provide basic data on what the share of waste management revenues is (in %), compared to total revenues.

In **row 4**, of the GENERAL AND FINANCIAL DATA Table, data on the percentage of collected tariffs in comparison to total invoiced revenues is entered. This data is used to calculate the necessary level of tariffs needed in order to achieve revenues at 100% collection, after tariffs are entered in the table on the right side of the worksheet (TARIFFS Table). When the appropriate tariff invoicing policy and the current tariff level are entered, the TARIFFS Table will calculate the necessary increase in tariff in order to achieve full cost coverage, (under the assumption that the tariffs are calculated on that basis) and if the collection of accounts receivable is equal to the invoiced amount.

Row 5 should contain financial data (in EUR, with the possibility to enter all financial data in local currency) on annual revenues originating from municipal waste management.

Row 6 should contain financial data (in EUR, with the possibility to enter all financial data in local currency) on Total annual expenditures on municipal waste management (Material costs, Salaries, Depreciation and other costs) related to collection and transport of waste, (in EUR, with the possibility to enter all financial data in local currency).

After entering data on the total revenues and expenditures of organized waste collection and transport, in row 8 and 9, the model calculates the necessary increase in revenues or decrease in costs which needs to be achieved in order to balance revenues and expenditures.

In **row 11** the number of employees of the Public Utility Company engaged in waste management is entered. After this entry the model calculates efficiency indicators for the Public Utility Company or operator such as quantity of waste collected annually per employee in tonnes, population served per employee, and employees per 1000 population served. Preferably the number entered should be the number of employees directly engaged in waste management.

Based on the financial data entered in this worksheet, the model calculates the cost of collecting and transporting municipal waste in EUR (or local currency if entered) per tonne in Row 15. This information is crucial for the company as well as for the municipality, as any future steps for improving efficiency or investment planning will depend on the quality of this data. That is why, before entering, this data needs to be carefully verified.

For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the next Worksheet. The same can be done by pressing the next worksheet tab at the bottom of the page.

2.9. Worksheet 8. – Investment financing

INVESTMENTS IN EQUIPMENT AND ASSETS FOR MUNICIPAL WASTE COLLECTION, TRANSPORT, WASTE TREATMENT AND LANDFILLS

Figure 8. Investment financing

This worksheet table can be used for assessing the additional expenditures for equipment renewal and investments in vehicles. Data is entered in columns 1-3, 5 and 7.

By entering the numeric values (row labelling for various equipment can be adapted to municipal needs) for the existing number of units in operation (**column 1**) and planned new purchases of waste containers and/or vehicles (**column 2**) and for single unit price (**column 3**), the model will calculate the total planned investment value in EUR or local currency.

Data is entered (**column 5**) on the deprecation rate for equipment and vehicles in use.

Data based on information on financing costs from banks on the annual amount of loan services (optional) is entered in **column 7.**

Column 8 calculates the sum of annual depreciation and financing costs, according to type of assets and the total sum per year.

This data is copied to the COLLECTION AND TRANSPORT COST CORRECTION Table, where in **row 3** data can be entered on estimated increase or decrease of the variable cost of collection and transport, i.e. increase of fuel costs, or decrease of maintenance costs, etc.

By entering data in this table the Model calculates the total investment value, depreciation and financing costs, all resulting in the calculation of the annual increase of cost for collection and transport per tonne in EUR and percentages, compared to current costs.

From row 39 all recycling, recovery and waste treatment investments are inserted. For depreciation reasons the investment is split into investigation, design and licencing costs, financial requirements for land purchasing, mechanical installations, mobile equipment and installation and civil construction.

From row 48 sanitary landfill construction related investments are inserted. For depreciation reasons the investment is split into investigation, design and licencing costs, financial requirements for land purchasing, mechanical installations, mobile equipment and installation and civil construction.

By entering data, the Model calculates the total investment value, depreciation and financing costs, all resulting in the calculation of the annual increase of costs for collection, transport treatment and landfilling per tonne in EUR and percentages, compared to present costs.

This Worksheet provides the municipality with information on what funds need to be invested in necessary or planned new equipment and vehicles, the cost of financing and the effect of different options of financing (in case of shortage of own funds) on the cost calculation for collection and transport of municipal waste, waste treatment and landfill investments. Furthermore, the cost calculated in this Worksheet (row 7 of the COLLECTION, TRANSPORT, RECYCLING AND LANDFILL COST CORRECTION) represents a foundation for calculating full cost coverage tariffs, as it includes operative costs, depreciation and investment (financing) costs. For internal use, a text box for notes is also provided below the worksheet.

When data is entered in this Worksheet and all the necessary calculations have been performed, press the HOME button at the bottom of the worksheet to return to the DATA ENTRY MENU, and go to the RESULT MENU – SUMMARY OF INDICATORS, or go to the next Worksheet. The same can be done by pressing the next worksheet tab at the bottom of the page.

2.10. Worksheet 9. – Municipal waste management narrative info

This worksheet is not used for calculations, but for gathering basic textual information on the organization of municipal waste management.

Figure 9. SW narrative info

A	B	C	D	E
	MUNICIPAL WASTE MANAGEMENT NARRATIVE INFORMATION			
	Example municipality			
1	Information gathering level		YES	NO
		Municipality	x	
		City		x
		District, Region		x
2	Type of collection		YES	NO
		Traditional	x	
		Separate collection of waste fractions	x	
		Separate collection of bulky waste		x
3	Waste recovery operations		YES	NO
		organized	x	
		unorganized		x
4	Location of organized separation		YES	NO
		Home	x	
		Street	x	
		Landfill		x
		Other		x
5	Name and address of operators collecting and transporting municipal waste			
6	Name of the responsible person			

5. TOTAL WASTE GENERATED / 4. WASTE MORPHOLOGY / 6. WASTE RECOVERY / 7. OKT COST COVERAGE / 8. INVESTMENT FINANCING / 9. SW NARRATIVE INFO

In this worksheet textual information is entered into the following fields: Type of collection, Waste recovery operations, Location of organized separation, Local Utility Company – operator, Name of responsible person, Last date of entry, Landfill - depositing site information, Full cost coverage for collection and transport to landfill/ depositing site, and Other.

The inventory of containers results in the presently provided volume as an indicator and comparable figure to the provided one under current service levels and those for optimal future service coverage levels of (100%).

3. Result interpretation

The primary goal of the SWIS model is to assist local governments in assessing and organizing information collection and processing, in a manner that will help them to obtain a clear picture of the state of waste management in their community.

The most important issues in municipal waste management that need to be assessed and the results of data processed and analysed are:

- What are the quantities of waste generated, and how much is collected?
- What is the structure of mixed municipal waste?
- What is the amount of separation achieved?
- Is waste treated, if so how, and how is it disposed of?
- What are the costs and efficiency of the existing system?

This is a starting point for LGA's in considering and planning further steps on how to improve municipal waste management in their communities.

3.1. Result related data entries

The data in ***Worksheet 1*** enables the local governments to create a "snapshot" in real-time of the current situation in municipal waste management as an executive summary of all present activities, as it compiles all the data entry worksheets and their calculations in summary form. In addition, it offers the municipalities the possibility to explore different options by entering planned waste management data in data entry Worksheets 2-8, as it compiles all the previous worksheets and their calculations in summary form.

This Worksheet consists of **44 indicators**, resulting from the data entry Worksheets. At a glance, each of the indicators provides information (based on the availability and quality of municipal data entered) on important aspects of municipal waste management. After data entry has been finalized, it is up to the municipalities to analyse the results and plan measures to improve the quality of waste management.

This worksheet also contains **average indicator ranges** for comparison of obtained solid waste management indicators with recognised averages in the field. This can be an introduction to **benchmarking** for municipal authorities and service providers, as it can be expected that after entering relevant and reliable data, the results can be compared with others performing solid waste management in a similar environment (for example: urban or rural, territory coverage size, quantity and age of equipment, number of inhabitants, industrial or economic development level, hilly or flat terrain, and so on).

Figure 10. Example on the results sheet

	Data for year	2015			
	Example municipality				
	Area in km²	235			
	Total Population	30,992			
	Total households	13,545			
	SUMMARY OF MUNICIPAL WASTE MANAGEMENT INDICATORS		Indicator Range	from	to
I	MUNICIPAL WASTE COLLECTION AND TRANSPORT				
1	Total households served	98%	> 70%	70%	100%
2	Service coverage urban areas	100%	> 90%	90%	100%
3	Service coverage rural areas	93%	> 60%	60%	100%
4	AVERAGE waste collected household/kg/day	2.83	1,05 - 3,6kg	1.05	3.60
5	Average waste generation per capita/kg/day	1.64	0,35 - 1,2kg	0.35	1.20
6	Quantity of waste collected annually per SWM employee/tons	829	> 650 ton/Empl.	650	1600
7	Population served per SWM Employee	603	> 1300 PE / Empl.	1,300	7,000
8	Employees in SWM per 1000 population served	1.66	1 - 2 Empl/1000 PE	1.00	2.00
9	Employment ratio administrative to operative employees 1:	3.40		14.00	25.00
10	SUM Collection Volume provided in m³	106.00		37.60	38.37
11	Service Volume required in m³ under current collection rate	37.60			
12	Service Volume required in m³ under 100% collection rate	38.37			
13	Ratio between provision and requirement under current collection rate	0.35	0.00	1.00	1.00
14	Ratio between provision and requirement under 100% collection rate	0.36		1.00	1.00
II	MUNICIPAL WASTE QUANTITIES				
15	Estimated total waste generated in tonnes/year	18,520			
16	Quantity of waste collected annually in tonnes	18,238			
17	Ratio between waste collected in Urban and Rural areas	2.64			
18	Estimated uncontrolled waste disposal in tonnes/year	282			
19	Uncontrolled waste disposal in % of total generated	2%			
20	Uncontrolled waste disposal in % of total collected	0%			
III	MUNICIPAL WASTE DISPOSAL ON LANDFILL WITHOUT SEPARATION				
21	Municipal waste disposed without separation on traditional landfill in %	0.00%		0.00%	0.00%
22	Municipal waste disposed without separation on controlled landfill in %	100.00%		100.00%	100.00%
23	Municipal waste incinerated without separation %	0.00%		0.00%	100.00%
IV	MUNICIPAL WASTE DISPOSAL AFTER SEPARATION				
24	Disposed on landfill after separation in % of collected	91.93%	65% - 35%	65.00%	35.00%
25	Average household waste disposed per capita/ kg/day	1.51	0,23 - 0,42kg/PE*day	0.68	1.26
26	Separated in % of total collected	8.07%	35% - 65%	35.00%	65.00%
27	Average household waste separated per capita/ kg/day	0.13	0,12 - 0,78kg/PE*day	0.37	2.34
V	MUNICIPAL WASTE RECOVERY AFTER SEPARATION				
28	% out of total separated waste recycled and marketed including stocks	100%	0% - 80%	0%	80%
29	% out of total separated waste incinerated with energy recovery	0%	0% - 40%	0%	40%
30	% out of total separated waste composted	0%	0% - 65%	0%	65%
VI	LANDFILL USAGE CAPACITY				
31	Present landfill capacity used to date	80%	0 - 100%	0%	100%
32	Landfill lifetime - years left at present depositing rate without separation or incineration	5.48	5 - 10 years	5.00	10.00
33	Landfill lifetime - years left after separation, recycling and recovery	5.96	> 30 years	5.00	30.00
34	Average waste disposed in tonnes per day before separation	49.97			
35	Average waste disposed in tonnes per day after separation	45.94			

As mentioned, this Worksheet is a summary of results derived from data entry Worksheets 2-8. The potential for analysis and use of these indicators is given separately by each worksheet, as follows:

By entering data in ***Worksheet 2***, the calculated result enables the municipality to assess information on:

- the total number of serviced waste generators,
- average waste density (conversion factor from m^3 to tonnes),
- total quantities of collected municipal waste in tonnes, according to type of waste origin,
- optimize equipment and facilities to quantities,
- making assumptions on future quantities,
- planning different (new options) on waste management,
- the structure of municipal waste according to type of waste origin,
- average daily quantities of waste collected per household,
- average daily quantities of waste generated per capita in kilograms ,
- currently provided collection volume (data from narrative info and container inventory),
- required collection volume under current collection rate,
- required collection volume under 100% collection rate.

By entering data in ***Worksheet 3***, the calculated result enables the municipality to assess information on:

- the total approximated quantities of municipal waste that is generated, including quantities covered by organized waste collection,
- number of known waste generators not covered by organized waste collection,
- estimation of how much waste out of total is not collected, representing the measured or estimated uncontrolled waste disposal in tonnes, at sites out of municipal control,
- potential for improving service coverage,
- potential for reducing uncontrolled waste disposal.

By entering data and determining the structure of municipal waste in ***Worksheet 4*** the local government can utilize this information for:

- determining the average structure of waste,
- assessing the potentials of waste management in the process of separation and recycling,
- planning targets for waste separation,

By entering data in ***Worksheet 5***, the calculated result enables the municipality to assess information on:

- the total quantities of municipal waste deposited on landfills,
- the structure of municipal waste and the quantities of recyclable materials that can be used for other purposes, but are deposited on a landfill because there is no organized selection,
- the potential of waste separation by type of recyclable material,
- the remaining landfill lifetime left for use if municipal waste is continually deposited at a given rate without separation,
- planning new facilities or different type of waste management,
- potential additional costs for unloading or depositing fees usually charged at the gate of a controlled landfill.

By entering data in ***Worksheet 6***, the calculated result enables the municipality to:

- determine how much municipal waste (in tonnes) is being separated and how much land filled, including the structure of the waste going into the landfill unused,
- explore various options for future steps and plans on the quantities of municipal waste by type of materials that are already separated (in order to improve selection for those who have started this activity) or can potentially be recycled (for those in the planning phase),
- determine the destiny of the separated materials, (marketed, composted or incinerated) so the local government will be able to assess the economic results and the environmental impact of these efforts,
- create awareness in the municipality on what the useful remaining lifetime of landfill is if municipal waste is continually deposited but waste separation is carried out, in comparison to landfill lifetime without separation,
- estimate the potential savings (as a result of the reduction of quantities of deposited waste) from unloading or depositing fees, usually charged at the gate of a controlled landfill.

By entering data in ***Worksheet 7***, the municipality can use the calculated information for:

- assessing the cost of collection and transport of municipal waste per tonne with existing equipment and the current type of waste management,
- assessing the necessary increase in revenues or decrease in costs which needs to be achieved in order to balance revenues and expenditures,
- assessing efficiency indicators such as the quantity of waste collected annually per employee in tonnes, population served per employee, and employees per 1000 population served,
- planning organizational or structural improvements in municipal waste collection and transport,
- comparison with other municipalities operating under similar conditions.

The calculated results in ***Worksheet 8*** enable the municipality to assess information on:

- what funds need to be invested in necessary or planned new purchases of equipment and vehicles,
- the cost of financing and the effect of different options of financing (in the event of shortage of own funds),
- the cost calculation for collection and transport of municipal waste, as a foundation for calculating full cost coverage tariffs, as it includes operative costs, depreciation and investment (financing) costs.

Worksheet 9. – Municipal waste management narrative info

This worksheet is only partly used for calculations, but mainly for gathering basic textual information on the organization of municipal waste management.

In this Worksheet the textual information on:

- type of collection,
- waste Recovery operations,
- location of organized separation,
- local Utility Company – operator,
- landfill - depositing site information,
- full cost coverage for collection and transport to landfill/ depositing site, etc.

can be used for waste management planning as well as providing various domestic and other institutions and potential investors with basic facts about the current state of waste management.

The calculated results in ***Narrative info*** enable the municipality to assess information on:

- current provided collection volume,
- service volume required in m^3 under current collection rate,
- service volume required in m^3 under 100% collection rate,
- ratio between provision and requirement under current conditions,
- ratio between provision and requirement under 100% collection rate conditions.

3.2. Indicator interpretation

The range of appropriate results depend greatly on topography, geography, city and peripheral structures, available technology and facilities and the overall economic situation (affordability). In addition, there are also local or regional structures of crucial importance and operating practices (collection during night, double shift system to achieve fixed cost digression) and the current banking services and loaning possibilities and conditions.

The range which can be modified shall be made explicit in a service level statement included in a policy clearly addressing the declaration of political will to:

A) Deliver an efficient and affordable service for the benefit of the population;

B) Achieve increased service levels and audit those against service level and key performance indicators.

Two new terms shall be incorporated in all strategic and planning papers in a uniform way:

- Service levels (rate of service as a % to full service provision);
- Key Performance Indicators (KPIs – efficiency indicators to allow comparison between different models, plans and service providers).

Table 1. Summary of indicators (Result sheet)

	Data for year	2015			
	Example municipality				
	Area in km²	235			
	Total Population	30,992			
	Total households	13,545			
	SUMMARY OF MUNICIPAL WASTE MANAGEMENT INDICATORS		Indicator Range	from	to
I	MUNICIPAL WASTE COLLECTION AND TRANSPORT				
1	Total households served	98%	> 70%	70%	100%
2	Service coverage urban areas	100%	> 90%	90%	100%
3	Service coverage rural areas	93%	> 60%	60%	100%
4	AVERAGE waste collected household/kg/day	2.83	1,05 - 3,6kg	1.05	3.60
5	Average waste generation per capita/kg/day	1.64	0,35 - 1,2kg	0.35	1.20
6	Quantity of waste collected annually per SWM employee/tons	829	> 650 ton/Empl.	650	1600
7	Population served per SWM Employee	603	> 1300 PE / Empl.	1,300	7,000
8	Employees in SWM per 1000 population served	1.66	1 - 2 Empl/1000 PE	1.00	2.00
9	Employment ratio administrative to operative employees 1:	3.40		14.00	25.00
10	SUM Collection Volume provided in m^3	106.00		37.60	38.37
11	Service Volume required in m^3 under current collection rate	37.60			
12	Service Volume required in m^3 under 100% collection rate	38.37			
13	Ratio between provision and requirement under current collection rate	0.35	0.00	1.00	1.00
14	Ratio between provision and requirement under 100% collection rate	0.36		1.00	1.00
II	MUNICIPAL WASTE QUANTITIES				
15	Estimated total waste generated in tonnes/year	18,520			
16	Quantity of waste collected annually in tonnes	18,238			
17	Ratio between waste collected in Urban and Rural areas	2.64			
18	Estimated uncontrolled waste disposal in tonnes/year	282			
19	Uncontrolled waste disposal in % of total generated	2%			
20	Uncontrolled waste disposal in % of total collected	0%			
III	MUNICIPAL WASTE DISPOSAL ON LANDFILL WITHOUT SEPARATION				
21	Municipal waste disposed without separation on traditional landfill in %	0.00%		0.00%	0.00%
22	Municipal waste disposed without separation on controlled landfill in %	100.00%		100.00%	100.00%
23	Municipal waste incinerated without separation %	0.00%		0.00%	100.00%
IV	MUNICIPAL WASTE DISPOSAL AFTER SEPARATION				
24	Disposed on landfill after separation in % of collected	91.93%	65% - 35%	65.00%	35.00%
25	Average household waste disposed per capita/ kg/day	1.51	0,23 - 0,42kg/PE*day	0.68	1.26
26	Separated in % of total collected	8.07%	35% - 65%	35.00%	65.00%
27	Average household waste separated per capita/ kg/day	0.13	0,12 - 0,78kg/PE*day	0.37	2.34
V	MUNICIPAL WASTE RECOVERY AFTER SEPARATION				
28	% out of total separated waste recycled and marketed including stocks	100%	0% - 80%	0%	80%
29	% out of total separated waste incinerated with energy recovery	0%	0% - 40%	0%	40%
30	% out of total separated waste composted	0%	0% - 65%	0%	65%
VI	LANDFILL USAGE CAPACITY				
31	Present landfill capacity used to date	80%	0 - 100%	0%	100%
32	Landfill lifetime - years left at present depositing rate without separation or incineration	5.48	5 - 10 years	5.00	10.00
33	Landfill lifetime - years left after separation, recycling and recovery	5.96	> 30 years	5.00	30.00
34	Average waste disposed in tonnes per day before separation	49.97			
35	Average waste disposed in tonnes per day after separation	45.94			

The summary page includes a total of 44 service level and key performance indicators.

(1-3) Collection rate of urban and semi-urban areas shall be above 90%. Previous research has shown that semi-urban areas such as city peripheries do not show great variations compared to urban areas, and are therefore included in the collection (service rate) of urban areas. The collection rate in rural areas shall be higher than 60%, which would result in a total service level of 70-80% municipal solid waste collection rate.

Proposed collection rates (service level indicators) in regard to time:

Urban and semi-urban areas:	>90% → >95% → ~100%
Rural areas:	>60% → >70% →>80% → >85% → ~100%

The total (depends on ratio of population in urban, semi-urban and rural areas and calculated according assumption 35-45%:65:55%)

Total:	>70% → >80% → >85% → >90% → >95%

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(4) The waste generation / collection of households depends on the per capita waste generation situation and on average members per household

It is strongly recommended to carry out a specific household waste generation survey – a standard programme and template is attached in chapter 4.4.

(5) Per capita waste generation/collection depend greatly on the economic situation, financial affordability and spatial location (urban or rural). The generation of municipal waste ranks from 0.35 kg up to 1.2 kg (excluding ELVs, WEEEs and other special waste streams, not under the responsibility of the public service provider)

(6-9) Employee specific benchmarks depend on the rate of mechanisation. The mechanisation rate to be selected depends significantly on income structure, unemployment rate and social constrains. An average mechanisation rate and usual (not optimum) ratio of administrative to operative staff allows **650** tonnes/employee per year. High mechanisation and an optimised ratio allow up to **1600** tonnes/employee per year.

The optimised ratio of administrative to operative staff starts from **1:14** and rises in extremely efficient service provision to **1:25**.

The population served per employee depends greatly on the spatial location, distance from the landfill, and collection system and population density of the served area. In urban areas, and at an average mechanisation rate, the usual ratio can be 3900 inhabitants served. This figure can reach levels above **7000** inhabitants. In rural areas one third (**1300** up to 2300 inhabitants) is realistic.

(10-14) Currently provided service volume is the product of located containers and collection devises by transport fluctuation. The current volume required is the product of the served population times the daily waste generation per inhabitant, divided by the specific waste density. The ratio between required and provided volume will be close to 1. The ratio between required volume under 100% collection conditions and current provided describes the additional volume needed and will support the investment decision-making process. If additional volume cannot be installed due to the lack of an investment budget, a multiple-shift system can be taken into consideration, with the additional positive effect on fixed-cost digression.

The required volume is strongly dependent on a daily waste generation rate per inhabitant and the waste density. The provided volume is the sum of all provided collection system for residues and recyclables.

(15-19) These calculation figures are mainly for information and comparison purposes. The difference between theoretical calculated waste generation and actual collected waste, results in the estimate of "uncontrolled" disposal.

(20-22) Waste disposal on traditional and sanitary sites are for information and planning purposes. In most cases there is an *either* – or situation, and there is only a few mixed systems, where traditional disposal is operating parallel with the sanitary landfill, especially during remediation activities filling the remaining volume.

(23-26) Waste disposal onto landfill after separation (source, area, MBA, on disposal site, etc.) is the remaining percentage and strongly depends on segregation efficiency. Recycling rates ranges from 0% to 65% (effective recycling quota – not to be compared with "recycling" rates actually published for Austria, Sweden and other EU countries, where thermal use and other recovery strategies are included in the recycling rates – >86%). The recycling rates per capita in kg per day depend on the spatial location (urban / rural) and waste generation per day, on the collection system for recyclables and on the waste composition (big differences between urban and rural areas). The range from 0 up to 0.42 kg/per inhabitant per day has to be taken into consideration. The figures reflect the effective (real) recycling quotas and not the recycling potential, which depends on consumer behaviour and waste composition.

(27-29) These benchmarks refer to the segregated waste and identify the amount of segregated waste recycled, recovered, reused, etc. Leftovers are mainly disposed, or used for thermal energy recovery. Separated waste components might have recycling rates from 0 up to 80%, recovery rates up to 40% and composting rates up to 65% (MBA – figures). All percentages are in relation to separate collected, recycled, recovered, reused and composted input weight.

(30-34) These benchmarks refer to landfill capacities and remaining capacities, and result in years left for landfilling purposes referring to:

- traditional disposal activities with and without recycling and recovery,
- sanitary disposal activities with and without recycling and recovery.

New installations shall have a lifespan (disposal period) of 30 years minimum in correlation with a minimum 25 years depreciation period of construction facilities and reasonable CBA calculation modelling. Traditional sites shall not remain in use longer than the usual transition period of **10**-15 years. The lifespan of a disposal facility increases proportionally to the recycling, recovery and reduction (avoidance) rates achieved.

(35-44) These figures, refer mainly to the financial implications for tariff development purposes with the aim of achieving full cost coverage. A comparison of current required collection costs with future projected costs (achieving 100% waste and tariff collection costs while taking the poor into consideration approximately 6-10% poverty rate included results in 90% of the fee collection rate) and also with future required investment costs including investment requirements for segregation, recycling, landfilling, treatment, recovery, reuse, etc. result in cost per tonne for municipal companies or operators and also fees per household and per year (for full cost coverage). These figures represent only rough indicators based only on the overall increase of total expenditures. For a more accurate calculation, the exact break down of costs and revenues for each segment should be performed, also including the specifics of possible technologies, financing options and institutional/organisational issues.

For landfilling there is currently a minimum tariff amounting to 15 EUR per tonne benchmarked in order to ensure an adequate and standardised landfill operation including depreciation. Therefore the difference between collection costs alone, and the sum of collection and disposal costs will be >15 EUR. Regardless of the method of financing investment (grants, soft loan, commercial loan, subsidies) the tariff calculation has been carried out under full-cost recovery perspectives.

3.3. Waste stream analyses (STAN model) – the next step

This chapter constitutes additional information provided. All data collection and processing activities lead into the next logical step of waste stream analyses for which various models can be used. One of these is STAN, which shall be explained on this page.

STAN (short for subSTance flow ANalysis) is a freeware that helps to perform material flow analysis according to the Austrian standard ÖNorm S 2096 (Material flow analysis - Application in waste management).

After building a graphical model with predefined components (processes, flows, system boundary, text fields) you can enter or import known data (mass flows and stocks, volume flows and stocks, concentrations, transfer coefficients) for different layers (goods, substance, energy) and periods to calculate unknown quantities. All flows can be displayed in Sankey style, i.e. the width of a flow is proportional to its value. The graphical picture of the model can be printed or exported. Microsoft Excel is used as an interface for import and export of data.

There is also an option of taking into consideration data uncertainties. The calculation algorithm uses mathematical statistical tools such as data reconciliation, error propagation and gross error detection.

4. Attachments

4.1. Remarks on data collection and most commonly used definitions

4.1.1. General remarks

The data requirements for this model are an attempt to "cover" relevant data for municipal waste collection and its computation in an information system model, but might not fit all countries as they have different levels of industrial development, social welfare, prosperity, consumption habits and technical development of waste management. This may sometimes lead to different data entries resulting in different indicators or misunderstandings of the indicators provided in the model, despite explanations and definitions.

4.1.2. Data gaps

First, it must be mentioned that non-availability of information does not necessarily signify the existence of a data gap. If data refers to a certain kind of waste management and this management does not exist, then, of course, this data cannot be entered. Lack of data for such a reason can be called an artificial data gap. These data gaps resulting from non-existent waste management activities such as 'collection of separate waste fractions' and 'other waste treatment facilities' (i.e. other than land filling) may explain major data gaps in the accession countries influencing possible comparison in waste management.

4.1.3. Insufficient waste book-keeping

In addition to the artificial data gaps mentioned above, 'semi artificial ' data gaps also exist. These are due to the non-capability or unwillingness of enterprises (municipal waste collectors) to specify waste sources and waste types for the waste they are collecting. These data gaps cannot be solved in the short or medium term. First of all, there should be an obligation for the enterprises to report on their waste management and these reports have to be controlled. Secondly, the reporting should be harmonized by applying certain reporting formats. Data gaps resulting from non-existent or undeveloped enterprise waste book-keeping can only be closed by the development and implementation of reporting formats from the side of the administration and through training of the responsible employees.

4.1.4. Data gaps resulting from non-existent surveys or missing data compilation

The data gaps which appear in waste management are mostly:

- the composition of mixed municipal waste;
- the collection of separate waste fractions;
- other waste treatment installations.

Although various studies on mixed municipal waste composition were carried out, it is very difficult for the accession countries to develop in this field. The most important problem which can be tackled directly is data quality.

4.1.5. Data quality

Data quality depends on the availability of technical and administrative tools.

First of all, weighing bridges for the precise determination of the quantities of waste must be available. This is usually not the case for most of the landfills operating in the accession countries. In addition, the precise determination of waste types, waste sources and the structure of waste with municipal companies or operators in most accession countries is just starting and cannot be regarded as reliable.

4.1.6. Most commonly used definitions[1] in waste management:

Waste

- Refers to materials that are not primary products (i.e. products produced for the market) for which the generator has no further use for their own purposes of production, transformation or consumption, and which he / she discards, or intends or is required to discard. Wastes may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity.

Municipal waste

- Municipal waste includes household waste and similar waste.

1 Eurostat/OECD

The definition also includes:

- bulky waste (e.g. white goods, old furniture, mattresses); and yard waste, leaves, grass clippings,
- households commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings).
- waste from selected municipal services, i.e. waste from park and garden maintenance, waste from street cleaning services (street sweepings, and the content of litter containers, market cleansing waste) [2].

Biodegradable waste

Any waste that is capable of undergoing anaerobic or aerobic decomposition such as food waste or garden waste, but also paper waste.

Bulky waste

Waste that, due to its bulky character needs special attention for its management, such as white goods, old furniture, mattresses, etc. Excludes construction and demolition waste.

Composting

Composting is a biological process in which biodegradable waste is subjected to anaerobic or aerobic decomposition, resulting in a product which is recovered.

Construction and demolition waste

Construction and demolition waste: rubble and other waste material arising from the construction, demolition, renovation or reconstruction of buildings or parts thereof, whether on the surface or underground. Consists mainly of building material and soil, including excavated soil. Includes waste from all origins and from all economic activity sectors.

2 Municipal waste) is a complex and blurred term. In general, it includes household waste and waste originating from other sources. The degree of precision and accuracy in definition is not yet satisfactory in most regions. This makes any comparison between countries fragile. Comparisons, having in mind different practices, can at best indicate differences.

Regarding municipal waste in general, there are three types of waste distinguished: Household waste (as a specific waste type); Bulky waste and others.

It is not easy for the accession countries nor for EU Member States and other OECD countries to split up their waste amounts collected accordingly. The reasons are that bulky waste belongs to household waste type if it is collected despite its 'bulkiness' together with 'normal' household waste. Only if the 'bulkiness'-character leads to separate collection activities, can it and should it be then specified. This might lead to a certain level of confusion because bulkiness is a relative concept related to the volume of garbage tonnes and containers available. Also the differentiation between household waste including similar waste and 'other waste' is not obvious nor easy to identify.

Controlled landfill

Landfill whose operation is submitted to a permit system and to technical control procedures in compliance with the national legislation in force. Includes specially engineered landfill.

Disposal

Disposal is defined as any waste management operation serving or carrying out the final treatment and disposal of waste. It covers the following main operations:

Final treatment:

- incineration without energy recovery (on land; at sea),
- biological, physical, chemical treatment resulting in products or residues that are discarded, i.e. going to final disposal.

Final disposal:

- disposal into or onto land (e.g. landfill), including specially engineered landfill,
- deep injection,
- surface impoundment,
- release into water bodies,

Landfill

Landfill is defined as disposal of waste into or onto land, including specially engineered landfill, and temporary storage of over one year on permanent sites.

Service level indicator – Population served by public service provider

The percentage of addresses within a municipality where household waste is collected regularly by or on behalf of the municipal authorities.

Recovery

Recovery is defined as any waste management operation that diverts a waste material from the waste stream and which results in a certain product with a potential economic or ecological benefit. Recovery mainly refers to the following operations:

- material recovery, i.e. recycling;
- energy recovery, i.e. re-use a fuel;
- biological recovery, e.g. composting;
- re-use.

Direct recycling or reuse within industrial plants at the place of generation is excluded.

Recycling

Recycling is defined as any reprocessing of material in a production process that diverts it from the waste stream, except reuse as fuel. Both reprocessing as the same type of product, and for different purposes should be included. Direct recycling within industrial plants at the place of generation should be excluded.

Treatment

Treatment means physical, thermal, chemical or biological processes that change the characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery.

Waste management

Waste management means the collection, transport, treatment and disposal of waste, including after-care of disposal sites.

4.2. Standard calculations

4.2.1. Standard collection calculation

0.6 kg/PE*day	≡ 3.5 l / PE*day
70%	collection rate in urban areas
25%	collection rate in peripheral areas
2%	yearly increase of waste production
750 kg/m^3	compacted waste on landfill
325 kg/m^3	loose waste from households

PE…	Population Equivalent
Vl…	Volume loose
Vc…	Volume compacted
Vtc…	Volume total compacted
VT…	Volume Total (inclusive cover material)
Wl…	Specific Weight of loose fraction
Wc…	Specific Weight of compacted fraction
Ru…	Collection Rate in urban areas
Rr…	Collection Rate in rural areas
Wr…	Waste increase rate
Y…	Years
Wp…	Waste production
Cf…	Cover material factor in 1+ % (0.15)

Wp = PE x 0.6 kg/day x 365 days → [kg/Year]
Vl = Wp / Wl → [m^3]
Vc = Wp / Wc → [m^3]

$Vtc = (Vcu \times Ru) \times (Wr)^Y + (Vcr \times Rr) \times (Wr)^Y$ → [m^3]
$Vtcy = [(Vcu \times Ru) + (Vcr \times Rr)] \times (Wr)^Y$ → [m^3]

$VT_y = Vtc \times Cf$ → [m^3]

4.2.2. Landfill calculation schemes

7 to 10%	Amount of demolition waste
2 to 03%	Amount of scrap metal
0 to 01%	Amount of other fractions
2%	Yearly increasing of waste production
560 kg/m^3	Compacted waste on landfill with Dozer
750 kg/m^3	Compacted waste on landfill with Compactor
1000 kg/m^3	Demolition waste
325 kg/m^3	Lose waste from households
1.72	Compaction rate with Dozer
2.31	Compaction rate with Compactor
10%	Settling rate of demolition waste

HW…	Household Waste	
DW…	Demolition Waste	
SM…	Scrap Metal	
OF…	Other Fraction	
V_{hw}…	Volume household waste	[in m^3]
V_{dw}…	Volume demolition waste	[in m^3]
V_{sm}…	Volume scrap metal	[in m^3]
V_{of}…	Volume other fractions	[in m^3]
P_{hw}…	Partial amount of household waste	[in %]
P_{dw}…	Partial amount of demolition waste	[in %]
P_{sm}…	Partial amount of scrap metal	[in %]
P_{of}…	Partial amount of other fraction	[in %]
CR_{hw}…	Compaction Rate household waste	[fact.]
SR_{dw}…	Settling Rate demolition waste	[in %]
Vtl…	Volume total lose	[in m^3]
Vtc…	Volume total compacted	[in m^3]
VT…	Volume Total (incl. Cover Material)	[in m^3]
Wl…	Specific Weight of lose fraction	[in kg/m^3]
Wc…	Specific Weight of compacted fraction	[in kg/m^3]
W_{DR}…	Waste disposal rate	[in m^3]
W_{RR}…	Waste recycling rate	[in m^3]
Wir…	Waste increase rate	[in %]
Y…	Years	[in a]
Wp…	Waste production	[in kg]
Cf…	Cover material factor	[in 1+ %]

$$V_{hw} = Vtl * P_{hw} \rightarrow [m^3]$$
$$V_{dw} = Vtl * P_{dw} \rightarrow [m^3]$$
$$V_{sm} = Vtl * P_{sm} \rightarrow [m^3]$$
$$V_{of} = Vtl * P_{of} \rightarrow [m^3]$$

$$Vtl = W_{DR} + W_{RR} = V_{hw} + V_{dr} + V_{sm} + V_{of} \rightarrow [m^3]$$
$$W_{DR} = V_{hw} + V_{dw} + V_{of} \rightarrow [m^3]$$
$$W_{RR} = V_{sm} \rightarrow [m^3]$$
$$Vtc = [(V_{hw} \times CR_{hw}) + (V_{dw} \times SR_{dw}) + V_{of}] \times (Wir)Y \rightarrow [m^3]$$

$$VT_y = Vtc \times Cf \rightarrow [m^3]$$

4.3. Advanced waste collection efficiency calculations

4.3.1. Waste collection time – Time Index

One very important figure, the Time Index, which reflects the Waste Collection time (WCt), and results in the ratio of the Loading Time (LT) and the Transport Time (TT).

4.3.2. Specific loading time (sLT)

This shows the time, which is used to drive one container to tip, and to drive back to point Y divided by the size of the container:

Table 2. Waste collection with skip – 5m³ containers

Capacity Calculation – Logistic System – Skip (5m³)																
TERMS		in Town				Landfill			in Town			Waste Collection Time (WCT)	Percent Loading Time (%LT)	Percent Transport Time (%TT)	Time Index Loading Time (LT) Transport Time (TT) LT : TT 1 : X
ZONE	Container Size [m³]	Time to Load [min]	Time for net [min]	Time to point x [min]	TOTAL	Time to Landfill [min]	Time to tip [min]	TOTAL	Time from Landfill [min]	Time to reload [min]	TOTAL				
I	5	5	3	8	16,00	20	6	26,00	20	5	25,00	70,00	23%	77%	3,38
II	5	5	3	6	14,00	20	6	26,00	20	5	25,00	63,00	22%	78%	3,50
III	5	5	3	5	13,00	20	6	26,00	20	5	25,00	63,00	21%	79%	3,85
IV	5	5	3	4	12,00	20	6	26,00	20	5	25,00	64,00	19%	81%	4,33
V	5	5	3	3	11,00	20	6	26,00	20	5	25,00	65,00	17%	83%	4,91

The Time Index describes the proportion between the net Loading Time (LT) to the net Transport Time (TT). A system will show a Time Index between 1:0.25 and 1:0.4.

The table above demonstrates inefficiency in the Time Index of 1:3.4 to 1:4.9. This shows very exactly that inefficient way times (over 70%) must be reduced by using less containers with higher volume capacity or to change the system to a 1.1m³ system, as shown in the next table.

Table 3. Waste collection with tractor

	in Town				in Town		TOTAL		
Item	Time to Load [min]	Time for net [min]	Time to point x [min]	Loading Time [min]	Time to Landfill [min]	Time to tip [min]	Time from Landfill [min]	Time to reload [min]	TOTAL/TOUR
Tractor 4m^3	90		10	**100**	25	8	25	0	**158**

Transport Time (TT) : Loading Time (LT) = 158 – 100 : 100 = 58 : 100 = **1 : 1.72**
% of Transport Time (TT) of Waste Collection time (WCt) = **37%**
% of Loading Time (LT) of Waste Collection time (WCt) = **63%**

Table 4. Waste collection with compaction trucks for 1.1m^3 containers

Capacity Calculation - Logistic System – Compaction Truck (1.1m^3)																
TERMS		in Town				Landfill			in Town							
ZONE	Container Size [m^3]	Time to Load[min]	Time for net [min]	Time to point x [min]	TOTAL	Time to Landfill [min]	Time to tip [min]	TOTAL	Time from Landfill [min]	Time to reload [min]	TOTAL	Waste Collection Time (WCT)	Percent Loading Time (%LT)	Percent Transport Time (%TT)	Loading Time (LT) Trans-port Time (TT) LT : TT 1 : X
I	1,1	4	0	0,23	**4,23**	0,57	0,17	**0,74**	0,57	0,14	**0,71**	**5,69**	**74%**	**26%**	**0,34**
II	1,1	4	0	0,17	**4,17**	0,57	0,17	**0,74**	0,57	0,14	**0,71**	**5,63**	**74%**	**26%**	**0,35**
III	1,1	4	0	0,14	**4,14**	0,57	0,17	**0,74**	0,57	0,14	**0,71**	**5,60**	**74%**	**26%**	**0,35**
IV	1,1	4	0	0,11	**4,11**	0,57	0,17	**0,74**	0,57	0,14	**0,71**	**5,57**	**74%**	**26%**	**0,35**
V	1,1	4	0	0,09	**4,09**	0,57	0,17	**0,74**	0,57	0,14	**0,71**	**5,54**	**74%**	**26%**	**0,36**

All these Times Indices are in the range between 1:0.25 and 1:0.4.

Main Figures and Measurements to decrease the Time Index:

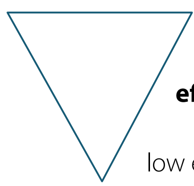
- System Change (from skip system to waste bin system)
- Size change of skip system (from 5m^3 to 7m^3) and container reduction
- Loading Stations for waste transfer (especially for tractors)

System Replacement		Skip System	Skip System	Skip System	Waste Bins	Tractor
	SIZE in m³	**m³**	**m³**	**m³**	**m³**	**m³**
System	**xx**	**3**	**5**	**7**	**1.1**	**4**
Skip-System	**3**	1	2	2	0	1
Skip-System	**5**	1	1	1	0	1
Skip-System	**7**	0	1	1	0	1
Waste Bin	**1,1**	2	4	5	1	3
Tractor System	**4**	1	1	2	0	1

4.3.3. Change of priorities regarding efficiency rates

Because the former system calculation shows the result that following hierarchy shall not be interrupted:

1 Compaction Truck – "Compactor"
2 Compaction Truck – Rotopress
3 Skip Truck 7 m^3
4 Skip Truck 5 m^3
5 Tractor



Only an upper system shall replace a lower system because of the lower time index, which also results in lower operation costs.

4.4. Analysis standards

The analysis shall be split into three different objectives:

- Qualitative Analysis in order to identify the waste composition and density;
- Quantitative Analysis in order to identify the specific waste production per Inhabitant (PE) and day;
- Transport and Collection rate analysis in order to identify the waste amount transported to the landfills in comparison to the produced waste within the investigation area

4.4.1 Qualitative analysis

Techniques

Qualitative waste analysis shall either be carried out in waste (management) recycling centres or on the spot of collection (field). All investigation areas have to be split into zones of 20,000 PE, while in every zone amount of at least $3m^3$ shall be analysed (equal to 3 containers of $1.1m^3$). All investigation points have to be described regarding their characteristics, collection system and identified with GPS (UTM coordinates).

A leader, an assistant, 3 to 4 workers and a local supervisor shall conduct the analysis. The labour force shall be hired locally or has to be organised from the public service provision company. The different components have to be segregated by hand and all organic components to be screened with a 40 mm grid. The weight and the volume of each component are to be measured, recorded and photographically documented.

Equipment needed is limited to 3 shovels, 3 brooms, 60 litre plastic bags for volume determination, 2 hand scales (1 to 3 kg and 1 to 20 kg) and PPE[3] for working and site safety such as uniforms, working boots, leather gloves and FFP1 dust filters. In addition a calculator and recording sheets (forms) will be required.

Segregated components

The investigation includes 20 different components such as Organic >40mm, Organic <40mm; Plastic packages such as PP, PS (foamed and not foamed), LDPE, HDPE; PET with recycling potential, compound materials such as nappies with energy recovery potential; recyclable glass (coloured and transparent) and none-recyclable glass (eg. Mirror); wood; inert material; hazardous components; paper (class I – III) and cardboard (class IV), and metals (Aluminium cans, ferrous metals and other none-ferrous metals). This detailed investigation allows a later calculation based grouping of components. In addition, all components are described according their specific characteristics.

The organic component <40mm shall be analysed in the laboratory regarding humidity (water content in %), ash content [%] and wet density [ml/1000ml]. Samples are prepared according to the "Quarter Methodology", while the whole amount of waste <40mm is divided quarterly several times until a relevant amount of 3 to 5 kg is reached. This amount was pre-segregated from plastic compounds and all artificial TOC[4] influencing components.

3 PPE = Personal Protection Equipment

4 TOC = Total Organic Carbon [in %] – European Landfill Standard <5% implemented since 01.01.2004 in Austria and 01.07.05 in Germany.

Form for qualitative analysis

Table 5. Standard template for qualitative municipal solid waste analysis

Municipal Solid Waste Analysis					
Mun/Com/Vil	(1)	Analysis Nr.	Date		(4)
Zone	(2)	(3)	System		(5)
Structure Description	(6) (7)				
Amount of Containers	(8)	Containers			
Amount of Volume	=(15)	litre			
Results	kg	Litre	Density	Mass %	Description
Organic	(9.1)	(10.1)	(11.1)	(12.1)	(13.1)
Organic <40mm	-	-	-	-	
Paper (Class I - III)	-	-	-	-	
Cardboard (Class IV)	-	-	-	-	
Glass (bottles)	-	-	-	-	
Glass (other)	-	-	-	-	
Ferrous Metal	-	-	-	-	
Metal – alumin . (cans)	-	-	-	-	
None -Ferrous Metals	-	-	-	-	
Wood	-	-	-	-	
Compound Material	-	-	-	-	
PET	-	-	-	-	
LDPE - Plastics	-	-	-	-	
HDPE - Plastics	-	-	-	-	
Polystyrene foamed	-	-	-	-	
Polystyrene - PS 5	-	-	-	-	
Other Plastics	-	-	-	-	
Textiles	-	-	-	-	
Inert Material	-	-	-	-	
Hazardous Waste	-	-	-	-	
others	-	-	-	-	
Results	(14)	(15)	(16)	(17)	

(1)… Name of Municipality or Commune or Village with (Abbreviation) in Brackets – M for Municipality; C for Commune and V for Village;

(2)… Zone of the investigation area in Roman letters; Example: **I**

(3)… Analysis Number in Arab numerals; Example: **1**; it can happen, that one zone, for whatever reason has to be analysed twice.

(4)… Date of analysis in dd/mm/yyyy; Example: **02/06/2011**

(5)… The system of the existing collection in volume and unit; Example: 1.1m^3; 5m^3, 0.06m^3, loose,…

(6)… Description of the waste producing facilities and living structure; Example: 85% apartments, 10% houses, 5% business and coffee shops

(7)… Coordinates of the waste collection point, measured with GPS in WGS 1984 and UTM Grid for further processing in GIS. One analysis investigates minimum 1 zone, which includes minimum 3 collection points. All of the points have to be measured. The points have to be described as following:

a) Location I – X

b) GPS – Waypoint Number; Example: WP 254

c) Coordinates in Raster Sector; Altitude; X-Coordinates; Y-Coordinates; separated by semicolon; Example: UTM 34T; 879; 0481369; 4496271

Example: Location I - WP 254 (UTM 34T; 879; 048136; 4496271); Location II - WP255 (UTM 34T; 866; 0481184; 4496526)

(8)… Amount of investigated bins; Example: 3

(9)… Sum of weight for each component in kg

(10)… Sum of volume for each component in litres

(11)… Calculation of Density according Formulas a.) – Result in kg/m^3

(12)… Calculation of % of total amount according Formula b1.) – Result in %

(13)… Description of specific condition of waste and composition; Example: 10% newspaper, 80% office paper, 10% mixed paper

(14)… Total sum of all component weights (Σ_w) in kg

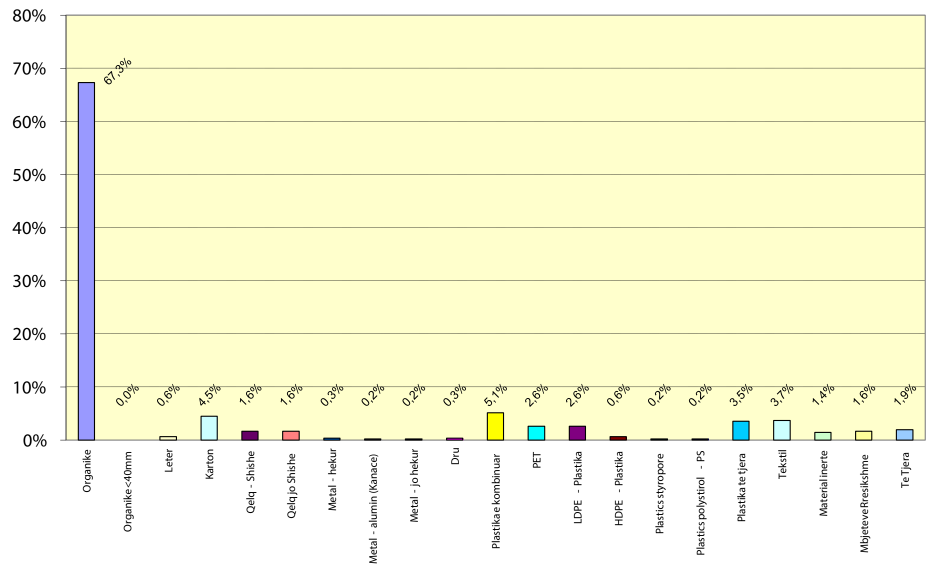
(15)… Total sum of all component volumes (Σ_v) in litres

(16)… Calculation of Total Density according Formulas a.) – Result in kg/m^3

(17)… Sum of total weight percentages; Result has to be 100%

(18)… Chart of weight percentages – x-categories are identical to waste components, y-axis are the percentages with a scale not exceeding an interval of 10%, bars in different colours for better identification. The chart has to be developed for each zone.

The Form and chart are produced in an Excel worksheet operating several functions automatically. In addition, the chart is generated automatically. All figures, shown in red in the chart have to be filled in, all figures shown in blue are automatic calculations. The chart is self-generating.



Formulas

a.) Density Calculation

$$\frac{\Sigma_w \text{Weight}_{net} \text{ of Component X [in kg]}}{\Sigma_v \text{Volume}_{net} \text{ of Component X [in litre]}} / 1000 \text{ litre x } m^{-3} = \textbf{Density Component X [kg xm}^{-3}\textbf{]}$$

b.) Percentage of Component to total amount

b1) Weight or Mass %

$$\frac{\text{Component X [in kg]}}{\Sigma \text{ Components [in kg]}} \text{ x } 100 = \text{Amount of Component X [in \%]}$$

b2) Volume %

$$\frac{\text{Component X [in litre]}}{\Sigma \text{ Components [in litre]}} \text{ x } 100 = \text{Part of Component X [in \%]}$$

c.) Water Content of Biodegradable Waste <40mm

$$\frac{a^6 - b}{a - c} = \frac{\text{Mass}_{net} \text{ [in gr]}}{\text{Mass}_{brut} \text{ [in gr]}} \text{ x } 100 = \text{Water Content [in \%]}$$

4.5. Quantitative analysis

4.5.1. Techniques

The quantitative analysis focuses on the daily waste production for a period of minimum 14 days and an optimum period of 21 days. A minimum of 20 households are investigated on a daily basis (also on weekends). Further, the number of occupants in each of the investigated households is registered. All waste production data is recorded in grams.

The equipment needed is limited to plastic bags, distributed to the involved households, one-hand scales (1 to 3 kg) and PPE[5] for working and site safety such as leather gloves. A calculator and recording sheets (forms) are also needed

The quantitative analysis is conducted in those zones (collection points), where the qualitative analysis had been conducted, in the surroundings of each collection point. Persons familiar with the local conditions and situations are hired and in most of the operation are inspected by the supervisor of the municipality or commune.

5 PPE = Personal Protection Equipment

Form for qualitative analysis

Table 6. Standard template for qualitative municipal solid waste analysis

Quantitative Waste Analysis Form																					
Mun/Com/Vil	(1)			Zone	(2)			First Day		(3)			Last Day			(4)					
Household HH	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVI	XVIII	XIX	XX	SUM
PE/HH	(5)																				
Day 1	(6)																				
Day 2																					
Day 3																					
Day 4																					
Day 5																					
Day 6																					
Day 7																					
Day 8																					
Day 9																					
Day 10																					
Day 11																					
Day 12																					
Day 13																					
Day 14																					
Day 15																					
Day 16																					
Day 17																					
Day 18																					
Day 19																					
Day 20																					
Day 21																					
SUM	(7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(8)
Days	(9)																				
Prod/day	(10)																				
Prod/day x PE	(11)																				

(1)… Name of Municipality or Commune or Village with (Abbreviation) in Brackets – M for Municipality; C for Commune and V for Village;

(2)… Zone of the investigation area in Roman letters; Example: **I**

(3)… First day of analysis in dd/mm/yyyy; Example: **02/06/2011**

(4)… Last day of analysis in dd/mm/yyyy; Example: **15/06/2011 (=first day+ (n days –1))**

(5)… Amount of inhabitants permanently living in the investigated household

(6)… Waste Production in grams for each day

(7)… Sum of the amount of waste (in grams) produced during the investigation period of the investigated household

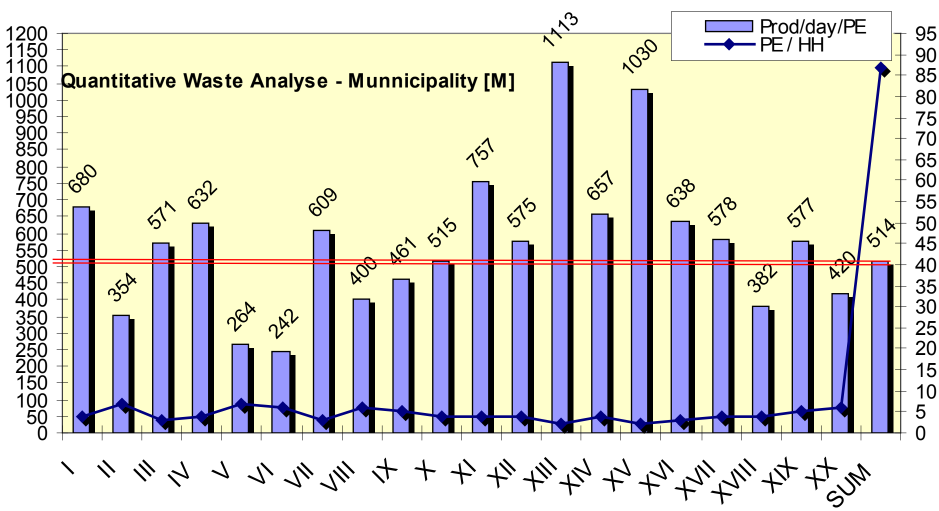
(8)… Sum of the amount of waste (in grams) produced during the investigation period from all investigated households

(9)… Analysis period of the investigated households (in days)

(10)… Waste production per day (in grams) of the investigated household; according to formula c) → Result in grams / day (or grams x day^{-1})

(11)… Waste production per day and inhabitant (PE) of the investigated household; according to formula d) → Results in grams / day / PE (or in grams x day^{-1} x PE^{-1})

(12)… Chart of average waste production per day and population equivalent (inhabitants) in grams – x-categories are identical with households investigated, the y1-axis shows the average waste production per day and inhabitant, with a scale not exceeding an interval of 50 grams and in bar form. Y2-axis represents the inhabitants of the different households as a line. The chart can be developed for each municipality or commune.



Formulas

c.) Average Waste Production per Day

$$\frac{\Sigma_w \text{ Weight of Waste of household}_{I \rightarrow XX} \text{ [in grams]}}{\Sigma_d \text{ Days of investigation}_{1 \rightarrow 21} \text{ [in days]}} = \textbf{average Waste Production / Day [grams/day]}$$

d.) Average Waste Production per Day and Inhabitant

$$\frac{\text{Average Waste Production / Day of household}_{I \rightarrow XX} \text{ [in grams / day / household]}}{\Sigma_{PE} \text{ Population Equivalent of household}_{I \rightarrow XX} \text{ [in PE]}} =$$

= **average Waste Production / Day / Population Equivalent [grams / day / PE]**

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ASSOCIATION
"AQUASAN
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