Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

ΥΠΟΥΡΓΕΙΟ
ΠΕΡΙΒΑΛΛΟΝΤΟΣ
& ΕΝΕΡΓΕΙΑΣ

giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

# Waste Composition Analysis for Greece and Proposals for the Amendment of JMD114218/1997

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## Final Report

26th February 2021

eunomia

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| | |
|---|---|
| BAT | BEST AVAILABLE TECHNIQUES |
| BMU | GERMAN FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY |
| CLO | COMPOST LIKE OUTPUT |
| DG REFORM | DIRECTORATE-GENERAL FOR STRUCTURAL REFORM SUPPORT OF THE EUROPEAN COMMISSION |
| EC | EUROPEAN COMMISSION |
| ECS | EDDY CURRENT SEPARATORS |
| EFW | ENERGY FROM WASTE |
| ELOT | NATIONAL BODY FOR STANDARDIZATION |
| EPR | EXTENDED PRODUCER RESPONSIBILITY |
| EU | EUROPEAN UNION |
| EUROSTAT | EUROPEAN STATISTICAL AGENCY |
| EWC | EUROPEAN WASTE CODE |
| FEL | FRONT END LOADER (TYPE OF JCB) |
| FODSA | SOLID WASTE MANAGEMENT ORGANIZATIONS |
| GIZ | DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT |
| HDPE | HIGH-DENSITY POLYETHYLENE |
| HRA | HELLENIC RECYCLING AGENCY OR ΕΟΑΝ IN GREEK |
| JMD | JOINT MINISTERIAL DECISION |
| LWMP | LOCAL WASTE MANAGEMENT PLAN |
| MBT | MECHANICAL AND BIOLOGICAL TREATMENT |
| MRF | MATERIAL RECOVERY FACILITY |
| MSW | MUNICIPAL SOLID WASTE |
| NCV | NET CALORIFIC VALUE |
| NECP | NATIONAL ENERGY AND CLIMATE PLAN |
| NIR | NEAR INFRA-RED |
| NWMP | NATIONAL WASTE MANAGEMENT PLAN |
| NWPSP | NATIONAL WASTE PREVENTION STRATEGIC PLAN |
| PET | POLYETHYLENE TEREPHTHALATE |
| PPC | PUBLIC POWER CORPORATION |
| PPP | PUBLIC PRIVATE PARTNERSHIP |
| PROS | PRODUCER RESPONSIBILITY ORGANIZATIONS |
| RDF | REFUSED-DERIVED FUEL |
| RSCS | RECYCLING SORTING FACILITIES OR ΚΔΑΥ IN GREEK |
| RSWMP | REGIONAL SOLID WASTE MANAGEMENT PLAN |
| SAS | SEGREGATION AT SOURCE |
| SRF | SOLID RECOVERED FUEL |
| SRSP | STRUCTURAL REFORM SUPPORT PROGRAMME |
| SWMA | SOLID WASTE MANAGEMENT ASSOCIATION |
| TORS | TERMS OF REFERENCES |
| WMP | WASTE MANAGEMENT PLAN |
| WTE | WASTE TO ENERGY |
| WTS | WASTE TRANSFER STATION |

| | |
|---|---|
| ΥΜΕΡΕΡΑΑ | OPERATIONAL PROGRAMME "TRANSPORT INFRASTRUCTURE, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT'' OR ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ "ΥΠΟΔΟΜΕΣ, ΜΕΤΑΦΟΡΩΝ, ΠΕΡΙΒΑΛΛΟΝ & ΑΕΙΦΟΡΟΣ ΑΝΑΠΤΥΞΗ" (ΕΠ ΥΜΕΠΕΡΑΑ) IN GREEK |
| YPEN | MINISTRY OF ENVIRONMENT AND ENERGY |

# Background and disclaimer

The competent Greek Authorities approached the European Commission (EC) for support in specific areas aiming for improvement of the implementation of the National Waste Management Plan (including the improvement of municipal waste management, regulatory issues of the waste sector, the management of specific waste categories) in order to raise the quality and quantity of recycling, to improve data quality and to effectively use economic instruments. To achieve the aforementioned goals, the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) provides "Technical support for the implementation of the National Waste Management Plan (NWMP) of Greece" from January 2019 to March 2021. The project is funded by the European Union (EU) via the Structural Reform Support Programme (SRSP) and the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), and jointly implemented by GIZ and the Hellenic Ministry of Environment and Energy (YPEN), in collaboration with the EC.

GIZ commissioned Eunomia Research and Consulting IKE to provide specific technical expertise to GIZ and YPEN from November 2020 to January 2021 by implementing the following project ''Waste composition analysis for Greece and proposals for the amendment of JMD 114218/1997''. The hereby Final Report entails a) guidelines for conducting municipal solid waste (MSW) composition analysis at national and regional level in Greece, and b) proposals for the amendment of the JMD 114218/1997 'Establishment of a framework of technical specifications and of general plans for solid waste management'.

| | |
|---|---|
| **Assignment** | **Waste composition analysis for Greece and proposals for the amendment of JMD 114218/1997** |
| **Contract No.** | **81261867** |
| **Project Name** | **Technical support for the implementation of the National Waste Management Plan (NWMP) of Greece (68.3045.9)** |
| **Client / Project Executing Agency** | **Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)**<br>**Project Manager: Ulrich Laumanns ( ulrich.laumanns@giz.de)**<br>**Senior Adviser: Vasiliki Panaretou (vasiliki.panaretou@giz.de)**<br>**Senior Adviser: Maria Pisimisi (maria.pisimisi@giz.de)** |
| **Consultant** | **Eunomia Research and Consulting**<br>**Vasiliki Stergiou, Senior Consultant (vasiliki.stergiou@eunomia.co.uk)** |
| **Contract term** | **04.11.2020 - 28.01.2021** |

**Disclaimer**

Eunomia Research & Consulting has taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the study. However, no guarantee is provided in respect of the information presented, and Eunomia Research & Consulting is not responsible for decisions or actions taken on the basis of the content of this report.

**This document was produced with the financial assistance of the European Union. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.**


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**Acknowledgements:** We would like to thank all the authorities, organisations and consultants that provided data to assist with this project. We are particularly grateful to Mrs A.Arfanakou, Mrs S.Mani and Mrs G.Matzava from the Directorate of Waste Management of YPEN and Mr. V.Stoilopoulos from EYD YMEPERAA for their constructive comments and input.

# Executive Summary

Eunomia Research and Consulting prepared this report for the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and the Ministry of Environment & Energy (YPEN) in order to develop a) guidelines for conducting municipal solid waste (MSW) composition analysis at national and regional level in Greece, and b) proposals for the amendment of the JMD 114218/1997 'Establishment of a framework of technical specifications and of general plans for solid waste management'.Greece has recently adopted the new National Waste Management Plan (NWMP)[1] setting ambitious targets and measures for 2020-2030 and has proceeded in the transposition of the new EC Directives on waste (2018/ 849/850/851/852)[2], as well as the adoption of the Single Use Plastics Directive 2019/904[3]. In this respect, this study aims at contributing to improving the national waste statistics of the municipal solid waste generation and to the accuracy of the National Waste Prevention Plan and the Regional Waste Management Plans (RWMPs).

The level of analysis of our work for the development of the Guide for conducting waste composition analysis for Greece and the proposals for the amendment of the JMD 114218/1997 is limited to the allocated working time and scope of deliverables as stipulated in the Terms of reference.[4] Our work also reflects the points discussed during the kick-off and the subsequent meetings with YPEN-GIZ.

## Guide for conducting sampling and analysis of unprocessed municipal solid waste at regional and national level

This report sets out a Protocol for conducting Waste Composition Analysis for unprocessed municipal solid waste (MSW) in Greece, aiming at providing common standards and guidelines to be followed by the competent authorities (FOSDA, etc.) at national and regional level in the country. It is important that this protocol is used for all compositional analysis of municipal waste carried out in Greece. Following the same protocol will ensure that the results obtained are reliable and consistent. This will help municipalities to understand the composition of their own municipal waste, compared to the composition in other municipalities. Furthermore, using this protocol will be indispensable for producing regional and national estimates of municipal waste composition. This will play an extremely important role in improving the management of municipal waste in Greece and meeting the targets of the National Waste Management Plan 2020-2030.

The Protocol provides practical instructions on how waste analyses should be carried out, as follows:

- **Design a sampling plan**, which will determine:
  - waste streams to be analysed (residual and recycling collections at a minimum);
  - when the analysis will be carried out, with at least two phases to control for seasonal variation;
  - the collection vehicles whose loads will be sampled, with the collection rounds of those vehicle selected so as to broadly represent the municipality or area analysed.

[1] ΠΥΣ 39/31.8.2020 (ΦΕΚ185/Α/29.9.2020) *'Έγκριση του Εθνικού Σχεδίου Διαχείρισης Αποβλήτων (Ε.Σ.Δ.Α.)'*
[2] http://www.opengov.gr/minenv/?p=11440
[3] Ν.4736/2020 (ΦΕΚ 200/1/20.10.2020) *'Ενσωμάτωση της Οδηγίας (ΕΕ) 2019/904 σχετικά με τη μείωση των επιπτώσεων ορισμένων πλαστικών προϊόντων στο περιβάλλον και λοιπές διατάξεις '*
[4] In particular, according to the ToRs, it is stipulated:
a) 14 working days (FTE) are foreseen for the research, data collection, analysis and development of 25 pages for the Protocol for conducting sampling and analysis of unprocessed municipal solid waste;
b) 10 working days (FTE) are foreseen for the development of 10-15 pages of concrete proposals for the amendment of the JMD 114218/97.

- **Collect the sample from the collection vehicle**, with a random selection of material from the vehicle load being extracted.
- **Manually sort the selected material into specified categories** (data collection templates are provided with this protocol that describe the categories that must be used).
- **Measure and record the weight** of each category of material.
  Once all the samples in the sampling plan have been analysed, **produce the results for each individual sample, and calculate combined results from all the samples** to produce a compositional estimate for each waste stream.
- **Health and safety measures** are described in the protocol and must be followed, as there are several hazards associated with waste analysis which must be properly controlled.
- **Templates** for sampling, recording and reporting results are developed and presented.

## Concrete proposals for the amendment of the JMD 114218/1997

The **JMD 114218** ***'Establishment of a framework of technical specifications and of general plans for solid waste management'*** is acknowledged as a predominant Greek legal document with a great level of detail in terms of the provision of technical specifications and design principles for solid waste management in Greece. However, since it has been initially enacted in 1997, there is considerable progress made both a) in terms of technological updates and new standards and b) in terms of the new national and EU legal framework and policies on waste management and circular economy.

Thus, the focus of our work is on reviewing this framework and providing strategic guiding recommendations, as well as selective, more detailed proposals on particular Chapters or Articles where needed and in agreement with GIZ and the Ministry of Environment and Energy (YPEN).

The level of amendments and technical details required were discussed with GIZ/YPEN and engagement with selective key stakeholders was accomplished to solicit valuable data. The stakeholder engagement was limited to the allocated time and resources as stipulated in the ToRs[5].

Our proposals on the amendment of the JMD 114218/1997 are high-level based on selected articles/ sections following engagement with YPEN. The level of detail with respect to the technical requirements set out in the JMD is reviewed in order: a) not to hamper the environmental permission, proper design and development of waste management infrastructure and systems, b) promote innovation and c) follow EU Best Available Techniques reference documents (BREFs).

Our proposals are developed per chapter of the JMD as bellow:

1. Technical specifications for the collection – temporary storage – transport of solid waste.
2. Technical specifications for the transfer of solid waste.
3. Criteria for the site selection of waste management infrastructure.
4. Technical specifications for separate collection systems.
5. Technical specifications for the landfill of waste.
6. Technical specifications for the landfill of aggregates (C&D).
7. Technical specifications for the mechanical biological treatment of waste.
8. Technical specifications for the thermal treatment of waste.
9. Technical specifications for the treatment of the sludge from the treatment of the municipal wastewater.

[5] According to the ToRs, 2 working days are foreseen for the research and data collection to be accomplished, therefore limited stakeholder engagement and market research was carried out.

# 1. Introduction

Eunomia Research and Consulting is pleased to present this report to the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ). Greece has recently adopted the new National Waste Management Plan (NWMP)[6] setting ambitious targets and measures for 2020-2030 and has proceeded in the transposition of the new EC Directives on waste (2018/ 849/850/851/852)[7], as well as the adoption of the Single Use Plastics Directive 2019/904[8]. In this respect, this study aims at contributing to improving the national waste statistics of the municipal solid waste generation and to the accuracy of the National Waste Prevention Plan and the Regional Waste Management Plans (RWMPs).

In particular, the scope of the assignment is dual; Primarily, the context of our work is based on the development of a Protocol for conducting Waste Composition Sampling and Analysis for unprocessed municipal solid waste (MSW) in Greece, aiming at providing common standards and guidelines to be followed by the competent authorities (FOSDA, etc.) at national and regional level in the country.

In addition, we aim at providing concrete proposals for the amendment of the Greek JMD 114218/1997 *'Establishment of a framework of technical specifications and of general plans for solid waste management'*. In respect of the second point above, we focus on reviewing the JMD and developing recommendations on both strategic and general guiding principles, as well as on selective, more detailed proposals on particular Sections or Articles where needed and following the engagement and in agreement with the Ministry of Environment and Energy (YPEN) and GIZ.

The level of analysis of our work for the development of the Guide for conducting waste composition analysis for Greece and the proposals for the amendment of the JMD 114218/1997 is limited to the allocated working time and scope of deliverables as stipulated in the Terms of reference.[9] Our work also reflects the points discussed during the kick-off and the subsequent meetings with YPEN-GIZ.

# 2. Scope and Objectives

## A. Protocol for conducting Waste Composition Analysis

This report sets out a Protocol for conducting Waste Composition Analysis for unprocessed municipal solid waste (MSW) in Greece, aiming at providing common standards and guidelines to be followed by the competent authorities (FOSDA, etc.) at national and regional level in the country.

It is important that this protocol is used for all compositional analysis of municipal waste carried out in Greece. Following the same protocol will ensure that the results obtained are reliable and consistent. This will help municipalities to understand the composition of their own municipal waste, compared to the composition in other municipalities. Furthermore, using this protocol will be indispensable for producing regional and national estimates of municipal waste composition. This will

[6] ΠΥΣ 39/31.8.2020 (ΦΕΚ185/Α/29.9.2020) *'Έγκριση του Εθνικού Σχεδίου Διαχείρισης Αποβλήτων (Ε.Σ.Δ.Α.)'*
[7] http://www.opengov.gr/minenv/?p=11440
[8] Ν.4736/2020 (ΦΕΚ 200/1/20.10.2020) *'Ενσωμάτωση της Οδηγίας (ΕΕ) 2019/904 σχετικά με τη μείωση των επιπτώσεων ορισμένων πλαστικών προϊόντων στο περιβάλλον και λοιπές διατάξεις '*
[9] In particular, according to the ToRs, it is stipulated:
a) 14 working days (FTE) are foreseen for the research, data collection, analysis and development of 25 pages for the Protocol for conducting sampling and analysis of unprocessed municipal solid waste;
b) 10 working days (FTE) are foreseen for the development of 10-15 pages of concrete proposals for the amendment of the JMD 114218/97.

play an extremely important role in improving the management of municipal waste in Greece and meeting the targets of the National Waste Management Plan 2020-2030.

Reliable compositional data will help municipalities, regional and central government, private waste contractors and anyone else involved in the collection, processing and management of municipal waste. However, this will only be possible if the data is collected in a consistent manner, thus the importance of following the instructions set out in this document.

Greece is obviously made up of a huge variety of different area types, from large urban conurbations to islands and rural areas. This protocol has been designed so that it is applied to a wide variety of locations. The protocol has been designed to be simple and clear, to ensure that it is possible to apply it universally across all the different areas of Greece.

There are a number of different possible approaches to analysing waste and this protocol specifies using a particular approach that is considered to be the most practical and affordable, involving sampling waste from collection vehicle loads. There are pros and cons to this approach, which are described in Section , so that readers can understand why this method has been chosen, and the challenges associated with this method.

Thereafter, the protocol provides practical instructions on how waste analyses should be carried out, as follows (Sections 0, 6 and **Error! Reference source not found.**):

- **Design a sampling plan**, which will determine:
  - waste streams to be analysed (residual and recycling collections at a minimum);
  - when the analysis will be carried out, with at least two phases to control for seasonal variation;
  - the collection vehicles whose loads will be sampled, with the collection rounds of those vehicle selected so as to broadly represent the municipality or area analysed.
- **Collect the sample from the collection vehicle**, with a random selection of material from the vehicle load being extracted.
- **Manually sort the selected material into specified categories** (data collection templates are provided with this protocol that describe the categories that must be used).
- **Measure and record the weight** of each category of material.
- Once all the samples in the sampling plan have been analysed, **produce the results for each individual sample, and calculate combined results from all the samples** to produce a compositional estimate for each waste stream.
- **Health and safety measures** are described in the protocol and must be followed, as there are several hazards associated with waste analysis which must be properly controlled.
- **Templates** for sampling, recording and reporting results are developed and presented.

## B. Proposals for the amendment of the Greek JMD 114218/1997

The **JMD 114218** ***'Establishment of a framework of technical specifications and of general plans for solid waste management'*** is acknowledged as a predominant Greek legal document with a great level of detail in terms of the provision of technical specifications and design principles for solid waste management in Greece. However, since it has been initially enacted in 1997, there is considerable progress made both a) in terms of technological updates and new standards and b) in terms of the new national and EU legal framework and policies on waste management and circular economy.

Thus, the focus of our work is on reviewing this framework and providing strategic guiding recommendations, as well as selective, more detailed proposals on particular Chapters or Articles where needed and in agreement with GIZ and the Ministry of Environment and Energy (YPEN).

Based on our previous work in reviewing relevant legislative frameworks in all EU Member States for DG Environment/ EC, we aim at focusing on the inter-related issues regarding technical specifications and standards for solid waste infrastructure, waste operations and related programs and schemes, with a view to transposing this to the Greek context. We also consider the existing national legal framework and regulations and base our recommendations on our local experience in solid waste management in Greece.

For the development of our proposals we designed a framework structure (Figure ) with the sections, subsections and articles included in the JMD in spreadsheet table format as we have done in our previous work for EC. The aim is to provide a clear classification and prioritisation of the relevant sections/articles with respect to the type and level of amendments required per case, such as:

- articles proposed to be repealed;
- articles to be partially amended;
- articles to be extensively amended;
- articles with no changes proposed.

**Figure 2-1 – Framework structure of the JMD in table format**

| Άρθ | Τίτλος | Προτεραιότ | Δράση | Σχόλια |
|---|---|---|---|---|
| Άρθρο 1 | Σκοπός | | | |
| Άρθρο 2 | Πεδίο εφαρμογής | | | |
| Άρθρο 3 | Πλαίσιο Τεχνικών Προδιαγραφών Διαχείρισης Στερεών Αποβλήτων | | | |
| **Παράρτημα Ι** | | | | |
| **1. ΤΕΧΝΙΚΕΣ ΠΡΟΔΙΑΓΡΑΦΕΣ ΣΥΛΛΟΓΗΣ –ΠΡΟΣΩΡΙΝΗΣ ΑΠΟΘΗΚΕΥΣΗ – ΜΕΤΑΦΟΡΑΣ ΣΤΕΡΕΩΝ ΑΠΟΒΛΗΤΩΝ** | | ΜΕΣΗ | Εκτενής Τροποποίηση | Έρευνα αγοράς για το τί είναι διαθέσιμο στη χώρα, τί χρηστιμοποιείται στην πράξη από φορείς<br>Επανεξέταση κριτηρίων επιλογής ΚΚΟΑ<br>Ο όρος "ζωλάτα" να παραμείνει<br>Προσθήκη πληροφοριών για μέσα συλλογής/μεταφοράς για χωριστά συλλεγέντα βιοαπόβλητα |
| 1. | Προσωρινή Αποθήκευση | | Εκτενής Τροποποίηση | Η ΚΥΑ στην οποία παραπέμπει το άρθρο καταργήθηκε από την Υ.Α Η.Π. 50910/2727/2003, η οποία με τη σειρά της καταργήθηκε από το άρθρο 95 παρ. β του Ν.4685/2020<br>Αντικαθίσταται από το Κεφάλαιο ι' και ειδικότερα το Άρθρο 83 του Ν.4685/2020 |
| 1.1. | Είδη μέσων προσωρινής αποθήκευσης (Μ.Π.Α) | | Διατηρείται ως έχει | |
| 1.1.1. | Σακούλες | | Ελάσσονα Τροποποίηση | Λαμβάνεται υπόψη η Οδηγία 2015/720 για τις πλαστικές σακούλες. |
| 1.1.2. | Κάδοι | | Εκτενής Τροποποίηση | |
| 1.1.2.1. | Κυλιόμενοι κάδοι οικιακών αποβλήτων (Κ.Κ.Ο.Α) | | Ελάσσονα Τροποποίηση | Ένταξη πρόβλεψης για κάδους βιοαποβλήτων.<br>Αφαίρεση του τμήματος για τις μικρές κοινότητες. |
| 1.1.2.2. | Τεχνικά χαρακτηριστικά κυλιόμενων κάδων οικιακών αποβλήτων (Κ.Κ.Ο.Α) | | Ελάσσονα Τροποποίηση | Το ΕΛΟΤ ΕΝ 840 έχει αναθεωρηθεί το 2012. |
| 1.1.2.3. | Κριτήρια επιλογής Κ.Κ.Ο.Α. από 80-1700 λίτρα | | | |
| 1.1.2.4. | Κάδοι σταθεροί | | Διατηρείται ως έχει | |
| 1.1.2.5. | Μεγάλοι υποδοχείς (Containers) | | Διατηρείται ως έχει | |
| 1.2. | Απαιτούμενη επιφάνεια για την τοποθέτηση των παρακάτω κυλιόμενων κάδων οικιακών αποβλήτων (Κ.Κ.Ο.Α) | | Διατηρείται ως έχει | |
| 2. | Συλλογή Στερεών Αποβλήτων | | Εκτενής Τροποποίηση | Η ΚΥΑ στην οποία παραπέμπει το άρθρο καταργήθηκε από την Υ.Α Η.Π. 50910/2727/2003, η οποία με τη σειρά της καταργήθηκε από το άρθρο 95 παρ. β του Ν.4685/2020<br>Αντικαθίσταται από το Κεφάλαιο ι' και ειδικότερα το Άρθρο 83 του Ν.4685/2020 |
| 2.1. | Οχήματα Συλλογής Μεταφοράς (Ο.Σ.Μ.) | | Διατηρείται ως έχει | Λαμβάνονται υπόψη οι προδιαγραφές ISO 43.160 |
| 2.1.1. | | | Ελάσσονα Τροποποίηση | Ονομασία άρθρου: Τεχνικά χαρακτηριστικά ΟΕΜ<br>Προδιαγραφές για συλλογή/μεταφορά βιοαποβλήτων βάσει ISO 43.160<br>Να ληφθεί υπόψη η πιστοποίηση CE |
| 2.1.2. | Οχήματα συλλογής-μεταφοράς αυτόματης πλάγιας φόρτωσης | | Ελάσσονα Τροποποίηση | Προστίθεται ότι για τη χρήση των οχημάτων συλλογής-μεταφοράς αυτόματης πλάγιας φόρτωσης απαιτείται ειδικός τύπος ΚΚΟΑ. |
| 2.1.3. | Δορυφορικά οχήματα | | Διατηρείται ως έχει | |
| 2.2. | Κριτήρια επιλογής Ο.Σ.Μ. | | Ελάσσονα Τροποποίηση | Προστίθενται κριτήρια:<br>-τύπος καυσίμου οχήματος<br>-ρεύμα ΑΣΑ για το οποίο θα χρησιμοποιηθεί (υπόλειμμα, ανακυκλώσιμα, βιοαπόβλητα κλπ) |
| 2.3. | Περιγραφή συστήματος ανύψωσης κυλιομένων κάδων στο Ο.Σ.Μ. | | Διατηρείται ως έχει | |
| 2.4. | Τρόποι πλύσης και απολύμανσης των κάδων | | Ελάσσονα Τροποποίηση | Προστίθεται πρόβλεψη για αυξημένη συχνότητα πλύσης και αποστείρωσης κάδων βιοαποβλήτων |
| 3. | Παράμετροι σχεδιασμού συλλογής Σ.Α. | | Ελάσσονα Τροποποίηση | Προστίθεται η δυνατότητα καθορισμού των δρομολογίων μέσω χρήσης σύγχρονων τεχνολογιών (GIS, smart systems κ.λπ) |
| 4. | Πλαίσιο τεχνικών οδηγιών για τη συλλογή των στερεών αποβλήτων | | Εκτενής Τροποποίηση | Λαμβάνεται υπόψη η ΚΥΑ οικ. 5688/2018 για τις Μ.Π.Ε.<br><br>Θραυσμένα **ή ελλατωματικά** Μ.Π.Α. πρέπει να επισκευάζονται μερίμνη του φορέα διαχείρισης.<br><br>Η συλλογή των βιοαποβλήτων λόγω της μικροβιακής τους αποσύνθεσης πρέπει να γίνεται το πολύ κάθε δύο μέρες.<br><br>"Η πλαστική σακούλα μπορεί να είναι παραδεκτή μόνο εφόσον είναι αδιαφανής, ανθεκτική και κλείνει γιατί οι ανοιχτές σακούλες εκτός από το αισθητικό πρόβλημα δημιουργούν και προβλήματα υγιεινής"<br><br>Η παράγραφος: "Πρέπει να διενεργούνται οι απαραίτητοι εμβολιασμοί στους εργάτες καθαριότητας, να φορούν τα ρούχα εργασίας, γάντια, μάσκες σε ειδικές περιπτώσεις. Επίσης είναι απαραίτητο το λουτρό μετά την εργασία του" αντικαθίσταται από την παράγραφο: "Οι εργάτες οφείλουν με ευθύνη του φορέα διαχείρισης να τηρούν όλα τα Μέτρα Ατομικής Προστασίας Μ.Π.Α. όπως προβλέπονται από την ΚΥΑ 43726/2019". |
| 5. | Πλαίσιο τεχνικών οδηγιών για την ασφάλεια του προσωπικού κατά τον πλήρη κύκλο συλλογής - μεταφοράς στερεών αποβλήτων | | Ελάσσονα Τροποποίηση | Η φράση "κατά τον ασφαλέστερο δυνατό τρόπο" αντικαθίσταται από την "βάσει των εγκεκριμένων πρωτοκόλλων υγιεινής και ασφάλειας". |
| 5.1. | Γενικά | | Διατηρείται ως έχει | |
| 5.1.1. | Έλεγχοι κατά τη λειτουργία | | Διατηρείται ως έχει | |
| 5.2. | Στους χώρους διάθεσης απορριμμάτων | | Διατηρείται ως έχει | |
| 5.2.1. | Είσοδος στο Χ.Υ.Τ.Α. | | Διατηρείται ως έχει | |
| 5.2.2. | Στη γεφυροπλάστιγγα | | Διατηρείται ως έχει | |

The level of amendments and technical details required were discussed with GIZ/YPEN and engagement with selective key stakeholders was accomplished to solicit valuable data. The stakeholder engagement was limited to the allocated time and resources as stipulated in the ToRs[10].

Our proposals on the amendment of the JMD 114218/1997 are high-level based on selected articles/ sections following engagement with YPEN. The level of detail with respect to the technical requirements set out in the JMD is reviewed in order: a) not to hamper the environmental permission, proper design and development of waste management infrastructure and systems, b) promote innovation and c) follow EU Best Available Techniques reference documents (BREFs).

[10] According to the ToRs, 2 working days are foreseen for the research and data collection to be accomplished, therefore limited stakeholder engagement and market research was carried out.

In terms of this report, the proposals for the amendment of the JMD (Section **Error! Reference source not found.**) are developed in Greek language, with a brief summary in English, as requested in the ToRs.

# 3. Preparation, Research and Data Collection

The main research and data tasks, up front, relate to:

a) **Identifying and engaging with selective stakeholders from regulatory bodies, competent authorities and industry to solicit available existing data,** such as:

- the Ministry of Environment and Energy (YPEN);
- the Hellenic Recycling Agency (E.O.A.N);
- the Managing Authority of the Operational Programme ''Transport Infrastructure, Environment and Sustainable Development (YMEPERAA)"
- waste management facilities (MBT/ Recycling Sorting Centres (RSCs or ΚΔΑΥ in Greek)/ transfer stations/ landfills) contractors/ operators in Greece.
- other key stakeholders (i.e. advisors, consultants engaged in related activities and bodies in the past, etc.)

The selection of key shareholders - not an extensive list – was contacted by email or/and structured telephone interviews, considering time and resource constraints during the lifetime of the project.

b) **Reviewing officially reported data and studies on waste composition analysis in Greece, such as:**

- the 2011 Study on waste composition analysis with respect to the previous NWMP 2015-2020;
- the 2018 data reported to YPEN (through questionnaires) from landfill operators or/and other competent authorities;
- previous relevant studies/ publications/ reports on waste composition analysis for Greece (i.e. study for the Region of Fokida (2012), Life projects in: Mun. of Chalandri (2020), etc.

c) **Considering other countries' approaches to setting protocols and guidelines and particular focusing on EU guidelines** regarding waste composition sampling and analysis. In particular, we draw on EU tools and standards and on our previous wide experience in waste composition analysis studies[11] and tailor our work with respect to the Greek context. Existing standards and methods we considered include the following:

- the Methodology for the Analysis of Solid Waste (SWA-Tool) developed for the European Commission (2004)[12].
- the European Standard EN 14899:2005 for the preparation and application of a sampling plan;
- the ASTM D5231-92 (2016) Standard Test Method for the Determination of the Composition of Unprocessed Municipal Solid Waste to the extend this is considered appropriate for the Greek context [13].

# 4. Analysis and Assessment of proposed methodological approaches

As mentioned, it is very important that any compositional analysis of municipal waste in Greece is carried out in a consistent manner, following exactly this protocol. There are various possible

[11] i.e.'National Household waste composition 2017', WRAP, January 2020, Eunomia Research & Consulting
[12] 'SWA-Tool, Development of a Methodological Tool to Enhance the Precision & Comparability of Solid Waste Analysis Data' under the 5th Framework Program, European Commission (March 2004)
[13] It is noted that our work primarily draws on the input from EU level (as prescribed in the ToRs). Input from other regions such as US is limited and carefully examined in terms of relevance to the Greek context.

methodologies for sampling municipal waste and this protocol specifies that sampling from collection vehicle loads is proposed to be used. This section provides the reasoning for selecting this methodology. Readers who want to go directly to the instructions of the protocol itself are advised to read from Section 5 onwards.

For the Greek context, two methodologies could be considered:

- *Container sampling,* with samples obtained from external waste bins/containers (such as used in kerbside collection);
- *Vehicle sampling,* with samples obtained from refuse or recycling collection vehicles, at the location where the vehicles tip their loads (transfer station, recycling sorting centre (RSCs), MBT, landfill site).

Another methodology in widespread usage is obtaining samples for individual households, but this is best suited to where kerbside collections from individual households is prevalent, whereas in Greece the main collection method is from street containers. Other available methodologies use visual assessments or surveys, but the quality of data obtained is much lower than for the methodologies considered here. Therefore, these alternative methodologies were not considered for this protocol.

*Container sampling* involves identifying and selecting street containers in various locations representative of the different area types in the municipality being studied. The material is collected in a sample collection vehicle (separately to the regular collection vehicle) just before the scheduled collection happens, in order to obtain an amount of material representative of that collection round. The material is taken to a suitable location (transfer station, etc) where each sample is manually sorted and the weights of each material category are recorded.

*Vehicle sampling* involves identifying a selection of collection rounds which are representative of the different area types in the municipality being studied. For the rounds selected, when the vehicle arrives at its tipping location (transfer station, etc) it tips the collected material in a separate designated area. Material is randomly extracted from the tipped load, such that a suitable sample size is obtained. The material is then manually or mechanically sorted and the weights of each material category are recorded.

The advantages and disadvantages of each methodology are summarised as follows:

**Table 4-1 Container sampling vs Vehicle sampling: Advantages and Disadvantages**

| Methodology | Advantages | Disadvantages |
|---|---|---|
| Container sampling | • Allows for more precise stratification of sample, associated with the container locations selected for the study.<br>• Sample is uncompacted, allowing for easier and more accurate sorting. | • Uncertainty about whether all the material obtained from the selected containers can be attributed to residents in the vicinity.<br>• Higher costs, separate sample collection vehicle required. Significant additional staff time required to collect the samples. More operationally complex. |

| Methodology | Advantages | Disadvantages |
|---|---|---|
| Vehicle sampling | • Samples are broadly representative of larger areas, associated with the collection rounds associated with the study.<br>• Simpler operationally, no separate collection of samples required.<br>• Lower cost, mainly due to no additional resources being needed to collect the samples and deliver them to the sorting location.<br>• Larger quantities sampled in shorter time periods. | • Less precise stratification of the samples.<br>• Extracting the sample from tipped loads requires some additional staff time.<br>• Mixing of waste in the vehicle results in some cross-contamination and therefore some inaccuracy in recorded weights, particularly moisture being absorbed by paper and cardboard.<br>• Where the waste is compacted, this makes it more difficult to sort the sample into separate categories. |

***Vehicle sampling*** entails considerable advantages and is predominantly used in EU. It has significantly lower costs than container sampling, and the samples are obtained from vehicles that are carrying out their normal collection rounds, and so there is no requirement to separately collect the samples from containers. This cost saving is slightly offset by additional effort needed with vehicle sampling to extract samples from tipped vehicle loads, but even so it is still much less expensive to carry out than container sampling.

Also, *vehicle sampling* is simpler operationally, with no separate sample collections required. It is essential that there is good planning and organisation of vehicle sampling in order to produce robust results. This is done through producing a sampling plan that carefully selects which vehicles will be included in the sampling programme, see Section 5 in detail. An important issue with vehicle sampling is the requirement to extract the sample from the tipped load. A typical refuse collection vehicle load can be around 4.5 tonnes, and it is not practicable for all of this material to be sorted. In this protocol, the amount of material required for the sample is approximately the amount that can be analysed within one working day by a four-person sampling team. Care must be taken to ensure that, as far as is practicable, the sample is randomly extracted from the whole pile, see Section 0 in detail.

On the other hand, ***Container sampling*** has the potential for producing precise results, due to more accurate sample stratification associated with the container locations and less mixing and compaction of the sample. However, it is often not possible to determine if the material deposited in the containers comes from the households in the vicinity that the containers are intended to serve. For example, businesses, or people who happen to walk past the containers may make use of them, since they are mostly located in public spaces and are effectively available for anyone to use.

An important criterion for the selection of the most suitable approach is the cost difference between the two approaches. As shown in the comparative table above the container sampling approach generates two significant cost issues: (i) separate sample collection vehicle required, additional to the scheduled routes, which would lead to increased fuel and personnel costs, and (ii) significantly more staff time required for the implementation of the protocol during all of the process' stages. Generally,

the significantly higher operational complexity of the container sampling approach could potentially lead to higher incidental costs during the usage of the protocol[14].

Considering the above and the diligent design and application of a vehicle sampling plan (Section 0), it is considered that the *vehicle sampling* methodology is able to produce accurate and precise data. Moreover, given the importance of cost considerations, and the likelihood that a lower cost approach will result in more waste composition analyses s being carried out, the selected methodology is *vehicle sampling*.

# 5. Sampling protocol

## 5.1 Sampling protocol: overview

The *sampling protocol* describes the methodology to obtain the material that will be analysed. As described in Section 4, vehicle sampling is proposed to be used. This means obtaining the samples from vehicles that carry out their regular collections, and then randomly extracting a portion of the material that they have collected, in order to then sort and weight that material into a standard set of categories. The methodology for sorting, weighing and analysing of the sample is described in Section 6.

The sampling protocol consists of the following tasks:

1. **Design a sampling plan** (Section 5.2), which will determine:
   - the type of waste streams to be analysed: residual and recycling collections at minimum, and also where applicable biowaste, paper, glass and industrial/commercial recyclable packaging;
   - when the analysis will be carried out, with at least two phases to control for seasonal variation;
   - the collection vehicles whose loads will be sampled, with the collection rounds of those vehicle selected so as to broadly represent the municipality or area analysed.
2. Check what **the size of each sample** should be (Section 5.3).
3. **Collect the sample from the collection vehicle** (Section 5.4), with a random selection of material from the vehicle load being extracted.
4. **Identify Health and Safety issues** (Section 5.5).

## 5.2 Sampling Plan

**Frequency of Sampling**

The proposed methodology shall be implemented in a 5-year basis[15] considering that no significant differentiations would be observed in shorter time frames. Furthermore, a 5-years frequency ensures that any amendments or updates of the National Waste Management Plan shall be considered as part of the analysis. Therefore, from a cost-effectiveness point of view it is preferable to invest in conducting analyses in additional geographical areas that would lead to more statistically significant results than to conduct more frequent samplings.

[14] A quantified comparison of the costs is not possible since indicative costs per cost item (personnel costs, fuel costs, subcontracting, area of analysis, waste transportation distance to area of analysis etc.) is case specific and varies significantly.
[15] Suggestion based on empirical data and previous experience in EU and other countries.

**Selecting the collection rounds by area type**

Initially it is important to develop a general overview of the municipality/region under investigation and the portion of the area to be involved in the waste analysis to provide a background context to the proposed study and assist in the round selection stage. The scope of the background context analysis is the identification of the various relevant geo-political districts and the levels at which relevant waste management data may be available.

**i. General population information:**

It is important to consider the distribution (within the municipality) of population, geo-political and economic characteristics:

- Type of area and economic activity
  - Agricultural
  - Touristic
  - Commercial
  - Residential
  - Other
  - Combination of the above
- Number of inhabitants and households and population density[16]
- Income distribution
- Types and proportions of residential structures (e.g. multi- or single-household establishments)

**ii. Waste Management information:**

Furthermore, the characteristics of the waste management plan implemented will also determine the selection of the collection rounds to be included in the sampling campaign. The characteristics to be considered are:

- Type of waste streams produced and collected (especially identification of areas where household and commercial waste are co-collected, e.g. commercial urban areas).
- Average numbers of households and/or persons using the containers.
- Waste weighing data (if available).

After developing an as much as possible in-depth understanding of the abovementioned characteristics of the area under investigation it is easier to proceed with collection rounds selection aiming at the best available representation of the various sub-areas in the final sample.

**Target waste and recycling streams**

Municipal kerbside residual and dry recycling collections will be sampled. If municipal biowaste collection is in place, and if these target materials other than food waste (such as garden waste, cardboard), then these could be included in the sampling plan, depending on whether targets have been set on municipal/regional or national level (i.e. via Local Waste Management Plans (WMPs), Regional WMPs, NWMP). Furthermore, other separately collected streams (where applicable) such as

[16] The 'equivalent population' (ισοδύναμος πληθυσμός) shall be considered.

paper, glass and industrial/commercial recyclable packaging, etc. shall also be included in the analysis as described in the following sections

**Sample selection and stratification**

For each study, the first stage will be to produce a sampling plan. Basic principles of the sampling plan are as follows:

- *Each kerbside stream to be sampled separately*: residual, recycling and (if appropriate) biowaste collections.
- *Two phases of sampling* to be carried out (indicatively) to control for seasonal variation and/or influx of tourists, or any other factors that can be expected to vary waste arisings by season, within a given year.
  Four phases of sampling can also be carried out (Winter, Spring, Summer, Autumn) in cases where higher level of detail is necessary. However, the most significant variations are expected to be provoked by the touristic activity (which is mainly increased during the second half of summer and during Christmas and Easter), hence two phases will provide a satisfactory level of detail without significantly increasing the budget expenditure. However, the selection of the time that samplings will be carried out should be conducted with attention to special events (e.g. Christmas period, Easter, summer high-season when people massively leave the urban centres etc.). Specifically, samplings should not take place during or around these periods of the year, when extreme (but occasional) variations will affect the accuracy and repeatability of the results. It is advised that at least one week before and after these periods will be allowed to conduct the samplings.
- *Five strata* for each stream and phase of sampling. This should comprise five collection rounds which correspond to five different areas that are representative of the municipality as a whole, in terms of population density, level of deprivation, housing type and economic activity.
  The number of strata that are necessary for each sampling campaign has been chosen considering two parameters: (i) even for really small municipalities/regions there should be at least 3 strata, to cover areas with different demographic and socioeconomic characteristics and (ii) a maximum number of 5 strata will sufficiently provide data even for the largest municipalities in Greece and only for cases of municipalities with more than 100,000 inhabitants it would be necessary to have more[17].

A basic example of a sampling plan is as follows:

| Collection stream | Phase 1: winter | Phase 2: summer |
|---|---|---|
| Residual | 5 samples, one for each stratum | 5 samples, one for each stratum |
| Recycling | 5 samples, one for each stratum | 5 samples, one for each stratum |
| Biowaste | 5 samples, one for each stratum | 5 samples, one for each stratum |

When selecting the collection rounds to be sampled, and therefore the strata associated with each round, it is important to consider what proportion of the municipality is represented by each stratum, as the results from each sample will need to be weighted in order to arrive at a

[17] Methodology for the Analysis of Solid Waste (SWA-Tool): User Version, European Commission, 2004

representative profile for the municipality as a whole. Guidance and worked examples is provided in Section 6.

## 5.3 Sample Sizes

The collection vehicles selected in the sampling plan (Section 5.2) will tip their loads in a separate designated area (Section 5.4). It is impractical for the whole vehicle load to be analysed. Therefore, only a proportion of the load tipped by the collection vehicle will be analysed.

The sample sizes specified in this protocol are such that a four-person sampling team would be able to sort and weight the material within one working day. In order to make this protocol practical for a wide range of circumstances, the sample sizes are given in terms of volume. This is because it is generally easier and less time consuming to assess the volume of a pile of material by measuring its dimensions, than it is to weigh the material.

**The size of each sample from each vehicle load will be at least 1.5 $m^3$**. This will apply to all samples, regardless of whether they are from residual, dry recycling or organics collection vehicles. The dimensions of a sample that will fulfil this requirement are:

- **Rectangular pile of dimensions: length 3m, width 1m, height 0.5m, or**
- **Circular pile of dimensions: diameter 2m, height 0.5 m.**

Further discussion of the rationale for the minimum sample size requirement is provided in Appendix 2.

## 5.4 Methodology: Obtaining the Samples

This section describes how the sample will be obtained from the collection vehicle.

1. **Designate separate area for obtaining the sample**

A separate suitable area where the vehicle can unload its waste safely must be identified. This area must be completely separate from other operations and activities, and be clearly designated with signage and traffic cones, of barrier tape if possible, to ensure that no other vehicles or mobile plant enter the sample collection area. The selected area should be of around 25-35 $m^2$, considering the amount of waste sample (1.5-3 $m^3$) and the need for space to tip a full load for the sample. If practicable, the area should be cordoned off with beacon tape. In most circumstances, the unloading area can be sited at the facilities where the collection vehicle carrying the sample would normally unload, such as a transfer station, RSC, MBT, landfill site or depot. This could significantly decrease the cost per sampling campaign (transportation cost and outsourced personnel costs). Furthermore, in cases where area availability allows this and all the Health & Safety protocols can be followed the analysis could be implemented in Green Points or other suitable waste collection sites within the boundaries of the Municipality. However, the sampling process in sites that the collection vehicle does not normally unloads shall be avoided. Where possible, a separate area (inside the selected waste facility) with concrete or hard standing surface should be selected.

If a hard standing area is not available, then a suitable flat area of solid ground should be used (with a suitable tarpaulin/ plastic covering if possible)[18].

A risk assessment must be carried out (see Section 5.5 below) to ensure that area is clearly designated and separated from other vehicle movements or operations at the facility. If any permit, in order to conduct the waste composition analysis, needs to be obtained at regional or municipal level, this needs to be considered during the planning phase.

**Selected collection vehicle unloads in the sampling area**

The collection crew for the selected vehicle will have been instructed in advance that they will tip their load off in the sample collection area. They will be directed to the unloading area. The sampling supervisor will check with the vehicle crew that the correct vehicle has been selected and confirm that they did their normal collection round. The identification of vehicle and time of arrival at the sampling area will be noted on the vehicle tracking sheet by the sampling supervisor. If there are any changes to the collection round (i.e. areas missed for any reason), this will be noted on the vehicle tracking sheet.

Once it is ensured that the vehicle is in the appropriate location to unload, and that all staff are in a safe location away from the vehicle and that it is safe to do so, the vehicle will unload its entire collection load onto the ground. The collection vehicle will then drive safely away from the area. For all vehicle movements, a risk assessment must be carried out and the required safety measures implemented (see Section 5.5).

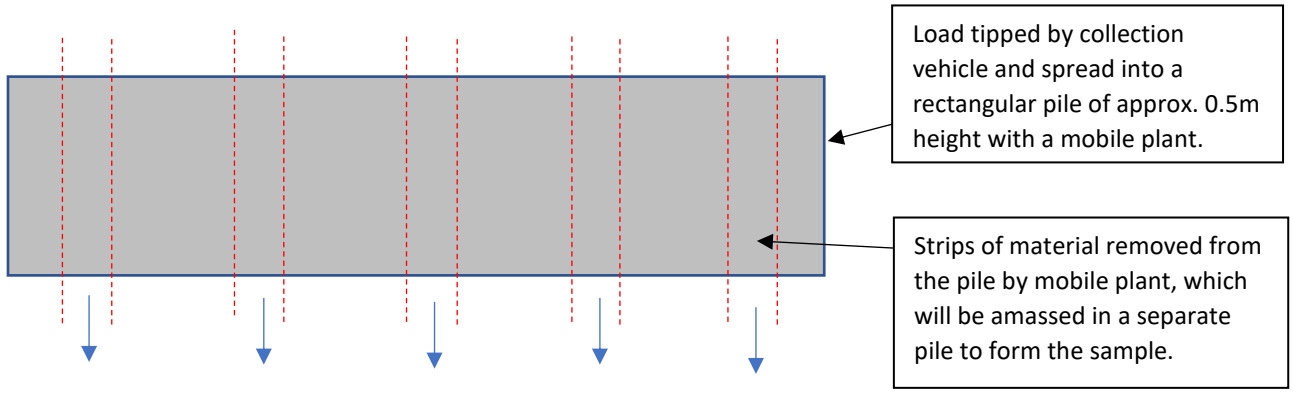
**Extracting the sample from the untipped load**

Depending on the specific capacity of the vehicle, this could leave a pile of material which could be of up to 10 $m^3$ in volume. From this pile, it is necessary to extract a sample of 1.5 $m^3$, and reasonable measures must be taken to ensure that the selected material is randomly selected from the pile. Coning and quartering is a common method for achieving this, but this is likely to be challenging for large loads of waste, especially where the waste has been compacted, and so it not advised for this protocol.

If a Front End Loader (FEL) or other suitable mobile plant (i.e. type of JCB) is available, this should be used to spread out the material on the ground so that it is forms a pile of roughly equal height, of about 0.5 m and which is laid out in a roughly rectangular strip. Thereafter, strips of material shall be removed from the pile, with the strips chosen in a random manner. Random selection shall be achieved by marking out with traffic cones where the strips will be extracted from along the length of the strip, with the marks being roughly equidistant from each other. The strip of material can be extracted using mobile plant, although the sampling team must stand outside the sampling area at a safe distance. The quantity of each strip will be pre-determined by the size of the JCB, hence in order to achieve a final sample of around 1.5 $m^3$ the distance between the strips -and so the number of strip- should be estimated accordingly.

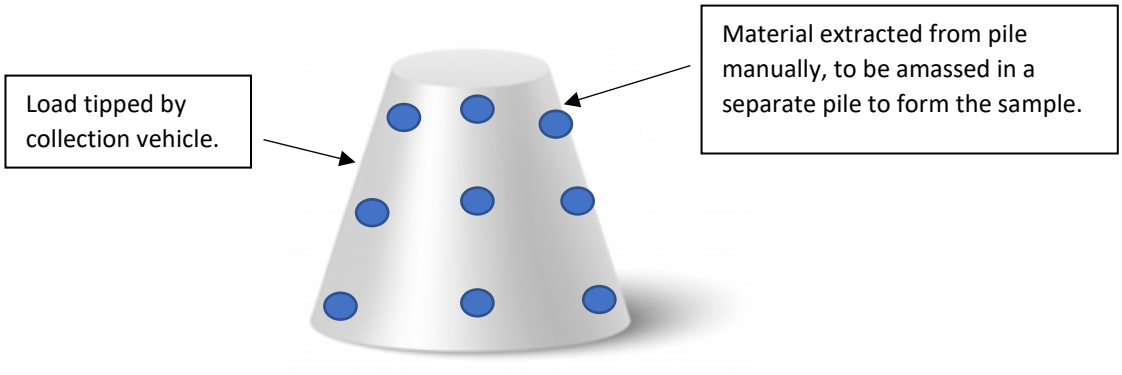
[18] If the sampling will take place in areas outside of waste facilities extra measures should be considered for leachate etc. even in concrete surfaces.

**Figure 5-1** ***Sample extraction from rectangular pile, using mobile plant***



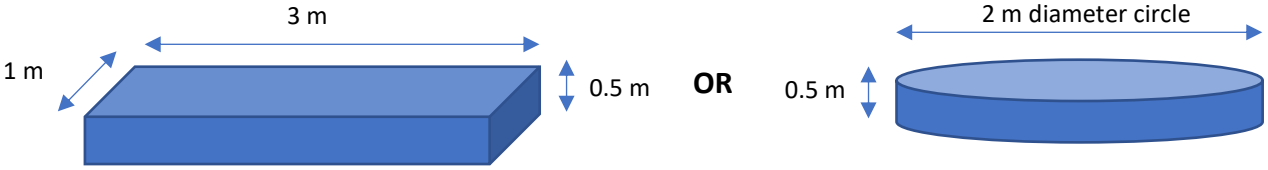

If a mobile plant is not available, it will be necessary to extract the sample from random locations from around the pile. This is far from ideal, as larger particles are likely to migrate towards the centre and the bottom of the pile, and therefore the sampling team should be mindful to, if possible, dig sufficiently into the pile, including near the bottom of the pile, so as to be obtaining as randomised sample as possible. In order to assist random selection, the perimeter of the pile should be marked with traffic cones (if available) at equidistant intervals, and material taken from near the bottom, middle and top of the pile by each of these markings. If the samples are extracted manually, the sampling team will need to use shovels and forks, or other suitable equipment (such as a wheelbarrow or tarpaulins) to extract and move the material.

**Figure 5-2 Manual extraction of the sample from tipped load**




The extracted material will be positioned in a separate pile and formed into a rectangular block of 0.5m height and 1m width and adding to the pile until a length of 3m is achieved. Alternatively (as indicated in Section 5.3), the sample can be amassed into a cylindrical pile of 0.5m height and 2m diameter.

**Figure 5-3 Minimum dimensions of the sample**

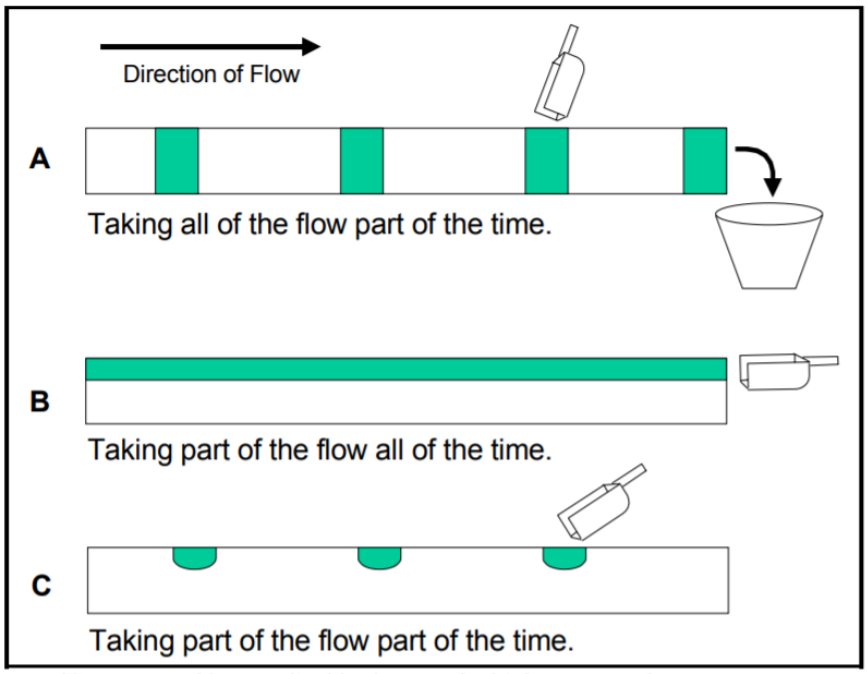


*Mechanical sampling (alternative option)*

Another approach in cases where the required equipment is available would be the mechanical sampling generation, through the utilization of conveyor belts. This is a narrowly used approached due to the fact that conveyor belts are rarely available and more costly to operate, however it could be proven the most accurate in terms of generating representative samples. The sample acquired through this approach would be an undisturbed cross section delimited by two parallel planes. As depicted in the following picture an ''unbiased'' sample can be obtained through collecting all of the conveyor belt's flow for part of the time. In practice, the condition can be me by using ''cross-stream'' sampling devices positioned at the discharge of a conveyor, hose, duct etc.

Three way of obtaining a sample from a moving stream/conveyor belt. ''A'' is the optimum for unbiased samples. ''B'' and ''C'' will obtain biased samples unless the material is homogeneous.

**Figure 5-4 Sampling from a conveyor belt, mechanical sampling**




**Adequate protection from natural elements for the sampling team and the sample**

The sample will need to be amassed in an area where it is protected from natural elements (rain, wind, etc). Therefore, an indoor area of a transfer station or similar facility would be ideal. Otherwise, if the weather is inclement, then a gazebo or similar protection of sufficient size will be required to provide shelter for the sampling team and to maintain the integrity of the sample. Alternatively, the sample can be loaded into a vehicle (for example by loading into bags, although care must be taken to include smaller particles from the sample) for transporting the sample and the sampling crew to a suitable indoor location where the sorting and analysis (Section 6) can be carried out in conditions that provide an adequate working environment for the sampling team, as well as protecting the sample from moisture or particles of the sample blowing away in the wind.

**Photographic evidence of the sample extraction**

The sampling supervisor should take photographs of the tipped load and the sample extraction procedure. These will be provided as a standard output as part of the results. The photographs should be given filenames that clearly indicate the date and location of the sample, so that they can be related to the sample. This evidence will be important in subsequently reviewing the results, as random sample extraction from tipped loads is a challenging part of the protocol's methodology, and it will be invaluable to understand how it has been carried out for each sample.

**Disposal of remainder of tipped load**

After the extraction of the sample, the majority of the tipped load will remain on the ground. A safe and practical procedure should be identified for loading this remainder into a suitable collection vehicle, to be taken to its normal tipping point. If mobile plant is available, this may be able to deal with the majority of this material, though if pushing walls are not present, this will leave some material on the ground which will be difficult to remove with mobile plant. In this case, any remnants will need to be manually loaded with shovels or other suitable tools into the back of a vehicle or into containers, for subsequent removal.

If a mobile plant is not available, it could be a significant manual operation to load the remainder into the back of a collection vehicle, and consideration should be given as to how this can be carried out safely and efficiently.

**Equipment required for the sampling protocol**

The following equipment and facilities are required for carrying out the sampling protocol:

1. **Separate area of hardstanding** for the collection vehicle to unload.
2. **Signage** and, if possible, **barrier tape** to mark off the sampling area.
3. Copy of the **vehicle tracking sheet**, to record which vehicle has provided load from which the sample will be taken.
4. **Camera or mobile phone**, to photograph the tipped load and sample extraction procedure.
5. **PPE and high visibility clothing** for the sampling staff (refer also to Section 6.4).
6. **For extracting the sample** from the pile of tipped material:
    - **Preferably: mobile plant**, that can manipulate the pile into a rectangular strip of reasonably uniform height, and which can remove strips of material from the pile;
    - **Alternatively**, and only if mobile plant is not available or practicable, **shovels, forks or other tools** that are capable of scooping out lumps of material from the pile.
7. **Traffic cones**, to mark off equal intervals along the pile from where material will be extracted.
8. **Wheelbarrow, tarpaulins, bins or other means to move the extracted material** to a separate place in the sampling area, where it can be amassed.
9. **Measuring tape and/or rods** to measure the depth and dimensions of the amassed extracted material, to ensure that the minimum sample size is achieved.
10. **If required for protection from the elements, a gazebo** of sufficient size, or similar, to provide shelter for the sampling crew, and to help maintain the integrity of the sample.

**Management, training and supervision**

Recruitment tasks for the sampling protocol include the following:

- Appointing a manager who will produce (or oversee the production of) the sampling plan (Section 5.2) and manage the whole sampling and analysis programme.
- Recruiting and overseeing a sampling team, which should consist of a suitably capable sampling supervisor, and three sampling operatives.

Once the sampling team is appointed, the sampling supervisor will need to become familiar with this protocol, and with the particular sampling plan produced for the municipality.

The crews for the collection rounds that have been identified in the sampling plan will need to be informed beforehand, so that they know to liaise with the sampling supervisor at the designated location for tipping the sample load. Where operationally feasible, the collection crew will be asked to avoid or to minimum compaction, so long as this does not affect their normal collection round. The collection crews will also be given instructions on following the relevant health and safety procedures for unloading the samples (Section 5.5). This is extremely important, in view of the high level of risk associated with the movement of collection vehicles.

A training session should be provided to the sampling operatives by the sampling supervisor, prior to any sampling taking place. This should explain all relevant aspects of the sampling and analysis protocol, all health and safety measures, and why it is important that these are followed.

If mobile plant is to be used to manipulate the tipped load and extract material for the sample, the driver must be given clear instructions on the sample extraction methodology (described above in this section) and health and safety measures. If mobile plant is to be used for sample extraction, the sampling team will also be provided health and safety instructions on keeping at a safe distance from mobile plant operations. Again, this is very important in view of the risks associated with the operation of mobile plant.

## 5.5 Health and Safety: Obtaining the Samples

Health and safety measures relating to the obtaining of samples have been mentioned already, but are dealt with separately here. The guidance provided here is general in nature, and it is the responsibility of users of the protocol to ensure that their own risks assessments are carried out and that health and safety measures are enacted and ensuring that statutory Health and Safety rules are followed[19]. Having said this, the key health and safety measures associated with the sampling protocol will include the following:

- Most importantly, **controlling risks associated with the movement and operation of collection vehicles and mobile plant.** This will include, but not be limited to:
    - **Clearly designating an area separate from other plant and vehicle movements**, for the unloading and obtaining of the sample, **marked off through use of signage, traffic cones and, where possible, barrier tape**.
    - Ensuring that the **collection vehicle crews and mobile plant drivers are instructed in the health and safety procedures**.
    - **Ensuring that all members of the sampling team, and any banksmen for directing vehicles or plant, maintain a safe distance from moving or operating vehicles or plant.**

[19] As described and specialized in the JMD 43726/2019: https://www.e-nomothesia.gr/autodioikese-demoi/koine-upourgike-apophase-437262019.html

- **Ensuring that the sampling team wears high visibility clothing and PPE at all times** (PPE for the analysis phase is described in Section 6.4).

- **Manual handling procedures**:
  - **If a mobile plant is used to extract the material for the sample, it will still need to be manipulated manually into a separate pile** of specific shape and dimensions in order to ensure that the minimum sample size is achieved.
    - This may **involve loading the extracted material manually with shovels onto a tarpaulin or into a wheelbarrow and moving it to a separate location** away from the remainder of the tipped load.
    - **Proper manual handling procedures should be followed,** particularly if heavy loads of materials are moved about.
  - **If mobile plant is not available, then material will need to be extracted manually** from the tipped pile.
    - **A separate risk assessment should be carried out** for this, as indicated in Section 5.4
    - For removing material from near the top of the pile, where possible long handled shovels or other tools should be used. **Any climbing onto the pile, or onto a stepladder, in order to reach near the top of the pile, must be avoided.**
    - **Care should be taken to ensure that the pile is not made unstable** through the removal of material.
    - **If it is not safe to obtain material from any part of the pile, then material should be obtained from those parts of the pile from which they can be safely removed.** This will reduce the randomness of the sample, but it is a higher priority to ensure that the procedure is safe for the sampling team.
    - As part of this protocol, the sampling supervisor must take photographs of the sample extraction, and this should include demonstrating any deviations from random material extraction on the grounds of health and safety.

Further health and safety measures pertain to the analysis phase of the protocol (Section 6.4).

# 6. Analysis protocol

## 6.1 Analysis protocol: overview

The analysis protocol describes how the collected sample will be sorted into standard categories and weighed, and how the results will be recorded and used to calculate municipal level estimates. Considerations relating to the calculation of regional and national estimates are provided in Appendix 1.

The analysis protocol consists of the following tasks:

1. **Manually sort the selected material into specified categories,** as set out in Section **Error! R eference source not found.**.
2. **Measure and record the weight** of each category of material, using the data collection templates provided (Section 5).
3. Once all the samples in the sampling plan have been analysed, **produce the results for each individual sample, and calculated combined results from all the samples** to produce a compositional estimate for each waste stream, as described in Section 6.5.
4. **Report and submit the results to the relevant authorities**.

## 6.2 Waste Category list

According to the proposed methodology, a set of sorting categories are defined in accordance with the waste categories listed in the National Waste Management Plan 2020-2030 for the municipal solid waste, defined by the six-digit EWC code for the waste.

In particular, a waste category sorting list is developed containing the compulsory primary categories (1st level sorting) and a number of recommended secondary waste categories (2nd and 3rd level sorting) which provide additional waste composition details according to their local waste information requirements and with respect to the Greek context.

The following table presents the proposed primary and secondary sorting categories and provides examples of materials or items that would be found in the subcategories of the category list used in this report. This is not intended to be a definitive or exhaustive list.

**Table 6-1 Proposed Waste Category list**

| Category Level | Waste Category | Waste code | Description (Directive 2000/532/EC) | Examples |
|---|---|---|---|---|
| **1** | **Food Waste** | 20 01 08 | biodegradable kitchen and canteen waste | Edible products not consumed originated in domestic kitchens or commercial/industrial canteens. |
| **1** | **Consumable liquids, fats & oils** | 20 01 25 | edible oil and fat | cooking oil residues from restaurants |
| **1** | **Garden waste** | 20 02 01 | garden and park wastes (incl. cemetery waste) biodegradable waste | Flowers, grass, leaves, pruning, branches, weeds |
| **1** | **Paper and cardboard** | 20 01 01<br>15 01 01 | paper and cardboard<br>paper and cardboard packaging | |
| ***2*** | ***2nd level: Recyclable paper*** | | | |
| 3 | Packaging paper | 15 01 01 | paper packaging | Paper bags, wrapping paper |
| 3 | News, mags, brochures, catalogues & directories | 20 01 01 | | Press, books, paper sheets, paper for writing |
| 3 | Other recyclable paper | 20 01 01 | | Books, paper sheets |
| ***2*** | ***2nd level: Non-recyclable paper (low grade paper)*** | **20 01 01** | | Tissues, wrapping paper that is laminated or contains foreign materials such as foil-coatings or glitter, photographic film, microwave containers, hardcover books, frozen food boxes, thermal fax paper, carbon paper, blueprints, aluminum foil boxes and binders |
| 3 | Non-recyclable paper | | | |
| ***2*** | ***2nd level: Cardboard*** | **15 01 01** | cardboard packaging | Cereal boxes, egg cartons, tissue boxes, toy boxes |
| 3 | Cardboard (thin card, thick & corrugated card) | | | |
| ***2*** | ***2nd level: Composite food and drink cartons (e.g.Tetrapak®)*** | **15 01 05** | composite packaging | Milk boxes, juice boxes, plastic film pack and containers, coffee capsules |

| Category Level | Waste Category | Waste code | Description (Directive 2000/532/EC) | Examples |
|---|---|---|---|---|
| **1** | **Glass** | 20 01 02<br>15 01 07 | Glass<br>glass packaging | |
| 3 | Packaging glass | 15 01 07 | | Beverages bottles and jars, food jars, medicine bottles |
| 3 | Non-packaging glass | 20 01 02 | | Pyrex, drinking glasses, flat glass, windows |
| **1** | **Ferrous Metals** | 20 01 40<br>15 01 04 | Metals<br>metallic packaging | |
| ***2*** | ***2nd level: Ferrous cans (drink & food cans)*** | | | |
| ***2*** | ***2nd level: Ferrous non-cans*** | | | |
| 3 | Other ferrous packaging (incl. aerosols) | | | Deodorant, perfume |
| 3 | Other ferrous non-packaging | | | Bike/car parts, cutlery, keys, paper clips, rings, screws |
| **1** | **Non-Ferrous Metals** | 20 01 40<br>15 01 04 | Metals<br>metallic packaging | |
| ***2*** | ***2nd level: Non-ferrous cans (drink & food cans)*** | | | Biscuits, carbonated drinks, fish, pet food |
| ***2*** | ***2nd level: Non-ferrous non-cans*** | | | |
| 3 | Aluminium foil | | | Aluminium foil |
| 3 | Other non-ferrous (incl. aerosols) | | | Bike/car parts, cutlery, keys, paper clips, rings, screws |
| **1** | **Plastic** | 20 01 39<br>15 01 02 | Plastics<br>plastic packaging | |
| ***2*** | ***2nd level: Plastic bottles*** | | | |
| 3 | PET bottles | | | Water bottles, beverage bottles |
| 3 | HDPE bottles | | | Beverages bottles, liquid soap, detergents |
| 3 | Other plastic bottles | | | |
| ***2*** | ***2nd level: Dense plastic non-bottles*** | | | |
| 3 | Dense plastic packaging | | | Egg packaging, cleaning products tubes, cosmetic products tubes, plastic tops, yoghurt jars |
| 3 | Dense plastic non-packaging (incl. pots) | | | Pots, credit cards, buttons, CDs, pens, |

| Category Level | Waste Category | Waste code | Description (Directive 2000/532/EC) | Examples |
|---|---|---|---|---|
| | | | | WC tops, hose, gardening tools, lighters |
| 3 | Polystyrene | | | PS packaging for fishes,<br>PS cover for fragile packaging |
| ***2*** | ***2nd level: Plastic film*** | **20 01 39**<br>**15 01 02** | Plastics<br>plastic packaging | |
| 3 | Carrier bags | | | Supermarket bags, shops bags, trash bags |
| 3 | Other packaging plastic film | | | Biscuits wrapping, cereal bags,<br>frozen food bags, sandwich bags |
| 3 | Non-packaging plastic film | | | Tape, tarpaulin, waxed canvas |
| **1** | **Wood** | 20 01 38<br>15 01 03 | wood other than that mentioned in 20 01 37<br>wooden packaging | |
| 3 | Wood (treated, non-treated) | | | Fiberboard, solid wood |
| 3 | Wooden packaging | | | Wood boxes, cork packaging and wrapping |
| **1** | **Textiles** | 20 01 10<br>20 01 11<br>20 01 09 | Clothes<br>Textiles<br>textile packaging | |
| ***2*** | ***2nd level: Clothing, shoes, bags & belts*** | | | |
| 3 | Clothing | | | Trousers, skirts, shocks, shirts, jumpers |
| 3 | Shoes, bags & belts | | | Shoes, sandals, belts, bags, leather bandages |
| ***2*** | ***2nd level: all non-clothing textiles*** | | | |
| 3 | Carpets | | | Various types of carpets |
| 3 | Other non-clothing textiles | | | Curtains, pillow, cases, pillows, rope,<br>mats, sheets, towels |

| Category Level | Waste Category | Waste code | Description (Directive 2000/532/EC) | Examples |
|---|---|---|---|---|
| **1** | **WEEE** | 20 01 21*<br>20 01 23*<br>20 01 35*<br>20 01 36 | -fluorescent tubes and other mercury-containing waste<br>-discarded equipment containing chlorofluorocarbons<br>-discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components<br>-discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35 | Electrical and electronic appliances, light bulbs (normal, fluorescent, energy saving). |
| 3 | Large WEEE | | | Home appliances, smart systems |
| 3 | Small WEEE | | | PCs, laptops, monitors, TVs |
| **1** | **Hazardous** | | | |
| 3 | Household Batteries | 20 01 33* | -batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries<br>-batteries and accumulators other than those mentioned in 20 01 33 | Different types of household batteries:<br>acid (lead), nickel-cadmium, other domestic batteries, car batteries etc. |
| 3 | Paints and varnishes | 20 01 27* | paint, inks, adhesives and resins containing hazardous substances | |
| 3 | Medicine | 20 01 31* | cytotoxic and cytostatic medicines | Medical residues, medical equipment residues, syringes |

| Category Level | Waste Category | Waste code | Description (Directive 2000/532/EC) | Examples |
|---|---|---|---|---|
| 3 | Other household hazardous waste | 20 01 13*<br>20 01 14*<br>20 01 15*<br>20 01 17*<br>20 01 19*<br>20 01 23*<br>20 01 26*<br>20 01 29*<br>20 01 37* | Solvents, Acids, Alkalines, Photochemicals, Pesticides, discarded equipment containing chlorofluorocarbons, oil and fat other than those mentioned in 20 01 25, detergents containing hazardous substances wood containing hazardous substances | Asbestos, fire extinguisher, domestic and garden chemical products, glue and solvents, methyl alcohol, mineral oil, filters, engine products, photo chemical products, cooling products |
| **1** | **Misc combustible** | | | |
| 3 | Sanitary products (incl. Absorbent Hygiene Products, etc.) | | | Sanitary towels and tampons, bandage, cotton, swab |
| 3 | Furniture | 20 03 07 | other municipal wastes bulky waste | Sofas, beds, tables, chairs |
| 3 | Mattresses | 20 03 07 | other municipal wastes bulky waste | Different types and sizes of mattresses |
| 3 | Other misc combustible | | | |
| **1** | **Misc non-combustible** | | | |
| 3 | Soil and stones | 20 02 02 | garden and park wastes (incl. cemetery waste) Soil and stones | soil, stones, pebbles, ceramic fragments |
| 3 | Other misc non-combustible (incl. plasterboard, etc.) | | | Plasterboard, bricks, gravel, ceramic, clay pots, porcelain, crockery |
| **1** | **Fines** | | | Ash, sand, small pieces <10 mm from any category |
| **1** | **Other wastes** | | | Rubber, cigarette buts |

## 6.3 Methodology: analysis of samples

**Suitable area for conducting the analysis**

A suitable area must be designated for carrying out the analysis of the sample. In many cases, this can be within the area for obtaining the sample described in the sampling protocol, see Section 5.4. However, this will only be suitable if the area is adequately sheltered (protection from sun, rain, wind, etc). Therefore, an indoor area of a transfer station or similar facility is ideal. Otherwise, a gazebo or similar protection of sufficient size will be required to provide shelter for the sampling team and to maintain the integrity of the sample.

Alternatively, the sample can be loaded into a vehicle (for example by loading into bags, although care must be taken to include smaller particles from the sample), and transporting the sample and the sampling crew to a suitable indoor location where the sorting and analysis (Section 4) can be carried out in conditions that sufficiently sheltered so as to provide an adequate working environment for the sampling team, as well as protecting the sample from rain or particles of the sample blowing away in the wind.

Similarly to the sampling protocol, the analysis area must be clearly marked off from other activities or operations that may be taking place at the facility, with signage, traffic cones and, where possible, barrier tape. Personnel at the facility must be informed that the analysis is being carried out, and they must be instructed to take due care in keeping clear of the analysis area.

**Analysis protocol: equipment required**

Suitable equipment that is fit for purpose is essential for the analysis phase of the project, and will consist of the following:

- **PPE for the sampling team** (see also Section 6.4):
    - High visibility tops.
    - Steel toe capped boots.
    - Anti-puncture gloves.
    - Overalls (splash proof and sharp proof).
    - Hard hat with eye protection screen, or helmet with protective glasses.
    - Masks with filters to prevent breathing in organic vapours, acid gases, ammonia, dust particles; and if appropriate for protection from Covid-19.
    - If the working environment is noisy, ear protection.
- **Fire extinguisher**, in case of flammable materials catching light.
- **Water, food and drink**, though this must be kept clean in sealed containers away from the sample, and team members must wash their hands and face prior to eating or drinking.
- **Medical and sanitary equipment**, including:
    - First aid kit
    - Anti-bacterial hand and face wash
    - Eyewash kit
    - Wet wipes.
- **Sorting tables**:
    - **1 or 2 tables, with a combined area of at least 4 m2** (for example, two tables of 2 $m^2$ area at a minimum).
    - If it is possible to obtain **tables with a 10 mm screen** that will make the sorting process more efficient.

        - **Otherwise, a separate manually held 10mm screen** will be required.
    - The tables must be on legs that are sturdy enough to bear significant weight.
- **Electronic platform scales** with a minimum surface area of 60 x 60 cm, with maximum weighing of up to 300 kg and accuracy to within 50 grams. The scales must be calibrated and have an internal rechargeable battery and waterproof keyboard.
- **Containers, bins or sacks in sufficient numbers to cover all the categories** in the list (Section **Error! Reference source not found.**), with additional spare containers.
    - **Waterproof and clearly legible labels** for each category being separated, to be attached to the relevant containers or bins.
- **Cutters** for opening refuse sacks
- **Magnets** to enable distinguishing between ferrous and non-ferrous metals
- **Data recording sheets** with waterproof cover, using the relevant data templates (Section 7).
    - **Wherever possible, a laptop or tablet for live inputting of the data** into the relevant Excel template (Section 7).
- **Shovels, brooms, bins and refuse sacks for disposal of the samples** once they have all been analysed, and to clean the area afterwards.

**Sorting the sample into categories**

Analysis of the sample must be completed within 24 hours of it being unloaded at the sampling location by the collection vehicle.

The sampling supervisor will ensure that the identity of the sample from the sampling plan, including the identity of the vehicle that delivered the sample, and the relevant date and location, are recorded at the top of the data collection template (Section 7).

The sorting table(s) will be positioning adjacent to the sample. As described in Section 5.4, the sample will be at least 1.5 $m^3$ in volume, laid out in the pile that is 0.5 m high. A manageable portion of the sample will be placed on the sorting table(s). The sampling supervisor will check that the area is safe and that the team understands the task. Obviously, the first analysis that is carried out will require particularly careful management by the sampling supervisor.

The sampling team will then methodically and carefully sort the material into the different categories set out in Section **Error! Reference source not found.**. Clearly labelled containers will be required for e ach category. In terms of the and their positioning in the sampling area, there is likely to be a degree of trial and error as the sampling progresses, in terms of positioning containers so that the sorting can be carried out more efficiently, with more commonly occurring categories being positioned closer to the sorting table. Particularly during the first analyses carried out, the supervisor should check carefully that the team is putting items in the correct container (or sacks), and to catch any errors or misunderstandings about categorisation early on.

There may also be a degree of trial and error in assessing the capacity of containers required for each category. It may be that containers for some categories fill quickly and need to be weighed off (see below) and emptied before sorting of that category can continue. The sampling supervisor should note which categories this pertains to, so that a larger container can be used when the next sample is analysed. The requirements for capacities of containers will obviously vary for analysing refuse, dry recycling or organics, and the sampling supervisor should ensure that the appropriate array of containers of sensible capacities is available for each stream analysed.

The first sample analysed is likely to take the longest time, and some allowance should be made for that, in terms of anticipating that one or two hours over a usual working day may be required on the first day. This could be mitigated by carrying out a 'test analysis', before the sampling plan is enacted, as part of the team's training.

The most time-consuming stream to analyse will be refuse, with dry recycling and organics likely to be much quickly (although for organics it can be a fiddly process if it involves separating bits of food from garden waste). If the sample is obtained from a compacted load, that increases the challenges, and often it will be necessary for composite lumps of material to be pulled apart. There will also be more mixing between categories, for example moisture leaking into paper and cardboard. However, reasonable efforts should be made to separate items down to a roughly 10 mm x 10 mm x 10 mm size (roughly the size of a sugar cube), where is it practicable to do so.

**Separating fines**

Any particles in the sample that are smaller than 10 mm x 10 mm x 10 mm should be put in the 'fines' category (Section **Error! Reference source not found.**). The separation of fines is quicker if the sorting t able is fitted with a 10 mm screen, as the fines will fall through the screen, where they can be collected in trays or containers positioned under the table. If a sorting table of this type is not available, the procedure will be to sort all the items on the table surface which are obviously larger than 10 mm x 10 mm x 10 mm, and then to sweep the remaining material onto a manually held 10 mm screen, with a tray or container below to collect the fines. Any particles not passing through the screen will then be sorted into the relevant categories.

**Items that are problematic to sort**

Some items may present dilemmas in terms of which category to select. For example, would an unopened tin of food go into food waste or metal? Ideally, the tin would be opened, the food tipped into the container for food waste, and the tin in the appropriate metal container. However, if this is not operationally feasible (for example due to time pressures), then in this case the judgement would probably be to put the unopened tin in the food waste (as the food is likely to weigh more than the tin), and for the sampling supervisor to make a note in the data collection sheet that food waste includes some unopened tins.

**Weighing and recording results**

When the sorting is complete (or if the container a particular category is filled up), each category should be weighed on the electronic scales of the type specified under 'Analysis protocol: equipment required' above. The scales should be tarred to the weight of each container, or the weight of the container must be recorded and subtracted from the total weight, to arrive at a weight only for the material in each category. Where it has been necessary to weigh off several times for a category (due to the container becoming full during the sort), then the weights must be totalled to arrive at a total weight per category for the sample. The data collection template Excel file (see Section **Error! R eference source not found.**) is set up to enable these calculations to be carried out easily.

Each bit of weighing data must be recorded on the data collection sheet, or preferably directly entered into the Excel template using a laptop or tablet. Each weighing should be checked and confirmed by another member of the sampling team, and the data entry should be double checked as well. It should be remembered that most of the weighing and data recording will take place at the end of the working

day, when the team members may be tired and more prone to making errors, and therefore double checking of each weight and data entry is vital.

**Disposal of the sample**

Once all the sample has been sorted and the weighing and data recording is complete, the sample must be properly disposed of. If recycling facilities are available, and if it is practical and safe to do so, recyclable fractions can be sent for recycling. Otherwise, the material will be aggregated and disposed of in a suitable manner. If this involves loading into a collection vehicle, or moving the material with mobile plant, the appropriate health and safety measures must be enacted to keep the sampling team at a safe distance from vehicle or mobile plant operations.

## 6.4 Health and safety: analysis of samples

The guidance provided here is general in nature, and it is the responsibility of users of the protocol to ensure that their own risks assessments are carried out and that health and safety measures are enacted and ensuring that statutory Health and Safety rules are followed. Having said this, the key health and safety measures associated with the analysis protocol will include the following:

- With regards to the analysing sample, there several **potentially hazardous items or materials** that can be present, and the **risks from these must be adequately controlled**:
    - Cuts and punctures from sharp objects (needles, broken glass, razor blades, etc.)
    - Slipping and falling, particularly if wet materials fall onto the ground
    - Hazardous chemicals
    - Medical wastes and sharps
    - Sanitary or other items contaminated with blood or human waste
    - Animal faeces
    - Hypodermic needles.
- **All members of the sampling team must be provided with and wear the following PPE**:
    - High visibility tops.
    - Steel toe capped boots.
    - Anti-puncture gloves.
    - Overalls (splash proof and sharp proof).
    - Hard hat with eye protection screen, or helmet with protective glasses.
    - Masks with filters to prevent breathing in organic vapours, acid gases, ammonia, dust particles; and if appropriate for protection from Covid-19.
    - If the working environment is noisy, ear protection.
- An area must be available **where team members can rest and cool off if they start experiencing symptoms of heat stress or fatigue**.
- **A fire extinguisher must be available**, in case of flammable materials catching light.
- **Risks from slips and falls must be controlled**, particularly if wet materials fall onto the ground.
- **Medical and sanitary equipment**, including:
    - First aid kit
    - Anti-bacterial hand and face wash
    - Eyewash kit
    - Wet wipes.
- **Hands and faces must be washed before eating or drinking**. Eating, drinking or smoking during sorting is prohibited.

- The **sampling team members should all be in good health** and not sensitive to odours or dust.
    - Preferably, sampling team members will have had vaccinations for tetanus, polio, Hepatitis A and Hepatitis B.
- **Training for the sampling team**:
    - All health and safety measures
    - First aid training for at least one team member
    - Identification of hazardous items in the sample, and understanding that the sampling supervisor should be informed when they arise
    - Fire drills or relevant emergency plans for the facility where the analysis is being carried out.
- As per Section 5.5, **controlling risks associated with the movement and operation of collection vehicles and mobile plant**. This will include, but not be limited to:
    - Clearly designating an area separate from other plant and vehicle movements, for analysing the sample, marked off through use of signage, traffic cones and, where possible, barrier tape.
    - Ensuring that vehicle crews and mobile plant drivers are instructed in the health and safety procedures.
    - Ensuring that all members of the sampling team, and any banksmen for directing vehicles or plant, maintain a safe distance from moving or operating vehicles or plant.
    - Ensuring that the sampling team wears high visibility clothing at all times.

Health and safety measures that pertain to the sampling phase of the protocol are described in Section 5.5. Finally, to note that the Health and Safety recommendations that will be contained in the methodology shall be in accordance with the statutory Health and Safety rules in Greece.

## 6.5 Calculation of results

The necessary calculation equations for performing the required data analysis is developed in a standard spreadsheet (ex. excel) template. In particular, the results for each sample analysed will be recorded in the Excel data collection template (Section 7).

According to the sampling plan (Section 5.2), there will be 5 samples analysed for each waste stream, with each sample taken from a vehicle representing a different area type within the municipality. Two phases of sampling will also be carried out. The details of how to select the area types and the associated collection rounds are provided in Section 5.2. In terms of calculation method, we will refer to the selected collection rounds simply as Round 1, Round 2, etc. Therefore, the data collected during the whole sampling plan will consist of:

**Table 6-2 Waste Composition Analysis database**

| RESIDUAL WASTE | | DRY RECYCLING | | ORGANICS | | OTHER WASTE STREAM (when applicable) | |
|---|---|---|---|---|---|---|---|
| **Phase 1** | **Phase 2** | **Phase 1** | **Phase 1** | **Phase 2** | **Phase 2** | **Phase 1** | **Phase 2** |
| Round 1 | Round 1 | Round 1 | Round 1 | Round 1 | Round 1 | Round 1 | Round 1 |
| Round 2 | Round 2 | Round 2 | Round 2 | Round 2 | Round 2 | Round 2 | Round 2 |
| Round 3 | Round 3 | Round 3 | Round 3 | Round 3 | Round 3 | Round 3 | Round 3 |
| Round 4 | Round 4 | Round 4 | Round 4 | Round 4 | Round 4 | Round 4 | Round 4 |
| Round 5 | Round 5 | Round 5 | Round 5 | Round 5 | Round 5 | Round 5 | Round 5 |

**Weighting results by round**

When calculating a combined composition profile from this data, the first consideration will be what proportion of the municipality is made up by each area type. The most reliable way of doing this is on the basis of the number of dwellings of each area type. For example, if Round 1 is from the area type “High rise apartments, low income households”, and it is known that these account for 10% of dwellings in the municipality, it will be concluded that the sample from Round 1 represents 10% of the municipality, as far as calculation of compositional estimates is concerned. For this to be done successfully, it will be necessary for reliable data on the number of dwellings of each of the five areas types represented in the sampling plan to be available, and the percentage of dwellings must be based on the total dwelling for those five area types. The calculation will be as follows:

> Proportion of Area Type X dwellings = Number of dwellings in Area X / Number of dwellings in Areas Types 1, 2 3, 4 and 5 combined.

Calculated in this way, the proportion of dwellings will be normalised so that they add up to 100%.

However, in many cases the same Area type will be represented by more than one of the collection rounds in the sample. If, for example, it is known that 60% of dwellings in a municipality are of the area type “suburban middle income households”, it would be sensible in the sampling plan for three of the samples to be collected from these areas, as this would make up 60% of the sample. Therefore, duplication of areas types in the rounds needs to be accounted for in the above calculation.

Where data is lacking, or if the calculation is deemed too complex, it is recommended that a default assumption of each Round representing 20% of the municipality is applied. This effectively weights all the rounds equally. This could introduce sampling errors if some the rounds are from areas that represent much less than 20% of the dwellings in the municipality. However, if the guidance in Section 5.2 on producing the sampling plan is followed, this will reduce any sampling errors arising from applying equal weighting to all samples. Moreover, it will be still possible to calculated weighted composition profiles by area type at the regional and national level (see Appendix 1).

The data collection template Excel (see Section **Error! Reference source not found.**) includes equal w eighting by round as a default, but with the option to weight rounds as described above. As indicated in the template, if non-equal weighting is applied, the calculation must be quality checked, and the data and a description of the assumptions and data upon which the weighting has been made must be provided.

**Calculating phase level results**

Once the data for all 5 founds for a waste stream has been entered into the Excel data collection template (see Section 7), and the appropriate weighting for the rounds has been entered (or the default of equal weighting used), the template automatically calculates a profile for each phase, and for each of the streams (residual, dry recycling and organics).

This process is repeated for the second phase of sampling, and the Excel template is set up to include data for both phases. The same assumptions regarding weighting by round should be used for both phases of the sampling plan.

The template then calculates a total composition profile from both phases of data, which provides the overall composition profile for each stream, i.e. residual waste, dry recycling and organics. The default assumption in the template is to calculate a simple average of the two phases.

However, there is the facility to apply weighting to the phases, if deemed appropriate. For example, if it is known that waste arisings are much higher in summer due to tourism, compared to winter, it would be appropriate to weight the summer phase of sampling in order to reflect this, provided that there is sufficiently robust data to support such a calculation. For instance, if operational tonnages were to show that collected in one half of the year represents 75% annual waste tonnages (for example, between April and September, with the sampling carried out in the middle of this period), the phase carried out in that half of the year would be weighted by 75%, and the other phase by 25%. As indicated in the template, if non-equal weighting is applied, the calculation must be quality checked, and the data and a description of the assumptions and data upon which the weighting has been made must be provided.

**Extrapolating percentage arising profiles to annual tonnage arisings**

The Excel data collection template (see Section 7) is set up to calculate overall compositional estimates for each waste stream, with the composition expressed in terms of percentage arisings of each category within the relevant stream.

The sample weights recorded in the study should not be used to extrapolate to total arisings in the municipality. Instead, the composition profile will need to be applied to operational data on total residual, dry recycling or organics, as appropriate, collected annually, in order to convert the percentages profiles for tonnage profiles for each stream. These calculations rely on data external to the sampling study and are therefore outside the scope of the protocol. However, it is advised that municipalities should ensure that they are confident about the reliability of operational data on collected tonnages, before grossing up compositional estimates to annual tonnage arisings for each category identified in the compositional study.

Further comments on grossing up from percentage arisings to tonnage arisings at a regional or national level are provided in Appendix 1.

**Provision of results to the relevant authorities**

Once the whole sampling plan has been delivered, all the relevant data entered into the Excel data collection template and the data quality checked, this should be sent to the relevant authorities (YPEN, FODSA, Regional authority, Municipality or other). This should be provided alongside the sampling plan (Section 5.2) and photographic records of the extraction of each sample from the tipped loads (Section 5.4). As well as providing invaluable data at the municipality level, this will provide the relevant authorities sufficient details on the sampling methodology, and the rounds level composition data, which will enable the calculation of regional and national compositional estimates (Appendix 1) that are of strategic importance to Greece.

## 6.6 Physical and chemical tests

For all the waste streams analysed in each Waste Characterisation Study the following parameters should be calculated. Samples to be analysed in a laboratory to determine different parameters (humidity, density, calorific values and type of fine particles) must be properly packed for later analysis. Generally, raw waste samples or its different categories will be deposited in high density

plastic sacks, sealed and tagged. Next step is the chemical lab once the samples are encoded, always ensuring confidentiality of their origin. This process will be carried out through the corresponding chain of custody. Regarding the size of the samples, 2-3 kg will be taken as sample. It is highly recommended tests to be carried out to provide a correction factor in the calculation equations, as well as inform future waste management decisions. Tests should be conducted by a specialised third party such as a designated chemical laboratory, or in collaboration with a university or research centre. The laboratory needs to be scheduled early in advance so that it allows for the laboratory to test the samples after the sampling is collected.

### i. Density

Definition of the density relates to the in situ apparent density and it will be obtained by performing successive weighing of the material in a known capacity container[20]

### ii. Humidity definition

To determine the total humidity, humidity 1(H1) must be defined by heating at constant temperature of 40 oC in stove, till constant weight is reached and following the method described in ASTM E790-87. Humidity 2 (H2) is also determined by drying in oven or muffle to 105 oC. These results can be used to calculate humidity:

$$TH = H1 + H2(\frac{100 - H1}{100})$$

### iii. Low heating value

By calorimeter bomb trials, higher (HHV) and lower (LHV) calorimeter values are obtained. Higher dry calorimeter value (HdCV) of the sample is calculated from HCV obtained from the calorimeter bomb and correcting its result with the current sample humidity value.

High gross calorimeter value is:

$HgCV = HdCV * (\frac{100-TH}{100})$On the other hand, lower dry calorimeter values (LdCV) is calculated from HdCV and following this formula:

$$LgCV = \left(LdCV * \left(\frac{100 - TH}{100}\right) - 5.49 * TH\right)$$

### iv. Organic material of fine particles

Having separated the fine particles as described in Section 1.1 a sample should be collected and analysed for its organic matter content. The calculation is conducted through calcination. The sample is introduced in a stove for 2 hours at 600 OC. Then the weight difference between the input and the output is calculated:

[20] The method has been obtained from AST E1109-86

$$Organic\ Matter = Fines\ (total) - Weight\ after\ stove$$

# 7. Templates for sampling, recording and reporting results to competent authorities

Templates for sampling, recording and reporting results have be developed. In particular, the protocol has developed standard spreadsheet templates for entering in and analysing and reporting data (such as weights during the sorting procedure). This includes indicatively the appropriate equations aiming at: a) performing the required data analysis, i.e. adding up the weight per waste category, division equations to calculate the percentage arising of each category, b) providing a simple, well-structured and user-friendly template.

## 7.1 Waste composition analysis protocol: check list for key tasks

The following is a check list to assist in tracking the completion of key tasks for the protocol.

**Figure 7-1 Waste Composition Analysis protocol check list**

| Task | Completed Y / N |
|---|---|
| **1. Develop sampling plan** | |
| **2. Identify location for sample to be tipped and sorted** | |
| **3. Identify if mobile plant can be booked and used for sample extraction** | |
| **4. Recruit and train four-person sampling team** | |
| **5. Obtain all equipment required** | |
| **6. Carry out all necessary risk assessments, produce health and safety policies, train all relevant staff involved** | |
| **7. Instruct collection crews where to take sample loads** | |
| **8. Obtain samples from tipped loads, including taking photographs** | |
| **9. Carrying out sorting and weighing of the sample** | |
| **10. Record and double check all weights** | |
| **11. Enter total weights into Excel data collection sheet** | |
| **12. Quality check all data entry** | |
| **13. Apply weightings to Rounds and Phases, if required; quality check of weighting calculations** | |
| **14. Where reliable operational tonnage data is available, apply final composition profile percentages to arrive an annual tonnage arising estimates** | |
| **15. Provide the completed and quality checked Excel data collection template to the relevant authorities, along with photographs of sample extraction from tipped loads for all samples** | |

| | |
|---|---|
| **16. Extract sample for laboratory testing to check specific parameters (humidity, density, net calorific values and type of fine particles)** | |

## 7.2 Waste composition analysis data collection template

This guide is accompanied by an excel spreadsheet which should be a user-friendly form for entering and analysing the data acquired through implementation of the Sampling and Analysis protocols.

The spreadsheet should be used both in its hard (printed) and soft versions:

- The hard version is suitable for direct data input during the sampling, sorting and weighing
- The soft version should be used for entering and analysing the data leading to the final results of the Waste Composition Analysis campaign

The spreadsheet provides the user with two different options depending on the level of detail chosen for the analysis (See Section 6.2).

The **simple analysis** consists of a 16-waste streams classification, which corresponds to the 1st level of the Waste Category list, while the **detailed analysis** breaks down some of the basic waste categories (Paper & Cardboard, Textiles, Glass, Plastics, Wood, Non-Ferrous Metals, Ferrous Metals, WEEE, Hazardous Wastes, Miscellaneous Combustible and Miscellaneous Non-Combustible) into 2nd and 3rd level sub-categories.

For the simple analysis only the 1st tab of the spreadsheet (''Basic Categories'') should be used, while for the detailed analysis the 1st tab is used for the waste categories that are not analysed to sub-categories and the 2nd tab (''Secondary and Tertiary Categories'') should be used for the breakdown of the specific waste categories. In the screenshots below some necessary user information are presented, as well as the printable version of the template is given.

**Figure 7-2 Data Template, Simple analysis**

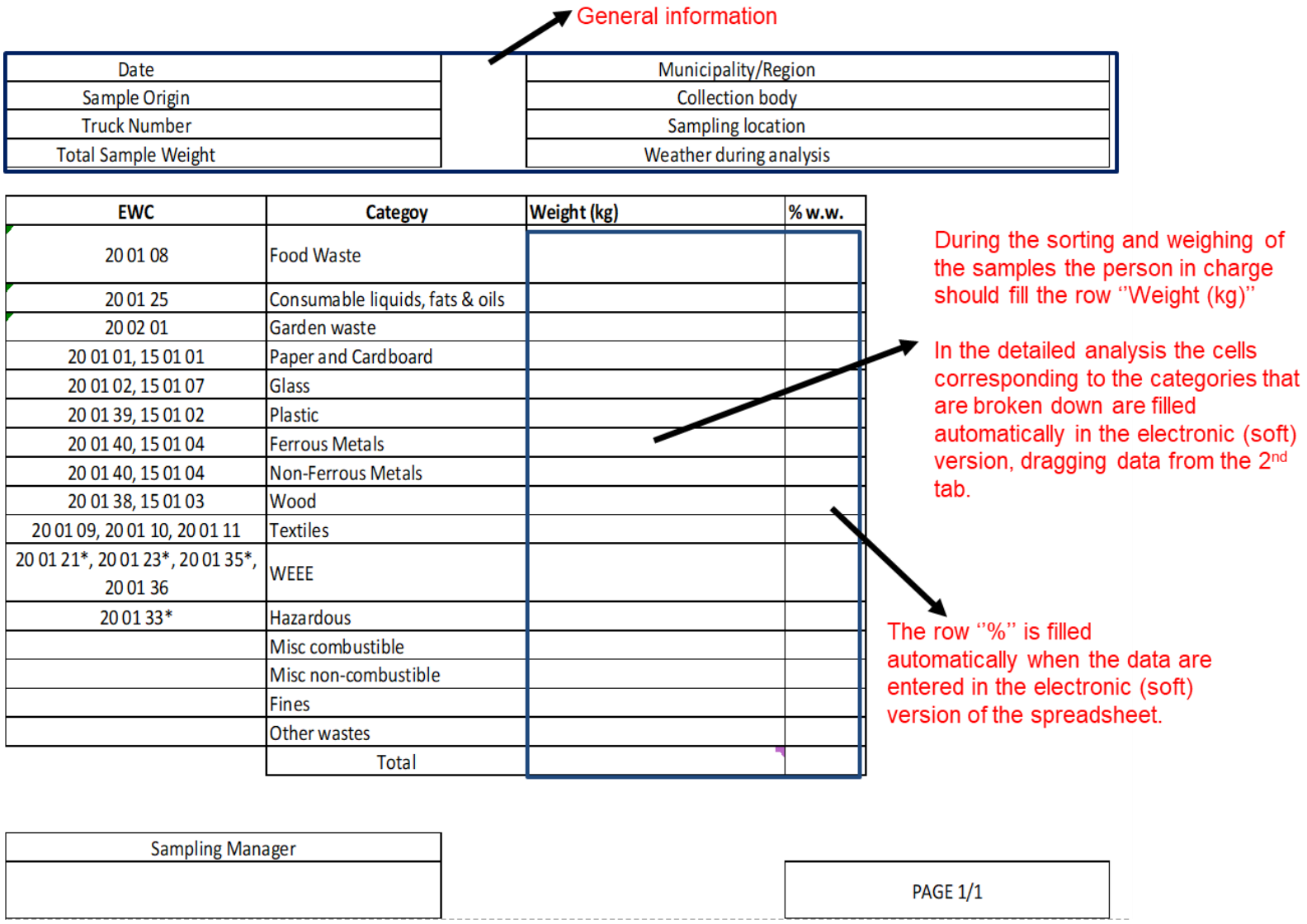


**Figure 7-3 Data Template, detailed analysis**

General information

| | | | |
|---|---|---|---|
| Date | | Municipality/Region | |
| Sample Origin | | Collection body | |
| Truck Number | | Sampling location | |
| Total Sample Weight | | Weather during analysis | |

**Basic categories** are auto calculated and filled in the tab ''Basic categories

| Paper & Cardboard: Subcategories | Weight (kg) |
|---|---|
| Recyclable paper | |
| Packaging paper | |
| News, mags, brochures, catalogues & directories | |
| Other recyclable paper | |
| Non-recyclable paper | |
| Cardboard | |
| Composite food and drink cartons (e.g. Tetrapak) | |

| Textiles: Subcategories | Weight (kg) |
|---|---|
| clothing, shoes, bags & belts | |
| Clothing | |
| Shoes, bags & belts | |
| All non-clothing textiles | |
| Carpets | |
| Other non-clothing textiles | |

| Glass: Subcategories | Weight (kg) |
|---|---|
| Packaging glass | |
| Non-packaging glass | |

| Plastic: Subcategories | Weight (kg) |
|---|---|
| Plastic bottles | |
| PET | |
| HDPE | |
| Other plastic bottles | |
| Dense plastic non-bottles | |
| Dense plastic packaging | |
| Dense plastic non-packaging (incl. pots) | |
| Polystyrene | |
| Plastic film | |
| Carrier bags (LDPE, HDPE, PP) | |
| Other packaging plastic film | |
| Non-packaging plastic film | |

| Wood: Subcategories | Weight (kg) |
|---|---|
| Wood (treated, non-treated) | |
| Wooden packaging | |

The use can either choose to weigh and fill the secondary categories or the tertiary ones. If choose to fill the tertiary, then the secondary are auto-calculated and filled

| Sampling Manager |
|---|
| |

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| | |
|---|---|
| Date | Municipality/Region |
| Sample Origin | Collection body |
| Truck Number | Sampling location |
| Total Sample Weight | Weather during analysis |

| EWC | Categoy | Weight (kg) | % w.w. |
|---|---|---|---|
| 20 01 08 | Food Waste | | |
| 20 01 25 | Consumable liquids, fats & oils | | |
| 20 02 01 | Garden waste | | |
| 20 01 01, 15 01 01 | Paper and Cardboard | | |
| 20 01 02, 15 01 07 | Glass | | |
| 20 01 39, 15 01 02 | Plastic | | |
| 20 01 40, 15 01 04 | Ferrous Metals | | |
| 20 01 40, 15 01 04 | Non-Ferrous Metals | | |
| 20 01 38, 15 01 03 | Wood | | |
| 20 01 09, 20 01 10, 20 01 11 | Textiles | | |
| 20 01 21*, 20 01 23*, 20 01 35*, 20 01 36 | WEEE | | |
| 20 01 33* | Hazardous | | |
| | Misc combustible | | |
| | Misc non-combustible | | |
| | Fines | | |
| | Other wastes | | |
| | Total | | |

| Sampling Manager |
|---|
| |

| | |
|---|---|
| Date | |
| Sample Origin | |
| Truck Number | |
| Total Sample Weight | |

| | |
|---|---|
| Municipality/Region | |
| Collection body | |
| Sampling location | |
| Weather during analysis | |

| Paper & Cardboard: Subcategories | Weight (kg) |
|---|---|
| Recyclable paper | |
| Packaging paper | |
| News, mags, brochures, catalogues & directories | |
| Other recyclable paper | |
| Non-recyclable paper | |
| Cardboard | |
| Composite food and drink cartons (e.g. Tetrapak) | |

| Plastic: Subcategories | Weight (kg) |
|---|---|
| Plastic bottles | |
| PET | |
| HDPE | |
| Other plastic bottles | |
| Dense plastic non-bottles | |
| Dense plastic packaging | |
| Dense plastic non-packaging (incl. pots) | |
| Polystyrene | |
| Plastic film | |
| Carrier bags (LDPE, HDPE, PP) | |
| Other packaging plastic film | |
| Non-packaging plastic film | |

| Textiles: Subcategories | Weight (kg) |
|---|---|
| clothing, shoes, bags & belts | |
| Clothing | |
| Shoes, bags & belts | |
| All non-clothing textiles | |
| Carpets | |
| Other non-clothing textiles | |

| Wood: Subcategories | Weight (kg) |
|---|---|
| Wood (treated, non-treated) | |
| Wooden packaging | |

| Glass: Subcategories | Weight (kg) |
|---|---|
| Packaging glass | |
| Non-packaging glass | |

| Sampling Manager |
|---|
| |

| | |
|---|---|
| Date | |
| Sample Origin | |
| Truck Number | |
| Total Sample Weight | |

| | |
|---|---|
| Municipality/Region | |
| Collection body | |
| Sampling location | |
| Weather during analysis | |

| **Non-Ferrous Metals: Subcategories** | |
|---|---|
| Non-ferrous cans (drink & food cans) | |
| Non-ferrous non-cans | |
| Aluminium foil | |
| Other non-ferrous (incl. aerosols) | |

| **Hazardous: Subcategories** | **Weight (kg)** |
|---|---|
| Household batteries | |
| Paints and varnishes | |
| Medicine | |
| Other household hazardous waste | |

| **Ferrous Metals: Subcategories** | **Weight (kg)** |
|---|---|
| Ferrous cans (drink & food cans) | |
| Ferrous non-cans | |
| Other ferrous packaging (incl. aerosols) | |
| Other ferrous non-packaging | |

| **Misc combustible: Subcategories** | **Weight (kg)** |
|---|---|
| Sanitary products | |
| Furniture | |
| Mattresses | |
| Other misc combustible | |

| **WEEE: Subcategories** | **Weight (kg)** |
|---|---|
| Large WEEE | |
| Small WEEE | |

| **Misc non-combustible: Subcategories** | **Weight (kg)** |
|---|---|
| Soil and stones | |
| Other misc non-combustible | |

| Sampling Manager |
|---|
| |

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# 8. Concrete Proposals for the amendment of the JMD 114218/1997

## English Summary

The **JMD 114218** ***'Establishment of a framework of technical specifications and of general plans for solid waste management'*** is acknowledged as a predominant Greek legal document with a great level of detail in terms of the provision of technical specifications and design principles for solid waste management in Greece. However, since it has been initially enacted in 1997, there is considerable progress made both a) in terms of technological updates and new standards and b) in terms of the new national and EU legal framework and policies on waste management and circular economy.

The focus of our work is on reviewing this framework and providing strategic guiding recommendations, as well as selective, more detailed proposals on particular Chapters or Articles where needed and in agreement with GIZ and the Ministry of Environment and Energy (YPEN). Our proposals on the amendment of the JMD 114218/1997 are high-level based on selected articles/ sections following engagement with YPEN. The level of amendments and technical details required were discussed with GIZ/YPEN and engagement with selective key stakeholders was accomplished to solicit valuable data. The stakeholder engagement was limited to the allocated time and resources as stipulated in the ToRs[21]. Moreover, the level of detail with respect to the technical requirements set out in the JMD is reviewed in order: a) not to hamper the environmental permission, proper design and development of waste management infrastructure and systems, b) promote innovation and c) follow EU Best Available Techniques reference documents (BREFs).

Our proposals are developed per chapter of the JMD as bellow:

10. Technical specifications for the collection – temporary storage – transport of solid waste
11. Technical specifications for the transfer of solid waste
12. Criteria for the site selection of waste management infrastructure
13. Technical specifications for separate collection systems
14. Technical specifications for the landfill of waste
15. Technical specifications for the landfill of aggregates (C&D)
16. Technical specifications for the mechanical biological treatment of waste
17. Technical specifications for the thermal treatment of waste
18. Technical specifications for the treatment of the sludge from the treatment of the municipal wastewater

[21] According to the ToRs, 2 working days are foreseen for the research and data collection to be accomplished, therefore limited stakeholder engagement and market research was carried out.

# Appendix 1: Calculation of regional and national estimates

**Calculation of regional and national estimates**

This protocol provides guidance for carrying out a waste compositional study using *vehicle sampling* at a municipality level. Regional and national estimates can be built up through combined analysis of these municipality level results.

Even for fairly simple regional and national calculations, the methodology can become complex (for example, reconciling dry recycling composition data with regional or national recycling operational data). It is beyond the scope of this protocol to provide an exhaustive and precise description of the methodology that would apply to Greece, as the exact methodology would depend on a number of factors (number of municipalities with composition data, which municipalities are sampled, the level of detail and robustness of regional and national tonnages for municipal waste and recycling collections, etc). Nonetheless, it is possible to set out some general approaches, as described here.

**Requirement for regional and national total tonnage data**

The calculation of regional and national compositional estimates from municipal level composition data has been used for several major studies in the United Kingdom (UK), most recently and comprehensively in the *WRAP National Household Waste Composition 2017 (Eunomia, 2019)* report[22]. In the UK, national compositional estimates have been based upon combining municipal level composition data (of the type that this protocol is designed for) and a national database of operational tonnages to which all municipalities in the UK are required to report (WasteDataFlow).

For Greece, a similar approach is advised, where data on tonnages of municipal waste collected nationally or regionally is cross analysed with the municipal level composition data produced through using this protocol. The municipal level composition data, on its own, can only provide information on the relative arisings of each category within the relevant stream (refuse, recycling or organics). It cannot be used to calculate or infer *how much* of each category arises in tonnage terms, unless it is analysed alongside data that demonstrates the total tonnage arising of that waste stream[23].

Whether such tonnage data exists for Greece at the regional or national level, which is sufficiently robust for the production of compositional estimates, is external to the scope of this protocol.

**Estimated number of municipal level studies required**

Assuming that such tonnage data exists, regional or national compositional estimates can be produced, provided that a sufficient number of municipal level studies have been successfully completed using this protocol. It is considered that in order to provide accurate national compositional estimates, analyses would need to be carried out in 20-25% of the Greek territory. In terms of municipality level, this could roughly correspond to about 70-80 municipalities, or approximately 5-6 municipalities for each of the 13 administrative regions.

[22] http://www.wrap.org.uk/content/quantifying-composition-municipal-waste

[23] In principle, composition data derived from samples collected from households can provide waste generation rates per household, which could then be extrapolated to municipal level, but this is not feasible for vehicle sampling.

**Calculation approach with representative mix of municipalities**

The most straightforward approach to producing national or regional estimates would be to select the municipalities where compositional analysis will be carried out, such that the sample municipalities are broadly representative of the relevant region or nation. The main factors that would be considered in determining representativeness would be those factors discussed in the sampling plan (Section 5.2), namely income level, area type, population density, collection system (especially, what materials are targeted for recycling or composting), commercial activity and tourism.

If a representative mix of municipalities is achieved in the composition data sample, the simplest calculation would be that for each waste stream a simple average of the arising of each category could be taken and multiplied by the total tonnage of the relevant waste stream for the region or nation. This has effectively been the main approach for some of the national compositional estimates produced for England[24], particularly for residual waste. There are still come complexities: in these studies, operational recycling tonnages provided some breakdown into some material types and composition data was used to analyse these further into a more detailed category list (for example, different types of paper, or a breakdown of paper and cardboard in mixed paper/cardboard collection tonnages).

A slightly more sophisticated approach is to weight arisings of the categories found in the compositional data by the tonnage arisings for different types of authorities in the region or municipality. This approach has also been used in the same UK studies mentioned previously, sometimes in parallel with the simple average method described above, to demonstrate the differences between each approach. For the UK, the two approaches have generally produced fairly similar results[25], but there is no guarantee that this would be the case in the Greek context.

**Calculation approach with non-representative mix of municipalities**

If it is not possible to ensure that the sample municipalities are representative of the region or nation, then the composition data should be aligned with total collection tonnages at the municipal level, to arrive at municipal level arisings. The protocol advises that this can be carried out by municipalities, if the appropriate data is available, (Section 6.5). The municipal level estimates will then be stratified and weighted to adjust for any non-representativeness in the sample, and regional or national arisings for each category in each collection stream will be calculated from the stratified array of data.

**Calculation approach using rounds data**

The protocol has been designed so that rounds level data is included in the reporting in the data collection template (see Sections 6.5 and **Error! Reference source not found.**). This enables a p otentially more robust approach to calculating regional or national estimates than using municipal level data. The rounds in each municipality are selected from the sampling plan (Section 5.2), in order to select different area types within the municipality. If there is regional or national data available on the size or prevalence of these area types in the region or nation as a whole (most obviously, on the

[24] Defra WR0119: A Review of Municipal Waste Component Analyses, England 2006/07, Resource Futures 2008

[25] The most comprehensive comparison of these approaches has been carried out for WRAP's Household food and drinks waste in the UK programme of work, for example: Synthesis of Food Waste Compositional Data 2014 & 2015, Resource Futures & WRAP. https://www.wrap.org.uk/content/household-food-waste-uk-2015-0

basis of population or number of dwellings by area type), this can be used to calculate regional estimates by aligning the rounds level compositional data with total tonnage arisings in the region or nation for the relevant stream. The sample would almost certainly need to be stratified in order to adjust for any non-representativeness in the number of sample rounds by area type, compared to the prevalence of the area type regionally or nationally. Care should be taken to ensure that factors, such differences in collection systems (particularly which materials are collected for recycling or composting), are controlled for in the stratification calculations.

Since the protocol requires that each municipal level study will provide 5 rounds level composition estimates for each stream analysed (with each round being analysed for two phases), this produces 5 composition data points per waste stream for each municipality studied. This greatly increases the amount of composition data available at the regional and national level, which would give much greater scope to apply statistical tests then regional or national estimates derived from municipal level data.

**Statistical tests and calculation of confidence intervals**

There are several different equations for calculating confidence intervals (usually at 95% for UK studies), depending on if the sample is stratified or not. Where the sample municipalities are representative nationally, a basic 95% confidence interval calculation (in Excel or statistical analysis package) can be applied. At the regional level there is unlikely to be a sufficient number of sample municipalities in order to calculate confidence intervals, and the range of statistical tests that can be carried out is limited. For regional or national estimates built up from round level data, as mentioned, there is greater scope for applying statistical tests, although some of the calculations could become complex, depending on how many factors have to be accounted for in stratifying the rounds level data so as to produce results that are representative at the regional or national level.

# Appendix 2: Minimum sample sizes

Minimum sample sizes for the sampling protocol are set out in Section 5.3. This Appendix provides the rationale for setting the sample size requirement in this way.

As described in the sampling protocol (Section 5), the collection vehicles selected in the sampling plan (Section 5.2) will tip their loads in a separate designated area (Section 5.4). It is impractical for the whole vehicle load to be analysed. For example, a typical load for a refuse collection vehicle can be around 4.5 tonnes, and it is estimated that it would take a four person sampling team about 8 days to sort and weight all this material[26]. This is far too long to be economically feasible, and also the integrity of the sample would be compromised over this period of time.

The sample sizes specified in this protocol are such that a four person sampling team (being properly trained and equipped) would be able to sort and weight the material within one working day. For residual waste it is estimated that the sampling team would be able to analyse approximately 500-600 kg per day. In order to make this protocol practical for a wide range of circumstances, the sample sizes are actually given in terms of volume, as it would be more time consuming to extract random material whilst carrying out weighing in order to ensure that the required sample size is achieved.

In terms of relating the weight and volume of samples, the bulk density of materials can vary, particularly in terms of composition and the level of compaction in the collection vehicle, so there are some uncertainties inherent in specifying sample sizes in terms of volume. However, the total weight of the sample extracted will be known once the material is sorted and weighed, which will provide some information on the sample weights that the protocol achieves for each individual study.

Taking the midpoint of 500 and 600 kg, i.e. 550kg, for the amount of residual waste that a four person team could analyse in a day, depending on the bulk density of the material this is estimated to equate to approximately 1.5 m3. In order to make the protocol easy to enact, this is expressed as a rectangular pile of waste of dimensions length 3m x width 1m x height 0.5m. Alternatively, a circular (or, strictly speaking, cylindrical) pile can be measured out, and with a diameter of 2m and height of 0.5m this would be approximately 1.6 m3. This is slightly larger than the minimum 1.5 m3 specified, but as the emphasis is on simplicity, it is considered better to provide round and easy to remember numbers for the dimensions of the sample.

The sampling plan (Section 3.2) requires separate analysis of different waste streams, of at least residual waste and dry recycling and organics; therefore 3 waste streams. Also, for each waste stream, two phases of sampling are carried out, and for each phase of sampling and waste stream analysed, the protocol recommends that 5 collection rounds are sampled. This results in a total of 30 samples (if organics collections are sampled as well). If each sample is at least 1.5 m3, this gives a total sample size of at least 45 m3. This is in line with the recommendations of the European

[26] *Methodology for the Analysis of Solid Waste (SWA-Tool), User Version, European Commission, 2004, p24:* Recommendation 18 uses an estimate of 6 person hours to sort 100 kg of waste, and this assumption has been applied in estimating the amount of material that could be sorted by a four person sampling team within one working day.

Commission's *Methodology for the Analysis of Solid Waste (SWA-Tool)*, which recommends aiming for a total sample of 45 m3 for household waste sampling[27].

Another good practice benchmark for sample sizes is provided by the national waste composition analysis programme in England. Although the study has been updated several times, the most thorough examination of sample sizes used in waste compositional analyses in England was provided as part of the 2006/07 estimates. Current practice in England, and indeed the UK, is still broadly in line with the sample sizes investigated in the 2006/07. The study found that the average weights of total material sampled for each municipality were:

- Residual waste 6.1 tonnes
- Dry recycling 4.7 tonnes
- Organics 5.2 tonnes[28].

As mentioned, there are uncertainties relating the weight and volume of samples, with variance in densities and levels of compaction. Having acknowledged this, it is estimated that the total weights of the samples analysed under this protocol (15 m3 for each waste stream, 2 phases of 5 collection rounds each of 1.5 m3) would be, very approximately, as follows:

- Residual waste ~6 tonnes
- Dry recycling ~3 tonnes
- Organics ~7 tonnes.

The sampling protocol is therefore likely to achieve total amounts of waste sorted that are in line with, or larger, than found in comparison to England compositional studies, in respect of residual and organics collections. For dry recycling, the sample weight appears to be lower in comparison. However, the overall sample weights across all collection streams in the sampling protocol are in line with the sample weights found in England compositional studies.

[27] *Methodology for the Analysis of Solid Waste (SWA-Tool), User Version, European Commission, 2004, p17:* Recommendation 10.

[28] Defra WR0119: A Review of Municipal Waste Component Analyses, England 2006/07, Resource Futures 2008, Appendix 3, p5.
http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=15133

# Appendix 3: Templates in excel spreadsheets (incl. calculations)

| | |
|---|---|
| Date | Municipality/Region |
| Sample Origin | Collection body |
| Truck Number | Sampling location |
| Total Sample Weight | Weather during analysis |

| EWC | Categoy | Weight (kg) | % w.w. |
|---|---|---|---|
| 20 01 08 | Food Waste | | |
| 20 01 25 | Consumable liquids, fats & oils | | |
| 20 02 01 | Garden waste | | |
| 20 01 01, 15 01 01 | Paper and Cardboard | | |
| 20 01 02, 15 01 07 | Glass | | |
| 20 01 39, 15 01 02 | Plastic | | |
| 20 01 40, 15 01 04 | Ferrous Metals | | |
| 20 01 40, 15 01 04 | Non-Ferrous Metals | | |
| 20 01 38, 15 01 03 | Wood | | |
| 20 01 09, 20 01 10, 20 01 11 | Textiles | | |
| 20 01 21*, 20 01 23*, 20 01 35*, 20 01 36 | WEEE | | |
| 20 01 33* | Hazardous | | |
| | Misc combustible | | |
| | Misc non-combustible | | |
| | Fines | | |
| | Other wastes | | |
| | Total | | |

| Sampling Manager |
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|---|---|
| Date | |
| Sample Origin | |
| Truck Number | |
| Total Sample Weight | |

| | |
|---|---|
| Municipality/Region | |
| Collection body | |
| Sampling location | |
| Weather during analysis | |

| Paper & Cardboard: Subcategories | Weight (kg) |
|---|---|
| Recyclable paper | |
| Packaging paper | |
| News, mags, brochures, catalogues & directories | |
| Other recyclable paper | |
| Non-recyclable paper | |
| Cardboard | |
| Composite food and drink cartons (e.g. Tetrapak) | |

| Plastic: Subcategories | Weight (kg) |
|---|---|
| Plastic bottles | |
| PET | |
| HDPE | |
| Other plastic bottles | |
| Dense plastic non-bottles | |
| Dense plastic packaging | |
| Dense plastic non-packaging (incl. pots) | |
| Polystyrene | |
| Plastic film | |
| Carrier bags (LDPE, HDPE, PP) | |
| Other packaging plastic film | |
| Non-packaging plastic film | |

| Textiles: Subcategories | Weight (kg) |
|---|---|
| clothing, shoes, bags & belts | |
| Clothing | |
| Shoes, bags & belts | |
| All non-clothing textiles | |
| Carpets | |
| Other non-clothing textiles | |

| Wood: Subcategories | Weight (kg) |
|---|---|
| Wood (treated, non-treated) | |
| Wooden packaging | |

| Glass: Subcategories | Weight (kg) |
|---|---|
| Packaging glass | |
| Non-packaging glass | |

| Sampling Manager |
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|---|---|
| Date | Municipality/Region |
| Sample Origin | Collection body |
| Truck Number | Sampling location |
| Total Sample Weight | Weather during analysis |

| Non-Ferrous Metals: Subcategories | |
|---|---|
| Non-ferrous cans (drink & food cans) | |
| Non-ferrous non-cans | |
| Aluminium foil | |
| Other non-ferrous (incl. aerosols) | |

| Ferrous Metals: Subcategories | Weight (kg) |
|---|---|
| Ferrous cans (drink & food cans) | |
| Ferrous non-cans | |
| Other ferrous packaging (incl. aerosols) | |
| Other ferrous non-packaging | |

| WEEE: Subcategories | Weight (kg) |
|---|---|
| Large WEEE | |
| Small WEEE | |

| Hazardous: Subcategories | Weight (kg) |
|---|---|
| Household batteries | |
| Paints and varnishes | |
| Medicine | |
| Other household hazardous waste | |

| Misc combustible: Subcategories | Weight (kg) |
|---|---|
| Sanitary products | |
| Furniture | |
| Mattresses | |
| Other misc combustible | |

| Misc non-combustible: Subcategories | Weight (kg) |
|---|---|
| Soil and stones | |
| Other misc non-combustible | |

| Sampling Manager |
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