Guideline for the Quantification and Characterization of Non-hazardous Solid Wastes and Residues for Ecuadorian Municipalities

Summary

September 2025

CLEAN AIR TASK FORCE

1. Introduction

The guide published by the Solid Waste Management and Inclusive Circular Economy project in Ecuador, which is part of the Ministry of Environment, Water and Ecological Transition, serves as a tool for standardizing technical procedures related to quantification and characterization studies of non-hazardous solid waste and residues. This guide is applicable to all municipalities in the country and is designed to enhance and streamline processes, enabling the generation of reliable data to support cross-cutting decision-making in areas such as urban solid waste management, circular economy strategies, and climate change initiatives.

The guide establishes a standardized process for collecting and analyzing solid waste data. The data obtained will provide municipalities with a comprehensive overview of the current situation, allowing them to plan waste management infrastructure projects in alignment with their capabilities and resources. Furthermore, reliable and up-to-date information enables municipalities to identify trends in waste generation, calculate per capita production rates, and forecast future demand for waste collection and treatment services.

In terms of scope, the guide is intended for municipal officials responsible for waste management as well as technical professionals in the field. It is also valuable for public and private entities collaborating with municipalities on solid waste planning, such as environmental consultants, waste management companies, Non-Government Organizations, and academic institutions. Additionally, the guide recommends that the analysis be conducted and updated every four years.

For more information, please visit the following link: https://nextcloud.ambiente.gob.ec/index.php/s/cb26aPSPd4zARdp

2. Legal Framework

The legal framework underpinning the guide provides essential context for understanding the obligations and responsibilities of municipalities regarding solid waste management. Within this framework, Integrated Solid Waste Management (ISWM) is defined as an approach that encompasses all aspects of waste management, from collection to final disposal and recycling. This approach seeks to reframe "waste" as a "resource," thereby promoting reuse and recycling. ISWM aligns with national policies and serves as a fundamental component of the circular economy, where waste is viewed not as a problem but as an opportunity to recover materials and reduce environmental impact.

In Ecuador, the legal responsibility for managing solid waste rests solely with municipalities, known as Municipal Decentralized Autonomous Governments. These entities must ensure that waste generation, collection, transportation, treatment, and final disposal are carried out in accordance with quality and sustainability standards. This responsibility includes conducting waste characterization studies to gain a detailed understanding of the specific characteristics of waste generated in each municipality. Such knowledge is essential for developing waste management infrastructure and services tailored to the specific needs of each city.

Additionally, the Ministry of Environment, Water and Ecological Transition, as the National Environmental Authority, is responsible for regulating and supervising solid waste management activities in Ecuador. Its role includes developing policies and technical standards to support municipalities in fulfilling their responsibilities. Furthermore, the institution provides technical assistance and guidance for implementing circular economy policies, enabling municipalities to adopt sustainable practices aligned with the national sustainability strategy.

The primary legal instruments governing ISWM are outlined below:

- The Organic Environmental Code
- Regulation to the Organic Environmental Code
- Organic Code of Territorial Organization, Autonomy and Decentralization
- The Organic Law for the Rationalization, Reuse and Reduction of Single-Use Plastics
- Organic Law for the Inclusive Circular Economy

3. Methodological basis

The methodology outlined in the guide is based on a thorough review of national and international regulations, along with pilot study implementations to ensure its efficacy. This methodological approach is designed to adapt to the specific needs of each municipality, allowing municipalities to obtain reliable and representative data tailored to their unique requirements. The proposed methodology is represented in two fundamental aspects:

A. Sampling Methodology and Categorization of Municipalities: To ensure accurate representation of waste generated in each city, the guide categorizes the municipalities by population size into micro, small, medium, large, and special. Additionally, it distinguishes between two primary categories of waste generators: household (including both urban and rural households) and non-household (such as businesses, institutions, hotels, etc.). This categorization ensures that sampling is representative of each generator type and that results reflect the unique characteristics of each area.

B. Sample Size Determination: To determine the optimal sample size, the guide applies statistical techniques, including equations for finite populations and Sakurai's method.[1] These methods ensure that the selected sample is representative and that the results can be extrapolated to the entire population. Determining sample size is a critical step, as an insufficient or improperly selected sample can compromise the reliability of results and, consequently, decision-making.

In accordance with this methodology, the phases for advancing the study, as outlined in the guide, are as follows:

- **Planning Stage:** This phase involves forming the management team and establishing procedures for data collection and structuring the study schedule. It includes task assignment and coordination with municipal departments and key stakeholders involved in waste management. Ensuring efficient data collection that aligns with the objectives of waste characterization is essential at this stage.
- **Design Stage:** During this phase, sources of waste generation are identified, the total population of the municipality is defined, and the required sample size is determined. Sampling sites and field equipment are also organized, and data coding is established to ensure proper handling of information. This design process facilitates representative sampling and efficient organization for data collection.
- **Field Stage:** This phase involves practical activities such as sampling, weighing, and classifying waste at designated sites. These activities follow standardized protocols to document waste density and type. The field team also conducts surveys to capture the selected generators' perceptions of the solid waste service, enhancing data collection.
- **Analysis Stage:** This stage focuses on tabulating and validating the collected data, calculating waste production within the municipality, and preparing the final report. The analysis enables the identification of key indicators such as waste density and composition, which will guide future studies and inform management policies.

4. Implementation Process

The guide outlines the process in four main stages: planning, design, fieldwork, and analysis. Each stage is meticulously crafted to ensure that the study is conducted with the highest level of precision, yielding reliable, high-quality data.

4.1 Planning Stage

Management Team

In the initial phase, a management team is established, consisting of a director and a field chief responsible for overseeing the study. This team is crucial for coordinating all activities and ensuring that the objectives outlined in the schedule are achieved. The experience and competence of the management team are pivotal to the success of the study and the quality of its results.

Compilation and Review of Existing Information

This phase involves gathering all pertinent documentation and historical data essential for contextualizing the study. Relevant documents include collection records, censuses, population data, previous studies, and any other applicable information. The compilation and review of existing information enables the management team to understand the current waste generation situation in the municipality, thus establishing a baseline for the study.

Timeline

The management team develops a comprehensive timeline that details the specific timeframes and resources allocated to each activity. This schedule covers all phases of the study, from preliminary preparations to the final presentation of findings. Comprehensive planning ensures the timely completion of activities and allows the management team to make necessary adjustments in response to unforeseen circumstances.

4.2 Design Stage

This critical stage involves organizing activities, assembling the human resources required for data collection, and preparing the necessary equipment and tools. The main steps are as follows:

Identification of Waste Generators

The objective of this phase is to identify and classify all sources of waste generation within the municipality. The guide categorizes generators into two main groups: household and non-household. Household generators include both urban and rural residences, while non-household generators encompass businesses, hotels, institutions, and similar entities. This classification system enables tailored analysis and the development of targeted strategies for each type of generator.

Determination of Total Population and Sample Size

In this phase, the total population of the municipality is calculated, including the floating population, such as tourists and temporary workers. Sample size calculation is based on rigorous statistical methods to ensure data representativeness. Accounting for the floating population helps ensure that the results accurately reflect the full reality of the city, preventing any potential underestimation or overestimation of waste generation.

Field Organization and Logistics

This phase addresses the practical aspects of data collection, including the preparation of data records and communication materials. Data records and communication materials are prepared, waste unloading and classification sites are designated, and coding systems are implemented to organize samples and facilitate subsequent analysis. Effective logistical planning is essential to ensure that the field team has the necessary resources, and that data collection proceeds efficiently.

Training of Field Personnel

The guide emphasizes the importance of training field personnel in sampling procedures and safety protocols. Personnel must be thoroughly familiar with the procedures for collecting, weighing, and sorting waste in accordance with the study guidelines. This training is essential to ensure the accuracy and consistency of data collection, minimize error margins, and guarantee the quality of the results.

4.3 Field Stage

In this phase, primary data is collected directly from waste generators (household and non-household). A series of activities are conducted to accurately measure and record the weight, density, and classification of the waste collected. The general structure is as follows:

Assignment of Work Sectors

Field teams are assigned their designated work areas. The field leader allocates and defines zones to ensure each team covers representative areas of waste generation to gather the required data.

Identification and Registration of Waste Generators

This activity involves listing the households, institutions, and businesses that will participate in the sampling process. Environmental promoters survey the designated areas, visiting both residential and non-residential waste generators to explain the study's purpose. Each generator is assigned a unique code and provided with a specific bag to collect waste, which must be filled and returned to the team for analysis. Promoters are briefed in advance and are provided with maps and information about the sampling locations.

Perception Surveys

Surveys are conducted with waste generators to assess their satisfaction with the waste management service. This information is valuable for identifying areas for improvement and enhancing the quality of services.

Sample Collection and Weighing

Over the course of eight days, the team collects waste bags from each generator. The bags are labeled with the generator's code and weighed daily. This process ensures the collection of a representative amount of waste from various contexts and days, allowing for the calculation of average solid waste generation.

Density Determination and Classification Samples

The collected waste is transported to a processing site where it is prepared for analysis. At this site, the waste is pooled and homogenized to ensure a representative classification. This process includes chopping large waste items, mixing them, and dividing them into manageable portions using a quartering technique. This ensures that each sample is identified facilitating density measurement and classification.

Determination of Waste Density

To calculate density, a standard container is filled with waste, and the total weight is recorded. This step is critical for understanding how much space the waste will occupy in landfills, which helps estimate landfill volume requirements and optimize their usage.

Solid Waste Classification Data Collection

The equipment is used to separate the waste into specific categories (e.g., paper, cardboard, glass, plastic, etc.). This process allows for determining the composition of the waste generated, providing a basis for recycling and waste reduction strategies. The sorted waste is then weighed and recorded on field forms.

Solid Waste Weight Record at Final Disposal Sites

To compare the estimated amount of solid waste generation with the actual waste entering final disposal, a vehicle scale is used to weigh the waste entering the disposal site during field activity. If a scale is not available, arrangements must be made to ensure its use during the study days.

4.4 Analysis Stage

After the field stage, the data collected is analyzed. This analysis is divided into several key steps:

Tabulating Information

The data collected in the field is organized into tables for easy interpretation and analysis. This includes data from waste generator registrations, sample weighing, and surveys assessing public perceptions of solid waste and its disposal.

Validation of Household Generator Data

This process involves reviewing the tabulated data for consistency and validity. Samples that fail to meet representativeness criteria, such as those with incomplete data or insufficient collection days, are discarded at this stage. An outlier elimination methodology is applied to enhance the accuracy of the study, and Per Capita Production is calculated.

Validation of Data from Non-Household Generators

Similar to the previous step, data from non-household generators is tabulated and calculated in the same manner to ensure consistency and accuracy.

Determination of Waste Production in Household Generators

After data validation, the amount of waste generated by households in urban and rural areas is calculated. This calculation provides authorities with a better understanding of waste management needs in different areas, especially those with varying population densities or consumption patterns.

Determination of Waste Production in Non-Household Generators

This step involves analyzing the waste generated by businesses, institutions, markets, and other establishments. The data collected is used to calculate the average waste generated by each type of establishment, providing an overall figure for each group.

Determination of the Per Capita Production and Solid Waste Production

This value is calculated to determine the average amount of waste produced per person or establishment. It helps standardize measurements for comparison with other areas or national averages. This calculation is performed using the methodology and annexes described throughout the guide, both at the household and non-household levels.[2]

Determination of the Density

Using the total solid waste generation in the municipality, along with the applicable formulas and methodologies described in the guide, a representative density value for the municipal solid waste is determined. This value is averaged between urban and rural areas and associated generators.

Determination of Solid Waste Composition

Using the tabulated data, a percentage calculation is made to determine the composition of solid waste from various generators, ensuring the result is representative of the municipality.[3]

Determination of the Amount of Waste Entering the Final Disposal Site

The data collected from the weighing process is tabulated to determine the total amount of waste entering the municipal final disposal site.

Preparation of the Report

Once all necessary data has been obtained and the expected results calculated, the non-hazardous solid waste quantification and characterization study is compiled.[4]

5. Examples of using the guideline

The guide outlines the process in four main stages: planning, design, fieldwork, and analysis. Each stage is meticulously crafted to ensure that the study is conducted with the highest level of precision, yielding reliable, high-quality data. The Guide was implemented in two municipalities, Cayambe and Puerto López, with the help of the Clean Air Task Force and other local groups. For further details, please refer to the following link, which includes reports for each municipality: https://wastemap.earth/resources

5.1 Municipality of Cayambe (July 13-20, 2023)

Located in the northeast of Pichincha province, Cayambe has a population of 113,269 approximately. The field phase included selecting and training technical and support personnel, as well as coordinating with the municipal sanitation company to improved local logistical efficiency and municipal capacities for future analysis. A total of 170 household samples (84 urban and 86 rural) and 84 non-household samples (including commercial sectors and street sweeping) were collected.

- **Waste generation:** 75.08 tons/day
- **Organic content:** 53.2 %
- **Per capita generation:** 0.65 Kg/person/day
- **Waste density:** 185 kg/m3

5.2 Municipality of Puerto López (July 31-August 9, 2023)

Puerto López, a tourist municipality in the Manabí Province with a population of 25,621, has a flooding population of 771 per day, applied the characterization methodology with recyclers and municipal staff. A total of 131 samples were gathered from households (70 urban and 61 rural) and non-household generators (e.g., restaurants, markets, and educational institutions.). Key lessons were learned about optimizing logistics, conducting surveys, and using protective equipment.

- **Waste generation:** 20.3 tons/day
- **Organic content:** 54 %
- **Per capita generation:** 0.78 Kg/person/day
- **Waste density:** 161.66 kg/m3

In addition, restaurants generated 10.62 kg of waste per day, highlighting the importance of targeting high-volume generators in municipalities with significant tourism.

6. Relevant milestones

- The data collected using the guideline will enable municipalities to develop effective solid waste management plans. Additionally, the classification of waste by type will facilitate the implementation of targeted recycling or composting programs, as well as optimize the use of sanitary landfills. This data will also aid in the establishment of waste reduction policies and help raise public awareness about the importance of minimizing waste generation.
- An understanding of per capita production and generation habits across different sectors enables the development of public policies and projects that contribute to the creation of a sustainable waste management system. Perception surveys also play a vital role in this phase, as they provide municipal managers with valuable insights into the community's expectations regarding waste collection and disposal services.
- The data collected in Cayambe and Puerto López helped the Ministry of Environment, Water, and Ecological Transition (MAATE) in developing additional technical guidelines and supporting sustainable solid waste management in another municipalities. Additionally, this data will help improve waste collection and classification processes, serving as a foundation for future operations of local governments across Ecuador.
- In summary, the guide offers a comprehensive framework for the development of effective non-hazardous solid waste management strategies, thereby supporting the sustainable development of Ecuador's municipalities.

1 Dr. Kunitoshi Sakurai designed this statistical methodology in 1982, and it has since been used for waste characterization studies in several Latin American and Caribbean countries. The method focuses on representative sampling, determining per capita generation, analyzing composition, and evaluating density.

2 Annex 13 contains three Excel sheets designed to assist users in calculating per capita production for all types of municipalities, according to their respective sizes.

3 Annex 16 contains the procedure, which is provided in Excel format as a user tool.

4 Annex 20 contains an Excel document to assist to users in preparing the main report.