# Physical composition of household and industrial solid waste under a rigorous statistical and case study analysis approach based on Python

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### Abstract

Efficient solid waste management and optimized resource recovery are crucial to environmental sustainability. In this work, a well-organized sampling and structured waste sorting approach were implemented, using a statistically reliable solid waste characterization method to verify the prediction model created in the Python language. The sample was based on Household and Industrial Waste and the total of waste collected were sorted into thirteen categories at level I, II and III. The results showed that Food waste (51%), which occupies the most dominant position, and Glass (2.06%), which has the lowest rate among Household and Industrial Waste. Statistical analyses revealed that the composition of Household and Industrial Waste was independent of variations in the Waste Generation Rate. Model 1 shows that the presence of family members in every household leads to an increase in Household Waste Generation Rate. As a result, the prediction of the Waste Generation Rate, model 2, was presented using linear models with seven exogenous variables, Paper, Waste Bags, Textiles, Metals, Waste Nonclassified Combustibles, and Other Waste. The research revealed a correlation between the endogenous and exagenous variables, except between the unemployemet rate and Household Waste Generation Rate. Furthermore, the individual percentage composition of Food Waste, Waste Nonclassified Combustibles, Glass, Special Waste and Other types are not significant in Waste Generation Rate, indicating that manual sorting of these waste types is not necessary.

**Keywords** : Household and Industrial Waste, Waste compositions and fractions, Waste Generation Rate, Statistical analyses, Socio-economics parameters, Python

## I- Introduction

Waste production, composition, and characterization are among the most crucial factors to consider when selecting the most appropriate collection method, treatment technology, and final disposal worldwide, particularly in developing countries (Phuong et al., 2021). The process of solid waste valorization involves a comprehensive analysis of waste types, composition, and potential applications. Moreover, solid waste streams vary widely, encompassing organic waste, plastics, paper, glass, and metals, each with distinct properties and recovery challenges. In this context, solid waste characterization and analysis emerge as vital tools that enable us to delve into the intricate realm of waste and provide the information necessary to address these challenges and promote a cleaner, more sustainable future.

## II- Methodology

#### 2-1 Phython-based model creation

This is the final process to evaluate if there are exist a coorelation with the differentes variable in the model Eq. (1) for each stading such us HGR, M, UR, E, Adu, Chi, Rev and nbr\_fam and in the model Eq. (2) likes WGR, FW, Pap, WB, Tex, Met, WNCC and Oth. Also, the other objectif is to predict if a household generation is true or fase based on the differentes measurements for the model 1 and if a Waste generation rate is true based on the differentes endogenous variables. In the first step, the loading libraries was implemented on the mitosheet interface. The several package was implemented in order to create the model. Import pandas as pd mean to working with the data sets, import numpy as np used to work with arrays from the dataset table. To create and customize visualisation, such as line plots, scatter plots, hystograms using the function and methods provided by the pyplot module is usually used matplotlib pyplot as plt. The import searborn portion of the code tells Python to bring the Seaborn library into the current environment (fig.2). The as sns portion of the code then tells Python to give Seaborn the alias of sns.

#### 2-2-Work orders



#### III- Results and discussion <u>3-1</u> Socio-economic parameters4

 $HGR_{it} = -0,216M_{it} + 1,076W_{it} + 0,767UR_{it} + 11,365E_{it} - 5,202Adu_{it} - 0,316Chi_{it} - 4,222Rev_{it} + 0,899nbr_fam_{it} - 43,943_{it}$ 

 $HGR_{it} = -6,983M_{it} - 7,420W - 1,306UR_{it} - 11,178E_{it} - 0,2328Adu_{it} - 3,7137Rev_{it} + 9,028nbr_{f}am_{it} + 131,439_{it}$ 

 $HGR_{it} = 19,681M_{it} + 10,958W_{it} + 0,333UR_{it} + 8,771E_{it} - 22,245Adu_{it} 17,644Chi_{it}+0,0001Rev_{it}+3,744nbr_fam_{it}+0,607_{it}$ 

**3-2** Physical parameters of solid waste composition

 $WGR_{it} = 0,022FW_{it} - 1,046Pap_{it} - 0,266WB_{it} - 0,482Tex_{it} + 0,309Met_{it} + 0,895WNCC_{it} + 0,5290th_{it} + 2,539th_{it} + 2,$ 

#### IV- Conclusion

he models proposed are linear models eq. (3) (4) (5) with nine variables, including one dependent variable and eight independent variables, to predict household solid waste production. Another linear model eq. (6) is used to predict Household and Industrial Waste (HIW). Qualitative and quantitative socio-economic data can be valuable for various sectors, including researchers, businesses, decision-makers, and the general public for further research. Additionally, the physical data on solid waste composition are highly useful for future research employing the same methods. However, the data on individual waste fractions require in-depth analysis, particularly regarding variable consideration and relationships.

For future studies, the authors recommend conducting quantification and physico-chimical characterization of Household Solid Waste (HSW). Sorting procedures should be performed following characterization with a larger number of skilled workers. It's also necessary to study developing a systematic optimization framework for the analysis of communal waste using mathematical modeling the evnironmental and socio-economic impact of individual waste composition using tools in this field.