Gravimetric composition of urban solid waste from the city of Manaus – AM

https://doi.org/10.56238/interdiinovationscrese-053

Melquizedec Arcos Rodrigues
Highest academic background: Doctor student in Mechanical Engineering. Master's Degree in Civil Engineering.
Current institution: State University of Campinas (UNICAMP).
E-mail: m230372@dac.unicamp.br

Kamal Abdel Radi Ismail
Highest education: Doctor in Mechanical Engineering.
Current institution: State University of Campinas (UNICAMP).
E-mail: kamal@fem.unicamp.br

Fátima Aparecida de Morais Lino
Highest academic background: Post-Doctorate in Mechanical Engineering.
Current institution: State University of Campinas (UNICAMP).
Campinas - SP, 13083-860.
E-mail: kamal@fem.unicamp.br

Inácia Oliveira de Azevedo
Highest academic background: Specialization in Psychopedagogy.
Current institution: Federal University of Amazonas (UFAM).
E-mail: I_azevedo10@hotmail.com

ABSTRACT

Research carried out by Abrelpe (2022) reveals that in 2022, 81.8 million tons of solid urban waste (MSW) were generated in Brazil, which means that each Brazilian citizen generated 381 kg of MSW, whose destination is landfills and dumps. Extinguishing or at least reducing landfills and dumps across the country is the desire of the entire population. It would greatly reduce health problems for the population, soil and river pollution, etc. The goal stipulated by the National Solid Waste Plan - PLANARES, of Federal Law No. 12.305/10 - National Solid Waste Policy (PNRS, 2010) is to get rid of dumps and landfills as final disposal sites for solid urban waste (MSW). by the year 2030. Factors such as the progressive increase in population combined with consumption and waste behavior, lack of public awareness, low percentage of other possible treatments, such as recycling, composting, biodigestion, have taken away hope of success for this goal . The city of Manaus, capital of the state of Amazonas, located in the central part of the Amazon jungle deposits more than one million tons of MSW per year, in an area of 66 hectares that has a useful life until the end of 2024. This work has The objective is to describe the activities carried out to characterize urban solid waste destined for the city's landfill through gravimetric analysis, consisting of three stages, required by NBR 10,007/2004: division, identification and weighing of waste categories. It was also possible to determine the apparent specific weight of these residues. The studies were carried out in eleven neighborhoods, between the months of July and October 2022. With these data in hand, a large amount of material was found to be able to be recycled (60% + 2%), despite publicity campaigns by the public authorities. , with an average apparent specific weight of 74 kg/m³. Thus, it is concluded that selective collection and sorting are of paramount importance, as alternatives for the reduction of waste destined for the city landfill, allowing its useful life and the reuse of recyclable materials, bringing economic, social and environmental benefits to the city. city and its inhabitants.

Keywords: Municipal solid waste, Gravimetry, Appropriate destination, Manaus – AM, Recycling.

1 INTRODUCTION

Federal Law No. 12,305/10, which instituted the National Solid Waste Policy (PNRS), gave a period of 10 years for the problems arising from MSW to be extinguished. By the end of the deadline, approximately 60% of the country's cities had not yet reached this goal. Controlled dumps and landfills currently occupy large areas in large urban centers, contaminating soils and groundwater, attracting animals and insects, increasing the risks to the health of the population and increasing the emission of greenhouse gases. A considerable portion of this MSW ends up in the beds of rivers and streams, clogging rainwater systems and causing flooding.

Between 2012 and 2022, MSW generation in Brazil increased by 11%, from 62.7 million tons to 81.8 million tons. In turn, per capita generation increased from 348 kg/year to 380 kg per year, on average, which is equivalent to 1.04 kilograms of urban waste per day per inhabitant (ABRELPE/IBGE, 2022).

In the city of Manaus, capital of the state of Amazonas, the largest state in Brazil, with its ecological and environmental riches, approximately 1,000,000 (one million) tons of MSW are landfilled every year, in an area of 660,000 m² whose capacity will be completed in 2024. In addition, the Brazilian Institute of Geography and Statistics (IBGE) classified Manaus as the fourth worst city in Brazil with garbage accumulation in public places. Approximately 6.2% of the surroundings of the households have accumulated garbage. Just near the creeks there are 108,000 residents affected by unpleasant odor, diseases and a lot of dirt. A total of 345,000 families are affected by the dirt in the streams of Manaus (IBGE, 2020).

The study area of this work focuses on the urban area of the city, on the 06 (six) administrative regions that the Manaus City Hall divides the city and on the Manaus urban solid waste landfill, located at Km 19 of Highway AM-010 – Manaus - Itacoatiara road. To achieve the proposed objectives, selective MSW collections were carried out in the six administrative regions of the city, namely: North, South, East, West, Central-South and Midwest. Approximately 3200 liters of MSW were collected in the neighborhoods that are part of these regions, in a total of 11 (eleven) neighborhoods, using the labor of experienced waste pickers and a vehicle with a body. For each collection site, gravimetry tests were performed: quarting, identification, measurement of volume and mass, and calculation of percentages, as well as calculation of apparent specific weight.

2 DEVELOPMENT

2.1 ENVIRONMENTAL IMPACTS

Rapid urbanization and the absence of effective waste management systems have turned landfills into one of the world's biggest problems. About 40% of the planet's solid waste goes to these areas, harming the lives of about 4 billion people. One of the solutions is the creation of sanitary landfills, a strategy adopted by the Brazilian government since 2010 to deactivate dumps and promote better management of what is discarded (MMA. 2019).

A study carried out by the World Wide Fund for Nature (WWF) shows that Brazil is the fourth country in the world that produces the most waste. That's more than 11 million tons per year. Our country is behind only the United States (1st place), China (2nd) and India (3rd). The Abrelpe study (2019) shows that the impact of landfills here in Brazil entails a cost of more than R$ 3 billion per year for the health system (MMA. 2019).

Latin America and the Caribbean region has one of the highest rates of urbanization in the world, with an estimated 500 million people living in cities, which translates to about 80% of the population. Among the various problems caused, those related to mobility, safety, health, well-being, sanitation and adequate management of MSW stand out. About 354,000 tons are produced daily, through inhabitants with the most diverse consumption habits, cultural characteristics and purchasing power. Of this fraction, it is estimated that 50% (or more) of the MSW generated is from food waste and materials of organic origin. Despite this great potential for recovery through different technological options that exist today, the portion of organic waste from MSW is discarded and deposited in landfills or dumps, bringing severe impacts to the environment, with the generation of Greenhouse Gases (GHG) in the face of the emission of methane gas (CH4), which is 25 times more harmful than carbon dioxide (CO2). and currently accounts for 3% of total GHG emissions into the atmosphere (ABREN, 2019).

In addition, there is the risk of contamination of water resources by leachate or leachate, that is, a reduction in the drinking water available on the planet. Due to its enormous volume (approximately half of MSW in developing countries), municipal organic waste deserves adequate and specialized management. In addition to being able to minimize costs and severe environmental impacts, it is possible to produce important by-products such as energy (electrical and thermal), fertilizers, and fuels (ABREN, 2019).

2.2 PUBLIC HEALTH

Landfills are a global health and environmental emergency. Landfills receive about 40% of the world's waste and serve 3 to 4 billion people. The 50 largest dumps affect the daily lives of 64 million people, a population the size of France. As urbanization and population growth continue, several hundred million people will be served by landfills, mostly in low-income countries. If the situation follows the usual scenario, landfills will generate 8 to 10% of man-made greenhouse gases by 2025 (ISWA, 2019).

More than 750 people died due to poor waste management in landfills in the first half of 2016 alone (ISWA, 2019). Abrelpe (2020) reports that landfills cost health systems a billion dollars per year. Even in times of pandemic, landfills continue to operate in Brazil and affect the health of more than 77 million people.

In addition to being a source of diseases such as dengue, yellow fever, zika and chikungunya, parasitosis and many others, combined with the deficient structure and scarcity of resources of the Unified Health System (SUS), there are also high social and economic costs in public spending by the municipality, state and federal government. In addition, zoonoses – infectious diseases capable of being naturally transmitted between animals and humans – account for 60% of all infectious diseases in humans and are on the rise due to the destruction of wild habitats resulting from the most diverse economic activities. These diseases certainly affect the tripod of sustainability – the economy, society and the environment, in addition to the negative impacts on community life (SANEAMENTO BASIC, 2020).

Basic sanitation Portal (2020) suggests that proposals for the environmentally correct disposal and treatment of garbage, in all its classifications, should first involve massive investments, in a planned and responsible manner, in sustainable alternatives with substantial gains for health, the economy and the environment with all the complexities that affect it. He cites what governments have done in the period of the Covid-19 pandemic, concerned with protecting populations, with even emergency and reserve investments, in two consecutive years so far.

The garbage that human beings produce and throw on the planet every day is a very serious risk to the health of all living beings and the planet itself. Here are some of the problems that trash can cause:

Diseases: Garbage that goes into open dumps or vacant lots produces bacteria and fungi. It also attracts cockroaches, rats, flies, mosquitoes etc. These animals can transmit serious diseases such as dengue, typhoid, cholera, dysentery, bubonic plague, and leishmaniasis (RETEC, 2015).

Air accidents: garbage accumulated near airports causes accidents, because the plane collides with a vulture or other large bird, for example. It can cause death of people, in addition, of course, to the death of the bird, which could have been avoided (RETEC, 2015).

Air pollution: garbage – burned or not, produces gases that are harmful to the health of living beings and the planet, such as methane gas and hydrogen sulphide gas. These gases pollute the air and can cause respiratory illnesses. Burned garbage produces carbon dioxide, a gas that is toxic if it is in large quantities. And if we remember that the planet's air is already full of carbon dioxide because of cars and factories (RETEC, 2015).

Flooding: PET bottles, plastic bags and other garbage are washed away in a heavy rain. They end up clogging storm drains and even preventing rivers from flowing through their beds. This causes terrible flooding. Dirty flood water spoils people's homes, kills domestic animals, and causes more diseases in the population (RETEC, 2015).

The problem of the disposition of MSW is big and affects the whole country, but it can be reduced if each of those involved does their part, governments, institutions, companies and every inhabitant of the nation. An example was studied by Ferreira (2018) in Brasília – DF. Due to the type and quantity of waste that was received in the controlled landfill of Jóquei, in the 1990s, when approximately 100 waste collectors moved to the region. When the landfill was decommissioned, it was estimated that there were about 2,000 to 3,000 people living and making a living in the region. Working and living in that place, under very harsh conditions The landfill did not have the minimum conditions for survival, such as lack of drinking water, lighting, violence, sub-human working conditions, health risks, child labor and proliferation of diseases, exposed to extreme pollution, with the possibility of suffering attacks from wild birds and rodents (FERREIRA, 2018).

The lack of structure and inadequate working conditions of the collectors of recyclable materials resulted in several accidents. According to survey data, from 2009 to 2017, at least 47 accidents were recorded. On the list are everything from burns and falls, to more serious cases, such as those involving the overturning of a truck and loss of fingertips, severed arm, being run over and death (FERREIRA, 2018).

2.3 SORTING AND RECYCLING

The sorting process is the separation of the materials that will be sent for recycling, according to their physical and chemical characteristics. This is an essential step in the recycling process and is considered the initial step in the production of new products. In addition, the Ministry of Cities defines a sorting shed, or sorting unit, for recyclable dry waste, as the set of buildings and facilities intended for the handling of materials from the selective collection of dry waste from household waste or similar to it (paper, plastics, metals, among others), by workers with recyclable materials, formally linked to organizations in this category, according to the logistics of implementation and operation (MINISTRY OF CITIES, 2010). These activities are not carried out in Manaus. The MSW collected by the transport trucks unload the waste and are then scattered and landfilled in the city's landfill.

In a sorting plant, the material from mixed collection and selective collection is received and then separated into materials of equal characteristics, at least in 03 (three) fractions: recyclables, organics and rejects. Depending on the population, which generates a lot of waste, it would need a large place and many people to separate all the MSW that arrives every day. The PNRS (2010) requires that organic material be destined for biodigesters or composting. Pyrolysis and incineration lose out on economic viability. Composting is best applied when you have waste with a lot of vegetables and tree debris (PRS, 2021).

Recyclable materials account for around 45% of all waste. A recycling facility is required for any material (plastic, paper, glass, electronics, plaster, etc.). The process of separating materials is a very simple service and Brazilian legislation requires that selective collection personnel and low-income people be classified in this process. Anyone who gets 15-30 minutes of training can join the team. The separated material must go to the industry to be reused in the production line. The market for recyclable materials emerges, which seeks the right buyer for the material to be evaluated, packages and delivers it to the industry (PRS, 2021).

Sorting can be done manually, automatically or semi-automatically. The first type involves the separation of household waste and the activity of garbage collectors. This is a type of screening that requires little investment, but has low production capacity and, therefore, is not very efficient (FRAGMAQ, 2015).

Automatic sorting, on the other hand, has the ability to receive a much larger volume of garbage, executing the sorting process quickly and without interruption for rest. In addition, the separation of garbage is done with higher quality and in a more reliable way. On the other hand, automatic garbage sorting requires high investment in equipment and space rental. It is a method more suitable for large cities. There is also semi-automatic sorting, which combines the work of garbage collectors with the installation of modern machinery (PRS. 2021).

2.4 CHARACTERIZATION OF MSW

The characterization of MSW is important to obtain data on its behavior under certain conditions, also allowing the study of ways to control or minimize its impacts on the environment. From these data, qualitative and quantitative, and with the application of statistical methods and analysis, it is possible to propose actions of selective collection and recycling, to verify if the recyclable materials have commercial value and if the organic matter is suitable for composting or biodigestion, or, to establish the appropriate treatment or destination, determine the necessary adaptations for the development of solutions for reduction, or even elimination, of the MSW from that community. In order to carry out a reliable waste characterization, it is necessary to carry out a reliable sampling, according to NBR 10007 – Solid waste sampling (ABNT, 2004).

2.4.1 Preparation for sampling

This subsection establishes the basic guidelines that must be observed before taking any sample, in order to define the sampling plan (sampling objective, number and type of samples, samplers, sampling site, flasks, and sample preservation).

2.4.2 Purpose of sampling

The purpose of sampling is to collect a representative amount of waste, in order to determine its characteristics in terms of classification, treatment methods, etc.

2.4.3 Pre-characterization of a waste

The pre-characterization of a waste is done by surveying the processes that gave rise to it. The information thus obtained (approximate volume, physical state, main constituents, temperature, etc.) allows the definition of the most appropriate type of sampler, the parameters to be studied or analyzed, the number of samples and their volume, the type of collection vial and the preservation method(s) that should be used.

2.4.4 Sampling plan

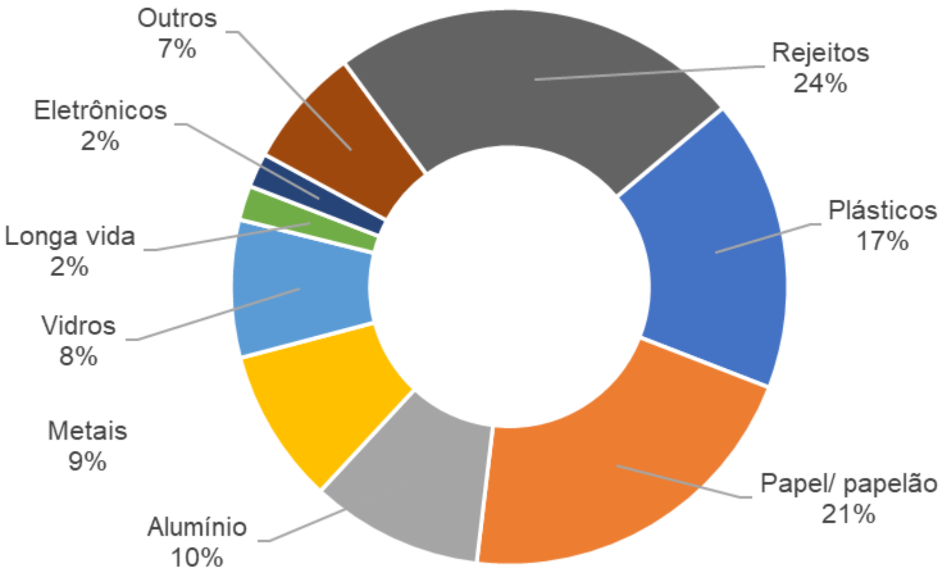
The sampling plan shall be established prior to the collection of any sample, shall be consistent with the purpose of sampling and the pre-characterization of the residue, and shall include: assessment of the site, form of storage, sampling points, types of samplers, number of samples to be collected, their volumes, their types (plain or compound), number and type of collection flasks, preservation methods and storage time, as well as the types of protective equipment to be used during collection. This plan should also set out the date and time of arrival of the samples at the laboratory. In NBR 10007 (2004) there are tables that present the methods of preservation and storage of solid and liquid samples.

2.4.5 Physical Characteristics

2.4.5.1 Gravimetry

The gravimetric composition of MSW is the percentage survey of the materials that form the MSW deposited in a given location. This is accomplished by measuring the mass of each material and calculating the percentage of that mass. For example, the gravimetric composition of MSW in Brazil is shown in Figure 1. Waste that is composed of residential garbage, leftovers from fairs, various packaging (long life, aluminum cans, glass) is equivalent to half. There is a large amount of organic matter that is thrown into the dumpsters mixed with other types of waste. As in other studies, paper/cardboard scraps continue to be the most collected types of materials (by weight), followed by plastics in general. The percentage of tailings is still high (around 24%), demonstrating the need for investments in raising awareness among the population so that they can correctly separate waste (CEMPRE, 2019).

Figure 1. Percentage composition of residues. Source: CEMPRE, 2019.



It is estimated that in the years 2020 and 2021 the situation tends to worsen as a result of the pandemic. According to Abrelpe (2020), the generation of solid waste increased during the pandemic by approximately 25%. Due to the protective quarantine measures, with working from home and children at home, there was an increase in consumption, delivery orders and a greater number of meals at home, and as a consequence a growth in MSW generation.

2.4.5.2 Apparent specific gravity

It is the weight of the loose waste by the volume freely occupied, without any compaction, given in kg/m³. The determination of the apparent specific weight is extremely important for the sizing of equipment and installations. In the absence of more precise data, the following values can be used: 231 kg/m³ for the specific weight of household waste (average); 280 kg/m³ for the specific weight of waste in health services; 1,300 kg/m3 for the specific weight of construction debris. Some other examples: 1213 Kg/m³ for organic matter; 338 kg/m³ for paper/cardboard; 240 kg/m³ for others (sand, rubble, among others); 224 kg/m³ for plastic film; 135 kg/m³ for rigid plastic; 119 kg/m³ for rags; 73 kg/m³ for rubber; 60 kg/m³ for pak; 53 kg/m³ for metal; 50 kg/m³ for glass; 41 kg/m³ for wood (DIAS, 2016).

3 INFORMATION ABOUT THE CITY OF MANAUS- AM

Manaus, capital of the state of Amazonas, is in seventh place in the ranking of capitals with a population of 2,116,254 people, being the largest and most populous city in the state of Amazonas, located right in the center of the Amazon rainforest, as shown in Figure 2. In territorial extension, it is the second largest in the country with an area of 11,401.092 km² (the largest is Porto Velho – RO, with 34,090.952 m²), so extensive that if you add all the sixteen capitals of the south, southeast and northeast regions (9,023 km²) Manaus alone still surpasses all in area.

In urban area, the city of Manaus has the fourth largest in the country, with 427 square kilometers, according to IBGE data (2020). The area of the Metropolitan Region of Manaus, on the other hand, has an area of 127,287.789 square kilometers. It is the largest Brazilian metropolitan area, larger than the area of some Brazilian states such as Pernambuco, Santa Catarina and Rio de Janeiro (being more than twice as large as the latter) and has approximately the same dimensions as some nations such as Iceland (103,000 km²) and South Korea (99,538 km²), and higher than countries such as Hungary (93,032 km²) and Portugal (92,391 km²) (IBGE, 2020).

3.1 NEIGHBORHOODS IN THE CITY OF MANAUS

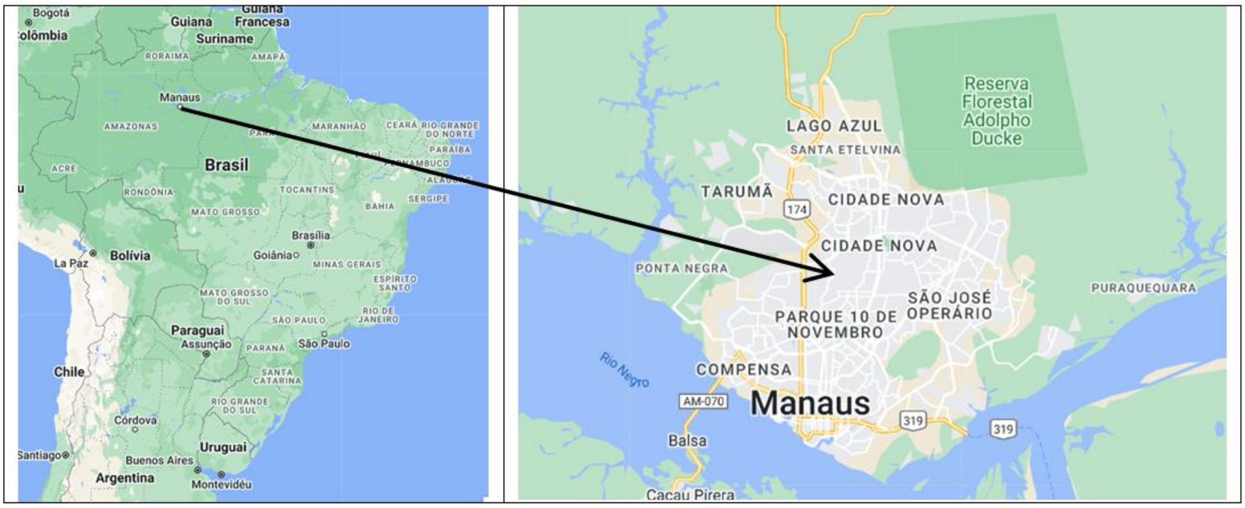
Since 2010, the Manaus City Hall has recognized 63 official neighborhoods (IBGE, 2010). Neighborhoods that are not recognized by the administrative body are considered to be part of other neighborhoods. The countryside is not divided into neighborhoods and is therefore not represented on the list. Among all the administrative regions of the city, the South zone is the largest in number of neighborhoods, with a total of 18 neighborhoods, and is also the most densely populated. However, the most populous neighbourhoods are found in the North and East zones, such as Cidade Nova and Jorge Teixeira, which each have more than 100,000 inhabitants. The last territorial division that took place in the municipality took place on January 14, 2010, through Municipal Law No. 1,401/10.1 By this measure, the neighborhoods of Cidade de Deus Distrito Industrial II, Gilberto Mestrinho, Lago Azul, Nova Cidade, Novo Aleixo and Tarumã-Açu were approved.

According to IBGE (2020), the Manaus neighborhood with the best quality of life and Human Development Index is Nossa Senhora das Graças, which has an HDI of 0.943, a quality of life similar to that of Norway, for example. However, Manaus also has poverty rates similar to those of poor countries, such as the community of Grande Vitória, which has an HDI of 0.658, similar to that of Bolivia, or the community of Parque São Pedro, which has an HDI of 0.688, which allows it to be compared to Vietnam. In total, thirteen communities and neighborhoods in Manaus were classified as in a state of "poverty" and another two as in "extreme poverty". The region of the city considered to have the best quality of life is the Center-South, in addition to other locations such as Ponta Negra and some parts of the Cidade Nova neighborhood. The region with the highest incidence of poverty is found in the communities of Nova Vitória, Grande Vitória and in the neighborhoods of Cidade de Deus and parts of Jorge Teixeira and Tarumã. Table 1 summarizes the population of the city's administrative areas.

Table 1. Population of the administrative areas of the city of Manaus-AM.

Administ Zone	Population	Area (m²)
NORTH	592.325	9.876,84
EAST	529.543	15.568,39
SOUTH	338.674	4.707,97
WEST	299.782	12.829,44
CENTRAL-SOUTH	180.577	3.556,97
MIDWEST	175.353	1.799,31
Total	2.116.254	48.338,92

Figure 2. Location of the city of Manaus - AM.



4 METHODOLOGY

4.1 GRAVIMETRY

A team consisting of a driver, three waste pickers and four properly equipped helpers of their PPE traveled to the neighborhoods of the city of Manaus, state of Amazonas, and collected approximately 3200 liters of MSW from each of the neighborhoods, in a car with a body, as illustrated in Figure 3. This amount was taken to a covered shed where another team of recyclers and helpers unloaded the MSW that was removed from the plastic bags, disaggregated and homogenized on plastic sheeting that covered the floor of the shed, until it formed a single mound. Soon after, a quarter was made and two of the diametrically opposite parts were discarded and the other two were used to fill plastic bucket containers with a capacity of 100 liters each, until a volume of 1,000 liters of waste was obtained. Each of the containers containing waste was properly placed on a Filizola scale, type 34, with a capacity of 150 kg, and its mass was measured and noted, as shown in Figure 4. After weighing the total sample, the waste was sorted on the plastic tarpaulin as follows: Paper/cardboard, wood, metals, glass, hard plastic (HDPE), soft plastic (LDPE), PET plastic, PP plastic, Styrofoam, rejects and organic material. Again, each container with each type of material was properly weighed, separately, to obtain the representativeness in weight of each type of material. With these data, the percentages of each type of material in that 1000-liter sample were determined, according to Equation 1, by dividing the percentage of the mass of each material by the total mass of the sample, as well as calculating the specific weight of the MSW, by directly dividing the total mass of the sample by the total volume.

Equation 1. Percentage of each type of material after screening.

$$\text{Percentage of each category (\%)} = 100 * \frac{\text{weight of each fraction (kg)}}{\left(\text{total sample weight (Kg)}\right)}$$

Where:

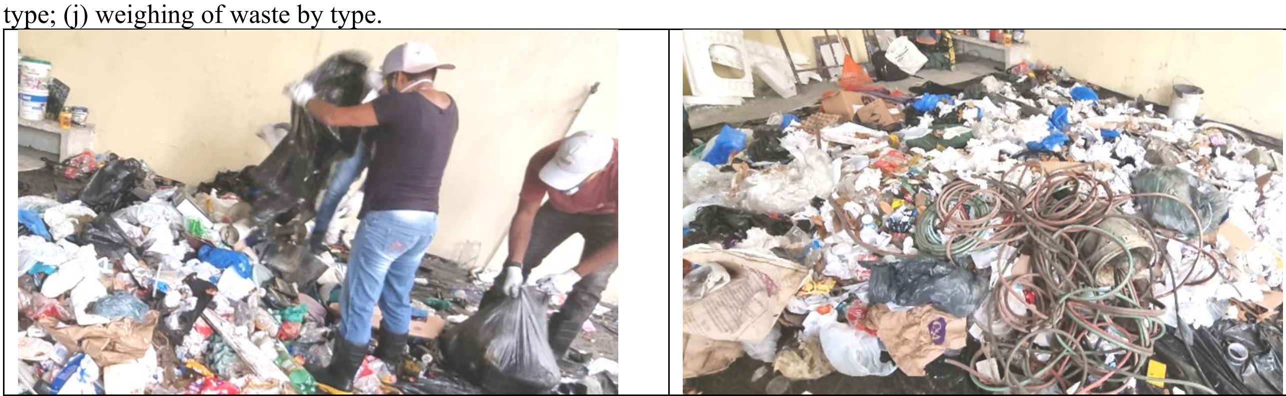
Percentage of each category = percentage of each class/type of waste present in the sample;

Weight of each fraction = weight of each class/type of waste after sorting.

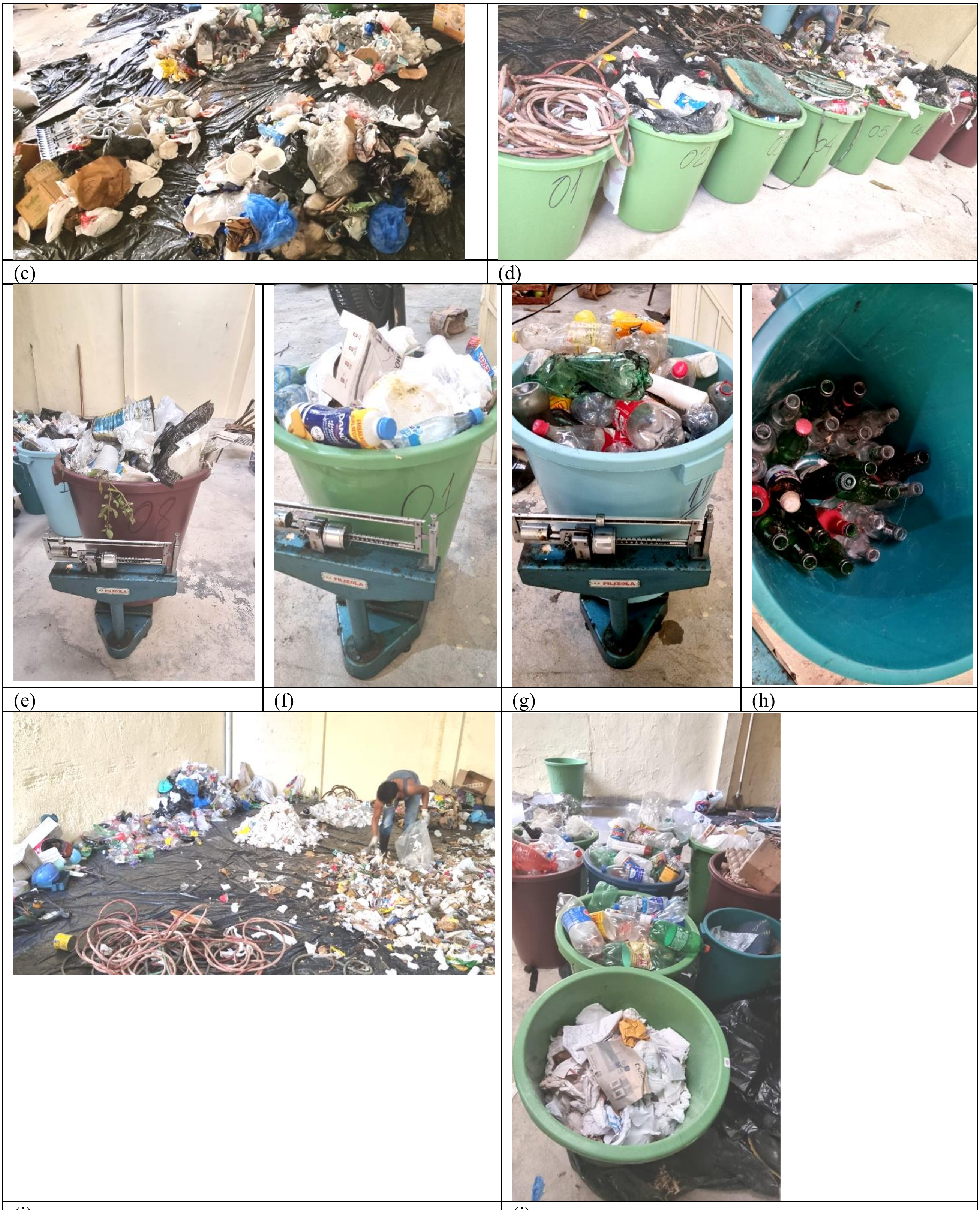
Figure 3. Selective collection. (a) On the streets; (b) in community dumps; (c) Vehicle used.

(a) (b) (c)

Figure 4. Gravimetry: (a) Removal of waste from plastic bags; (b) mixing of waste; (c) quartering; (d) separation of 1m³ of waste; (e) and (f) weighing of mixed waste; (g) and (h) weighing of waste separated by type; (i) separation of waste by type; (j) weighing of waste by type.



(a) (b)

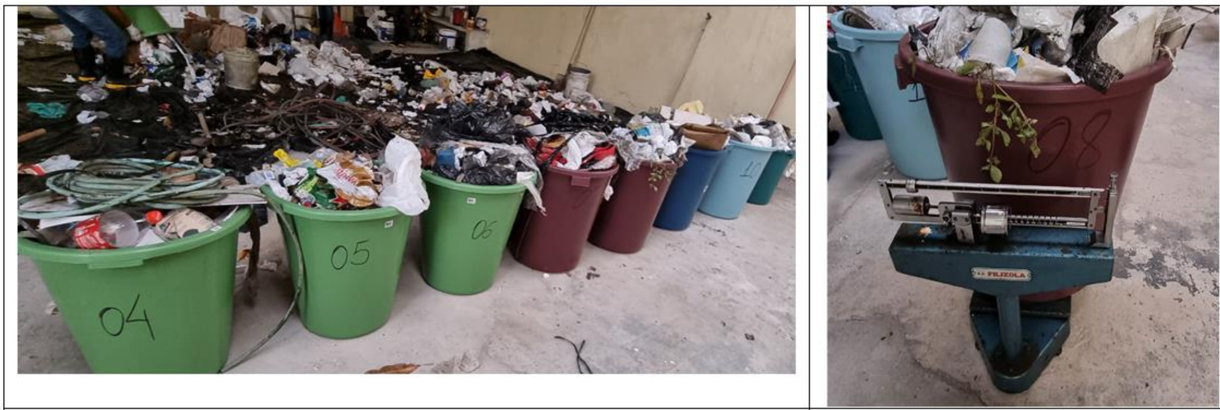


(c) (d) (e) (f) (g) (h) (i) (j)

4.2 APPARENT SPECIFIC GRAVITY

From the volume of MSW collected from the clays, mixed and quartered and placed in 100-liter bucket containers, in a total of 1000 liters for each of the neighborhoods, the mass of each of the buckets was placed on the scale and measured, obtaining the total mass of the volume of 1000 liters, as shown in Figure 5. The arithmetic division of this mass by the volume is called the apparent specific weight of the material, according to Equation 2. This parameter is of paramount importance for selective collection companies. Because it is quantitative, it reflects the density of MSW and varies greatly according to its composition. Their knowledge results in an adequate sizing of routes, number of collection trucks and compaction machinery.

Figure 5. Weighing the volume of 1m³ of MSW: (a) Volume measurement; (b) Mass measurement.



(a) (b)

Equation 2. Apparent specific weight.

$$Specific\ weight\ \left(\frac{Kg}{m^3}\right) = \frac{mass\ of\ waste\ (Kg)}{waste\ volume\ (m^3)}$$

5 CONCLUSION

5.1 GRAVIMETRY

Detailed sampling of the gravimetric profile of urban solid waste from each of the neighborhoods worked resulted in the data and percentage proportions presented in Table 2. It is possible to perceive the quantities and percentages of each material constituting the waste collected and processed. The mean of the neighborhoods was extracted, as well as the standard deviation of the sample.

Table 2. Gravimetry of each of the administrative regions of the city of Manaus-AM.

Neighborhoods. NORTH ZONE	Kg	Kg	C.Nova	N.Israel	Average	DP
Mat. Organic	18,0	19,0	23,4%	23,1%	23,2%	0,2%
Paper/Cardboard	16,2	17,1	21,1%	20,8%	20,9%	0,2%
Mole Plastic	6,7	10,3	8,7%	12,5%	10,6%	2,7%
Hard Plastic	7,9	9,0	10,3%	10,9%	10,6%	0,5%
PET	8,0	7,4	10,4%	9,0%	9,7%	1,0%
PP	1,4	1,8	1,8%	2,2%	2,0%	0,3%
Isopor	1,7	2,2	2,2%	2,7%	2,4%	0,3%
Year	3,9	3,0	5,1%	3,6%	4,4%	1,0%

Wood	1,1	0,8	1,4%	1,0%	1,2%	0,3%
Glasses	3,2	2,5	4,2%	3,0%	3,6%	0,8%
Rejects	8,8	9,2	11,4%	11,2%	11,3%	0,2%
TOTAL	76,9	82,3	100%	100%	100%	
Neighborhoods. SOUTH ZONE	Kg	Kg	P.14	Students	Average	DP
Mat. Organic	19,4	16,1	24,5%	24,5%	24,5%	0,0%
Paper/Cardboard	16,0	13,9	20,2%	21,1%	20,7%	0,7%
Mole Plastic	10,8	9,8	13,6%	14,9%	14,3%	0,9%
Hard Plastic	2,8	2,6	3,5%	4,0%	3,7%	0,3%
PET	5,3	4,7	6,7%	7,1%	6,9%	0,3%
PP	2,3	1,7	2,9%	2,6%	2,7%	0,2%
Isopor	2,1	1,0	2,6%	1,5%	2,1%	0,8%
Year	2,7	1,8	3,4%	2,7%	3,1%	0,5%
Wood	0,0	0,0	0,0%	0,0%	0,0%	0,0%
Glasses	4,7	2,7	5,9%	4,1%	5,0%	1,3%
Rejects	13,2	11,5	16,6%	17,5%	17,1%	0,6%
TOTAL	79,3	65,8	100%	100%		
Neighborhoods. EAST ZONE	Kg	Kg	T. Neves	A. Mendes	AVERAGE	DP
Mat. Organic	17,6	18,5	24,2%	24,4%	24,3%	0,2%
Paper/Cardboard	13,0	14,6	17,9%	19,3%	18,6%	1,0%
Mole Plastic	13,3	14,2	18,3%	18,7%	18,5%	0,3%
Hard Plastic	3,8	4,1	5,2%	5,4%	5,3%	0,1%
PET	5,4	6,0	7,4%	7,9%	7,7%	0,4%
PP	2,3	2,6	3,2%	3,4%	3,3%	0,2%
Isopor	1,8	1,7	2,5%	2,2%	2,4%	0,2%
Year	5,0	4,0	6,9%	5,3%	6,1%	1,1%
Wood	0,4	0,5	0,5%	0,7%	0,6%	0,1%
Glasses	3,2	2,8	4,4%	3,7%	4,0%	0,5%
Rejects	7	6,8	9,6%	9,0%	9,3%	0,5%
TOTAL	72,8	75,8	100%	100%		
Neighborhoods. WEST ZONE	Kg	Kg	Tarumã	Compensates	Average	DP
Mat. Organic	31,5	18,9	28,5%	27,8%	28,1%	0,5%
Paper/Cardboard	20,3	12,4	18,4%	18,2%	18,3%	0,1%
Mole Plastic	15,1	9,1	13,7%	13,4%	13,5%	0,2%
Hard Plastic	9,1	5,2	8,2%	7,6%	7,9%	0,4%
PET	7,3	4,7	6,6%	6,9%	6,8%	0,2%
PP	3,5	2,0	3,2%	2,9%	3,1%	0,2%
Isopor	1,6	1,1	1,4%	1,6%	1,5%	0,1%
Year	2,2	2,9	2,0%	4,3%	3,1%	1,6%
Wood	1,1	0,0	1,0%	0,0%	0,5%	0,7%
Glasses	5,1	2,9	4,6%	4,3%	4,4%	0,2%
Rejects	13,8	8,9	12,5%	13,1%	12,8%	0,4%
TOTAL	110,6	68,1	100%	100%		
Neighborhoods. CENTRAL-SOUTH ZONE	Kg	Kg	P. Dec	Flowers	Average	DP
Mat. Organic	18,2	15,3	25,9%	24,8%	25,3%	0,8%
Paper/Cardboard	17,3	13,7	24,6%	22,2%	23,4%	1,7%
Mole Plastic	7,6	6,9	10,8%	11,2%	11,0%	0,3%
Hard Plastic	5,7	6,5	8,1%	10,5%	9,3%	1,7%
PET	5,1	5,8	7,2%	9,4%	8,3%	1,5%

PP	2,3	2,0	3,3%	3,2%	3,3%	0,0%
Isopor	1,0	1,2	1,4%	1,9%	1,7%	0,4%
Year	2,5	1,6	3,6%	2,6%	3,1%	0,7%
Wood	0,5	0,5	0,7%	0,8%	0,8%	0,1%
Glasses	1,8	1,6	2,6%	2,6%	2,6%	0,0%
Rejects	8,4	6,7	11,9%	10,8%	11,4%	0,8%
TOTAL	70,4	61,8	100%	100%		
Neighborhoods. MIDWEST ZONE		Kg	Dawn			
Mat. Organic		15,80	24,3%			
Paper/Cardboard		15,90	24,5%			
Mole Plastic		7,20	11,1%			
Hard Plastic		6,00	9,2%			
PET		5,10	7,8%			
PP		2,60	4,0%			
Isopor		1,30	2,0%			
Year		1,60	2,5%			
Wood		0,50	0,8%			
Glasses		2,00	3,1%			
Rejects		7,00	10,8%			
TOTAL		65,0	100%			

The values expressed in the table above are shown in graphs for better visualization, in Figures: 6, 7, 8, 9, 10 and 11.

Figure 6. Gravimetry of the North Zone. Average values.

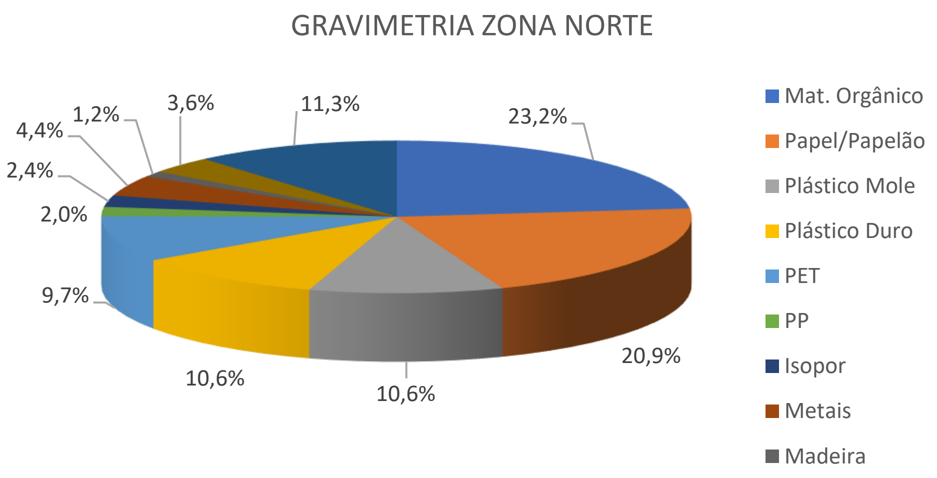


Figure 7. Gravimetry of the South Zone. Average values.

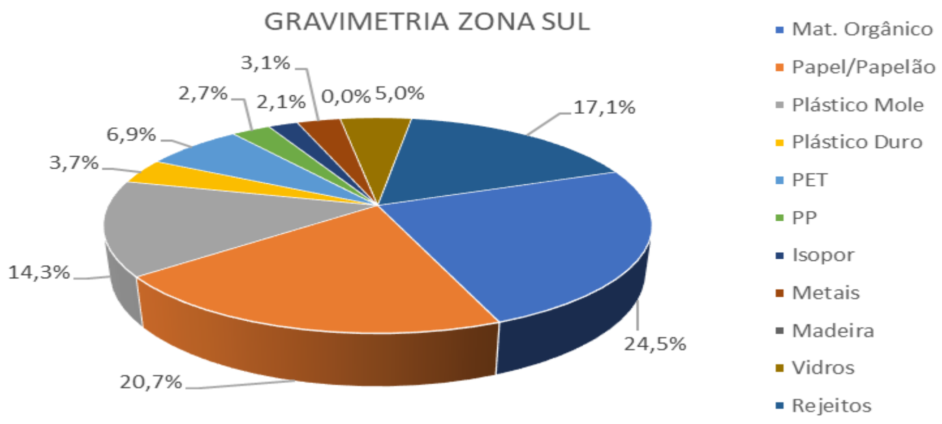


Figure 8. East Zone gravimetry. Average values.

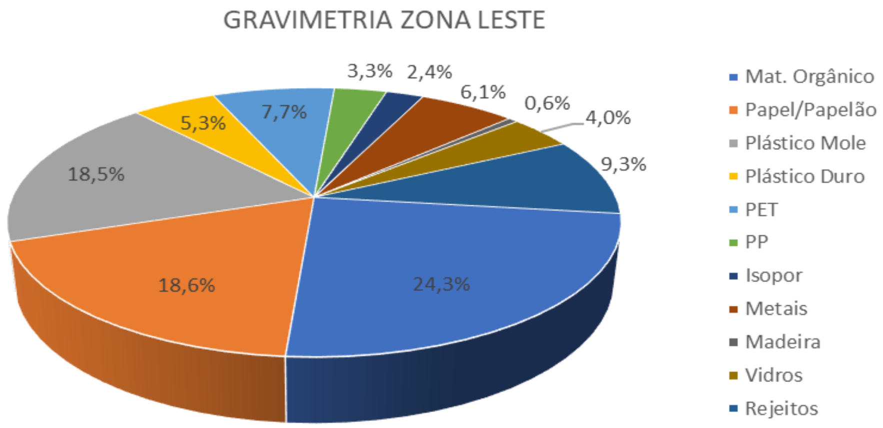


Figure 9. West Zone gravimetry. Average values.

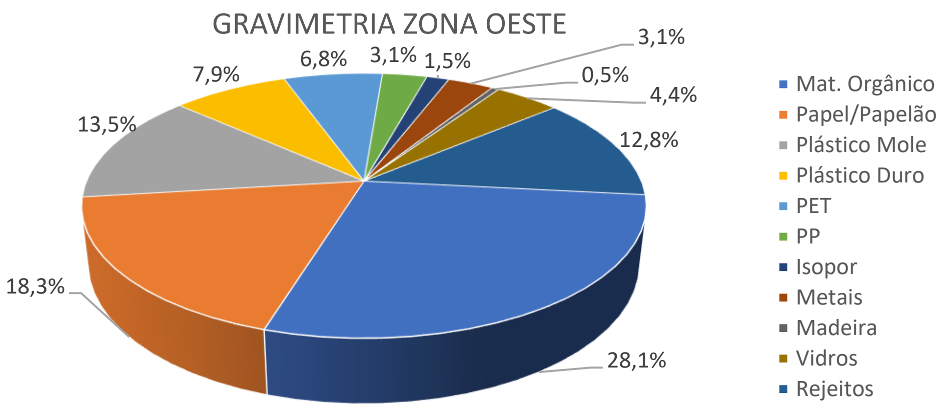


Figure 10. Gravimetry of the Central-South Zone. Average values.

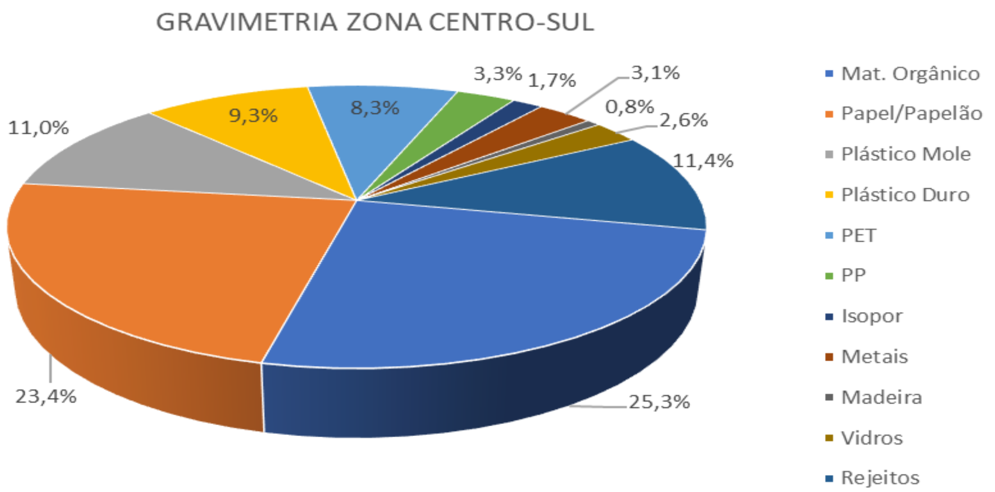
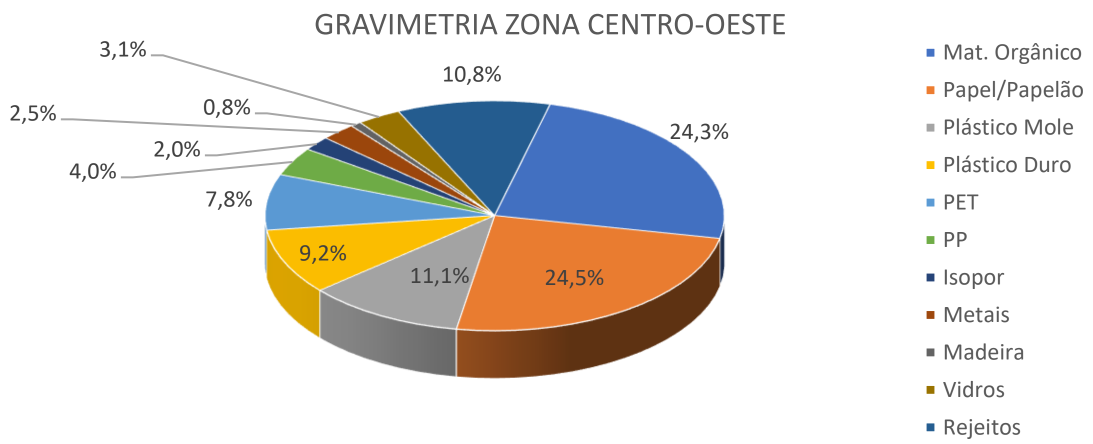


Figure 11. Gravimetry of the Midwest Zone. Average values.



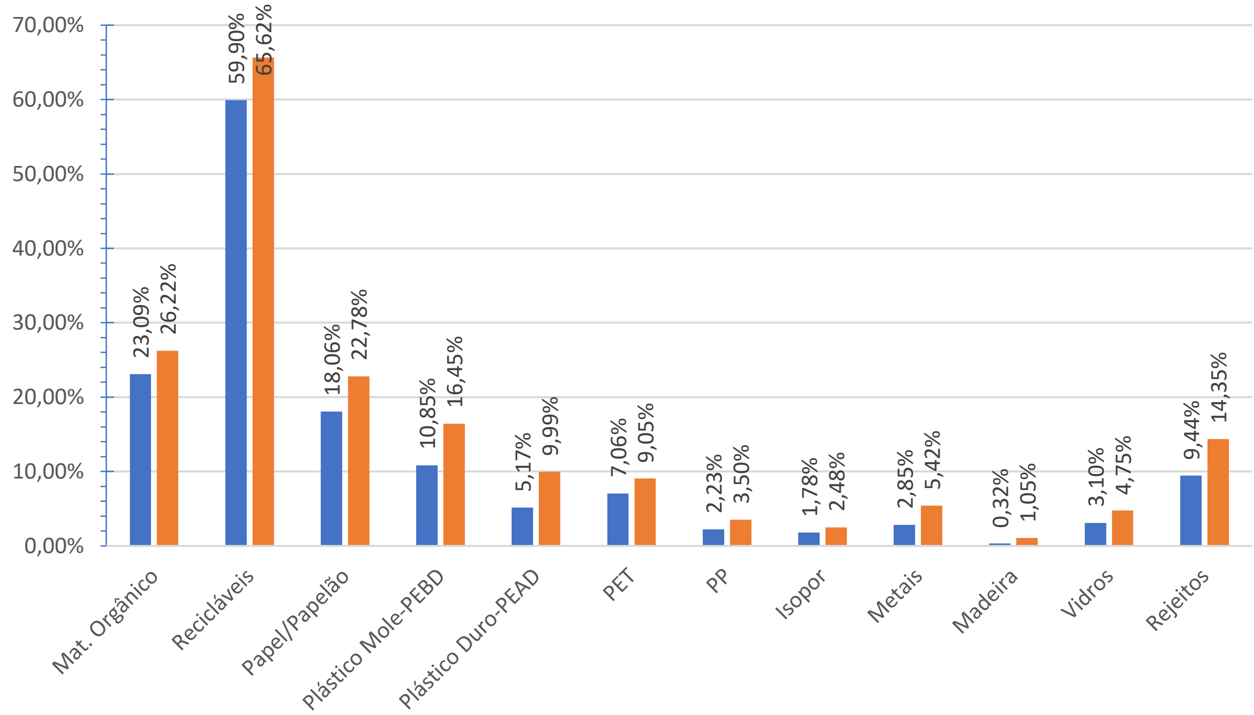
The results indicated a partial variation in certain materials when compared to the national average. The waste profile differs in that it presents a higher amount of recyclable materials such as paper, cardboard and plastics, in relation to the national average, while organic waste is shown in a higher percentage. This is due to the separation carried out in this work between tailings and organic material, which can be easily disposed of by biodigestion or composting, as summarized in Table 3.

Table 3. Percentage fractions by administrative area and weighted average of each material component of the MSW.

COMPONENTS	PERCENTAGE FRACTION						AVERAGE	WEIGHTED AVERAGE
	NORTH	ON	EAST	WEST	CENTRAL-SOUTH	MIDWEST		
Mat. Organic	23,25%	24,5%	24,3%	28,1%	25,3%	24,3%	24,96%	24,66%
Recyclable	64,24%	58,47%	65,81%	58,61%	62,55%	64,15%	62,31%	62,76%

Paper/Cardboard	20,92%	20,7%	18,6%	18,3%	23,4%	24,5%	21,04%	20,42%
Mole-LDPE Plastic	10,61%	14,3%	18,5%	13,5%	11,0%	11,1%	13,16%	13,65%
Hard Plastic-HDPE	10,60%	3,7%	5,3%	7,9%	9,3%	9,2%	7,69%	7,58%
PET	9,70%	6,9%	7,7%	6,8%	8,3%	7,8%	7,86%	8,05%
PP	2,00%	2,7%	3,3%	3,1%	3,3%	4,0%	3,06%	2,87%
Isopor	2,44%	2,1%	2,4%	1,5%	1,7%	2,0%	2,02%	2,13%
Year	4,36%	3,1%	6,1%	3,1%	3,1%	2,5%	3,69%	4,14%
Wood	1,20%	0,0%	0,6%	0,5%	0,8%	0,8%	0,64%	0,69%
Glasses	3,60%	5,0%	4,0%	4,4%	2,6%	3,1%	3,79%	3,92%
Rejects	11,31%	17,1%	9,3%	12,8%	11,4%	10,8%	12,10%	11,90%
TOTAL	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Weighting factor	0,2799	0,1600	0,2502	0,1417	0,0853	0,0829		

Figure 12. Final gravimetry of the city of Manaus -AM.



For a better understanding, Figure 12 seeks to show the final values, taking into account the weighting according to the population of each of the administrative areas, as shown in Table 4.

Table 4. Population and weighting coefficient by administrative area of the city Manaus – AM.

ZONE	Population (inhab)	Weighting (w)
NORTH	592.325	0,2799
NORTH EAST	338.674	0,1600
EAST	529.543	0,2502
WEST	299.782	0,1417
CENTRAL-SOUTH	180.577	0,0853
MIDWEST	175.353	0,0829

	2.116.254	1,0000

The greater representativeness of recyclable waste (59% to 65%) and the small proportional reduction of organic waste (23% to 26%) and waste (10% to 14%), while the national average these values are 28%, 50% and 22% respectively, are possibly consequences of the excessive use of packaging, due to the number of people who start to live in the vicinity of the Manaus Industrial Pole and the commercial and service area existing in the urban area of the city. city. In the field analysis, it was found that at least 50% of this plastic material comes from recyclable packaging (or with easy commercial value in the market), evidencing the possibility of selective collection if a sorting plant is installed before the waste is landfilled. These characteristics are due to the fact that the use of packaging is increasing, evidencing the need for local public policies for post-consumption responsibility, product life cycle analysis and priority marketing of products with sustainable packaging.

5.2 APPARENT SPECIFIC GRAVITY

The volumes and masses of the samples from each of the neighborhoods of the six administrative regions are shown in Table 5, as well as the results of the apparent specific weights after the application of equation 2.

Table 5. Apparent specific weight of MSW in the administrative regions of the city of Manaus-AM.

LOCAL	VOLUME:	BRUTE:	LIQ:	SPECIFIC GRAVITY:
	Litres	Kg	Kg	Kg/m³
Novo Israel	988,0	105,10	82,30	83,30
New town	988,0	99,70	76,90	77,83
Students	988,0	88,60	65,80	66,60
Square 14	988,0	102,10	79,30	80,26
Armando Mendes	988,0	98,60	75,80	76,72
Tancredo Neves	988,0	95,60	72,80	73,68
Compensates	988,0	90,90	68,10	68,93
Tarumã	988,0	133,40	110,60	111,94
Flowers	988,0	84,60	61,80	62,55
Park Ten	988,0	93,20	70,40	71,26
Dawn	988,0	87,80	65,00	65,79
AVERAGE	**988,0**	**95,60**	**72,80**	**73,68**

One of the consequences of the presence of a high percentage of packaging and recyclable materials is the average value of apparent specific weight, 73.68 Kg/m³, approximately one third of the national average, confirming the large amount of light materials containing air inside, such as packaging and enabling a high degree of compaction when dimensioning the route and the number of waste compactor collection trucks.

The studies carried out in these neighborhoods were fundamental for the collection of initial and updated data, which enabled the gravimetric characterization of solid waste in the city of Manaus, state of Amazonas, and will enable other studies. For the time being, there has been a large amount of material with the capacity to be recycled (62% ± 2%), despite the publicity campaigns of the public authorities, with a low apparent specific weight, confirming little organic matter and a lot of light material that can be recycled, leading to the thought of installing a sorting plant as an alternative to reduce the waste destined to the city's landfill. increasing its useful life and the reuse of recyclable materials, bringing economic, social and environmental benefits to the city and its inhabitants.

REFERENCES

ABNT. NBR 10007/2004 - Amostragem de resíduos sólidos. Rio de Janeiro, RJ. 2004.

ABRELPE: Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais. Panorama Dos Resíduos Sólidos No Brasil 2018/2019. Brasília. DF. 2020.

ABRELPE: Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais. Panorama Dos Resíduos Sólidos No Brasil 2020/2021. Brasília. DF. 2022.

ABREN: Associação Brasileira de Recuperação Energética de Resíduos. Regulação Nacional e Internacional de Waste-to-Energy. WASTE EXPO BRASIL, 12-14 novembro de 2019. São Paulo – SP.

CEMPRE: COMPROMISSO EMPRESARIAL PARA A RECICLAGEM. Preço do Materiais Reciclavéis. Revista Cempre Review. Ed. 159, 2019. Disponível em < http://cempre.org.br/cempre-informa/id/115/preco-dos-materiais-reciclaveis>. Acesso em 12 nov. 2020.

DIAS. J. O. V. ESTUDO PARA A IMPLEMENTAÇÃO DE UM SISTEMA INTEGRADO DE GESTÃO DE RESÍDUOS SÓLIDOS URBANOS NA ESCOLA SUPERIOR DE TECNOLOGIA. Monografia. Universidade do Estado do Amazonas - UEA. Manaus-AM. 2016.

FERREIRA. R. S. Desativação do Aterro Controlado do Jóquei X Transferência para o Aterro Sanitário de Brasília: Análises dos Principais Aspectos Sociais e Ambientais. UNICEUB- DF., 2018.

IBGE. Instituto Brasileiro de Geografia e Estatísticas. Conheça cidades e estados do Brasil. 2020. Disponível em < https://cidades.ibge.gov.br/brasil/am/panorama>. Acesso em 29 set. 2020.

ISWA – International Solid Waste Association. Dumpsites: A Global Waste Emergency. Out, 2019. Disponível em <https://closingdumpsites.iswa.org/why/why-close-dumpsites/>. Acesso em 12 Dez. 2020.

LEI Nº 12.305, DE 2 DE AGOSTO DE 2010. Política Nacional de Resíduos Sólidos. 2010.

MCIDADES: Ministério das Cidades. Secretaria Nacional de Saneamento Ambiental. Termo de referência técnico: elaboração do projeto básico e executivo completo de galpão / unidade de triagem para coleta seletiva, 2010. Disponível em < https://antigo.mdr.gov.br/images/stories/ArquivosSNSA/Arquivos_PDF/16_TRProjRSUGalpao_triagem%202010_2011.pdf>. Acesso em 14 abr. 2021.

MMA - MINISTÉRIO DO MEIO AMBIENTE. MMA abre consulta pública para alavancar a cadeia de reciclagem e reutilização de embalagens. 2020. Disponível em < https://mma.gov.br/component/k2/item/15752-mma-abre-consulta-p%C3%BAblica-para-alavancar-a-cadeia-de-reciclagem-e-reutiliza%C3%A7%C3%A3o-de-embalagens.html >. Acesso em 25 out. 2020.

PRS: PORTAL DOS RESÍDUOS SÓLIDOS. Como montar uma usina de triagem de resíduos sólidos. Disponível em <https://www.youtube.com/watch?v=XqI-J7pRYbM>. Acesso em 11 abr. 2021.
RETEC: TECNOLOGIAS EM RESÍDUOS. Problemas que o lixo causa. 2015. Disponível em <https://www.retecresiduos.com.br/problemas-que-o-lixo-causa/#:~:text=Doen%C3%A7as%3A%20O%20lixo%20que%20vai,disenteria%2C%20peste%20bub%C3%B4nica%20e%20leishmaniose.>.

Acesso em: 24 mai. 2020.

SANEAMENTO BÁSICO. 2020. Artigo: Lixões a céu aberto são tão graves quanto uma pandemia, de 19/05/2020. Disponível em < https://www.saneamentobasico.com.br/lixoes-ceu-aberto-pandemia/>. Acesso em: 25 nov. 2020.