Design and implementation of an efficient model for the transformation and use of organic solid urban waste

Diseño e implementación de un modelo eficiente para la transformación y aprovechamiento de residuos sólidos orgánicos urbanos

Desenho e implementação de um modelo eficiente de transformação e aproveitamento de resíduos sólidos orgânicos ur

Lida Esperanza Ruiz Martínez[1]
Jesús Alberto Serna Caicedo[2]
Yasira Helena Vásquez Aguilar[3]

Received: March 5th, 2022
Accepted: April 15th, 2022
Available: May 15th, 2022

How to cite this article:
L.E. Ruiz Martínez, J.A. Serna Caicedo, Y.H. Vásquez Aguilar, "Design and implementation of an efficient model for the transformation and use of organic solid urban waste," *Revista Ingeniería Solidaria,* vol. 18, no. 2, 2022.
doi: https://doi.org/10.16925/2357-6014.2022.02.06

Research article. https://doi.org/10.16925/2357-6014.2022.02.06

[1] Departamento de Ingeniería Ambiental. Facultad de Ingeniería. Universidad Libre.
Email: lidae.ruizm@unilibre.edu.co
ORCID: https://orcid.org/0000-0002-8547-4410

[2] Departamento de Ingeniería Ambiental. Facultad de Ingeniería. Universidad Libre.
Email: jesusa-sernac@unilibre.edu.co
ORCID: https://orcid.org/0000-0003-0390-0680

[3] Departamento de Ingeniería Ambiental. Facultad de Ingeniería. Universidad Libre.
Email: yasirah-vasqueza@unilibre.edu.co
ORCID: https://orcid.org/0000-0003-2438-8073

Abstract

Introduction: This article is the development of the “Design and implementation of an efficient model for the transformation and use of organic solid waste”, in the “El Conjunto Residencial de Ontario in Bogotá. (Colombia)”. Developed at the Universidad Libre 2021.

Problem: The accumulation of solid urban waste by the residential community shows an environmental problem that results in health problems, bad odors, the attraction of rodents and a poor physical appearance in the common areas of this complex, caused by the lack of use of this organic waste.

Objective: to formulate an efficient model for the transformation and use of organic solid waste in the “Conjunto Residencial Tejar de Ontario”.

Methodology: Characterization by the method of quartering and use of organic waste through the design of a micro composting plant.

Results: Physical properties such as color, odor and texture are recognized as well as chemical parameters such as C / N, pH and humidity, with these tools we obtain a good quality and fertile compost.

Conclusion: The transformation of urban organic solid waste is an effective way of mitigating the environmental impact caused by not using it and simultaneously preventing this waste from reaching landfills.

Originality: This transformation and use design was carried out for the first time in the “Conjunto Residencial Tejar de Ontario”, it also contains management strategies that allow optimizing the composting operation.

Limitations: Find tools that are easily understood by the community to strengthen knowledge of recycling, source separation and composting.

Key Words: Bogotá, characterization, domestic, Exploitation, organic, set, waste.

Resumen

Introducción: El presente artículo es el producto de la investigación “Diseño e implementación de un modelo eficiente para la transformación y aprovechamiento de residuos sólidos orgánicos”, en el “El Conjunto Residencial de Ontario en Bogotá. (Colombia)”. Desarrollada en la universidad Libre en el año 2021.

Problema: La acumulación de residuos sólidos por parte de la comunidad residencial, evidencia una problemática ambiental que traen como consecuencia, problemas de sanidad, malos olores, atracción de roedores y un deficiente aspecto físico en las áreas comunes de este conjunto, causadas por el no aprovechamiento de estos residuos orgánicos.

Objetivo: formular un modelo eficiente para la transformación y aprovechamiento de residuos sólidos orgánicos en el Conjunto Residencial Tejar de Ontario.

Metodología: Caracterización por el método del cuarteo y aprovechamiento de residuos orgánicos por medio del diseño de una micro planta de compostaje

Resultados: Se reconocen propiedades físicas como el color, olor y textura además de parámetros químicos como lo son C/N pH y humedad, con estas herramientas obtenemos un compost de buena calidad y fértil.

Conclusión: La transformación de residuos sólidos orgánicos urbanos es una forma efectiva de mitigar el impacto ambiental causado por el no aprovechamiento de los mismo y de forma simultánea se evita que estos residuos lleguen a los rellenos sanitarios.

Originalidad: Este diseño de transformación y aprovechamiento se llevó acabo por primera vez en el conjunto residencial Tejar de Ontario, además contiene estrategias de gestión que permiten optimizar la operación del compostaje.

Limitaciones: Encontrar herramientas de fácil comprensión por la comunidad para afianzar conocimientos de reciclaje, separación en la fuente y compostaje.

Palabras Clave: Aprovechamiento, Bogotá, caracterización, conjunto, domésticos, orgánicos, residuos.

Resumo

Introdução: Este artigo é o produto da pesquisa "Desenho e implementação de um modelo eficiente para a transformação e uso de resíduos sólidos orgânicos", no "El Conjunto Residencial de Ontário em Bogotá. (Colômbia)". Desenvolvido na Universidade Libre no ano de 2021.

Problema: O acúmulo de resíduos sólidos pela comunidade residencial apresenta um problema ambiental que resulta em problemas de saúde, maus odores, atração de roedores e mau aspecto físico nas áreas comuns deste complexo, ocasionado pelo não aproveitamento desses resíduos orgânicos.

Objetivo: formular um modelo eficiente de transformação e aproveitamento de resíduos sólidos orgânicos no Conjunto Residencial Tejar em Ontário.

Metodologia: Caracterização pelo método de esquartejamento e aproveitamento de resíduos orgânicos através do dimensionamento de uma micro central de compostagem

Resultados: São reconhecidas propriedades físicas como cor, cheiro e textura, assim como parâmetros químicos como C/N pH e umidade, com essas ferramentas obtemos um composto de boa qualidade e fértil.

Conclusão: A transformação dos resíduos sólidos orgânicos urbanos é uma forma eficaz de mitigar o impacto ambiental causado pela sua não utilização e simultaneamente evitar que estes resíduos cheguem aos aterros.

Originalidade: Este projeto de transformação e uso foi realizado pela primeira vez no complexo residencial Tejar em Ontário, também contém estratégias de gestão que permitem otimizar a operação de compostagem.

Limitações: Encontre ferramentas que sejam facilmente compreendidas pela comunidade para fortalecer o conhecimento sobre reciclagem, separação na fonte e compostagem.

Palavras-chave: Uso, Bogotá, caracterização, conjunto, doméstico, orgânico, resíduos.

1. Introduction

One of the main environmental impact problems generated in urban areas is the inadequate handling of biodegradable organic solid waste. [1]

In Colombia, 12 million tons of garbage are generated and only 17% is recycled, therefore the crisis of landfills is reaching dangerous levels. In the case of Bogotá, about 7,500 tons are generated per day and between 14% and 15% are recycled, even below the national average". [2]

According to the Tunjuelito mayor's office, the lack of environmental education on the management and classification of household solid waste generates a poor disposal of said waste, this leads to the presence of rodents and vectors affecting human health. [3]

In accordance with the problem of generating waste classified as usable, non-usable and organic, the initiative to mitigate the environmental impact caused by taking this solid organic waste to landfills, [4] taking as a strategy use and transformation thereof.[5] through solid waste recycling methods, through systems designed for housing models subject to the horizontal property regime [6-10].

The method used for the characterization and quantification of the solid organic waste generated in the complex was the quartering, [11] which provides in detail the weight and a clear classification of the waste found in the temporary storage room of the "Conjunto Residencial Tejar de Ontario".

Subsequently, a design is implemented in accordance with the needs of the complex, considering the composting area [12], percentage of composting, number of compost bins, materials, design of the use model, environmental education, budget, and the items to consider so that the implementation of the model be efficient. It is an urban composting project, which invites the community to become environmentally aware that in turn is on the path to changing habits and teaching that it is possible to make a better disposal of organic solid waste, considering that most of the waste generated in homes is of this type (figure 1).

Composting production is a recycling modality that takes advantage of the organic waste produced in residential units, by collecting prunin material, food scraps, fruits, and vegetables from the apartments, making it possible to use it as organic fertilizer for the green areas themselves. Of the whole or even its commercialization [13].

The production of composting at the urban level is an experience that has been developing for quite some time, there are multiple projects for food production and obtaining fertilizer through the practice of alternative composting generation techniques, these projects are the product of the initiative of individuals and communities [14], likewise, experience has shown that the rate of production and the type of organic waste in the urban environment, allows the formalization of this type of initiative [14] (figure 3).

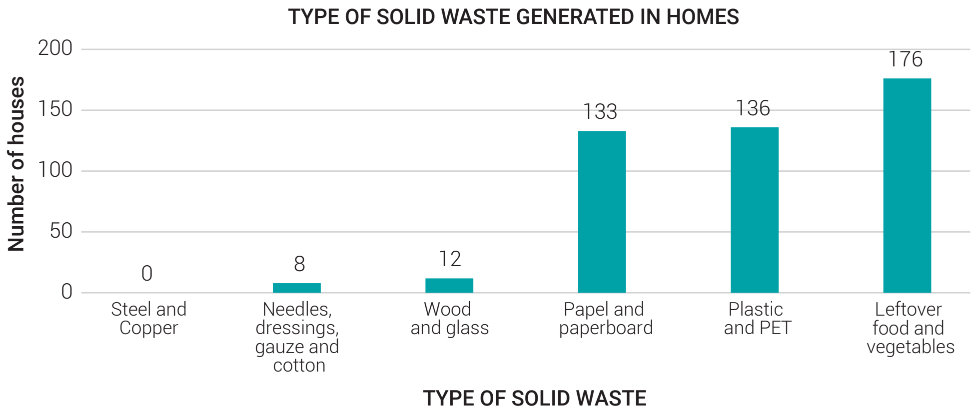


Figure 1. Type of solid waste generated in homes
Fountain: [9] (p.21)

TYPICAL WASTE IN URBAN AREA			
TYPE OF WASTE	DESCRIPTION	USE	DECOMPOSITION
Raw waste	They correspond to waste before food preparation, such as fruits, vegetables in general, fruit and vegetable peels, leftover vegetables, juice preparation waste in general, grains, etc.	Excellent material to use in the production of organic fertilizers, it is better to add fresh residues before they decompose.	Slow
Lavaza	Consisting of foods that have gone through some cooking process, among these are: leftover food and meat, remains of aromatic plants, etc.	Its use in the production of organic fertilizers is not recommended due to the possible microbiological contamination generated by human saliva and its high salt content. Its use is recommended for non-agricultural activities.	Quick
Pasture	Residue generated when the lawn is mowed.	When it is freshly cut it contains high amounts of nitrogen, and as time goes by the nitrogen content is reduced and is replaced by carbon, it is a good material to produce organic fertilizers, in addition, once it is dry, it can be accumulated to carry out its introduction in the composting piles and balance the carbon/nitrogen ratio.	Quick
Sawdust	Coming from carpentry work.	This residue is very good to be able to have an adequate carbon/nitrogen ratio, and it can be stored for long periods of time and introduced when the mixture is made.	Very slow
Tree chipping	Residue that is generated in the activity of cutting trees that fall to the ground and dry.	Chopped or chipped, it is an excellent material to introduce into mixtures, since due to its rigidity it provides porosity to the pile and allows the passage of air into the mixture.	Very slow
Leaf litter	Residue that comes from the leaves of trees that fall to the ground and dry.	Good material for use in composting piles and worm bed assembly, it also has the advantage that it can be accumulated for long periods of time, so I can have accumulated material and introduce it into the mixtures as needed.	Slow
Eggshells	Shells of chicken eggs or other birds.	Material with a high calcium content, enriches the fertilizer, the ideal is to introduce it pulverized	Very Slow
Leached	Liquid from the destruction of biodegradable waste, which can be collected and recirculated before passing through the thermophilic phase.	They are liquids that have high microbial loads, they are good to use in the first phases of degradation of the composting piles, but not after the pile increases the temperature to the thermophilic phase, since we will have to be introducing pathogenic microorganisms again.	Quick
Buttermilk	Obtained by manufacturing processes of dairy products such as cheese and yogurt	They are good at the beginning of the composting phase, since they lower the colonies of pathogenic microorganisms in the compost mixtures.	Quick
Cup of coffee	Waste generated from coffee preparation	Excellent material to cover compost piles and thus avoid the presence of flies and rodents.	Slow

Figure 2. Typical urban area waste.
Fountain: [13] (p. 33, 34)

2. Materials and methods

2.1 Study Area

The Tejar de Ontario residential complex is located in the city of Bogotá, in the sixth town Tunjuelito, more precisely at the address Calle 56a Sur No. 27 - 75. [6] This complex comprises approximately 230 apartments, with an area of 14,007 m² that borders on the south western side with the Tunjuelito river on the east with Av. Boyacá one of the main roads of the city, this avenue runs through the city from south to north and covers about 25 km. [7]

(a) (b)

Figure 3. Picture of residential complex Ontario of Tejar (Calle 56a Sur No. 27 – 75) where the project was made. (a) Sight in the structure, (b) entrance of the complex.
Source: Google Street view.

Considering that, in the composting process, those responsible for or agents of the transformation are living beings, all those factors that may limit their life and development will also limit the process itself. [17, 18]

The factors that intervene are complex, but temperature, humidity and aeration can be pointed out as important. [19]

The residential urban organic waste composting process consists of various microbial populations degrading organic matter in the presence of oxygen and water, producing a stable product called COMPOSTING, generating gases and heat as residues of microbial metabolism (figure 4). [20]

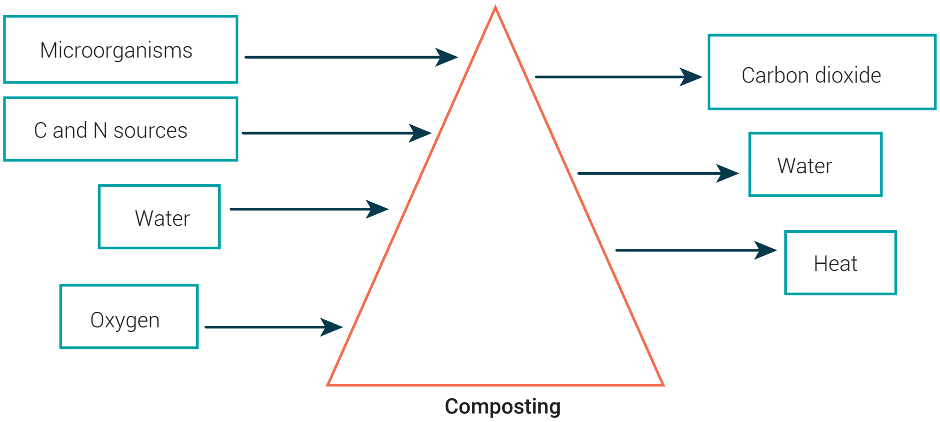


Figure 4. Dynamics of composting generation
Fountain: [13] (P.19)

The phases that occur in the composting production process are the following [13]

Mesophyll phase. The starting material begins the composting process at room temperature and within a few days (and even hours), the temperature rises to 40°C.

This increase in temperature is due to microbial activity, since in this phase the microorganisms of soluble compounds, such as sugars, generates organic acids and, therefore, the pH can drop. (up to about 4.0 or 4.5). This phase lasts a few days (between two and eight days). (p. 39)

Thermophilic or Hygienization Phase. When the material reaches higher temperatures, between 40 and 45 °C, the mesophilic microorganisms are replaced by filamentous bacteria(actinomycetes) and fungi. Above 45°C, thermophilic bacteria appear, which act by facilitating the degradation of more complex carbon sources, such as cellulose and lignin. This phase can last from a few days to months, depending on the starting material, the climatic conditions of the place and other factors. This phase is also called the sanitization phase since the heat generated destroys bacteria and contaminants of fecal origin such as Escherichia coli and Salmonella spp. This phase is important because temperatures above 55°C eliminate helminth eggs, phytopathogenic fungal spores and weed seeds that can be found in the starting material (figure 4), giving rise to a sanitized product. (p. 39)

Cooling phase. Depleted carbon sources (particularly nitrogen in the composting material) the temperature drops again to 40-45°C. During this phase, the degradation of polymers such as cellulose continues and some fungi visible to the naked eye appear. When lowering 40°C, mesophilic organisms they restart their activity and the pH of the medium drops slightly, although in general the pH remains slightly alkaline. This cooling phase requires several weeks and can be confused with the maturation phase. (p.39)

maturation phase. It is a period that lasts months at room temperature, during which secondary reactions of condensation and polymerization of carbon compounds take place for the formation of humic and fulvic acids. (p. 40)

Mesophilic	thermophilic	Mesophilic II or cooling	Maturation
Ambient temperature up to 40°C	40 to 70°C or more	Temperature drops at 40-45°C	18 a 22°C
Mesophilic and thermotolerant fungi. mesophilic bacteria.	Bacteria Actinomycetes Fungi	bacteria invertebrate fungi	Bacteria Actinomycetes Fungí
pH 5 – 5.5	pH 8 – 9	pH 8.5	pH 7- 8

Figure 4. Phases in the composting degradation process, predominant microorganisms in each phase and pH

Fountain: [13] (p. 40)

2.2 CONDITIONS OF THE COMPOSTING PROCESS

Considering that, in the composting process, those responsible or agents of transformation are living beings, all those factors that may limit their life and development will also limit the process itself. [8]

The factors involved are complex, but temperature, humidity and aeration can be noted as important. [9]

2.2.1 C / N ratio: It is the amount of carbon and nitrogen present in a material. All living things are composed of carbon and nitrogen (carbohydrates and proteins) and must take them from the food they eat. Likewise, the microorganisms responsible for degradation also need C and N to reproduce and use the material. Organic waste is largely composed of C and N in different proportions, which is very important to know in order to establish the possible mixtures when carrying out a composting process and thus achieve a compost with an ideal C / N ratio. for field application.

2.2.2 pH: It is another important parameter to evaluate the process conditions and the stabilization of the residues. Its value, as well as the temperature varies over time during the process. At the beginning the material has a pH between 6-7, and in the first days it decreases due to the production of organic acids in the system. Later it can go up to 8-8.5 during the entire thermophilic phase and when cooling begins it reaches a value in the range of 7-8, in mature compost. [18]

2.2.3 Temperature: As mentioned above, a series of microorganisms intervene in each phase of the process, each with a different temperature range.

- Latency and growth phase: 15-45º C
- Thermophilic phase: 45-70º C
- Ripening phase: below 40º C [19]

According to Arenas, C. The increase in temperature during fermentation occurs mainly due to the exothermic biochemical reactions that occur there, associated with the activity of the microorganisms present. [20] [40]

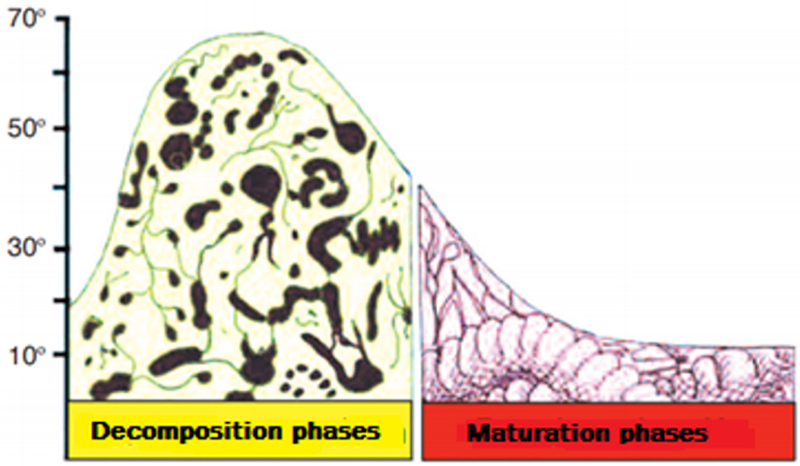


Figure 5. Phases of the composting process [21]

2.2.4 Humidity: This factor is essential for microorganisms, since water is the environment in which they live, move and feed. In the practice of composting, high humidity must always be avoided because it would displace oxygen and, consequently, the process would stop being anaerobic (absence of air) or, what is the same, putrefaction. On the other hand, if the amount of humidity in the waste pile is low, the activity of the microorganisms decreases and consequently the process is delayed. [21] [40]

It should be considered that the heat generated in the process causes a decrease in humidity. We consider as optimal levels, humidity of 40 to 60%, depending on the mixture of more or less fibrous materials of the pile content.

2.2.5 Aeration: Oxygen is essential for microorganisms to effectively decompose organic matter. Therefore, the air supply at all times must be suitable to maintain microbial activity, without the appearance of anaerobic conditions, which, in addition to hindering the process, lead to the appearance of odors and a lower quality product. So that the anaerobic process does not start, a minimum of 10% aeration must be exceeded. For this reason, it is important to control the materials introduced into the pile, since many of the plant debris, especially grass, tend to become caked and cause rot. [21] [40]

2.3 CHARACTERISTICS OF COMPOSTING

Composting is a process by which various organic substrates decompose and stabilize due to the action of a mixed population of microorganisms, obtaining a final product called compost, organically stable, free of pathogens and weed seeds that can be applied efficiently. to the ground to improve its properties. [22]

In aerobic composting there are mainly three types of systems: Rows, static piles and closed reactors. Rows and static stacks, sometimes referred to as open systems, are used more than closed reactors. [23] In open systems the material to be composted is stacked on an impermeable platform, such as concrete or asphalt. Sometimes a layer of polyethylene is used as an extra precaution to ensure that no contaminants reach the ground through the cracks, if they exist. [24]

2.2.1 Types of Composting:

Large-scale or Industrial Composting: There are numerous systems to carry out the decomposition and maturation process on a large or industrial scale. Thus, to carry out the first classification, two main categories can be established: open systems (piles, heaps, plateaus) and closed systems (containers, tunnels). [25]

Small-scale, community, and residential composting: Community composting is developed in spaces or gardens of homes, sports or recreational spaces, schools, and urbanizations. This type of composting represents an interesting and educational social practice, although it involves a certain organization of resources and people. And residential composting is carried out at the family level, in the garden, terrace, orchard or any other appropriate place, with small amounts of waste and using the simplest systems. [25]

Table 1. Matrix of methods of composting (cost and benefits)

Composting method	capacity	Location	time	cost
Flipped Stacks	Open system 8,775 m3 or 8,775 Liters	Surface Width 1.5 m, length 3.9 m and height 1.5 m	Between 10 to 12 weeks	Low cost of construction and maintenance. $ 500.000
Static Stacks with passive aeration	System closed 35 m3 or 35 Liters	Surface Width 2 m long 5 m and height 3.5 m	Between 6 to 10 weeks	High cost of construction and maintenance Approximately $ 750,000
Static Stacks with forced aeration	Mechanized aeration system 35m^3 or 35 liters	Surface Width 2 m long 5 m and height 3.5 m	Between 6 to 10 weeks	High cost of construction and maintenance Approximately $ 1,000,000
Closed Stacks	System closed 300-liter recycled plastic or wood composters	Approximate surface from 15 to 20 m2	Between 8 to 10 weeks	High cost of construction and maintenance Approximately $ 900.00
Flipped Stacks	Open system 8,775 m3 or 8,775 Liters	Surface Width 1.5 m, length 3.9 m and height 1.5 m	Between 10 to 12 weeks	High cost of construction and maintenance Approximately $ 750,000

Source: self-made.

2.4 DEVELOPED METHODOLOGIES

The execution of this project has two types of scope: descriptive (it allowed to examine the characteristics of the problem that were present in the residential complex, which is the accumulation of waste). In addition, it is part of a mixed research of a qualitative nature (through survey collection and awareness of the community) and quantitative (collection of numerical data to determine the variables of the waste generated). This process was divided into 2 phases:

- Characterize the generation and storage of solid waste of the inhabitants of the Tejar Residential Complex of Ontario. It consists of determining the various types of waste generated in the set by applying the quartering method, [18] which allows to calculate the generation in percentage according to the weight of the different residues found corresponding to the generation in a determined period of time. With the sample size and weight differentiated by type of material, it is possible to estimate the generation of each one of them on a monthly and annual basis, as well as to calculate the generation per capita. In percentage according to the waste found, generation determined time.

- Design a comprehensive system for the transformation and use of organic solid waste that best adapts to the needs of said residential complex. Where the characteristics of the design and the alternatives for the use of urban organic solid waste were analyzed and determined in order to subsequently dimension a functional system that allowed the use of organic solid waste in the residential complex.

3. Results

Characterization of Organic Solid Waste.

For the characterization of the solid waste from the Tejar complex in Ontario, the waste that was only in 5 bins was randomly taken and that amount of waste makes up the sample to be characterized. To determine the per capita production, the average weight of the fully filled cans was used and yielded a data of 55,134 kg. According to the characterization carried out within the Tejar residential complex in Ontario, it was found that 551.34 Kg corresponds to the total production of the inhabitants of the complex in one day, therefore, 100% of the waste production corresponds to 1,102 Kg these generated every two days. [26]

Table 2. Solid Waste Characterization Format in the Ontario Tejar Complex

SOLID WASTE CHARACTERIZATION FORMAT IN THE TEJAR DE ONTARIO GROUP										
DAY	WEIGHT IN Kg OF WASTE GENERATED									Total
	ORGANIC	PAPER	PAPERBOARD	PLASTIC	METALS	GLASS	TETRAPAK	ICOPOR	Others Not usable	Kg
1	22,00	1,11	0,80	1,86	0,40	0,35	0,23	0,08	0,20	27,03
2	18,52	2,06	0,52	1,56	0,31	0,42	0,24	0,10	0,35	24,09
3	20,26	1,10	0,56	2,28	0,36	0,39	0,24	0,08	0,28	25,55

(continúa)

(viene)

SOLID WASTE CHARACTERIZATION FORMAT IN THE TEJAR DE ONTARIO GROUP										
DAY	WEIGHT IN Kg OF WASTE GENERATED									Total
	ORGANIC	PAPER	PAPERBOARD	PLASTIC	METALS	GLASS	TETRAPAK	ICOPOR	Others / Not usable	Kg
4	20,43	1,15	0,76	1,66	0,42	0,41	0,22	0,83	0,23	26,11
5	19,78	1,63	1,42	2,01	0,25	0,00	0,52	0,60	0,16	26,38
6	19,29	1,88	1,77	1,68	0,15	0,00	0,24	0,40	0,32	25,72
7	21,79	2,63	0,77	2,11	0,30	0,00	0,22	0,20	0,28	28,29
8	22,24	2,13	0,67	2,46	0,29	0,30	0,22	0,00	0,51	28,81
9	17,87	2,23	1,00	3,40	0,23	0,00	0,13	0,00	0,31	25,18
10	21,45	1,23	1,10	2,66	0,55	0,00	0,22	0,00	0,11	27,33
									Total	264,49
Daily average (kg / day)	10,18	0,86	0,47	1,08	0,16	0,09	0,13	0,11	Daily average (kg / day)	26,45
Total daily average (kg / day)	13,22								**average weight per bin**	55,134
% Daily average	76,99	6,480	3,543	8,195	1,237	0,709	0,945	0,865		

Source: self-made

3.1 WASTE STORAGE

In accordance with the provisions of (RAS-2000. Urban Cleaning Systems), all buildings for multi-family, high-density multi-family, institutional or commercial use, and those that the cleaning entity determines, must have a collective storage system of solid waste, designed as a minimum with the requirements and criteria presented below and other current provisions related to the matter. [27] The collective storage system must meet the following requirements: [28]:

Table 3. Collective storage system

concept	verified
ready-made finishes to facilitate cleaning and prevent the formation of environments conducive to the growth of microorganisms	☑
They will have ventilation systems (air extractors), water supplies, sewage, electricity, prevention and control of fires	☑
They will be built in such a way as to avoid the access of insects, rodents and other kinds of animals.	☑
sufficient storage capacity according to the collection frequency	☑
must comply with access for collection vehicles	☑
The storage areas will be cleaned, fumigated and disinfected by the user, with the regularity required by the nature of the activity that takes place there, in accordance with the requirements and standards established by the competent authorities.	☑
storing garbage outside the storage area is prohibited	☑
The storage area must have storage containers in sufficient quantity and dimensions that do not allow the accumulation of solid waste on the floor of the same. The selection of these containers should consider the type of collection vehicle of the system	☑

Source: self-made

The Tejar Residential Complex in Ontario has all the requirements for the correct operation and storage of solid waste. According to criteria established in Ras 2000. The solid waste storage room of the Tejar Residential Complex in Ontario is presented below.

(a) (b)

Figure 3. Temporary solid waste storage room, (a) exterior, (b) interior.
Source: Authors

Observation

Taking into account Resolution No. 2184 of 2019 which became effective in 2021, the white, black and green color code for the separation of waste at the source, it is essential to implement the color code within the storage room indicating the correct disposition using the new resolution. [29]

- Usable = White
- Not usable = Black
- Organic = Green

In this way, the characterization of the waste is synchronized from the source of generation to the temporary storage point and later to its use and final disposal. In this way, it is guaranteed that there is no confusion when disposing of any waste.

3.1.1 Proposal for the distribution of the bins

The bins will be distributed in the waste storage room so that people can identify where they are going to deposit their waste, counting on the fact that there will be a greater number of bins for organic waste since the percentage of production and accumulation is higher; total will be 10 bins for storing organic waste. For usable and non-usable waste, there will be 6 bins and 4 bins respectively.

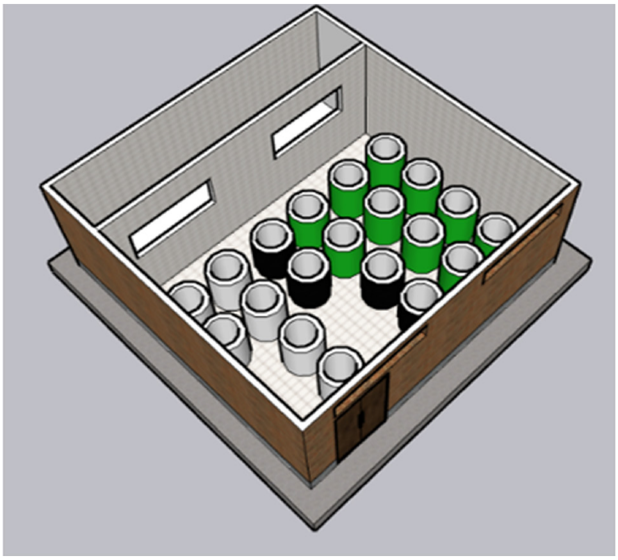


Figure 7. Distribution of waste storage bins inside the temporary storage place. [31]
Source: Authors

3.2 Design of the system for the use of organic solid waste

3. Design aspects

The design aspects that are considered for the construction of a compost bin [32] for the Tejar Residential Complex of Ontario are:

- Percentage of organic waste generation
- Weight of the material to be composted
- Number of containers required

The longitudinal compost bin is designed as follows at a generic level:

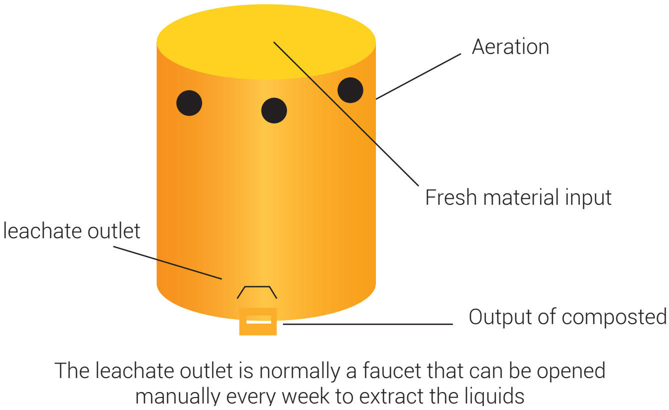


Figure 8. Design examples of longitudinal rotating composters

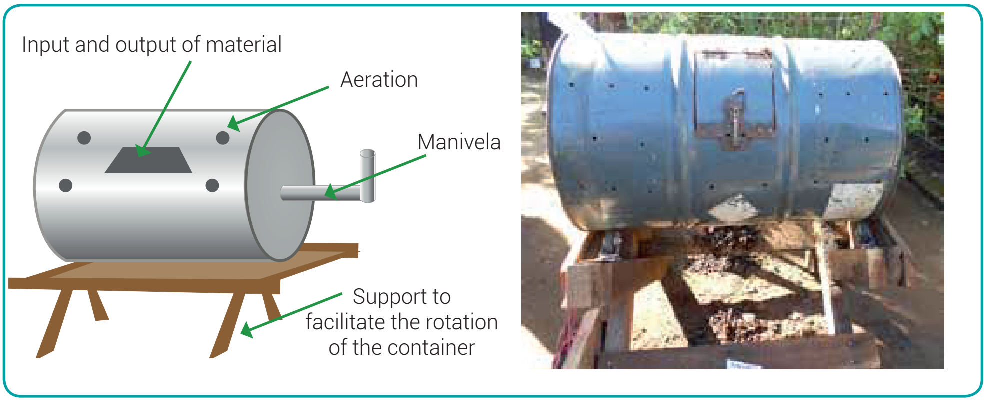


Figure 9. Design examples of longitudinal rotating composters. [33]

Figure 10. Rotating or rotating drum composter. [34]

Figure 11. Composter made of galvanized iron coated with anticorrosive paint, barrel completely closed and highly resistant to pests and produces minimal odor. [35]

The Prototype consists of a high-density plastic container with a cylindrical geometry which will be supported on a metallic structure that allows the weight of the container to be supported, it must have a pole that facilitates the action of turning, turning or mixing the material within it. It will also have mesh holes for air to circulate inside the compost bin [36], this will be easily removable to measure parameters such as pH, temperature, and humidity.

The tank used to build the compost bin has a volume of 30 gallons (113.55 Liters), each tank has a diameter of 0.41 m and 0.8 m high. Figure 5 shows the design of the compost bin.

Proposed design of the proposed composting system

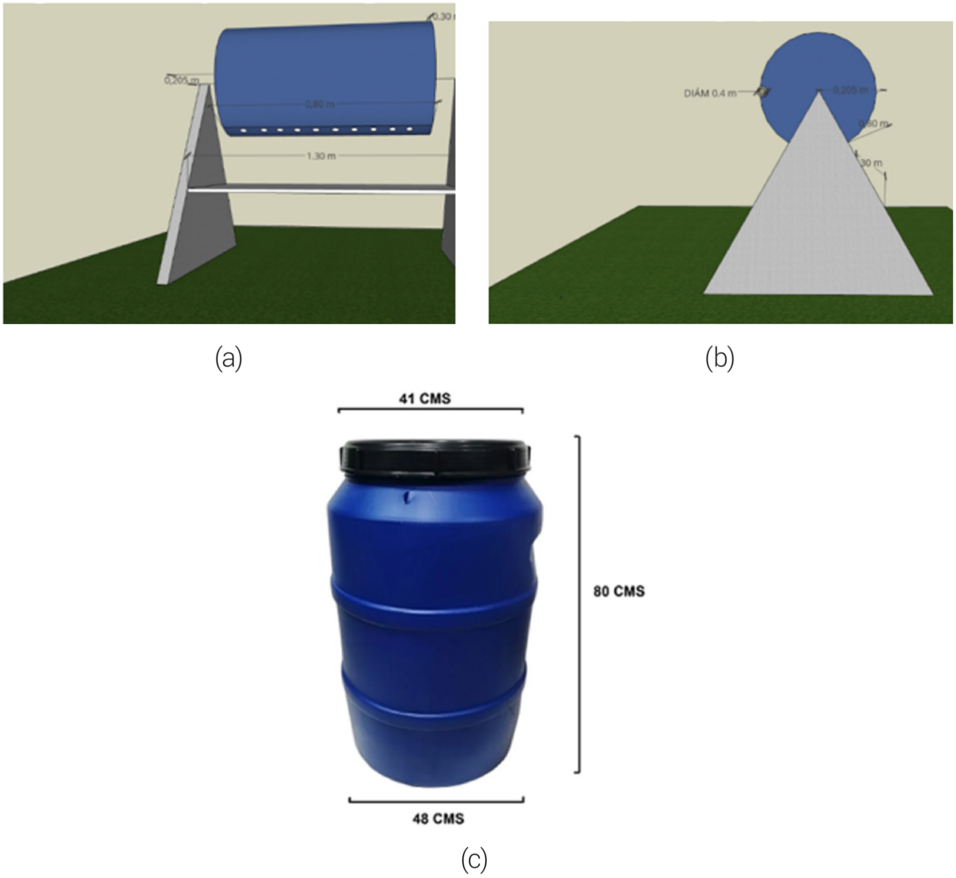


Figure 5. Diagram of the compost bins designed. (a) front view of the compost bin, (b) side view, (c) bin used to build the compost bin. Source: Own elaboration in the Google SketchUp program web version [36].

3.2.1 Sampling

To determine the size of the sample and the number of bins to sample, perform the characterization and be able to justify the design of the compost bin, what is described below was carried out.

In cases in which the population is finite, that is, the total population is known and it is desired to know how much of the total should be studied, the sample size is determined as follows. [36].

$$n = \frac{N * Z \propto^2 * p * q}{e^2 * (N-1) + Z \propto^2 * p * q}$$

In the above equation, N is the size of the population, Z∝ ^ (2) (1,952) for a precision of 95%, p is the expected proportion (if you have no idea of this value, take 50%, with which maximizes the sample size), q = 1-p, e is the desired precision.

Table 4. Sampling table

Variable	Units	Value
Total, mass of waste	kg	850
Precision	%	95
Z_α		1,96
p		0,5
q		0,5
e		0,5
Number of cans to sample	kg	4

Source: self-made

3.4 Composter

Next, the variables for the construction of the compost design are determined:

Table 5. Composter design construction

Variable	Unit	Value
Production per capital	kg/(hab*día)	0,648
Number of inhabitants	hab	850
Total waste production	kg/día	550,8
Organic waste percentage	%	78

(continúa)

(viene)

Variable	Unit	Value
Mass of waste to compost	kg	429,624
Compost height	m	0,8
Compost diameter	m	0,43
Total volume of the compost bin	m^3	0,12
Percentage of compost volume occupied with waste	%	40
Volume of waste in the compost bin	m^3	0,12
Density of shredded organic waste	kg/m^3	350
Mass of waste in the compost bin	kg	42
Percentage of waste to be composted	%	10
Mass of waste to compost	kg	42,9624
Number of compost bins required for 1-day waste	Und	2
Composting time	días	30
bins necessary to compost all the waste in one day	Und/día	10
bins necessary to compost all the waste generated	Und	300
Area occupied by each bin	m^2/Und	1,442
Area occupied by the cans	m^2	432,6

Source: self-made

3.4.1 Process operation manual

The inhabitants of the complex must deposit their organic waste in the manner mentioned above, that is, chopped and without plastic bags that will later be taken to the solid waste storage room and will dispose of in the organic waste area previously organized to avoid confusion (the bins for organic waste are the green bins).

1.

- The organic waste will be taken from the temporary storage every 2 days and will be taken to the transformation zone.
- Once in the transformation zone, the chopped waste will be dumped into the compost bin together with efficient micro-organisms that will help accelerate the decomposition process.
- Three compost bins will be used for one day's waste, these compost bins will be distributed in an area of 432.6 m2 and fenced to avoid accidents with the resident community.
- The temperature and humidity will be measured twice a day, with a thermo-hygrometer.
- or it is important to least 4 to 6 turns to the cylinder composting whenever be measured temperature, it means, 2 times a day.

2.

- Every day the temperature of the compost is measured in the morning and in the afternoon the temperature and humidity are measured, each time the humidity and temperature are measured, the compost is made 4 or 6 times, to turn the content and aerate it.
- Approximately 10% of mature compost should be left inside each compost bin in order to have micro-organisms that help speed up the composting process of the new waste that is loaded.
- the compost maturation point reaches when the material temperature reaches a maximum value between 60 ° and 70 °. After reaching this maximum value, the compost temperature begins to drop. When the compost begins to descend, it is left for another week and after that week the material is removed, packed in bags, mainly to be used in the gardening of the residential complex for its inhabitants or later for sale.
- Once the compost matures, the community will be able to access the organic material by requesting it from the administration.

Methodological guide

This guide describes in a general way the step by step of the implementation of the system that allows, as an objective, the reduction of the percentage of organic solid waste that is taken to the sanitary landfills and simultaneously reduce the collection fee. methodology to be used and the related aspects for the elaboration of the project. This will allow having a frame of reference to be applied in other scenarios.

Step 1. Each apartment must separate the waste of interest, in this case organic solid waste. These should be delivered chopped and taken to a storage room without a bag.

Step 2. From the storage room they will be taken to the transformation area and the chopped waste will be poured into the compost bin, along with efficient micro-organisms that will help speed up the decomposition process.

Step 3. The temperature of the compost will be measured daily in the morning and in the afternoon the temperature and humidity are measured. Each time the humidity and temperature are measured, the compost bin is turned 4 to 6 times to turn the content. and air it out.

Step 4. Once the compost is mature. (The maturation point of the compost is reached when the temperature of the material reaches a maximum value between 60° and 70°. After reaching that maximum value, the temperature of the compost begins

e-ISSN 2357-6014 / Vol. 18, no. 2 / may-august 2022 / Bogotá D.C., Colombia
Universidad Cooperativa de Colombia

to drop). Subsequently, approximately 10% of compost will be left so that these new micro-organisms help with the decomposition process of organic matter.

Step 5. Once the compost matures, the community will be able to access the organic material by requesting it from the administration.

Collection Fee Reduction

According to Yanlicer Pérez Hernández, deputy director of Collection, Sweeping and Cleaning of the Special Administrative Unit for Public Services-UAESP in an interview with the Bogota mayor's office on its website, he mentions the benefits that "all users grouped in real estate units have, housing centers, residential complexes, condominiums or any similar property that is registered as horizontal property. Multi-users must compulsorily register* and production is measured every time the waste is collected". [38]

"In this new phase of the regulation of the cleaning service, where the activity of the use was duly regulated, the figure of the 'multi-user' is very opportune, since it allows generating appropriate behaviors from the separation at the source (differentiating the usable waste from the waste) and, to the extent that they are strengthened, they will make it possible to generate less ordinary waste, which will be reflected in a lower rate. In addition, a general benefit is generated for the entire city, such as lengthening the useful life of sanitary landfills" [38]

According to what was said by Yanlicer Pérez Hernández, deputy director of Collection, Sweeping and Cleaning of the Special Administrative Unit of Public Services-UAESP. Everything included in the concept of 'multi-user', for example, a residential complex, a condominium, among others, will be able to differentiate usable waste, as only organic waste is, in this particular case, separating it at the source and transforming it, allowing it to reduce the generation of waste, which will reflect a lower collection rate since this is measured by its weight, this means that the less weight of waste that must be collected and transported, the lower the collection of the cleaning fee of these people who live in called by Yanlicer Pérez Hernández as multi-user.

Next, the following matrix summarizes the content previously exposed:

ACTIVITY	OBJECTIVE	DETAILS
Residue recollection	Take to the system where they are shredded and facilitate composting	Chopped and without plastic bags
Load the waste	Load the waste to start the composting process	The chopped waste will be dumped into the compost bin along with microorganisms to speed up the decomposition process.

(continúa)

(viene)

ACTIVITY	OBJECTIVE	DETAILS
Composting	Transform biodegradable organic matter into a biologically stable product, in order to be soil amendment and as a plant substrate.	Daily or twice a day the temperature and humidity should be measured.
		Approximately 10% of mature compost should be left inside each compost bin.
		When the compost begins to descend, it is left for another week and after that week the material is removed.
Maturation	Avoid generating pollution and toxicity problems for plants.	It is packed in bags, mainly to be used in the gardening of the complex for its inhabitants or later for sale.
		Once the compost matures, the community will be able to access the organic material by requesting it from the administration.

Source: self-made

3.5 Design of the education and communication strategy

Environmental education is the initiative to care for the environment. It is a process which is imparted, ecological knowledge, environmental awareness and values. It is necessary to have a constant commitment from the inhabitants of the complex to be able to take advantage of organic waste and usable material. For this reason, it is important to guarantee that the subject is widely explained, understood and appropriate for the community in such a way that the system for the use of organic waste can be operated with the material previously separated by the community. Community participation is one of the strategies that are considered fundamental, since the importance of the classification and selection of waste is highlighted. Strategies were proposed to promote environmental culture in the community and to counteract the direct causes of poor management of organic solid waste[39]. The objectives of this type of education are defined by UNESCO, and are the following:

Awareness: make people aware of problems related to the environment

Knowledge: help to be interested in the environment.

Attitudes: acquire interest in the environment and willingness to conserve it.

Skills: help acquire skills to solve the problem.

Evaluation capacity: evaluate Environmental Education programs. The current problem regarding pollution and climate change has made the environment on everyone's lips and has increased the concern of citizens about the possible consequences that a harmful treatment has on the environment that surrounds us.

Participation: develop a sense of responsibility to take appropriate action.

After having evaluated the compost design, it is important to promote the implementation of the education and communication strategy, in order to provide the residents of the Ontario residential complex with environmental awareness.

Educational program

Through training, the responsibility that they have as generators of organic solid waste will be made known, promoting the correct way in which the daily work of accumulation, transfer, treatment and disposal of each type of waste within the residential complex of Ontario.

- Training through workshops aimed at groups of children.
- Training through workshops directed towards groups of adults.

PROGRAMS	OBJECTIVE
Recovery and use of organic solid waste.	Promote the separation at the source and the use of organic solid waste within the Tejar complex of Ontario
Environmental Education and Community Participation	Develop an educational process which changes habits, develops values and promotes participation in the community.
All this in order to generate habits of separation at the source in the residents. Minimize the amount of unusable solid waste to be disposed of in the sanitary landfill. Promote communication mechanisms and community participation.	

Source: self-made

Segregation program in the source.

Quantitatively identify the increase in organic solid waste.

Through allusive notices, will be released, the proper way to segregate organic solid waste in the source.

Observations

Identify the places that are most traveled by the community of the residential complex, and thus install the notices, billboards, brochures in order to be allusive to the integral management of organic solid waste.

Stipulate a day in which all residents get involved delivering solid organic waste.

3.6 BUDGET

Next, the breakdown of the costs associated with the implementation of the project is presented to have an approximation to the investment that must be made to make the system functional. In addition to the implementation costs, the adjustment of the functions of the general services personnel must be taken into account and whether such adjustment generates additional costs to the operation of the system.

Ítem	**Unit value**	**Quantity**	**Total value**
Bins capacity 120L	$ 50.000	7	$ 350.000
Metal support for bucket	$ 100.000	6	$ 600.000
Adequacy of the composting area	$ 25.000	6	$ 150.000
Leachate collection tray	$ 15.000	6	$ 90.000
Microorganisms for compost inoculation	$ 25.000	10	$ 250.000
Mixing handle	$ 30.000	7	$ 210.000
Thermohydrometer	$ 100.000	1	$ 100.000
Compost analysis in laboratory	$ 250.000	3	$ 750.000
Communication education strategies and workshops	$ 400.000	1	$ 400.000
Subtotal			$ 2.900.000
Total			$ 3.074.000

Source: self-made

4 DISCUSSION AND CONCLUSIONS

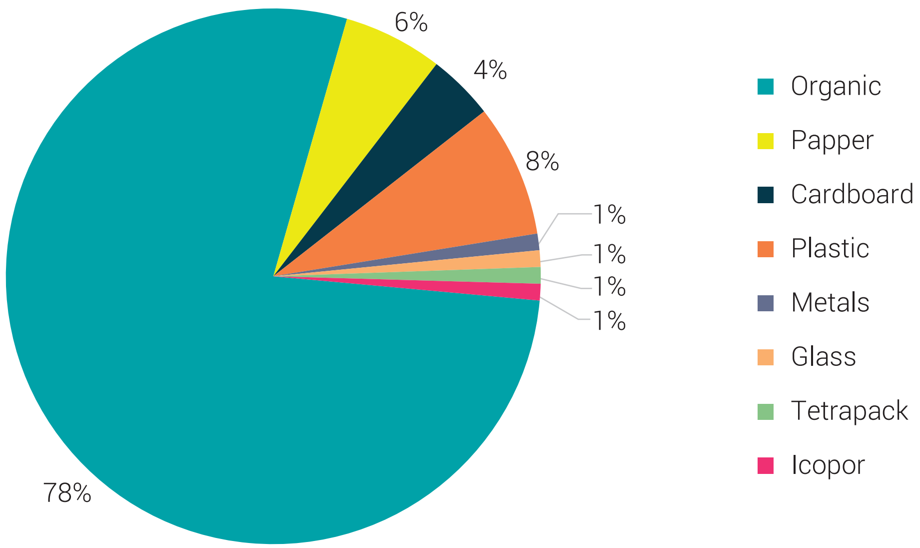
The main benefits that the implementation of this system entails is a reduction in the percentage of organic solid waste that reaches the sanitary landfill and inherently achieving a reduction in the collection fee over time, which is contemplated in the cleaning bill, Since the rate is charged in terms of weight thus, with the transformation of this organic waste a significant reduction in weight will be achieved and consequently a lower rate in the cleaning service. An extra benefit that the transformation of organic solid waste provides is the reduction in the use of inorganic fertilizers, which it replaces, it also saves irrigation water due to the water retention capacity of the compost and not least provides the necessary nutrients for the development of plants naturally.

The initial cost of implementing this model is considerably low considering the types of materials that will be used and their resistance in terms of time, that is, their duration.

The total value of the implementation was $ 3,074,000 where all the variables are considered and its construction and start-up are viable since it is specially designed for this set, this does not mean that it cannot be adapted to different urban environments that have similar characteristics.

According to the data obtained, it was possible to determine according to the demographic characteristics, that is, a stratum 2 residential complex in the city of Bogotá, inhabited by people of medium or low income, has a per capita production of 0.648 kg / (inha * day) this indicates that the projection of waste generation has increased less than 3.7% according to DANE figures, for the year 2018 Bogotá had a per capita production of 515 kg.

The average organic waste that goes from homes to the temporary storage room was determined and it was established that the percentage of organic solid waste is 78%, this means that by transforming the total organic waste, it would be possible to reduce approximately by 50% the impacts that the poor disposal of organic waste brings, such as: methane emissions, which is a powerful greenhouse gas, contamination of aquifers by leaching and odors in inhabited areas.



Graph 1. Total percentage of waste
Source: self-made

The difficulties that arise when carrying out this type of project go hand in hand with the item of environmental education, where it is important to explain and encourage people so that there is a change in recycling and transformation habits, giving the community the tools enough so that by their own means they acquire the will to work hand in hand with the other inhabitants of the complex and achieve not only the transformation of organic solid waste but also the possibility of a change in favor of a collective benefit for the residential complex and the planet .[40]

recommendations

Identify the places that are most traveled by the community of the complex, to install notices, billboards, brochures alluding to the integral management of organic solid waste.

Stipulate a day where all residents get involved delivering organic solid waste.

Conclusions

Include in the discussion as well as in the conclusion, when making the percentage of waste, say that the net production in the residential complex would be reduced by x percentage. The proposal can be expanded to other materials that can be used. The cleaning fees.

It is possible to apply methods and processes of transformation of organic solid waste in urban areas where the discipline and technical management of the tools allow a correct operation of a planned design taking into account the social, environmental and economic characteristics, in this way it is possible to guide communities to provide a collective benefit with little economic investment.

The characterization and generation of household solid waste provides detailed information that is deposited in temporary storage rooms and based on this, take measures and also find its potential for use; However, the fact that the waste reaches the deposit together reduces this possibility.

It is essential to generate qualitative and quantitative information on the quantity and characteristics of the organic solid waste produced through the management of statistical sampling methods, in order to optimize the management and quantify the management of organic solid waste from the Tejar de Ontario.

5. REFERENCES

[1] Avendaño, Edwin. (2015) "Panorama actual de la situación mundial, nacional y distrital de los residuos sólidos. análisis del caso Bogotá D.C." programa basura cero. PP. 1-112. Universidad Nacional Abierta y a Distancia UNAD. https://repository.unad.edu.co/handle/10596/3417

[2] Semana. (30 de agosto de 2017). Colombia genera 12 millones de toneladas de basura y solo recicla el 17%. Revista Semana, ISSN 2745-2794 p. 1

[3] Peña D. (2016). Plan ambiental local 2017 – 2020 Alcaldía local de Tunjuelito. Alcaldía local de Tunjuelito. Bogotá D.C., p. 84-92. https://docs.google.com/viewerng/viewer?url=https://oab.ambientebogota.gov.co/wp-content/uploads/dlm_uploads/2018/11/PALTunjuelito2017a2020.pdf

[4] Castro L & Montenegro V. (2020). El problema de las basuras en Bogotá-diseño de una idea de negocio para la Creación de una empresa de reciclaje. Las empresas de recliclaje: ¿solución a la problemática de la contaminación ambiental en Bogotá? Cuadernos Latinoamericanos de Administración, VI, (10), pp. 77-102. ISSN: 1900-5016

[5] Clarin. (30 Abril de 2017). Mundo: Se genera por hora 228 mil toneladas de basura y el 30% no se levanta. Clarín, Actualizado al 2017 2:15 Diario El Clarín, medio ambiente. Pp. 10-11 https://www.clarin.com/suplementos/zona/mundo-genera-hora-228-mil-toneladas-basura-30-levanta_0_Syz1sQM1b.html

[6] Enciso B. (2019). Servicio para el aprovechamiento de residuos en conjuntos residenciales de la localidad de Engativá, Bogotá D.C. Universidad del rosario, maestría en Emprendimiento e Innovación (MEI). Pp. 6-10 https://repository.urosario.edu.co/bitstream/handle/10336/20853/EncisoJim%E9nez-Briyith-2019.pdf;jsessionid=5C97610EC19341EFDA254CD71FB6C664?sequence=1

[7] Fonseca D, Palomino N & González I. (2005). Manejo de los residuos sólidos domiciliarios en tres conjuntos del municipio de Chía (Cundinamarca). Universidad Libre, facultad de ingeniería. p. 20 https://repository.unilibre.edu.co/bitstream/handle/10901/10971/proyecto.pdf?sequence=1&isAllowed=y

[8] Melo D, Castro E. (2010). Modelo de gestión de residuos sólidos domiciliarios en unidades residenciales. Caso de estudio: Portal de la 183. Componente epidemiológico y salubridad Universidad Militar "Nueva Granada", facultad de Ingeniería, planeación ambiental y manejo de recursos naturales. pp. 28–36 , doi:10.1016/j.resconrec.2009.06.009.in press. https://repository.unimilitar.edu.co/bitstream/handle/10654/488/MeloEscobarDiego2010.pdf?sequence=2&isAllowed=y

[9] Fierro W, & Molina A. (2020). Concepto técnico de análisis al manejo y disposición final de los residuos sólidos generados en tiempos de pandemia en la propiedad horizontal residencial; conjunto cerrado Montecarlo reservado, ubicado en la comuna 8 de la ciudad de Villavicencio – Meta. Universidad Santo Tomas, facultad de ingeniería ambiental. pp. 30-32 https://repository.usta.edu.co/bitstream/handle/11634/30451/2020williamfierro.pdf?sequence=5

[10] Vélez C. (2016). Plan de gestión integral de residuos sólidos en el conjunto residencial Bosques de la Martina, Cali-Colombia. Universidad Autónoma de Occidente, facultad de ciencias básicas departamento de ciencias ambientales, programa de administración del medio ambiente y de los recursos naturales Santiago de Cali. pp.28 https://red.uao.edu.co/bitstream/handle/10614/9316/T06986.pdf?sequence=1&isAllowed=y

[11] Abel, Alfredo& Rodríguez, Yokasta. (2010). Caracterización residuos sólidos domiciliarios en Santo Domingo Oeste, provincia Santo Domingo, (I). Ciencia y Sociedad. 35. 556. Vol. Núm 4. DOI:10.22206/cys.2010. PP.566-587.. Instituto Tecnológico de Santo Domingo Santo Domingo, República Dominicana. https://www.redalyc.org/pdf/870/87020011003.pdf

[12] Góngora P, & Vergel C. (2018). Diseño e implementación del plan educativo en torno al manejo de los residuos sólidos en el conjunto multifamiliar "El Vergel del Country". Universidad Distrital Francisco José de Caldas, facultad de ciencias y educación, especialización en educación y gestión ambiental. pp. 31 https://repository.udistrital.edu.co/bitstream/handle/11349/8925/G%C3%B3ngoraBerm%C3%BAdezPatricia2018.pdf?sequence=1&isAllowed=y

[13] M.T. Ortíz Villota, C.D. Patiño Casallas, D.C. Blanco Ayala. "Composting of Solid Waste from The Coffee Milling Process Using Trench Composting and A Bioreactor with The Help of Efficient Microorganisms in The Libre University, Socorro Headquarters," Revista Ingeniería Solidaria, vol. 17, no. 1, 2021. Pp. 4 doi: https://doi.org/10.16925/2357-6014.2021.01

[14] Alcaldía mayor de Bogotá- Secretaría distrital de hábitat. (2013). Guía técnica para el aprovechamiento de residuos orgánicos a través de metodologías de compostaje y lombricultura. Unidad Administrativa Especial de Servicios Públicos. Pp.63-78 https://www.uaesp.gov.co/images/Guia-UAESP_SR.pdf

[15] Instituto Distrital de Turismo. (2019). Mapa Turístico Bogotá. http://www.bogotaturismo.gov.co/mapas-turisticos-de-bogota. Pp.1

[16] INCOL, (2018). Tejar de Ontario. Bogotá D.C. https://www.incol.com.co/portfolio-item/tejar-deontario/. Pp.1

[17] Quintanilla, P. Taller de compostaje doméstico. Departamento Gestion Ambiental. Ilustre Municipalidad de San Antonio. pp. 20-25 https://www.sanantonio.cl/images/stories/UNIDADES/DIMAO/QU_ES_EL_COMPOSTAJE.pdf

[18] Bohórquez W. (2019). Factores implicados en el proceso de compostaje. El proceso de compostaje. Pp. 9- 22 Universidad de la Salle. Bogotá D.C. Colombia obtenido de: https://ciencia.lasalle.edu.co/cgi/viewcontent.cgi?article=1071&context=libros

[19] Corporación autónoma Regional e Antioquia (CORANTIOQUIA) (s.f.). Cartilla Técnica De Compostaje para Residuos Domiciliarios Separados en la Fuente. Pp. 31-32 https://www.corantioquia.gov.co/ciadoc/residuos%20solidos/ga_cn_8650_2010.pdf

[20] Revista de Ciencias Ambientales. (2019). Analysis of Organic Solid Waste Mixtures Used in the Manufacture of Non-structural Ecological Bricks. http://dx.doi.org/10.15359/rca.53-1.2. https://www.scielo.sa.cr/scielo.php?script=sci_arttext&pid=S2215-38962019000100023

[21] Arenas C. (2017) Implementación de un sistema integral de compostaje para el tratamiento de los residuos orgánicos en el Centro Educativo Rural Josefa Romero, Municipio de Dabeiba. Universidad Pontificia Bolivariana. Medellín. Pp. 32-36 https://repository.upb.edu.co/bitstream/handle/20.500.11912/3303/Implementaci%C3%B3n%20de%20un%20sistema%20integral%20de%20compostaje%20para%20el%20tratamiento.pdf?sequence=1

Revista de Ciencias Ambientales. (2019). Analysis of Organic Solid Waste Mixtures Used in the Manufacture of Non-structural Ecological Bricks. Pp. 4 http://dx.doi.org/10.15359/rca.53-1.2. https://www.scielo.sa.cr/scielo.php?script=sci_arttext&pid=S2215-38962019000100023

[22] Ministerio de medio ambiente, medio rural y marino. (2011) Manual del compostaje. Que pasa dentro del compostador. Gobierno de España. Pp. 18-21 https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/prevencion-y-gestion-residuos/Manual%20de%20compostaje%202011%20PAGINAS%201-24_tcm30-185556.pdf

[23] Amigos de la Tierra. (2011) Manual de Compostaje. Parámetros del proceso de compostaje. Pp.12-14. Lyma Getafe. Empresa municipal Limpieza y medio ambiente. http://www.madrid.org/cs/BlobServer?blobkey=id&blobwhere=1202767672745&blobheader=application%2Fpdf&blobheadername1=Content-Disposition&blobheadervalue1=filename%3DMANUAL_COMPOST_ADT_2008.pdf&blobcol=urldata&blobtable=MungoBlobs

[24] CERAI Aragón. Equipo de Dinamización local Agroecológica. (11 de Dieciembre de 2021). El compostaje y sus tipos. Equipo de Dinamización local Agroecológica. Fertilidad de la tierra, en el huerto ecológico, el compostaje y sus tipo. Pp. 1 https://www.lafertilidaddelatierra.com/el-compostaje-y-sus-tipos/

[25] D.E. Aparicio Plazas, D. H. Angulo Flórez, E. C. Cipagauta Esquivel, D. A. Barragán Currea, R. J. Zipa Romero,"Diagnosis of Hospital, Hazardous And Similar Waste Management Of An Institution Providing Health Services – IPHS," Revista Ingeniería Solidaria, vol. 16, no. 3, 2020. doi: https://doi.org/10.16925/2357-6014.2020.03.09

[26] Sepúlveda L; Alvarado J. (2013). Tipos de compostaje. Manual de compostaje, p. 38-42. Colombia, Medellin. http://www.earthgreen.com.co/descargas/manual-compostaje.pdf

[27] Ruiz Morales, M. (2012). Caracterización de residuos sólidos en la Universidad iberoamericana, ciudad de México. Revista Internacional de Contaminación Ambiental. Pp. 95-96 https://www.revistascca.unam.mx/rica/index.php/rica/article/view/29709

[28] Alcaldía D. M. (2019). Informe de la caracterización de residuos sólidos generados en el sector residencial del área urbana y rural del Municipio de Medellín y sus cinco corregimientos. Consorcio Residuos Sólidos Medellín. Pp.77-104, http://doi.org/10.1016/j. ccs.2011.11.007 https://www.medellin.gov.co/irj/go/km/docs/pccdesign/medellin/Temas/MedioAmbiente/Programas/Shared%20Content/Documentos/2019/Informe%20-Residencial%20Final.pdf

[29] Reglamento técnico del sector de agua potable y saneamiento basico RAS - 2000. (2000). Sistemas de aseo urbano. Pp. 1 http://www.ceo.org.co/images/stories/CEO/ambiental/documentos/Normas%20ambientales/1990-2000/2000/Resolucion%201096%20de%202000%20-%20Titulo%20F.pdf

[30] Requisitos legales sobre el almacenamiento colectivo de residuos. (Artículo 2.3.2.2.2.2.19 del Decreto 1077 de 2015). (2015). Recuperado 5 de marzo de 2021, de ESPECIFICACIONES TÉCNICAS PARA LA PRESTACIÓN DEL SERVICIO DE ASEO A NUEVAS CONSTRUCCIONES Pp. 15 website: https://www.aaa.com.co/wp-content/uploads/2020/05/Especificaciones%20Te%CC%81cnicas%20para%20Prestacio%CC%81n%20%20Servicio%20Aseo%20Nuevas%20Construc....pdf

[31] SketchUp. (2020). Recuperado 18 de febrero de 2021, de Software de diseño 3D. Pp.1 website: https://www.sketchup.com/es

[32] Códigodecoloresparalaseparaciónderesiduosanivelnacional.(2021).MinisteriodeAmbiente. Pp.1-6 https://www.aaa.com.co/wp-content/uploads/2020/05/Especificaciones%20Te%CC%81cnicas%20para%20Prestacio%CC%81n%20%20Servicio%20Aseo%20Nuevas%20Construc....pdf

[33] Cava G, Cubas K. (2020). Efectividad del compost mediante métodos de pilas dinámicas y compostera giratoria, obtenidas de los residuos orgánicos de la Universidad Peruana Unión. Universidad peruana unión, facultad de Ingeniería y Arquitectura, escuela profesional de ingeniería ambiental. pp. 22-30 http://hdl.handle.net/20.500.12840/3378

[34] Aguyaro M, Garro M, Galarza C, & Hours R. (2019). Bokashi de un residuo proteico industrial en dos sistemas: tradicional y cerrado con aireación. 1er Congreso Argentino de Agroecología:

libro de resúmenes/compilado por María Flavia Filippini; Silvina Greco. - 1a ed adaptada. - Mendoza : Universidad Nacional de Cuyo. Secretaría de Ciencia, Técnica y Posgrado, 2020. ISBN 978-987-575-210-8 pp. 18-20

[35] Organismo provincial para el desarrollo sostenible. (s.f). Catálogo de diseños y construcción de composteras. P.3 https://www.opds.gba.gov.ar/sites/default/files/006%20CATALOGO%20DE%20DISE%C3%91O%20Y%20CONSTRUCCI%C3%93N%20DE%20COMPOSTERAS.pdf

[36] Universidad Nacional de Costa Rica. (2014). Guía práctica para el manejo de los residuos orgánicos utilizando composteras rotatorias y lombricompost. Universidad Nacional de Costa Rica. Pp. 8-12 https://documentos.una.ac.cr/bitstream/handle/unadocs/3818/Manual%20Composteras.pdf?sequence=1&isAllowed=y

[37] Tamaño de muestra. (2018). Recuperado 18 de febrero de 2021, de Youtube, Pp. 1, website: https://www.youtube.com/watch?v=1xZAa4jbMqc

[38] Pérez Y, Recolección, Barrido y Limpieza de la Unidad Administrativa Especial de Servicios Públicos-UAESP. (2016). Pp. 1 website: https://bogota.gov.co/mi-ciudad/habitat/asi-es-como-puede-pagar-menos-en-el-recibo-de-aseo.

[39] CR Malaver Flor, RJ Trullo Guerrero, JA Caicedo Muñoz, y JA Mosquera Bolaños, "Enfoque para el Manejo de Residuos Aprovechables No Peligrosos Utilizando una Estación Ecológica", *ing. Solidario* , vol. 12, núm. 20, págs. 109 a 110, octubre de 2016. https://doi.org/10.16925/in.v12i20.1547

[40] Revista Colombiana de Investigaciones Agroindustriales. (2020). Review of sustainable strategies for the use of organic waste in organizations. Pp. 77 https://doi.org/10.23850/24220582.3141. https://revistas.sena.edu.co/index.php/recia/article/view/3141/4335