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Reverse Logistics of Organic Waste from a Manufacturing Facility

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Abstract:

Background: *This study proposes the implementation of reverse logistics for organic waste and explores the opportunities that can be generated through the utilization of these waste materials as raw materials for the production of a new subproduct. The research also considers how to leverage these opportunities to create positive environmental impacts, subsequently benefiting the climate. This approach aims to contribute to the reduction of greenhouse gas emissions and overall waste production through specific processes that can be developed within the company.*

Materials and Methods: *The methodology applied in the development of this scientific article was exploratory and descriptive, encompassing a qualitative approach.*

Results: *The overarching objective of this study is to demonstrate how organic waste from a manufacturing unit can be effectively reduced.*

Conclusion: *The research concludes by emphasizing the imperative need to rethink our business practices and the manner in which we dispose of waste generated through production processes. It advocates for a conscientious and committed approach to changing habits and attitudes, thereby contributing to environmental pollution mitigation on a daily basis. The study underscores the significance of corporate understanding that sustainability should be a priority, not only for the potential added value but also for the commitment to reducing environmental impacts and passing on this legacy to future generations. The realization of producing with zero waste is both possible and tangible, contingent on a serious commitment to making it happen.*

Keywords: *Keywords: Reverse Logistics; Organic Waste; Subproduct; Waste.*

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I. Introduction

This article comprises a study on the utilization of organic waste generated in a manufacturing unit, taking as an example the proper utilization of waste from the cafeteria, pruning's, and sludge produced daily. Through this study, it is considered possible to contribute to the reduction of atmospheric pollution as well as to add value to the supply chain, serving as an example for other business organizations.

The methodology applied to this scientific article was exploratory and descriptive, encompassing a qualitative approach, aimed at analyzing reverse logistics as an alternative for reducing environmental impacts and developing new opportunities from organic waste generated.

The general objective of this study is to demonstrate how we can reduce organic waste from a manufacturing unit. The planned specific objectives are as follows: to investigate actions that can promote the perception of the opportunity for the utilization of the organic waste by-product; to research whether it is possible to contribute to the reduction of greenhouse gas emissions within the manufacturing environment; to discuss how to add value to the supply chain through organic waste generated in the manufacturing unit.

This article is structured into four sections. The first is the introduction, which consists of a brief presentation of the article's subject matter. The second is the theoretical framework, which establishes a discussion on solutions for organic waste, the possibility of reducing greenhouse gas emissions, and opportunities for reusing

waste generated daily in manufacturing units. The third section covers the methodology employed for the research development. The fourth section is reserved for the final considerations, where analyses of the conducted research are discussed.

II. Material And Methods

The methodology applied in this scientific article was exploratory and descriptive, encompassing a qualitative approach, aimed at analyzing reverse logistics as an alternative for reducing environmental impacts and developing new opportunities from the organic waste generated.

The study was grounded in existing literature to better comprehend this thematic area and gain theoretical knowledge of its possibilities, feasibility, and effectiveness in addressing the primary goal, which is to facilitate a change in culture and behavior regarding environmental factors related to waste production within the company.

The research was conducted at a manufacturing unit located in Maracanaú-CE, stemming from the need to address a current problem and to develop best practices in waste management and proper disposal. The six-month study period allowed for a comprehensive understanding of how the process behaves and how it can align with the supply chain.

For this study, authors such as Lorena et al. (2017), Pozzetti and Caldas (2019), Prinsloo (2019), and Reis and Fernandes (2021) were consulted. Their works provided inspiration and motivation for the studied theme, aiding in understanding the necessity and opportunity, feasibility of the studies, and grasping the steps to follow for the desired success.

III. Literature Review

This study is based on opportunities for the disposal of organic waste generated from the manufacturing activities of a beverage production plant in Maracanaú-CE. Thus, we analyzed routine activities, as well as the frequency and quantity of generated waste, and how we could utilize this material.

Global waste production is estimated to increase from 1.3 billion tons to 2.2 billion tons by the year 2025, according to estimates from the United Nations Environment Programme (UNEP). Experts from the organization state that waste management and proper disposal of materials are becoming increasingly essential for the world to move towards sustainable development[5].

It is crucial in today's world for organizations to have environmental concerns regarding their business operations, including the purchase of goods for their production processes and the disposal of waste generated during production. Without this concern, coupled with a genuine interest in understanding, studying, and acting on the opportunities presented by the production process, there will be no advancement in production processes, and society will regress in terms of environmental and planetary health.

Confronted with the existing problem in our business, we were compelled to seek new opportunities to address something that is present in our daily lives in a clear and objective manner. Thus, there arises the need to rethink how organic waste from our activities is disposed of, and thereby also consider a by-product.

The recommendation is to transport all waste generated in the business park to a composting company for treatment. There, the waste will be transformed into stable and highly nutritious material, characterized as compost organic fertilizer, and once ready, it should be transported to a sugarcane mill partnered with the enterprise. The organic fertilizer generated from the waste will be used in the planting process, aiming to replace chemical compounds with natural fertilizer[8].

Biological treatment of organic waste will prevent leftovers from being abandoned in the environment, thereby producing leachate, which can pollute watercourses, reduce oxygen, and kill organisms.

III. 1 Opportunity for Utilization of Organic Waste By-Product

The opportunity to utilize a by-product arises from our attempt to solve a problem that is routine in our activities. Where there is already concern about waste disposal, there is an opportunity to create a new by-product that can add value to the supply chain and close the production and consumption cycle by sending this by-product to our sugar mills[8].

Reverse logistics, as defined by Federal Law No. 12,305, is characterized as:

An instrument for economic and social development characterized by a set of actions, procedures, and means aimed at enabling the collection and return of solid waste to the business sector for reuse in its cycle or in other production cycles, or other environmentally appropriate final disposal[3].

Reverse logistics reflects on the three pillars of sustainability: economic, social, and environmental. The economic aspect pertains to financial gains, the social aspect involves gains received by society from activities involved in reverse logistics, and the environmental aspect relates to minimizing problems caused by incorrect waste disposal and utilization[14].

During the process of studying opportunities in waste disposal, the opportunity to create a new by-product that can also add value to the production chain was perceived. This by-product will primarily consist of organic waste and will be used at the end of our production chain, in the sugarcane planting process, from which the sugar used in our products originates[14].

This by-product, called organic fertilizer, can bring several benefits to the sugarcane cultivation process, such as avoiding the use of chemical compounds, increasing nutrient retention capacity, increasing microbial activity, and improving water storage[14].

Biological treatment of organic waste prevents improper waste disposal and minimizes environmental degradation. Recycling organic leftovers is a sustainable solution for waste generators, avoiding waste accumulation in landfills and providing an economical alternative that does not require sophisticated technology[16].

Organic waste is currently the most significant portion of the total amount generated by the manufacturing unit, along with waste from tree pruning and sludge generated in treatment stations. These previously discarded wastes have been segregated for this study[16].

This is an age-old problem, but with a current perspective on how we can improve the impacts caused by generated waste, contribute to the environment, and generate a new by-product for use in the raw material production chain used in our production process. Genuine concern about waste production and the possibility of recycling and reuse has sparked profound interest in this topic, as such practices can also contribute to reducing greenhouse gas emissions and global warming by sequestering carbon from the soil[16].

If there is greater interest from everyone and organizations generating large quantities of waste, we can have a significant and unique impact on our daily lives, bringing about environmental improvement and enhancing products that receive organic fertilizer as compost[18].

Due to its simplicity, this process involves microorganisms such as bacteria and fungi decomposing organic matter in the presence of oxygen, transforming them. The result of this process is called humus, a nutrient-rich fertilizer that strengthens plant roots[16].

This process consists of three phases: decomposition, semi-maturation, and maturation or curing. During the process, it is essential to observe temperature, humidity, and air presence, as failure to do so may result in the opposite effect, delaying or nullifying microbial activity.

III.2 Possibility of Reducing Greenhouse Gas Effects

It is essential to have an environmental focus and a genuine concern with real interest in improving production processes and understanding what can be done to mitigate the impacts of activities on the planet, making it a daily goal. This study also seeks advantages that we can offer, such as changing the way waste management is conducted.

According to Meneghini (2021, p. 01), "zeroing greenhouse gas emissions is the path to the future, as this type of gas causes climate changes and severe impacts that can last for decades[10]."

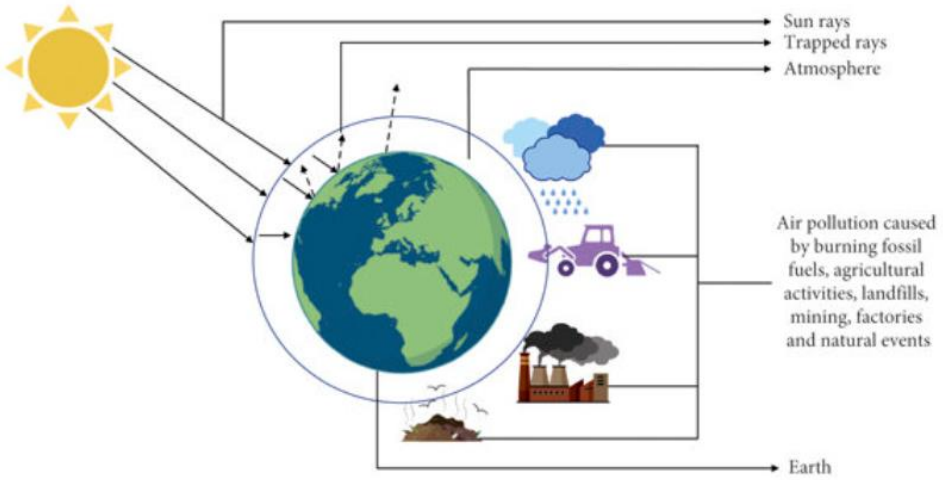
Recycling waste and reusing inputs are ways we can reduce the use of non-renewable natural resources and the amount of waste in landfills, which cause methane emissions. This is a commitment we must undertake daily because this path can lead us to a future. It is already known that the changes caused by environmental disregard can last for long periods and bring severe impacts to humanity and the environment.

But what is the greenhouse effect? The greenhouse effect is a phenomenon responsible for warming the planet's surface due to the presence of gases in the atmosphere that prevent the Earth from losing heat. Among these gases, the main ones are carbon dioxide (CO_2), methane gas (CH_4), and water vapor (H_2O)[15].

The purpose of the greenhouse effect is to prevent the Earth from cooling too much. However, human actions such as the burning of fossil fuels have aggravated its effects through increased gas emissions into the atmosphere, especially CO_2, primarily since the Industrial Revolution, which became known as ground zero.

Figure 1 illustrates the energy exchanges between outer space, the atmosphere, and the Earth's surface. Figure 2 presents the percentile contribution of greenhouse gases to global warming on the planet.

Figure 1 - Schematic representation of the greenhouse effect operation.

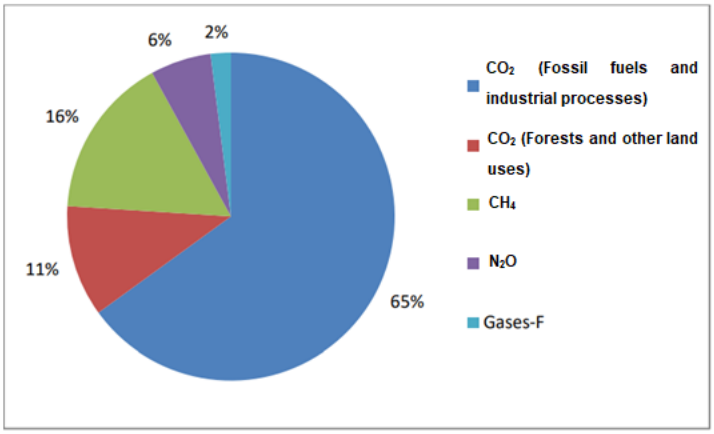


Source: Kaka, Opute and Maboeta (2021)[7]

Figure 1 depicts the schematic representation of the greenhouse effect operation, showing that the Earth absorbs 48% of greenhouse gases. The largest contribution of these gases comes from CO2 (resulting from fossil fuels and industrial processes).

Through studies conducted over time, it has been realized that it is possible to work towards reducing these emissions through production processes, and in some stages, even zeroing such emissions. To achieve these results, it requires serious dedication to understanding the processes and comprehending how we can work to attain such outcomes.

Figure 2 - Illustrates the proportional contribution of the main greenhouse gases.



Source: Environmental Protection Agency in the United States – EPA (2018, cited in PRINSLOO, 2019, p. 02)[15].

It is worth noting that despite constituting a federal crime, one-third of municipalities still have open-air landfills. The initial deadline to eradicate landfills in the country expired in 2014. Many municipalities continue to improperly dispose of waste, without treating leachate and gases. In 2020, landfills were granted the right to exist for another four years[6].

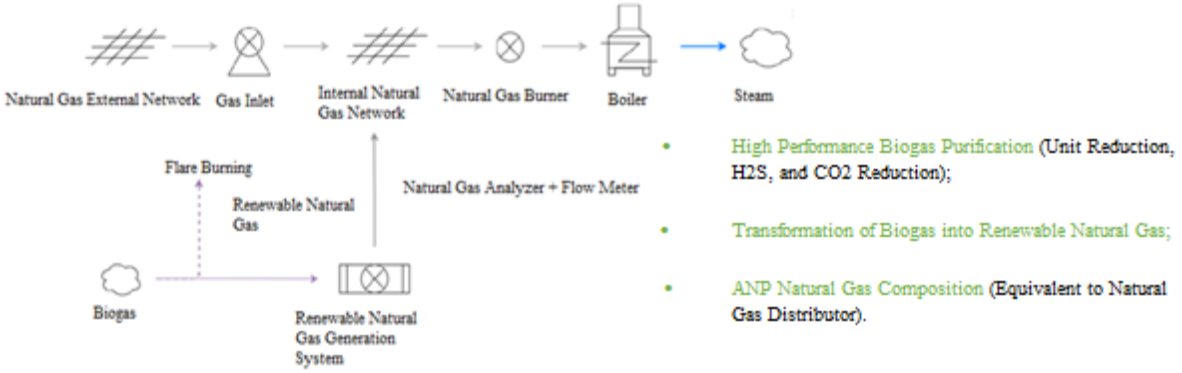
Conversely, the development of public policies establishing quality criteria for treated effluents encourages the exploration of new techniques and methods to ensure adherence to these standards[12].

In this study, we highlight some of the most commonly used alternatives for waste disposal and a sustainable option for the planet, where the goal of having zero-waste factories becomes possible and tangible.

III.2 Utilization of Biogas

Among the strategies used to reduce greenhouse gas emissions, one alternative is the utilization of biogas. In the same factory unit, alongside the proposed project, there is an alternative for utilizing the gas burned in the flare, wherein it is captured, purified, and returned to operation within biogas specifications, referred to as Biomethane. With this project, the flare is eliminated, greenhouse gas emissions (GHG) are reduced, and costs and consumption of natural gas are also reduced. Therefore, biogas holds enormous growth potential in the country. A study conducted by the Brazilian Biogas and Biomethane Association - ABIOGÁS, in 2018, indicated that Brazil has the potential to produce 84.6 billion m^3/year of biogas[13].

Figure 3 – Gas transformation flow.



Source: Researchers' Data

In the market, we have found a solution for flare combustion that also addresses other needs and opportunities for our business, with zero investment required from the factory unit. The unit only provides the space for equipment installation and the necessary input for biogas production. It is worth noting that with the proposed solution, we will reduce energy costs (both thermal and electrical).

Our expectation is that, in the near future, our units will operate with zero flare, thus enhancing our sustainability efforts. We aim to grow while prioritizing sustainable and viable solutions for our business.

Biodigesters (Figure 4) are equipment used to accelerate the decomposition process of organic matter in the absence of oxygen. The waste materials utilized include those from plant production (leaves, straw, crop residues), animal production (such as manure and urine), human activities (feces, urine, household waste), and industrial residues.

The waste should be shredded or reduced to the smallest possible size, and the correct mixture for optimal functioning is 75% water and 25% organic waste, which should be periodically stirred.

Figure 4 – Biodigester

Source: Marsh (2022)[9]

The implementation of biodigesters in our units is a company goal. This initiative aims to internally manage waste, produce our own fertilizer, and provide an additional source of biogas. Despite the urgency, it is essential that such measures are taken consciously, ensuring that our goals are not compromised at any point. We must maintain a sense of urgency and seriousness in reviewing processes and effecting changes conscientiously.

III.3 Wastewater Treatment Plants

Wastewater Treatment Plants are facilities that aid in environmental preservation by allowing effluents to be disposed of in accordance with all relevant regulations. In some cases, they enable effluent reuse in various applications. Different types of effluents exist depending on the origin and composition of the liquid waste generated. Table 1 presents some examples:

Table 1 - Typologies of Effluents and Characteristics

Effluents	Characteristics
Domestic	Originating from households, they contain high amounts of organic matter;
Industrial	They vary according to the type and size of the industry;
Leachates	From landfills, it is a liquid with a strong odor, turbidity, and intense coloration;
Agricultural	Pesticides applied in plantations can accumulate in the soil and leach into different bodies of water;
Hospital	The excessive use of antimicrobials in hospitals can disseminate resistance genes into the environment;
Stormwater	They are generated by rainfall and carry pollutants present on the soil surface.

Source: Braga et al. (2023)[2]

This classification of effluent types is of paramount importance to ensure that disposal complies with current environmental legislation. It also serves to guide the development of efficient and sustainable treatment technologies and processes for each specific need. Moreover, it is useful for monitoring water quality in rivers and lakes near disposal sites.

III. 4 Adding Value Through Organic Waste

As the subject of this scientific article, we need to develop ways for these residues to add value to the supply chain and even close the production cycle chain. After being transformed into a byproduct, this organic compound will be sent to sugar mills, where the organic fertilizer will be used in sugarcane planting. This reduces losses, improves product quality, adds value to our business, and brings a sustainability perspective to our daily activities.

The value chain is defined as the set of activities performed by a company from relationships with suppliers and production and sales cycles to the final distribution to the customer. In other words, it is a set of activities that add value to a product or service performed by a company[1].

It should be emphasized that this premise must be carried out at all stages of the production chain, and with waste disposal and processes involved in the production of byproducts, it cannot be different. We will address these stages with the seriousness, interest, and dedication that the topic demands. Alongside us, we have partners committed to the best waste management practices and environmental protection, aiming to make our production processes sustainable and meet the responsibility demanded by the topic.

Waste generation is considered one of the greatest environmental impacts, but it is possible to reduce generation and even recycle or reuse it. In this study, we highlight at least two current solutions in our factory located in Maracanaú, CE.

Organic compost, a byproduct of organic waste generated in our operational and administrative routines, will be sent to sugarcane mills to replace chemical fertilizer with a natural one. Additionally, biogas or biomethane generated through flare burning, transformed into natural gas specifications, and returned to pipelines to be used as a replenishment source. The expectation is that the unit will be self-sustainable in natural gas, using the supplier as an option in case of extra need.

There are numerous benefits to this process. While on one hand, the industry that generates the waste can dispose of it properly (as provided by the PNRS), on the other hand, the recipient processes it in a way that it becomes organic fertilizer, returning to the land, energetically recovering it[17].

As the world increasingly suffers from the difficulty and complexity of extracting new resources from the Earth, a process that entails serious environmental impacts, we discard thousands of tons of materials every day that could be

reused. According to ISWA (International Solid Waste Association), humanity will go from producing 2 billion tons/year of waste in 2016 to 3.4 billion tons in 2050[11].

Investing in the circular economy means generating savings more than once in the same product and optimizing gains. With seriousness and efforts, we can transform production processes. By using waste that would be discarded into profitable and sustainable byproducts, we generate economic value and add value to our brand, producing and delivering with social and environmental responsibility, reducing losses, waste, and impacts on the society surrounding our factory[4].

IV. Conclusion

The research fully met the proposed objectives of providing solutions for organic waste generated in our factory unit. It brings forth solutions that can reduce the amount of waste and improper disposal. Additionally, it aims to generate byproducts from these wastes and add economic value through these byproducts, also addressing circular economy principles with our business partners and the reverse logistics of received inputs.

The study highlighted the need for serious and responsible consideration in seeking effective and efficient solutions for the wastes generated through our production processes. It suggests exploring possible market solutions that are suitable for the needs of each business, understanding how we can utilize the generated waste to transform it into a new product capable of generating value and becoming a new business within the organization.

Finally, it is recommended to think sustainably and review the habits that are already in operation within organizations, analyzing how we can transform our products and/or businesses into sustainable sources, generating fewer environmental impacts and transforming the environment in which we operate. Whether through selective collection, composting, or in a professional manner, we must not forget that natural resources can be exhaustible or depletable depending on their exploitation and natural recovery capacity. Therefore, as citizens, we should take care of our sources and work towards managing new resources consciously and sustainably.

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