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FOOD WASTE MANAGEMENT AND THE CIRCULAR ECONOMY IN THE BRAZILIAN SEMIARID

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ABSTRACT

The circular economy contrasts with the current production system, to assess the impact of products and reduce waste generations. The Federal University of the Semi-Arid Region (UFERSA), located in the municipality of Mossoró, Rio Grande do Norte, has a university restaurant responsible for serving around 1,600 daily meals. A large amount of food waste generated, about 50-80 kg/day, mainly composed of the leftover food, has required the development of processes aimed at its sustainable reuse. In this study, we applied the circular economy concept to propose an adequate food waste management system. This integration system included: (i) the training of employees on waste management, (ii) the construction of a thermophilic composting plant, and (iii) transportation logistics for organic waste collection and distribution of organic compost and liquid fertilizer. The thermophilic composting plant built consists of eight polyethylene cylinders with a fiberglass cover. Each cylinder has a diameter of 1.1 m and a height of 1.0 m and a processing capacity of up to 50-80 kg of food waste/day. The composting plant contains a PVC tube drainage system, connecting all cylinders and a 500 L collection box, for the temporary storage of the liquid fertilizer. The following parameters of the organic compost must be monitored and corrected weekly, when necessary: pH, humidity, and temperature. In suitable conditions of operation of the thermophilic composting plant, the production of 2,500 kg of organic compost is expected every 100- 120 days, depending on the composition of the waste and climatic conditions. It is important to highlight the need for frequent educational campaigns to sensitize university students in reducing the amount of food waste in a university restaurant. Composting food waste contributes to fuel savings and reduction of carbon dioxide emissions, since this waste, which was previously transported to the landfill, will be treated at the university itself. The composting plant also contributes to the useful life of the landfill and to reduce spending on the purchase of organic compost and liquid fertilizer, used in the university

experimental farm and afforestation. Thus, with the savings generated by the production of organic compost, the university will be able to offer free meals to a larger number of poor students, contributing to the Sustainable Development Goal 2: end hunger and promote sustainable agriculture.
Key words: Biofertilizer. Organic compost. Composting plant. Leftover food. Sustainable development goal.

RESUMO

A economia circular contrasta com o sistema produtivo atual, para avaliar o impacto dos produtos e reduzir a geração de resíduos. A Universidade Federal do Semi-Árido (UFERSA), localizada no município de Mossoró, Rio Grande do Norte, possui um restaurante universitário responsável por servir cerca de 1.600 refeições diárias. A grande quantidade de resíduos alimentares gerados, cerca de 50-80 kg/dia, compostos principalmente pelas sobras de alimentos, tem exigido o desenvolvimento de processos voltados ao seu reaproveitamento sustentável. Neste estudo, aplicamos o conceito de economia circular para propor um sistema adequado de gestão do desperdício de alimentos. Esse sistema de integração incluiu: (i) treinamento de funcionários sobre gestão de resíduos, (ii) construção de usina de compostagem termofílica e (iii) logística de transporte para coleta de resíduos orgânicos e distribuição de composto orgânico e adubo líquido. A usina de compostagem termofílica construída é composta por oito cilindros de polietileno com cobertura de fibra de vidro. Cada cilindro tem um diâmetro de 1,1 m e uma altura de 1,0 me capacidade de processamento de até 50-80 kg de resíduos alimentares/dia. A usina de compostagem contém um sistema de drenagem de tubos de PVC, conectando todos os cilindros e uma caixa coletora de 500 L, para armazenamento temporário do adubo líquido. Os seguintes parâmetros do composto orgânico devem ser monitorados e corrigidos semanalmente, quando necessário: pH, umidade e temperatura. Em condições adequadas de funcionamento da central de compostagem termofílica, prevê-se a produção de 2.500 kg de composto orgânico a cada 100-120 dias, dependendo da composição dos resíduos e das condições climáticas. É importante destacar a necessidade de campanhas educativas frequentes para sensibilizar os universitários na redução da quantidade de desperdício de alimentos em um restaurante universitário. A compostagem de restos de alimentos contribui para a economia de combustível e redução das emissões de dióxido de carbono, uma vez que esse resíduo, que antes era transportado para o aterro, será tratado na própria universidade. A usina de compostagem também contribui para a vida útil do aterro e para a redução dos gastos com a compra de composto orgânico e

adubo líquido, utilizados na fazenda experimental universitária e na arborização. Assim, com a economia gerada pela produção de composto orgânico, a universidade poderá oferecer refeições gratuitas a um número maior de alunos pobres, contribuindo para o Objetivo de Desenvolvimento Sustentável 2: acabar com a fome e promover a agricultura sustentável.

Palavras-chave: Biofertilizante. Composto orgânico. Usina de compostagem. Sobra de comida. Objetivo de desenvolvimento sustentável.

1 Introduction

The concept of the circular economy is somewhat complex and can include the reduction, reuse, and recycling of materials, with the perspective of sustainable development and its dimensions of social equity, economic prosperity, and environmental quality (Kirchherr et al., 2017). Geissdoerfer et al. (2017) define the circular economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. Another definition of the circular economy that considers the perspective of sustainable development was presented by Korhonen et al. (2018), in which they describe the circular economy as an economy constructed from societal production-consumption systems that maximize the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows in integrated production.

In a circular economy, the goal is to maximize value at every stage of a product's life. Additionally, the use of resources for the longest time possible can contribute to job creation and waste and atmospheric emissions reduction (Stahel, 2016). In the circular economy, we can identify five stages: (i) innovation, with the development of new technologies that make the circular economy viable; (ii) sustainable resource extraction, (iii) manufacturing, with the need for fewer resources, (iv) distribution and (v) use of products by consumers (Stahel, 2016).

Worldwide, a significant amount of food is lost, resulting in loss of energy and water, both for food production and for waste management (Kibler et al., 2018). According to the World Resources Institute, food waste is food fit for human consumption that is discarded —either before or after it spoils; either the result of negligence or a conscious decision to throw food away, while the United States Environmental

Protection Agency defines food waste as uneaten food and food preparation wastes from residences, commercial and institutional establishments (Kibler et al., 2018). In 2011, the Food and Agriculture Organization of the United Nations (FAO) estimated that roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (FAO, 2011). In addition to wasting water and energy, it is also important to consider the negative impacts on the environment caused by food production and, additionally, by food waste. These can include contamination of water and soil, emission of greenhouse gases, and loss of biodiversity.

In Brazil, university restaurants are an important source of food waste that have three origins: (i) part of the food is discarded during processing, (ii) the meal is prepared, but there is not enough consumer for all available meals, (iii) food is served on the plate, but the consumer consumes only part of this food. It is estimated that the total rate of food waste in university restaurants is higher than 20% when we consider the three sources of food waste origin (e.g., Castro et al., 2003; Zotesso, 2016). These food waste rates can be associated with conservation and underutilization of food, portion sizes, food preferences (Zotesso, 2016), and low meal prices. In this study, we applied the circular economy concept to propose a food waste management system and thus contribute to the Sustainable Development Goal 2: end hunger and promote sustainable agriculture.

2 Methods

The central campus of the Federal University of the Semi-Arid Region (UFERSA) is located in the municipality of Mossoró, Rio Grande do Norte, semi-arid region of Brazil. There are three other campuses in the municipalities of Angicos, Pau dos Ferros, and Caraúbas. The Köeppen Climate classification is BSwh, semi-arid, steppe type, very hot, with a rainy season in summer. The annual precipitation is usually less than 750 mm and the average annual temperature is 27.2ºC (Ageitec, 2020). The region is inserted in the Caatinga biome and suffers from water scarcity, especially in the dry season, from August to December.

UFERSA, campus Mossoró, has an experimental orchard, which is used to conduct research and practical classes on the production of fruits such as guava, passion fruit, coconut, pineapple, pomegranate, cashew, among others. UFERSA also has an experimental farm, with approximately 400 ha, for research and teaching in agriculture and fruit and animal production. This University has 10,585 undergraduate

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students and approximately 600 graduate students and has a university restaurant at Mossoró responsible for serving around 1,600 daily meals. Most university restaurant users are undergraduate students, who pay approximately 1/4 (or US$ 0,5) of the original meal price (US$ 2,0). The menu of the university restaurant is of the popular type, consisting of rice or pasta, beans, a type of meat, a type of salad, and a fruit. Meals have a fixed price and users can freely use all foods. Only meat is limited to one portion.

To implement the sustainable management of food waste from the university restaurant, we recorded: (i) the amount and composition of food waste produced daily by the UFERSA university restaurant, campus Mossoró; (ii) the number of waste bins needed to transport food waste, (iii) type of composting plant suitable for the Brazilian semiarid region and (iv) adequate capacity of a composting plant.

3 Results and Discussion

Integrated Waste Management System For the sustainable management of food waste of the UFERSA, we propose an integration system between the university restaurant, composting plant, and university experimental farm and orchard (Figure 1).

Fig. 1 Example of a proposed circular economy for adequate waste management from a university in the Brazilian semiarid.

University Restaurant

Food Waste

Food Production

Circular Economy

Composting Plant

Organic Compost

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The integration system between a university restaurant, a composting plant, and a university experimental farm and orchard included: (i) the training of employees on waste management, (ii) the construction of a thermophilic composting plant, and (iii) transportation logistics for food waste collection and distribution of organic compost.

(i) Training of employees: The training of employees on food waste management and the circular economy was carried out in two stages: production of a didactic guide and short course in loco. The topics discussed in the course were: circular economy, nutrient cycle, and decomposition of organic material, use, and importance of individual safety equipment, operation, and management of composting plants, and quality of organic compost.

(ii) Composting plant: To make food waste management and the circular economy viable, UFERSA acquired in 2019 a composting plant (Figure 1). The thermophilic composting plant built consists of eight polyethylene cylinders with a fiberglass cover. Each cylinder has a diameter of 1.1 m and a height of 1.0 m and a processing capacity of up to 50 kg of food waste/day. The composting plant contains a PVC tube drainage system, connecting all cylinders and a 500 L collection box, for the temporary storage of the liquid fertilizer. The following parameters of the organic compost must be monitored and corrected weekly, when necessary: pH, humidity, and temperature (Figure 2). In suitable conditions of operation of the thermophilic composting plant, the production of 2,500 kg of organic compost and liquid fertilizer is expected every 100-120 days, depending on the composition of the waste and climatic conditions. The thermophilic composting process reduces the decomposition time of food waste, and the compost provided by a thermophilic plant provides good humus to enrich the soil and provides basic nutrients for the plants (Elango et al., 2009). Studies indicate that thermophilic composting speeds up the decomposition time of food waste when compared to conventional composting. The quality of the organic compost produced in thermophilic plants has also been highlighted (Xiao et al., 2009).

Transportation logistics: To make an integrated food waste management system viable, transportation logistics is an essential element. Employees and a truck are needed to collect food waste at the university restaurant, transport food waste to the composting plant, transport soil and dry leaves to the composting plant, and finally, transport the organic compost produced to the experimental farm and orchar.

3.1 *Benefits of food waste management*

The implementation of an integrated system of food waste management at a university generates several benefits (Figure 3), including the possibility of conducting research, for example, on nutrient cycling, quality of organic compost, and cost associated with circular economy versus traditional economy. The thermophilic composting plant also serves students during the practical classes of the undergraduate courses in agronomy, agricultural and environmental engineering, and ecology. Elementary and high school students from Mossoró and the region also visit the thermophilic composting plant to learn about the organic decomposition processes. From the integrated management of food waste, UFERSA can save money with the production of organic compost for the farm and orchard, and with the end of sending food waste to the landfill. Thus, with the savings generated by the production of biofertilizer, the university will be able to offer free meals to a larger number of poor students, contributing to the Sustainable Development Goal 2: end hunger and promote sustainable agriculture.

The environmental benefits of integrated food waste management include, for example, the reduction of atmospheric CO2 emissions, as the production of organic compost within the university reduces fuel consumption in transporting food waste to the landfill and purchasing fertilizer. Food waste management also contributes to the useful life of the landfill. Also, suitable waste management reduces the risk of soil and water contamination. The environmental benefits of the composting plant include contributing to nutrient cycling and the production of organic compost, which can be used for the production of food and trees. For example, a cost-benefit analysis of composting plants in Asia indicated that medium and low-scale composting plants are financially viable compared to smaller and larger capacity plants. This study also found that the economic viability of composting plants depends on the number of factors, such as the selection of suitable processing methods, technologies, scale, and product quality (Pandyaswargo and Premakumara, 2014).

3.2 *Food Waste Reduction*

Although the food waste management system has several benefits, it is necessary to invest in a program that reduces food waste in university restaurants in its three origins: (i) production of food waste during food processing, (ii) the meal is prepared, but there is not enough consumer for all available meals, (iii) food is served on the plate, but the consumer consumes only part of this food. Some research shows that a good adequacy and monitoring system can significantly reduce food waste (e.g., Almeida et al., 2008; Zotesso, 2016). The adequacy of the menu and the size of the portion served to seem to directly contribute to the reduction of food waste (Almeida et al., 2008). It is important to highlight the need for frequent educational campaigns to sensitize university students in reducing the amount of leftover food in the university restaurant. Training courses for employees preparing meals and educational campaigns for students can also contribute to a significant reduction in food waste (Borges et al., 2019).

Conclusion

The concept of circular economy applied to food waste management can contribute to different sustainable development goals: produce organic compost for agriculture (Goal 2: end hunger and promote sustainable agriculture), promote education (Goal 4: quality education), and reduce greenhouse gas emissions (goal 13: climate action). Indirectly, sustainable waste management is also related to sustainable communities and cities (Goal 11) and life on land (Goal 15).

The food waste management system proposed for a university in the Brazilian semiarid proved to be economically viable, efficient, and useful. For this system to achieve a higher degree of sustainability, it is necessary to promote employee training and educational campaigns for consumers.

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