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Production of Biofertilizer and Composting from Solid Organic Residues of a Restaurant: A Case Study

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Abstract: Biofertilizer is the liquid effluent derived from the fermentation of organic matter. It is rich in vitamins, enzymes, soil-nourishing antibiotics and, furthermore, protects and provides resistance to plants from the attacks of external predatory agents. Thus, the objective was to analyze the domestic composting process, through the influence of environmental and chemical parameters (relative humidity, temperature, precipitation and pH) obtained by way of the decomposition of organic, animal and vegetable matter coming from restaurants. The collection of food waste occurred on March 8 and 22, 2019, rainy season, in a restaurant located in the city of Paragominas - PA. The method employed in the research was the inductive with quantitative and qualitative nature, and with experimental procedure. The data obtained were statistically treated with the application of Pearson's Correlation. The analysis of these data indicated that there is production of biofertilizer and organic fertilizer by maturation of organic compounds; the pH was revealed to be from slightly acid to acid (4.0 to 5.0), then, applicable as an irrigating liquid and of good fertility. Therefore, it is of major importance to recycle organic food waste as an alternative solution for its accumulation and incorrect disposal in the environment.

Key words: Organic Materials, Recycling, Vegetation.

1. Introduction

Biofertilizer is the liquid effluent derived from the fermentation of organic matter, it is rich in vitamins, enzymes, soil-nourishing antibiotics and, furthermore, protectsand provides resistance to plants from attacks by external agents [1].

As for the application techniques, the biofertilizer has the most varied utilities, among which stands out the fertilization of small and large crops, that benefit the natural environment, because they have nutritional substances that help in plant development: nitrogen (N), phosphorus (P) and potassium (K), which are soil enrichers and do not constitute heavy materials that are harmful to cultivation [2].

As another method of treating organic residues, composting stands out. This is a biological process solution, which consists in the controlled degradation of organic matter by microorganisms, in an environment favourable for humidity, temperature and oxygen availability, resulting in the production of carbon dioxide, water, minerals and a stabilized gross product called fertilizer or organic compost [3].

The composting process can be sped up through the turning unit mechanism, which is subdivided into two ways: (1) barrel rotary turning, which consists of homogenization of organic compounds within five to ten days to acquire appropriate carbon/nitrogen mixture (2) rolling ball, which occurs due to an achievable percentage of relative humidity, which will

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provide high residue retention due to increased performance of the oxygen-supplying aerobic bacteria [4].

In addition, the chemical nature of organic waste determines the class of active organisms during the decomposition process, with the relationship between carbon (C) and nitrogen (N) being one of the main indicators of compost maturity. The C/N relation should be determined on the material to be decomposed for nutrient balance purposes and also into the final product for compost quality [5].

In addition to these relationships between chemical elements, must be made the control over the hydrogen potential (pH), because the mean values at the beginning of decomposition range from 7 to 8, due to the mesophilic and thermophilic stages that occur in composting and, in these values microorganisms have a high decomposition rate [6].

Regarding the formation of compounds, the organic residues generated in restaurants, in general, comes from the variety and quantity of foods offered that exceed the consumption need, thus, there is the occurrence of leftovers and waste, which contributes to an increase in the generation of these residues [7]. Consequently, in order to obtain an agronomically applicable compound, prior separation of the non-organic material is of paramount importance to reduce the chances of contamination and, thus, the composition may be of better quality [8].

The use of composting can reduce the amount of organic waste produced in restaurants by up to 80%. This has been proven by studies in Missouri (USA) where 140 tons of food residues are produced annually, which, after decomposition, return to schools and are used as a substrate in the composition of gardens [9].

For this to occur, the anaerobic decomposition process is used, in which one of the purposes is to obtain fertilizers. Thus, the organic residues from restaurants are managed sustainably and energy can be generated through the production of methane gas (CH4). Another factor is the use of raw materials that may include biodegradable materials such as pruning waste, sewage [10].

It is known nowadays that the return of organic matter to soil can play a key role in the organization of such waste, avoiding inappropriate disposal such as landfilling and incineration; organic matter sources can also have significant amounts of macro and micronutrients, mainly (N and P), having positive effects on soil fertility increase and, also functioning as a source of nutrients for plants, with the end of the nutrient cycle [11].

This research becomes relevant because it will expose alternative solutions for the inappropriate accumulation and disposal of organic food residues generated by restaurants.

2. Objective

To analyse the domestic composting process, through the influence of environmental and chemical parameters (relative humidity, temperature, precipitation and pH) obtained by decomposition of organic, animal and vegetable matter that comes from restaurants.

3. Material and Methods

The research method is inductive because, according to what was exposed by Prodanov C. C. and Freitas E. C. [12], starts from the observation of facts or causal phenomena whose the causes are intended to know, and in this research, starts from the generation of humid organic solid waste and the reuse for generation of organic fertilizer. Thereafter, it is aimed to compare these processes, in order to discover the existing relationship between them and, lastly, it is proceeded to generalization, in basis of the verified relation between the facts or phenomena.

Regarding nature, as described by Oliveira M. F. [13], it is quantitative and qualitative. At first, residual quantities and volume measurements of the generated liquid were used in composting; in the second, this liquid was classified according to its use in tree vegetables as an irrigation factor.

The data obtained were statistically treated with the use of electronic spreadsheets contained in the Excel software [14], with application of descriptive statistics (average). Was applied the Pearson Correlation, to verify the relationship between the measured environmental parameters (temperature and air humidity). Values for “r” (r = 0, no correlation; 0.10 at 0.30, weak correlation; 0.40 to 0.60, moderate correlation; 0.70 to 1.00 strong correlation) were adapted from Ref. [15]. They were, then, tabulated according to the Brazilian Institute of Geography and Statistics (IBGE) [16].

The research was conducted in a restaurant located at Teresina Avenue, Célio Miranda neighbourhood, Paragominas-PA. Two collections were made (March 08 and 22, 2019), from organic residues generated by the establishment. The collected material was sent to the Environmental Quality Laboratory of Pará State University, campus VI-Paragominas. Then occurred the segregation of nutritional waste (vegetable, cooked, and animal). To make the composer (Table 1) and the biodigester (Table 2) several materials were employed.

For the composting, the technique described by Melo S. W. [17] was used, but adapted according to the purpose of this research: the holes in the bottom of the buckets (Fig. 1a) for the slurry between the waste and two piles with three reservoirs - one stores cooked

Table 1 Materials used to make the composter, Campus VI, Paragominas - PA.

Materials	Amount	Utility
Plastic bucket (V = 15 e 18L)	6	Store organic compounds and sawdust
Sawdust	6.1 kg	Responsible for maintaining C/N relation
Digital scale	1	Measure the mass of organic waste
Scissors	3	Cut organic compounds into smaller pieces
Tap	2	Collect slurry
Post hole digger	1	Grind food

Table 2 Materials used to make the biodigester, Campus VI, Paragominas - PA.

Materials	Size	Amount
Plastic drum (bombona)	80 L	1
PVC flange¹	20 mm	3
Weldable PVC Union	20 mm	1
Weldable PVC Adapter	20 mm	6
PVC Pipe	20 mm	2m
Galvanized crosshead	½’	1
PVC double niple	20 mm	2
Metal ball register	20 mm	2
PVC elbow	20 mm	1
Male Spike	20 mm	1
PVC female adapter	20 mm	1
PVC cap	20 mm	2
PVC “T”	20 mm	2
Pipe glue		1
Thread sealing tape		1

PVC: Vinyl Polyacrylate; “T”: Triple-output rod, smooth.

animal meat leftovers and the other one, cooked vegetable waste (Fig. 1b); It is then mixed with sawdust. Subsequent to these procedures the residues are turned together with the sawdust; The composters were placed in a shelter made of wood and covered with plastic mesh screens (Fig. 1c), under a tree plant, so that the ambient temperature was not as influential as that of the compound itself.

Inside the shelter there is an Incotermthermo-hygrometer containing dry and wet bulb, to the daily measurement for 12 (twelve) days, from 07h00 to 17h00, with intervals of one in one hour, relative humidity and room temperature were measured.

For the construction of the biodigester was performed the same procedure elaborated by Metz, L. E. G. [18], however, adaptations were made: (1) the degree of angulation (Fig. 2a) of the drain in the plastic drum (Fig. 2b); (2) gas outlet position (Fig. 2c) being shifted further to the center of the plastic drum, in order for the outflow to result in a 90° angle, it was relocated to the top; (3) 10% reduction in the amount of elements (manure, water and waste). This happens because the mixture could not reach the gas outlet (Fig.

2d); (4) for the mixer there was a small adaptation, where it was only reduced because, unlike the Metz procedure, the plastic drum was smaller and consequently it had to be reduced from 25 mm to 20 mm.

(a) (b) (c)

Fig. 1 a) holes in the bottom of the buckets; b) waste segregation; c) composters placed in a shelter made of wood and covered with fabric screens. Paragominas - PA.

(a) (b) (c) (d)

Fig. 2 a) 15° drain angle position that aids in removal of biofertilizer as it is slightly sloping downward; b) drain already applied to the plastic drum and allocated in a space reserved for the composer; c) gas outlet, relocated to the side of the plastic drum; (d) distance between the gas point of outflow and the food residues (organic and nutritional). Campus VI, Paragominas - PA.

4. Results and Discussion

The data obtained and analysed indicated that the environmental parameters, temperature and relative humidity were favourable to the proliferation of microorganisms that interfere with the composting procedure (Fig. 3).

According to University of Illinois Extension [4], organisms such as aerobic bacteria are the most important decomposers for composting. They are very abundant, so much so that in a gram of soil or decomposing organic matter there may be millions of them. They are also the ones with the greatest diversity of species, and feed on almost all types of food or waste. Bacteria use the chemical element carbon (C) as a source of energy and nitrogen to create protein, important in their growth and reproduction.

In this study, the results corroborate those of the University of Illinois, although the process of decomposition of organic matter was accelerated in 12 days. Even not mentioning the percentage of relative humidity considered ideal, in both studies, it is considered a preponderant factor in the appearance of soil fauna microorganisms, which in this study had the percentage of 92.5%.

Data analysis also indicated that the interrelation between the environmental parameters analyzed, temperature and air humidity (r = -0.8368) was inversely proportional (Fig. 4).

Such that there was an increase of 92.5% relative humidity on March 16 and a tendency to decrease in temperature corresponding to 25.5°C on March 16, and occurred a relative humidity decrease of 80.2% on March 20 and a rise in temperature of 28.5°C on the same day.

As for the analysis of the slurry from the composting process, it was found that: (1) where animal food was deposited, a volume equal to 210 mL was obtained; (2) of the nutritional residues, that is, cooked vegetables, generated 175 ml. Concerning the generation of slurry by composting, a study was carried out in the city of Salvador (BA) by Metz, L. E. G. [18], concludes that temperature and humidity are intervening variables in the composting process, since when a humidity higher than 68% is obtained, it indicates that the composting method intensifies, water accumulates inside the compost containing organic waste, which contributes to the generation of large amounts of methane (CH4), limits oxygen (O) and causes the entrance of putrid odor into atmospheric air. However, other factors, such as precipitation, may contribute to the presence of putrid odors from slurry, which according to Metz, L. E. G. [18] is due to the excessive elevation of relative humidity. Due to the fact that the city of Paragominas is in the midst of its rainy season, the precipitation rate in the Campus VI was surveyed (Fig. 5).

Regarding the hydrogen potential (pH) it was verified that: (1) the organic residues of animal origin presented pH equivalent to four; (2) for plant residues the pH measured resulted in five, validating that it is one of too acidic pH. On the theme related to the influence of pH, Costa A. R. S. et al. [19] performed a procedure in Recife-PE, and found that the change in the pH level varies according to the type of organic residue used in the composting, which may interfere in the process, since there is organic matter of slower decomposition when compared to others. Thus, pH of four and five are rated as close to neutrality, once the process is still starting, and the bactericidal action is beneficial.

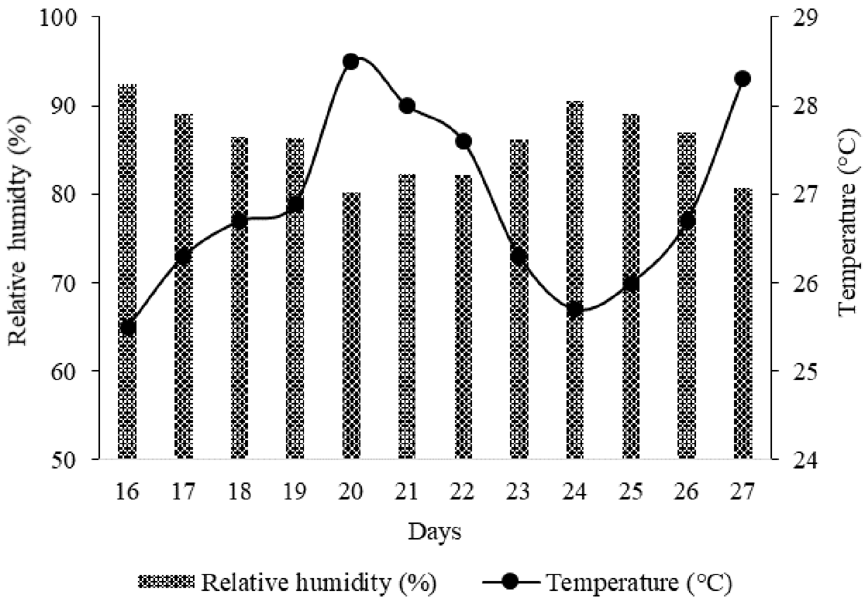

Fig. 3 Values for the means of two environmental parameters (relative humidity and temperature) in the composer allocation space, Campus VI, Paragominas - PA.

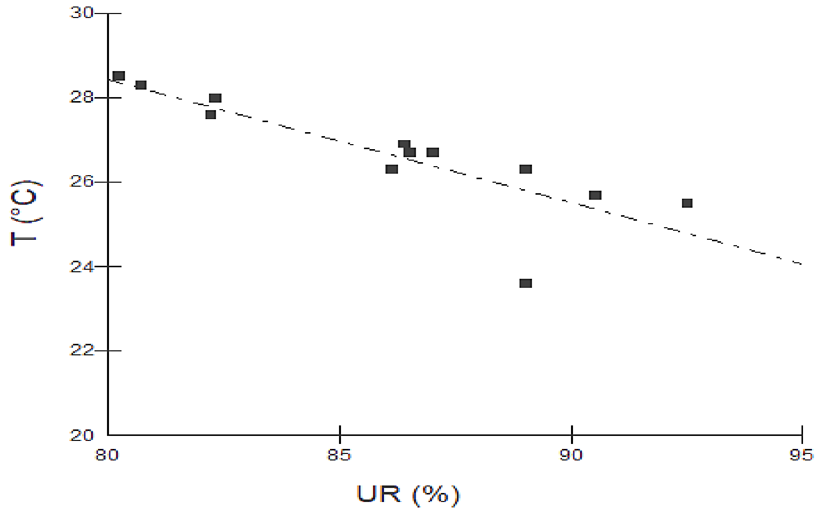

Fig. 4 Pearson correlation between environmental parameters (temperature and relative humidity) in the composer allocation space, Paragominas - PA.

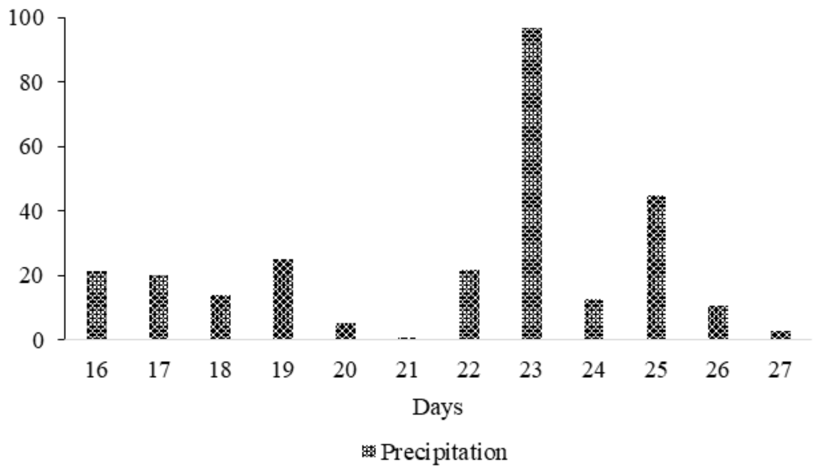

Fig. 5 Precipitation average values. Campus VI, Paragominas-PA.

5. Conclusion

The practice of composting proved to be efficient in the reuse of organic matter for recycling. Animal and vegetable residues were proved to be effective in the final composting process, generating substances such as slurry, important in raising the humidity contents of these wastes, associated with the rainfall rate of the region. The pH variation was a result of the presence of elements associated with organic waste (cooking process) and anaerobic reaction inside the compost. Biofertilizer production from the composting process can also be an alternative in fertility and weed control in the soil.

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