Revista ARACÊ
ISSN: 2358-2472

IMPLEMENTATION OF AN ORGANIC WASTE TREATMENT SYSTEM THROUGH COMPOSTING (STROC) IN AN EDUCATIONAL INSTITUTION IN SÃO LUÍS/MA

https://doi.org/10.56238/arev7n1-122

Submission date: 12/13/2024 **Publication date: 01/13/2025**

Daniel Rocha Pereira[1], Thiago Rafael Gonçalves Duarte[2], Sarah Bianca Neves de Sousa[3], Lara Victoria de Sousa Machado[4], Osman José de Aguiar Gerude Neto[5], Fillipe Miranda de Albuquerque[6], Alexsandro Ferreira dos Santos[7] and Rita de Cássia Mendonça de Miranda[8]

[1] Doctor in Biodiversity and Biotechnology - BIONORTE
Federal University of Maranhão - UFMA
E-mail: daniel.rocha.drp@gmail.com
ORCID: orcid.org/0000-0002-7048-8027
LATTES: lattes.cnpq.br/7706265054412490
[2] Master in Construction Processes and Urban Sanitation
Federal University of Pará - UFPA
E-mail: thiagorgduarte@icloud.com
ORCID: orcid.org/0009-0002-4747-0790
LATTES: lattes.cnpq.br/1732731565400484
[3] Technician in Administration and Environment Environment
Maranhão State Institute of Education, Science and Technology (IEMA Pleno Rio Anil)
E-mail: sarahneves1200@gmail.com
ORCID: orcid.org/0009-0001-8645-2002
LATTES: lattes.cnpq.br/3971547639683667
[4] Student of Pedagogy
Maranhão State University - UEMA
E-mail: laravicmach@outlook.com
ORCID: orcid.org/0009-0001-9622-0694
LATTES: lattes.cnpq.br/3036517949525076
[5] PhD student in Biodiversity and Biotechnology - BIONORTE
Federal University of Maranhão - UFMA
E-mail: osmangerude@hotmail.com
ORCID: orcid.org/0000-0003-3979-1922
LATTES: lattes.cnpq.br/1199184922159968
[6] Master's student in Environment
CEUMA University
E-mail: fillipe_miranda@hotmail.com
ORCID: orcid.org/0009-0009-3295-6609
LATTES: lattes.cnpq.br/7879249466856870
[7] PhD in Health Sciences
Federal University of Maranhão - UFMA
E-mail: fs_alexsandro@yahoo.com.br
ORCID: orcid.org/0000-0001-7470-4607
LATTES: lattes.cnpq.br/7288050405760370
[8] Doctor in Fungal Biology
Federal University of Pernambuco - UFPE
E-mail: rita.miranda@ceuma.br
ORCID: orcid.org/0000-0003-2116-1797
LATTES: lattes.cnpq.br/1952235749528138

Revista ARACÊ
ISSN: 2358-2472

ABSTRACT
Most of the waste generated in society is organic in nature, and a large portion is still disposed of inappropriately, when it could be treated in a more beneficial manner. Composting is one of these forms of treatment, being not only economically viable, but also environmentally justifiable, as it helps in the production of organic compost for fertilization. The objective of this research is to develop an Organic Waste Treatment System through Composting (STROC) and analyze the quality of the compost produced, aiming at the environmentally appropriate disposal of the waste generated in a school restaurant in São Luís/MA. To this end, the waste was quantified and classified, and then used in the STROC design. The resulting compost was subjected to chemical analysis to assess its quality. The results demonstrated that the STROC design was efficient, treating 3,074.35 kg of organic waste, avoiding its disposal in inappropriate places, and generating a high-quality product. This system has the potential to be replicated in similar contexts. It is concluded that the adequate treatment of organic waste from the school restaurant results in a value-added product that can be used in the recovery of degraded areas, in food production, in addition to offering socio-environmental benefits to the surrounding communities.

Keywords: Carbon/Nitrogen. School Restaurant. Biocatalyst.

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

We currently live in an era of overconsumption, marked by the massive production of waste, especially organic waste, which creates challenges in the management of these materials, evidenced by overloaded landfills and the low use of sustainable techniques, such as composting, whose neglect not only prevents the generation of wealth, but also deprives society of alternatives for producing energy and gas, as highlighted by Varenholt (2015).

A large part of the waste generated is organic in nature and often destined for unsuitable locations; however, this fraction could be treated in a way that generates several economic, environmental and social benefits. In this context, composting emerges as an efficient solution, being an economically viable and environmentally beneficial process, capable of producing organic compost suitable for fertilization, according to Inácio (2010).

The composting process, mentioned above, consists of the controlled exclusion of organic matter by microorganisms, resulting in a reduction of more than 60% in the volume of waste, which demonstrates its efficiency as a sustainable management technique. The material generated, known as organic compost or biofertilizer, is a stable product that can be used as a soil conditioner or fertilizer, contributing to soil enrichment and improving agricultural productivity. However, as warned by Massukado (2008), the agronomic quality of the final product may be compromised if the waste is not specially segregated or mixed, reinforcing the importance of careful management during the composting process.

Organic compost is produced through anaerobic fermentation of organic matter. This natural fertilizer improves agricultural production without the risk of chemical contamination, in addition to reducing production costs, as noted by Kiehl (2005). In addition, the practice of composting helps to extend the useful life of landfills, reinforcing their economic and sustainable prospects. Grossi and Valente (2002) emphasize that composting benefits soil quality, contributing to more balanced environmental management.

In the school environment, the implementation of composting programs is even more significant. This initiative promotes interdisciplinarity, integrating teaching and research, in addition to making classes more dynamic and stimulating. Costa et al. (2011) point out that activities like these awaken students' curiosity and investigative spirit, which are fundamental for active and transformative learning.

In this context, the creation of organic waste treatment systems is justified, especially in school environments, such as school restaurants. This proposal aims not only at an environmentally correct disposal of the waste generated, but also at promoting environmental education practices, and the reuse of the compost generated for activities such as the recovery of degraded areas, the production of vegetable gardens, and gardening.

In this sense, the main objective of this study is to build an Organic Waste Treatment System through Composting (STROC). At the same time, it seeks to analyze the quality of the compost generated, evaluating its predictions for agronomic use. The project will be developed in a school restaurant located in São Luís, Maranhão, and intends to integrate technical, pedagogical, and environmental aspects. Thus, the initiative contributes to environmental awareness, in addition to promoting the relevance of composting as a sustainable solution for the management of organic waste in different contexts.

METHODOLOGY

This research was carried out from October 2022 to July 2023.

CHARACTERIZATION OF THE STUDY AREA

The school unit, which is the object of study, is public and is located in the city of São Luís/MA, in the Anil neighborhood, in an area of 02 hectares, under the coordinates -2.545747; -44.237965, and began its activities in 2021, with Full-Time Technical High School. It currently has 900 students, enrolled in 08 (eight) technical courses, distributed in 27 classrooms. The institution has a school restaurant that offers 3 (three) meals a day (morning snack, lunch, afternoon snack) for 900 students, 85 teachers, and 50 technical and administrative staff.

The Organic Waste Treatment System through Composting (STROC) was implemented in a flat area of 329.10 m², located in the school itself. It consists of 9 bays for composting beds, 10 vegetable beds, and 1 chapel-type greenhouse measuring 6.5 x 3.5 m.

QUANTIFICATION OF ORGANIC WASTE

The organic waste collection period at the school restaurant was divided into two moments, from 11/14/2022 to 12/02/2022 and from 04/24/2023 to 06/23/2023, totaling 12 weeks. During this period, there was a pause in the school restaurant's activities, due to school holidays and a strike by state school teachers. The composting process used

Revista ARACÊ
ISSN: 2358-2472

organic waste generated in the school cafeteria. The daily mass of waste was initially quantified using a digital scale and the approximate number of meals served per day was calculated to assess the daily waste generation (total waste and generation per capita per day, week, month and year), and then to size the Organic Waste Treatment System by Composting (STROC).

IDENTIFICATION OF ORGANIC WASTE

After quantifying the mass, the waste was identified using the weekly menu and information from the head chef and confirmed during weighing. When the waste arrived at STROC, it was sorted to separate the leftovers from the meals and the leftovers from fruits, vegetables and greens (FLV), as well as incorrectly discarded waste, such as plastic, paper and metal cutlery.

CONSTRUCTION OF THE STROC

The STROC is composed of three operational units: Composting windrow bays; Vegetable beds and a chapel-type greenhouse.

Composting bays

The method used in the composting process was adapted from the “Windrow” windrow system, according to Paiva (2011), which is conducted by periodic turning with the aim of introducing air (oxygen) and correcting the amount of water in the compost mass. The composting process using windrows is viable in temperate climate conditions and lasts up to 120 days, when it has a dark color, smells like wet earth, is easy to mold in the hands, reduces the volume of the mass to 1/3, has a minimum of 40% organic matter (OM), Nitrogen above 1.7%, a minimum moisture content of 25%, pH above 6.0 and a carbon/nitrogen (C/N) ratio in the range of 10/1 and 15/1 (MMA, 2001; TIQUIA et al., 2002; PEREIRA NETO, 2007; BERNAL et al., 1998; BNDES, 2013; TEIXEIRA et. al., 2004). Based on the data above, regarding the duration, the sizing of the composting beds was divided as follows: One bed was set up every 7 days, always on Saturdays, containing waste from 5 days of school meals (Monday to Friday). Therefore, 4 beds were set up per month, totaling 12 (twelve) beds per cycle. Thus, each bed will wait up to 120 (one hundred and twenty) days for the end of the process. In each bay, a bed was set up, according to the carbon/nitrogen ratio, with the following waste:

Revista
ARACÊ
ISSN: 2358-2472

• Nitrogen source: food waste (school cafeteria);

• Biocatalyst and Nitrogen: animal feces (goat, horse and cattle: small local producers; rodent: UFMA laboratory)

• Carbon source: grass prunings and tree prunings (maintenance of the school's green areas); pine shavings (UFMA laboratory); mixed shavings (carpentry company in the surrounding area);

Carbon/nitrogen ratio

The C/N ratio range followed the studies of Kiehl (2004), where the ideal C/N ratio should be between 25/1 and 35/1. To calculate the carbon/nitrogen ratio, C/N values from research in the area were used, as shown in the table1.

Table 1 – C/N Ratio Used in the Dimensioning of the STROC

Source Type	**Residue**	**C/N**	**Characteristics**	**Author**
Nitrogen	Meal	15.00/1	UFRRJ Dining Hall	AQUINO et al., 2005
Nitrogen	FLV	30.00/1	FLV	ALENCAR et al., 2012
Biocatalyst and Nitrogen	Cattle Feces	20.13/1	Cow and Bull Feces	BATTISTI & BATTISTI, 2011
Biocatalyst and Nitrogen	Goat Feces	17.01/1	Goat and Buck Feces	AMORIM, 2002
Biocatalyst and Nitrogen	Horse Feces	30.00/1	Fresh Horse Feces	RICHARD et al., 2005
Biocatalyst and Nitrogen	Rodent Feces	35.60/1	Laboratory Rat and Mouse Feces	PULLOPAXI CIFUENTES, 2019
Carbon	Pine Sawdust	107.40/1	6-Month-Old Pine	MAIA et al., 2003
Carbon	Mixed Sawdust	240.00/1	Woodworking Sawdust	NASCIMENTO, 2022
Carbon	Tree Pruning	35.52/1	Dry Twigs and Leaves	BATTISTI & BATTISTI, 2011
Carbon	Grass Pruning	37.73/1	Grass Clippings	BENITES, 2004

Height of the windrows

According to Aquino (2005), the size of the compost pile formed on the ground should be 1.0 to 1.5 m high. Regarding the width of the pile, this can vary according to the availability of area and waste, but should not exceed 1.5 to 2 m. Depending on the quantity of organic waste obtained, the width of the pile should be estimated and the area demarcated with stones or tree stumps.

Based on the aforementioned quote, the height of the windrows was 1 meter, while the width and length followed the quantity of waste per windrow.

Revista ARACÊ
ISSN: 2358-2472

Setting up the windrows

The windrows were set up as follows:

a) The food waste generated during the week (Monday to Friday) was weighed daily and separated into meals and fruits and vegetables; b) Based on the mass of food waste, the carbon/nitrogen calculation was performed, according to formula 1 (GOMES et al., 2001) and table 1, to then define the quantity of carbon source and biocatalyst.

Parts of carbon-rich material = (Material rich in N) / (Material rich in C) = ((30x%N) - %C) / (%C - (30x%N)) (1)

c) The windrow was assembled by alternating the different types of waste in layers with a thickness of around 20 cm according to Kiehl (2004). In this way, a layer with a carbon source was formed, followed by another with a nitrogen source and biocatalyst. Then, another layer of carbon was added, and then another with a nitrogen source again, and so on until the waste was exhausted. d) The STROC was built during the region's rainy season (according to Table 2), so the wetting process took advantage of the rainfall index. However, the moisture level was monitored to maintain the windrows within the value recommended by Kiehl (2004), which is 60%. When necessary, it was supplemented with water from an artesian well.

e) For aeration, the turning cycle was performed manually once a week. The aerobic fermentation method was used, in an open environment, with a slow decomposition process. According to Inácio (2010), in the composting process in aerated static piles, with natural ventilation, oxygen is supplied to the mass through manual turning. When turning is carried out, the organic waste comes into contact with the atmosphere rich in O2, allowing the aeration needs of the biological process to be momentarily met.

Greenhouse and Organic Vegetable Garden Beds

A chapel-style greenhouse was built, with dimensions of 19.5 m² in area (6.5x3.5m) and 3.0 m in height, with a wooden structure, with a roof covered with 32 m² of transparent low-density polyvinyl chloride (PVC) film, and the sides were covered with 28 m² of shade cloth (50%).

10 beds measuring 5.5x1.0m were built. The beds were used to plant vegetables, using the organic compost generated, thus closing the cycle, with the vegetable production available for the school restaurant. In addition to the socio-educational, economic and ecological bias and, in some cases, even generating income.

Revista ARACÊ
ISSN: 2358-2472

QUALITY OF THE ORGANIC COMPOUND GENERATED BY STRONG

At the end of the process, the organic compound generated was later sent to the Soil Chemistry Laboratory - LABQSOL of the Maranhão State University - UEMA, for analysis of the attributes present in the organic compound, according to the methods of the Brazilian Agricultural Research Corporation - EMBRAPA. The chemical parameters analyzed are: Organic Matter (OM); Hydrogen Potential (pH); Aluminum (Al); Phosphorus (P); Potassium (K); Calcium (Ca); Magnesium (Mg); and Sodium (Na).

RESULTS AND DISCUSSIONS

QUANTIFICATION OF ORGANIC WASTE

During the periods from 11/14/2022 to 12/02/2022 and 04/24/2023 to 06/23/2023, approximately 43,215 meals were served in the school restaurant, which generated 2064.33 kg of organic waste, which were taken for treatment at STROC, then added 451.27 kg of animal feces, 561.78 kg of vegetable prunings and wood shavings, totaling 3074.35 kg of waste treated at STROC. At the end of the research, 1410.89 kg of organic compost were produced. Table 2 below shows the daily quantification of waste generated in the school restaurant, as well as the approximate number of daily meals and daily waste generation per capita.

Table 2 – Daily Quantification of Waste Generated in the School Restaurant

Week	Date (Monday)	Approximate Number of Meals	Meal Mass (kg)	Food Preparation Waste (kg)	Post-Meal Waste (kg)	Total Waste Generated (kg)	Daily Waste Generation per Capita (g/person/day)
1	14/11/22	-	-	-	-	-	-
2	21/11/22	750	450.00	5.15	12.08	17.23	22.97
3	28/11/22	556	333.60	4.32	16.03	20.35	36.60
4	24/04/23	630	378.00	3.56	13.85	17.41	27.63
5	01/05/23	-	-	-	-	-	-
6	08/05/23	862	517.20	9.72	36.78	46.50	53.94
7	15/05/23	835	501.00	12.57	37.63	50.20	60.12
8	22/05/23	696	417.60	9.81	25.34	35.15	50.50
9	29/05/23	894	536.40	14.68	53.55	68.23	76.32
10	05/06/23	763	457.80	8.37	21.88	30.25	39.65
11	12/06/23	926	555.60	10.48	40.24	50.72	54.77
12	19/06/23	1100	660.00	25.63	61.38	87.01	79.10
Total		8012.00	4807.20	104.29	318.76	423.05	501.62
Minimum		556.00	333.60	3.56	12.08	17.23	22.97
Average		801.20	480.72	10.43	31.88	42.31	50.16
Maximum		1100.00	660.00	25.63	61.38	87.01	79.10
Standard Deviation		157.37	94.42	6.42	16.92	22.97	18.85

Revista ARACÊ
ISSN: 2358-2472

Table 3 – General Quantification of Waste Generated in the School Restaurant

Overall Result	Approximate Number of Meals	Meal Mass (kg)	Food Preparation Waste (kg)	Post-Meal Waste (kg)	Total Waste Generated (kg)	Waste Generation per Capita (g/person)
Total Overall	43215.00	25929.00	677.98	1386.35	2064.33	2554.12
Minimum Overall	556.00	333.60	3.54	9.23	13.58	15.96
Average Overall	785.99	471.59	12.26	25.36	37.61	46.48
Maximum	1100.00	660.00	31.20	61.38	89.18	88.29
Standard Deviation Overall	123.02	73.81	6.53	12.65	18.24	17.21
Variation Coefficient Overall (%)	15.65	15.65	53.27	49.89	48.51	37.03

It can be seen in Tables 2 and 3 that during the execution of the research, 43,215 meals were served in 55 days to students, teachers, and technical-administrative staff, with a daily minimum of 556 meals and a maximum of 1,100, with an average of 785.99 (standard deviation = 123.02) and a coefficient of variation equal to 15.65%. It was observed that on Wednesdays the number of meals was highest (9,443) and on Mondays the lowest (8,012). A total of 25,929 kg of food was distributed, where the average daily meal mass during the research period was 471.59 kg (standard deviation = 73.81 kg) and a coefficient of variation equal to 15.65%, with a daily minimum of 333.60 kg and a maximum of 660.00 kg.

The total amount of food preparation waste was 677.98 kg, where the daily average during the research period was 12.26 kg (standard deviation = 6.53 kg) and a coefficient of variation equal to 53.27%, with a daily minimum of 3.54 kg and a maximum of 31.20 kg.

Total food waste (residue after meals) was 1,386.35 kg and remained daily between 9.23 kg and 61.38 kg, with an average of 25.36 g (standard deviation = 12.65 g) and a coefficient of variation of 49.89%. According to data provided by the school restaurant, the per capita quantity served per meal is approximately 600 g, this value corroborates the study carried out by Zanini et al. (2013), at the University Restaurant of UFSM, which presented an average weight of 600 g. A study carried out at the University Restaurant of Ceará found an average weight of 665 g (RICARTE et al., 2008). During the research period, 2064.33 kg of waste were generated, with a daily minimum of 13.58 kg and a daily maximum of 89.18 kg, with a daily average of 37.61 kg (standard deviation = 18.24 kg) and a coefficient of variation of 48.51%.

Revista ARACÊ
ISSN: 2358-2472

The total per capita waste generation was 2554.12 g/person, where the daily average of this waste generation during the research period was 46.48 g/person x day (standard deviation = 17.21 g/person x day) and a coefficient of variation of 37.03%, with a daily minimum of 15.96 g/person x day and a maximum of 88.29 g/person x day. Similar results were observed in studies carried out by Zanini et al. (2013), at the University Restaurant of the Federal University of Santa Maria, and in a study carried out at the Agricultural College of Guarapuava, in Paraná (MOURA et al., 2010), which showed a variation of 30 to 200 g/person x days, with an average of 60 g/person x day; Another study that presents results that reinforce the research was carried out at a metallurgical company, in Piracicaba, SP, the values ranged from 40 to 90 g/person x days (AUGUSTINI et al., 2008).

Another study carried out at the University Restaurant of UFSM, in 2001, observed that the per capita remainder was 80.87 g/person x days, before the implementation of a waste awareness campaign called “Zero Remains”, reduced to 41.88 g/person x days in subsequent years (ZIMMERMANN; MESQUITA, 2011). Lack of awareness of the cause of waste generation and food waste, the quality of preparation, the temperature of the meal served and food preferences are some factors that can interfere with and hinder the reduction of waste (ZANINI et al., 2013). Table 4 below presents the consolidated data on the waste generated weekly. Where the average weekly generation was 171.78 kg, with a standard deviation of 84.04 kg and a coefficient of variation of 48.93%. The minimum value found was 80.23 kg and the maximum was 371.09 kg.

Table 4 – Weekly Quantification of Waste Generated in the School Restaurant

Week	Period	Waste Generated (kg)	Daily Average Waste (kg)	Number of Meals	Daily Average Meals	Meal Mass (kg)	Food Preparation Waste (kg)	Post-Meal Waste (kg)	Per Capita Waste Generation (g/person/week)	Daily Per Capita Waste Generation (g/person/day)
1	14 to 18/11/22	118.15	39.38	2193	731.00	1315.80	36.15	82.00	161.51	53.84
2	21 to 25/11/22	80.23	16.05	3634	726.80	2180.40	23.94	56.29	111.16	22.23
3	28/11/22 to 02/12/22	103.21	20.64	3203	640.60	1921.80	36.15	67.06	161.45	32.29

Revista ARACÊ
ISSN: 2358-2472

4	24 to 28/04/23	185.76	37.15	3661	732.20	2196.60	66.27	119.49	248.68	49.74
5	01 to 05/05/23	114.87	28.72	2873	718.25	1723.80	42.83	72.04	159.93	39.98
6	08 to 12/05/23	194.64	38.93	3899	779.80	2339.40	67.88	126.76	250.46	50.09
7	15 to 19/05/23	163.15	32.63	3713	742.60	2227.80	48.41	114.74	214.78	42.96
8	22 to 26/05/23	152.27	30.45	3889	777.80	2333.40	56.55	95.72	200.43	40.09
9	29/05/23 to 02/06/23	267.52	53.50	4323	864.60	2593.80	86.60	180.92	309.85	61.97
10	05 to 09/06/23	92.42	30.81	2077	692.33	1246.20	26.28	66.14	133.56	44.52
11	12 to 16/06/23	218.04	43.61	4757	951.40	2854.20	65.18	152.86	229.23	45.85
12	19 to 23/06/23	374.09	74.82	4993	998.60	2995.80	121.74	252.35	373.08	74.62
Total		2064.33	446.69	43215	9355.98	25929	677.98	1386.35	2554.12	558.16
Min.		172.03	37.22	3601	779.67	2160.75	56.50	115.53	212.84	46.51
Mean		80.23	16.05	2077	640.60	1246.20	23.94	56.29	111.16	22.23
Max.		374.09	74.82	4993	998.60	2995.80	121.74	252.35	373.08	74.62
Standard Deviation		84.69	15.46	903.41	106.25	542.05	27.82	57.40	75.63	13.48
Variation Coefficient (%)		49.23	41.54	25.09	13.63	25.09	49.25	49.68	35.53	28.98
Monthly Average		688.11	148.90	14405	3118.66	8643	225.99	462.12	851.37	186.05
Annual Average		6192.99	1340.06	129645	28067.9	77787	2033.94	4159.06	7662.36	1674.49

From Table 4 above, it is possible to estimate the monthly average of waste generated, which is approximately 688.11 kg, while the monthly average of meals distributed is 14,405, and the monthly per capita waste generation is 851.37

Revista ARACÊ
ISSN: 2358-2472

g/person/month. Finally, it is estimated that the annual average of waste, considering only 9 months of school activities, since the other months are vacations, is 6,192.99 kg.

IDENTIFICATION OF ORGANIC WASTE

The food was identified by cross-referencing information collected at the restaurant (menu) with the waste sorting at the time of weighing. The varied distribution of food over the 55 days can influence the quality of the organic compost generated. According to Campbell (1995), the greater the variety of materials the compost is made from, the greater the variety of nutrients it can supply to plants, and these nutrients are so beneficial that they are released as the plants need them.

CONSTRUCTION OF THE STRONG

The construction of the STROC was carried out by assembling 09 composting windrow bays; 10 vegetable beds and 01 greenhouse.

Composting windrow bays and windrows

The windrows were assembled at 1 m in height. According to Pereira (2010), the dimensions of the windrow can affect the retention of heat inside it, since in a small windrow up to 1 m in height, the heat generated by the microbial activity of degradation of organic matter is dissipated more easily, due to the greater surface area in contact with the environment, accelerating the heat exchange processes. On the other hand, according to Pereira Neto (1987) and BRITO (2008), very large composting piles or windrows, i.e., 2.5 to 3 m high, tend to harm microbial activity due to temperatures that are too high for microorganisms, as well as their compaction, due to their weight, which makes aeration difficult. The ideal size and shape to maintain the windrow temperature and allow aeration may vary. However, the volume of 1.5 m x 1.5 m x 1.5 m is considered by Brito (2008) as good for different types of waste.

The method used in composting was the turned windrow, known as the windrow system, which is considered simple to operate, low cost, and can be used in the treatment of the most varied organic waste. In this system, the waste pile is placed under the waterproofed or compacted soil, and the material is turned over manually or mechanically (MASSAKUDO, 2008). Table 5 below shows the schedule for assembling the windrows, which was prepared with the aim of assembling 16 windrows at the end of the cycle.

However, during the execution stage, only 12 windrows were built due to the student vacation period. The period determined for each windrow cycle was 120 days for composting the waste. Normally, the composting time, including the degradation and maturation phases, is 120 to 130 days (TEIXEIRA et. al., 2004). It is worth mentioning that the STROC was designed with 9 bays, where the first 3 windrows were processed from November 2022 to March 2023, and the others from March to October 2023, without the need to build 12 bays.

After the completion of the 12 windrows, their respective materials were sent to the STROC organic garden and donated to the surrounding community..

Table 5 – Pile Assembly Schedule

Week	Pile	Waste Collection Period	Pile Assembly Date	Estimated Completion Date	Completion Deadline (days)	Final Completion Date
1	1	14 to 18/11/22	19/11/2022	19/03/2023	120	19/03/2023
2	2	21 to 25/11/22	26/11/2022	26/03/2023	120	26/03/2023
3	3	28/11/22 to 02/12/22	03/12/2022	02/04/2023	120	02/04/2023
4	4	24 to 28/04/23	29/04/2023	27/08/2023	120	27/08/2023
5	5	01 to 05/05/23	06/05/2023	03/09/2023	120	03/09/2023
6	6	08 to 12/05/23	13/05/2023	10/09/2023	120	10/09/2023
7	7	15 to 19/05/23	20/05/2023	17/09/2023	120	17/09/2023
8	8	22 to 26/05/23	27/05/2023	24/09/2023	120	24/09/2023
9	9	29/05/23 to 02/06/23	03/06/2023	01/10/2023	120	01/10/2023
10	10	05 to 09/06/23	10/06/2023	08/10/2023	120	08/10/2023
11	11	12 to 16/06/23	17/06/2023	15/10/2023	120	15/10/2023
12	12	19 to 23/06/23	24/06/2023	22/10/2023	120	22/10/2023

It can be seen in Table 6 that food waste is composed of: meal waste (C/N=15:1) and FV waste (C/N=30:1). This C/N ratio of meal waste was based on a similar study by Aquino et al. (2005), carried out in a University Restaurant at UFRRJ, while the C/N ratio of FV waste was based on the study by Alencar et al. (2012). The C/N ratio of food waste was calculated using the formula 1.

Revista ARACÊ
ISSN: 2358-2472

Table 6 – Distribution of Nitrogen Source (Food Waste) and C/N Ratios

Pile	Meal Waste (kg)	C/N Ratio of Meal Waste	FLV Waste (kg)	C/N Ratio of FLV Waste	Total Food Waste (kg)	Meal Waste / Total Food Waste Ratio (%)	FLV Waste / Total Food Waste Ratio (%)	Meal Waste / Total Mass (%)	FLV / Total Mass (%)	Food Waste / Total Mass (%)	C/N Food Waste
1	95.23	15:1	22.92	30:1	118.15	80.60 %	19.40 %	44.93 %	10.81 %	55.74 %	17.9:1
2	63.56	15:1	16.67	30:1	80.23	79.22 %	20.78 %	47.60 %	12.49 %	60.09 %	18.1:1
3	86.45	15:1	16.76	30:1	103.21	83.76 %	16.24 %	52.51 %	10.18 %	62.69 %	17.4:1
4	142.23	15:1	43.53	30:1	185.76	76.57 %	23.43 %	41.07 %	12.57 %	53.64 %	18.5:1
5	86.25	15:1	28.61	30:1	114.87	75.09 %	24.91 %	38.16 %	12.66 %	50.82 %	18.7:1
6	168.25	15:1	26.37	30:1	194.62	86.45 %	13.55 %	58.40 %	9.15%	67.55 %	17:1
7	143.28	15:1	19.86	30:1	163.14	87.82 %	12.18 %	62.88 %	8.72%	71.59 %	16.8:1
8	139.13	15:1	13.13	30:1	152.26	91.38 %	8.62%	64.90 %	6.12%	71.03 %	16.3:1
9	211.89	15:1	55.62	30:1	267.51	79.21 %	20.79 %	59.36 %	15.58 %	74.95 %	18.12:1
10	81.23	15:1	11.19	30:1	92.42	87.89 %	12.11 %	59.49 %	8.20%	67.68 %	16.82:1
11	185.56	15:1	32.47	30:1	218.03	85.11 %	14.89 %	64.20 %	11.23 %	75.43 %	17.23:1
12	305.78	15:1	68.30	30:1	374.08	82.40 %	17.60 %	63.84 %	13.63 %	77.47 %	17.64:1
Total	1708.85	-	355.43	-	2064.33	-	-	-	-	-	-

A C/N ratio for meal residue was also found close to the value used, such as in the research carried out by Inácio (2010), at the Rio de Janeiro International Airport Restaurant, which obtained a C/N ratio = 13.12: 1 and in a research carried out by Nascimento (2022), at the IFES University Restaurant, which obtained a C/N ratio = 12: 1. While the C/N ratio for FLV residue was 25: 1, according to Adhikari et al., (2013) and 40: 1 according to Richard et al., 2005..

Table 7 – Distribution of Biocatalyst and Nitrogen Source (Feces) and their C/N Ratios

Pile	Type of Biocatalyst	Horse Feces (kg)	Cattle Feces (kg)	Goat and Sheep Feces (kg)	Rodent Feces (kg)	Total Biocatalyst (kg)	Biocatalyst / Total Mass Ratio (%)	C/N Biocatalyst Total
1	Horse	42.56	0.00	0.00	0.00	42.56	20.08%	30:1
2	Horse	22.53	0.00	0.00	0.00	22.53	16.87%	30:1
3	Horse	19.45	0.00	0.00	0.00	19.45	11.81%	30:1
4	Cattle	0.00	51.16	0.00	0.00	51.16	14.77%	20.13:1
5	Cattle	0.00	58.43	0.00	0.00	58.43	25.85%	20.13:1
6	Goat	0.00	0.00	23.07	0.00	23.07	8.01%	17.1:1
7	Goat and Rodent	0.00	0.00	25.00	13.50	38.50	16.89%	23.59:1
8	Goat and Rodent	0.00	0.00	25.00	13.50	38.50	17.96%	23.59:1
9	Goat, Cattle, Rodent	0.00	4.00	40.00	2.75	46.75	13.10%	18.45:1
10	Goat	0.00	0.00	25.00	0.00	25.00	18.31%	17.1:1
11	Goat	0.00	0.00	40.42	0.00	40.42	13.98%	17.1:1
12	Cattle and Rodent	0.00	20.00	0.00	24.90	44.90	9.37%	28.71:1
Total	84.54	133.59	178.49	54.65	451.27	-		

Table 7 shows that the biocatalyst source was divided into: horse feces, C/N=30:1 (RICHARD et al., 2005); cattle feces, C/N=20.13:1 (BATTISTI & BATTISTI, 2011), goat and sheep feces, C/N=17.1:1 (AMORIM, 2002) and rodent feces, C/N=35.6:1 (PULLOPAXI CIFUENTES, 2019). For the windrows where more than one type of biocatalyst was used, the C/N ratio was calculated using formula 1. A C/N ratio for the biocatalyst source was also found close to the values used, as shown in Table 7, above.

Table 8 – Distribution of Carbon Source and Their Respective C/N Ratios

Pile	Carbon Source Type	Tree Pruning (kg)	Sawdust (kg)	Dry Leaves (kg)	Sugar Cane (kg)	Rice Husk (kg)	Total Carbon Source (kg)	Carbon Source / Total Mass Ratio (%)	C/N Carbon Source Total
1	Tree Pruning	26.11	0.00	0.00	0.00	0.00	26.11	12.68%	40:1
2	Tree Pruning	17.92	0.00	0.00	0.00	0.00	17.92	11.64%	40:1
3	Tree Pruning	12.87	0.00	0.00	0.00	0.00	12.87	7.82%	40:1
4	Rice Husk	0.00	0.00	0.00	61.23	0.00	61.23	17.42%	20:1
5	Rice Husk	0.00	0.00	0.00	79.69	0.00	79.69	34.59%	20:1
6	Rice Husk	0.00	0.00	0.00	116.07	0.00	116.07	40.02%	20:1
7	Rice Husk	0.00	0.00	0.00	150.00	0.00	150.00	40.34%	20:1

Revista ARACÊ
ISSN: 2358-2472

8	Rice Husk	0.00	0.00	0.00	150.00	0.00	150.00	42.27%	20:1
9	Rice Husk	0.00	0.00	0.00	182.25	0.00	182.25	53.33%	20:1
10	Rice Husk	0.00	0.00	0.00	122.06	0.00	122.06	39.69%	20:1
11	Rice Husk	0.00	0.00	0.00	138.39	0.00	138.39	46.91%	20:1
12	Rice Husk	0.00	0.00	0.00	170.00	0.00	170.00	37.61%	20:1
Total	-	57.90	0.00	0.00	1074.65	0.00	1132.55	-	-

Table 8 shows that the carbon source was divided into: Tree pruning, C/N=35.52:1 (BATTISTI & BATTISTI, 2011); Grass pruning, C/N=37.73:1 (BENITES, 2004), Pine shavings, C/N=107.4:1 (MAIA et al., 2003) and Mixed shavings, C/N=240:1 (NASCIMENTO, 2022). For windrows where more than one type of carbon source was used, the C/N ratio was calculated using formula 01. A C/N ratio for carbon source was also found close to the values used, as shown in Table 8 above.

Table 9 – Estimated Nutrient Distribution in Different Piles (N, C, and P)

Pile	Nitrogen in Food Waste (kg)	Nitrogen in Biocatalyst (kg)	Nitrogen in Carbon Source (kg)	Total Nitrogen (kg)	Carbon in Food Waste (kg)	Carbon in Biocatalyst (kg)	Carbon in Carbon Source (kg)	Total Carbon (kg)	Phosphorus in Food Waste (kg)	Phosphorus in Biocatalyst (kg)	Phosphorus in Carbon Source (kg)	Total Phosphorus (kg)
1	5.88	1.42	0.65	7.95	29.57	1.06	0.00	30.63	0.04	0.00	0.00	0.04
2	3.73	0.84	0.42	4.99	18.77	0.72	0.00	19.49	0.03	0.00	0.00	0.03
3	5.08	0.79	0.47	6.34	12.25	0.58	0.00	12.83	0.04	0.00	0.00	0.04
4	9.22	1.57	0.99	11.78	51.99	2.71	0.00	54.70	0.07	0.00	0.00	0.07
5	5.43	1.12	0.64	7.19	79.63	3.65	0.00	83.28	0.04	0.00	0.00	0.04
6	10.14	1.46	0.87	12.47	111.84	5.12	0.00	116.96	0.08	0.00	0.00	0.08
7	8.94	1.38	0.82	11.14	149.83	6.02	0.00	155.85	0.07	0.00	0.00	0.07
8	8.75	1.31	0.80	10.86	149.96	6.02	0.00	156.00	0.07	0.00	0.00	0.07
9	13.33	2.02	1.23	16.58	182.44	7.83	0.00	190.27	0.10	0.00	0.00	0.10
10	5.05	0.95	0.61	6.61	121.35	4.91	0.00	126.26	0.04	0.00	0.00	0.04
11	10.59	1.71	1.04	13.34	137.97	5.79	0.00	143.76	0.09	0.00	0.00	0.09
12	16.49	2.54	1.53	20.56	170.65	7.65	0.00	178.30	0.12	0.00	0.00	0.12

Revista ARACÊ
ISSN: 2358-2472

To tal	99.6 0	14.40	8.86	123. 87	1077 .53	43.88	0.00	1121 .41	0.71	0.00	0.00	0.71

Table 9, above, describes the proportion of waste in the windrows and their respective C/N ratios, where the C/N ratio of the windrows was calculated using formula 1, and the values of the carbon/nitrogen ratio were collected from research in the area, as shown in Table 1.

To start the composting process, the ideal C/N ratio should be between 25/1 and 35/1 (KIEHL, 2004). Thomsen (2000) states that, according to the requirements of microorganisms, composting should have an initial C/N ratio between 30/1 and 40/1. However, as the great challenge of solid waste management is the disposal of nitrogen-rich waste, researchers seek to obtain good performance in the process by creating windrows with a lower initial C/N ratio (HECK et al., 2013; SBIZARRO et al., 2017; ANDRADE et al., 2017). A C/N ratio above 50/1 indicates nitrogen deficiency and results in prolonged ripening time. If the C/N ratio is below 10/1, nitrogen may be lost through volatilization in the form of ammonia (KIEHL, 2004; BARREIRA, 2005).

In a study conducted by Inácio (2010), with 16 windrows of 32,000 kg each, totaling 518,400 kg, and dimensions of 16.0 m x 1.2 m and 0.8 m to 1.2 m in height, the C/N value = 26.05:1. While Silva (2016) in research with 6 piles of 50 kg each, totaling 300 kg, the C/N value = 31.3:1. Alencar et al. (2012), with 9 piles of 730 kg each, totaling 6570 kg, and dimensions of 1.0m x 1.0m and 1.5m high, the value of C/N=25:1.

Organic vegetable garden beds and greenhouse

10 beds and 1 chapel-style greenhouse were built and part of the organic compost generated for planting vegetables was added to them. According to Cavalcante (2008), greenhouse cultivation ensures greater stability in production, which is a fundamental condition for maintaining constant productivity and profitability in the long term.

QUALITY OF ORGANIC COMPOST

After the completion of the 12 rows, their materials were chemically analyzed and their results are presented in table 10 below.:

Revista ARACÊ
ISSN: 2358-2472

Table 10 – Quality of the Finalized Compounds

Pile	Organic Compound Produced (kg)	Organic Compound / Total Mass Ratio (%)	OM (g/dm³)	pH (CaCl2)	P (mg/dm³)	K (mmol/dm³)	Ca (mmol/dm³)	Mg (mmol/dm³)	Na (mmol/dm³)	SB (mmol/dm³)	Al (mmol/dm³)	CTC (mmol/dm³)	V (%)
1	113.34	53.47	80	6.8	333.8	4.9	71	21	7.8	104.7	0	135.7	77.2
2	54.56	40.86	54	6.9	170	3.7	67	27	6.3	104	0	119	87.4
3	87.53	53.16	60	6	424.4	3.2	66	26	4.6	99.8	0	120.8	82.6
4	143.26	41.37	70	6.2	835	6.5	50	55	9.8	121.3	0	135.7	89.4
5	135.27	59.84	86	6.3	597	6.5	59	49	9.3	123.7	0	135.9	91
6	133.46	46.32	86	6.7	475	9.4	75	32	12.4	128.8	0	139.8	92.2
7	113.25	49.7	86	6.3	662	6.4	67	45	9.1	127.5	0	150.6	84.6
8	106.9	49.86	112	6.7	661	7.2	56	57	9.3	129.5	0	151.7	85.4
9	151.07	42.32	111	6.2	817	7.1	50	51	9.7	117.7	0	135.5	88.1
10	61.34	44.92	95	6	501	10.3	43	54	12.4	119.7	0	138.8	86.2
11	115.74	40.04	67	6.5	229	6.5	21	17	9.8	54.3	0	73.3	74.1
12	195.19	40.76	79	6.9	938	12.4	64	28	13.9	118.3	0	158.3	74.7
Min	54.56	40.04	54	6	170	3.2	21	17	4.6	54.3	0	73.3	74.1
Avg	117.58	46.89	82.17	6.46	553.60	7.01	57.42	38.50	9.53	112.4	0	132.9	84.4
Max	195.19	59.84	112	6.9	938	12.4	75	57	13.9	129.5	0	158.3	92.2
Std Dev	38.80	6.35	18.11	0.33	242.70	2.64	14.90	14.69	2.59	20.8	0	21.99	6.12

Coefficient of Variation (%)	33.00	13.54	22.04	5.18	43.84	37.68	25.95	38.15	27.16	18.5	0	16.54	7.25

It can be seen in Table 10 that the amount of organic compost generated was 1410.91 kg, with a minimum of 54.56 kg, a maximum of 195.19 kg, an average of 117.58 kg (standard deviation = 38.80) and a coefficient of variation equal to 22.04%. The ratio of organic compost generated to total mass is between 40.04% and 59.84%, with an average of 46.89% (standard deviation = 18.11 kg) and a coefficient of variation equal to 22.04%. According to Massukado (2008), composting is one of the alternatives for treating organic waste, as it can reduce its volume by more than 60%, producing at the end of the process a stable material that can be used as a soil conditioner or even act as a fertilizer. The organic matter content is between 54 and 112 g/dm³, with an average of 82.17 g/dm³ (standard deviation = 18.11 kg) and a coefficient of variation equal to 22.04%, which corroborates the values found by Garcia et al. (2020) and Gerude Neto et al. (2023), respectively 94 g/dm³ and 139 g/dm³. The organic matter available in the soil contributes to the retention of colloids, due to the amount of negative charges, which attract exchangeable cations to their surface, thus improving the water retention capacity of the compost (TAVARES FILHO, 2016). The observed pH is in the range of 6.0 to 6.9, with an average of 6.46 CaCl2 (standard deviation = 0.33) and a coefficient of variation equal to 5.18, which is in line with the values found by Cotta et al. (2015), which varied between 6.9 and 8.9. According to Kiehl (2002), a compound is considered mature when the pH is above 6.0. For Pereira Neto (2007), the ideal pH of the material should be neutral. According to Albanell et al. (1988, cited by Cotta, 2015), the variation in pH can be attributed to the production of organic acids and CO_2 by microorganisms. The phosphorus found is in the range of 170.0 and 938 mg/dm³, with an average of 553.60 mg/dm³ (standard deviation = 242.70) and a coefficient of variation equal to 43.84, which corroborates the values found by Aguiar et al (2022) and Magalhães et al (2022), respectively 382.0 and 261.0 mg/dm³. According to Duarte et al. (2017), phosphorus is the macronutrient that is absorbed in smaller quantities compared to the others, however, its presence in the soil is essential for plant growth and production. According to Heinrichs and Soares Filho (2014), it contributes to the premature growth of roots, quality of fruits, vegetables, grains and seed formation. The potassium found is in the range of 3.2 and 12.4

Revista ARACÊ
ISSN: 2358-2472

mmol/dm³, with an average of 7.01 mmol/dm³ (standard deviation = 2.64) and a coefficient of variation equal to 37.68, which corroborates the values found by Gerude Neto et al. (2023) and Garcia et al. (2020), respectively 4.1 and 18.1 mmol/dm³. According to Malavolta (1997), potassium stimulates vegetation and tillering, and its deficiency causes chlorosis followed by necrosis of the margins of old leaves, decreased apical dormancy, iron deficiency, loss of cambial activity, among others. The calcium found is in the range of 21.0 and 75.0 mmol/dm³, with an average of 57.42 mmol/dm³ (standard deviation = 14.90) and a coefficient of variation equal to 25.95, which corroborates the values found by Garcia et al (2022) and Vitor et al (2022), respectively 65.0 and 80.0 mmol/dm³. According to Silva and Costa (2022), calcium is essential for soil quality, as it plays a crucial role in soil structuring, contributing to particle aggregation and improved drainage. The manganese found is in the range of 17 and 28.8 mmol/dm³, with an average of 38.50 mmol/dm³ (standard deviation = 14.69) and a coefficient of variation equal to 38.15, which corroborates the values found by Vitor et al (2022) and Magalhães et al (2022), respectively 45.0 and 49.0 mmol/dm³. According to Milaleo et al (2010), Manganese is an essential element in plant metabolism, playing crucial roles, mainly in photosynthesis and acting as an enzymatic antioxidant cofactor; however, its function can vary between being a vital nutrient or a toxic element, depending on the concentrations present in plant tissues. The sodium found is in the range of 4.6 and 13.9 mmol/dm³, with an average of 9.53 mmol/dm³ (standard deviation = 2.59) and a coefficient of variation equal to 27.16, which corroborates the values found by Gerude Neto et al. (2023) and Garcia et al. (2020), respectively 7.4 and 28.8 mmol/dm³. According to Girard et al. (2009), sodium can significantly influence soil fertility by negatively affecting its structure and cation exchange capacity, increasing the risk of salinization in soils with a high concentration of this element, which compromises plant health and agricultural productivity; therefore, adequate management of salinity and the adoption of practices that reduce sodium concentration are essential to maintain soil quality. The Sum of Bases (BS) found is in the range of 54.3 and 129.5 mmol/dm³, with an average of 112.34 mmol/dm³ (standard deviation=20.84) and a coefficient of variation equal to 18.53, which corroborates values in found by Gerude Neto et al. (2023) and Garcia et al. (2020), respectively 186.53 and 163.9 mmol/dm³. According to Malavolta (2006), the sum of bases (SB) is a crucial parameter in the assessment of soil fertility, representing the total concentration of exchangeable basic cations, including calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+) and sodium (Na^+), these cations are essential for plant development, contributing directly to soil structure, water retention and nutrient availability. According to Raij et al (2021), soils with high SB tend to be more fertile, as they have a greater amount of nutrients available to plants. On the other hand, a low sum of bases may indicate the need for soil correction, such as the application of limestone, to increase the availability of essential cations (SOUSA & LOBATO, 2004). No values were found for aluminum in the 12 windrows. According to Oliveira (2018), although aluminum is often considered a toxic element for many plants, its presence in the soil plays a crucial role in the interaction with other nutrients and in the formation of complexes that can affect the availability of essential elements for plant growth.

The CEC found is in the range of 73.3 and 158.3 mmol/dm³, with an average of 132.93 mmol/dm³ (standard deviation = 21.99) and a coefficient of variation equal to 16.54, which corroborates the values found by Vitor et al (2022) and Magalhães et al (2022), respectively 155.3 and 157.1 mmol/dm³. The cation exchange capacity (CEC) is a fundamental indicator of soil fertility, as it reflects the soil's ability to retain and make available cations essential for plant growth, such as calcium, magnesium, and potassium. Soils with low CEC have a lower capacity to retain these nutrients, which can lead to nutritional deficiencies in plants and negatively affect crop yield (SANTOS et al., 2020).

The base saturation found is in the range of 77.2 and 158.3 mmol/dm³, which corroborates values found by Garcia et al (2022) and Magalhães et al (2022), respectively 86.8 and 91.0 mmol/dm³. Base saturation is an excellent indicator of general soil fertility conditions, and is even used as a complement in soil nomenclature (EMBRAPA, 2010).

The organic compost generated by STROC was used in the Organic Garden beds, improving the soil and increasing vegetable production for the school cafeteria. Part of the compost was sold in the community, generating resources for the maintenance of STROC. In addition, the system functioned as a practical laboratory for environmental education, involving participants in activities on organic waste management and vegetable cultivation.

According to Lima et al. (2008), the organic compost at the end of the process has relevant nutritional characteristics and can be used to fertilize the soil, favoring organic horticulture, gardening and even improving income generation for practitioners.

FINAL CONSIDERATIONS

Considering the results, the organic waste generated in the school restaurant, when treated correctly, generates a value-added product that can be used to recover degraded

Revista ARACÊ
ISSN: 2358-2472

areas, produce food, and contribute to socio-environmental issues in the surrounding communities. It is also worth noting that STROC was also used as an environmental education laboratory, in which students, teachers and the surrounding community had the opportunity to be made aware of the issues of organic waste.

In order to be optimized, the composting process requires monitoring and control of intervening parameters, such as humidity, temperature, pH and oxygenation. Therefore, it is recommended for future work that research be carried out into the implementation of a system that can monitor and control such parameters..

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. ADHIKARI, B. K. et al. Emissões de gases influenciadas pela configuração do sistema de compostagem doméstica. Jornal de gestão ambiental, v. 116, p. 163-171, fev. 2013. Disponível em: https://www.sciencedirect.com/science/article/abs/pii/S0301479712006366. Acesso em: 12 mar. 2023.

2. AGUIAR, M. C.; PINHEIRO, N. C. A.; ARAGÃO, F. M. M.; GOMES, L. B.; ARAUJO, N. A.; NASCIMENTO, B. M.; GERUDE NETO, O. J. A. Compostagem como alternativa para o tratamento do lodo de floculação da estação de tratamento de água. In: PEREIRA, D. R.; NETO, O. J. de A. G. (Orgs). Abordagens multidisciplinares no processo de compostagem. 1ª Ed: Gradus Editora. Bauru, São Paulo, 2022.

3. ALBANELL, E.; PLAIZATS, J.; CABRERO, T. Chemical changes during vermicomposting (Eisenia fetida) of sheep manure mixed with cotton industrial wastes. Biology and Fertility of Soils, v. 6, 1988. p. 266-269.

4. ALENCAR, Bertrand Sampaio de; OLIVEIRA, Maria de Fátima G. de; ARAUJO, Roberto Correa de. Avaliação dos resíduos sólidos e da qualidade do composto orgânico produzido no Centro de Abastecimento Alimentar de Pernambuco. XII Safety, Health and Environment World Congress, São Paulo, 2012.

5. AMORIM, Ana Carolina. Caracterização dos dejetos de caprinos: reciclagem energética e de nutrientes. Dissertação de Mestrado. Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, Jaboticabal/SP, 2002.

6. ANDRADE, F. C. et al. Compostagem de resíduos agrícolas. In: DAL BOSCO, T. C. (Org.). Compostagem e vermicompostagem de resíduos sólidos: resultados de pesquisas acadêmicas. São Paulo: Blucher, 2017. p. 135-158.

7. AQUINO, Adriana Maria de; OLIVEIRA, Arlene Maria Gomes; LOUREIRO, Diego Campana. Integrando compostagem e vermicompostagem na reciclagem de resíduos orgânicos domésticos. Circular Técnica, Embrapa, Seropédica/RJ, 2005.

8. AUGUSTINI, V. C. M.; KISHIMOTO, P.; TESCARO, T. C.; ALMEIDA, F. Q. A. Avaliação do índice resto-ingesta e sobras em unidade de alimentação e nutrição (UAN) de uma empresa metalúrgica na cidade de Piracicaba/SP. Rev. Simbio-Logias, p. 99-110, 2008; 1(1). Disponível em: http://www.ibb.unesp.br/Home/Departamentos/Educacao/Simbio logias/ARTIGO_07_NUTR_avaliacao_indice_resto-ingesta.pdf. Acesso em: 02 fev. 2023.

9. BARREIRA, L. P. Avaliação das usinas de compostagem do estado de São Paulo em função da qualidade dos compostos e processos de produção. 204f. Tese (Doutorado em Saúde Ambiental) – Universidade de São Paulo, São Paulo, 2005.

10. BATTISTI, Dione Patrícia; BATTISTI, José Fernando. Avaliação da eficiência do uso do esterco bovino e do EM-4 na compostagem de resíduos de poda de árvores do

Revista ARACÊ
ISSN: 2358-2472

município de Medianeira - PR. Monografia. Universidade Tecnológica Federal do Paraná, Medianeira, 2011.

11. BENITES, V. M. et al. Produção de adubos orgânicos a partir da compostagem dos resíduos da manutenção da área gramada do Aeroporto Internacional do Rio de Janeiro. Boletim de Pesquisa e Desenvolvimento, 50. Embrapa Solos, Rio de Janeiro, 2004.

12. BERNAL, M. P.; SANCHEZ-MONEDERO, M. A.; PAREDES, C.; ROIG, A. Carbon mineralization from organic waste at different composting stages during their incubation with soil. Agriculture Ecosystems & Environment, v. 69, 1998. p. 175-189.

13. BNDES. Análise das diversas tecnologias de tratamento e disposição final de resíduos sólidos no Brasil, Europa, Estados Unidos e Japão. Pesquisa científica BNDES FEP, nº. 02/2010, 2013.

14. BRITO, M. J. C. Processo de compostagem de resíduos urbanos em pequena escala e potencial de utilização do composto como substrato. Programa de Pós-Graduação em Engenharia de Processos, Universidade Tiradentes, Aracaju, fev. 2008.

15. CAMPBELL, Stu. Manual de compostagem para hortas e jardins: como aproveitar bem o lixo orgânico doméstico. São Paulo: Nobel, 1995.

16. CAVALCANTE, A. S. da S. Cultivo orgânico de alface em diferentes épocas de plantio, preparo e coberturas de solo. 2008. 66 f. Tese (Mestrado em Agronomia: Produção Vegetal) – Universidade Federal do Acre, Rio Branco, 2008.

17. COSTA, André Pereira da et al. A compostagem como recurso metodológico para o ensino de ciências naturais e geografia no ensino fundamental. Enciclopédia Biosfera, Goiânia, Brasil, vol. 7, ed. n. 12, 15 out. 2011. Disponível em: http://www.conhecer.org.br/enciclop/conbras1/a%20compostagem.pdf. Acesso em: 3 nov. 2023.

18. COTTA, Jussara Aparecida de Oliveira; CARVALHO, Nayhana Lara Chaves; BRUM, Túlio da Silva; REZENDE, Maria Olímpia de Oliveira. Compostagem versus vermicompostagem: comparação das técnicas utilizando resíduos vegetais, esterco bovino e serragem. Engenharia Sanitária e Ambiental (Online), v. 20, 2015. p. 65-78.

19. DUARTE, C. F. D.; PAIVA, L. M.; FERNANDES, H. J.; CASSARO, L. H.; BREURE, M. F.; PROCHERA, D. L.; BISERRA, T. T. Capim-piatã adubado com diferentes fontes de fósforo. Revista Investigação, Aquidauana/MT, 2016. p. 58-63.

20. EMBRAPA. Conceitos de fertilidade do solo e manejo adequado para as regiões tropicais. São Paulo, 2010. 9 p.

21. GARCIA, S. S. R.; Pereira, D. R.; Dutra, M. L. S.; Ribeiro, A. W. P.; Menezes, K. D. C. de; Cruz, R. F.; Gerude Neto, O. J. de A. (2020). Análise comparativa de adubos orgânicos oriundos de diferentes tipos de compostagem. Interfaces Científicas - Saúde e Ambiente, v. 8, n. 2, 2020. p. 115-126.

22. GERUDE NETO, O. J. de A.; MENEZES, K. D. C. de; RIBEIRO, A. W. P.; CRUZ, R. F.; GARCIA, S. S. R.; PEREIRA, D. R.; ROSA, F. C.; GOMES, E. de B.; SILVA, D. F. da; MIRANDA, R. de C. M.. Influence of fibrous material on the composting, with the inclusion of different biocatalysts. Ciência e Natura, Santa Maria, v. 45, e26, 2023. Disponível em: https://doi.org/10.5902/2179460X72317. Acesso em: 3 nov. 2023.

23. GIRARD, J. S. et al. Impacto do sódio na fertilidade do solo e na nutrição das plantas. Soil Science Society of America Journal, v. 83, n. 3, 2019. p. 678-688.

24. GOMES, T. C. A.; SILVA, J. A. M.; SILVA, M. S. L. Preparo de composto orgânico na pequena propriedade rural. Instruções Técnicas da Embrapa Semi-Árido, 53. Petrolina: Embrapa Semi-Árido, 2001.

25. GROSSI, M. G.; VALENTE, J. P. S. Compostagem doméstica de lixo. Botucatu, SP: Fundacentro - Universidade Estadual Paulista - Unesp/Botucatu, 2002.

26. HECK, K. et al. Temperatura de degradação de resíduos em processo de compostagem e qualidade microbiológica do composto final. Revista Brasileira de Engenharia Agrícola e Ambiental, v. 17, n. 1, 2013. p. 54-59.

27. HEINRICHS, R.; SOARES FILHO, C. V. Adubação e manejo de pastagens. Birigui: Boreal, 2014. p. 180.

28. INÁCIO, Caio de Teves. Compostagem de restos de alimentos com aparas de grama e esterco de animais: monitoramento do processo. Circular Técnica, 46. Embrapa Solos, Rio de Janeiro, 2010.

29. KIEHL, Edmar José. Manual de compostagem: maturação e qualidade de composto. EMBRAPA, São Paulo, n. 4, p. 173, 2004. Disponível em: https://limpezapublica.com.br/manual-decompostagem-maturacao-e-qualidade-docomposto/. Acesso em: 27 mar. 2023.

30. KIEHL, J. E. Fertilizantes orgânicos. Piracicaba: Agronômica Ceres, 2005. 492 p.

31. LIMA, Josanidia et al. Rede de cooperação no êxito de iniciativas voltadas para a utilização de composto orgânico na produção de hortaliças por pequenos agricultores em Camaçari-BA. Revista Brasileira de Agroecologia, v. 3, n. 3, p. 47-52, 2008. Disponível em: https://orgprints.org/id/eprint/27470/1/Lima_Rede.pdf. Acesso em: 27 mar. 2023.

32. MAGALHÃES, W. M. A.; SILVA, D. F.; ARAGÃO, F. M. M.; VILAS BÔAS, I. C. C.; ARAUJO, N. A.; PINHEIRO, D. L.; GERUDE NETO, O. J. A.. Casca de mandioca e fibra de coco como fontes alternativas no processo de compostagem. In: PEREIRA, D. R.; NETO, O. J. de A. G. (Orgs). Abordagens multidisciplinares no processo de compostagem. 1ª ed. Bauru: Gradus Editora, São Paulo, 2022.

33. MAIA, C.M.B.F.; MANGRICH, A.S.; BUDZIAK, C.R.; SANTOS, J .C.P.. Compostagem de resíduos florestais: um guia para produção de húmus através de reciclagem e aproveitamento de resíduos floresta. Curitiba: Paraná, 2003.

Revista ARACÊ
ISSN: 2358-2472

34. MALAVOLTA, E. Manual de nutrição mineral de plantas. 1. ed. São Paulo: Agronômica Ceres, 2006.

35. MALAVOLTA, E.; VITTI, G. C.; OLIVEIRA, S. A. Avaliação do estado nutricional das plantas: princípios e aplicações. Piracicaba: Potafós, 1997. 319 p.

36. MASSUKADO, L. M. Desenvolvimento do processo de compostagem em unidade descentralizada e proposta de software livre para o gerenciamento municipal dos resíduos sólidos domiciliares. 182 p. Tese (Doutorado), Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2008.

37. MILLALEO, R.; REYES-DÍAZ, M.; IVANOV, A. G.; MORA, M. L.; ALBERDI, M. Manganese as essential and toxic element for plants: transport, accumulation and resistance mechanisms. Journal of Soil Science and Plant Nutrition, v. 10, n. 4, 2010. p. 470-481.

38. MMA. Ministério do Meio Ambiente. Manual para implantação de compostagem e de coleta seletiva no âmbito de consórcios públicos, 2001.

39. MOURA, P. N.; HONAISER, A.; BOLOGNINI, M. C. M. Avaliação do índice resto ingestão e sobras em unidade de alimentação e nutrição (UAN) do Colégio Agrícola de Guarapuava (PR). Revista Salus-Guarapuava (PR). V. 3(10): p. 15-22. 2009. Disponível em: http://revistas.unicentro.br/index.php/salus/article/viewFile/702/1158. Acesso em 02 dez. 2023.

40. NASCIMENTO, Wilker Marcolino. Avaliação do papel e do papelão como fontes alternativas de carbono na compostagem doméstica. Monografia, Instituto Federal do Espírito Santo, 2022.

41. OLIVEIRA, J. R. A. A importância do alumínio no solo e seus efeitos na fertilidade. Editora AgroEdit, 2021.

42. PAIVA, E. C. R. Variáveis de projeto, operação de sistemas de leiras estáticas aeradas e qualidade do composto produzido com carcaças de aves mortas. Tese (Doutorado em Engenharia Agrícola) – Universidade Federal de Viçosa, Viçosa, 2011. 112 p.

43. PEREIRA NETO, J. T. Manual de compostagem: processo de baixo custo. 1. ed. Viçosa: UFV, 2007.

44. PEREIRA NETO, J. T. On the treatment of municipal refuse and sewage sludge using aerated static pile composting - A low cost technology approach. University of Leeds, Leeds, 1987. 272 p.

45. PEREIRA, Débora Corrêa de Mello Santos. Compostagem pelo método de aeração passiva: uma solução sustentável para resíduos orgânicos da indústria de celulose e papel. 2010. 90 f. Dissertação (Mestrado) – Universidade de Taubaté, Programa de Pós-Graduação em Ciências Ambientais, 2010.

46. PULLOPAXI CIFUENTES, Antony Javier. Tratamiento de residuos orgánicos generados

en el Bioterio de la Facultad de Ciencias de la Escuela Superior Politécnica de Chimborazo mediante compostaje. Escuela Superior Politécnica de Chimborazo, Riobamba, 2019.

47. RAIJ, B. van; CANTARELLA, H.; QUAGGIO, J. A.; FURLANI, A. M. C. Recomendações de adubação e calagem para o estado de São Paulo. (Boletim técnico, 100). 2. ed. Campinas: Instituto Agronômico, 2001. 285 p.

48. Ricarte, M.P.R., Fé M.A.B.M., Santos I.H.V.S., Lopes A.K.M. Avaliação do desperdício alimentar produzido por comensais em restaurante universitário no sul do Brasil por meio de gráficos de controle. Latin American Journal of Business Management, v. 8, n. 2, 2013. p. 118-133.

49. RICHARD T.; TRAUTMANN N.; KRASNY M., FREDENBURG S.; STUART C. Compost. Universidad de Cornell. 2005. Disponível em: http://compost.css.cornell.edu/science.html. Acesso em: 25 dez. 2023.

50. SANTOS, A. C.; NEVES, J. C. L. A importância da capacidade de troca catiônica para a fertilidade do solo. In: Sistemas de produção e manejo do solo. Editora Agropecuária, 2020.

51. SBIZARRO, M.; DAL BOSCO, T.C.; PRATES, K.V.M.C.; PRESUMIDO, P.H.; PINTO, A.A.S.; SOUZA, A.V.D. A. Tratamento de dejetos ovinos, bovinos e palha-de-açúcar via vermicompostagem. In: BOSCO, Tatiane Cristina Dal. Compostagem e vermicompostagem de resíduos sólidos: resultados de pesquisas acadêmicas. São Paulo: Blucher, 2017. p. 45-68.

52. SILVA, Alice Sabrina Ferreira da. Avaliação do processo de compostagem com diferentes proporções de resíduos de limpeza urbana e restos de alimentos. Universidade Federal de Pernambuco. (Dissertação de Mestrado). Recife, 2016.

53. SILVA, M. J.; COSTA, R. F. A importância do cálcio na saúde do solo e na produtividade das culturas. Revista Brasileira de Ciência do Solo, v. 45, n. 3, 2022. p. 456-470.

54. SOUSA, D. M. G.; LOBATO, E. Calagem e adubação para culturas anuais e perenes. In: SOUSA, D. M. G.; LOBATO, E. (Orgs). Calagem e adubação para culturas anuais e perenes. Brasília: Embrapa Cerrados, 2004. p. 283-315.

55. TAVARES FILHO, João. Física e conservação do solo e água. 1. ed. Londrina: EDUEL, 2016. 256 p.

56. TEIXEIRA, L. B. et al. Processo de compostagem, a partir de lixo orgânico urbano, em leira estática com ventilação natural. Empresa Brasileira de Pesquisa Agropecuária - Embrapa Agrobiologia. Circular Técnica nº 33/2004/PA. Belém: Ministério da Agricultura, Pecuária e Abastecimento, 8 p., out. 2001. Disponível em: https://www.infoteca.cnptia.embrapa.br/bitstream/doc/407137/1/Circ.tec.33.pdf. Acesso em: 01 mar. 2023.

57. THOMSEN, I. K. C and N transformations in (15)N cross-labelled solid ruminant manure

during anaerobic and aerobic storage. Bioresource Technology, v. 72, 2000. p. 267-274.

58. TIQUIA, S. M.; WAN, J. H. C.; TAM, N. F. Y. Dynamics of yard trimmings composting as determined by dehydrogenase activity, ATP content, arginine ammonification, and nitrification potential. Process Biochem, v. 37, p. 1057-1064, 2002. https://doi.org/10.1016/S0032-9592(01)00317-X. Acesso em: 01 mar. 2023.
59. VARENHOLT, Helton. A importância da compostagem dos resíduos orgânicos gerados em ambiente doméstico. 32 f. Trabalho de conclusão de curso (Especialização em Gestão Ambiental em Municípios) – Universidade Tecnológica Federal do Paraná, Medianeira, 2015.

60. VITOR, T. S.; SILVA NETO, V. M.; ARAGÃO, F. M. M.; VILAS BÔAS, I. C. C.; ARAUJO, N. A.; SILVA, F. A. M.; GERUDE NETO, O. J. A. Papel como fonte alternativa de fibra no processo de compostagem. In: PEREIRA, D. R.; NETO, O. J. de A. G. (Orgs). Abordagens multidisciplinares no processo de compostagem. 1ª ed. Bauru: Gradus Editora, São Paulo, 2022.

61. ZANINI, R. R. et al. Avaliação de desperdício alimentar produzido por comensais em restaurante universitário no sul do Brasil por meio de gráficos de controle. Latin American Journal of Business Management, v. 8, n. 2, 2013. p. 118-133.

62. ZIMMERMANN, A. M.; MESQUITA, M. O. Campanha Resto Zero em um restaurante universitário. Disc. Scientia. Série: Ciências da Saúde, v. 12(1): p. 115-125, 2011. Disponível em: http://sites.unifra.br/Portals/36/2011/Saude/11.pdf. Acesso em: 01 mar. 2023.