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Composting and Agroecological Garden of UnAPI: An Alternative for Recycling Organic Waste at UFMS

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Abstract. The composting process is an alternative for recycling organic waste, facilitated by microorganisms that produce compost or organic fertilizer in the presence of oxygen. The resulting compost can be used as fertilizer, significantly improving soil structure. The "Composta UFMS" project aims to environmentally manage organic solid waste generated on the UFMS University City campus in Campo Grande. Currently, dry leaves, pruning and weeding residues, wood shaving from vivarium, and organic waste from the University Restaurant are being directed for composting. In addition to valuing organic waste generated on the UFMS campus and used in the production of organic compost for the extension activities of the UnAPI Agroecological Garden project, the Biovalorization of Organic Waste project also includes scientific initiation subprojects, such as the study of growth potential of fungi of the genus Pleurotus on substrates derived from different organic residues and their mixtures for mushroom production. In addition to Environmental Education actions in schools with the Composting and Urban Agriculture in Schools project using the composting method directly on the soil, eliminating the need for turning. These actions resulted in the year 2023, the diversion of 4 tons of wood shavings from the vivarium and 4.8 tons of organic waste from the University Restaurant for composting, the care of around 60 elderly people in the UnAPI Agroecological Garden project and 5 schools in the Compostagem and Urban Agriculture in Schools. The results of this study will serve as a basis for the management of organic waste on the UFMS Campo Grande campus, as well as for future research on composting, as well as new Environmental Education and Scientific

Dissemination actions.

Keyword:

Composting, recycling, fertilizer, organic compost, University.

1. Introduction

The increasing population growth, urbanization, agricultural activity, and industrialization have led to the generation of increasingly larger amounts of organic waste [1,2]. According to NBR 10004 [3], waste is the material generated in agricultural, industrial, and transportation activities, including sludges from sewage and water treatment systems, as well as those generated in pollution control equipment and facilities. Waste can be either liquid or solid and should not be discharged into public sewage systems or bodies of water, requiring the implementation of solutions to mitigate its potential harm.

Organic waste represents approximately half of the solid waste generated in Brazil, confirmed by the gravimetric study carried out by the Panorama of Solid Waste in Brazil [4], and can be treated at different scales (domestic, institutional, community, industrial and municipal).

Brazil is one of the world's largest food producers, which makes the agro-industrial sector responsible for generating a large amount of organic waste. Additionally, a significant amount of organic waste is also generated in urban areas. Overcoming the challenges presented by the growing generation of organic waste involves the development of effective waste management [5].

For society as a whole to pay more attention to organic waste and recognize its value, what we call biovalorization, it is necessary for universities to contribute by conducting more research and, especially, extension activities involving citizens of all age groups, from children to the elderly.

The world's population has been experiencing a significant increase in the number of people over the age of 60, resulting from declining fertility rates and mortality rates in recent decades. Currently, the elderly is the fastest-growing segment of the population, and it is estimated that by the year 2025, Brazil will have the sixth-largest elderly population in the world. [6].

The World Health Organization defines individuals aged 65 years or older as elderly in developed countries and those aged 60 years or older in developing countries.

Aging is a natural process that characterizes a stage of human life and involves physical, psychological, and social changes that affect each individual differently with extended survival. [7]. Aging brings with it various problems that affect a person's quality of life. It is a process that often occurs alongside physical limitations, cognitive losses, the onset of depression, and social isolation. Although a large part of the elderly population has at least one disease related to the onset of these symptoms, healthy aging depends on the interaction between mental and physical health, independence, and social integration of the individual. [8].

In addition to this, in this stage of life, there is a high incidence of chronic diseases, which can compromise the health of the elderly. A portion of these chronic diseases may be related to poor dietary habits. Therefore, there is a perception that maintaining health through a healthy and balanced diet directly influences the quality of life during the aging process [9].

Practices related to the consumption of natural products, such as medicinal herbs and spices, and the knowledge of their therapeutic indications, are often attributed to the elderly, who maintain this knowledge through oral tradition passed down from generation to generation. However, the continuity of this knowledge is often threatened by easy access to medical services, the popularization of the internet, and the loss of family traditions. [10].

It is already a consensus that the inappropriate and indiscriminate use of medicinal plants, without proper knowledge, can cause serious health problems due to the presence of toxic substances. However, with proper care and by combining popular beliefs with scientific knowledge, phytotherapeutic treatment can effectively and efficiently address health problems. Additionally, it allows the elderly to reduce medication use and grants them autonomy in seeking their own care. [11].

Cultivating and consuming fresh foods allows the intake of vitamins and minerals essential for maintaining health, as well as promoting better physical conditioning and occupation through the activities required for cultivation [12]. Encouraging them to engage in practical activities is essential to prevent sedentary behavior and promote various benefits, such as improving well-being, adopting healthy eating habits, boosting self-esteem, strengthening social relationships, occupational engagement, and connecting with nature.

Community gardens have positive results in social organization as they serve as a positive example to the communities in which they are located. [13]. When placed in a university environment, a garden brings with it the use of idle spaces, making them pleasant and useful for cultivating various species. [14]. Due to its proximity to the study site, cultivation can serve as a theme for didactic activities developed in the classroom [15]. Furthermore, the integration of agriculture in a community setting allows social interaction for the elderly, stimulating their self-esteem, creativity, and organization, [16], and sometimes recalling activities that their parents or grandparents performed.

It's also worth noting that community gardens contribute to a better quality environment by responding to soil conditions, increasing relative air humidity, and mitigating microclimatic temperature extremes. Additionally, they serve as a means to reduce environmental pollution and disguise undesirable views. [17]. Furthermore, they also play important roles in maintaining ecosystem stability, ensuring the continuity of species diversity.

Community gardens can also play an important role when implemented in schools. They can be used by teachers from various subjects for the development of didactic-pedagogical activities with a practical approach. For example, in Campo Grande – MS, most public schools have green areas where educational gardens and gardens can be implemented.

Linked to the idea of using community gardens, led by the elderly or by students, teachers, and school staff, is the concept of biovalorization and recycling of organic waste through the composting process, whether produced at universities, schools, or in the homes of those involved in garden-related activities.

The composting process has been one of the main ways of effectively disposing of organic waste due to the benefits it presents. One of the main benefits is the transformation of waste into a value-added product, representing an environmentally and economically viable solution. [18, 19].

It is important to emphasize that, according to the National Solid Waste Policy (Política Nacional de Resíduos Sólidos), composting is a form of environmentally adequate final disposal for organic waste [20], contributing to more sustainable development.

Composting is a controlled process where aerobic decomposition of organic material occurs by microorganisms that obtain nutrients and energy, transforming chemically complex compounds into simpler ones. [18].

The final result of composting is a substrate of high biological value, which can be used as a soil conditioner, improving numerous aspects, including nutrient supply; increase in organic matter content; particle aggregation; stimulation of microbiota; water infiltration stimulation; increased moisture retention capacity; reduction of erosion losses and viability of invasive plant seeds. [21]. These improvements result in increased productivity and quality of agricultural products, as well as reduced production costs for plant products. [22].

The most conventional way of composting, in piles or windrows, involves aeration through periodic turning, which can make it difficult to implement in universities and schools due to a lack of dedicated labor for this task.

An alternative is to simplify composting by depositing the material directly into the soil where the garden bed will be implemented. As organic waste, such as food scraps (peels, leaves, and stems), is deposited, it is covered with vegetative material from pruning, weeding, and leaf sweeping. Aeration is then achieved by regularly perforating the deposited material with a broom handle, for example. These perforations in the old deposited material can be made, for instance, when a new batch of waste and vegetative material is being added [23].

In the context of what has been discussed, extension and research projects have been developed at the University Campus of UFMS with the aim of giving greater visibility to the importance and potential use of organic waste, especially regarding its recycling and application in promoting community gardens. This initiative aims to stimulate therapeutic and recreational activities for the elderly and didactic-pedagogical activities for children and adolescents in public schools in Campo Grande.

One of these projects is the Agroecological Garden of UNAPI, an extension action linked to the "Universidade Aberta à Pessoa Idosa" (UnAPI) program at UFMS. Through this action, participating seniors have access to information exchange among themselves and with faculty, technicians, and students from UFMS, expanding their knowledge related to composting, cultivation, consumption, and plant management. Additionally, it promotes an incentive for balanced nutrition and health, as well as encouraging the maximum utilization of food.

Another extension project is the Composting and Urban Agriculture in Schools, where, with the help and involvement of teachers and staff, composting is carried out directly in the soil in some available green area in the school. The aim is to form a bed with a high content of organic matter and its subsequent use for planting vegetables, greens, herbs, and medicinal plants.

It is also important to mention that some Scientific Initiation projects are developed with themes related to the biovalorization, composting, and recycling of organic waste. In one of these projects, the objective is to evaluate the feasibility and obtain data related to composting directly in the soil of preparation waste (leaves, peels, and stems) and food consumption at the university restaurant. In another project, the objective is to evaluate the feasibility and quality of organic liquid fertilizers from the fermentation of waste generated on the university campus, such as weed remains, leaf sweeping, cattle manure, chicken coop bedding, and bioterium shavings. There is also a project aimed at producing edible mushrooms of the *Pleurotus* genus (commercially known in Brazil as Shimeji) in substrates formed by the mixture of different organic waste.

Thus, with the central focus on the biovalorization of organic waste through its processing and subsequent use in organic gardens, the aim is to assist in improving the management of such waste, as well as providing an experience of self-care, citizenship, and protagonism, which makes a simple reality, but has become rare to see. Moreover, it aims to awaken individual and collective concern for environmental issues, developing critical awareness and stimulating the confrontation of environmental and social issues among those involved.

2. Methodology

The activities focused on the study and dissemination of sustainable actions through the management of organic waste are carried out at the University City of UFMS, in Campo Grande, within the scope of extension projects such as Composta UFMS and the Agroecological Garden of UNAPI, as well as the research project Biovalorization of Organic Waste. These broader projects are linked to other projects, such as the Composting and Urban Agriculture in Schools and Scientific Initiation projects. The practical activities of these extension actions and research projects are conducted in an area at the Faculty of Veterinary Medicine and Animal Science (Famez) of the Federal University of Mato Grosso do Sul (UFMS) in Campo Grande, MS.

2.1. Composta UFMS

Through the "Composta UFMS" project, work related to the environmentally correct disposal of organic solid waste generated at the UFMS Campus in Campo Grande is developed. The project involves faculty and undergraduate students, primarily from the Environmental Engineering program.

For the composting process, organic waste generated at the UFMS Campus in Campo Grande is used, including pruning and weeding residues, livestock waste such as chicken coop bedding and cattle manure, wood shavings used in the animal facility, and a portion of the organic waste generated at the University Restaurant, such as food preparation leftovers (leaves, stems, and peels).

Composting is carried out in piles or windrows with periodic turning. Organic matter decomposition occurs through aerobic processes, and oxygen is introduced into the pile through regular turning of the compost mass.

Composting piles are assembled with an initial composition containing a C/N ratio close to 30/1. Each compost pile contains approximately 1.5 m^3 of carbon-rich material, along with the corresponding amount of nitrogen-rich material.

During the thermophilic phase, turning and moistening of the piles are carried out every three days. After this phase, this procedure is performed every 7 days. To moisten the pile material, irrigation is carried out during the turning process until, when squeezing a portion with the hand, water appears between the fingers but does not drip (known as the "hand test").

The quantification of wood shavings used in the animal facility and the organic waste generated at the University Restaurant consisted of weighing the materials that were sent for composting. Wastes from pruning and weeding, chicken coop bedding and cattle manure are not yet being quantified.

2.2. Agroecological Garden of UnAPI

The Agroecological Garden of UnAPI started in 2023, the activity alternates between theoretical and practical classes, once a week, with a duration of about three hours each session.

The theoretical part of the course is conducted in the classroom, covering topics such as sustainable production methods, Environmental Education, composting, concepts of medicinal plants, herbs, and unconventional edible plants (PANCs), culinary workshops focusing on using all parts of vegetables in healthy and economical recipes, as well as courses and workshops to train members of the community garden in agricultural practices and other related themes.

The practical part takes place in the area of FAMEZ-UFMS, where the works of the "Composta UFMS" project are also developed. At the beginning of the activities, the area was cleaned, and the beds were marked. Five beds measuring approximately 5 meters in length by 1 meter in width were delimited, with pathways between the beds measuring about 90 centimeters. Some raised beds, made with reused crates, were used to facilitate access for the elderly. Then, the organic compost produced within the scope of the "Composta UFMS" project was added, along with limestone to correct the soil pH.

Once the beds were ready, a variety of vegetables and greens were planted semi-annually using agroecological techniques. Seedlings purchased from specialized agricultural product stores, a watering can, hoe, and shovel were used for planting. Seedlings of kale, cabbage, cilantro, parsley, green onion, broccoli, gherkin, lettuce, carrot, beetroot, eggplant, and okra were planted.

Pits were dug and organic compost was added for planting larger tomato seedlings. In the raised beds, herbs, medicinal plants, and unconventional edible plants (PANCs) were cultivated.

After planting, dry leaves and grass were spread to cover the beds, preventing excessive water evaporation, considering the relatively high temperatures in Campo Grande. Students from UNAPI and the Environmental Engineering course, as well as third-party UFMS employees, are responsible for caring for and maintaining the garden, including irrigation, which is temporarily done manually until a drip irrigation system can be implemented (a goal for the projects to function better).

During cultivation, liquid organic fertilizer resulting from vermicomposting performed in boxes was also used to supplement the initial compost fertilization.

After the plant development period, the elderly participants harvest and share the produce. Each semester, a new group, consisting of both new and returning students, is formed, renewing the beds for new planting. Unproductive vegetables are removed, some replanted, and the soil is turned and supplemented with more organic compost.

At the end of each semester, a questionnaire with objective questions is administered to assess the progress of the activity by the students.

2.3. Biovalorization of Organic Waste

In addition to valorizing organic waste generated on the UFMS campus and used in the production of organic compost for the extension activities of the UnAPI Agroecological Garden project, as mentioned earlier, the Biovalorization of Organic Waste project also includes undergraduate research subprojects.

As an example, one of these projects involves studying the growth potential of fungi of the *Pleurotus* genus (commercially known in Brazil as Shimeji) on substrates derived from different organic wastes and their mixtures for mushroom production. Mushrooms are fruiting bodies of fungi belonging to the Basidiomycetes taxonomic division (Basidiomycota), and many of them are edible [23]. Among basidiomycete fungi, those of the *Pleurotus* genus are extensively cultivated worldwide for edible mushrooms [24, 25], comprising about 19% of global production [26]. There are approximately 40 *Pleurotus* species that can potentially be used for cultivation and consumption, ranging from temperate to tropical climates [27]. For example, in Sri Lanka, mainly four species are cultivated commercially: *P. djamor*, *P. eous*, *P. ostreatus* and *P.* cystidiosus [25]. In Brazil, they are commonly marketed under the name Shimeji, with variations such as white Shimeji or black Shimeji, depending on the species or isolate. Besides their culinary, nutritional, and even medicinal importance [25], *Pleurotus* fungi are considered biological models, as they are easy to cultivate and have a relatively short life cycle compared to other fungi used as biological models [24]. *Pleurotus* fungi have a distinguishing ability to easily grow on a variety of substrates consisting of organic waste, some of which are recalcitrant, with high cellulose, hemicellulose, and lignin content, such as sawdust, straw, and rice husk [25]. Therefore, knowledge about the growth of different *Pleurotus* fungus isolates on different organic wastes is interesting both economically, for the valorization of waste and cost reduction in mushroom production, and environmentally, contributing to greater sustainability. Within the subprojects related to mushroom production, the following organic wastes and their mixtures in different proportions are being tested: malt bagasse, coffee grounds, cattle manure, semi-cured organic compost and bioterium shavings.

2.4. Composting and Urban Agriculture in Schools

As described earlier, the Composting and Urban Agriculture in Schools project is utilizing the method of composting directly in the soil, eliminating the need for turning. This is crucial for the project to be adopted by students, teachers, and school staff, as it eliminates the need for dedicated labor for turning.

After the school expresses interest in participating in the project, a presentation is conducted where the principle of composting, the methodology of composting directly in the soil, and, most importantly, the need for the school to take ownership of the project are explained. It's emphasized that the results are long-term since one semester is required for the composting process to form the beds, and only in the following semester can planting activities for the garden formation begin. During the development of the project there was interaction with 5 schools.

3. Results and Discussions

Table 1. Total organic waste generation per year from the University Restaurant and Vivarium.

	2021	2022	2023
Waste from the University Restaurant (t)	6,0	4,2	4,8
Wood shavings used in the animal facility (t)	5,0	3,5	4,0

The “UFMS Composting Project” has been presenting positive results in the management of the institution's organic waste, in line with the guidelines of the National

Solid Waste Policy, Law 12,305/2010, with the purpose of facing the challenge that Brazil faces in this regard. Observing the annual comparisons of the generation of organic waste on the Campo Grande campus (Table 1), in 2023 it was observed the diversion of approximately 4 tons of *Pinus* sp. sawdust with animal excrement (rats, mice, hamsters and laboratory possums) from the biosafety level 1 (NB-1) breeding area of the vivarium, in addition to around 5 tons of food waste from the University Restaurant, were recycled through composting. Waste from pruning and weeding was also recycled, although the exact amount was not measured.

The organic compost produced from 2023, with the implementation of the Composta UFMS project, began to be used in the activities of the UnAPI Agroecological Garden project, which served around 60 elderly people in that year. Additionally, the allocation of an area for the production of organic compost from waste generated on the UFMS Campus in Campo Grande stimulated the proposal and activation of other projects, such as the Organic Waste Valorization project, Composting and Urban Agriculture in Schools, and even the creation of a Medicinal Plants Garden, the latter still under development.

Within the UnAPI Agroecological Garden project, it was observed that the interaction of the elderly with the composting project sparked a deeper interest in the subject. During the composting class, many already performed composting in their homes in different ways, showing that composting is an environmentally accessible practice that can be carried out by different age groups, with different methodologies, and in different locations.

Through the UnAPI Agroecological Garden project, the elderly have access to basic information about planting and cultivating different crops, composting concepts, soil preparation, fertilization, sowing, planting, cultural practices, and harvesting vegetables. Healthy and sustainable eating is also emphasized, with workshops on medicinal herbs and Non-Conventional Food Plants (NCFPs), along with practical cooking classes with recipes and preparations using ora-pro-nobis, for example.

Participation in the activities can bring a series of significant benefits for the elderly, including social interaction, maintenance of physical and mental health, continuous learning, and a sense of purpose and accomplishment. Research among students participating in the UnAPI garden revealed overall high satisfaction, with recognition of the benefits to quality of life and mental health. Some suggestions for improving the garden's infrastructure were made to optimize the learning experience. Additionally, there is an interest in learning more about medicinal plants and Non-Conventional Food Plants (NCFPs) in future classes.

Preliminary studies on different isolates of *Pleurotus* have shown the influence of the type and proportion of organic residues on mushroom growth, with experiments underway to quantify such differences. Interaction with schools has resulted in 5 completely different histories, with some schools showing positive engagement and others facing challenges, such as renovations or lack of involvement. The interaction with schools has resulted, so far, in 5 completely different scenarios.

In school 1, with students from basic and high school cycles, the project had a good start, with strong student engagement primarily. However, due to the need for renovations, the school had to temporarily occupy another building. Therefore, the project was temporarily suspended in this school.

In school 2, also with students from basic and high school cycles, it became clear that the main interest was from the administration, with no engagement from teachers and staff. After several attempts at development, the school ultimately decided not to continue with the project.

In school 3, with high school students, there was a good start and support from the administration and some teachers for the adoption of the project. The school has good infrastructure and some projects already underway related to gardening, even without a focus on composting. The involved teachers requested a temporary suspension of the actions due to the need to reformulate projects within the school, but expressed positivity regarding the continuation of the project.

In school 4, with high school students, there was strong engagement from some interested students. With one of the teachers keen on participating in the project, there was good organization regarding the collection and addition of waste to the composting bed. The plan is to conduct compost bed formation during the first semester of 2024 and to start planting and forming the garden itself in the second semester of 2024.

In school 5, with preschool-aged children, there was good adoption by teachers and staff. During the second semester of 2023, organic waste was deposited, and the compost bed was formed. During the first semester of 2024, activities involving the children and planting were initiated. A second compost bed is being formed while the first one is being used for activities.

4. Conclusions/Summary/Future Perspectives

Composting results in several benefits, including reducing the volume of organic waste sent to landfills, thereby increasing their lifespan and reducing the cost of final disposal of urban waste. Additionally, it also leads to a decrease in the emission of greenhouse gases, such as carbon dioxide (CO_2) and methane (CH_4).

The garden activity at UNAPI has proven to be an integrative strategy, involving students not only in class but also in garden maintenance, with schedules and scales defined by them. Moreover, it is a highly valuable opportunity for the exchange of knowledge and experiences among students. The implementation of the community garden is proving to be a sensitizing strategy for environmental issues, significantly contributing to the well-being and health of the elderly, as well as serving as an excellent link between society and the institution.

During this one year of monitoring the project, it was possible to contribute to the environmentally correct disposal of 8.8 tons of waste. Furthermore, it is a highly valuable opportunity to exchange knowledge, also providing well-being for the elderly who participate in activities as a form of therapy and integration.

The Biovalorization of Organic Waste project, still in its experimental phases, is an initiative aligned with the principles of effective organic waste management. It aims to utilize these resources efficiently by reducing waste and implementing closed-loop product cycles.

The Composting and Urban Agriculture project not only contributes to sustainable waste management but also helps participants understand the importance of planting and cultivation. By acquiring healthy habits and reducing food waste, participants are encouraged to bring these lessons into their homes.

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