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The Technical and Administrative Feasibility of Bokashi Composting as a Solution for Food Waste Treatment in a Typical North American Educational Facility Setting

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Abstract: Food waste is a nationwide problem in the US, leading to environmental concerns. A fermentation-based composting method, the Bokashi compost method, is proposed to mitigate the negative consequences of food waste (FW) disposal in educational facility settings. Bokashi utilizes fermentation to break down large molecular compounds in FW and convert them into compost. It presents several theoretical advantages over the currently widespread landfill methods. This method was subsequently examined for its technical and administrative feasibility and value through experiments and data analysis. Technically, the composting process can break down FW without defects such as odor emission, and produce compost with nutritional value for agricultural use; Administratively, the Bokashi composting method is found to be slightly less economical than the conventional landfill method. A typical high school has the capacity to process the FW generated, and there is a high likelihood of community cooperation. There is significant potential for scaling this model across educational facilities. However, studies on optimizing Bokashi workflow remain pending.

Keywords: Bokashi composting, Food waste management, Educational facility, Sustainable development

1. Introduction

Food waste (FW) is a significant environmental and economic issue that has garnered increasing attention worldwide. In the United States, food waste constitutes a substantial portion of the waste stream, with institutional food service settings, including schools, contributing to approximately 8% of the total food waste generated in the country [1]. A 2019 World Wildlife Foundation report [2] estimates that U.S. schools alone produce approximately 530,000 tons of food waste annually. This waste predominantly ends up in landfills [3] where it occupies valuable land resources and emits harmful greenhouse gases (GHGs) such as methane, exacerbating the global climate crisis [4] Addressing food waste in schools is therefore not only a matter of reducing waste but also a critical component of mitigating environmental impacts and promoting sustainability in educational settings.

A case study conducted at Stony Brook School in Stony Brook, New York provides a vivid example of the scale of this issue. Over a five-day period, the amount of leftover food waste was recorded after each meal, revealing an alarming trend: on average, 160 kg of food waste was generated per meal, amounting to approximately 86 tons per academic year. This food waste constituted more than 50% by volume of the total waste disposed of by the school, most of which was sent to local landfills. The case study underscores the urgency of finding effective food waste management solutions that can be implemented in schools to reduce the environmental impact and promote more sustainable waste disposal practices.

Figure 1: Wasted food scale

The wasted food scale updated from the food recovery hierarchy [5] (Figure 1) offers a structured approach to food waste management, ranking methods from the most preferred (source reduction) to the least preferred (landfill or incinerate). While the ideal approach is to prevent food waste at the source, this is often challenging in institutional settings such as schools, where large quantities of food are prepared and served daily. As a result, many schools resort to landfilling as the primary method of disposal, despite it being the least preferred option due to its environmental repercussions [6]. Although composting is not the optimal method for food waste processing, it is considered a more environmentally friendly alternative to landfilling [7], particularly when the more preferred methods—such as food donation and animal feed are difficult to implement.

Among the various composting methods, dry composting is the conventional approach widely used for decomposing organic material. However, its application in school settings presents several challenges. First, the specific content makeup of school food waste, which includes a high percentage of fluids, proteins, and lipids from meat, makes dry composting impractical: The breakdown of these materials in a dry compost system releases considerable amounts of VOCs such as sulfur-containing organics and halogenated compounds [8] which produce odors and health risks. Additionally, dry composting is less energy-efficient compared to other methods, as it relies on aerobic respiration, which converts a large portion of carbon into carbon dioxide ($CO2$), resulting in energy loss in the form of heat [9][10]. Moreover, dry composting is temperature-dependent, requiring industrial-scale operations to maintain functionality during colder seasons, which is not feasible for many schools.

In contrast, Bokashi composting, an alternative method originating from East Asia, offers a promising solution to these challenges. Bokashi composting employs Effective Microorganisms (EM), systematically named by Higa [11], to ferment organic materials in an anaerobic environment, transforming them into nutrient-rich compost without the need for oxygen [12]. This enclosed system prevents the release of odors, and allows for the composting of proteins and lipids more effectively than dry composting [13] by the microbial activities of EM including Lactobacillus [14]. Additionally, Bokashi composting is less dependent on temperature, making it suitable for use in diverse climatic regions, including those with colder winters [15]. It is also less demanding to the C/N ratio of the input material [16]. It has been claimed that the fermentation process in a Bokashi system also produces less energy loss, as it minimizes the conversion of carbon to $CO2$ [17], resulting in a more energy-efficient process with less GHG emission [13][18].

Despite these theoretical advantages, the practical application of Bokashi composting in educational settings remains underexplored. While Bokashi composting appears to be a more suitable option for managing food waste in schools, its feasibility must be rigorously tested through empirical

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studies. This includes evaluating the compost ability of specific food waste materials, assessing the energy efficiency of the process, and determining the system's operability at a large scale throughout the academic year. Furthermore, the economic costs and benefits of implementing a Bokashi composting system in schools must be carefully analyzed to ensure its viability. Schools typically operate with limited budgets, and any proposed waste management solution must be cost-effective while delivering tangible environmental benefits.

Figure 2: The food waste content from the high school

In addition to these technical considerations, administrative challenges must also be addressed. These include managing the non-compostable materials that remain after the composting process and ensuring collaboration with the local community to support the initiative. The success of a Bokashi composting program in schools will depend on its ability to process large volumes of food waste efficiently, produce compost that can be used or sold, and integrate seamlessly into the existing waste management infrastructure.

The potential environmental benefits of implementing a Bokashi composting system in educational facilities are significant. However, to determine its feasibility, both the technical and administrative aspects of the system must be thoroughly examined. This research aims to explore these dimensions by analyzing existing literature and conducting a series of experiments designed to assess the practical application of Bokashi composting in schools. The findings of our research will contribute to a deeper understanding of how educational institutions can adopt more sustainable food waste management practices, ultimately reducing their environmental footprint and promoting a culture of food recovery among students and staff.

2. Materials and Methods

The specific setup for the research experiment evaluating the technical and administrative feasibility of Bokashi composting as a solution for food waste management in a typical North American educational facility is as follows.

(1) The first experiment was designed to test the feasibility of Bokashi composting in relation to the soil and environmental conditions of the northeastern US. The experimental setup consisted of two stacked 20 L plastic buckets. The top bucket had holes drilled at the bottom, which were then covered with metal screens with 3mm*3mm openings, allowing the free flow of liquids while retaining any solid FW content in the upper bucket. Household FW was used as the compost material to test the setup, along with commercially available EM, primarily consisting of yeast. The compost was observed at 3-day intervals, and the temperature was recorded using an IR thermometer. After

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the dry mass had mostly decomposed by day 18, the composted material was transferred to the soil, where it further decomposed by the soil community. The compost from the first experiment was cnocted after soil treatment. A 6m*3m experimental field was divided into two 3m*3m sections, each growing several types of common vegetable plants (Pepper (Capsicum chinense), eggplants (Solanum melongena), tomatoes (Solanum lycopersicum). The growth of the plants was then estimated visually. No odors were detected near the experimental setup. It was also observed from the temperature data that the Bokashi system was in equilibrium with the ambient temperature.

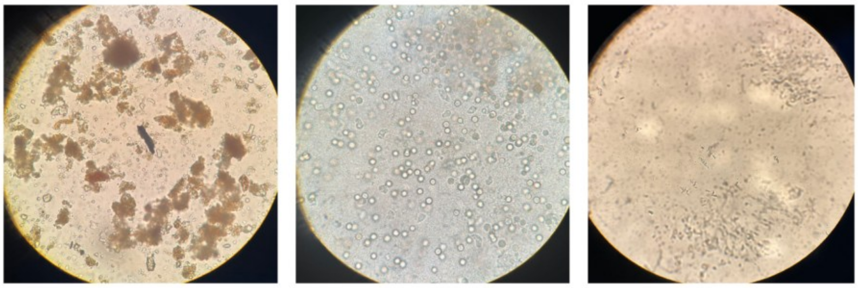

Figure 3: Three groups of microorganism under optical microscope, from left: EM with LAB, commercial EM, and fermented starch water

Figure 4: The temperature gauge installed on the Bokashi setup

Figure 5: Bokashi setup made of stacked buckets upon completion, revealing the drained residue water

(2) The second experiment consisted of three Bokashi setups with proportioned materials to closely simulate the food waste (FW) composition of a school cafeteria. Three sets of 10 L of dry matter for Bokashi composting were first prepared, consisting of 60% carbohydrates, 20% proteins, 20% lipids,

and trace amounts of other materials, proportioned according to the statistical mean macronutrient intake among adults aged 20 and over from 2015-2018. To achieve this, expired toast bread pieces were combined with a mixture of cat food and oil. Fibrous contents, including both shredded boiled and raw cabbage, each constituting 25% of the original mixture's weight, were then mixed into the system to study the breakdown of leftover vegetables with or without intact cell walls at the cellular level. These sets of mixtures were then transferred to a similar experimental setup as in experiment 1. After the addition of EM, sufficient additional water (approximately 1000mL) was added until the runoff appeared from the drainage holes in the setup. The data from this experiment is intended to determine the optimal EM for the fermentation process. 200mL of each of the three different microorganism groups—(a) EM with LAB as the dominant microorganism group, (b) commercial EM with yeast as the dominant microorganism group, and (c) fermented starch water—were used in separate 20L containers, each holding 10L of contents simulating the food waste composition of high school meals. A control group was then set up with 10.2L of soil in a similar stacked bucket setup to evaluate ambient temperature. Four analog dial thermometers were inserted through predrilled holes in each of the composting setups. Temperatures were recorded at 18:00 each day for 20 days, as shown in Table 1. The contents of the three experimental groups, which had significantly decreased in volume by approximately 33%, were then transferred to soil for further treatment. After 30 days of soil treatment, the contents had turned into black soil with no visible remnants of the original mixture.

Table 1: Variation in Temperature of three bokashi compost with different EM.

Day	A Temp	B Temp	C Temp	Ambient Temp
1	21	21	21	25
2	24	23	22	23
3	29	28	28	24
4	25	24	23	24
5	26	24	25	26
6	21	21	20	23
7	21	21	22	23
8	20	21	19	23
9	20	21	20	20
10	27	26	26	25
11	30	29	29	23
12	30	29	28	26
13	26	24	25	23
14	20	19	18	16
15	19	19	18	16
16	27	26	25	23
17	26	25	24	23
18	27	28	26	25
19	31	29	29	27
20	20	20	19	17
21	21	20	20	17

(3) A third Bokashi system was established on a high school campus on Long Island, NY, as a prototype for large-scale composting in an educational facility setting. Using a similar Bokashi setup

as in the previous experiment, 10L of collected FW from the campus cafeteria was thoroughly mixed with commercial Bokashi grains. The composting process began in mid-October. Data from the analog thermometer was collected and compared to the ambient temperature to study compost activity in low winter temperatures. During the 20-day fermentation stage, the data were recorded as follows.

Table 2: Bokashi system and ambient temperature.

Day(s)	Ambient Temp	System Temp	Delta Temp
1	15	15	0
2	18	19	1
3	20	21	1
4	17	19	2
5	17	20	3
6	15	16	1
7	10	11	1
8	13	13	0
9	15	16	1
10	18	18	0
11	19	19	0
12	18	19	1
13	23	24	1
14	11	13	2
15	13	12	-1
16	9	9	0
17	4	5	1
18	7	7	0
19	12	12	0
20	14	14	0

After transferring the sample to the soil, it was noted that the breakdown speed of the fermented FW was significantly lower than in the previous two experiments. This may be due to the absence of micro- and macro-organism activity and the reduced reaction rate of biochemical processes at temperatures near freezing, following frequent precipitation. The decomposition then quickly resumed as the temperature rose above 0°C. The resulting compost was compared against regular soil using two criteria to evaluate its effectiveness. The compost was first sampled from various locations, then sealed and frozen until it could be chemically analyzed for various contents (Table 3). P, K, Ca Mg levels were tested using both Mehlich III, reported in ppm, and Morgan, reported in kg/ha.

Table 3: Analytical Contents of Soil Before and After Bokashi Treatment.

Indicator		Bofore Treatment	After Boakshi
pH		6.3	7.7
Organic Matter, %		1.2	2.4
CEC, meq/100g		4.6	13.1
Other Nutrients, ppm	Na	8.4	64.6
	Al	965.2	408.6
	Zn	7.8	9.8
Phosphorus (P)	Mehlich, ppm	51.4	55.0

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Table 3: (continued).

	Morgan, kg/ha	≤1.1	28.8
Potassium (K)	Mehlich, ppm	36.0	63.3
	Morgan, kg/ha	72.4	126.5
Calcium (Ca)	Mehlich, ppm	732.2	2186.0
	Morgan, kg/ha	1252.0	4472.3
Magnesium (Mg)	Mehlich, ppm	95.2	193.0
	Morgan, kg/ha	217.2	441.7
Base Saturation Values, %	K	2.0	1.2
	Ca	80.0	83.0
	Mg	17.2	13.6
	Na	0.8	2.1
	H	0.0	0.0

The compost was then used in a comparative experiment against regular soil to grow four different types of plants—Bellis perennis, Cosmos bipinnatus, Salvia officinalis, and Salvia rosmarinus—on the school campus. The experiment was conducted in a sectioned-off flowerbed area. Four of each of the four plant species were used. The plants were arranged in interlacing rows, with the flowerbed divided down the middle. Two of each plant species were assigned to each set. The right-side set received processed Bokashi compost every 10 days. The set was left to grow for 20 days in an open field, evenly exposed to precipitation and sunlight. Plant height was recorded 20 days after the application of Bokashi compost, as shown in Table 4.

Table 4: Stem length change of length in 20 days.

Group	Control		Bokashi		Control	Bokashi
	Stem Length in mm (±5mm)					
Item	Before	After	Before	After	Total Change	
Bellis perennis	68	116	68	114	48	46
	92	124	67	131	32	64
Cosmos bipinnatus	123	155	113	193	32	80
	115	173	109	145	58	36
Salvia officinalis	100	124	77	107	24	30
	95	105	58	100	10	42
Salvia rosmarinus	138	155	118	131	17	13
	144	190	155	201	46	46

(4) The fourth experiment, still in progress, involves a large Bokashi composting setup on the school campus to examine the feasibility of full-scale composting. Some raw data from the experiments, requiring processing, were then analyzed.

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3. Results and Discussion

3.1. Technical Feasibility

3.1.1. Addressing Possible Negative Factors of Bokashi System

The Bokashi system is capable of composting FW produced by a typical educational facility, effectively decomposing large food debris without significant negative effects, such as odors. Throughout the three experiments, no residues larger than 50mm in length were observed. No odors were detected. During Experiments 2 and 3, the temperature of the Bokashi compost remained below 40°C and matched the ambient temperature, as shown in Fig. 1, corroborating previous studies [19]. Minimal measures are required to maintain the temperature of the Bokashi compost, and no external power source is needed. This poses no potential problems for implementation in a campus setting, where residential areas are near the composting setup. The acidic anaerobic environment of the Bokashi system also suppresses the growth of human pathogens [20].

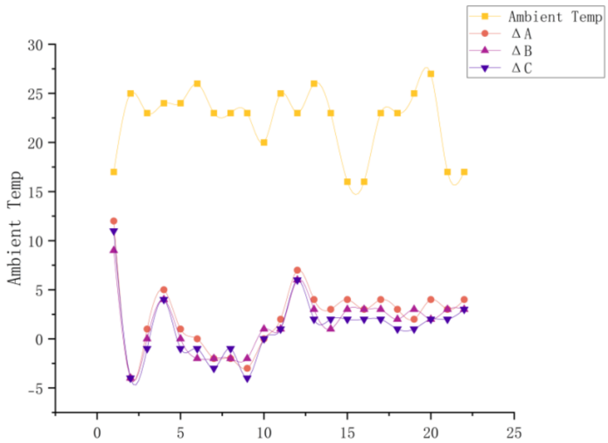

Figure 6: the ambient temperature of the Bokashi compost.

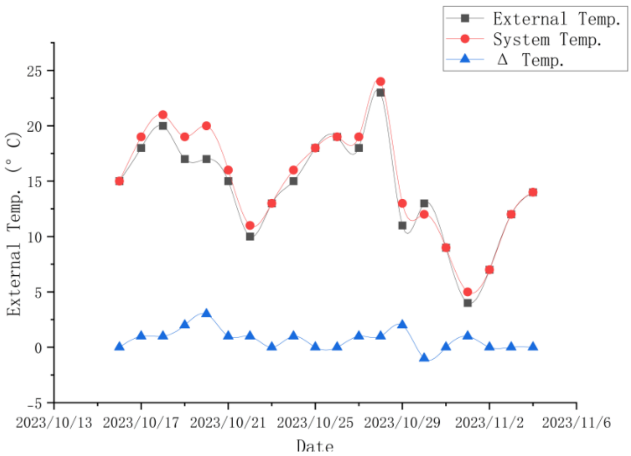

Figure 7: the external temperature of the Bokashi compost.

3.1.2. Examination of the Significance of Nutrients

After the Bokashi process, the resulting compost material presents significant nutrients. This may be concluded both from the analytical data and from the effective contents in the soil, and from the field data of botanical growth.

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In terms of pH, the Bokahsi group shows a slightly acidic pH of 6.0 before stabilization process in soil. (Table 3) This is expected from the organic acids of the fermentation residue [17]. However, after the soil stabilization process, the pH becomes slightly basic at 7.7. This contradicts with the hypothesis that due to the acidic environment of the Bokashi compost, a drop in pH is expected in the produced compost. This may be explained by the composition of the local soil used for treatment for Boakshi compost or error in sample collection and analysis.

The cation exchange Capacity (CEC) level increased from the original level of 4.6% to 13.1% meq/100g (Table 5). This indicated a higher capability for the soil to store nutrients. This may be due to the increased surface area per volume from increased organic matter makeup [21][22]. The Organic matter in soil doubled from 1.2% to 2.4%. The essential plant nutrients, including Phosphorous (P), Potassium (K), Calcium and Magnesium, all showed increase with Mehlich 3 testing. The soil samples were also put under Morgan scale testing. Most notably, the Phosphorus content increased from ≤1.12 to 28.8 kg/ha (≤1 to 25.7 lbs/acre).

Although Nitrogen content of the compost was not tested, many previous research shows that Bokashi can produce N-rich compost [16][20][23][24]

Both methods, Morgan and Mehlich III, agreed on the improvement of the net nutrient content from the soil treatment. The observable increase in Na concentration from 8.4 ppm to 64.6 ppm may be derived from FW sodium input. Potential sources of error may include the relatively small sample size (3 per set) and their relatively close sampling location.

The higher nutrient content in the Bokashi pile is also evident from the field test data. Of the two experiments where the yielded Bokashi were put into field comparison test, the measured plant growth is significantly increased with the addition of Bokashi when compared to plants grown in regular soil. The result from the first experiment, although in agreement with the hypothesis that Bokashi compost aids in plant growth, lacks quantifiable data to directly compare between plants that grow on regular soil and plants that grow on lands where Bokashi compost is implemented. This is due to the obvious lack of precision and subjective nature of visual estimation. To more accurately measure the aid in growth provided by Bokashi, the compost yielded from experiment 3 was used in a compared experiment described in 2.3, where the accurate stem length growth over 20 days is measured.

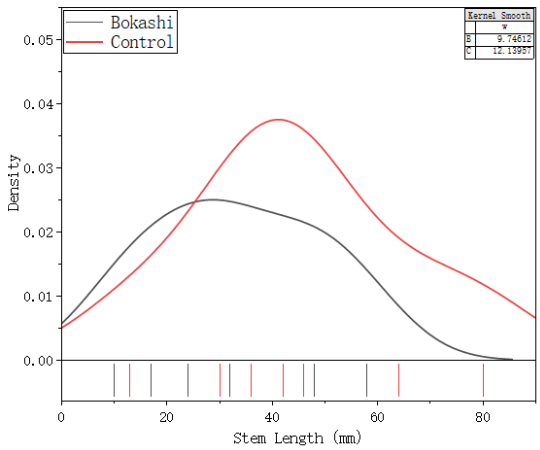

Figure 8: The density against stem length of bokashi and control.

3.1.3. Temperature of Bokashi System

The reaction rate of the Bokashi process slowed significantly due to the low winter temperatures. The process resumed as the temperature increased, corroborating the conclusion of a previous study by [20]. During the third experiment conducted in winter, the difference between the Bokashi system and ambient temperature was also slightly lower compared to the Bokashi system in Experiment 2 during the summer (S2). It was also hypothesized that the slower rate of decomposition in Experiment 3 might be due to the different soil type in the region where the experiment took place, as soil type is considered a key factor in composting [25][26]. However, it soon became evident that soil type was not a major factor, as decomposition resumed when the temperature increased in S1. Further research is needed to optimize the Bokashi system for winter or low-temperature conditions. The slower processing speed caused by the lower winter temperatures led to severe buffering of excess food waste in Experiment 4, which may disrupt an established composting workflow in a campus setting.

This issue may be addressed in the future by optimizing insulation and utilizing the heat generated by biological and chemical processes, or by adding an external heating system. The latter has been shown to ensure continuous composting progress coupled with an automation system [19].

The correlation of the system temperature is also found to be only marginally affected by the specific type of EM used (table 1). One possible explanation may be that the type of EM has less influence on the composting process than the native microorganism group that the FW originally carries, or the organic substrate that the EM was carried in, as suggested by [27] and [28]

3.2. Administrative Feasibility

3.2.1. Economic Analysis

The economic analysis of composting involves evaluating both costs and benefits. It is crucial to justify the economic feasibility of composting based on potential profits and expenditures. The initial investment in the food waste treatment system should be relatively affordable, with environmental benefits that align with this investment. This process involves calculating the financial and labor costs associated with compost maintenance, as well as exploring potential commercial partnerships.

Table 5: Economic analysis of Bokashi systems applications.

	Subject	Cost Type	Category	item/Unit	Number	Unit cost	Total
1	Bokashi Cost/year	Direct Material Cost	Processing	Composting System	10	75.00	750.00
2				EM	5	100.00	500.00
3			Transportation	Club Car Fuel	7	3.50	24.50
4			Tools	Stationary Tools	1	350.00	350.00
5				Mobile tools	4	10.00	40.00
6		Direct Personnel Cost	Person Wage	hrs	627.9	20.00	12558.00
7		Indirect Cost					0.00
8	Non-Compostable cost/year	Direct Material Cost			1	916.29	916.29
9		Direct Personnel Cost	Person Wage	hrs	273	20.00	5460.00
10	Bokashi Profit/year				27.25248	-52.36	-1426.83
	Σ SUM						19171.96
1	Conventional Cost/year	Direct Material Cost	Storage	trash storage bins	10	200.00	2000.00
2			Transportation	Club Car Fuel	10	3.50	35.00
3			Processing	Trash Bill	1	2458.50	2458.50
4				Tax	2458.50	0.05	122.93
5			Purchase of Compost	Organic compost	14.8	65.45	968.59
6		Direct Personnel Cost	Person Wage	hrs	546	20.00	10920.00
7		Indirect Cost					0.00
	Σ SUM						16505.02

A 55-acre (0.223 km²) campus was used in this specific case study, with a green plot ratio of 40% hypothesized. According to the standard of 4.8 g/m², 0.024m depth recommended by [29] (1 lb. N per 1000 square yards, 1 inch depth) and (200mg / dm^3) [30], a total of 267.6 kg of N is needed. According to data from [16] and [31], organic compost typically contains 1.16% N, whereas Bokashi contains 2.45% total N. This abundance of nitrogen may reduce the required fertilizer weight from 23.1 tons of organic compost to 10.9 tons when using Bokashi. At a typical market compost cost of 65.4 USD/m³ (50 USD/yard³).

The cost of compost needed without Bokashi would be 1,509 USD. Based on surveyed data from this school, an annual total of 70 m^3 of cafeteria waste is expected. After excluding the volume loss from sorting out non-compostable materials and from the Bokashi process, 27.2 m^3 of Bokashi residue is expected, leaving an excess of 16.3 m^3 of Bokashi per year. Assuming an institutiona;0% retail rate at the same market price as the originally purchased compost, a profit of 1,426 USD would benefit the Bokashi plan. A reduction of trash processing fees and taxes to 20% of the original amount is also expected. Due to the increased need for Bokashi, assuming no volunteer assistance, the daily labor hours would increase from the original 2 hours to 3.3 hours. This increase in labor for Bokashi is anticipated based on existing research [16] and experimental results.

The resulting total cost for Bokashi is 19,170 USD per year, compared to the existing 16,505 USD per year for the conventional landfill and off-the-shelf compost solution. This increased cost may lead to resistance among educational facilities in adopting the Bokashi method. However, compared to the conventional method, Bokashi significantly reduces the carbon footprint by minimizing the need for transporting both trash and gardening compost to and from the campus.

Potential commercial partnerships, including a cheaper source of EM from industrial products or byproduct may further lower the cost of Bokashi to a closer cost to the landfilling method.

3.2.2. Processing Capacity

In educational settings, the capacity to process food waste and generate compost can be justified by the volume of waste produced. As demonstrated in previous discussions, educational institutions generate substantial amounts of food waste, necessitating robust processing capabilities. The Bokashi system can efficiently handle the volume of food waste and produce significant quantities of high-quality organic compost for internal use or retail, all without the need for large-scale industrial infrastructure, which these facilities typically lack.

Since the typical processing time of a Bokashi compost, according to the consensus of the currently existing research [17][19] and practical experiment, 2–4 weeks, is longer than the FW collection interval, a rolling workflow must be implemented. As some sets of Bokashi undergo fermentation, others can be at different stages of the process, continuously creating fertilizers. The ongoing Experiment 4 has verified the feasibility of this rolling processing workflow. This is largely attributed to the relatively low maintenance required once the compost system is sealed, which aligns with the analysis by [16]. An automation system may also be a future solution to further optimize the limited personnel hours required to manage the Bokashi system, such as ones proposed by Lew et al. in [19].

In the specific case study at the Stony Brook School in Stony Brook, NY, the predominant regional soil type is Psamments from glacial outwash [32], which consists of arid sand and is prone to soil blowing, making it an unsuitable soil type for plant growth. Due to the need for gardening and lawn fertilization in high schools and similar institutions, organic fertilizers must be transported from distant locations if organic fertilizers are needed (due to concerns such as runoff [33], better long-term soil fertility [34][35], or to combat against bacterial wilt [12], this transportation process creates unnecessary carbon emissions. It can be presumed that many schools nationwide may need to introduce organic matter or nutrients to address discrepancies in soil quality. Moreover, the compost could be retailed or donated to local communities, further reducing carbon emissions from compost transportation and packaging.

3.2.3. Community Cooperation and Management

Managing non-compostable materials separately from the composting system and fostering community collaboration are feasible, as demonstrated by scaled surveys and research. Of the 40 students surveyed, 95% were willing to sort out non-compostable plastics from their leftovers and contribute their food waste to a separate container for Bokashi composting, while the other 5% preferred to use conventional trash disposal. 0% of students contributed non-compostable items to the Bokashi compost. This trend in popularity of supporting composting program is within the expectation, as previous studies has shown the importance of reducing FW regarded by faculty and students in educational facility [36], and a similar value was obtained in a survey in a by [37], where 92% of the staff member in an office setting agreed to the separation in of food waste at the source for composting.

4. Conclusions and Perspectives

Bokashi composting is a feasible solution for converting FW into nutrient-rich compost in a typical educational facility. Technically, Bokashi composting is: 1) capable of decomposing macro-level food waste with varying C/N ratios without releasing odors at a stable temperature; 2) capable of producing compost that supports plant growth; and 3) capable of operating at low temperatures, though it does experience inhibition of chemical reactions at very low temperatures.

From an administrative standpoint, compost: 1) is economically viable with proper management, with an annual maintenance cost of approximately $19,000 for a Bokashi system in the case study conducted, making it a competent alternative to treating FW via landfill, which costs approximately $17,000 per year but has a much more significant environmental impact. Moreover, if the on-campus Bokashi model can be scaled to other educational facilities, the cost may be further reduced, resulting in a greater economic advantage compared to the conventional landfill method.

During experimental research, it was also found that: 1) the Bokashi system maintains a temperature similar to the ambient temperature while decomposition occurs; and 2) the addition of EM has a marginal impact on the overall efficiency of the Bokashi system, as the decomposition time consistently converges within a 20-day span.

The ease of use and relatively low cost of the Bokashi system make it a viable option for high schools worldwide that lack access to commercial composting, allowing them to adopt it as a temporary solution to food waste. This may significantly reduce the negative consequences of food waste and provide schools with either compost for local green areas or funds from selling the compost. The on-campus system may also provide students with educational opportunities.

Future direction of research includes 1) the optimization of Bokashi composting process in low temperature, 2) the exploration of a more accessible source of EM from industrial byproducts, for example, the residue produced of beer brewery. 3) the specific microbial mechanism and systematic method of Bokashi composting.

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References

[1] NEPIS, "Wasted Food Report Estimates of Generation and Management of Wasted Food in the United States in 2018, " USEPA, Nov. 24, 2018. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1010CMB.txt

[2] B. O. McDaniel et al., "Food Waste Warriors: A deep dive into food waste in US schools, " World Wildlife Fund, 2019. Accessed: Dec. 18, 2024. [Online]. Available: https://c402277.ssl.cf1.rackcdn.com/publications/1271/files/original/FoodWasteWarriorR_CS_121819.pdf?1576689275

[3] J. DeWaters and S. Grimberg, "Food to Energy: A K12/University Partnership to Develop a Resource Recovery Program, " 2021 ASEE Virtual Annual Conference Content Access Proceedings, 2021. https://www.semanticscholar.org/paper/Food-to-Energy%3A-A-K12-University-Partnership-to-a-DeWaters-Grimberg/c7abad9d67848261c8c0d4cda9bb30c3c9ede3b2 (accessed Oct. 13, 2024).

[4] J. Romero, D. Dodman, O. Geden , B. Hayward, H.-O. Pörtner, and Y.-M. Wei, "Climate Change 2023 Synthesis Report, " Pakistan, 2023. Available: https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf

[5] S. Kenny et al., "From Field to Bin: The Environmental Impacts of U.S. Food Waste Management Pathways, " Oct. 2023. Accessed: Dec. 21, 2024. [Online]. Available: https://www.epa.gov/system/files/documents/2023-10/part2_wf-pathways_report_formatted_no-appendices_508-compliant.pdf

[6] M. P. Prescott, A. Grove, M. Bunning, and L. Cunningham-Sabo, "A systems examination of school food recovery in Northern Colorado, " Resources, Conservation and Recycling, vol. 154, p. 104529, Mar. 2020, doi: https://doi.org/10.1016/j.resconrec.2019.104529.

[7] R. Hodges, J. Buzby, and B. Bennett, "Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use, " The Journal of Agricultural Science, vol. 149, pp. 37–45, Feb. 2011, doi: https://doi.org/10.1017/S0021859610000936.

[8] Y. Jiang et al., "Volatile organic compounds conversion pathways and odor gas emission characteristics in chicken manure composting process, " Frontiers in Ecology and Evolution, vol. 11, May 2023, doi: https://doi.org/10.3389/fevo.2023.1192132.

[9] F. Di Maria, M. Benavoli, and M. Zoppitelli, "Thermodynamic analysis of the energy recovery from the aerobic bioconversion of solid urban waste organic fraction, " Waste Management, vol. 28, no. 5, pp. 805–812, Jan. 2008, doi: https://doi.org/10.1016/j.wasman.2007.03.021.

[10] A. Sokolovs, L. Grigans, L. Dzelzkaleja, G. Majore, and L. Bikulciene, "Heat Recovery Technologies from Aerobic Bio-degradation: From Theoretical Finding to Modeling Results, " Procedia Computer Science, vol. 77, pp. 141–150, 2015, doi: https://doi.org/10.1016/j.procs.2015.12.371.

[11] T. Higa and G. Wididana, "The Concept and Theories of Effective Microorganisms, " 1988. Available: https://www.infrc.or.jp/knf/PDF%20KNF%20Conf%20Data/C1-5-015.pdf

[12] M. R. Fontenelle et al., "Microbial Attributes of Infested Soil Suppressive to Bacterial Wilt by Bokashi Amendments, " Agricultural Sciences, vol. 06, no. 10, pp. 1239–1247, 2015, doi: https://doi.org/10.4236/as.2015.610119.

[13] L. Aguinaga et al., "Traditional Composting, Bokashi and Takakura: Efficiency in the Degradation of Organic Waste, " Chemical Enginering Transactions, vol. 100, no. 7984, 2023, doi: https://doi.org/10.3303/CET23100014.

[14] Silvina Fadda, Y. Sanz, G. Vignolo, M.-Concepción Aristoy, G. Oliver, and ToldráF., "Hydrolysis of Pork Muscle Sarcoplasmic Proteins by Lactobacillus curvatus and Lactobacillus sake, " Applied and Environmental Microbiology, vol. 65, no. 2, pp. 578–584, Feb. 1999, doi: https://doi.org/10.1128/aem.65.2.578-584.1999.

[15] M. A. Altieri, "Agroecology: the science of natural resource management for poor farmers in marginal environments, " Agriculture, Ecosystems & Environment, vol. 93, no. 1–3, pp. 1–24, Dec. 2002, doi: https://doi.org/10.1016/s0167-8809(02)00085-3.

[16] Dana Mae Christel, "The Use Of Bokashi As A Soil Fertility Amendment In Organic Spinach Cultivation, " UVM ScholarWorks, 2017. https://scholarworks.uvm.edu/graddis/678/?utm_source=scholarworks.uvm.edu%2Fgraddis%2F678&utm_medium=PDF&utm_campaign=PDFCoverPages (accessed Oct. 14, 2024).

[17] K. Hillberg, "Bokashi -kitchen waste treatment without greenhouse gas emissions?, " 2020. Available: https://stud.epsilon.slu.se/16691/3/hillberg_k_210429.pdf

[18] M. Norzaidi, S. Ambong, W. Nawawi, and N. Ramli, "Producing fertilizer from food waste recycling using berkeley and bokashi method, " PONTE International Scientific Researchs Journal, vol. 72, Jan. 2016, doi: https://doi.org/10.21506/j.ponte.2016.4.11.

[19] P. S. Lew, N. N. L. Nik Ibrahim, S. Kamarudin, N. M. Thamrin, and M. F. Misnan, "Optimization of Bokashi-Composting Process Using Effective Microorganisms-1 in Smart Composting Bin, " Sensors, vol. 21, no. 8, p. 2847, Apr. 2021, doi: https://doi.org/10.3390/s21082847.

[20] M. Olle, "Review: Bokashi technology as a promising technology for crop production in Europe, " The Journal of Horticultural Science and Biotechnology, vol. 96, pp. 1–8, Aug. 2020, doi: https://doi.org/10.1080/14620316.2020.1810140.

[21] R. Rennekamp, "Ohio Agronomy Guide 15th Edition Ohio Agronomy Guide, 15th Edition, " 2017. Available: https://stepupsoy.osu.edu/sites/hcs-soy/files/472%20Ohio%20Agronomy%20Guide%2015%20Ed%20red_0.pdf

[22] D. Mengel, "Fundamentals of soil cation exchange capacity (CEC), " Purdue.edu, 2019. https://www.extension.purdue.edu/extmedia/AY/AY-238.html

[23] C. L. Boechat, J. A. G. Santos, and A. M. de A. Accioly, "Net mineralization nitrogen and soil chemical changes with application of organic wastes with 'Fermented Bokashi Compost, '" Acta Scientiarum. Agronomy, vol. 35, no. 2, Mar. 2013, doi: https://doi.org/10.4025/actasciagron.v35i2.15133.

[24] M. Quiroz and C. Céspedes, "Bokashi as an Amendment and Source of Nitrogen in Sustainable Agricultural Systems: a Review., " Journal of Soil Science and Plant Nutrition, vol. 19, no. 1, pp. 237–248, Jan. 2019, doi: https://doi.org/10.1007/s42729-019-0009-9.

[25] K. Shin, G. van Diepen, W. Blok, and Ariena. H. C. van Bruggen, "Variability of Effective Micro-organisms (EM) in bokashi and soil and effects on soil-borne plant pathogens, " Crop Protection, vol. 99, pp. 168–176, Sep. 2017, doi: https://doi.org/10.1016/j.cropro.2017.05.025.

[26] M. S. Girvan, J. Bullimore, J. N. Pretty, A. M. Osborn, and A. S. Ball, "Soil Type Is the Primary Determinant of the Composition of the Total and Active Bacterial Communities in Arable Soils, " Applied and Environmental Microbiology, vol. 69, no. 3, pp. 1800–1809, Mar. 2003, doi: https://doi.org/10.1128/aem.69.3.1800-1809.2003.

[27] B. Formowitz, F. Elango, S. Okumoto, T. Müller, and A. Buerkert, "The role of 'effective microorganisms' in the composting of banana (Musa ssp.) residues, " Journal of Plant Nutrition and Soil Science, vol. 170, no. 5, pp. 649–656, Oct. 2007, doi: https://doi.org/10.1002/jpln.200700002.

[28] J. Mayer, S. Scheid, F. Widmer, A. Fließbach, and H.-R. Oberholzer, "How effective are 'Effective microorganisms® (EM)'? Results from a field study in temperate climate, " Applied Soil Ecology, vol. 46, no. 2, pp. 230–239, Oct. 2010, doi: https://doi.org/10.1016/j.apsoil.2010.08.007.

[29] J. Heckman, "FS839: How to Calculate the Amount of Fertilizer Needed for Your Lawn (Rutgers NJAES), " njaes. rutgers.edu, Oct. 2003. https://njaes.rutgers.edu/FS839/

[30] T. Kleiber, A. Komosa, and A. Niewiadomska, "Optimization of lawn fertilization with nitrogen. Part I. Soil resources, yield and ornamental values of turf., " ResearchGate, 2009. https://www.researchgate.net/publication/287815514_Optimization_of_lawn_fertilization_with_nitrogen_Part_I_Soil_resources_yield_and_ornamental_values_of_turf (accessed Nov. 26, 2024).

[31] F. Storino, J. S. Arizmendiarrieta, I. Irigoyen, J. Muro, and P. M. Aparicio-Tejo, "Meat waste as feedstock for home composting: Effects on the process and quality of compost, " Waste Management, vol. 56, pp. 53–62, Oct. 2016, doi: https://doi.org/10.1016/j.wasman.2016.07.004.

[32] D. Aller, K. Shahinian, and J. Amsili, "Characterization of Soil Health in Suffolk County, Long Island – What's Cropping Up? Blog, " Cornell.edu, Apr. 16, 2021. https://blogs.cornell.edu/whatscroppingup/2021/04/16/characterization-of-soil-health-in-suffolk-county-long-island/ (accessed Nov. 26, 2024).

[33] Z. Cheng, E. L. McCoy, and P. S. Grewal, "Water, sediment, and nutrient runoff from urban lawns established on disturbed subsoil or topsoil and managed with inorganic or organic fertilizers, " Urban Ecosystems, vol. 17, no. 1, pp. 277–289, Feb. 2013, doi: https://doi.org/10.1007/s11252-013-0300-9.

[34] S. Xiaohou, T. Min, J. Ping, and C. Weiling, "Effect of EM Bokashi application on control of secondary soil salinization, " Water Science and Engineering, vol. 1, no. 4, pp. 99–106, Dec. 2008, doi: https://doi.org/10.3882/j.issn.1674-2370.2008.04.011.

[35] M. Diacono and F. Montemurro, "Long-Term Effects of Organic Amendments on Soil Fertility, " Sustainable Agriculture Volume 2, vol. 2, pp. 761–786, 2011, doi: https://doi.org/10.1007/978-94-007-0394-0_34.

[36] M. Marais, Y. Smit, N. Koen, and E. Lötze, "Are the attitudes and practices of foodservice managers, catering personnel and students contributing to excessive food wastage at Stellenbosch University?, " South African Journal of Clinical Nutrition, vol. 30, no. 3, pp. 60–67, Feb. 2017, doi: https://doi.org/10.1080/16070658.2017.1267348.

[37] J. Jiménez-Antillón, C. Calleja-Amador, and L. Romero-Esquivel, "Food Waste Recovery with Takakura Portable Compost Boxes in Offices and Working Places, " Resources, vol. 7, no. 4, p. 84, Dec. 2018, doi: https://doi.org/10.3390/resources7040084.