ZIBELINE INTERNATIONAL™ PUBLISHING

Water Conservation & Management (WCM)

DOI: http://doi.org/10.26480/wcm.02.2024.164.170

ISSN: 2523-5664 (Print)
ISSN: 2523-5672 (Online)
CODEN: WCMABD

CrossMark

RESEARCH ARTICLE

WASTEWATER MANAGEMENT AND APPLICATION TO COMPOST FOR URBAN FARMING

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ARTICLE DETAILS

Article History:

Received 23 September 2023
Revised 15 October 2023
Accepted 24 November 2023
Available online 27 November 2023

ABSTRACT

While restaurants and households discharge wastewater into public sewers and rivers for many years, however, some sludge contains rich organic matter and some contains poor nutrition. To increase the sludge quality, especially oil and grease from wastewater treatment plants, co-compost with food waste should be experimented. The “Wastegetable” project of Bangkok Rooftop Farming Company on the Center One Superstore building was a social innovation to solve environmental problems. They convert the food waste to organic compost for growing organic vegetables. Thus, this research aims to study the wastewater management of the superstore and recommend composting applications from oil and grease for urban organic farming in Bangkok. This study applied the mixed research approaches of both social science and scientific approaches. The semi-structured interview will be applied with the stakeholders of urban farmers and the experiment approach will be used for the development of the composting alternative from oil and grease. The results found that there were two primary wastewater streams: water consumed for daily activities and toilet wastewater. The management of thickening sludge and grease stemming from the Center One Superstore's wastewater activities generates a significant volume. The co-compost application experiments found that grease and food waste were successful in co-composting up to 30%, while oil was successful in co-composting only 10%. The nutrition quality and heavy metal of co-composting of all experiments passed the standard of organic fertilizer by the Department of Land Development, Thailand. The policy implication for supporting this circular economy was appealed.

KEYWORDS

Grease, Oil, Organic Fertilizer, Composting Process, Urban Farmer

1. INTRODUCTION

Wastewater management is a critical global issue that poses significant challenges to public health, the environment, and sustainable development. These are some of the major global problems associated with wastewater management. The first is the urbanization and population growth, rapid urbanization and population growth strain existing wastewater treatment infrastructure, leading to inadequate service coverage and increased pollution. The second is water pollution, improper or inadequate treatment of wastewater leads to the discharge of pollutants such as heavy metals, pathogens, chemicals, and nutrients into water bodies like rivers, lakes, and oceans. This contaminates water sources, making them unsuitable for human consumption, agriculture, and ecosystem health. Finally, many places, particularly in developing nations, lack the essential infrastructure, technology, and financial resources for successful wastewater treatment. This leads to untreated or poorly treated wastewater being discharged into the environment.

Over the years, the disposal of wastewater from restaurants and individual houses into public sewers has raised concerns. These establishments often release significant amounts of fat, oil, and grease (FOG) into the sewage system, gradually reducing the capacity of public sewers (Shamsuddin et al., 2020). Grease and oil-based substances enter the sewage system either through direct dumping or escape from grease traps. These substances can solidify and form deposits on the pipe's surface, obstructing the flow of wastewater (Hussain et al., 2014). Consequently, oil and grease tend to stick to the surface of drain and sewer pipes, leading to blockages that hinder sewage flow and may result in sanitary sewer overflows (SSO). SSOs emit unpleasant odors, attract pests like bugs and rats, and can even contaminate water sources, polluting ground, and surface water. In Thailand, household wastewater accounts for about 80 percent of the water used, with an estimated daily volume of 150 liters per person and dirt content of 120 milligrams per liter (Pollution Control Department, 2012). The current methods of managing wastewater, especially oil and grease, are inefficient and fail to contribute to a circular economy (General Problem).

In recent times, there has been a shift in the waste and wastewater management approach, moving from merely disposing of trash to embracing resource recovery (Fernando-Foncillas et al., 2021). This shift is evident in wastewater treatment facilities, which are now regarded as water resource recovery facilities. The goal is to tie wastewater treatment to the production of renewable biological products, maximizing resource recovery and nutrient retrieval from wastewater as value-added products (Holmgren et al., 2016). Sewage sludge from wastewater treatment facilities holds the potential value that can be recovered in the form of energy or resources, depending on the method used (Healy et al., 2015). However, some sewage sludge contains a high concentration of organic matter (carbohydrates, proteins, and lipids) that can be biologically fermented to produce additional value-added products, while others have low nutritional levels (Fernando-Foncillas et al., 2021). These sludges must be scientifically tested by putting them composted thoroughly for a

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Cite The Article: Nuttakit Iamsomboon, Surasak Jotaworn, Wanjai Lamprom, Pimnapat Bhumkittipich, Issara Siramaneerat (2024). Wastewater Management and Application to Compost for Urban Farming. *Water Conservation & Management, 8(2): 164-170*.

wide range of people to comprehend and use the composting process in their everyday lives.

Composting is a natural process where microbes break down organic matter into simpler nutrients, enhancing the quality of sewage sludge (oil and grease) from wastewater treatment plants. Aerobic composting is a widely accepted method for stabilizing organic waste and transforming it into a valuable compost product as it is the fastest way to generate high-quality compost (Farshad Golbabaei Kootenaei et al., 2014). However, since the oil and grease from wastewater may contain unnatural components that cannot fully degrade and produce compost, co-composting with other resources could help to increase nutrients and quality products. If some of the oil and grease components were to mix with the soil, the soil quality would deteriorate, and it could become contaminated with pathogens again. In response to environmental challenges, the "Wastegetable" project by Bangkok Rooftop Farming Social Enterprise has emerged as a social innovation with private sector involvement. This project converts food waste into organic compost for growing organic vegetables, promoting productivity and generating income from a mere 200 square meters of rooftop space in the Center One Superstore building. However, this project composts only food scraps without co-composting with the sludge and direct cooking oil and grease from restaurants.

Based on the general problems described by wastewater management and the specific issues of uncertainty high and low nutrient sludge and the co-compost with cooking oil and grease by the social enterprise need to be examined, this research aims to study the wastewater management process of the superstore and its application to compost for supporting urban farming in Bangkok.

2. LITERATURE

2.1 Wastewater Management Process

The main objective of wastewater management is to reduce potential health risks associated with water waste and minimize the amount and weight of sludge generated. The process of wastewater management involves four stages: sludge formation, thickening, treatment or stabilization, dewatering, and final disposal (Figure 1).

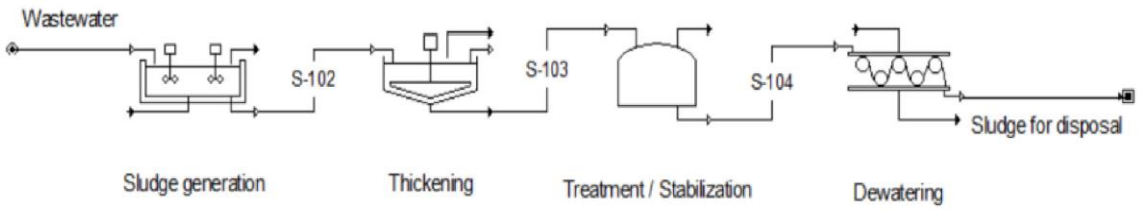

Figure 1: Scheme of sludge management

Source: (Fernando-Foncillas et al., 2021)

Figure 1 illustrates the initial step of combining wastewater from all sources in the area. The next stage involves sludge thickening, which increases the concentration of particles, thereby reducing the volume of water rapidly. Following this, the sludge is stabilized to minimize the presence of germs and eliminate unpleasant odors. Subsequently, the sewage sludge undergoes dewatering to improve waste management. The dewatered and stabilized sludge can be disposed of through various methods, such as land spreading, landfilling, or incineration. Land spreading involves applying sludge to the soil, which enhances soil structure, and water infiltration, and provides nutrients like nitrogen and phosphorus. However, it is essential to adhere to specified limits for heavy metals, nitrates, and other pollutants when using sludge on soil (Mackenzie, 2010). Furthermore, sewage sludge finds application in the cement and brick industries (Chang, 2020). This utilization of sludge helps in resource recovery and reduces the environmental impact of waste disposal.

Based on the literature review of sewage sludge management and utilization in developed countries such as those in Scandinavia, several disposal options are available after sludge treatment, including landfill, incineration, composting, agricultural use, and others. Among these options, the most prevalent practices in Scandinavia involve utilizing sludge in agricultural production, as a landfill cover, or as a fertilizer on fields. However, in contrast to the well-documented practices in developed countries, there is limited research on wastewater and sewage sludge management, particularly in developing countries like Thailand. Notably, Thailand faces significant pollution challenges, with wastewater being a major contributor to environmental degradation. The majority of wastewater is generated by industrial and commercial activities in both the public and private sectors. It is estimated that approximately 14 million cubic meters of community wastewater are produced daily in Thailand, with the district administration contributing around 9 million cubic meters, the Bangkok Metropolitan Administration (BMA) providing 2.5 million cubic meters, and the remaining 1,687 municipalities contributing 2.5 million cubic meters (Chokewinyoo and Khanayai, 2013).

Given the sludge management and utilization literature in developed countries, as well as the environmental challenges through the increasing volume of sludge production data in Thailand, it inspired multi-stakeholders to create a comprehensive solution and innovation. One of the most popular applications for sewage sludge management in Thailand is its use as fertilizer after stabilization. However, one drawback of this application is the lack of understanding regarding the appropriate composting ratio and nutrient content, resulting in sludge-based fertilizers being of lower quality compared to conventional fertilizers (Shaddel et al., 2019; Kehrein, 2020). To address this issue and improve the composting application in Thailand, this study adopts an experimental approach inspired by the co-composting process used in a superstore of Bangkok Rooftop Farming social enterprise.

2.2 Wastewater Application

Based on the sewage sludge of the superstore in Bangkok, it is the byproduct resulting from the thickening process of oil and grease derived from restaurants, food services, and shops. This sludge can be collected either manually or automatically, after its separation in grease traps. Its ultimate fate depends on local regulations, wherein it is either recycled into biodiesel or disposed of openly alongside solid waste (Almeida et al., 2017). A recent study has explored potential applications for processing and reusing oil and grease to mitigate the volume being disposed of in landfills (Hussain et al., 2014). Among various technologies aimed at recycling organic solid waste, composting has gained recognition as a low-technology and low-investment approach to converting organic solid waste into a beneficial soil supplement, known as compost (Vicencio de la Rosa et al., 2013). Composting is a biotechnological process that involves the biodegradation of organic materials by diverse microbial communities, leading to the formation of simpler nutrients and, subsequently, complex organic macromolecules such as humic acids during a secondary stage (Vicencio de la Rosa et al., 2013; Roman et al., 2013). However, composting oil and grease poses inherent challenges due to their nutrient deficiency, particularly in terms of low nitrogen and phosphorus content (Ruggieri et al., 2008). Consequently, a comprehensive investigation of various types of sludge is necessary, necessitating the design of a diverse range of experiments to achieve optimal composting results.

One of the experimental designs is to apply microorganisms naturally which facilitates the decomposition of organic matter into simpler nutrients through the process of composting. Aerobic composting, a well-established method, is employed to stabilize organic waste and convert it into a valuable compost product. This application is renowned for its efficiency in producing high-quality compost. The initial compost mixture in this study consisted of dehydrated sludge from the wastewater treatment plant, secondary sedimentation, food waste, and coconut flake (Farshad Golbabaei Kootenaei et al., 2014). To enhance the scale of composting and reduce wastewater pollution, various ratios of oil and grease were tested. Coconut flake was incorporated as an agent due to its high moisture content and the small dimensions of the inlet materials (Doublet et al., 2011). Previous research on the aerobic digestion of municipal waste sludge, combined with grease trap waste mixture, revealed that the use of high-strength wastes as co-substrates, such as grease trap waste from different commercial sites, can significantly challenge the digestion process. Such challenges manifest as a series of events leading to digester failure, including the buildup of fatty acids, sludge flotation, washout, and scum development. This research found that a higher grease trap/sludge ratio of 10% was found to promote digestion failure (Shakourifar et al., 2020). Hence, it is imperative to experiment with this gap with various ratios of grease and oil for co-composting with other components based on existing literature to better understand their effects on the composting process.

2.3 Wastewater Utilization: Urban Farmers

When the study's gap is filled up, it contributes to many stakeholders in both rural and urban areas who are interested in co-composting their food scraps and using oil or grease. The Urban Farmer initiative emerged as a collaborative effort between the Sustainable Development Network Association, a non-profit organization, and Center One Shopping Plaza Co., Ltd., in conjunction with Bangkok Rooftop Farming, a Social Enterprise. This project aimed to address the pressing issue of organic waste by implementing a green innovation approach that converts food waste into organic fertilizer. A key aspect of this endeavor involved transforming a 200 square meter rooftop area into an organic vegetable farm, utilizing food scraps converted into organic fertilizers. This integrated model exemplifies a prototype of circular development, wherein waste materials are harnessed for sustainable agricultural practices. The inaugural urban farm, named "Wastegetable," was established on the rooftop of Center One Superstore. This successful pilot project laid the foundation for a network of individuals and companies expressing interest in contributing to the expansion of urban organic farming on a circular economy framework across six areas of Bangkok. Such expansion entails the development of economic zones with multiple small agricultural areas within the same locality or community. Nevertheless, implementing this prototype or replicating it in other building areas proved challenging due to the dearth of knowledge and experience among urban agricultural entrepreneurs regarding the establishment of a vegetable farm business within the constraints of the circular economy.

Moreover, Thailand's water resources conservation network which played a crucial role in the management of rivers in urban areas can be included. The organization of this network constituted a significant component of the urban water conservation approach, as their collective drive to enhance the environment and water quality. They tried to educate people on the field of wastewater management and the composting application for the cultivation of urban agricultural ventures has been relatively understudied (Lamprom et al., 2023). Therefore, the experimental process has primarily relied on real-world limitations of urban space that households, businesses, building owners, and stakeholders can apply and are interested in participating in such innovative endeavors. This co-composting application facilitates decisions on granting space or investing in the use of space to promote green areas and a circular economy in Thailand.

3. METHODS

This research employed a mixed approach, combining both social science and scientific methods. To gain insights into the current wastewater management practices, a semi-structured interview was conducted with the superstore manager in Bangkok. Additionally, experimental methods were employed to compost oil and grease, as shown in Figure 2.

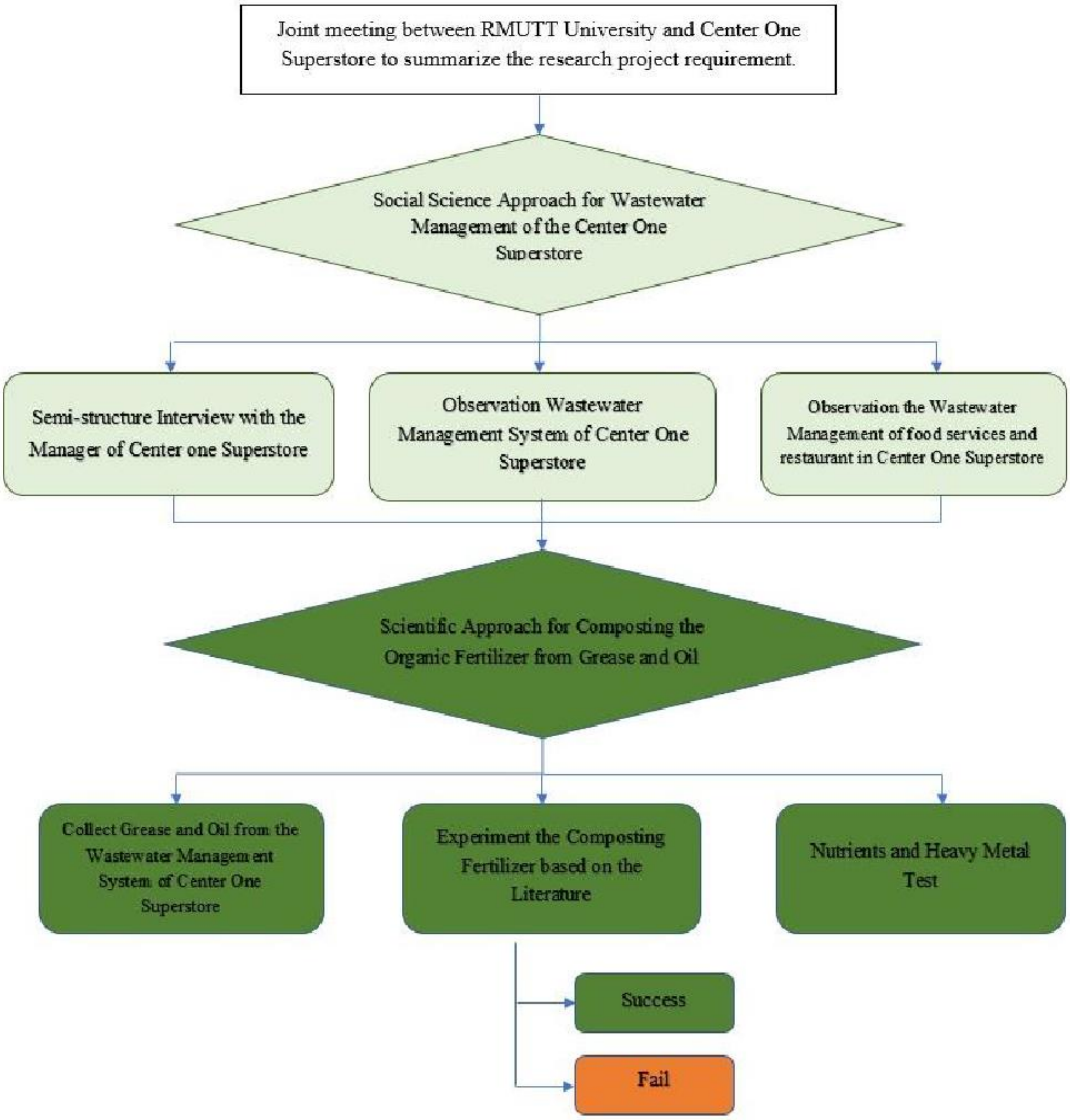

Figure 2: Research Methodological Process

3.1 Research Design

For collecting primary data, semi-structured interviews were designed to cover various aspects of wastewater management. The manager and environmental division technicians of the superstore were identified as key informants to ensure data reliability. Following the interviews, these key informants guided the researchers in observing the actual wastewater management system, including specific points within the superstore such as food shops and restaurants.

This study also involved experimental research, divided into three sets: Experiment A, Experiment B, and Control C. Experiment A consisted of grease, food waste, cow dung, and coconut husk, while Experiment B included oil, food waste, cow dung, and coconut husk. The Control C set comprised only food waste, cow dung, and coconut husk. The co-composting proportion was 1:1:1 (food waste: cow dung:c coconut husk). However, considering the literature's suggestions that an increase in grease and oil content (10%) could hinder composting, Experiment A and B sets introduced a ratio of 1-3 parts of grease and oil to co-compost with 1 part food waste, 1 part cow dung, and 1 part coconut husk, as depicted in Figure 3.

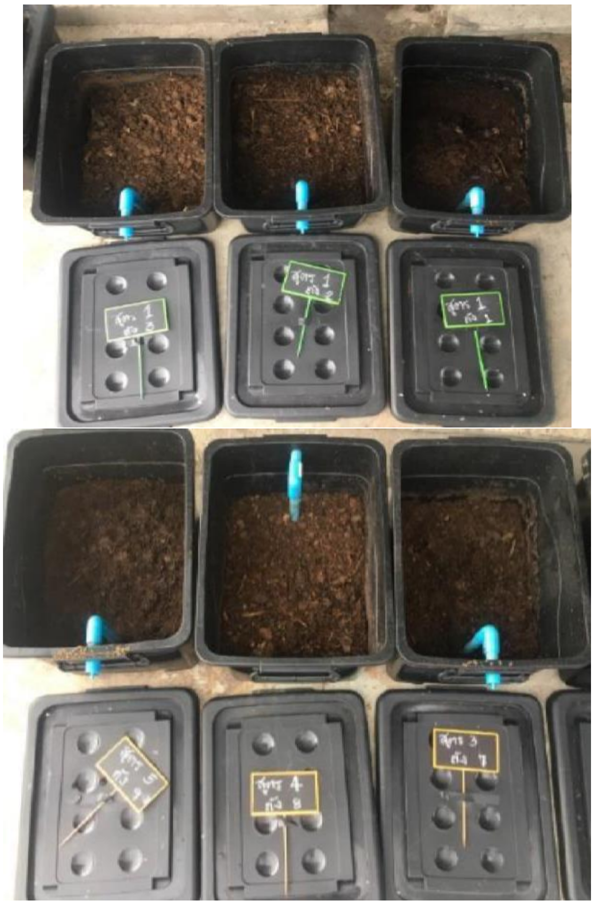

Figure 3: the Experimental Design for Composting the Organic Fertilizer.

Figure 3 illustrates the different proportions of the main components (grease, oil, and food waste) in different boxes of both the experiment and control sets. To ensure the success of urban farming, factors like space, moisture, and smell were considered, and an appropriate composting box with a perforated design was selected to facilitate aerobic digestion during the composting process.

3.2 Data Collection

3.2.1 Social Science: Interview and Observation

The results of semi-structured interviews and observations were meticulously recorded and transcribed to form a comprehensive overview of wastewater management at the Center One superstore in Bangkok. The interviews were conducted face-to-face with key informants from April to May 2022.

3.2.2 Scientific: Co-composting Experiment

The thickened grease or the grease trap waste mixture (GTWM) was provided by the wastewater treatment system of Center One Superstore located in the middle of Bangkok, Thailand. GTWM was collected from the mix of various food processing services (i.e. fast food restaurants, coffee shops, bakeries, meat/butcher shops, seafood places, etc.) of the Center One Superstore. It was stored in the tanks which are located on the ground floor of the superstore.

The used oil was collected by the restaurant in the food court directly. The cooking oil was washed out by water in the sink of all the restaurants. Based on the Government Gazette Announcement of the Ministry of Public Health: Determining the Business Operations to Provide Grease Traps 2022, It enforced all food services and restaurants to install grease traps under the sink. When the used oil was stored for a week, it would thicken up, then the staff collected and put it in the trash bag for throwing to the waste store of Center One superstore. It will harm the health of scavengers and increase the carbon emission in a landfill later. To decrease this situation, the food services, and restaurants where cooking by order, a la carte, and fast-food cooking, will be provided the bottles to store the used oil.

3.3 Data Analysis

The content analysis method was applied to validate the information obtained through semi-structured interviews. Observations of the superstore's wastewater management operation were also conducted to ensure data reliability. In the composting analysis, physical and chemical assessments were performed on parameters such as temperature, Nitrogen (N), Phosphorus (P), Potassium (K), Copper (Cu), Cadmium (Cd), and Lead (Pb). Based on the standard organic fertilizer, the Department of Land Development has defined the nutrition ratio as follows;

- Total nitrogen (N) not less than 1.00% by weight,
- Total phosphate (P2O5) not less than 0.50% by weight,
- Total potash (K2O) not less than 0.50% by weight.

In terms of heavy metal, the Department of Land Development has defined as follows:

- Cadmium (Cd) not more than 5 mg/kg,
- Copper (Cu) not more than 500 mg/kg,
- Lead (Pb) not more than 500 mg/kg

4. Results

4.1 Wastewater Management of Center One Superstore in Bangkok

From the semi-structured interview and observation with the manager and technician staff of Center One Superstore, the wastewater management process uses oxygen from an aerator installed in buoyancy or attached to a platform to add enough oxygen to the water for microorganisms. This process can be used to decompose organic matter in wastewater faster than allowing it to decompose naturally. The aeration pond wastewater treatment system can effectively treat wastewater by using microorganisms under aerobic conditions as shown in Figure 3.

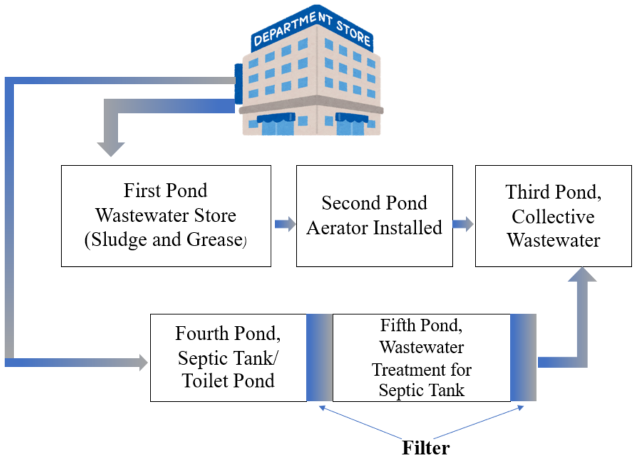

Figure 3: Wastewater Management of Center One Superstore

Figure 3 shows the process of used water flow into the wastewater management system, there were two channels of wastewater flowing:

water consumption and toilet water. The water consumption from food service, shops, and restaurants in the Center One Superstore flows to the first pond (wastewater store), the aeration pond is the second process to fill up the oxygen for digestion of the sludge. Finally, the third pond is the sewage treatment pond which combines all used water to treat before release. Meanwhile, the toilet water flows straight to the fourth pond which is the septic pong. It filters the sewage before releasing it as well.

Based on the semi-structured interview, it was found that thickening sludge or grease generated from the first pond (wastewater store) is a large amount. The Center One Superstore uses the service of the Bangkok Metropolitan Administration (BMA) to pump sludge and grease every 3 months. The amount of sludge and grease sludge is 10 cubic meters, on average per 1 pumping. The ratio is 6 (sludge/grease): 4 (septic waste). This was an opportunity to reduce the amount of sludge and grease for creating organic fertilizer.

4.2 Wastewater Management of Food Services, Restaurants, and Others in Center One Superstore

From interviewing and observing wastewater management of food services, restaurants, and shops in Center One Superstore, it was discovered that grease traps were installed in every unit of the food services inside the superstore, including the dishwasher area of the food court zone, as shown in Figure 4.

Figure 4: Grease Trap in Restaurants of Center One Superstore

Figure 4 describes that there will be no grease residue from the dishwashing area because the staff must clean and scrub every day for hygienic use of vehicles, plates, bowls, spoons, drills, and consumables and follow the policy of the Center One superstore as well. However, oil and grease from food services; a la carte restaurants, rice and curry restaurants, and other types in the food court can be found in large amounts every week which is caused by the cook of food. The method of managing such oil and grease residues was scooping them up into black bags every day. Not all employees know that cooking fat such as oil and grease can be used to create added value or another circular product.

4.3 Composting Application Experiment

There were several conditions to monitor for making reliable and valid composting experiments. Time condition, it was starting to compost on May 10, 2022, with a time limit of 30 days, June 10, 2022, will be inspected. If one of the experiments A, B, and control C were successful in composting, it will be tested for nutrition and heavy metal for growing plants further. Finally, the temperature was measured and the digestion was observed with the appearance of the fungus every 5 days. From measuring the temperature and observing the microorganisms that help digest the fertilizer, it was found that there was a fluctuating temperature during the composting process, and the occurrence of white fungus was different.

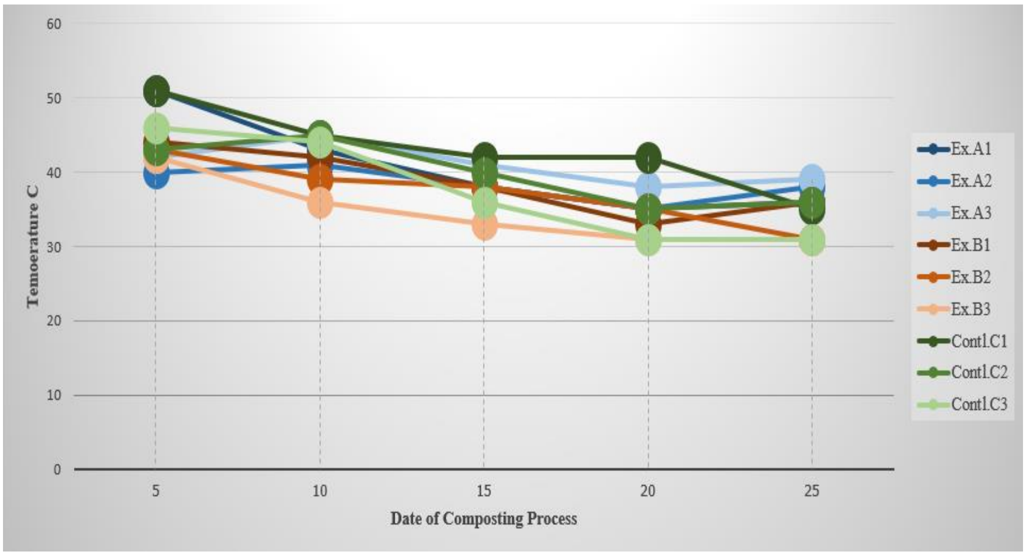

Figure 5: Temperature Change inside the Compost during 30 days

Figure 5 shows the results of the 30-day composting experiment, it was found that Experiment A1-3 composting boxes were successful in digestion. The temperature would increase after 5-7 days of fermentation and gradually decrease in sequence until the condition is similar to the soil in the end. While the Experiment B2-3 composting process failed, the humidity was high due to the addition of 20%-30% of the used oil. It made the temperature greatly reduced and the digestion process of fungus was not formed. The Compost of Control. C1-3 successful composting process even with its high moisture content.

Cite The Article: Nuttakit Iamsomboon, Surasak Jotaworn, Wanjai Lamprom, Pimnapat Bhumkittipich, Issara Siramaneerat (2024).
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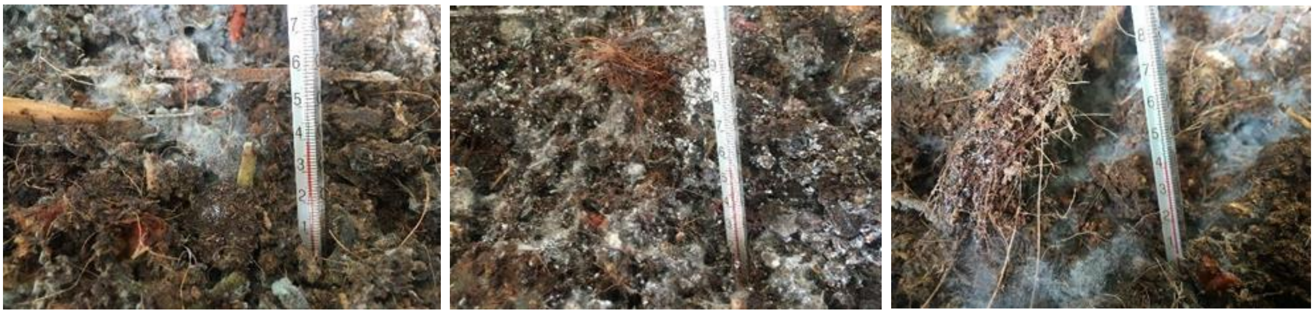

Figure 6: White Fungus during the Composting Process

Figure 6 shows that the white fungus produced during fermentation was noticeably different in appearance. The experimental boxes A1-3 were a spreading filament. While the experimental boxes B1-3 were granular and scattered in dots all over the fermentation box. Finally, the control boxes C1-3 have a spreading form of white fungus similar to experimental box A. It can be summarized that the fungus characteristics are related to the success and failure of digestion in the organic composting process.

When the composting process reaches 30 days, it will check the success and failure of digestion for being a fertilizer. The result found that Experiment A1-3 succeeded in composting, Experiment B1 was successful, while B2-3 failed to compost an organic fertilizer. Finally, the control C1-3 successfully digests. Thus, the first box of experiments A, B, and control C tested the nutrition and heavy metal for further analysis of the quality of organic fertilizer from food waste, grease, and oil.

Table 1: Nutrition and Heavy Metal Test of Composting Fertilizer

Lists	Experiment A	Experiment B	Control C
Nitrogen (N)	1.90%	1.60%	1.40%
Potassium (P)	0.70%	0.70%	0.90%
Phosphorus (K)	1.10%	1.30%	0.88%
Cadmium (Cd)	0.035 mg/kg	0.051 mg/kg	0.045 mg/kg
Copper (Cu)	17.472 mg/kg	17.308 mg/kg	50.462 mg/kg
Lead (Pb)	1.1 mg/kg	1.267mg/kg	26.2 mg/kg

Note: Experiments A1, B1, and control C1 were used to investigate nutrition and heavy metal

Table 1 describes that samples 1 kg from the first box of experiments A, B, and control C were sent to the lab for testing the nutrition and metal. The result found that experiment A (grease) was the highest nitrogen at 1.90%, followed by experiment B (oil) at 1.60%, and control C (no addition element, food waste only) at 1.40%. While potassium, the highest was the control C at 0.90%, followed by experiments A and B at 0.70%. Finally, the highest phosphorus was in Experiment B at 1.30%, followed by Experiment A at 1.10% and Control C at 0.88%. For the heavy metal, cadmium found in the oil compost of experiment B was the highest ratio at .051 mg/kg, followed by the control C at .045 mg/kg and grease compost from experiment A at .035 mg/kg. Finally, the copper and lead were found to have the highest ratio from control C at 50.462 mg/kg and 26.2 mg/kg, while experiments A and B followed in a similar ratio.

5. Discussions

Based on the empirical result, the nutrition and heavy metal test passed the standard of organic fertilizer by the Department of Land Development (section 3.3. Data Analysis). Total nitrogen should not be less than 1% by weight, the result revealed that nitrogen from all sampling was higher than the defined number (1.9%, 1.6%, and 1.4%). Total phosphate should not be less than 0.50% by weight, all the experiment and control sets had a higher value (0.70%, 0.70%, and 0.90%). Total potash should not be less than 0.50% by weight; it was found to have a higher result than the defined number at 1.10%, 1.30%, and 0.88%, respectively. For the heavy metal that can severely harm the health of consumers and plants, the Cadmium must not exceed 5 mg/kg, it all passed the standard at 0.035 mg/kg, 0.051 mg/kg, and 0.045 mg/kg. The copper must not exceed 500 mg/kg, it passed the standard at 17.47 mg/kg, 17.30 mg/kg, and 50.46 mg/kg. Finally, the lead must not exceed 500 mg/kg with all findings passed at 1.1 mg/kg, 1.26 mg/kg, and 26.2 mg/kg. In literature, composting oil and grease is inherently difficult due to their nutrient deficiency, with especially low nitrogen and phosphorous content (Ruggieri et al., 2008), this fact was argued by this empirical result which passed the standard of organic fertilizer from the Department of Land Development, Thailand.

Based on the experiment design, the different volumes of grease, oil, and food waste must succeed in composting by 30 days. The characteristics of composted stuff, temperature, and fungus were used to consider. The experiment found that the experiment A1-3 which added the grease from 10% to 30% was success composting, while the experiment B1 from oil was success composting which added 10%. Finally, control C which added the food waste from 10% to 30% was successful in composting. Thus, the literature on a 10% increased ratio of grease trap /sludge supports failure digestion (Shakourifar et al., 2020). This study was consistent with the oil composting in experiment B. The moisture of oil influenced the temperature during the digestion process. It can be seen a dramatic decrease in temperature in experiments B2 and B3. Finally, the fungus from fermentation was different from others. Thus, adding oil up to 20% and 30% has supported the failure of composting. In contrast, adding more grease and food waste from 10%-30% did not influence digestion. To sum up, adding more different types of ingredients to compost the fertilizer depends on the humidity. If that component has high humidity such as oil, it can fail to compost in the end.

Based on the proportion of the control group, the first box (C1) comprised; food waste (1); cow dung (1): and coconut husk (1). This proportion is the foundation of all types of experiments. The result found that this proportion can lead to the success of composting. This basic proportion was challenged by adding other types of components (grease and oil) and increasing 10% of food waste and other types of components. There was still success in composting every box of grease and food waste, except the oil which succeeded in only one box. Thus, A disadvantage of this approach is the lack of information regarding a valid proportion mixture for creating organic fertilizer, nutrient content which makes sludge a low-quality fertilizer in the literature (Shaddel et al., 2019; Kehrein, 2020) was solved by this study. This proportion will be applied to other types of composting for creating organic fertilizer.

Bangkok Rooftop Farming Company produces organic fertilizer with food waste from the Center One superstore up to 1,400 kg/month. It helps to reduce environmental problems caused by food waste in the landfill such as methane, greenhouse gas emission, and the disease from sanitation. This study provided the maximum in co-composting which can add up to 30% of the grease from wastewater. When compared to the monthly fertilizer production of Bangkok Rooftop Farming Company, grease will be used in the production of up to 420 kg/month. Based on the interview with the manager of the Center One superstore, it was found that every 3 months, they will use the sewage sanction truck of Bangkok Metropolitan to manage the grease and sludge of the superstore approximately 10 cubic meters per time. Thus, if the grease of wastewater was utilized in the organic fertilizer process, it would reduce the grease up to 1,260 kg, or almost 1 cubic per time. The results of this research contributed both academically and practically to oil and grease composting from wastewater into the organic fertilizer production process on the rooftop of Center One superstore by Bangkok Rooftop Farming Company. Thus, the policy implication for supporting this research implementation is as follows:

- Collaborative policy among Bangkok Rooftop Company, Center One Superstore, and research institutions for supporting the development of alternative organic fertilizer, applying technology, and utilizing the benefit of the research,
- Incentive policy for inspiring the restaurants, food service, and community around to participate the composting organic fertilizer from grease, oil, and food waste,
- Environmental policy for setting the goal of reducing the grease, oil, and food waste from waste and wastewater into the river.

6. Conclusions

Over the years, the issue of restaurants and households releasing wastewater containing fat, oil, and grease into public sewers has persisted. Interestingly, sewage sludge exhibits varying levels of organic content, with some being rich while others are nutrient-deficient. To enhance the quality of sewage sludge, particularly concerning oil and grease derived from wastewater treatment facilities, it is imperative to comprehensively examine wastewater management processes and introduce co-composting applications to benefit urban farmers. This research aims to study wastewater management and recommend a co-composting application tailored to oil and grease for urban organic farming in Bangkok.

The research findings revealed two primary wastewater streams: water consumed for daily activities and toilet wastewater. The water used in food service establishments, shops, and restaurants within the Center One Superstore is directed to the initial pond, which serves as a wastewater reservoir. Subsequently, the aeration pond represents the second phase, where oxygen is infused to facilitate sludge decomposition. The third pond acts as the sewage treatment facility, merging all utilized water for comprehensive treatment before discharge. In contrast, toilet wastewater flows directly to the fourth pond, serving as a septic tank, where sewage is filtered before release. Notably, the management of thickening sludge and grease stemming from the Center One Superstore's wastewater activities generates a significant volume. To address this, the Bangkok Metropolitan Administration (BMA) is enlisted to pump out sludge and grease every three months. On average, each pumping operation handles 10 cubic meters, with a ratio of 6 (sludge/grease) to 4 (septic waste). Simultaneously, a substantial amount of used cooking oil from various food service establishments, such as a la carte restaurants, rice and curry joints, and other food court vendors, accumulates weekly. These oils are typically discarded as wet waste, collected in black bags, devoid of any value-added products or integration into a circular economy.

Through the co-compost application experiments, it was observed that experiment A1-3, focusing on grease, successfully produced compost. Conversely, experiment B2-3, centered on oil, encountered challenges, mainly due to elevated humidity resulting from the addition of 20%-30% used oil. Meanwhile, control C1-3, which incorporated food waste as the base component, effectively underwent the composting process. In terms of nutritional quality, all variations involving the addition of components (grease and oil) and the fundamental component of food waste met the organic fertilizer standards set by the Department of Land Development in Thailand. Furthermore, the investigation into heavy metal content revealed levels within permissible limits, ensuring safe use for urban farming and consumption.

The Bangkok Rooftop Farming Company faces certain constraints due to its rooftop farming operation at the Center One Superstore. Challenges include concerns about odor and moisture control in this confined space, significantly influencing the composting experiment's design. Another hurdle arises from the logistical aspects of transporting grease from the wastewater treatment plant, which is situated on the ground floor, to the rooftop experiment area. Scaling up the production of organic fertilizer derived from grease proves to be a formidable task in this context. For future research, it is recommended to explore additional wastewater sources that local authorities monitor, such as water hyacinth and duckweed. These aquatic plants proliferate rapidly in oil, grease, and coliform-contaminated water bodies, blocking sunlight and depleting oxygen levels, ultimately harming water quality and biodiversity. The current method of managing these plants involves dredging and depositing them on the canal floor for natural decomposition. There is potential to establish a new circular economy by transforming these plants into a novel compost recipe suitable for growing vegetables.

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