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Daily life waste materials: Transforming kitchen leftovers into sustainable organic fertilizers for enhanced plant growth

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Abstract

With the increasing awareness of environmental friendliness in agriculture, there is a growing concern about the harmful effects of chemical fertilizers. As a result, alternative methods are being sought that enhance plant growth and improve soil health without harming the environment. This paper discusses waste materials used in daily life, such as banana peels, tea leaves, egg shells, coffee grounds, and other vegetable or fruit residues, which can be easily converted into organic fertilizers. The paper discusses the nutritional value of these materials, such as potassium, nitrogen, phosphorus, and calcium, which help in healthy plant growth and root strength. It explains how these materials improve soil microbial activity and help in providing the right amount of nutrients required by plants. In addition, the method of converting waste materials into compost or directly applying them to the soil is also explained in detail. This method not only reduces waste, but also acts as an environmentally friendly and effective method in agriculture, which can prove to be a sustainable and cost-effective alternative for farming. Through this method, it is possible to maintain environmental balance along with agriculture and can be profitable for farmers, which will usher in a new era in agriculture.

Keywords: Daily Life Waste; Kitchen Leftovers; Organic Fertilizers; Plant Growth

1. Introduction

Increased production, environmental protection and food security have become important goals in the current global agricultural system. However, one of the biggest problems associated with the global agricultural production system is the excessive use of chemical fertilizers, which is having a serious impact on soil, water and the environment. Due to chemical fertilizers, soil nutrition and health are being damaged, and this is reducing crop yields, which is becoming a major challenge for farmers. For this reason, the need for a sustainable and environmentally friendly alternative for agriculture has become very clear [1]. Here, the idea of producing organic fertilizer from everyday kitchen waste has come to the fore as a potential alternative. Kitchen waste such as fruit peels, vegetable scraps, tea leaves, egg shells, etc. are usually thrown away, but they contain very valuable nutrients such as nitrogen, phosphorus, potassium and other micronutrients, which are very beneficial for plant growth. About 50%–70% of the waste associated with the daily lives of people worldwide is food-related, most of which is known as kitchen waste. This waste is usually disposed of or burned somewhere, which causes excess gas and pollution in the environment. However, if this waste can be processed properly, it can be a great resource for agriculture. This will not only reduce the waste, but it will also be possible to convert this waste into effective organic fertilizer that will increase plant growth and soil fertility [2].

In fact, the idea of converting kitchen waste into organic fertilizer is an important step towards establishing a sustainable agricultural system. While on the one hand it reduces pollution on the environment, on the other hand it can provide low-cost nutritious fertilizer for farmers, which will help improve plant growth and yield. For example,

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various types of waste such as fruit peels, vegetable scraps, tea leaves, coffee grounds, egg shells, etc. can be used to make daily fertilizer, which is more cost-effective and environmentally friendly than chemical fertilizers. The use of chemical fertilizers in global agriculture is increasing greatly, but it is not sustainable for long-term productivity and the environment. Chemical fertilizers quickly deplete the soil of nutrients and increase the acidity level of the soil, which helps reduce plant growth and yield. In addition, greenhouse gas emissions increase, which can create a crisis due to global warming and climate change. Therefore, the use of natural and environmentally friendly fertilizers is very important for sustainable agriculture [3].

In this context, the idea of making affordable and environmentally friendly fertilizer from kitchen waste can be very effective. On the one hand, this will solve the waste management problem, and on the other hand, it will increase soil nutrients and improve agriculture. Currently, through various research and projects, a lot of important information is available about the use of kitchen waste as organic fertilizer, which proves the effectiveness of this idea [4]. In addition, if you want to properly convert kitchen waste into organic fertilizer, this can be done through composting, vermicomposting, liquid fertilizer preparation, and other processes. Composting is a very effective method, where fertilizer is made by decomposing tree bark, vegetable scraps, and other waste. In the vermicomposting method, this waste is converted into rich fertilizer for the soil using earthworms. Similarly, some kitchen wastes such as banana peels and tea leaves can be used as liquid fertilizers, which are helpful in increasing the growth of leaves and roots of plants. In addition, there are challenges and limitations in using fertilizers, such as some wastes can be difficult to process, or they can cause odor and pest infestation due to improper decomposition. However, these problems can be solved through technological advancements and new methods. Many new studies are testing innovative methods to make kitchen waste more effective fertilizers [5].

In addition, it is possible to revolutionize agriculture through agricultural research by properly using kitchen waste as organic fertilizers. This will increase the income source of farmers on the one hand, and on the other hand, it will also bring positive results for the environment. Making organic fertilizers from kitchen waste can create a clear path for sustainable agricultural development, which will bring an integrated improvement for the environment, farmers and society [6]. Through this study, we will discuss in detail the process of making organic fertilizers from kitchen waste and its benefits. How this waste can be properly converted and how it can increase production in agriculture.

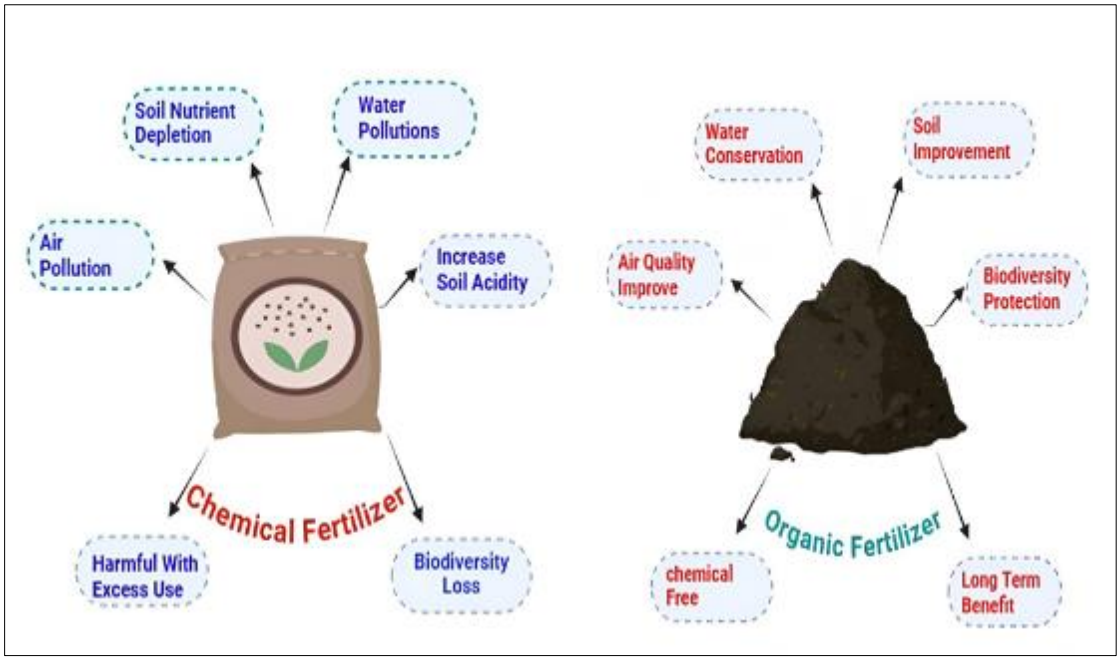

Figure 1 Showing effect of natural Organic manure and Chemical fertilizer comparison on environment

2. Kitchen waste that can be used as organic fertilizer

It is possible to properly make organic fertilizer from kitchen waste, and through this, a positive impact can be made on the environment. Kitchen waste is an unused resource that is mainly left after food consumption and it contains various types of nutrients that are very beneficial for plants. Here are some common kitchen wastes and their benefits:

- Fruit peels: Fruit peels such as banana, apple, papaya, etc. are easily available and contain a lot of potassium, which is very important for the flowering and fruiting of plants. Banana peels act as a balanced source of nutrients and help increase soil fertility. Since it decomposes quickly, it easily mixes with the soil and provides nutrients to the roots of plants.
- Vegetable scraps: Wastes from carrots, beans, peas, tomatoes, etc. are also very beneficial. They contain a lot of nitrogen, phosphorus, and magnesium, which help in the growth of leaves, roots, and flowers of plants. The decomposition process of vegetable scraps is easy and fast, which helps in controlling the pH of the soil. It improves soil health and reduces soil acidity [7].
- Eggshells: Eggshells are an excellent source of calcium for plants. They help in balancing the pH of the soil and help in the development of plant roots. When eggshells are used as part of fertilizer, they maintain the fertility and nutritional balance of the soil. In particular, they provide energy for the plant roots [8].
- Tea leaves and coffee grounds: Tea leaves and coffee grounds are also very beneficial for the soil. They contain acidic elements and nitrogen, which help in improving the growth of plant leaves and organic matter. In addition, these elements increase the acidity of the soil, which can be especially beneficial for plants that prefer acidic soil [9].
- Nut and nut shells: Various types of nut shells such as walnuts, cashew nuts, etc. contain high quality nutrients. Although their decomposition process is a bit slow, they provide important mineral elements for the soil.

In addition, vegetable and fruit juices, smoothie leftovers, various types of crisp foods (such as bread, cakes, etc.), and bakery products can be decomposed in various ways and used to make fertilizer for plants [10].

Table 1 Nutrient composition of daily life waste materials used as organic fertilizer basis on fresh weight

Kitchen Waste Materials	Nitrogen (N) %	Phosphorus (P) %	Potassium (K) %	Calcium (Ca) %	Magnesium (Mg) %	Sulfur (S) %	Ref.
Banana, Apple	0.1 – 0.11	0.03-0.05	0.7-0. 8	0.3- 0.5	0.02 - 0.05	0.01-0.02	[3]
Cucumber, Carrot	0.3 - 0.6	0.1 - 0.4	0.3 - 0.7	0.02- 0.08	0.03 - 0.06	0.02- 0.04	[9]
Tea Leaves	3 - 5	0.2 - 0.4	1 - 2	0.1 - 0.3	0.05 - 0.1	0.03 - 0.1	[11]
Potato (Ripe)	0.2 - 0.4	0.1 - 0.3	0.4 - 0.6	0.05 - 0.1	0.02 - 0.04	0.02- 0.05	[12]
Oil Residues	0.1 - 0.3	0.05 - 0.1	0.2 - 0.4	0.01- 0.03	0.01 - 0.03	0.01- 0.02	[13]
Eggshells	0.1 - 0.3	0.02 - 0.05	0.2 - 0.5	30 - 40% (Ca)	0.05 - 0.2	0.1 - 0.2	[14]
Orange and Guava	0.1 - 0.4	0.05 - 0.2	0.3 - 0.6	0.02- 0.08	0.03 - 0.05	0.02- 0.05	[15]
Coffee Grounds	0.2 – 0.5	0.1 - 0.3	1 - 1.5	0.1 - 0.3	0.05 - 0.1	0.02- 0.05	[16]
Rice Husk	0.5 - 1	0.3 - 0.5	0.4 - 0.7	0.02- 0.05	0.03 - 0.06	0.02- 0.04	[17]
Papaya Peels	0.3 - 0.6	0.1 - 0.3	0.4 - 0.7	0.02- 0.05	0.03 - 0.06	0.02- 0.04	[18]
Popcorn Husks	0.1 - 0.2	0.05 - 0.1	0.3 - 0.5	0.01- 0.02	0.02 - 0.04	0.01- 0.03	[19]

The above value might change significantly when dried. As drying reduces moisture and increase nutrients concentrations per unit weight.

3. Process of converting kitchen waste into organic fertilizer

The process of converting kitchen waste into effective organic fertilizer is an environmentally friendly and sustainable approach that can play a special role in agriculture. Kitchen waste management not only helps in reducing waste but also helps in adding nutrients to agricultural production. In this section, we will discuss in detail how to process various kitchen wastes into organic fertilizer. The main methods include composting, vermicomposting, and liquid composting.

- **Composting:** Composting is a natural method by which kitchen wastes such as fruit peels, vegetable scraps, tea leaves, egg shells, etc. are collected and processed. In this process, the wastes decompose together in the presence of soil and oxygen and turn into a nutritious organic fertilizer. To make compost, first a place must be selected, where there are necessary conditions for plant growth and waste processing [20].

- Waste collection: Kitchen waste such as fruit peels, vegetable scraps, egg shells, etc. should be collected. Since these wastes are biodegradable, they easily mix with the soil.
- Oxygen and soil mixture: These can be mixed with some amount of dry leaves, grass, or wood chips. This will help increase soil fertility and ensure proper oxygen supply.
- Decomposition process: Over time, the wastes decompose and create a type of fresh organic fertilizer, which is able to add nutrients to the roots of plants and soil. This method of fertilizer usually takes 3-6 months to complete.

The advantage of compost is that it is a completely natural and environmentally friendly method. It controls the pH of the soil, improves soil structure and helps in the growth of plant roots.

- **Vermicomposting:** Vermicomposting is an advanced method where earthworms are used to decompose kitchen waste. Earthworms move underground and decompose the waste to produce organic fertilizer from it. In this method, earthworms eat waste and after their digestion process, they produce a nutritious fertilizer [21].
- Earthworm collection: In the vermicomposting method, first some earthworms have to be collected. They are usually found in the soil of the field or in the compost pile.
- Waste preparation: Kitchen waste such as fruit peels, vegetable scraps, and tea leaves can be used as food for earthworms. These wastes go through the digestion process of the earthworms and after decomposition, they become natural fertilizer.
- Earthworm process: After the earthworms eat the waste, a decomposition process takes place inside their stomachs and this decomposed material becomes a vermicompost fertilizer that is very beneficial for the soil.

Vermicomposting is a fast process, where high-quality organic fertilizer can be prepared in a short time. The fertilizer prepared in this method is very beneficial for the growth of plants and it helps in restoring the nutrients in the soil [21].

- **Liquid Composting:** Liquid composting is a method of making liquid fertilizer that can be made from kitchen waste. In this method, various wastes such as banana peels, tea leaves, coffee grounds, etc. are soaked in water, and then liquid fertilizer is made which can be applied directly to the roots of the plants.
- Waste selection: Some wastes such as banana peels and tea leaves are biodegradable and suitable for making liquid fertilizer. These wastes are soaked in water in a container.
- Liquid fertilizer making process: After soaking the waste in water, this water will be ready as liquid fertilizer within a few days. This will help provide nutrients to the roots and leaves of the plants.
- Benefits for plants: This type of liquid fertilizer is helpful in improving the leaves and roots of the plants and helps in accelerating the growth of the plants.

The advantage of this method is that it is quick and easy to use. It is very beneficial for the leaves and roots of the plants and helps in accelerating the growth of the plants [22].

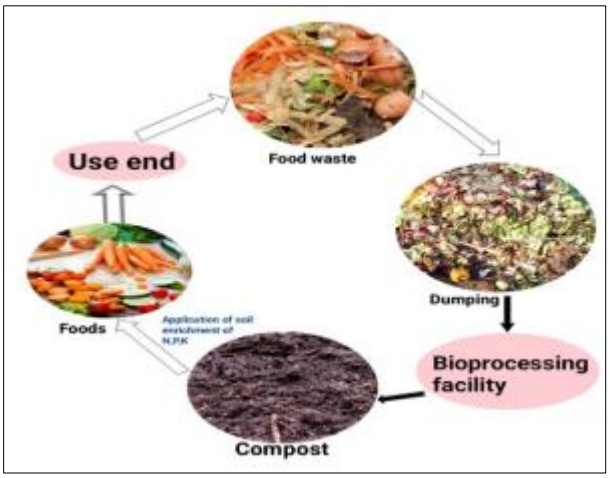

Figure 2 Showing one Process of making compost from kitchen waste

4. Plant growth of using kitchen waste

Organic fertilizer made from kitchen waste can play an important role in plant growth and agricultural development. Natural fertilizers contain various nutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium, which are helpful in increasing the growth of plant roots, leaves, branches, and flowers. To make this fertilizer from kitchen waste, the process must be done correctly, so that all the nutrients required by the plant are present in the right amount [23].

Plant growth and nutritional requirements: Various nutrients are very important for the growth and development of plants. Especially nitrogen, phosphorus, and potassium are the main elements that help in maintaining the growth and strength of plants, while minor elements such as iron, zinc, and magnesium also play an effective role in maintaining the health of plants. These elements are naturally found in fertilizers made from kitchen waste, which help in increasing the strength of the roots, leaves, and flowers of plants. In addition, the organic matter in compost made from kitchen waste increases the organic content of the soil, improves soil structure and water retention, which is very beneficial for plant roots [24].

Fertilizer Process and Plant Root Structure: As easily as we can make compost or vermicompost from kitchen waste, it can be beneficial for plant root growth. Kitchen waste fertilizer encourages the natural growth of plant roots, as it strengthens the natural elements in the soil in addition to increasing soil health. When the roots are strong, they can absorb more nutrients, thus accelerating plant growth. The use of kitchen waste fertilizer controls the pH of the soil and through it, the roots of the plant flow deeply into the soil, which is very important for the strength of the plant [25].

Comparison of kitchen waste fertilizer and chemical fertilizer: There is a big difference between organic fertilizer and chemical fertilizer. While chemical fertilizers may help plants grow immediately, they can have a negative impact on soil structure and biodiversity. On the other hand, organic fertilizers made from kitchen waste provide long-term benefits. They help maintain soil fertility and stabilize soil health. The advantage of compost fertilizer is that it meets the nutrient needs of the soil and does not use any chemicals or unnatural ingredients. As a result, the strength of the roots and other parts of the plant increases and it is more beneficial for increasing the yield of the plant[26] .

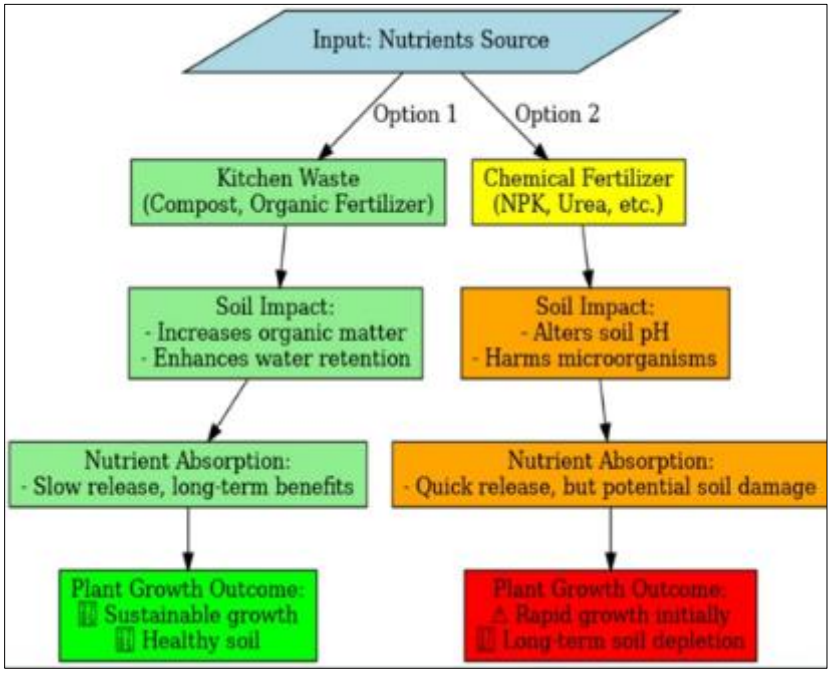

Figure 3 This is a flowchart showing the effects of kitchen waste fertilizer and chemical fertilizers on plant growth

Plant Yield and Root Structure: The use of kitchen waste fertilizer can increase the yield of the plant and strengthen the root structure. Specifically, the fertilizer made from kitchen waste increases the amount of organic matter in the soil, which is helpful for the growth of the plant roots. It improves root growth and increases the height and yield of the plant by properly absorbing nutrients. For example, some studies have shown that the use of kitchen waste fertilizer increases

the size and quantity of the fruit of the plant and also improves the health of the roots. This increases the water holding capacity of the soil, which helps the roots of the plant grow better in dry conditions.

Kitchen waste fertilizer to meet the nutritional needs: Furthermore, fertilizer made from kitchen waste plays an important role in meeting the nutritional needs. Fertilizer made from kitchen waste adds elements like nitrogen, phosphorus and potassium to the soil, which increase the health of the roots, leaves, branches and flowers of the plant. Among these, nitrogen helps in the growth of branches and leaves of the plant, phosphorus helps in the production of flowers and fruits, and potassium helps in increasing the strength of the entire body of the plant. The natural supply of these elements through fertilizer from kitchen waste provides healthy growth to the roots and other parts of the plant [27].

"This flowchart shows how Kitchen Waste and Chemical Fertilizer affect plant growth. Kitchen Waste increases the organic matter of the soil, ensuring sustainable growth in the long term. On the other hand, Chemical Fertilizer, while providing immediate nutrients, can damage the health of the soil in the long term. The flowchart explains the difference between these two sources in a simple way [28]."

5. Challenges and Limitations of Composting

While the process of making organic compost from kitchen waste is environmentally friendly and sustainable, it also has some challenges and limitations. In this section, we will discuss the challenges that can hinder the process of composting from kitchen waste. These include lack of suitable materials, insufficient space for the process, and lack of public awareness. In addition, the time required for composting, selection of the right materials, and lack of technology and equipment to increase the efficiency of the process will also be highlighted in this section.

- Lack of Suitable Materials: To make organic compost from kitchen waste, first of all, suitable waste materials must be collected. However, many times, kitchen wastes are obsolete or cannot be processed properly. For example, excess oil, meat waste, or some other solid material that does not decompose quickly. Such waste can hinder the production of compost. Most of the time, these materials are difficult to process and are not suitable for composting or vermicomposting methods [29].
- Lack of adequate space for processing: The process of making organic fertilizer from kitchen waste properly requires some space. In many urban areas where there is a shortage of space, it is difficult to find the necessary space for waste processing. To properly process waste, an open space is needed where the waste can be properly updated and oxygenated. In addition, vermicomposting and composting require space and the right environment, which is not possible in many areas of the city [30].
- Lack of proper technology: The right technology and equipment are needed to improve the process of making fertilizer from kitchen waste. Modern composting or vermicomposting methods can use some equipment such as compost turning machines or earthworm pits. However, those equipment are not easily accessible to most people in the city, especially those living in small spaces. Moreover, some technologies are not even available to urban farmers, thus hampering the process of making suitable fertilizer for them.
- Duration of the process: A major challenge in making organic fertilizer is that the process is quite time-consuming. The composting or vermicomposting process usually takes a few months. This period is not suitable for large-scale farming or agriculture, as farmers want quick yields and need quick fertilizer. Due to this long-term process, many farmers are turning to chemical fertilizers instead of fertilizers, which give instant results, but are harmful to the environment.
- Lack of public awareness: Another major challenge is the lack of public awareness. Many farmers and the general public are not aware of the method of composting from kitchen waste. It is important to make the public aware of the benefits of proper waste management, composting, and vermicomposting. If government or private institutions take effective programs to raise awareness, it will help in gaining widespread acceptance among farmers and the public. However, many people are still accustomed to using chemical fertilizers, because they want to see results easily and quickly [31].
- Economic constraints: Some financial investment may be required for many farmers or families to start organic fertilizer production methods. Especially vermicomposting or in some cases modern composting methods require specific equipment. The cost of these equipment can sometimes be difficult for the farmer or family to purchase.
- Limitations of Fertilizer Use at Field Level: The process does not end with making fertilizer from kitchen waste, it is very important to use it properly at the field level. Many times, there is a lack of proper fertilizer application in the field or in agricultural work and due to this, the full benefits of fertilizer use are not available. If fertilizer is not applied in the right amount and at the right time, proper plant growth is not possible.

Faced with all these challenges and limitations, the process of making organic fertilizer from kitchen waste cannot yet spread in many places. However, if adequate initiatives are taken to address these challenges, it can become part of an improved and environmentally friendly fertilizer management [32].

Table 2 Showing Insertion of benefit and challenges of kitchen waste compost

Aspect	Benefits	Challenges
Nutrient Content	Provides essential nutrients to the soil and increases crop productivity.	Excessive use may disturb soil pH balance [33].
Environmental Protection	Reduces environmental pollution by recycling waste.	Improper use can cause bad odor and pest issues [34].
Cost Savings	Reduces the cost of purchasing chemical fertilizers.	Composting requires time and effort [35] .
Soil Quality	Enhances organic matter in the soil.	May contain pathogens harmful to crops [36].
Water Retention Capacity	Improves soil water retention, reducing irrigation needs.	Excess moisture may lead to fungal problems [37].
Sustainable Agriculture	Encourages sustainable and organic farming practices.	If not balanced properly, some nutrient deficiencies may occur [38].

The table presents the benefits and challenges of kitchen waste composting across aspects like nutrient content, environmental protection, and soil quality. It highlights both advantages and potential drawbacks of composting practices [39].

6. Future Research and Directions

Although organic fertilizer made from kitchen waste is a potential way to protect agriculture and the environment, some research and innovation are needed for its further use and development. In the future, it will be possible to develop more effective and sustainable methods through these studies. In this section, we will discuss future research and directions, which will help to ensure the wider use and effectiveness of this topic. Currently, there are some technical limitations in the method of making organic fertilizer from kitchen waste. Such as the rapid decomposition process, the diversity of waste materials, and the problem of controlling bacterial contamination, etc. In the future, it may be possible to solve these problems, especially by using biotechnology and microbiology. The process of making fertilizer by quickly decomposing waste with the help of new technologies such as advanced biodegradable materials, solar technology, and microorganisms can be more effective. The process of making fertilizer based on the quantity and quality of kitchen waste needs further research [40]. Many times, kitchen waste is not available in sufficient quantities, which is not sufficient for its large-scale use in agriculture. For this, some research can be done that will make the collection and processing of kitchen waste easier and more accessible. On the other hand, research is also needed on the quality of kitchen waste and its components. So that fertilizer can be made from the right waste material and it is beneficial for plants. Especially, some types of kitchen waste, such as meat or dairy products, can create harmful substances in the environment if processed properly. Developing proper processing methods for such waste is an important area of research.

Government support and awareness raising at the farmer level are needed to further expand the use of fertilizer made from kitchen waste in agriculture. Research activities should focus on how to develop simple and effective methods for farmers, so that they can produce and properly use improved fertilizers using kitchen waste. This research will increase awareness and skills among farmers. Agricultural environments and conditions vary in different regions of the world. For example, while it is possible to collect a lot of waste in developing countries, the opportunity to collect large amounts of waste properly may be less in developed countries. Therefore, research should be done on how kitchen waste fertilizer can be used in different types of agricultural environments and its effectiveness. This will provide a clearer idea of the potential and effectiveness of using kitchen waste fertilizer in different regions and agricultural systems in the future. In addition, research should be done on the social and economic impact of using fertilizer made from kitchen waste in the future. It is necessary to study how the use of environmentally friendly fertilizers in agricultural systems can improve the quality of life of people and create new jobs for farmers [41]. If kitchen waste is used properly, it can become a profitable business for farmers, which will help improve their economic situation. In the midst of the global

environmental crisis, making fertilizer from kitchen waste can be an important environmental solution. Future research will make it possible to understand how the use of this fertilizer will have a positive impact on the environment and protect biodiversity. This will help reduce carbon dioxide emissions and increase the organic structure and fertility of the soil [42].

7. Conclusion

Creating organic fertilizer from kitchen waste is a very effective and environmentally friendly method, which is important for agriculture and environmental conservation. Through this method, farmers can reduce their dependence on chemical fertilizers and increase the fertility of their land through cheap and easily available organic fertilizers. In addition, through kitchen waste management, those wastes can be reused in the agricultural system instead of being harmful to the environment, which if managed properly will help in building a sustainable agricultural system. However, there are some challenges for the widespread use and production of this fertilizer, such as the diversity of waste materials, the time frame for the decomposition process, health risks and the need for proper sanitation. To overcome these challenges, proper research, technological innovation and awareness creation among farmers are required. In the future, technological development and innovation are essential to make the process of making fertilizer from kitchen waste more effective and sustainable. If the use of eco-friendly fertilizers increases in agriculture, it will have a positive impact on the environment and help reduce global carbon emissions. Through a coordinated effort by governments, researchers, and farmers, producing organic fertilizer from kitchen waste can be a breakthrough process, opening up new possibilities for agriculture and the environment.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest to be disclosed.

Authors contributions statements

Md. Nahid Mahmud* and Ahmed Ali Omar collaboratively developed the concept of transforming kitchen leftovers into sustainable organic fertilizer. They conducted research on eco-friendly waste management and its impact on plant growth. Md.Nahid Mahmud* contributed to writing, analysis, data collection , table making and formulation of organic fertilizer techniques and editing Gmail: 22309124@iubat.edu. Ahmed Ali Omar contributed to review, data analysis, data collection ,analysis advisor and editing Gmail: ahmedaliomar72@gmail.com. Their work aims to promote sustainable agriculture and environmental conservation

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