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Utilizing kitchen waste for producing horticultural crops on rooftops: An overview

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Abstract
The number of people living in cities around the world is rising quickly. Urban food supply systems are under tremendous pressure due to increased urbanization, which is also creating issues including a sharp decline in green space and an increase in heat island effects in cities. Vegetable farming on rooftops can absorb carbon and noise, lower air temperatures on the roof and in the surrounding area, and diminish the impact of the urban heat island. Certain urban rooftop gardens employ mineral insecticides and fertilizers. Scientists have shown that compost can act as a nutrition source in place of mineral fertilizers. In addition, it can raise soil moisture content, decrease soil erosion, and manage pests, weeds, and illnesses. Given that kitchen garbage is a frequent household item in metropolitan settings, composted kitchen waste can be a beneficial addition to rooftop vegetable gardens. Rooftop gardening is a relatively new concept in Bangladesh. Understanding rooftop gardening and conducting further study on rooftop gardens would be aided by this review work.

Keywords: Rooftop, vegetable, composting, and kitchen waste

Introduction
According to United Nations (2014), 54% of the world's population currently resides in urban areas and by 2050, that number is expected to rise to 66%. Urban food supply networks are under tremendous pressure due to the rapid growth and urbanization of cities. In addition, many cities across the globe are dealing with issues including an increase in heat island effects and a sharp decline in green space. Rooftop farming and urban agriculture are suggested as viable solutions to these issues (Smit *et al*., 2001). When food is grown nearby, it is not necessary to go far to obtain fresh, pure food, which lowers the amount of fossil fuel used for transportation and benefits the environment (SGUFS, 2014) [26]. Rooftop vegetable production can diminish the urban heat island effect (Hui, 2011) [13] and lower air temperatures on nearby roofs, which serve to chill the local environment overall (Ries, 2014) [23]. Additionally, rooftop gardening can reduce noise and carbon emissions (Dubbeling, 2014) [7]. Because plants absorb and retain rainwater, the overflowing effect on infrastructure is lessened (Ries, 2014) [23]. Vegetable-filled rooftops can make wonderful places to unwind, and this type of farming can readily provide jobs for people (SGUFS, 2014) [26]. Growing vegetables on rooftops promotes biodiversity and serves as a home for a range of insects and birds (Higher Ground Farm, 2019) [12]. In urban settings, container gardens, organic farming, hydroponics, green roofs, and aeroponics are the most common methods used for rooftop farming (Asad and Roy, 2014) [1]. A variety of fertilizers, insecticides, and pesticides are employed in agricultural production; however, their overuse can have detrimental effects on human health, degrade the environment, and increase the cost of crop production. Currently, agricultural research institutes and universities are concentrating on integrated pest and nutrient management through the modification of multiple conventional methods and the use of diverse microbial natural resources as biofertilizer (Sinha *et al*., 2010) [27]. Various types of kitchen trash are generated on a daily basis in homes, canteens, hotels, and mess areas. Kitchen trash can include various forms of vegetable and fruit waste (fruit, vegetable, vegetable and fruit remains, and peelings), eggshells and coffee sediments, filter bags for tea and coffee, tainted food, non-liquid cooked food waste, bones, stale bread and biscuits, tissues, paper towels, and biodegradable paper sacks. In the presence of oxygen, a variety of

microorganisms such as bacteria, fungus, and actinomycetes may compost kitchen trash and turn it into humus. Wilson (2009) [35] suggests that humus can be utilized for rooftop vegetable growing, which is very beneficial. Growing vegetables on a roof.

The practice of growing various kinds of vegetables on the roofs of buildings in large cities is known as rooftop vegetable farming (Sustainability Television, 2019) [29].

Urban building rooftop cultivation typically involves the use of container gardens, hydroponics, organic gardening, aeroponics, and green roofs (Asad and Roy, 2014) [1]. Hydroponic gardening methods with a specifically made greenhouse are the most productive (Sustainability Television, 2019) [29]. According to Liu *et al*. (2016) [15], rooftop vegetable gardening has the potential to both improve the environment and supply a substantial amount of vegetables for urban residents. Additionally, rooftop vegetable growing provides large number of social and environmental advantages for densely inhabited metropolitan areas (Hui, 2011) [13]. With roofs for growing vegetables, it is feasible to acquire social, financial, and environmental sustainability for metropolitan city constructions. Due to that could aid in the growth of urban food systems by increasing the production of food locally, satisfy the people's need for nutrition met by availability of nutrient- food, less air pollution, and more storm water capacity for retention, enhancement of public health, improvement of the metropolitan area's aesthetic value surroundings and enhancement of communal activities Localize (2007) [16]. Global production of vegetables grown on rooftops, in order to support agricultural sustainability in urban settings, growing numbers of people are growing vegetables on rooftops. Rooftop agriculture contributes to the development of local food security and makes urban areas more sustainable in their use of resources. Roof-top gardens offer alternate locations for the production of vegetable products for urban markets and are increasingly playing a significant role in the recent revival of urban agriculture (Ouellette *et al*., 2013) [14]. According to Gaglione *et al*. (2010) [10], growing vegetables on rooftops should not be seen as a substitute for large-scale vegetable production in rural areas, but rather as a way to support the urban food movement by adding another source of fresh, local produce (Tomalty *et al*., 2010) [33]. Nowadays, more than 20% of the vegetables needed in many urban areas are produced inside city limits. While some cities in industrialized countries throughout the world aim to supply at least some of their food requirements locally, urban agriculture is frequently used in developing countries (MacRae *et al*., 2010) [17]. According to MacRae *et al*. (2010) [17], a number of cities, including Bologna (Italy), Chicago (USA), Cleveland (USA), Hong Kong (China), Montreal (Canada), New York (USA), Portland (USA), Seattle (USA), Shanghai (China), Taipei (Taiwan), Tokyo (Japan), Toronto (Canada), and Vancouver (Canada), have seen a notable increase in the local food supply as a result of urban agricultural activities. According to Science for Environment Policy (2015) [28], rooftop gardens in Bologna, Italy, could produce about 12,500 tons of vegetables annually, meeting 77% of the city's resident vegetable needs. Additionally, an estimated 624 tons of CO2 could be captured annually if all available flat roof space was used for urban agriculture. More than a thousand people can be supplied with veggies from Lufa Farms in Montreal, which grows more than 25 different varieties (Carrot City, 2014) [5]. Every year, the Brooklyn Navy Yard farm yields over 50,000 pounds of organic produce. Every year, the Chicago-based Gary Comer Youth Center grows 450 kg of food (Clarke, 2015) [5]. Vegetable crop cultivation within city limits must expand for urban agriculture to be most successful. However, vacant lots and other land in metropolitan areas that has historically been utilized for agriculture remain susceptible to future development. Thus, the inadequacy of accessible area in cities to satisfy the present demand for locally produced foods poses a challenge to urban agriculture. In this way, green roofs can successfully restore the green area that is lost during building construction. Consequently, rooftop agriculture has emerged as a desirable way to expand localized urban agriculture, especially with regard to green roof production systems (Ouellette *et al*., 2013) [14].

Growing vegetables on a roof

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Global production of vegetables grown on rooftops

In order to support agricultural sustainability in urban settings, growing numbers of people are growing vegetables on rooftops. Rooftop agriculture contributes to the development of local food security and makes urban areas more sustainable in their use of resources. Roof-top gardens offer alternate locations for the production of vegetable products for urban markets and are increasingly playing a significant role in the recent revival of urban agriculture (Ouellette *et al*., 2013) [14]. According to Gaglione *et al*. (2010) [10], growing vegetables on rooftops should not be seen as a substitute for large-scale vegetable production in rural areas, but rather as a way to support the urban food movement by adding another source of fresh, local produce (Tomalty *et al*., 2010) [33]. Nowadays, more than 20% of the vegetables needed in many urban areas are produced inside city limits. While some cities in industrialized countries throughout the world aim to supply at least some of their food requirements locally, urban agriculture is frequently used in developing countries (MacRae *et al*., 2010) [17]. According to MacRae *et al*. (2010) [17], a number of cities,

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Rooftop vegetable farming in India

The practice of rooftop farming is rapidly spreading throughout India. These days, many people are interested in rooftop gardening, particularly in urban areas. Numerous people have already made their passion a business. Retired businesspeople, industrialists, and employees of the public and commercial sectors have taken up rooftop farming as a hobby. Despite the dearth of arable land there, their efforts are contributing to the cities being greener. Some people even rent others' roofs for the purpose. Its growing because consumers consistently choose organic fruits and vegetables that are devoid of chemicals. Furthermore, these individuals are fostering the development of a healthy urban environment by spreading plants on rooftops (The Daily Star, 2019). In India, rooftop gardens cultivate about twenty-five different crops. Rooftop farming is thought to be the source of Lucknow city's brinjal (61%), Indian spinach (47.8%), chilli (45.3%), and gourds (25%) production. Additionally, according to calculations, the following crops are planted in Chattogram City: brinjal (48%), Indian spinach (35.7%), gourds (35.6%), ladyfinger (31%), tomato (23.7%), red amaranth (23%), bean (18%), cabbage, and cauliflower (7%). The Agricultural Extension Division gives people the instruction and supplies they need to develop their horticulture skills and grow roof gardens. The "Green Roof Movement," which focuses on the financial and technical aspects of roof gardening, is being conducted by the Roof Garden Association (RGA) in Bangladesh (Uddin *et al*., 2016) [34].

Kitchen trash composting

The natural "rotting" or decomposition of organic waste by microorganisms under regulated conditions is known as composting. After being composted, raw organic materials like food scraps, animal feces, agricultural residues, some municipal wastes, and appropriate industrial wastes become more acceptable for use as fertilizer in soil. Another way to describe composting is as a natural process that transforms organic material into a rich, black material. This material is referred to as humus or compost (FAO, 2002) [9]. An abundant supply of organic matter is compost. In order to maintain soil fertility and, consequently, sustained agricultural production, soil organic matter is essential. It enhances the soil's physicochemical and biological qualities in addition to providing plant nutrients (FAO, 2002) [9].

Composting types

Depending on the type of decomposition process, composting can be classified into the following categories.

Composting via aerobic means

Composting that is aerobic takes place when oxygen is present.

Organic stuff is broken down by aerobic microbes and release the comparatively stable organic end product, ammonia, water, heat, and carbon dioxide (CO2). While some intermediate molecules, including organic acids, may be produced during aerobic composting, aerobic microorganisms further break them down. The resultant compost, with its relatively unstable structure of organic matter, has little risk of phyto-toxicity. The heat generated enhances the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destructs many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Aerobic composting is thought to be more effective, productive, and beneficial than anaerobic composting for agricultural productivity, despite the fact that more nutrients are lost from the materials. Aerobic composting is the main topic of this publication (FAO, 2002) [9].

Composting anaerobically

Anaerobic composting occurs in environments with little or no oxygen. With this process, methane, organic acids, hydrogen sulfide, and other intermediate chemicals are dominated and enhanced by anaerobic microorganisms. These substances build up and are not further broken down in the absence of oxygen. Some of these substances are phytotoxic, and many of them have strong smells. Due of its low temperature, anaerobic composting preserves diseases and weed seeds. Additionally, the procedure typically takes longer than aerobic composting. These disadvantages frequently outweigh the benefits (FAO, 2002) [9].

Vermicomposting

Vermicomposting is the process of composting organic waste by using earthworms.

Earthworms are capable of consuming almost any kind of organic matter, including their own body weight; for example, one kilogram of worms can consume one kilogram of residues day. Nitrate and accessible forms of P, K, Ca, and Mg are abundant in the worms' excreta, or castings. Bacteria and actinomycetes develop more when soil passes through earthworms. When worms are present, actinomycetes thrive, and their concentration in worm casts is more than six times that of the original soil (FAO, 2002) [9].

Vermicomposting with garbage from the kitchen
The following procedures can be used to compost kitchen waste:

Gathering of information
Kitchen scraps are gathered from homes and hotel canteens, let to air dry, and then ground into tiny particles. To initiate microbial activity, these ground waste materials are combined with cow dung in a 4:1 (w/w) ratio and then put through an aerobic composting process. The combination is then placed in plastic containers covered with paper that has holes to allow for aeration in order to obtain the final composted material. The moisture level of the ingredients is kept between 60% and 70%. For adequate microbial activity, this combination is manually adjusted at regular intervals and rehydrated (Bharadwaj, 2010) [4].

Earthworm collection
The mixture is employed as a vermicomposting substrate once the temperature stabilizes and the mixture's color changes from brown to black. Earthworms (*Eisenia foetida*) were gathered for vermicomposting.

Physicochemical evaluation
According to the techniques recommended by other researchers, the material is examined for a variety of physicochemical characteristics, including pH, organic carbon, total nitrogen, available phosphorus, exchangeable potassium, C: N ratio, and organic matter. Additionally, earthworm number, biomass, cocoon production, and weight loss of organic substrate during the composting process are measured. Following 15, 45, and 75 days of vermicomposting, the samples are inspected at regular intervals during the experiment (Bharadwaj, 2010) [4].

Advantages of growing vegetables on rooftops using compost
The subsequent subsection provides a description of the possible advantages of applying compost:

provision of nutrients
As an alternative to mineral fertilizer, compost can be utilized as a source of nutrients (Blanco *et al*., 2013). The amount of fertilizer substitutes depends on the compost's nutrient content and rate of application (Audsley *et al*., 1997; Hansen *et al*., 2006) [2, 11]. Additionally, compost is seen as a profitable alternative for recycling phosphorous (Cordell *et al*., 2009) [6], a problem that is becoming more prevalent due to the anticipated shortage of mineral P for fertilization in agriculture (Syers *et al*., 2008) [23].

Sequestration of carbon
Carbon can be thought of as being removed from the atmosphere and moved into soil in order to reduce CO2 emissions (Blanco *et al*., 2013). When calculating the benefit from carbon sequestration, the assessment's timehorizon is crucial.
When calculating contributions to global warming, a century is thought to be a significant time range (Favoino and Hogg, 2008) [8].

Suppression of diseases, weeds, and pests
Compost can be applied in place of pesticides and herbicides to manage diseases, weeds, and pests. Reducing the usage of pesticides and herbicides is also good for the environment (Martínez Blanco *et al*., 2013).

Cut down on soil erosion
Composting could prevent the loss of arable land by reducing soil erosion (Blanco *et al*., 2013). Land habitation and land modification are the causes of soil deterioration (Saad *et al*., 2011) [24]. Carbon losses and a decrease in net productivity are caused by soil erosion (Núñez *et al*., 2013) [19].

Moisture content of soil
Enhancing the soil's ability to hold onto green water—that is, rainfall and irrigation water retained in the soil as soil moisture—in order to reduce irrigation and the use of blue water—that is, water from surface and groundwater resources—is one possible advantage of compost. Two possible outcomes of this are that blue water is conserved and agricultural productivity may rise in regions without irrigation water (Blanco *et al*., 2013).

Biodiversity and biological characteristics of soil
Following the application of compost, changes in soil biodiversity may have a favorable impact on hydrological processes, nutrient cycling, and pest occurrence, among other ecosystem services, or they may have negative effects related to the replacement or compensation of those services. However, other from an initial attempt to establish a preliminary relationship, there is no data relating compost use, biodiversity, and ecosystem services (Nemecek *et al*., 2011) [18]. Furthermore, depending on regional and scale-dependent characteristics, the consequences of land management approaches vary greatly (Bengtsson *et al*., 2005) [3]. Considering ecosystem services and biodiversity as separate endpoint categories is an alternate strategy (Zhang *et al*., 2010) [36].

Composting's limitations
Composting is regarded as an environmentally friendly process that enables the recycling of garbage while also producing organic fertilizer. However, it is not very safe, particularly for those who are engaged in this procedure (Kokhia, 2013) [14].
Any method of waste management carries a number of risks, all of which have been thoroughly documented by many scientists (Panikkar *et al*., 2004) [21]. Many times, the workers who do the composting are not aware of the sanitary composting requirements. Additionally, there can be negative effects that make composting less popular overall. Therefore, it's important to raise awareness of the dangers associated with composting.
The composting process involves at least 50 species of fungi and a wide variety of bacteria (about 2000) (Kokhia, 2013) [14]. Not only do bacteria, fungus, and actinomycetes actively participate in this process, but invertebrates also have a major impact. Ants, beetles, cutworms, fruit beetle larvae, millipedes, mites, nematodes, earthworms, earwigs, woodlice, springtails, spiders, enchytraeids (white worms), and others are the primary inhabitants of the soil. Numerous soil creatures take part in the physical grinding of the material throughout the composting process. Additionally, these animals aid in the mixing of the compost's different ingredients (Kokhia, 2013) [14].
In temperate areas, earthworms are essential to the final

phases of composting and the additional insertion of organic matter in the soil. Composting is therefore a multi-step, intricate process. The different groups of organisms that make up each stage define it (Shalanda, 2009) [30]. The composting process is linked to several occupational dangers, such as microbiological, allergic, and pathogenic toxins. These risks are caused by common fecal pathogens, which include bacteria, viruses, intestinal parasite cysts, and eggs. The emergence of meso- and thermophilic fungi and actinomycetes, which are crucial to the breakdown of garbage, is linked to the second risk. Allergy disorders are found among the infectious infections caused by these bacteria (Kokhia, 2013) [14].

It has been demonstrated by epidemiological and experimental research that pathogenic mold may grow during the composting process. This leads to extremely negative outcomes, particularly for those working on the production. It was found that exposure to fungal spores was clearly associated with an unusual development of allergic rhinitis, conjunctivitis, and asthma (Kokhia, 2013) [14].

Composting is helpful for managing kitchen trash and producing organic manure, despite its disadvantages. for the production of vegetables and other agricultural pursuits.

Conclusion

India's agricultural areas are shrinking because of human demand for food and shelter. The landscapes of many nations are similar. Vegetable farming on rooftops can be a viable substitute for soil-based food production. The usage of artificial fertilizers, pesticides, and hormones in food production will decrease if kitchen waste compost can be utilized to produce more food in urban settings. Rooftop vegetable production is growing in popularity in India, which is undoubtedly excellent for the country. However, further research is required to determine how to use the waste to agricultural areas in order to address the waste management issue in the nation.

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