J. Environ. Sci. & Natural Resources, **11(1&2):253-259 , 2018** ISSN 1999-7361

Use of Kitchen Waste in Rooftop Vegetable Production - A Review

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Abstract

Worldôs populations, living in urban areas, are increasing rapidly. Rapid urbanization is placing enormous demand on urban food supply systems and causing problems like rapid decrease in green space and increase in heat island effects in urban areas. Rooftop vegetable production can reduce the temperature of roofs and the surrounding air, help to lessen urban heat island effect, can absorb carbon and noise. In some urban rooftop gardens mineral fertilizers and pesticides are used. Researchers observed that compost can be used as a source of nutrient instead of mineral fertilizers. Moreover, it can control pest, weed and diseases; reduce soil erosion; and increase soil moisture content. As kitchen wastes are common in every household in urban areas, kitchen waste compost can be a good supplement in rooftop vegetable gardens. In Bangladesh the rooftop gardening is a quite new phenomenon. This review work will help to understand rooftop gardening and to conduct future research work on rooftop gardens.

Key words: Composting, Kitchen waste, Rooftop, Vegetable

Introduction

In the world, 54 percentage of the total population is living in urban areas and is predicted that it will increase to 66 percentages by 2050 (United Nations, 2014). Rapid urbanization and urban growth is placing enormous demand on urban food supply systems. Moreover, many cities in the world are suffering from problems like rapid decrease in green space and increase in heat island effects. Urban agriculture or rooftop farming is recommended as a potential solution to these problems (Smit *et al.,* 2001).

When the food is produced locally, there is no need to go far to get fresh and pure foods which reduces use of fossil fuel for transportation and consequently has a positive effect on the environment (SGUFS, 2014). Rooftop vegetable production can reduce the temperature of roofs and the surrounding air that contribute to overall cooling a local climate (Ries, 2014) and can help to lessen urban heat island effect (Hui,2011). Rooftop farming can also absorb carbon emissions and noise (Dubbeling, 2014). Rain water is captured and absorbed by the plants and overflowing effect on infrastructure is reduced (Ries, 2014). Rooftops filled with vegetation can be a great place to relax and this kind of farming can easily offer employment to people (SGUFS, 2014). Vegetable production in rooftops helps to increase biodiversity and provide habitat for a variety of insects and birds (Higher Ground Farm, 2019). Farming on the rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014).

Different types of fertilizers, insecticides and pesticides are used in agricultural production, but extensive use of fertilizers, insecticides and many other pesticides have negative effect on human health, degrade the environment, and make the crop production expensive. At present, Agriculture Universities and Research Institutes are focusing in integrated pest and nutrient management by utilizing various microbial natural resources as bio fertilizer by altering several conventional practices (Sinha *et al.,* 2010). Everyday different kinds of kitchen wastes are produced in houses, canteens, mess and hotels. Kitchen waste can be vegetable and fruit waste of different types (fruit, vegetable, vegetable and fruit remains and peelings), eggshells and coffee sediments ,tea and coffee filter bags, tainted food, non-liquid cooked food waste, bones, stale bread and biscuits, tissues, paper towels and paper sacks that are biodegradable. Kitchen waste can be converted into humus by composting by various micro-organisms including bacteria, fungi and actinomycetes in the presence of oxygen. Humus can be used in rooftop vegetable production that is extremely useful (Wilson, 2009).

Rooftop vegetable production

Rooftop vegetable production is the cultivation of different types of vegetable on the top of buildings in the major cities (Sustainability Television, 2019). Cultivation on the rooftop of the buildings in urban areas is usually done by using green roof, hydroponics, organic, aeroponics or container gardens (Asad and Roy, 2014). The most fruitful form is hydroponics techniques using a specially designed Greenhouse (Sustainability Television, 2019). Rooftop vegetable farming could benefit the environment and provide a significant proportion of vegetables for urbanites (Liu *et al.,* 2016). Rooftop vegetable production also offers many environmental and social benefits to high populated urban cities (Hui, 2011). By utilizing rooftops for vegetable cultivation, it is possible to obtain social, economic and environmental sustainability for the buildings in urban cities. Because it can contribute to the development of urban food systems by enhancing local food production, meet the nutrition demand of the people by access to nutritious food, reduction of air pollution, increasing storm water retention capacity, improvement of public health, enhancement of the aesthetic value of the urban environment and amplification of community functions (Localize, 2007).

Worldwide rooftop vegetable production

The practice of producing vegetables on rooftop has been increasing in recent years to facilitate agricultural sustainability in urban areas. Rooftop agriculture allows urban areas to become more sustainable in their resource exploitation, and to help the development of food security for local residents. Rooftop gardens are becoming an important part of the recent regeneration of urban agriculture, and provide alternative spaces to grow vegetable products for urban markets (Ouellette *et al.,* 2013). The production of vegetables on rooftops should not be thought of as an alternative for massive-scale vegetable production in rural areas (Gaglione *et al.,* 2010) but rather as an enhancement to the urban food movement by providing another source of local, fresh, foods (Tomalty *et al.,* 2010). Many urban areas are now producing over 20% of their vegetable needs from within city boundaries. Urban agriculture is widely utilized in developing countries, although some cities in developed countries worldwide strive to source at least a portion of their food requirements locally (MacRae *et al.,* 2010). The contributions of urban agricultural activities to local food supplies is now significant in several 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) to name a few (MacRae *et al.,* 2010). In Bologna, Italy, if all suitable flat roof space is used for urban agriculture, rooftop gardens in the city would produce around 12,500 tons of vegetables annually which would meet 77% of residentsô needs for vegetables and an estimated 624 tons of CO_2 would be captured each year (Science for Environment Policy, 2015). Lufa Farms, Montreal produces over 25 types of vegetables and production is enough to meet the needs of over 1000 people (Carrot City, 2014). The farm of Brooklyn Navy Yard produces more than 50,000 pounds of organic produce annually. The Gary Comer Youth Center of Chicago grows 450 kg of food per year (Clarke, 2015). For urban agriculture to be most successful; there is a need to increase vegetable crop cultivation within city boundaries. However, land that has traditionally been used for agricultural purposes within urban areas, such as vacant lots, is vulnerable to potential development. Thus, urban agriculture is challenged by the lack of available space in cities to meet current demands for locally produced foods. Green roofs can be used in this capacity to effectively replace green space lost during building construction. Therefore, rooftop agriculture (particularly green roof production systems) has become an attractive possibility to increase localized urban agriculture (Ouellette *et al.,* 2013).

Rooftop vegetable production in Bangladesh

Rooftop farming is increasing throughout the Bangladesh very fast. Nowadays, many people are being interested in rooftop gardening, especially in city areas. Many have already turned their passion into a commercial endeavor. Retired government and private service holders, businessmen and industrialists have passed their leisure time by getting involved in rooftop agriculture. Their efforts are helping to make the cities greener, despite lack of cultivable lands there. Some people even rent others' roofs for the purpose. It's expanding also because people always prefer chemical-free organic vegetables and fruits. They can easily get organic and fresh food from rooftop gardening. Moreover, through the spread of greenery on the rooftop, these people are also contributing to creating a healthy environment in urban areas (The daily star, 2019). Approximately, 25 vegetables are grown in the rooftop gardening in Bangladesh. It is estimated that in Dhaka city brinjal (61%), Indian spinach (47.8%) and chilli (45.3%) and gourds (25%) are produced in rooftop farming. It is also calculated that in Chattogram city brinjal (48%), Indian spinach (35.7%), gourds (35.6%), ladyǿs finger (31%), tomato (23.7%), red amaranth (23%), bean (18%), cabbage and cauliflower (7%) are grown (Uddin *et al.,* 2016). Agricultural Extension Division provides training and necessary logistics to the individuals for roof gardening and horticultural development. Roof Garden Association (RGA) in Bangladesh is conducting **"**Green Roof Movement**"** which focuses on technical and financial aspects of roof gardening (Uddin *et al.,* 2016). We hope that the day is not far when every city including Dhaka will have a layer of greenery.

Composting of kitchen waste

Composting can be defined as a natural process of ǿrottingô or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as, food garbage, animal wastes, crop residues some municipal wastes and suitable industrial wastes, increase their suitability for application to the soil as a fertilizing resource, after having undergone composting. Composting can also be defined as a natural process that turns organic material into a dark rich substance. This substance is called compost or humus (FAO, 2002).

Compost is a rich source of organic matter. Soil organic matter plays a vital role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physicochemical and biological properties of the soil (FAO, 2002).

Types of composting

Composting can be divided into following types based the nature of the decomposition process.

Aerobic composting

Aerobic composting occurs in the presence of oxygen. Aerobic microorganisms break down organic matter and release carbon dioxide (CO_2), water, heat and humus, ammonia, the relatively stable organic end product in this process. Although aerobic composting may produce some intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable structure of organic matter, has little risk of phytotoxicity. 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. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient, fruitful and useful than anaerobic composting for agricultural production. Most of this publication focuses on aerobic composting (FAO, 2002).

Anaerobic composting

Anaerobic composting takes place where oxygen is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and improve intermediate compounds including methane, organic acids, hydrogen sulfide and other substances. In the absence of oxygen, these compounds accumulate and are not metabolized further. Many of these compounds have vigorous odors and some present phytotoxicity. As anaerobic composting is a low-temperature process, it leaves weed seeds and pathogens intact. Moreover, the process usually takes longer compare to aerobic composting. These drawbacks often offset the merits of this method, viz. little work involved and fewer nutrients spoiled during the process (FAO, 2002).

Vermicomposting

The term vermicomposting refers to the use of earthworms for composting organic residues. Earthworms can consume practically all types of organic matter and they can eat their own body weight per day, e.g. 1 kg of worms can consume 1 kg of residues every day. The excreta (castings) of the worms are rich in nitrate, available forms of P, K, Ca and Mg. The passage of soil through earthworms enhances the growth of bacteria and actinomycetes. Actinomycetes develop well in the presence of worms and their content in worm casts is more than six times that in the original soil (FAO, 2002).

Vermicomposting using kitchen waste

Composting of kitchen waste can be carried out by the following steps:

Collection of material

Kitchen waste materials are collected from houses, hotel canteen then air dried and grinded into small pieces. This ground waste materials are mixed with cow dung in the ratio of 4:1 (w/w) and is subjected to aerobic composting to start microbial activity. Moisture content of the materials are controlled to 60% to 70% and this mixture is then transferred in plastic containers covered with paper that has holes to facilitate aeration in order to get final composted material. This mixture is hand manipulated at regular time intervals and remoistened for sufficient microbial activity (Bharadwaj, 2010).

Collection of earthworms

When the temperature becomes constant and color of the mixture change brown to black, it is used as substrate for vermicomposting. For vermicomposting the earthworms (*Eisenia foetida*) were collected.

Physicochemical analysis

The material is analyzed for different physicochemical attributes such as pH, organic carbon, total nitrogen, available phosphorus, exchangeable potassium, C: N ratio and organic matter as per the methods suggested by other workers as well as for earthworm number, biomass, cocoon production and weight loss of organic substrate during the composting process. During the course of investigation the samples are examined at periodic intervals after 15, 45 and 75 days of vermicomposting (Bharadwaj, 2010).

It is understood from the data presented in Table 1 that kitchen waste material (control) is characterized with high values of pH (9.32), organic carbon (7.25%) and organic matter (12.49%). However, other nutrients such as total nitrogen (0.214%), available phosphorus (0.11%) and exchangeable potassium (0.086%) were found in very trace amounts. The vermicomposting activity significantly modified the physical and chemical properties of kitchen waste material that can be an important tool for organic farming. It is indicated in Table-1 that during vermicomposting the pH declines (from 9.32 to 8.37) with the advancement of vermicomposting period (from 0 to 75 days). It might be on account of high mineralization of nitrogen and phosphorus into nitrates/nitrites and orthophosphate. Moreover, the organic carbon content, organic matter and C:N ratio of the kitchen waste material also showed the same pattern and decline gradually up to 75 days. The highest values of organic carbon, organic matter and C:N ratio were obtained in control (0 day) i.e. 7.25%, 12.49% and 30.08% respectively and lowest values were obtained after 75 days of vermicomposting i.e. 3.69%, 6.37% and 4.79%, respectively (Bharadwaj, 2010).

Table 1. Effects of vermicomposting on different physicochemical parameters of kitchen waste (Bharadwaj, 2010)

SI. No.	Parameters	Duration of vermicomposting			
		0 days	**15 days**	**45 days**	**75 days**
1.	pH	9.32	9.22	8.9	8.37
2.	Organic carbon (%)	7.25	5.265	5.078	3.696
3.	Total nitrogen (%)	0.241	0.301	0.361	0.771
4.	Available phosphorus (%)	0.110	0.12	0.16	0.18
5.	Exchangeable potassium (%)	0.0086	0.132	0.196	0.386
6.	C:N ratio	30.08	17.49	14.06	4.79
7.	Organic matter (%)	12.499	9.076	8.754	6.371

Benefits of using compost in rooftop vegetable production

The potential benefits derived from application of compost are described in the following sub-section:

Nutrient supply

Compost can be used as a source of nutrient instead of mineral fertilizer (Blanco *et al.,* 2013). The quantity of substituted fertilizers relies on the content of nutrients of the compost and their application rate (Audsley *et al.,* 2003; Hansen *et al.,* 2006). Furthermore, compost is considered as a fruitful option for phosphorous recycling (Cordell *et al.,* 2009), which is a growing issue as a result of the foreseen lack of mineral P for agriculture fertilization (Syers *et al.,* 2008).

Carbon sequestration

Sequestration of carbon into soil can be seen as removal of carbon from atmosphere and relocated to save CO_2 emissions **(**Blanco *et al.,* 2013**)**.The time-horizon used in the assessment plays an essential role when estimating the benefit from carbon sequestration. A time frame of 100 years is considered to be relevant for estimating contributions to global warming (Favoino and Hogg, 2008).

Pest, weed and disease suppression

Pest, weed and diseases can be controlled by application of compost instead of herbicides and pesticides. It is also beneficial for environment to reduce the use of herbicides and pesticides (Martínez-Blanco *et al.,* 2013).

Reduce soil erosion

The utilization of compost could decline soil erosion and thereby avoid losses of arable land (Blanco *et al.,* 2013). The degradation of the soil occur because of land transformation and land occupation (Saad *et al.,* 2011). Because of soil erosion carbon losses and net productivity reduces (Núñez *et al*., 2013).

Soil moisture content

One potential benefit of compost is to enhance the capability of soil to retain green water, i.e., rainfall and irrigation water stored in the soil as soil moisture, in order to decline irrigation and consumption of blue water, i.e. water from surface and groundwater resources. This may result in two different consequences: Blue water is saved; and crop yield could increase in those areas where irrigation water is not available (Blanco *et al.,* 2013).

Soil biological properties and biodiversity

Changes in soil biodiversity after compost application might influence either positively or (e.g., hydrological processes, nutrient cycling, and pest incidence), with consequences in terms of impacts associated to the substitution or compensation of those ecosystem services. However, data linking compost use, biodiversity, and ecosystem services are non-existing apart from a first attempt of establishing a preliminary relation (Nemecek *et al.,* 2011). In addition, the effects of land management practices are highly variable depending on regional and scale-dependent factors (Bengtsson *et al.,* 2005). An alternative approach is to consider biodiversity and ecosystem services as independent endpoint categories (Zhang *et al.,* 2010).

Limitation of composting

Composting consider as an environmentally clean method which allows, on the one hand- recycle waste and on the other hand- obtain organic fertilizer. But it is not really safe, especially for people involved in this process (Kokhia, 2013).

The waste management using any technique involves many risks which are described quite well by different scientists (Panikkar *et al.,* 2004).The labors who are involved in the composting are often unconscious of the hygienic composting criteria. Moreover, there may be adverse impact that will facilitate the rejection of composting on the whole. Thus, it is necessary to shed the light on the risks encountered during composting. Many kinds of bacteria (å2000) and at least 50 species of fungi take part in the composting process (Kokhia, 2013). In this process not only bacteria, fungi and actinomycetes are actively involved, but also the invertebrates play a significant role. These are the main soil habitants: ants, beetles, and cutworms, fruit beetle larvae, millipedes, mites, nematodes, earthworms, earwig, woodlice, springtails, spiders, enchytraeids (white worms) and others. Many soil animals participate in the process of composting material in terms of its physical grinding. These animals also help mixing of the various components of compost (Kokhia, 2013).

Earthworms play the main role in the last stages of the composting process and the further insertion of organic matter in the soil in temperate climates. Thus, composting is a complex, multi-step process. Each stage is characterized by its various consortiums of organisms (Shalanda, 2009).

Occupational hazards are associated with composting process those include the pathogenic, allergenic and microbial toxins. The sources of these hazards are common pathogens of faecal origin (bacteria, viruses, cysts and eggs of intestinal parasites). The second danger is associated with the development of meso-and thermophilic fungi and actinomycetes, which play an important role in the degradation of waste. Among these microorganismsô infectious pathogens, allergic diseases are detected (Kokhia, 2013).

Epidemiological and experimental studies have proved that pathogenic mold can be developed potentially during the producing of compost. This turns to very adverse consequences, especially for people involved in the production. A clear link of an atypical development of allergic rhinitis, conjunctivitis and asthma in contact with the spores of fungi was detected (Kokhia, 2013).

Despite of some drawbacks of composting, it is useful to manage kitchen waste and produce organic manure for vegetable production as well as other agricultural activities.

Conclusions

The agricultural lands are decreasing in Bangladesh due to human pressure for accommodation and food. In many countries of the world the scenery is same. Rooftop vegetable production can be a good alternative to produce food instead of soils. If Kitchen wastes compost can be used for higher quantity of food production in the urban areas thus will reduce the use of chemical fertilizers, pesticides and hormones in food production. In Bangladesh the Rooftop vegetable production is becoming popular day by day, which is no doubt a good sign for the nation, but more studies are needed to use the wastes to agricultural lands so that we can solve the problem of waste management in the country.

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