Chapter

Composting and Organic Waste Recycling a Better Option for Food Safety and Food Security

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Abstract

Composting is a process of degrading organic waste to form a stable material through a control process called aerobics with a biodegradation conversion process that allows the colonization of beneficial microorganisms. Careful handling of inorganic waste was significant to reducing the cost of compounding livestock feed and minimizing waste disposal in the community. Innovative technologies can inactivate pathogens in organic waste. Compost has been found to be effective in stimulating plant growth and suppressing diseases and pathogens. Safety standards remains essential for producing food rich in proteins. The use of compost can sufficiently address the challenges of malnutrition and poverty worldwide. Composting through invertebrates was also found to be significant. This is the basis upon which life exists because of the continued recycling of waste. Food security and safety goes hand in hand with the use of compost. None of these parameters must be overlooked if food production is required to meet the needs of the continuously growing population in the future.

Keywords: Compost, food safety, food security

1. Introduction

Food availability in many regions of the world has become inefficient. This has resolved into malnutrition and inadequate access among small communities in different parts of the world [1]. In this regard, innovative ideas are required to convert organic waste into compost and animal feed, which is pathogen free [1, 2]. In other words, compost is an organic substance that prioritizes food safety and security [2]. It is a source of energy that is required to provide nutrients to sustain biodiversity [2]. The inorganic components of a compost include (N, P, K, and S), secondary nutrients (Ca and Mg), and micro nutrients (B, Cl, Cu, Fe, Mn, Mo, and Zn) [2, 3]. It plays an important role in building resilience farming systems [3, 4]. It is an organic source and nutrient source in greenhouse horticulture [5]. It is a growth medium for nursery plants. It decreases the total cost associated with fertilizer and pesticides and improves nutrient retention within vegetative systems by reducing erosion and leaching [5]. Livestock manure also contains large numbers of pathogenic microorganisms [6, 7]. These organisms can pose risks to human health. These pathogens are easily transmitted from animals to humans through diverse means, such as feed processing from waste, direct contact and others. Livestock manure is used for composting [6, 7]. Some farmers applied manure directly to the farm without pretreatment [6, 7]. Livestock manure contains toxic heavy metals that may affect plant growth and reduce the efficiency of agricultural land [7, 8]. Excessive application can impair nutrient elements and are often leached beneath the reach. These toxic heavy metals not only affect plants but also animals through grazing on fertilized pasture land via ingestion [6–8]. The presence of these heavy metals (**Table 1**) in the body tissue is detrimental to human health [6–8]. These attributes of livestock manure, however call for safety and security [6–8]. The use of modern technology is required to produce a compost that is more reliable and resilient at suppressing the global distribution of soil-borne pathogens that threaten food security [5–8]. According to research findings, effective control of Rhizoctoria can be prepared from lignocellulosic substrates such as tree bark, which colonize Trichoderma spp. [9]. Compost products based on poultry are hosted by *Rhizoctonia spp. solari* and *Escherichia. coli* [9]. Composting is a biological process through which microorganisms convert organic materials into useful end products, which may be used as soil conditioners and/or organic fertilizers [9, 10]. It is a thermophilic process that stimulates the action of microorganisms to digest organic waste under aerobic conditions to produce an end product that is stable and free of pathogens. Aerated compost teas (ACT) are products in which the compost-water extract is actively aerated during the fermentation process [8–10]. Non-aerated compost teas (NCT) are products in which the compost-water extract is not aerated or receives minimal aeration only at the initial mixing stage of the fermentation process [9, 10]. Compost performs the functions of fertility and carbon sequestration in thermophilic phases [9, 10]. This allows compost to mature and be cured. One of the biggest initiatives is to develop sustainable solutions to end hunger and achieve food security through small-scale farmers and sustainable food production systems [9–11]. Research

Trace metal	Content value	Mean value
Range Mean		
Arsenic (As)	23–74	52
Boron (B)	108–240	174
Beryllium (Be)	9–39	18
Cadmium (Cd)	2.5 14.8	7.5
Cobalt (Co)	6–84	48
Chromium (Cr)	100–280	170
Copper (Cu)	280–1100	610
Mercury (Hg)	15–25	21
Manganese (Mn)	385–1600	800
Molybdenum (Mo)	20–35	25
Nickel (Ni)	90–180	140
Lead (Pb)	385–4100	1630
Selenium (Se)	3.5–6.9	4.8
Titanium (Ti)	2200	2200
Vanadium (V)	38–310	170
Zinc (Zn)	465–2250	1350

Table 1.
Trace elements and heavy metal available in untreated livestock waste source: [7].

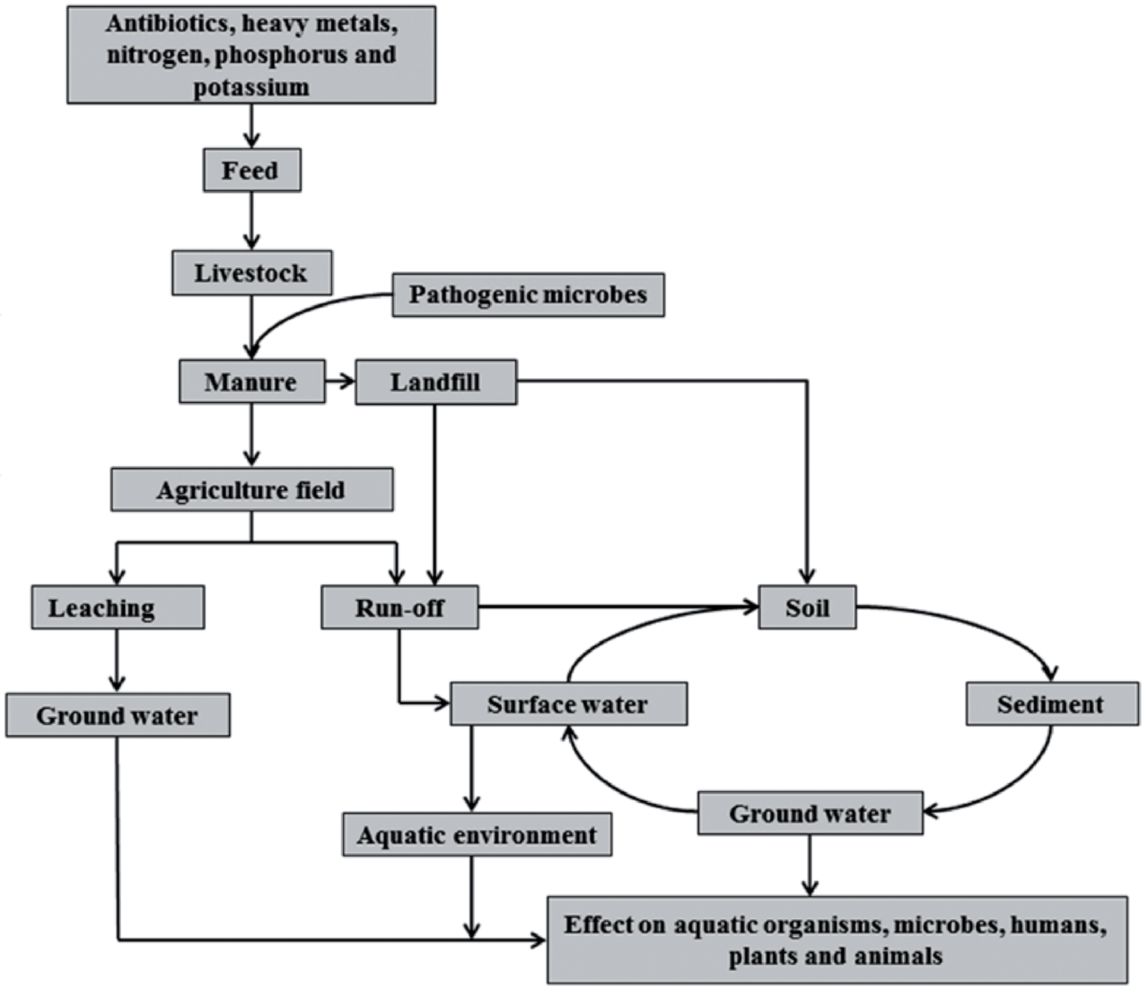

Figure 1.
Influence of untreated livestock waste on the ecosystem sourced: [11].

has focused on identifying the most sustainable and safe strategies for food waste [9–11]. This is a priority for turning waste into a resource by valorizing them into the agri-food supply chain [9–11]. **Figure 1** above, however describes the influence of untreated livestock waste on the ecosystem.

2. Organic waste as a supplement in animal feed

According to the United Nation findings in 2019, the world population was estimated to be 7.7 billion and was projected to be 9.7 billion in 2050 [2, 3]. In the recent times, hunger and food insecurity has become a global problem [2, 3]. Undernourishment or micronutrient deficiency was aggravated due to increasing population. Likewise, health challenges e.g. obesity may become an issue by 2025 [2, 3]. This is because human nutrition increases with increasing consumption of sugar, oils and fat compared to proteins [4]. Looking at the future, the demand for animal product such as meat may become unsustainable by 2050 [4]. In order to make provision for this, meat production is expected to double the amount of 455 million tons by 2050 [2, 3]. The production of poultry is increasing at alarming rate compared to livestock production [12]. The consumption of chicken meat and eggs has become a major source of proteins across the globe. Unfortunately, the food production may not be proportionate to human consumption due to finite natural resources [12, 13]. Urban development and industrial revolution has drastically influence the availability of land for food production. It was also estimated that

1.3 billion tons of food are produced globally and are wasted during production, postharvest, and processing [12, 13]. A huge portion of organic waste include edible and inedible food. Organic waste generated at the latter part of food supply is comparatively higher than at the early stage of the chain. It was also projected that increasing demand for animal product may result in high demand for feed particularly the coarse grains such as maize and protein meal by 2025 [12–14]. The conventional poultry and swine diet depend on maize and soyabean as energy and proteins sources [12–14]. As well, these same, staple food is largely consumed in many part of the world particularly in the developing countries [13, 14]. As a result, a notable increase in the cost of staple food for animal feed drives the cost of production. However, the likely solution for this could be organic waste from cereal grains and plant proteins sources used in animal nutrition. However, production cost is reduced with introduction of food waste due to its low cost compared to conventional feeds [13–15]. Food organic waste from poultry, cattle, etc. is mixed with livestock feed. This reduces the amount of waste disposal in the community [13–15]. In other words, waste retains nutritive value, which may reduce the cost of feeding. However, the waste, the type and quantity of other foodstuffs, the way the excrement is treated and the species to which the treated excrement is fed is related to its efficiency [14, 15].

3. The shelf life of processed organic waste and relevance

The efficiency of organic waste largely depend on its safety at acquiring security. This is required particularly when composing organic waste with the feed [16]. This prolonging the shell life of processed organic waste [17, 18]. The treatment of organic waste can be obtained by cooking, extrusion, pellatizing, dehydration, ensiling and probiotics [17, 18]. The shelf life of the organic waste are better prolonged with extrusion, pellatizing, and dehydration than cooking and ensiling [19]. The dehydration treatment is helpful when considering the treatment of resultant food waste in swine [19, 20]. The moisture content of organic waste varies between 50% and 85%. This may threatened the use of organic waste in animal feed but the application of adequate treatment reduced the moisture content to produce a safe organic waste [19, 20]. Adequate heat could prevent organic waste susceptibility to oxygen. This helps to prolong shelf life of waste during storage and as well prevent lipid peroxidation [20, 21]. Solar energy was identified to be economical and environmental viable at transforming organic waste into dried waste. Solar energy was used at pasteurizing and drying of organic waste. This process produce low carbon emissions and energy efficient [20, 21]. Likewise in a findings, it was also revealed that 92.74% dry matter was obtained from the use of solar energy. The crude proteins, EE and crude fiber content were 25.68%, 21.57% and 0.75% respectively [21, 22].

Furthermore, the quality and quantity of dietary proteins are of importance in poultry and swine feed [21, 22]. 15% - 23% of crude proteins was found in organic waste on a dry basis [22, 23]. The C.P obtained in organic waste in an experiment on a dry basis was estimated to be 18.9%. This was significantly higher than the conventional feed [22, 23]. The amino acid content of organic waste was higher compared to that of conventional feed [22, 23]. It was also revealed that the lysine, methionine, threonine and tryptophan content of organic waste was higher compare to the conventional feed while a similar result was obtained comparing the two diets [24]. Phosphorus and calcium are important element relevant for cell division and tissue formation. The availability of phosphorus and calcium was studied in an investigation [24]. It was found that organic waste contain 0.004% to 0.46%

calcium on a dry basis [24, 25]. This has a similarity with result obtained with soyabean meal 0.27% - 0.47% with a C P of 47.2%. This was higher than result obtained from corn (0.01–0.03%) [24, 25]. The breeding of broiler was experimented using different concentration of organic waste. Result revealed that the dried leftover food produced 20.02% C P and 9.99% EE [25]. The concentration of DHA in meat from broiler group fed dried leftover was not significantly higher than the control group. It was also recorded that the arachidonic acid content in broiler meat was not different among the treatment. However, the leftover treatment produced a better result than the control [25]. The salt content in organic waste compared with conventional feed made from corn in an experiment. It was reported that salt content of organic waste was higher compare to the conventional feed [25, 26]. The salt content of organic waste was recorded to be between 2.0% to 2.5% and approximately 3.28% on a dry basis. The present of salt in animal diet was very helpful. It enhances palatability [26–28]. It prevent the growth mold. It regulates growth and performance of the animals [28, 29]. Adequate salt level provide a soft texture of pork. It was recorded in a study that the salt content of organic waste was higher compare to convention feed composed from corn and soyabeans [28, 29]. It was also found that the performance of poultry and pig was strictly due to high salt content. Organic waste can be used as a substitute for salt if properly incorporated into diet because high salt level may result into poisoning [29]. It may also be subjected to rancidity [29]. Animal feed contribute to alleviation of food security through utilization of organic waste. Some bioactive compound and nutrients are found helpful to animal feed [29]. The use of organic waste in poultry and pig was found to be promising.

4. Food waste and pathogens

Moreover, waste generated by animal compounds is a more serious problem than waste voided by humans. Human waste is treated before it is released into waterways, but animal waste is not or poorly processed [30]. It has been reported that disease organisms may be transmitted from animal to animal through the use of organic manure in feed processing. The transfer of these diseases may constitute a problem to animal and public health [31]. Chicken waste is well known for Salmonella and Campylobacter spp. [32]. Cattle are known to host a gram of cattle manure with up to 10 million Salmonella organisms [31, 32]. Several methods have been used by researchers to inactivate pathogens before they are introduced into animal feed. The use of the stack method was found to be effective by some researchers [31, 32]. Some Salmonella species require an approximate temperature of 63°C (145°F), whereas *E. coli* requires heat of approximately 68°C (153°F) [31, 32]. Fermentation was also used to breakdown the bacteria in manure [33, 34]. This was an ensilage process. It involves the ensiling of waste with various grasses stored in airtight silo. In this situation, higher temperatures is ideal for killing infectious organisms [34]. Under these conditions, poultry litter buffers acids that destroy bacteria [35, 36]. In other words, some bacteria and coliforms were not completely controlled by ensilage. In a different finding, it was also recorded that stacking and fermentation is not as effective as the use of heating and drying method [35–37]. This involves subjecting manure or litter to the hot air blast from the oven. The temperature here is approximately 150°C (300°F) or higher, depending on the method [36, 37]. Campylobacter jejuni, *E. coli* Samonella, germisia and Listeria were found to survive prolonged anaerobic digestion [36, 37].

The use of organic manure in feed processing allows the transfer of disease-causing bacteria to spread resilience strains that may not be associated with organic waste. Most of these diseases inactivate at different temperatures [35–37].

Disease	Organism	Lethal conditions (moist heat)
Anthrax	*Bacillus anthracis*	Over 100°C
Brucellosis or Contagious abortion	Brucella species	10 mins - 60°C
Cholera	Vibrio cholera	15 mins - 55 °C
Diphtheria Diphtheria	Corynebacterium	10 mins - 58°C
Dysentry	Shigella species	60 mins - 55 °C
Food poisoning	Salmonella species	20 mins - 60 °C
Leptospirosis (Weil's disease)	Leptospira species	10 mins - 50 °C
Plague	Pasteurella pestis	5 mins - 55 °C
Staphylococcal infections	Staphylococci	30 mins - 60 °C
Streptococcal infections	Streptococci	30 mins - 55°C
Tuberculosis	Mycobacterium	20 mins - 60 °C
Typhoid fever	Salmonella typhi	20 mins - 60 °C
Vibriosis Intestinal worms	Vibrio fetus	5 mins - 56°C
Round worm	Ascaris lumbricoides	60 mins - 55 °C
Tape worm	Taenia saginata	A few minutes - 55 °C
Hookworm	Ancylostoma duodenale and *Necator americanus*	1 min - 55 °C

Table 2.
Lethal- time conditions for some common pathogen sourced: [2].

In addition, European safety rules for food should be followed by a high level of protection of human health, and the production of edible terrestrial invertebrates as food should be safe and wholesome and reared and marketed as food [37–42]. The lethal time conditions for some common pathogens are shown in the **Table 2**.

5. Invertebrate function as food and compost

The population of certain invertebrate are excellent source of biologically valuable protein, micronutrients, minerals, and vitamins in the human diet [43]. This species contains high protein content in the range of 54.6–71% dry matter and is rich in amino acids considered essential for humans. It also rich in fat, with content ranging from 7.3–10% of dry matter [43]. Certain invertebrate such as earthworm are grown in organic waste in a confined area for consumption purpose and vermicomposting [43, 44]. European safety rules for food must be followed with high level of protection for human health. The production of edible terrestrial invertebrates as food must be safe and wholesome for consumption and for market purpose [43, 44]. This invertebrate meal such as earthworm, millipede therefore has interesting nutritional proprieties but in order to be commercialized as a product for human consumption and/or animal feed, it must be safe for final consumption [44]. Safety standards must be ascertained to ensure disease organism are cured from these invertebrates before they are introduced for consumption [45, 46]. The finished food product must undergo assessment and as well ensure its hygienic and undesirable substances. To achieve the safety on food product, it is necessary to evaluate the microbiologic profile, testing for microorganism indicators of process hygiene and verifying compliance with food safety parameters, chemical profile, the presence of pesticide residue and toxic elements [45, 46]. Similarly, the growth of earthworm provides sufficient vermicompost as an organic fertilizer that allows a reduction in the use of mineral fertilizers in other production systems [45, 46]. For food purposes, earthworms for instances were subjected to a deep washing and vacuum freeze-drying procedure, a useful dehydration method is used to preserve nutritional quality [47–50]. Then, the earthworm meal are defatted to obtain a meal rich in protein and other nutrients and to decrease perishability. Food are free of pesticides or mycotoxin. The meal possesses safety traits in relation to possible public health risks [51–54].

6. Vermicompost sustainable means for food security

Invertebrate communities are made up of detrivores, microbivores, predators that are functional at engineering ecosystem [55]. The physical and chemical composition of the soil may be related to the present of certain invertebrate [56]. The invertebrate communities perform the function of imputing organic matter into the soil through frequent mulching, compost, biosolid into soil habitat [55, 56]. It involves the breaking down of tree leaf, litter to grass clipping and root exudate [55, 56]. The availability and the abundant of these invertebrate determines the efficiency of the ecosystem. The invertebrate apart from earthworm that are found effective at composting organic waste this include dipteran larva, fruit fly (Drosophila spp.) and the P (Dipteran) [55, 57]. Dipteran larva composes waste at a mesophilic temperature not higher than 40°C but fruit fly (Drosiphila spp) has proven to be efficient at a thermophilic temperature greater than 40°C. The P (Dipteran) was found to have cured waste at a temperature less than 40°C [56–58]. Earthworm had been the most common invertebrate well known at composting. Vemicompost has been used in bioconversion of fruit and vegetable waste releasing organic soluble for plant growth, which is sustainable, cost-effective, and ecological approach that can contributes to the reduction of food waste [56–58]. Fruit and vegetable waste as a substrate for the growth of earthworms produces a valuable product that can influence agricultural land and crops [57, 58]. In nowadays, scientist consider use of terrestrial invertebrates such as earthworms used as an alternative source valid at restoring land productivity, especially by reintroducing fruit and vegetable waste into the food supply chain, hence turning waste into a resource [58]. Pressmud is a byproduct of bagasse. Pressmud contains about 25–30% organic matter. The major plant nutrient constituent of pressmud include N, P, K, Ca, Mg & S and the minor elements like Fe, Zn, Mn, Cu, B & Mo. Pressmud can be used in vermicomposting [58, 59]. The population of earthworm called Eisenia foetida are very effective and excellent source of biologically micro and macronutrients [58, 59]. Recycling biodegradable waste into compost and compost tea is being promoted as a viable option for treating waste material [60]. As well as the use of compost as a bulk fertilizer and soil ameliorant. A considerable evidence also shows that compost and liquid preparations such as compost tea can suppress soil-borne diseases [60]. However, the effect of compost and compost tea on soil-borne diseases varies greatly depending on the properties of the compost as affected by compost formulation, the composting and compost tea brewing process, and the environmental conditions in which the material is used [60, 61]. According to [61], the efficacy of biological control as trichoderma harmatum increases as compost mature and the ratio of cellulose lignin than hay or straw based on composts. Mature compost with wood chips or bark and anaerobic digestion suppresses Rhizoctonia [60, 61]. Compost with wood as an ingredient passing through the gut of earthworm provides a healthy micro biome that provide ecosystem functions including promotion of plant growth. The microbes however, mediates and prevent limiting organisms to releasing plant nutrient. This indicate that beneficial microbe compete with antagonizing pathogen [60, 61]. Likewise, these microbial species produce antibiotics to combat pathogens, manufacture plant growth hormone or induce systematic plant defense that promote plant growth. However, a good composition and curing method deliver a national consortium of microbes for biological control of diseases [60, 62].

7. Composts suppress diseases organisms in the root

Disease suppressiveness vary differently with respect to pathogens for instance some soil with compost were found suppressive to Fusarium wilt [62]. The suppression of diseases are specific to composition and the various components blended together during composting. A compost that is steam sterilized are found efficient and stable [62, 63]. Pythium and root knot nematode was found suppressed with the application of organic manure in the growth of tomato, sweet peppers and ornamental [64, 65]. Soil borne diseases was also found suppressed with the use of compost during plant growth [66, 67]. Mature compost suppresses diseases with the addition of organic amendment and biological control agent [66, 67]. The use of compost increases the suppression of diseases. Compost application prevent quick re-infestation of soil by pathogen. Diseases such as bacterial cancker and wilt of tomato are caused by *Clavibacter michiganensis* and *Ralstonia solanacearum* [67]. It was also recorded that compost was effective at reducing botrytis cinerea on cucumber and melon bacterial leaf spot of *Xanthomonas campestris* on tomato [68]. The control of these pathogens minimized the invasion of diseases. However, the security of crops using mature compost during vegetative growth and fruiting is significant to increasing farm output. As a result, the palatability of crops are enhanced. The appearance of crop are appealing to the eyes. More so, the volume of harvest in the market for final consumer is at maximum [67, 68]. Compost can be used as alternative to synthetic fertilizer which has been found to be detrimental to ecosystem through surface runoff [69, 70]. Most farmers in attempt to increase yield, applies synthetic fertilizer in excess. Excessive use of synthetic fertilizer increases yield at a diminishing rate because continuous addition of synthetic fertilizer become toxic to beneficial organisms and as well reduce yield [70]. Synthetic fertilizer infestation pests and disease organisms through competition from weed [71, 72]. It was also recorded in a findings that excessive use of synthetic fertilizer can accelerate early rot of food crop and vegetables before and after harvest [71, 72]. The palatability of food crop are negatively affected with the use of synthetic fertilizer. However, mature compost are naturally inclined. They produce beneficial organisms that fight pathogens. Mature compost releases nutrient gradually released into the soil. It increases soil moisture and aeration. Compost application to vegetables and food crop can be helpful at achieving food security if properly managed [73].

8. Conclusions

Invertebrate plays a significant in carbon cycle and green community development. It is a good source of protein. Little or no attention are given to these organisms. They provide the required energy needed to sustain biodiversity through composting. However, compost has been identified as organic component that

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contains requires micro and macro nutrients that is capable of restoring nutrient into the soil. In this case, plant and animal waste are of significant interest. Waste are subjected to either aerated or non-aerated temperature to produce a pathogen free compost. The end product contains some compounds that could stimulate development of plant and animal. Pretreatment are required at an appropriate temperature essentially to inactivate disease organisms and pathogens. Compost has been used as a supplement for animal feed, it reduces the cost of production. Likewise, disposal of organic waste in waterways or occupying large land mass in the community. Compost has been used to boost germination and growth of plant. It suppresses wide range of disease varying from one plant to the other. Likewise, safety standard must be ensured and storage of food to keep the public free of zoonotic diseases. In a nutshell, if compost are properly managed, it is capable of increasing food production. Wiping away malnutrition and poor access to food across the globe.

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