Community-based Composting and Management of Leftover Food for Urban Agriculture

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学 位 論 文 要 旨

Community-based Composting and Management of Leftover Food for Urban Agriculture
市街地農業のためのコミュニティベース食品残渣コンポスト化とそのマネジメント

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The development of urban agriculture varies from country to country and region to region depending on climatic, demographic, economic, social and cultural circumstances. The outcome of the study, therefore, would supplement existing urban agriculture (UA) in general approaches of literature. Focusing on social and technological approaches has led to promote the successful implementation of Urban Agriculture in developed and developing countries. Related to the Urban Agriculture concept, this paper stressed the waste management in an urban area. A social approach was initiated in Fuchu city as community-based composting activity and a technology approach was conducted as an odor control experiment of its composting process. The community-based composting was the first action to be accepted by the farmers or residential people who had similar motivations and understandings to bear the risk of co-operation. The observation was found that management of organization required synergy endeavor of stakeholders in the related organizations among local government agencies, universities, research and development institutions, employers and others as it is the key factor to be able to continue well-functioning composting management system in the Urban Agriculture. Previous discussion explained that the conviction from the farmers in Fuchu city was an interesting in using compost from leftover food and they confirmed its ability to improve nutrients in their field. On the next stage, the community faced various obstacles and challenges that addressed in this study i.e. the risk of odor from composting facilities and unavailable of lunch servers. Thus, the obstacle had to be solved by technological approach in odor control. At the beginning some trials were as follows: starting with high quality feed stock, cutting corner for delay of fresh material, mixing between rich nitrogen feedstock and rich carbon feedstock, frequently turning of material position, shifting the smell into drainage-canal, and in active aeration. The observation of initial characteristics of the composting materials in different seasons and the monitor of its physical properties indicated that the composting process was not satisfied for agricultural needs and environmental conservation. However, within a range of ammonia gas concentrations, no complain of odor was obtained from the residents. Another achievement was the reduction of ammonia gas by using clinoptilolite in composting of leftover-food. In particular, this study focused on the correlation between ammonia emissions and temperature at different doses of clinoptilolite in the thermophilic stage, which occurred in the early days of compost and from which ammonia gas was actively discharged. The addition of 31.5 – 47.2 % clinoptilolite to leftover food composting affected the reduction of ammonia emission and the composting properties. The results of this study demonstrate that natural zeolite from Japan “Itaya Zeolite-13” acts as an adsorbent and has great potential for removing ammonia from fermenters composting of leftover food especially in granular form (<4mm). Based on the results above, the possibility of extension of the community-based approaches was discussed in reference to another city in Japan, Denpasar or other city in the world. This paper also could be the answers and the solutions for Urban Agriculture problems which might be occurred in any city anywhere in near future. Any effort of composting will face the problem in "to how to mitigate the odor ". Technology approach in odor control and social approach in initiated the community-based approach in this study will contribute in the future of research and development of waste management. Especially Denpasar-Bali is the city which just started the development of community-based composting and realized on how the importance of community-based composting to promote Urban Agriculture.

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Abbreviation

ADS	anaerobically digested sludge
AP	animal by-product from slaughterhouse
Asdep	asisten deputi (assistant deputy)
BSI PAS	the british standards institution’s publicly available specification
BPKS	badan pengelolaan kebersihan sarbagita (a sarbagita hygiene management agency)
CBO	community-based organizations
CIRAD	the centre de cooperation international en recherche agronomique pour le developpment
DMDS	dimethyl disulfide
DCG	denpasar clean and green
DKP	department of hygiene and urban landscaping of denpasar
EC	electrical conductivity
EPR	extended producer responsibility
FAO	united nation’s food and agriculture organization
FIT	fit-in tariff
FOCIF	food and organic chains Initiative in Fuchu
EPR	
HH	partially hydrolyzed hair from the leather industry
MC	moisture content
mdpl	meter dari permukaan laut (height from sea level (meters))
MSW	municipal solid waste
NARO	national agriculture and food research organization in Japan
NEC	Nippon electric company
NGO	non-government organization
NTT	national telegraph and telephone corporation
OFMSW	organic fraction of municipal sewage sludge
OM	organic matter
PPLH	pusat pendidikan lingkungan hidup (Bali Environmental Education Center)
PKK	pembinaan kesejahteraan keluarga (the woman in family welfare movement
PTA	a parent-teacher association
PTSA	parent-teacher-student association
P-1DS	protein-one spindle double garbage disposal tank-compost system
RS	raw sludge
TA-N	total ammonia nitrogen
TMG	Tokyo metropolitan government
TPA	the final waste disposal
TUAT	Tokyo university of agriculture and technology
UA	urban agriculture
UN-HABITAT	united nation’s human settlements program
USDA	united states department of agriculture
USAID	United States Agency for International Development
VOA	volatile organic acids
VFA	volatile fatty acids
VS	volatile solid
3Rs	reduce, reuse, and recycle

Chapter 1
Introduction

1.1. Background

Loss of productive land for agriculture in rural area will not be prevented due to increasing population pressure, rapid increase in economic growth, rapid urbanization, industrialization, culture degradation, less human interest in agriculture activity, etc. Rural area will change into urbanized area and then will develop many industries and processes followed by associated problems which occurred due to its implementation. The problems occurred especially for environmental aspects that facing today as part of global climate changes, such as environmental health issues including visual untidiness, soil erosion, destruction of vegetation, siltation, and depletion of water bodies and pollution of resources (soil, air, water). Refer to the UA definition that is an industrial located within (urban-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grow and raises, processes and distributes a diversity of food and non-food products, (re)-using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area (Mougeot, 2000). However, it is not impossible for the first appearance urban agriculture (UA) develops in the city, provides beneficial for city inhabitant and becomes promising solutions when faced with the problems above.

The UA is different from, and complementary to, rural agriculture in local food systems: urban agriculture is integrated into the local urban economic and ecological system (Mougeot, 2005). Other supported definition stated by Deelstra and Girardet (2000) is that the UA not only provides food production and self-employment but also helps to create an improved microclimate, promotes soil conservation, improves the nutrient recycle, improves water management and biodiversity, balances O_2–CO_2, and to increases the environmental awareness of city inhabitants. Along with the increase of knowledge in various aspects and increasing concerns about climate change especially for saving the environment, action/behavior of city inhabitant changed. Public awareness and initiatives pioneered by few local farmers and society followed by local authority have promoted the growth and potential of agriculture in and around cities. More local authority or city governments are now seeking to create and support programs, exchange policy and technical application to better deal with a spreading trend/phenomenon in their own city. Social approaches which are from community, by community and for community are needed to support those things above.

Here, we present a study from modern city like Fuchu, Tokyo, Japan. Describing a project which developed by a community-based composting in Fuchu city, Tokyo. In this community, each individual can easily deliver their initiatives mainly in organizational management and an odor control management in order to produce a traceable composting in urban agriculture. Because the composting facilities are located in an urban area, the technology and management approach in composting system was needed. Record histories of entire composting management system were collected, i.e., categories of organization, stakeholders involved, management of organization of community-based composting, positive and negative factors, solving actions to the negative factors and obstacles, management approach of composting, initial characteristics and monitoring of composting materials. From those all data, a well-functioning composting management system in urban agriculture can be achieved. Another study comes from small city like Denpasar, Bali, Indonesia; clean and green city becomes a target in all sector as Denpasar is a major tourist destination. However, the problems come along from environmental awareness of city inhabitant and the difficulties of government to change public behaviors on municipal solid waste management. Establishment in regulation of biomass utilization can be applied to the answer of that kind of problems. Because it became a strategy to see the biomass from the different perspective i.e.

purchase of biomass recycle into values and energy.

The UA contributes to social sustainability while increasing ecological sustainability through the transformation of wastes, natural resources saving, soil erosion prevention, greening and reduction in pollution (Madaleno, 2000). Municipal solid waste could be one of the beneficial materials which are easy to collect in urban area and does appear to be a limitation. Composting is the answer in tackling the waste matters problem, especially in urban area since the landfill become limited. Composting can be particularly effective in converting wet materials to a more usable or easily disposable form. Food waste is an example of non- harmful material, easy to collect in urban area and suitable material for composting. The diverting food waste and turning it into compost can be solution of the waste problem in the city. However, composting material or compost is generated by biological decomposition of time consuming processes (Haugh, 1993) and carry potential risk for odor pollution. Control of odors is undoubtedly the most difficult problem in present composting practice (Haugh, 1993). Properly and favorably managements in composting are absolutely needed. Producing compost material particularly is one of the UA activities.

The influence of ammonia emission was investigated under the composting process especially in the early thermophilic stage and in different doses of clinoptilolite which uses a small-scale composting reactor. In particular, the study focused on the correlation between ammonia emission and temperature at different doses of clinoptilolite. Moreover, this study used food waste such as leftover food-rice hull from school lunches that was widely available and easy to collect in urban areas. Although its content was relatively safe, other ingredients such as bulking agents and odor management were required. The results suggested that social and technology approach may be widely applicable, if appropriately planned and integrated into urban design, those kinds of UA activities can contribute to the comfort of citizen play an especially significant role to promote UA.

1.2. Literature Review

1.2.1. Urban Agriculture Concept

According to Smit et al. (1996), definition of UA stresses the recycling of urban waste. The definition is as follows: UA is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area. Mougeot, (2005) stated that this definition has been used in technical and training publication by UN-HABITAT's Urban Mangement Programe (Cabannes and Dubbeling, 2001; Dubbeling and Satandreu, 2003), the special Programe for Food Security of the UN's Food and Agriculture Organization (FAO) (Drescher, 2001), and international agricultural research centers such as the Centre de Cooperation International en Recherche Agronomique pour le Developpment (CIRAD) (Moustier and Salam Fall, 2004). The definition of UA will continue to evolve, as they are applied to an ever-diverse range of context and purpose (Mougeot, 2005).

Urban-agriculture requires an organic resource that provided not only from animal husbandry but also from food production. The relationship between urban agriculture and resources can be described as being three-pronged (Smit *et. al.,*1992). First, some urban by-products, such as waste water and organic solid waste, can be recycled and transformed into resources or opportunities for growing agricultural products within urban and peri-urban areas. Second, some area of cities, such as idle lands and bodies of water, can be converted to intensive agricultural productions. Third, some other natural resources, such as energy for transportation and cooling, can be conserved through urban agriculture (Sachs and Silk, 1990).

In most developing countries, municipal solid-waste management remains centralized, capital-intensive and deficit-ridden. In several African cities, neighborhood and micro-enterprise composting has been effective in application of UA (Mougeot, 1999). Mougeot, 1999 stated that outside Asia, the developing countries experienced the limited of waste management system with citywide integration; this includes the use of UA to achieve environmental sustainability; this includes the use of UA to achieve environmental sustainability, as contained in the definition of UA before. Havana and Cagayan Del Oro are now witnessing the expansion of small-livestock systems relative to plant crops (Mougeot, 1999). Whereas UA for self-consumption relies less on the use of agrochemicals (Lourenço-Lindell 1995), more intensive market production might make excessive use of certain products, as observed in Bamako and Lomé. De Bon et al. (1997) in Dakar and Kouvonou et al. (1998) in Lomé found that market vegetable farming makes more extensive use of organic rather than of mineral fertilizers, thereby giving value to sub-products of animal husbandry. In Cuba, the use of chemical fertilizers is prohibited within city limits and producers rely on integrated pest management and organic soil management (Altieri et al. 1999). Lewcock (1995) found in Kano, Nigeria, that peri-urban farms are a traditional informal and growing market for large quantities of minimally composted waste; he also found that these producers lacked knowledge on the safety of waste materials for uses as fertilizer or stock feed. Few cities outside Asia sell and deliver truckloads to large clients on the urban fringe, or encourage at-source sorting and pre-collection of organic waste by organized groups for local composting and UA use. In Egypt, compost was found to be severely contaminated with heavy metals because of poor sorting of inorganic waste (Lardinois & van Klundert 1994). Another example of environmental sustainability in the city is stated by Son (2010) that Davis was proudly named the first platinum Bicycle Friendly City in October 2005 by the League of American Bicyclists. The city's recent sustainability efforts have also ensured that bicycling is recognized as an effective tool for lowering our carbon footprint, improving air quality, benefiting public health and reducing childhood obesity. Tokyo's super eco-towns that recycle waste, buildings made from biodegradable materials that dampen heat emissions and alternative energies that power homes, offices and motor vehicles are all steps toward a zero waste city (Fujita, 2007). Kozuka, (2013) stated that some Japanese have found truly ingenious ways such as to bring farming to a big city in Pasona O2 building, the project aims to bring the farm to the office as well as to educate their employee and the local public about agriculture in Roppongi Nouen, they have made it a mission to bring agriculture closer to city life and remind people how important the job is in City Farm, they offer customers assistance in growing fruits and vegetables that are staples in the Japanese diet, like kabocha (pumpkin) squash, rice, and soybean in Ginza Honey-Bee project, the nonprofit whose members run the gamut from patisserie chefs to lawyer to teacher producers, hit upon be raising as a way to simultaneously contribute to the economic and ecological life of their neighborhoods in Green Potatoes Program, telecommunications giant NTT has been working on an interesting initiative to make greening easier and less hassle. Their solution is sweet potatoes.

Community-based Composting typically came from non-governmental organization and can be formed from several stakeholders, a public-private and community partnership. The initiative can grow from the individual or organization which is created a solution that could sustainably manage municipal solid waste, reduce costs of the city on waste management investments, reduce methane emission from waste and create employment opportunities for urban poor, who have traditionally earn money by sorting through trash then collect and sell the recyclables. The composting activity becomes the main activity which is organized locally. Mostly in developing countries, centralized composting plants are often not economical due to high operational, maintenance, and transportation costs. Cities in developing countries may lack the resources to administer this type of service. Decentralized composting locations can be an alternative because they handle small amount of biomass and require simple technological, less human labor and financial. Usually, community-based composting has worked at a micro-level: in a locality or neighborhood. Without sustained support and participation of the municipality and larger communities it is difficult to upscale the community-based in a short time. Any community project needs the support of its stakeholder's i.e. waste pickers, residents, local municipal body, and community-based organizations (CBOs), volunteers, etc., to operate and sustain itself.

The initiative and incentive in every community waste management systems should come from the government. Ideally, land for composting and other basic infrastructure should be provided by the local government. Currently, urban planning provided by the local government does not include such needs in its spatial city plans. Common request after the initiating composting and recycling activity from the community is the markets, which is needed to be developed for compost products made from urban waste. Private sector investment in this area has been floundering owing to its inability to sell the compost due to the competition from the heavily subsidized chemical fertilizer industry. While energy products are being subsidized from the government, the greener compost products need urgent attention.

1.2.2 Food-garbage-waste composting

Composting of sludge, yard waste, manure, food waste, refuse and other substrates has become a very popular management option and food wastes are always near the top of the list (Haug, 1993). Some foods generate more wastes than the others e.g. cabbage and green coconuts in tropical climates.

One of the most significant imports into urban areas is food. At the same time, cities export daily a vast volume of wastes into their adjacent regions, with low-income cities having a much higher share of total waste as organic and food wastes. Converting food waste through the composting then use the compost to produce a fresh food in own field can reduce food cost production, improves quality of food available because using organic compost, improves the environment for living because can create an interesting view of cultivation, creates jobs and reduces municipal management costs if manage by city government. Pascual et al. (1999) found that the organic fraction of food waste compost was mostly comprised of the remains of fruit and vegetables with high carbohydrate content and it was easily used as carbon and energy source by microorganisms. Food waste compost could be an alternative to chemical fertilizer to increase soil microbial population and enzyme activities, and to promote the soil nutrient for lettuce growth (Lee, et al., 2004). Such recycling of organic waste materials maintains soil nutrient levels, and has been shown to stimulate various aspect of soil fertility (e.g. levi-Minzi et al., 1985; Elsgaard et al., 2001).

Some organic from food wastes have medium nitrogen content and some are high. It is common to mix between two materials which have high and medium contents of nitrogen since it's substantially to enhance the composting activity. The organic wastes with medium nitrogen content are organic fraction of municipal sewage sludge (OFMSW), raw sludge (RS) and anaerobically digested sludge (ADS). The others with high nitrogen contents are animal by-product from slaughterhouse (AP) and partially hydrolyzed hair from the leather industry (HH). For example HH was mixed with RS (1:1 weight ratio) to act as inoculum in the composting process since in previous experiments with HH alone there was no composting activity probably due to the strong chemical treatment applied to cow skin to remove and hydrolyze hair (Pagans et al., 2006). Food waste such as leftover food from school lunches is widely available and easy to collect in urban areas. The studies of the composting of food waste from the school lunch and cafeteria are shown in Table 1.1. Although its content is relatively safe, other ingredients such as bulking agents and odor management are required.

1.2.3 Composting Odor Management

The air in nature will never be found at all clean with no pollutants. Air pollution can occur naturally by all living system or due to human activities. It is reasonable to assume that the pollutant will contain many molecules that are potentially odors, some pleasantly, acceptable level and other disagreeably. Some gases such as sulfur dioxide (SO_2), hydrogen sulfide (H_2S), volatile organic acid, mercaptans, methyl sulfide and carbon monoxide (CO) are always released into the air as a byproduct of natural processes such as volcanic activity, the end product of anaerobic metabolism, forest fires, and so on. Ammonia (NH_3) and Hydrogen sulfide (H_2S) are good example of anaerobic product. Ammonia is a primary offending odor and a prominent odor which is in laboratory used as anhydrous ammonia (gas or liquid) and classified as toxic and dangerous for environment. Organic natural resources can be recycled through biochemical processes into compost, which can be used as a soil improver or organic fertilizer. However, waste processing can contribute to odor pollution, especially in urban areas. If not managed and utilized properly, in fact, it causes closure of some composting facilities and becomes a bottleneck for urban agriculture to continue their activity and even more to expand their utility program. Potential nuisances most often associated with composting are odors, dust, insect development, and attraction of bird and rodent. Therefore, odor management is required to minimize the impact because odor is the most crucial problem in composting and to make composting more environmentally acceptable. Chemicals that commonly translate to odors include ammonia gas (NH_3) and some volatile organic acids (VOA). Natural zeolite is used commonly in waste water treatment, animal husbandry, because of its unique adsorption, ion exchange, molecular sieve, and catalytic properties.

The release of ammonia gas has been successfully reduced by adsorbents such as zeolite in composting piles of municipal solid waste (Turan and Ergun, 2007), sewage sludge (Villasenor et al., 2011; Witter et al., 1988), waste water treatment (Emadi et al., 2001; Cooney et al., 1999) and animal rearing facilities (Witter and Kirchmann, 1989; Venglovsky et al., 2005). Clinoptilolite (a naturally occurring zeolite) is the most abundant natural zeolite and has the chemical formula $Na_{0.1}K_{8.57}Ba_{0.04}$ $(A_{l9.31}\text{-}Si_{26.83}O_{72})_{19.56}H2)$ (Galli et al., 1983).

In Table 1.1 earlier studies have shown that clinoptilolite or certain other natural zeolites are effective in removing ammonia from composting. However, there are few studies on the effects of natural zeolites on ammonia reduction during the thermophilic stage of food waste composting. There is also a significant variation in the ion-exchange characteristics and structural rigidity of clinoptilolites from different sources, which can create differences in the ability of clinoptilolite in different countries.

The main function of bulking agent is to provide the adequate porosity. From previous study it was found that the organic waste such as raw sludge, anaerobically digested sludge mixed with bulking agent in a volumetric ration 1:1 (bulking agent: sludge) as optimal for sludge composting (Gea et al., 2003). While the high pH amendments had little impact on the compost quality in the project in Norway, Campbell et al. (1997) reported that the finished compost had a lower maturity and higher final pH and salts due to the wood ash additions (Das, 2000). The earlier studies of rice hull used as a bulking agent in food waste composting as shown in Table 1.1

Composting has a rather unique ability to buffer both high and low pHs back to a neutral range as composting proceeds. This ability to buffer extremes of pH is caused by the fact that both carbon dioxide (a weak acid) and ammonia (a weak base) are released as a result of organic decomposition. Very low or very high pH levels can impose rate limitations to microbial activity. High pH levels are commonly encountered with municipal sludge because of the practice of lime conditioning. These compounds will tend to neutralize extremes of low or high pH. Additional lime is used to manage the pH of composting process. For example, Lystad (2002) reported results of a project at a composting facility in Norway in which lime was added to food and green wastes ("biowaste") to raise the initial pH to 11.9 in order to control the odor emissions during handling and the early stages of composting. They reported that the overall odor situation improved and that the pH recovered to levels below 8 after a few days of composting in an enclosed vessel.

Table 1.1 Study references on organic composting.

material/parameter	research	reference
Food waste from school lunch and cafetaria	composting of food waste	Chikae et al., 2006; Maeda et al., 2000; Jeong et al., 2001
Clinoptilolite	removing ammonia using natural zeolite	Turan et al., 2007
Rice hull	bulking agent for composting	Chikae et al., 2006
Lime	controled pH in composting	Kofujita et al., 2007; Maeda et al., 2000; Redondas et al., 2012
Temperature	environmental temperature of food waste composting	Horisawa et al, 2001
Ammonia	ammonia uptake in MSW composting	Turan et al., 2007
MC	MC retained by natural zeolite, optimum of MC in food waste composting	Turan et al., 2007; Maeda et al., 2000
VS	reducing of Volatile matter through decomposition	Maeda et al., 2000
pH	optimum value of pH in composting	Bertoldi et al. 1983
EC	effect of natural zeolite on salinity level	Turan et al, 2008
C:N ratio	enrichment on chemical properties of MSW compost	Iqbal et al, 2010
TA-N	conservation of nitrogen in aerobic composting	Jeong et al., 2001

Also, lime and wood ash have been intentionally added to raw composting feedstock with the purpose of temporarily slowing the biological activity and prevent the formation of odorous compounds (Lystad, et al., 2002; Campbell et al., 1997). Lime doses as high as 30 to 40% are used for stabilization. Even these large amounts would not overly tax the neutralizing capacity of the composting process. Rate limitation in the early stages of composting might occur until sufficient organic decomposition is realized to lower pH. Conversely, from aforementioned statement, pH adjustment of the starting substrates is usually not required and is not a common practice. Two cautions to this general rule are noted. The first applies to sludge conditioned with very high lime dosages which may exhibit an excessively long lag period before neutralization. The second applies to low pH low nitrogen substrates which may lack sufficient protein to supply the ammonia needed to neutralize the acidic conditions. Table 1.1 has shown the early study of how lime was used to control the pH in food waste composting.

The most important parameter to be considered in ammonia control composting management is temperature, as temperature is an excellent indicator of the biological activity of the composting process (Haugh, 1993). Temperature influences the composition of the microorganisms (Miller, 1993; Strom, 1985), the rate of biological activity, the rate of chemical reactions, moisture loss, aeration (e.g. thermal convection), oxygen diffusion and the transport of gaseous compounds. In almost all respiration experiments, the measurement of respiration activity is carried out at standard temperatures of about 30-37 ^{o}C (USDA, 2001; Iannotti et al., 1993; Lasaridi and Stentiford, 1998). It is considered that respirometric activities measured at that fix temperature are good indicator of the mean metabolic potential of compost. Nevertheless, composting is the complex process where the rate of degradation is a result of the metabolic activity from a mixed microbial population that includes microorganisms with different optimum growth temperatures. It can be considered that although respirometric experiments performed at fixed temperature are a useful indicator of the compost stability, they do not show the actual metabolic stage of the process and, therefore, cannot be used to follow its evolution (R.B.Gomez et al., 2005). Up to a limit of approximately 60 °C (Miller, 1993), increasing temperature generally increases biological activity and, hence, the rate of decomposition. Contradiction result found by Epstein (1997) which reports a study by Wilbur and Murray (1990) that shows decreasing odor emissions at a bio solids composting facility with increasing temperature, from 46 ºC up to 68 ºC. However, the upper temperature threshold for composting is still debated. Several researchers have suggested thresholds greater than 60 °C (Epstein, 1997). Derikx et al (1991) reported the increasing rates of DMDS (Dimethyl disulfide) generation with increasing temperatures up to 90 °C. Pagans et al (2006) showed that temperature appeared to be the most suitable parameter to control ammonia emission when composting of organic waste. Suler and Finstein reported that 56-60 °C was the optimum values for composting food waste. Temperature influences the composition of the microorganisms (Miller, 1993; Strom, 1985), the rate of biological activity, the rate of chemical reactions, moisture loss, aeration (e.g. thermal convection), oxygen diffusion and the transport of gaseous compounds. In Table 1.1 has shown the previous study of the optimum temperature for degradation was 30-40 °C for exploiting biological activity effectively with lowest use of energy in composting of food waste.

Ammonia is one of the main compounds responsible for the generation of offensive odors and atmospheric pollution (Pagans et al., 2006) when composting organic waste such as household waste, meat and many types of food processing waste (Beck-Friis et al., 2001; Rynk, 1992) with high nitrogen content. Witter et al. (1988) reported that high losses of ammonium nitrogen not only contribute to the pollution of the environment, but also reduce the agronomic value of the end-product and represent a waste of valuable resources. Ammonia (NH_3) is used in the decomposition process as a source of nitrogen for microorganism activity and to adjust pH during decomposition process. Ammonia, amine, dimethylsulfide, and acetic acid played key roles for this kind of odor problem compared to Volatile Organic Compounds and could be indices used to evaluate the efficiencies of odor elimination for odor control engineering (I.-F. Mao et al., 2006). Even though food waste composting is enforced environmental policy and the decomposition of raw materials at different plants varies, NH_3 and amines were detected at all plants; these compounds require intensive control (I.-F. Mao et al., 2006). The strategy of using an intermittent (discontinue process/ starting-stopping) aeration are tested and proved to be effective in decreasing the ammonia emissions (Elwell et al., 2002), however, this causes an oxygen limitation in the aerobic process and a loss of biological activity. Ammonia gas is the main compound found in exhaust gases from composting, except for carbon dioxide. Ammonia emitted in the composting of the five wastes investigated revealed a strong dependence on temperature, with a distinct pattern found in ammonia emission for each waste in the thermophilic first stage of composting (exponential increase of ammonia emitted when increasing temperature) than that of the mesophilic final stage (linier increase of ammonia emission when increase temperature) (E. Pagans et al., 2006). Ammonia emission starts when thermophilic >45 ^{o}C and adequate pH coexist in the composting environment. And, it is widely reported that high temperatures inhibit the nitrification process (Grunditz and Dalhammar, 2001), and thereby, the possibility of ammonia emission is high (Kirchman and Witter, 1989). Therefore, it is necessary to take measures against ammonia gas emission in the thermophilic stage which is an early stage of the composting process. In Table 1.1 has shown the previous study of the successful of ammonia uptake by natural zeolite in MSW compost.

Composting is usually applied to solid or semisolid materials and the practical moisture content must be considerably <100% (Haug, 1993). Fibrous or bulky material such us straw or wood chip can absorb relatively large quantities of water and still maintain their structural integrity and porosity (Haug, 1993). Schulze (1961) concluded that ground food waste and dewatered sludge cake were too high in bulk weight and moisture to compost as such and that “those materials have to be mixed with a dry and bulky component such as refuse, waste paper, corncobs, wood shaving, rice hulls, etc. As air is heated by the composting material, it picks up moisture and thus dries the remaining material (Haug, 1993). In Table 1.1 has shown the early study of MC retained by natural zeolite and optimum of MC in food waste composting.

Organic matter represent combustible content or “volatile solids” (VS) and is typically reported in term of total weight loss on ignition as VS or OM. Organic matter may also be surmised from the total-carbon analysis where it is reported as TOC (total organic carbon). Conversely, carbon may be surmised from OM and woods end finds in composts it comprises typically 54% of VS. As with moisture, there is no absolute level of carbon or organic matter which is ideal; rather the quantities must be viewed in relation to the age of material, its nitrogen content, and its intended use. It is useful for purpose of composting to report the initial OM and contrast it with OM determined periodically at later points. This gives an idea of the extent of decomposition. Organic matter may be lower than expected because of incorporation of soil or sand during processing. In Table 1.1, the early study of volatile matter was reducing through decomposition process in food waste composting.

The pH indicates that the acidity and alkalinity of the chemical environment of composting or compost. It is a measure of the relative concentration of hydrogen (H) and hydroxide (OH) ions. pH affects, and is affected by, the chemistry and biology of composting. It helps to determine the microorganisms that thrive and the direction and nature of chemical reactions. Because of the inherent robustness of the composting process and the great diversity of microorganisms that participate, composting takes place over a broad range of pH levels (Oshins, 2006). It is important to keep the pH closer to neutral (6.5 to 8.0), this is due to extreme pH levels which can substantially inhibit biological activity. At high pH (> 8), soluble ammonium (NH4+) is converted to volatile ammonia. The smell of ammonia is particularly evident with feedstock that have a high pH, including poultry manure, and feedstock that include wood ash or lime (e.g. lime-treated biosolids). In contrast, lower levels of pH (<7) favor the formation of hydrogen sulfide, relative to the soluble sulfide ions, S2- (Sawyer and McCarty, 1978, p. 478). Hydrogen sulfide, perhaps other reduced sulfur compounds too, become non-volatile at pH levels above 8 (Das, 2000 and Sawyer and McCarty, 1970). The combination of low pH and anoxic conditions constitutes with “reducing environmental impacts.” In reducing environmental impacts, incomplete biological processes prevail including anaerobic decomposition and fermentation. In this situation, chemical elements tend to exist within "reduced" states, meaning that they are not completely degraded. Reduced compounds retain some energy. When oxygen is present, they are further degraded (i.e. oxidized) by organisms. Thus, reduced compounds are often termed intermediate compounds. Many odorous compounds identified with composting are intermediate and reduced forms, including hydrogen sulfide, organic sulfides, amines, ammonia, VFAs and alcohols. Reducing potential is influenced by both the concentration of oxygen and the pH but extremes of one or the other can lead to reducing conditions. Alcohol can accumulate during the early stages of composting when the pH drops to a very low level. The alcohols result from fermentation of the organic substrates and then accumulate because of the lack of either oxygen or biological activity due to the low pH. In Table 1.1, the early study of optimum values of pH in composting should be in value of 5.5~ 8.5 in organic waste composting.

Soluble salt level (salinity) in a sample is estimation based on measurement of the electrical conductivity (EC) of saturated paste. Component contributing most to salinity are sodium, potassium, chloride, nitrate, sulfate, ammonia, and VOA. Low levels are expected for potting compost (<2) whereas in the case of fresh compost the values may be acceptable in the range of from 3 to 10, and depend on the purpose of the compost. Low values will indicate lack of available minerals, while high values indicating a large quantity of the material are used. The unit of conductivity in the report was the traditional mmhos/cm, which is equivalent to dS/m. The ideal value of EC for compost depends on the use of the compost, according to Petrik (1985), the ideal compost should have EC no higher than 2 mS cm^{-1}. When the EC in compost higher than 2 mS cm^{-1} composts are described as saline. In Table 1.1 has shown the early study of the effect on natural zeolite on salinity level of poultry litter compost.

According to Golueke (1981) a C:N ratio below 20 is an indicator of acceptable maturity and a ratio of 15 or less is preferable. The importance of nutrient balances is nitrogen (N). If nitrogen is abundant relative to carbon (e.g. C:N ratio < 20), volatile forms of nitrogen, mostly ammonia, are produced from the surplus N. However, if the same amount of N is available with a proportional amount of available C (or more), the available N is used by microorganisms and incorporated into their biomass (e.g. compost). On the other hand, when the C:N ratio is very high, an excess amount of C exists. In this situation, decomposition slows because other nutrients limit the microbial metabolism. However, if easily decomposable C sources are present, volatile C compounds can accumulate and become noticeable as the dominant odor VFAs, alcohols, phenols and terpenes, for example. It is customary to use C:N figures to assess the rate of decomposition of composting mixtures. The C:N ratio is customarily calculated from laboratory analyses, which provide the total concentrations of C and N. However, total C is often a poor indicator of how much C is available to the microorganisms (Das, 2000). If we know that the material has undergone composting, C:N ratio may accurately reflect when ripeness has been reached. However, caution is necessary before taking any action based on the C:N figures alone. One must consider that not all the total carbon is actually available for microbial use. Or, if nitrogen is lost, C:N ratio may go up not down during late stage of composting. C:N value must be weighed against observed decomposition traits. Compost may be considered finished anywhere around a C:N of 17 or less, unless coarse woody material remain. In some regions, a product is not considered to be compost unless the C:N is less than 25:1. The previous study indicated enrichment on chemical properties such as C:N of MSW compost using rock phosphate, lime and $FeSO_4$ in food waste composting as shown in Table1.1

Ammonia is usually present in the early stage of composting as organic nitrogen is decomposed and the concentration is eventually reduced through volatilization or oxidation to the nitrate form (Haug, 1993). Ammonia is un-ionized, and has the formula NH_3 while ammonium is a nitrogen compound which is usually colorless and readily soluble in water, the ammonium ion is generated when ammonia, a weak base, reacts with Brønsted acids (proton donors)(Wikipedia):

$$H^+ + NH_3 \rightarrow NH_4^+ \qquad (1)$$

Biologically, Ammonium ions are a waste product of the metabolism of animals. In fish and aquatic invertebrates, it is excreted directly into the water. In mammals, sharks, and amphibians, it is converted in the urea cycle to urea, because urea is less toxic and can be stored more efficiently. In birds, reptiles, and terrestrial snails, metabolic ammonium is converted into uric acid, which is solid and can therefore be excreted with minimal water loss (Campbell, 2002). Ammonium is an important source of nitrogen for many plant species, especially those growing on hypoxic soils. However, it is also toxic to most crop species and is rarely applied as a sole nitrogen source (Britto and Kronzucker 2002). The usual TA-N level in composting is in the range from 2.0 to 6.0 g/kg TS defending on the initial C:N ratio (Switzenbaum et al., 1994; Morisaki et al., 1989). TA-N or total ammoniacal –N measures by indophenol blue absorptiometry. The early study was shown an aerobic composting using struvite crystal in food waste composting as shown in Table 1.1.

1.3. Objectives

It is not impossible to find the solution to answer the urban agriculture problems related to environment especially air pollution even more wide to deal with greenhouse gas emission. Focuses on social and technology approach will lead to promote the successfully implementation of urban agriculture in developed and developing country. The goal of the research is to achieve an odorless composting management for urban agriculture. Specifically, this study intended to achieve following objectives:

1. To investigate the establishment of collaborative committee of community-based composting in Fuchu city with focuses on management and technology approach.
2. To investigate a recent process, development and application of UA in Denpasar, Bali in the Five Year Development Plans to support “go green program” and to promote sustainable urban agriculture.
3. To investigate the reduction of ammonia gas emissions that mainly causes odor pollution by clinoptilolite. In particular, this study focuses on the correlation between ammonia emissions and temperature at different doses of clinoptilolite in the thermophilic stage, which occurs in the early days of compost and from which ammonia gas is actively discharged.

1.4. Thesis Structure

This thesis is divided into five chapters. The first chapter is the introduction which describes the background issues, literature review and objectives of this study. This chapter presents the connection between urban agriculture and community based composting. The second chapter discusses odor control approach and management of organization in community-based composting in Fuchu city. The third chapter discusses reduction and mitigation odor emission by natural zeolite in composting of leftover food waste. The fourth chapter discusses the development and application of UA faced by Denpasar, Bali in the five year development plans to support “go green program” and to promote sustainable urban agriculture. Finally, the fifth chapter is summary and conclusion with some suggestions for future research.

Chapter 2
Community-based composting in Fuchu city

2.1 Introduction

Community-based composting can be formed from several stakeholders, a public-private and community partnership and available in both developed and developing country. Differences of the recent process and the development of community-based composting observed across regions of the world. To investigate the establishment of a collaborative committee of community-based composting in Fuchu city, Tokyo focuses on the management and the technology approaches, we have conducted to found record histories of entire composting management of the project which developed by a community-based composting in Fuchu city, Tokyo.

2.2 Survey methods

2.2.1. Reviewing approach

In order to produce quantitative and qualitative data of community-based composting in Fuchu city, research methods covering interviews, observations and document reviews were used in this study. Fieldwork was carried out over a 3 year period between 2011 until 2013. Almost the data collection comes from hearing the Shibusawa laboratory members and community-based composting members. The record histories were collected and traced i.e. categories of organization, stakeholders involved, positive and negative factors, solving actions to the negative factors and obstacles, composting materials, and composting process.

2.3 Result of survey

2.3.1 Environmental Policy of Tokyo

In Japan, the Basic Environment Law, which set out basic principles and directions for formulating environmental policies, was enacted in November 1993. In December of the same year, the "National Action Plan for Agenda 21" was submitted to the United Nations. In December 1994, an action plan called "the Basic Environment Plan" is adopted. The Basic Environment Plan was established by the Cabinet decision on December 16, 1994, as a long-term comprehensive national plan for environmental conservation, in accordance with the Article 15 of the Basic Environment Law (Law No. 91, 1993). The Plan sets the following four long-term objectives; Sound Material Cycle: in order to minimize the burdens on the environment generated at various stages of socioeconomic activities, to establish a socioeconomic system fostering environmentally sound cycling of substances through reexamining the current system dominated by mass production, mass consumption and mass disposal; Harmonious Coexistence: in order to ensure that the blessings of the environment will be enjoyed by both present and future generations, to maintain or restore the sound ecosystems and to ensure harmonious coexistence between nature and human beings; Participation: to build a society where all parties, including the central and local governments, corporations, citizens and private organizations, participate voluntarily and actively in environmental conservation activities, cooperate, and share burden fairly; International Activities: to promote international environmental efforts in cooperation with the other countries that share our common global environment (Ministry of the Environment Government of Japan).

Related to this study, we specifically focused on the offensive odor control law in Japan. With the progress of industrial development and urbanization, complaints about environment pollution such as air pollution, noise and offensive odors increased sharply in the 1970s in Japan. To take measures against offensive odors, the “Offensive Odor Control Law” was enacted in 1972 and regulates offensive odors emitted from business activities. The Ordinance is effective from the date of enforcement (31 May 1972).

Table 2.1.The offensive odor substances in each standard value.

Substance	Concentration (ppm)
Ammonia	1-5
Methyl mercaptan	0.002-0.01
Hydrogen sulfide	0.02-0.2
Dimethyl sulfide	0.01-0.2
Dimethyl disulfide	0.009-0.1
Trimethylamine	0.005-0.07
Acetaldehyde	0.05-0.5
Propionaldehyde	0.05-0.5
Butyl aldehyde	0.009-0.08
Isobutyl aldehyde	0.02-0.2
Valeraldehyde	0.009-0.05
Isovaleraldehyde	0.003-0.01
Isobutyl alcohol	0.9-20
Ethyl acetate	3-20
Methyl isobutyl ketone	1-6
Toluene	10-60
Styrene	0.4-2
Xylene	1-5
Propionic acid	0.03-0.2
Butyric acid	0.001-0.006
Valeric acid	0.0009-0.004
Isovaleric acid	0.001-0.01

The range of regulation standard for concentration of the specified offensive odor substances at the boundary of the site refer to ordinance of the Prime Minister's office No. 39 of 1972 and the last amended by ordinance of the Prime Minister's Office No.10 of 1999 (Ministry of the Environment Government of Japan). “Offensive Odor Substances” is stipulated by the law to denote a group of chemical substances that could constitute unpleasant odors and possibly impair the living environment of residents. Currently, 22 substances have been designated as Offensive Odor Substances and local governments determine each standard value within the range described below in Table 2.1. The ammonia substance is the highest concentration which is put in the top position within the substances. Beside ammonia gas also is the prominent odor and the primarily offensive odor in the composting. The regulation is enforced to ensure that their concentrations in air or water do not exceed the standard values.

In this case study, Fuchu city which is the part of implementation of environmental policy of Tokyo tried to make an effort to enforce the plan sets the following four long-term objectives and to obey the regulation which was mentioned above. Fuchu city is the city in Tama area and located in western Tokyo Metropolitan, Japan. The modern city was founded on April 1, 1954. As of 2010 statistics, the city has an estimated population of 255,394 and a population density of 8,700 persons per km^2. The region is mostly flatland with the total area is 29.34 km^2. The agricultural activity is developed in some areas. About 176 hectares is the farmland area with the numbers of farm household is 370 farmers. Direct selling of agriculture products which are produced in the city are scattered in several region, named farmer market. Besides, some industrial companies such as Suntory Company, NEC Company and Toshiba Company are located in Fuchu city. The development of potencies of Fuchu city which mentioned above was always referred to the environmental policy of Tokyo.

2.3.2 Classes of organization to produce composted feedstock

There are three classes of organization to produce composted feedstock i.e. at centralize, on-farm and community composting facilities according to The British Standards Institution's Publicly Available Specification 100 (BSI PAS 100:2005)(Russell, S and L. Best, 2006). Collaboration which was formed in Fuchu city, Tokyo categorized as community composting facilities. Those organizations have formal and informal stakeholder (L.A. Guerrero et al., 2013). Community-based composting was easily implemented in developed countries because of awareness, attitude and behavior of city inhabitant. However, the existence of community-based composting faced the challenge to continue their activities due to a critical issue of its management namely the odor control approach.

2.3.3 Stakeholders involved

A community-based composting could be formed depend on the goals and needs which is as follows. Apparent stakeholders were the city hall, city farmers, an agricultural cooperative, and TUAT researchers, while passive stakeholders were lunch servers and teachers of the primary school, and staff of Eco-advance Company The project commission was formed in order to run a well organization. The chair of the commission was a professor from TUAT and the chief of local region promotion department, agricultural cooperative was a vice-chairman position. The member of the commission consisted of the economy-tourism division, department of life environment; the division of health and school lunch, department of life environment; the waste reduction promotion division, department of life environment; the headmaster of minami-shiraitodai primary school; the chairman of Fuchu city organic agriculture seminar also as a parent-teacher association (PTA); and researcher fellowship from national agriculture and food research organization (NARO). The observers of the commission were came from researcher and student of Shibusawa laboratory, TUAT; Eco-Advanced Company; executive officer from the waste reduction promotion division, department of life environment; the chief of the school lunch center, department of education; and department of economic promotion, the tama-branch agricultural cooperative. The illustration of a community-based composting was shown in Figure 2.1.

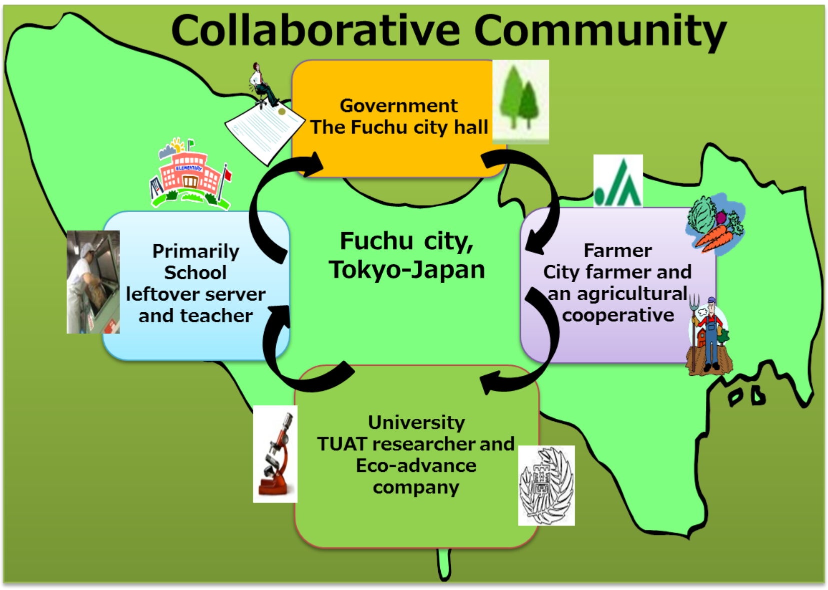


Figure 2.1 Schematic of community composting facilities.

2.3.4 Structure of Community-based composting

The conviction of farmer in term of formation of community-based composting structure was continued and supported by local government to increase the value of waste and to educate people in Fuchu city. It was synergetic with the duty of department of Life Environment of Fuchu city, actually. The entire structure of Fuchu city office was consisted of the secretary from year of 2013, the policy affair department, the administrative management section, the citizens section, the living environment department, the citizen cooperation headquarter, the culture and sport section, the welfare health department,the children and family section, the urban development section, the treasure division, the board of education secretariat education department, the audit office, the agriculture committee secretariat and congress secretariat. There three divisions which are a part of the living environment department were involved namely of economy-tourism, the waste reduction promotion and environmental policy division which have their own duty in environmental aspect.

The economy-tourism division, department of life environment is engaged with the agricultural policy in order to promote of urban agriculture, conservation of agricultural land, development of agricultural leaders, and the safety of distribution of agricultural products. Besides that, the department has the business related, such as town planning with agriculture. In tourism aspect, it is mainly to achieve the promotion of tourism. The waste reduction promotion division, department of life environment, worked in order to achieve the life extension and the effectively of valuable resource in final disposal sites, also cooperated with everyone of citizens in town and promoted the "3R" which are reduce, reuse, and recycle. While, department of environmental policy division, department of life environment, has the main duty to make the citizens live comfortably, also developed the business on the conservation of living environment.

As a result of the decision of the commission which is mentioned from section of stakeholder involved, the primary school was selected as the source of composting material and location of composting. The challenge was to educate at an early age of people how important is doing composting, but the risk of odor emission that can be produced from the composting in the school environment could be a negative factor in continuing the project. The small scale composting project started in 2009 and collaborative communities have a job to evaluate the project. Formal stakeholder included the city hall, city farmers, an agricultural cooperative, and TUAT researchers while informal stakeholders included lunch servers and teachers of the primary school, and staffs of Eco-advance Company. The formal stakeholders recognized to set up the policies and provision of composting management project. The other side, the informal stakeholder also recognized to stand in frontline of the composting process i.e. to maintain the composting machine, to collect and to load the leftover food daily, otherwise the process will be stopped. The community-based composting needed support from their stakeholder’s i.e. the waste pickers, residents, local municipals, and the community-based organizations (CBOs), volunteers, etc., to successfully operate and sustain itself.

That collaboration in community has pro-active in re-using resource such as leftover food from school lunches to produce composting material. Researchers from TUAT suggested and applied a composting management approach i.e. starting with the high quality of material and safe feedstock, cutting corner or way of distribution from delay of fresh material, mixing the feedstock which rich in nitrogen and rich carbon feedstock, frequently turning of the material position, shifting the smell into drainage-canal, and in an active aeration. The Eco-advance as an informal stakeholder has a responsibility in installment and maintenance the P-1DS (Protein-One Spindle Double Garbage Disposal Tank-Compost System). This management was based on the experience from the past, i.e. they have experience to utilize the compost from food waste in a learning group "Food and Organic Chains Initiative in Fuchu (FOCIF)" in 2004 and tried to solve the odor problem from composting.

2.3.5 Obstacle and solving actions

There were positive and negative factors of whole composting management system which can appear and involve in this community-based composting. Using communication transfer among the different stakeholders was solved some negative factors and some obstacles in order to reach a well-functioning composting management system in urban agriculture (L.A. Guerrero et al., 2013). Therefore, positive and negative factors which potentially occur in the whole composting management system need to be managed recorded and solved the problem in order to produce traceable composting material. The improvement of nutrients in the farmer's farm and education of the people at an early age was found as the positive factors. Because of the composting produced in the city area, it was run some risk of smell pollution. The need to produce the odorless compost was required. The risk of odor was one of the negative factors which has solved in this study. This risk has been tried with the composting management approach suggested by the researcher of TUAT. From this study, it was proven that there was no complain from residents surrounding the composting facility against the composting activity and those should be record as a management approach to composting

Some obstacles have been identified from first year establishment i.e. in 2011; the composting operation was stopped because of on March, 11 the earthquakes hit Japan which was influenced the Tokyo city included Fuchu city, there was a possible risk that rice hull and wood chip as a bulking agent could contaminated by nuclear radiation. However, there was no evident that the nuclear radiation has affected the bulking agent material. The second obstacle was the unavailable of labor or the server of lunch which also have a job to feed the leftover food material into composting machine. However, those all obstacles have solved by a well communication transfer among the different stakeholders

2.3.6 Composting Facility

The small scale composting project started in 2009 in Fuchu city, Tokyo and a primary school was selected as the investigation site for composting experiment. Figure 2.2~ 2.3 shows a map of Tokyo Metropolitan and more specific location of composting facility. This composting facility produced composting materials from leftover food of student lunch in one of primary school in Fuchu city. Figure 2.4 was some pictures of experimental composting site, the composting facility located in a primary school namely Minami Shiraitodai Shougakou. A red circle in figure 2.4 clarified the position of the warehouse of composting facilities in the school area. The location of composting facility is surrounded by residential house. From these facilities, all the material such as the leftover food, rice hull and wood chip was only mixed, the complete composting process was then continuing on the farmer's farm.

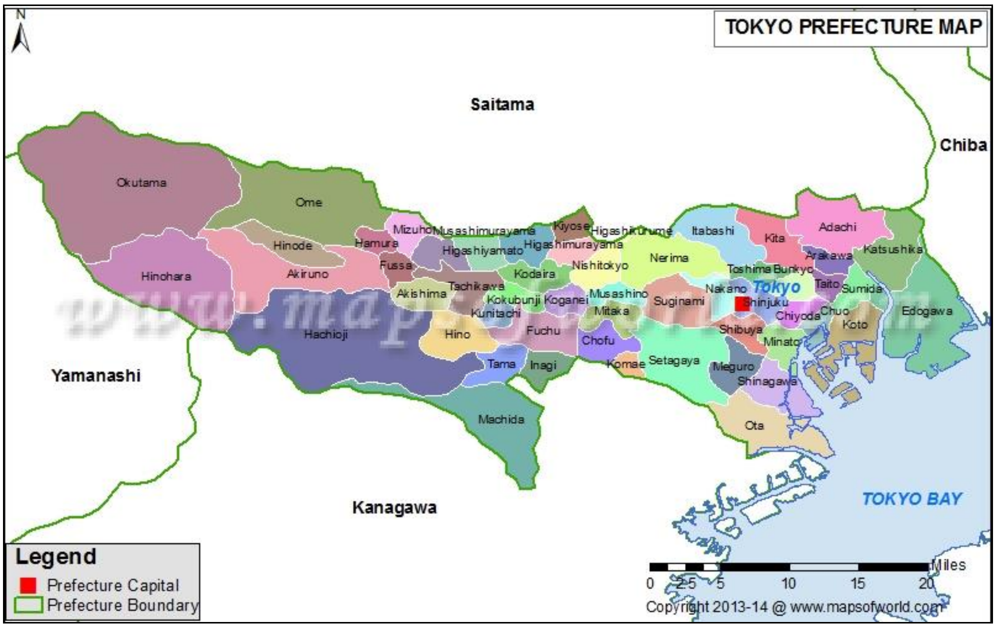


Figure 2.2 Tokyo prefecture map.

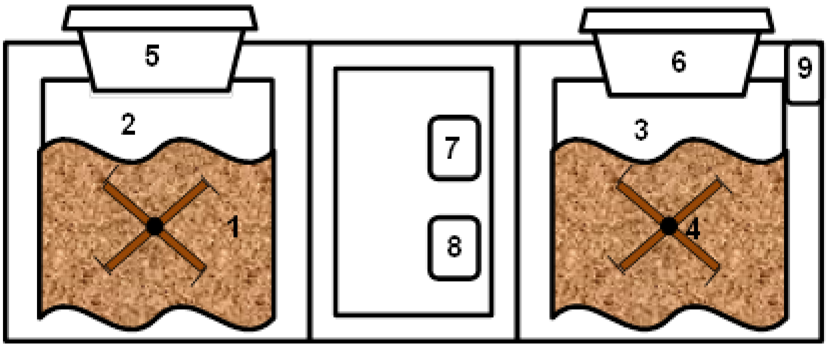
Figure 2.3 Location of composting facility.

Figure 2.4 Environment of Minami Shiraitodai elementary school (left to right).

2.3.7 Laboratory observation

The composting material were produced from the composting machine named **P**rotein-**O**ne spindle **D**ouble garbage disposal tank-compost **S**ystem (P-1DS, Karuizawa hygiene company, Karuizawa, Japan). The machine had two reactors and operated separately, as shown in Figure 2.5. Each reactor was equipped with a mixing blade, a blower, a heater, and an exhaust vent (Figure 2.6). The maximum decomposition capacity of composting machine according to the manufacture's specifications was 30 kg/day.

Figure 2.5 P-1DS composting machine.



1. Composting Material 2. 1^{st} reactor 3. 2^{nd} reactor
4. Mixing blade 5. 1^{st} hopper 6. 2^{nd} hopper
7. Blower 8. Heater 9. Exhaust vent.

Figure 2.6 Schematic of P-1DS composting machine.

The materials of compost were consisted of light and dense feedstock. The light feedstock was rice hulls and wood chips as a source of carbon. And the dense feedstock came from leftover food which used for the source of nitrogen. The rice hulls came from Fuchu city farmer's field and the wood chips came from Nagano prefecture. The leftover food contained of rice, noodles, vegetables, meat, fish, grain and seasoning which have the diameter sizes less than 10mm.

The process started with loading 23 kg rice hulls (Figure 2.7) and 32 kg wood chips (Figure 2.8) then mixed well in the reactors. In the next day, average of 18.5 kg leftover food (Figure 2.9) loaded daily for 1.5~ 2 months. The 18.5 kg is also an average of leftover food produce from the school every day. After loaded, the material stayed and got turning or agitating process in the reactors for 1.5~ 2 months. The leftover food has 78.26 % MC, 5.53 pH, 4.84 EC mS/cm and 16.70 C/N ratios respectively. The average of 2595 kg of composting material was produced in 2011~ 2015 based on the report from community based-composting.

Figure 2.7 Rice Hulls used in the experiment.

Figure 2.8 Wood Chip used in the experiment.

Figure 2.9 Leftover-food for P-1DS composting machine.

In the composting facilities, a composting management approach i.e. starting with the high quality and safe feed stock which was mean rich in nutrient content and free for contamination, cutting corner for the delay of fresh material which was mean directly loading and processing into machine, mixing between the rich nitrogen feedstock and rich carbon feedstock, frequently in turning of material position, shifting the smell into drainage-canal, and application of active aeration.

In order to investigate the initial characteristics of physical properties of composting material, MC was determined by an oven dry method at 105ºC for 24 hours. To calculate the percent of MC for each material and feedstock mixture, the following step are, a). Weight a small container, b). Weight 10 g of the material into the container. c). Dry the sample for 24 hours in a 105~ 110 degree C oven. d). Reweigh the sample, subtract the weight of the container, and determine the moisture content using the following formula:

$$Mn\ (\%) = \left(\frac{Ww - Wd}{Ww}\right) x100 \qquad (2)$$

in which :

Mn= moisture content (%) of material n

Ww= weight of the sample, and

Wd= weight of the sample after drying.

Volatile solid was obtained by determining the loss of mass after ignition on triplicate samples at

600ºC for 2 hours according to Page et al., (1982). To calculate the percent of compost organic matter for each material and feedstock mixture, the following step are, a).Clean crucibles and measure the weight by electric balance (always use tong to take a crucible) b). Burn the empty crucibles for 1 hour in a 750 degree C by electrical muffle furnace, (always use a heat resistant glove to prevent from heat), c). Put crucibles in desiccators until reach the room temperature and measure the weight (the weight have to confirm to previous weight and the variation of the weight after burning within ±0.0002), d). Weight 2 g of the drying compost material into crucibles, e). Burn the sample for 1 hour in a 600 degree C by electrical muffle furnace. d). Reweigh the sample, subtract the weight of the container, and determine the compost organic matter using the following equation:

$$\mathrm{COM}(\%) = \frac{(mr + md) - (mr + mb)}{(mr + md) - mr} x100 \qquad (3)$$

in which :

mr= weight of a crucible

md= weight of drying compost

mb= weight of burned compost.

C/N ratio was measured using C/N analyzer (Sumigraph NC-220F, Sumika Chemical Analysis Service. Ltd, Japan). To measure C/N for each material and feedstock mixture, the following step are, a). Make sure that the reductive copper column is available, b). Open the valve of carrier gas (He) and oxygen, adjust the pressure 100 and confirm the oxygen gas flow to be 0.2 mL/min, c).160 mA d). Turn on the power button, COOL, NC-L, NC-H, Power and a compressor, e).Make sure that the combustion furnace are 800OC after 20~30 minute, f). Turn on computer recorder, g). Prepare the standard of Asparic acid, spoon, tongs, and paper, h). Open the software in the computer, press F9 and checking for gas, and other component, i). Press F5 for setting the standard and sample; click the balance symbol, set for standard and sample, how many standard/sample and how many repetition you have and save, j). Set 1 blank, and check reset option. Check current status of blank, standard and sample with the repetition, k). For baking process: Set total of 2 blank, 2 standards, and the samples with repetition you have by press boat button in auto sampler group. Set the time of purge, pump, meas (10/100/10) respectively. After the beep sign appear from ready and start button, you can start the baking process. It will take 2 minute each empty boat, while the baking processes run, you can put the sample of compost in each boat just after the boat baking, l). Weight 200 mg or about 0.2 g of the aspartic acid into 2 boats with the paper, record the precise weight. Add 2 blank boats. Measure 200 mg or about 0.200 g for each compost sample, record the precise weight, after the samples and repetitions ready, press baking button to stop baking process, m). Make a baseline of x : 0~8 min and y : 500~3000 μV, try to set the baseline between 0-600μV use coarse or fine if you need more range, n). For NC process: Set the time of purge, pump, meas (50/250/270) respectively, then press ready/start button and click go in software. The process will run and record to the computer automatically, o). After all finish, you will continue the instruction in the software, press yes then look for CSV file and save, p). Turn off the power button, COOL, NC-L, NC-H, Power and a compressor power, q). Check for F9 maintenance of gas, r). Close the valve of carrier gas and turn off the gas chromatograph, s). Clean up around the apparatus and balance, t). Turn off the computer. Values for pH and EC were measured by the glass electrode method (Horiba D-24, Horiba, Ltd, Japan) at a ratio of 1 : 10 (feedstock mixture : water). To measure pH for each material and feedstock mixture, the following step are, a).calculate the % MC of material or compost (use the % MC to figure out how much water to add), b). Weight 5 g of the material into the container, c). Add the calculated amount of distilled water to each sample, d). Mix thoroughly for 5 seconds, e). Let stand for 10 minutes, e). Read the pH with a calibrated mete and record as compost pH in water.

2.3.8 Initial characteristics of composting material

The initial characteristics of composting material have to be observed in order to know whether it is appropriate for composting. The data were collected in different seasons during 2012~ 2013. The first data of initial characteristics of material mixture was collected in the summer season of 2012. The second and third data were collected in the winter season of 2012 and the spring season of 2013. Total of 10 samples in different locations of the reactor of P-1DS machine was collected in each season. According to the analysis of data collection procedures in the previous section, retrieval of data in a different season presented in Table 2.2 and 2.3 categorized as suitable material for being used in composting in order to produce traceable composting material for urban agriculture.

Table 2.2 Initial characteristics of the material mixture.

Parameter	Composting material (Leftover food, innoculance, Rice hull, wood chip)
Moisture (%)	22.99
Organic Matter (%)	88.63
C/N ratio	8.6
pH (1:5)	5.76
Electrical Conductivity (mS/cm)(1:5)	7.46

Table 2.3 Initial characteristics of the composting material.

Properties	Result		
	summer season	winter season	spring season
Moisture (%)	22.99	17.61	15.47
Organic Matter (%)	88.63	91.03	89.82
C/N ratio	8.6	10.09	9.95
pH	5.76	5.56	5.58
EC (mS/cm)	7.46	7.53	8.76
month, year	4~ 8, 2012	9~ 12, 2012	11, 2012~ 3, 2013
reactor	second	first	second

The information on a single process of interest was conducted. It is implied on traceability i.e. initial characteristic of composting material. Moisture content, Organic matter, C/N ratio, pH and Electrical Conductivity were a group of factors affecting the composting process which depended on the formulation of the composting mixture. The value of each properties of material mixture was rich in organic matter, nitrogen and carbon source. However, moisture content remained low from season to season. The moisture was remained low and it was suggested to have treatment using water in order to reach 60 % of the optimum value of moisture content. The optimum MC is a 60% of MC which should set in the beginning of composting process. pH value was reached the optimum value but remained low EC. During the machine process, decomposition process was faster as all material was well mixed and got frequency turned but did not reached metabolic process (themophilic and mesophilic process). The materials mixture which consisted of leftover food, rice hull, and wood chip was initially, the composting material was still immature compost. Immature means that the monitoring of physical properties of material indicated that the process in composting machine didn't reach management approach of composting in order to reduce odor and produce mature compost. Furthermore, 3~ 4 months of composting in the reactor needed to have the monitoring some properties of composting material on a day of processing in composting machine in order to confirm the properly and safe of composting material especially to reach the goal of odorless composting material

2.3. 9 Minimum process monitoring of physical properties

The minimum process monitoring of physical properties of material composting during the composting was conducted such as temperature, moisture content (MC), bulk density and ammonia. Monitored records were evaluated to ensure that were acceptable and successfully in the process and also achieved traceability. The odor control approach was applied for input material and process i.e. starting with high quality feed stock, cutting corner for delay of fresh material, mixing between rich nitrogen feedstock and rich carbon feedstock, frequently turning of material position, shifting the smell into drainage-canal, and in active aeration.

The minimum process monitoring defined here as a limit of data monitor under the condition of some compost properties in the machine. The chosen dates for monitoring were June, 3 and June, 10 in 2013. The data was collected in 5th week when there was no addition leftover food material and in 6th week when there was leftover food material. In order to investigate minimum process monitoring of physical properties of composting material, temperature, MC, EC, bulk density and ammonia were all determined using a Decagon 5TE soil moisture sensor. Decagon's Procheck reader has used to have direct value of MC, Temperature and EC. To use 5TE soil moisture sensor I didn't calibrate because I didn't require more accurate VWC than ±3 % beside the composting material has low EC. At first, leveling the 1 m2 of composting material in composting machine, then directly insert the sensor and checking the result in Decagon's Procheck reader. Ammonia gas was measured by gas detection tube. Bulk Density measured by gallon bucket. To measure BD for feedstock mixture, the following step are, a).With a 1-gallon measurement container, fill 5 gallon bucket with 5 gallons of water as the brim of a "5 gallon bucket" is not necessarily 5 gallons. Mark this line on at least 3 places on inside of the bucket with a permanent pen, b). using the bucket with diameter top not same as diameter bottom find the two intermediate lines by measuring first 1 2/3 gallons (=1.67 gal or 6.31 liters) then 3 1/3 gallons (=3.33 gallon or 12.62 liters) of water into the bucket and marking where the water line is at both volumes with a pencil when wet, then a permanent pen when dry, c). Compost used should be representative of the pile. Take handful samples (not large shovel full samples) from several locations in the pile. Dig into pile a couple of feet; do not take from dried-out outer layer of pile, d). Filling bucket to the 1/3 line with compost. Drop bucket squarely from approximately 1 foot high to the ground (hard surface) 10 times, e). Filling bucket to the 2/3 line. Drop bucket squarely from approximately 1 foot high to the ground (hard surface) 10 times, f). Filling bucket to the 3/3 (5 gallons) line. Drop bucket squarely from approximately 1 foot high to the ground (hard surface) 10 times, g). Filling bucket to the 3/3 (5 gallons) line and weight in pound, h). Multiply weight in pounds (excluding bucket weight) by 40. This is your bulk density, in pound per cubic yard then you can convert into kilogram g per cubic meter. A single process interest was conducted. It is implied on traceability i.e. initial characteristic of composting material and monitoring records for some properties of composting material. This was observed to know whether it is properly in management of composting and is environment friendly. Initially, the composting material was still immature. Unfortunately, temperature of composting material was not reached the management approach of composting recommendations for both conditions while MC was reached only when adding new material. Bulk density was reached the management approach of composting recommendations for both conditions. Detection of ammonia was relatively high especially when no additional new material. The monitoring data were indicated that the composting process was not properly and environment friendly. According to some references in composting of food waste in Table 2.4, it was shown that temperature of composting material did not reach the recommendations while MC and bulk density were reached. The EC was remained low or no higher than 2 mS/cm and ammonia emission was detected relatively high. Composting in the P-1DS machine was only to make the material mixed because the process was not reached the thermophilic process. After well mixed in composting machine, the materials was send to the commercial farm and continued to have composting process until mature enough and ready to apply to the field.

Table 2.4 Minimum process monitoring of physical properties of composting material.

	3 months composting				**Reference**
	5th week (weekend) no additional new material		**6th week (weekday) additional new material**		
	10:00 AM	**18:00 PM**	**10:00 AM**	**18:00 PM**	
Temperature(^{O}C)	33.14	34.18	32.70	35.30	Horisawa et al, 2001
MC(VWC)	14.52	8.62	13.38	22.60	Wilber and Murray, 1990
EC(mS/m)	0.176	0.074	0.084	0.772	Turan et al, 2008
Ammonia (ppm)	18.4	37.4	9.4	14.0	Turan et al., 2007
Bulk density (kg/m^3)	290	317	301	379	Oshin, 2006

2.3.10 Fluctuation of initial characteristics for chemical and physical properties of composting material

Table 2.5 shows more complete initial characteristic for chemical and physical properties of composting material provided by Tokyo livestock hygiene service center Fertilizer and Feet Inspection Stn. The regular checking was done 3~ 4 time a year to ensure consistency composting material and to solve if there any problem appeared during composting. It also aims to provide information to farmers on compost produced as evidence at an advanced composting process. It shows how they were fluctuating from time to time because it is dependent on leftover food which is varied every day. The results from Table 2.5 show that the compost has not yet reached maturity, or immature but has mixed well in the composting machine. Further, immature compost continued to ferment in farmer's field and used as a fertilizer to grow vegetable such as Chinese green cabbage.

Table 2.5 Initial characteristics for chemical and physical properties of composting material

Analysis items	Unit	Measurement value								Analytical method
		11/29/2010	1/6/2011	4/7/2011	7/26/2011	10/8/2011	6/15/2012	8/20/2012	12/27/2012	
Moisture content	%	33.23	14.84	21.13	30.01	29.05	26.2	29.33	17.94	Loss on heating per material
Nitrogen	%	3.26	4.1	3.33	4.16	2.79	4.32	2.25	3.56	Sulfuric acid method per dried material
Phosphoric acid	%	1.46	2.35	1.14	1.67	0.8	1.19	1.04	0.94	Vanadomolybdate Ammonium per dried material
Potassium	%	1.43	1.06	1.43	1.71	1.46	1.47	1.49	1.12	Atomic absorption photometry per dried material
C/N ratio		10.2	10.5	9.3	8.8	12	4.27	20	12	Carbon-nitrogen ratio (combustion method)
Lime	%	0.7	0.64	0.65	0.94	0.3	0.29	3	0.26	Atomic absorption photometry per dried material
Magnesium	%	0.46	0.25	0.42	0.41	0.14	0.21	0.31	0.14	Atomic absorption photometry per dried material
Sodium	%	1.53	1.39	1.56	2.31	1.38	1.71	1.44	1.55	Atomic absorption photometry per dried material
Oil content	%	0.88	6	2.03	1.77	1.08	2.12	2.84	4.07	Diethyl ether extraction per dried material
Copper	mg/kg	17.4	4.6	11.2	17.05	2.9	6.39	18.6	2.2	Atomic absorption photometry per dried material
Zinc	mg/kg	66.4	32.1	56.5	84.23	38.6	42.73	58.6	30.7	Atomic absorption photometry per dried material
pH		8.51	5.8	8.11	8.31	8.35	7.84	8.5	8.03	Glass electrode method at a ratio of 1 : 10 (material : water)
Electrical conductivity	mS/kg	5.82	3.6	6.26	4.25	5.26	7.46	4.82	5.53	Electro conductivity meter at a ratio of 1 : 10 (material : water)

Date of the analyses shows the date of production

Tokyo livestock hygiene service centre Fertilizer and Feet Inspection Stn.

Table 2.5 Continued.

Analysis items	Unit	Measurement value							Analytical method
		3/27/2013	5/8/2013	8/29/2013	10/3/2013	4/3/2014	8/22/2014	2/19/2015	
Moisture content	%	18.78	15.06	12.61	15.27	15.54	18.2	15.8	Loss on heating per material
Nitrogen	%	4.37	5.02	2.76	4.56	3.52	4.65	4	Sulfuric acid method per dried material
Phosphoric acid	%	1.08	1.14	0.67	1.63	0.73	1.21	0.8	Vanadomolybdate Ammonium per dried material
Potassium	%	1.37	1.33	0.89	1.41	1.02	1.48	1.1	Atomic absorption photometry per dried material
C/N ratio		9.66	8.7	15.6	9.57	11.8	8.5	11	Carbon-nitrogen ratio (combustion method)
Lime	%	0.37	0.4	0.41	0.21	0.2	0.23	0.23	Atomic absorption photometry per dried material
Magnesium	%	0.22	0.16	0.12	0.19	0.14	0.23	0.11	Atomic absorption photometry per dried material
Sodium	%	1.66	0.3	1.9	5.23	1.51	0.99	1.6	Atomic absorption photometry per dried material
Oil content	%	5.1	1.55	1.55	4.12	2.64	1.79	2.5	Diethyl ether extraction per dried material
Copper	mg/kg	6.1	1.7	1.1	1.9	4.93	12.5	2.4	Atomic absorption photometry per dried material
Zinc	mg/kg	41.89	43.1	31.3	58.42	28.95	34.4	28.3	Atomic absorption photometry per dried material
pH		7.4	7.18	6.99	7.06	7.17	6.67	6.92	Glass electrode method at a ratio of 1 : 10 (material : water)
Electrical conductivity	mS/kg	8.58	8.01	5.52	8.81	7.74	9.46	5.58	Electro conductivity meter at a ratio of 1 : 10 (material : water)

Date of the analyses shows the date of production

Tokyo livestock hygiene service centre Fertilizer and Feet Inspection Stn.

2.3.11 Farmers used compost produced at primary school

Figure 2.10 and 2.11 shows two famers in the city were cultivated and produced vegetable by applied compost from primary school. Mister Kobayashi which farms located at Oshitate-cho Fuchu-shi was prepared to shipping a Chinese green cabbage which used for school meals. Mister Totsuka which farms located at Oshitate-cho Fuchu-shi. He had raised delicious vegetables using the Production compost of a collaborative committee of community-based composting in Fuchu city.

They had been providing vegetables to primary school for school meals before the collaboration community composting had started. Vegetables were cultivated in their farms using compost produced from the composting facility in primary school. The farmer's observations found that the growing rate was normal and was no concern of problem appeared in using the compost because the compost did not contain any chemical substances and also because made from school meals residue which the salt concentration had adjusted. It was also mentioned that one of a great advantage over using the leftover food compost was because there were no grass seeds included on compost.

The vegetables produced were shipped for school lunch meals. The two farmers had been sending about 600 kg Komatsuna (Chinese green cabbage) every month to the supply center of school lunch meals and about 120 kg (20 %) of them had been produced by using the production compost from the composting facility in primary school. The farmer had succeeded to make a resource circulation which completed in the Fuchu city itself with the support from stakeholders and lots of people in various circumstances. The leftovers food of the school lunch meals became the compost, and the compost was used to grow the vegetables, and the vegetables were back to school for lunch meals.

Figure 2.10 Harvest and preparation of shipping a Chinese green cabbage

Figure 2.11 Farmer's conviction toward delicious vegetables using compost from Shiraitodai primary school.

2.4 Discussion

With the result of survey, the plan under the basic environment law, systematically clarifies the measures to be taken by the national and local governments, as well as actions to be carried out by citizens, businesses and private organizations by the beginning of the 21st century in Japan. It also defined the roles of parties involved and the ways and means for effectively pursuing environmental policies. More specific regulation was needed i.e. the offensive odor control law in Japan that it could be progressive as few countries have laws applying only to offensive odors. Odor is generally recognized as the critical issue for composting. In order to manage the activities including in the issue above, the synergy and cooperation of communities around the urban area which is tackled by a local municipal authority is fully required.

FOCIF, which was an acronym for “Food and Organic Chains Initiative in Fuchu”, it was the first community-based composting system which organized by farmers, Nippon Electronic Company (NEC) factory (a non-food industry as sources of organic waste compost) and Tokyo University of Agriculture and Technology (TUAT). This was a learning group formed in 2004, because previously, farmers had shown an interest in using compost from food waste and shredded paper then confirmed its ability to improve nutrients in their field. That community and their practice showed a good experience of the implementation of urban agriculture in Japan. They have harnessed the food waste and shredded paper from the NEC factory cafeteria as the composting material then continued to use in their farm. The composting materials processed in the small U-HSC type spindle rotation processor machine and have made the food-garbage uniform by mixing and fragmenting, and therefore the products were suitable for composting (Hu jiang et. al., 2005). The target barrier appeared when the composting process continuing to become mature compost. Because of the improperly manage of the composting process, the process became a source of odor. The complaints from resident surrounding the composting facilities started. The organization did not have the force of law against complaints. Financial support was only temporary because the organization was a non-profit organization. The result on the complaint on odor emission was the interruption or closure of composting facilities. Because this project has worked at a micro-level: in a locality or neighborhood, so without sustained support and participation of the Fuchu city authority and larger communities it looked difficult to develop or will continue dealing with obstacles.

It can be concluded that the FOCIF was the pioneer of community-based composting in Fuchu which was the very important first action in continuing sustainable of development of urban agriculture in Fuchu city, Tokyo. The harmful pesticide and inorganic fertilizer should be eliminated as society and industry need safety as well as quality of foods. From those trending topic, it was a big challenge for farmers or community of farmers to produce agricultural products that use organic fertilizers in urban agriculture. The demand of organic fertilizer used in agriculture product not only came from the customers but also from the farmers who had shown an interest in using organic fertilizer and confirmed its ability to improve nutrients in their farm. We have learned from this experience that the crucial problem appeared was odor complaint from residents, the lack of management of organization, inadequate technical expertise and insufficient financial support when the local government which referred to the basic environment low was unable to provide sufficient service.

There have been several studies on the composting of food refuse using compost with its community-based; however the management organization of such interface or interaction have never been fully examined or adequately documented. Beside a single process interest involving one-step-up and one-step-down process information which are implied on traceability also never been fully documented. The traceability has diverging needs ranging from the organic farmer to the public environment, but this observation would nevertheless supplement record histories of traceable composting material with special emphasis on physical properties of composting material for UA.

2.5 Summary

The collaboration of the community has succeeded in mobilizing the organization, funding and solving the obstacles in order to reach a well-functioning composting management system in UA development. The demand of farmer's interest leads to natural organic sources. The histories of entire composting management were; 1. Collaboration which was formed in Fuchu city categorized as community composting facilities". Apparent stakeholders included the city hall, city farmers, an agricultural cooperative, and TUAT researchers while passive stakeholders included lunch servers and teachers of the primary school, and staffs of Eco-advance Company; 2. The synergies and cooperation from stakeholders and departments of Fuchu city government are required. The sentence has changed into. 3. Communication transfer could solve the obstacles between the different stakeholders in the community composting facilities. 4. The materials mixture (leftover food, rice hull, wood chip) were suitable for composting traceability. The social and technology approaches could combine to achieve a well-functioning composting management system for UA development.

Chapter 3:
Application of Urban Agriculture concept

3.1 Introduction

Urban agriculture concept is now available on a large number of regions, countries and cities in particular developing countries and integrated into the local urban economic and ecological system. To provide information of development of UA concept, investigation of a recent process, development and application of UA which faced by Denpasar, Bali in the Five Year Development Plans to support "go green program" and to promote sustainable urban agriculture in association with problems, issues and challenges. This chapter especially presents the waste management in Denpasar city of Bali and was a problem finding which is need a recommendation on odor control approach.

3.2. Background information of Denpasar

Denpasar, the capital city and the most populous city of the Indonesian province of Bali, situated on the island of Bali, it is known worldwide as a major tourist destination, and is the main gateway to Bali. Denpasar is located at a height of 0-75 mdpl. The region is mostly flatland with the total area of 127.78 km² or 2.18% of the total area of Bali Province. From the use of land, 2768 hectares of land are paddy, 10,001 hectares is dry land and the remaining land area of 9 hectares is another. Figure 3.1 presents the Bali island map.

Figure 3.1 Map of Bali Island, Indonesia.

Denpasar is the Land of Rice Subak. Subak is an indigenous people who have agraris-socio religious characteristics, which are an association of farmers who manage irrigation water in paddy fields. Understanding Subak as it was basically stated in the regulation of local government areas of Bali Province No.02 / PD / Parliament / l972. As per 2007 data bank (http://bankdata.denpasarkota.go.id), Subak in Denpasar area (hectares) consists of South Denpasar 935 ha, 726 ha of East Denpasar, North Denpasar and West Denpasar 284 772 ha. The population of Denpasar was 834,881 in 2012, up from 788,445 at the 2010 Census. The surrounding metropolitan area has roughly 2 million residents. The municipality's area extent, population, and density are similar to San Francisco.

3.3. Methodology

In order to produce both quantitative and qualitative data, a range of research methods covering interviews, observations and document reviews were used in this study (Layder, 1993). Table 3.1 presents the outline of data collection methods and corresponding objective.

Table 3.1 Outline of data collection methods and corresponding objectives

	Method of data collection	Institution	objective	Description
1	Dialogue with local government staff	Department of Hygiene and Urban Landscaping, Denpasar city.	● Interviewing the Head of Department of Hygiene and Urban Landscaping, Denpasar City.	● Background information of Denpasar ● Problem, strategic issue and challenges ● Recycling method and Waste collection ● Stakeholders involved ● Disposal practice Socialization ● Current practice adopted **(Development of micro-enterprise/Bank of Trash)**
2	observation	● A Sarbagita Hygiene Management Agency (BPKS) ● Community-based Composting " Cemara" ● Denpasar Clean and Green (DCG) Berlian office.	● Hearing information from BPKS (Badan Pengelola Kebersihan Sarbagita) ● Interviewing head of village and staff of facility in Community-based Composting " Cemara" ● Hearing information from NGO (DCG Berlian Kota Denpasar)	● Potential for alternative disposal options such as composting, bio-pore, biogas ● ● Process of establishment community-based composting facilities ● Public perception and attitude of waste management and their expectation ● Deficiency in disposal practice ● Effect of Bank Trash
3	Reviewing document	Department of Hygiene and Urban Landscaping, Denpasar city.		● A Government Regulation on Environment ● Waste Statistic

3.4. Study findings and interpretation

3.4.1. Problem, issue and challenges

With the rapid growth of the tourism industry in Bali, Denpasar has encouraged and promoted business activities and ventures, contributing to it having the highest growth rate in Bali Province. Estimate municipal solid waste (MSW) generation index of Denpasar is 0.8 kg/capita/day. To date, Denpasar was faced a solid waste problem similar to many other urban areas in Indonesia. Decreasing of available landfill was not prevented for the next decade. The major problem was revealed in this study that the public attitude toward waste separation and disposal scheduled was still poor. It was generally regarded that the waste managements were the responsibility of local authorities, and that the public was not expected to contribute.

The office of Department of Hygiene and Urban Landscaping of Denpasar (DKP) located in the middle of the city and surrounded by public facilities such as parks, tennis courts, public service offices, sports fields and housing residents, Figure 3.2 illustrates the gate of the office.

The DKP was faced to an issue of some strategies in management of waste and beauty of the city i.e. support the Bali province as a Green Province; provision of infrastructure, sanitation and gardening which are geared to meet the capital intensive working pattern without reducing the labor intensive working patterns that have been done so far; behavior and public awareness of Denpasar in waste management were still low, so that supervision and intensive counseling were needed; the waste management involved community participation was possible from upstream to downstream, which are mandated by President Regulation number 18 year 2008 on Waste Management, and landscape management in the city of Denpasar was enabled to meet the program beautify the face of the city, but also aimed to support the city of eligible children, the elderly and healthy urban city. Indicator of performance of DKP from 2011 ~ 2015 which includes waste management in the city of Denpasar reached 50%; the level of community participation through privatization of waste management to reach 30%; waste management in the community through self-managed group of cleanliness reached 20%; Denpasar municipal waste reduction reached 30%. Adipura is a tribute to cities in Indonesia which are managed in hygiene and urban environmental management. Adipura has been held every year since 1986, and then stopped in 1998. In the first five years, the program is focused on encouraging clean city cities in Indonesia to "Clean and Quiet Town".

Figure 3.2 Office of Department of Hygiene and Urban Landscaping of Denpasar.

Adipura re-launched in Denpasar, Bali on June 5, 2002, and continues today. Adipura is organized by the Ministry of Environment. In 2014, the city of Denpasar clean city trophy won for the category of Large City, after the year 2013 and reached the Charter clean city. However, there were more important things to note, how Denpasar's people committed and consistence to instill the spirit and soul of this Adipura on people to take care and take responsibility for the cleanliness of the city of Denpasar so as to improve the quality of the environment and improve the health of people in Denpasar. Although some improvements have been achieved in accordance with the Adipura program, the current waste management system was generally needed to be improved to address a wide range of waste disposal problems in Denpasar.

It was also found that when a local government is interested and gives priority to solid waste issues, they supported strategies which include more efficient collection systems, better infrastructure and low cost recycling technologies. However, without community participation in the implementation of the 3Rs, it was found to be difficult for the government to handle the waste problem. Also, the successfully of recycling not only depends on public participation levels but on the efficiency of the equipment and infrastructure as a support from local government. These results are in agreement with the findings of Manaf et al. (2009) who report that the irregular collection services, inadequate equipment used for waste collection, inadequate legal provisions are key factors that are challenging the waste recycling scenario in Malaysia today.

The operational activities of DKP were cleaning of roads and sewers, garbage collection and transportation, hygiene promotion, monitoring, inspection, socialization and demolition. Figure 3.3 illustrates a direct approach in fostering citizen. And also in order to carry out the punishment to the guilty party, the court implemented to safeguard the prestige of the government, as illustrated in Figure 3.4.

Figure 3.3 Monitoring, inspection, socialization and demolition.

Figure 3.4 Law enforcement of waste management in the city.

3.4.2. A Government Regulation

In Denpasar, the basic legal framework on municipal solid waste management was required because those are required for guideline and law enforcement. Referring the President Regulation number 32 2003 on Local Government, the President Regulation number 18 2008 on Waste Management and President Regulation number 32 2009 on Environmental Management and Protection in Indonesia, participation of community in management of waste in Denpasar was needed. The main mandate of waste management of President Regulation number 18 years 2008 is changed the paradigm of waste management from collect-transport-throw become reduce at source and resources recycle. The implementation of the 3Rs – reduce, reuse and recycle, extended producer responsibility (EPR), waste utilization and final waste processing in landfill with the environmental sound manner are a right approaching to change an end of pipe system which was available previously. The main objective of waste management according to ministry of environment of Indonesia is to increase public health and environmental quality along with creating waste into sustainable resources.

The study which was done in Denpasar has shown that the local government has considered the implementation of 3Rs as an alternative option when dealing with waste disposal, however not implemented entirely. With the vision of DKP of Denpasar that is to improve the cleanliness and beauty of Denpasar with the creative and insightful culture in balance and harmony, those legislation above, have had an essential power to increase public participation on waste management and to create a modernized sustainable system.

3.4.3. Waste collection and Recycling method

The strategic steps to be implemented by DKP of Denpasar were 1). Improve hygiene and beauty of city management services to support the Denpasar Clean and Green and Bali as a green province, 2). Improve the work quality of services labor, 3). Improve the quality and quantity of infrastructure to support Denpasar tourist attraction also aimed to support the city of eligible children, the elderly and healthy urban city, 4). Improve community participation as possible from upstream to downstream and 5). Implementation of reward and punishment for citizen.

Denpasar was expected to generate 2500-2700 meter cubic of MSW every day. The types of waste were brought to the community official disposal site from household, institutional, construction, health care, agriculture, industry and commercial. Figure 3.5 illustrates the special characteristic of Bali's garbage which is very hard to decompose such as coconut leave, flower, fruit skin, other leave and etc. Figure 3.6~ 3.7 illustrates other type of garbage in Bali island such as pet bottle, plastic wrapping, plastic packaging, plastic container, styrofoam container and etc.

Figure 3.5 Special characteristics of garbage in Bali.

Figure 3.6 Other type of garbage in Bali (1).

Figure 3.7 Other type of garbage in Bali (2).

The waste was collected by a labor who works for government with some equipment, and transportation owned by government (Figures 3.8~ 3.9). Management of waste treatment applied in Denpasar was sweeping, collection, transportation and final disposal.
The final waste disposal site or they called Tempat Pemrosesan Akhir Suwung (TPA Suwung) was located in Suwung village, district of south of Denpasar. Policies on landfill suwung are included as a closed area. Waste that goes to landfill selected and set the ban for waste sources such as: medical waste, garbage of glassware, trash from materials meat, shrimp, and the like that have expired, garbage old tires, rubber scrap, and so flammable, all sorts of carcasses and feces. Now a days, the DKP has responsibility on handling about 61% of garbage in Denpasar, 28% do not go into the landfill, 5% dealt with the private sector, 3% are self-managed, and 3% are handled by the regional companies belonging to the municipality. It was found that on the household level, separating waste according to the 3Rs principle still cannot be done by the community in all area of Denpasar.

Figure 3.8 Place/dumping container

Figure 3.9 Labor service

Figure 3.10 Example of transportation Facilities. *Top of right and left:* garbage truck and car crane. *Bottom of right and left:* garbage bin motorcycle and wheelie bin.

In order to process the waste, the composting system was applied in TPA Suwung, where this system was one way to reduce the volume of garbage piled up in the landfill. Besides, the composting also aims to increase the economic value of garbage. The production capacity of the landfill Suwung namely the amount of waste to be processed 5 ton per day and the compost produced reaches 1~ 2 ton per day. The benefits of compost produced by landfill Suwung namely providing micro-nutrients to plants, loosening the soil, increase crop production and slow the dryness of the soil. The compost produced was intended to landscaping the city of Denpasar.

There was problems faced in composting activities at the landfill Suwung: limited landfill area, prone to fires in the dry season and the rainy season often occurs as a result of road congestion to the point landfills filled with mud and corrugated; complaints from the community due to odors, flies and air pollution.

3.4.4. Stakeholders involved

The stakeholders of waste management systems were identified during the observation. The formal stakeholders included the local authority, agency under the government, NGO and private contractors providing services. The local government was the most important stakeholders which set up policies and the provision of solid waste management systems respectively. The private contractors were also regarded as important stakeholders as well as the service users such as: households, civil organizations, commercial and industrial sector. Less mentioned was educational and research institutions, political parties, farmers (including poultries, fisheries), health care centers, media, donor organizations, Chamber of Commerce and Industry, recycling companies, police and religious leaders. The university was expected to more actively participate in the introduction of waste management technologies. Guererro et al. 2013 stated that universities, research centers and centers of excellence have a very important role in preparing professionals and technicians in environmental fields, including waste management; some developing countries have already seen the positive effects of investing in education and research by having cleaner cities, citizens assuming their responsibilities and higher status of solid waste workers. The informal stakeholders were included such as waste pickers collecting door to door, at the street or in the disposal site, itinerant waste buyers, junk shop owners and street sweepers.

Enactment of the President Regulation number 22 year 1999 on Regional Government, known as the legal authority of regional autonomy implementation, A Sarbagita Hygiene Management Agency (BPKS) involving the city of Denpasar, Badung, Gianyar and Tabanan was initiated and started to work effectively in 2004 through placement of professional personnel. BPKS was a forum of cooperation among municipalities in Bali province which is has 1) the same problems; 2) needs; 3) perspectives; 4) understanding and willingness to bear the risk of co-operation; 5) and the political will of the respective local leaders to cooperate, when dealing with MSW. PPLH Bali (Bali Environmental Education Center) is a Non-Government Organization established in 1997 that concentrates on addressing environmental problems and society empowerment. The group runs environmental awareness and education programs that aim to conserve natural environment of Bali Province. Other NGO also known as Denpasar Clean and Green organization (DCG) Berlian; it is an environmental NGO and as a partner of Denpasar city government, dedicated to educate people, increasing people participation and ability in utilization of Denpasar MSW. They also involved in wide range of environmental issue and outside as part of a coalition of non-governmental organizations. Guererro et al. 2013 stated that detailed understandings on who the stakeholders are and the responsibilities they have in the structure are important steps in order to establish an efficient and effective system. Communication transfer between the different stakeholders is of high importance in order to get a well-functioning waste management system in the cities in developing countries (Guererro et al. 2013). The woman in family welfare movement (PKK) is categories as a stakeholder which was the household mother.

This kind of women's association is available in every village government, sub-district government, district government, and provincial government. The PKK started in the 1960s in Central Java with a program, of alleviating village poverty. It expanded into other provinces in the following two decades and has been involved in community health, family planning and education.

3.4.5. Development of micro-enterprise

The involvement of micro-enterprises is widely practiced in Latin America (Moreno, Rios, & Lardinois, 1999) and numerous forms of public–private partnerships exist that involve micro- and small enterprises (Haan et al., 1998). In developing countries, micro-enterprises constitute the majority of the small business sector, a result of the relative lack of formal sector jobs available for the poor. Therefore micro-enterprises in developing countries then tend to be the most frequent form of business. As explained by Aneel Karnani: Most microcredit clients are not micro entrepreneurs by choice. They would gladly take a factory job at reasonable wages if it were available.

Wastes need to be seen not as a problem but a resource for sustainable development. Reduce, reuse, and recycle (the 3Rs), composting and anaerobic digestion would help to reduce waste; they need to be promoted further through public participation and education to become effective. The implementation of 3Rs has been developed as a micro-enterprise. In Denpasar or in Indonesia in general, it was found the idea of smart innovation on how to invite the community to sort out the trash. The current practice of a micro-enterprise in Denpasar called bank of trash. This is an effective effort carried out because people see waste as valuable or similar trash equate to money. It is conducted by organized community-based who managed trash to cash. It was found in Denpasar that when citizens receive information about the benefits of recycling, how to sort the waste and they participate in the designing of the programs, they were more likely to participate if it was having benefit directly to them.

Guererro et al. 2013 stated an effective system which was not only based on technological solutions but also environmental, socio cultural, legal, institutional and economic linkages. At-source sorting and doorstep collection is crucial to increase usable volumes and improve the safety and acceptance of organic waste use in UA.

Figure 3.11 Educated people in early age. *Top of right and left:* education poster about paper recycling and education poster about recycling. *Bottom of right and left:* received training craft manufacture and learn to make bags of plastic waste packaging.

Figures 3.11 and 3.12 illustrate the development of micro-enterprises in Denpasar. The woman in family welfare movement (PKK) in each area of Denpasar and PPLH Bali tried to educate people in Denpasar to utilize the recyclable materials included in this study were: plastic, paper, and plastic bottle. They came from a variety of generations, from young to oldest. The target of PKK and PPLH is to educate children from an early age to take advantage of the garbage that benefit from its use. After they got expert to produce the handicraft, they can sell and earn money from the product. They were transformed trash into crafts that can be sold to the public or at exhibitions themed environment.

Figure 3.12 Trash into art. *Top of right and left:* lamp craft from bottle plastic lid waste and bag craft from plastic waste packaging. *Bottom of right and left:* selling the recycling product and tray from news paper recycling.

3.4.6. Example of community-based composting

The community-based composting was found in South part of Denpasar, officially named community-based composting of "Cemara". The idea came from embryonic movements of cleanliness and environmental care in the village of Sanur kaja.

Figure 3.13 Community-based Composting "Cemara".

This community has initiated by a group of women in family welfare movement (PKK) program since April, 12 2004. The group was enthusiastically involved in a PKK program to make their environment area clean and healthy. In the early start, financial support and location was came from non-government organization i.e. USAID, Asdep Bali and PPLH Bali and individual i.e. Mr. Ketut Karsa whose has the land of 2.5 acre in north of Sanur. In 2006, from the achievement of the first winner of National competition of categories of clean and health environment; this group of women had significant contribution in Adipura trophy in 2014 as mention in previous section. Since that, the local government of Denpasar has supported to organize the community-based composting which namely Cemara. Figure 3..14 illustrates the entire process of composting. Though the composting processes looked simple and still use the man power from their production, however the demand from the hotel and restaurant which located in in South part of Denpasar was existed.

There was many community-based composting in Denpasar, however "Cemara" have more consistently running their program. This was because the community was financially supported by the government in Sanur village. They maintain this community because it could make their village clean and also supporting their hygiene program in the region. Beside that also this community-based composting was also an effort to create jobs for the surrounding community.

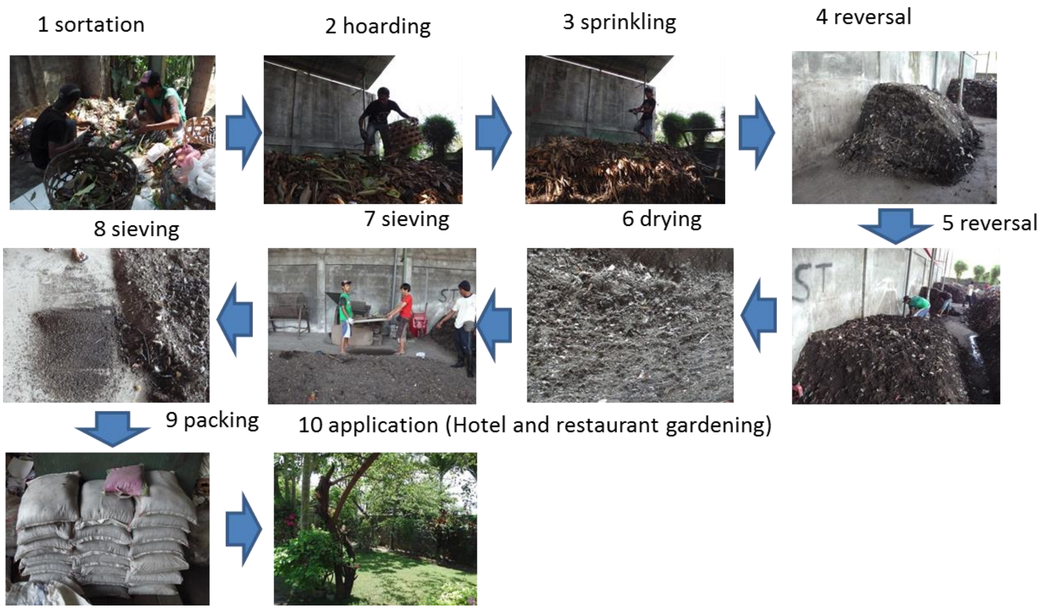


Figure 3.14 Schematic of windrow process of composting.

3.5. Discussion

Denpasar-Bali with a tropical climate has the potential of renewable energy. In Indonesia, the current energy mix is dominated by oil still reached 46.7%, while only 6% renewable energy (Wiratmaja Puja, 2014). National policy roadmap for the development of renewable energy is very important. According to staff experts of minister of energy and mineral resources of Indonesia, various policies to accelerate renewable energy development in Indonesia has been published such as fit-in tariff (FIT) for generating the mini / micro hydro, and intensive biofuels, biogas, biomass and garbage. The chapter introduces the development of waste management through community-based composting to promote UA and accelerates renewable energy development in the Five Year Development Plans in Denpasar. Next, there will be various obstacles and challenges that need to be addressed to develop UA in Denpasar, especially from the aspect of technology, infrastructure aspects, economic aspects, inter-agency coordination, licensing, and culture and social aspects. To that end, the synergy of various government agencies, universities, research and development institutions, employers and others is the key to be able to optimally utilize renewable energy such as biomass.

The clean and green city becomes target in all sectors as Denpasar is a major tourist destination. However, the problems come along was environmental awareness of city inhabitant was poor and government had difficulties to change public behaviors mainly on municipal solid waste management. Establishment in regulation of biomass utilization can be applied to answer that kind of problems. Because it became a strategy to see the biomass from the different perspective i.e. purchase of biomass recycle into values and energy.

It is a good opportunity for the city of Denpasar, especially if it can be working together with foreign governments such as Japan. Because Japan will continue its efforts to expand cooperation with the governments of other countries, international agencies, and other bodies with the aim of building a sound material-cycle society worldwide according to Ministry of the Environment Government of Japan. Still according to the Ministry of the Environment Government of Japan, in 2009, the Regional 3R Forum in Asia was established at Japan’s proposal as a platform for broad cooperation on promotion of the 3Rs – reduce, reuse and recycle – in Asia. Members include central governments, international agencies, aid agencies, private sector entities, research bodies, NGOs and other relevant parties. Forum members have held high-level discussions on policies, provided support for the implementation of 3R projects in member countries, shared useful information, and are building networks for the further promotion of 3R initiatives. Japan hosted the inaugural Regional 3R Forum in Tokyo in 2009, and has cosponsored subsequent Forums together with the governments of host countries and the United Nations Centre for Regional Development (UNCRD). After the fourth forum, the name was changed to Regional 3R Forum in Asia and the Pacific. The Fourth Regional 3R Forum held in Ha Noi, Viet Nam, in March 2013 adopted the Ha Noi 3R Declaration Sustainable 3R Goals for Asia and the Pacific for 2013~ 2023 . It is a legally non-binding and voluntary document which aims to provide a basic framework for Asia-Pacific countries to develop measures and programs to promote 3Rs including a set of 3R indicators for monitoring specific progress.

3.6 Summary

The outcome of this study has generated some essential information for the waste management situation and potential of UA in Denpasar as UA offers environmental benefits. The development of the UA concept in this study found that the local authority could play role in offering technical support and providing markets and could be assisted by either a micro-enterprise or an NGO. The chapter provided convincing evidence of the importance of the usage of wastes as medium to promote UA concept. The result of this work may have contributed to some extent to launching of the UA program in Denpasar, Bali.

Chapter 4
Natural Zeolite uses in Composting of Leftover Food Waste

4.1 Introduction

Previous studies have shown that clinoptilolite, and certain other natural zeolites are effective in removing ammonia from wastewater (Emadi et al., 2001; Zorpas et al., 1999). However, there are few studies on the effects of natural zeolites on ammonia reduction during the thermophilic stage of food waste composting. To investigate the reduction of ammonia gas emissions that mainly cause odor pollution by clinoptilolite, in particular, the study focused on the correlation between ammonia emission and temperature at different doses of clinoptilolite, we have conducted the 7 days composting of leftover food using a small-scale composting reactor in 2013 (first experiment) and in 2014 (second experiment).

4.2 Materials and Methods

4.2.1. Characteristic of feedstock mixture

Leftover food waste was collected from sixteen primary schools of Fuchu city in Tokyo, and the lunch was managed by the school lunch center of Fuchu city. The leftover food image is given in Figure 4.1. The test materials were sent to the laboratory and stored in a cooler container at 5^{o}C. As there was no hard organic debris, the materials were cut into smaller sizes (<10mm) manually using a shovel. Japanese rice hulls have a nitrogen content of 0.34 mg/g and were added to achieve a bulk density of less than 496 g/L as recommended by Oshins, (2006). Hydrated lime (Ca(OH)2) was used to prepare the acidity of the composting. In this experiment, in order to observe the property of clinoptilolite clearly, only 0.25% of $Ca(OH)_2$ was added as it was alkaline. About 60 L (60.25 kg) of leftover food from the lunch center was mixed with 120 L (12.5 kg) of rice hulls (volume ratio 1: 2) and added with 0.25% (0.18 kg) of hydrated lime.

Figure 4.1 Leftover foods for reactor composting.

The initial characteristics of each material are given in Table 4.1 for the first and second experiments. The collecting time of material was different from the first and second experiment, so that made the leftover food materials was different. The first experiment was conducted in July, 2013 and the second experiment was conducted in August, 2014 and the rice hulls and the clinoptilolite had almost the same value.

Table 4.1 Initial characteristics of each material.

	first experiment			second experiment		
	Leftover food	rice hull	clinoptilolite	Leftover food	rice hull	clinoptilolite
MC (%)	76.00	11.56	6.34	64.56	10.86	6.34
VS (%)	95.00	84.35	5.55	96.15	82.11	5.55
pH	4.30	7.03	9.96	4.45	7.01	9.96
EC (mS/cm)	4.03	0.21	0.35	4.03	0.28	0.35
C:N ratio	15.72	112.57	28.74	14.26	111.44	28.74

The image of feedstock mixture is given in Figure 4.2 and the initial characteristics of the feedstock mixture are given in Table 4.2. The feedstock mixture was rich in organic matter, nitrogen and carbon. The initial characteristics of the feedstock mixture were a moisture content of 65.0%, volatile solid of 89.8%, a pH of 5.2, electrical conductivity of 4.6 mS/cm and a C/N ratio of 18.6. The moisture content reached the general optimum values of less than 70% at the initial state of composting. The results obtained suggested that these materials were available and suitable for use in the composting process.

Figure 4.2 Feedstock mixture.

Table 4.2 Initial characteristics of feedstock mixture.

Parameter	Feedstock (Leftover food and rice hulls)
	Mean
Moisture(%)	66.3
Organic matter (%)	89.3
pH	4.8
EC (mS/cm)	4.7
C/N ratio	21.7

EC: Electrical Conductivity

4.2.2. Doses of zeolite in reduction of ammonia gas concentration

The preliminary experiment was conducted to choose the doses which were considerable reducing the ammonia gas. According to some references that natural zeolite was used commonly because of their unique adsorption, ion exchange, molecular sieve, and catalytic properties, some amendments such as peat, zeolite, and basalt have been used to adsorb ammonia in composting (Bernal et al., 1993; Witter et al., 1989). We selected "Itaya Zeolite-13" from Japan which is a kind of natural zeolite and determined the dose based on study reference. The image of natural zeolite is given in Figure 4.3. From the preliminary result it was found that decreased ammonia gases by adsorption of different doses of granular natural zeolite were 2100-500, 1000-100, 1300-350, 350-50, 210-30 ppmV for 0%, 3.3%, 23%, 33.3% and 50% of granular natural zeolite (<4mm) on a wet mass basis respectively (Madrini et. al 2014a). It was concluded that "Itaya Zeolite-13" (50~ 100%) could reduce ammonia gas concentration as the result above nearly odor index regulation by Japan Ministry of Environment (5-10 ppmV for ambient environment) and could be an adsorbent in composting process of leftover food waste.

Figure 4.3 Granular zeolite (<4 mm).

4.2.3. Granulated vs. powder zeolite

In order to find the differences in adsorption of ammonia from two differences zeolite particle sizes, a preliminary experiment was conducted using granulated zeolite and powder zeolite. A significant difference was observed between granulated zeolite and powder zeolite (Madrini et. al 2014c). Decreased ammonia gas was monitored from day 1, and its gas range were 2283-136, 1386-94, 910-47, 491-31 ppm V for 0%, 23%, 33.3% and 50% of granular natural zeolite (<4mm) respectively, while in the powder zeolite treatment 1265-85, 956-147, 1093-167, 337-105 ppm V for

0%, 23%, 33.3% and 50% respectively. Application of powder zeolite did not result in any consistent reduction of ammonia gas concentration. Based on those preliminary results, a natural zeolite (clinoptilolite) in granular form that has the commercial name "Itaya Zeolite-13," was used in this experiment, which was registered by the Japan Fertilizer and Feed Inspection Association. It was passed through a sieve to achieve uniformity of less than 4 mm. The properties of "Itaya Zeolite-13" are shown in Table 4.3 (data provided by the manufacturer).

Table 4.3 Properties of ITAYA Zeolite (Japan Fertilizer and Feed Inspection Association).

Component	Concentration	
Total Silicic Acid (SiO_2)	69.7	%
Aluminum Oxide(Al_2O_3)	10.0	%
Total Potassium(K_2O)	3.06	%
Sodium Oxide(Na_2O)	2.36	%
Iron Oxide(Fe_2O_3)	1.23	%
Total Unslaked Lime (CaO)	0.91	%
Total Mgnesia (MgO)	0.17	%
Ignition Loss	3.76	%
Cation Exchange Capasity (CEC)	170	cmol kg-1
Moisture Content (MC)	5.92	%
pH	7.5	-

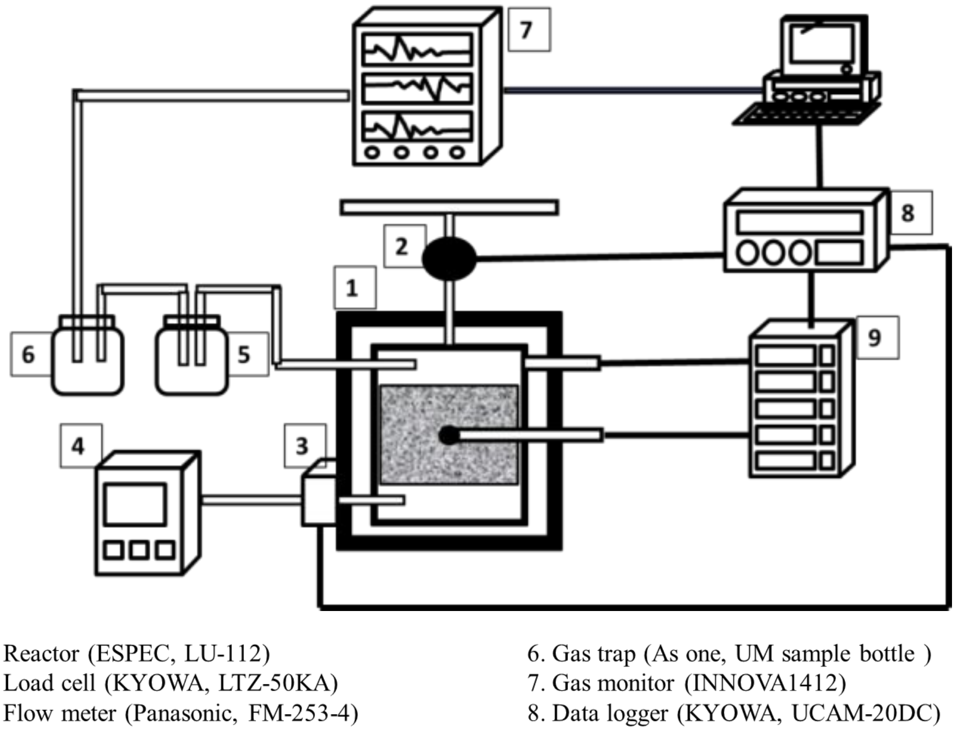
4.2.4. Lime treatment

Lime treatment had greater ability to increase the initial acidity of the material feedstock; thus, it can have a better decomposition rate. Hydrated lime (Ca(OH)2) was used to lighten the acidity of the composting. Hydrated lime (Ca(OH)2) was used to prepare the acidity of the composting. In this experiment, in order to observe the property of clinoptilolite clearly, only 0.25% of Ca(OH)2 was added as it was alkaline. Even though pH adjustment of the starting substrates is usually not required, however in this study, additional lime in first experiment didn't have effect in increasing pH value. Conversely, in second experiment, additional of 0.25 % raised the initial pH to 5~ 6. The result of optimization of decomposition process showed that either lime or zeolite can be potential material for reducing the ammonia emission (Madrini et. al 2014b).

4.2.5. Contained composting vessels (Run)

The composting processes were conducted in the laboratory in seven closed fermenters of 10-L cylindrical reactors 250 mm in diameter and 270 mm deep (Figure 4.5). The reactors were made of stainless steel material with a well enclosed structure and a double-chamber system with high insulation to maintain a constant atmospheric condition. All of the seven closed fermenters of 10-L cylindrical reactors were set under controlled conditions.

As shown in Figure 4.4, one thermocouple was placed horizontally at the center of each reactor at a depth of 135 mm from the top. It was used for monitoring the material temperature and controlling the reactor temperature. The cylinder was insulated with a chamber to minimize the conduction heat loss through the fermenter. The temperature in the chamber was controlled to follow the material temperature within 1ºC accuracy. Temperature and gasses were monitored and recorded using data loggers connected to a personal computer. Two bottles of trapped gas were connected to a photoacoustic field-gas monitor (Type 1412, Innova) with data loggers to monitor the ammonia gas concentration.



1. Reactor (ESPEC, LU-112)
2. Load cell (KYOWA, LTZ-50KA)
3. Flow meter (Panasonic, FM-253-4)
4. Compressor (ANEST IWATA, CLD15B-8.5D)
5. Water trap (As one, UM sample bottle)
6. Gas trap (As one, UM sample bottle)
7. Gas monitor (INNOVA1412)
8. Data logger (KYOWA, UCAM-20DC)
9. Temp. controller

Figure 4.4 Schematic of composting reactor.

Figure 4.5 Composting reactor.

4.2.6. Experimental setup

Two experiments in different years were carried out in using closed fermenter 10-L cylindrical reactors. The first experiment was conduct in 2013. The amount of feedstock mixture and clinoptilolite in each experimental run (hereafter Run) in dry mass basis is shown in Table 4.4. After being well mixed by a power mixer (WPM-70A Minato Industrial) (Figure 4.6) for 5 minutes, about 4.5 kg of the total amount of feedstock mixture plus clinoptilolite was added to each fermenter while the amount of application was limited by the fermenter size.

Table 4.4 Mixture composition of test materials in each run.

Run	name	Feedstock mixture(FM) mass kg	Feedstock mixture(FM) ratio %	Clinoptilolite mass kg	Clinoptilolite ratio %	Clinoptilolite per FM %
1	CL 0%	4.500	100.0	0.000	0.0	0.0
2	CL 1.6%	4.429	98.4	0.071	1.6	1.6
3	CL 3.1%	4.360	96.9	0.140	3.1	3.2
4	CL 13.7%	3.883	86.3	0.617	13.7	15.9
5	CL 21.8%	3.520	78.2	0.980	21.8	27.8
6	CL 31.5%	3.084	68.5	1.416	31.5	45.9
7	CL 47.2%	2.376	52.8	2.124	47.2	89.4

Figure 4.6 Power mixer WPM-70A.

One night before the experiment was used for the experimental preparation as the acclimation time less than 25°C required for the activity of microorganisms in the material to adapt to the mesophilic condition. Temperature and ammonia data were monitored and recorded continuously from the first day at 1-minute intervals and at 9-minute intervals during the following 7 days of composting, respectively. The short period of 7 days was considered necessary to observe the ammonia emission pattern that developed starting from the thermophilic stage (>45°C). Compressed air of 100 kPa was introduced to the bottom of each reactor and distributed to the material mixture through a perforated plate at a flow rate of 0.4 L/min.

The second experiment was needed as a validation data. For the second experiment in 2014, the amount and the setting of the materials used was the same as the first experiment in 2013. However the leftover food material used was different from previous experiment, and the feedstock mixture was divided into twelve portions. The twelve portions consisted of three repetitions; repetitions 1, 2 and 3 (Run1'=CL 0 %), repetitions 1, 2 and 3 (Run5'=CL 21.8 %), repetitions 1, 2 and 3 (Run6'=CL 31.5 %), and repetitions 1, 2 and 3 (Run7'=CL 47.2 %) with clinoptilolite on a dry mass basis, respectively.

4.2.7. Sampling and Analysis

Both first and second experiment, the properties of moisture content (MC), volatile solid (VS), pH, C/N ratio, ammonium nitrogen (TA-N) and electrical conductivity (EC) were measured to determine the initial conditions of the feedstock mixture. MC was determined by an oven dry method at 105ºC for 24 hours and VS was obtained by determining the loss of mass after ignition on triplicate samples at 600ºC for 2 hours; and VS is regarded as the organic matter content. Values for pH and EC were measured by the glass electrode method (Horiba D-24) at a ratio of 1 : 10 (feedstock mixture : water). The C/N ratio was measured using the C/N analyzer (Sumigraph NC-220OF). TA-N was measured by indophenol blue absorptiometry using the supernatant of extract by 2 mol/l potassium chloride solution but only in the first experiment in 2013. Correlation analyses between temperature and ammonia emissions were performed using Microsoft Excel. The ammonia emission rate was calculated by formula (4).

$$E = \frac{\sum(C_{\mathrm{amo}} \times f) \times 17.03 \times 60}{D_{\mathrm{org}} \times 22.4} \tag{4}$$

E: ammonia emission rate [mg/kg VS], C amo: ammonia gas concentration [ppm = mL/L], f: air flow rate (= 0.4) [L/min], D org: mass of decomposed organic material [kg], 17.03: molecular weight of ammonia [g/mol], 22.4: unit volume [L/mol]

Correlation analyses between temperature and ammonia emissions were performed using Microsoft Excel.

4.3 Results and Discussions

4.3.1. Composting Temperature

During composting of leftover food, temperature discovered varying in seven days composting. Figure 4.7 of the first experiment shows temperature changes under all test conditions. Significant differences in the temperature profiles were confirmed among the conditions of the thermophilic stages of each treatment. Temperature development in all treatment reactors on Day 1 ranged from 36 to 64ºC. However, the temperature in each treatment did not tend to decrease especially for the high clinoptilolite addition groups (21.8%, 31.5% and 47.2%) due to a weak fermented state by a lower moisture content if compared with Run 1~ 4. The maximum temperatures were 52.3, 53.1, 60.5, 53.5, 66.0, 64.0, 64.0 ºC for 1.6%, 3.1%, 13.7%, 21.8%, 31.5% and 47.2% of clinoptilolite content, respectively.

The second experiment in 2014, validation of each repetitions 1, 2 and 3(Run1’=CL 0%), repetitions 1, 2 and 3(Run5’=CL 21.8%), repetitions 1, 2 and 3(Run6’=CL 31.5%), and repetitions 1, 2 and 3(Run7'=CL 47.2%) clinoptilolite indicated the temperature of each validation data set were observed lower (< 65 ºC) than first experiment, however the trend was about the same. As show in figure 4.8~ 4.11, increasing the amount of clinoptilolite in the high clinoptilolite concentration groups (Run5', Run6' and Run7') also did not affect the decreasing temperature. The averages of maximum temperatures were 57.8, 58.7, 55.1, and 61.6 ºC for 21.8%, 31.5% and 47.2% of clinoptilolite content, respectively.

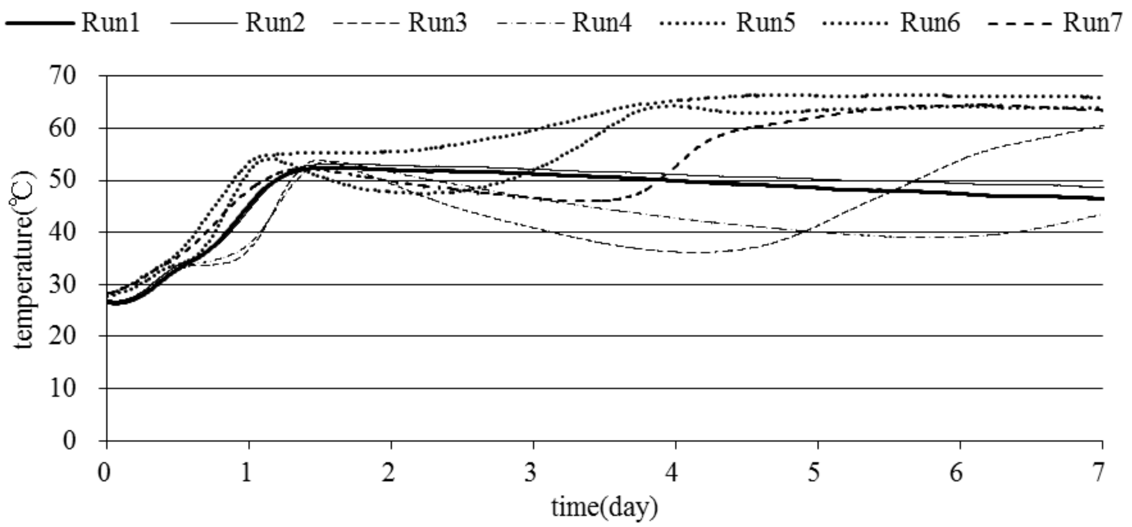


Figure 4.7 Temperature profile in first experiment.

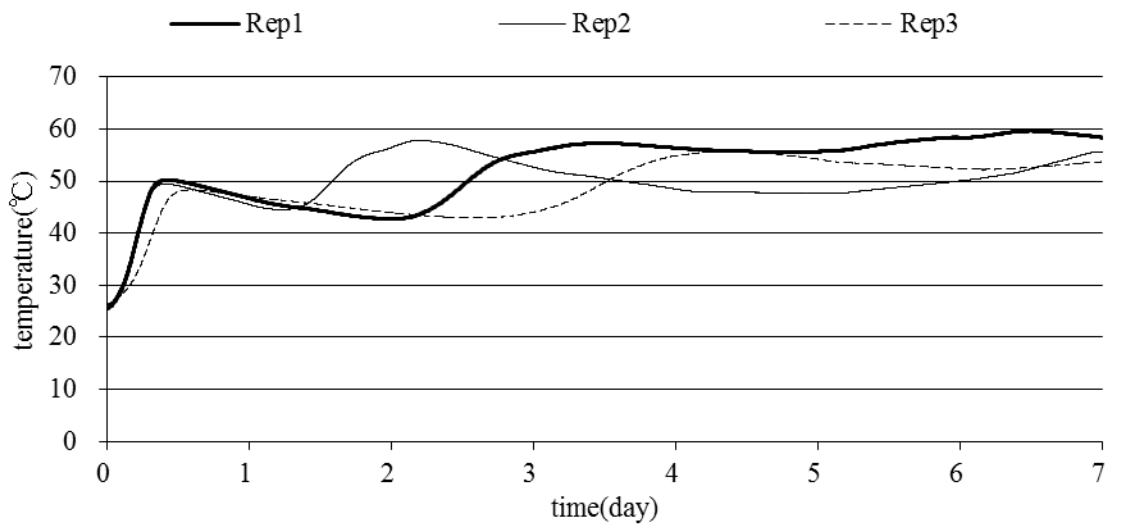


Figure 4.8 Temperature profile for Run1'=CL 0%.

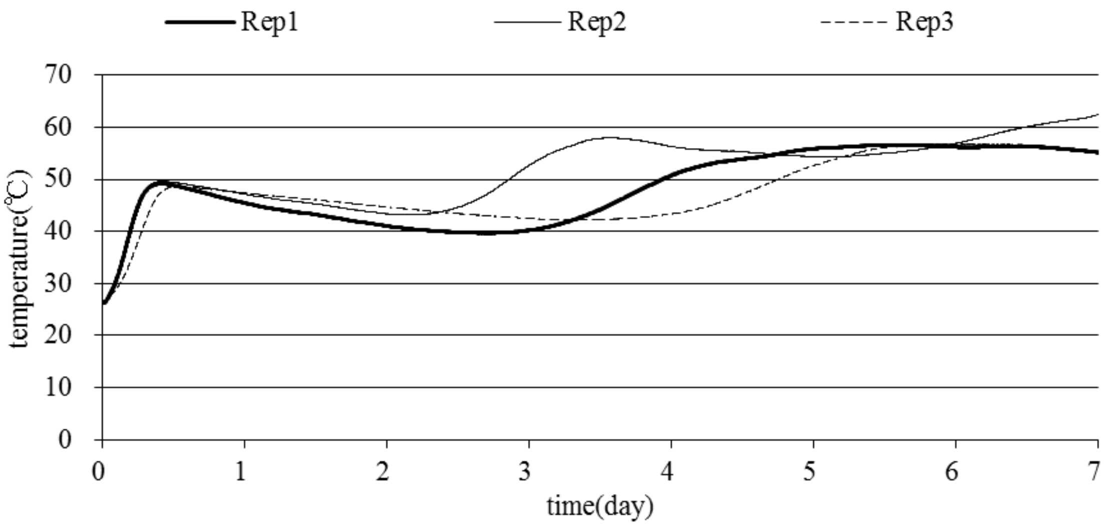


Figure 4.9 Temperature profile for Run5'=CL 21.8%.

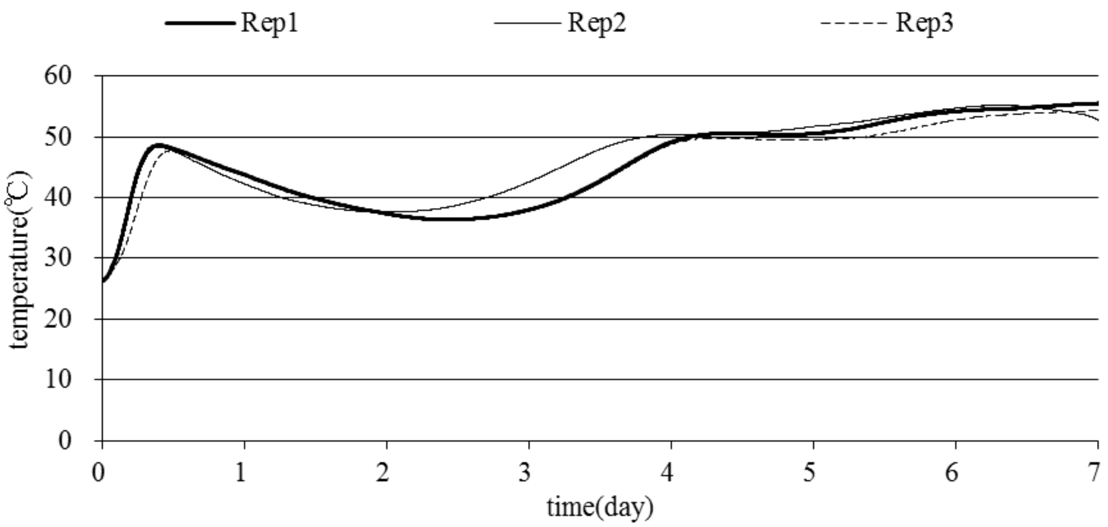


Figure 4.10 Temperature profile for Run6'=CL 31.5%.

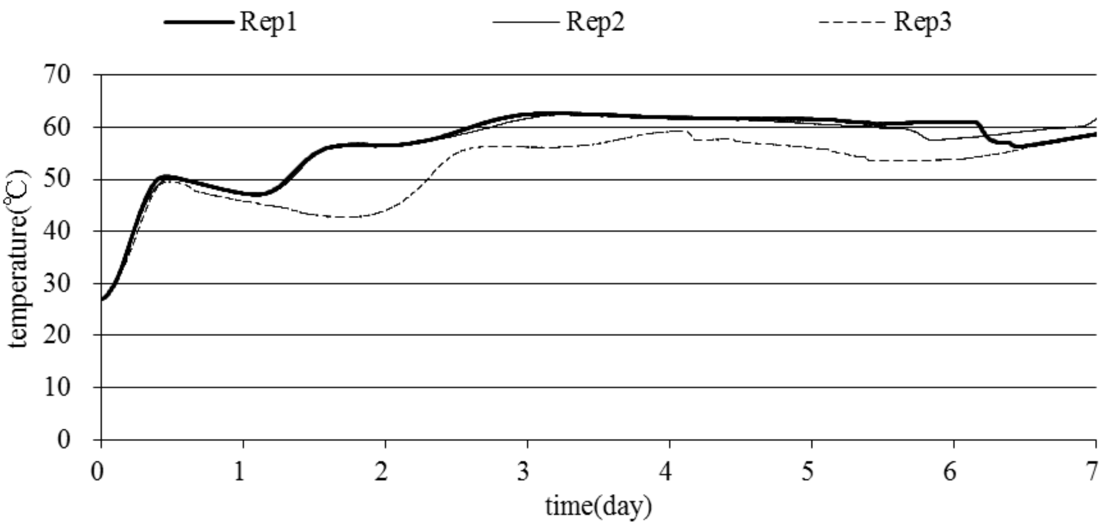


Figure 4.11 Temperature profile for Run7'=CL 47.2%.

4.3.2. Ammonia emission

Thermophilic stage occurs in the early days of composting and from which ammonia gas is actively discharged; the decreasing of ammonia emission in the high clinoptilolite concentration groups (21.5%, 31.8% and 47.2%) were observed. Figure 4.12 illustrates the transition of ammonia gas concentration. In Run 1 ~4, because of a defect of the measuring device, the data from 6.3 days onwards was lost. Ammonia gas emission data was calculated using only 6.3 days of data. A gradual decrease was observed in ammonia gas concentration by different doses of clinoptilolite. Maximum ammonia gas concentrations were 1850, 1891, 1605, 1308, 1386, 910, and 491 ppm for respective Runs 1 to 7. And the averages of ammonia gas concentrations were 997, 979, 520, 448, 744, 193, 127 ppm for Runs 1 to 7, respectively. The results clearly showed that ammonia emissions reached higher levels in the non-added and the lowest doses of clinoptilolite (1.6%). The ammonia concentration decreased with the increase in the dose of clinoptilolite, except for Run 5. Run 3 showed the highest temperature range (55~ 66ºC) during the composting process. Gradual decreases of ammonia were observed in 31.5% clinoptilolite for Run 6 and 47.2% clinoptilolite for Run 7.

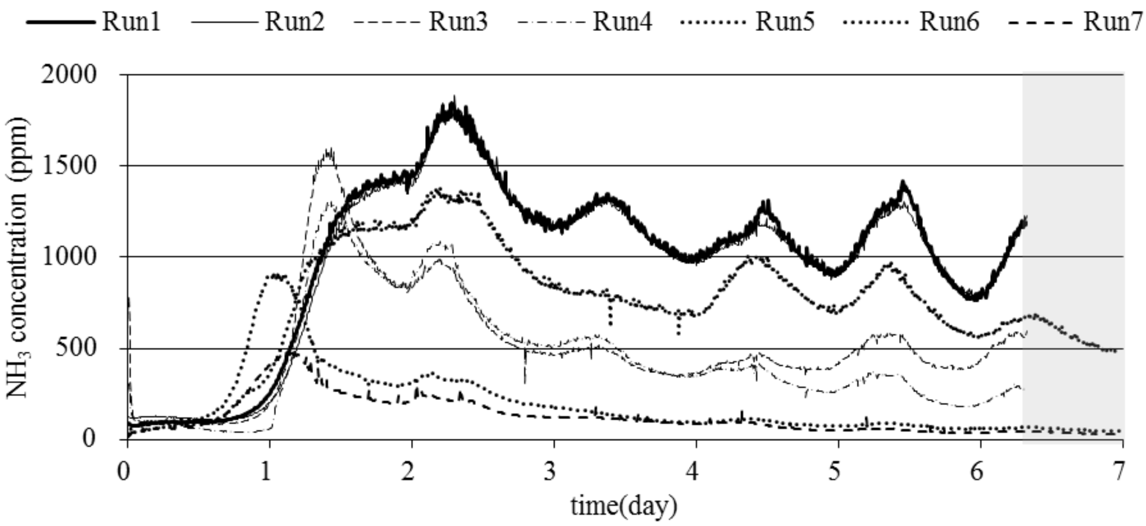


Figure 4.12 Evolution of ammonia emissions in first experiment.

4.3.3. Zeolite as an adsorbent

Validation of each set in second experiment in 2014 for repetitions 1, 2 and 3(Run1'=CL 0%), repetitions 1, 2 and 3(Run5'=CL 21.8%), repetitions 1, 2 and 3(Run6'=CL 31.5%), and repetitions 1, 2 and 3(Run7'=CL 47.2%) clinoptilolite shown in Figure 4.13~ 4.16. Maximum of ammonia emission 317, 719, 238, 217 ppm (for Run1', Run5', Run6', and Run7' respectively) and average of ammonia emission 141, 186, 117, 103 ppm (for Run1', Run5', Run6', and Run7' respectively) were observed. The ammonia gas emission was observed approaching 67, 99, 33 ppm for Run1', Run5', Run6', and Run7' respectively from the maximum temperature. In general, the same trend from first experiment in addition of 21.5~ 47.2% clinoptilolite was observed.

However, the average of 29.94 ppm ammonia gas concentration was found in Run 5' in repetition 3 of second experiment. The maximum ammonia gas emission was 39.54 ppm of the average of ammonia in 5 degree temperature interval. This was the lowest one when we compared with others maximum result in second experiment. The very low concentration of ammonia was observed in Run 5' in repetition 3 categorized as an error of the experiment, probably due to unsuccessful decomposition process.

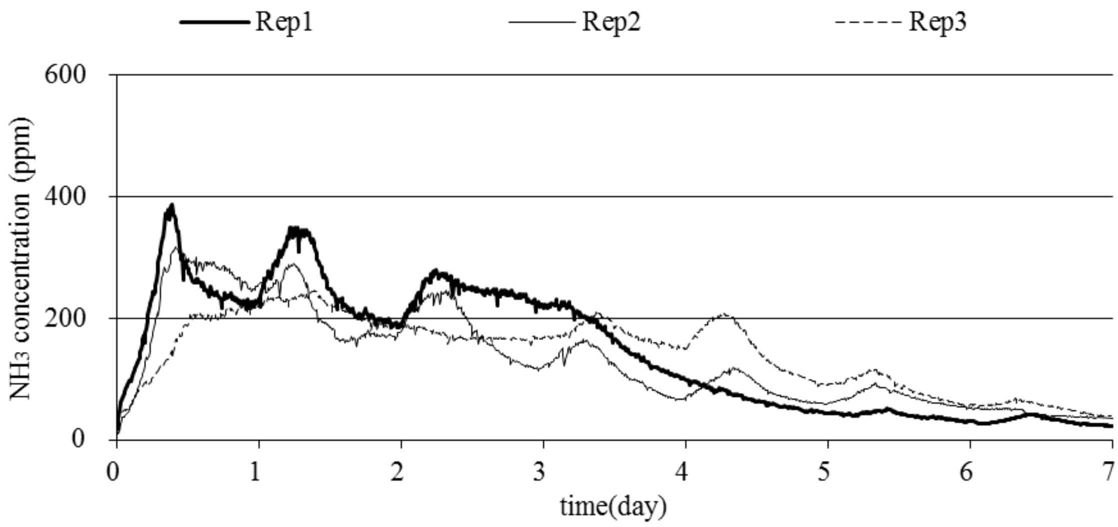


Figure 4.13 Evolution of ammonia emissions for Run1'=CL 0%.

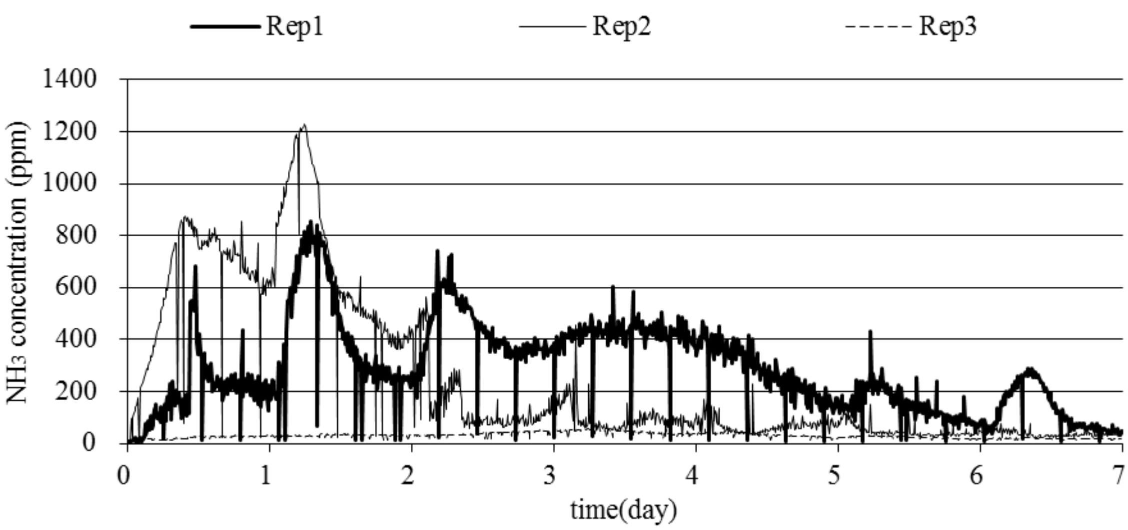


Figure 4.14 Evolution of ammonia emissions for Run5'=CL 21.8%.

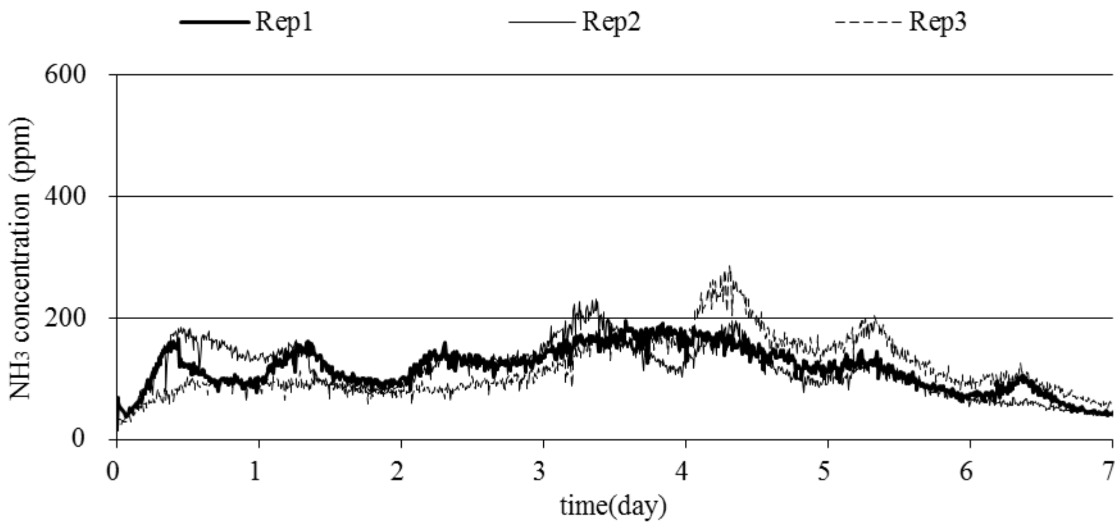


Figure 4.15 Evolution of ammonia emissions for Run6'=CL 31.5%.

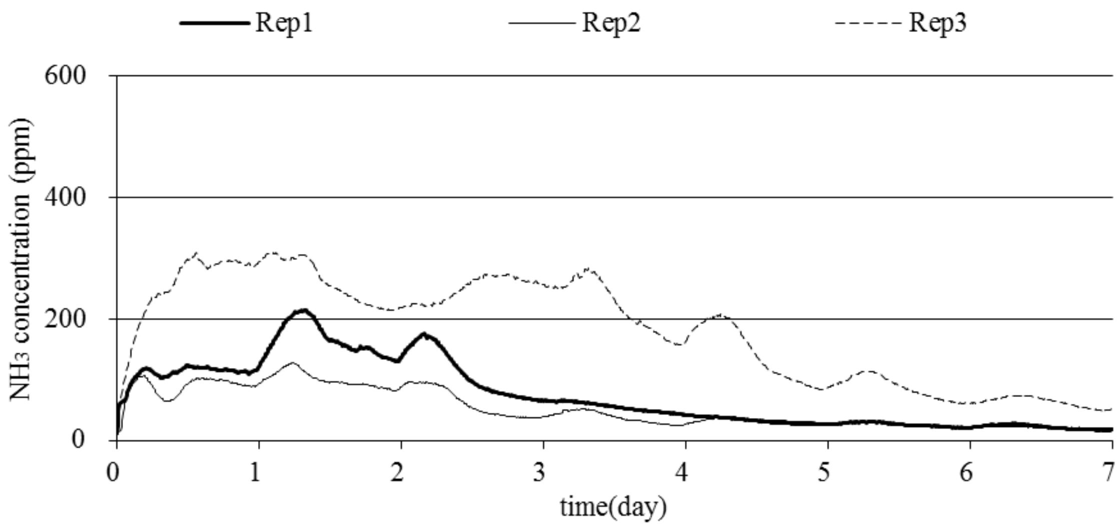


Figure 4.16 Evolution of ammonia emissions for Run7'=CL 47.2%.

Figure 4.17 shows the effect of temperature on ammonia gas concentration under the respective experimental conditions. Correlation curves of temperature and ammonia gas concentration were calculated from the rising-up to the maximum temperatures. During the period, ammonia gas concentration exponentially increased with temperature. The increasing rate of ammonia emission was moderated by the increase of the clinoptilolite dose. The correlation coefficients between the ammonia emission and temperature are calculated by more than 0.5 for all treatment. The same trend also occurred for Run1', Run5', Run6', and Run7' as shown in Figure 4.18~ 4.21.

Table 4.5~ 4.6 also shows average of ammonia in 5 degree temperature interval. The beginning of ammonia emission was observed at 45ºC, and the peak of ammonia emission appeared at 50~ 55ºC. The low average values of ammonia emission were observed in the groups of high concentrations of clinoptilolite addition (Run 6~ 7).

Table 4.5 The average of ammonia gas in 5 degree temperature interval in first experiment.

	Ammonia Gas(ppm)						
℃	Run1	Run2	Run3	Run4	Run5	Run6	Run7
25-30	86.6	122.8	102.5	112.2	43.0	76.7	46.8
30-35	95.1	113.8	95.1	59.6	68.6	109.9	67.1
35-40	115.2	112.7	398.3	231.7	86.4	258.8	98.2
40-45	182.9	165.3	506.5	367.2	131.5	327.8	199.4
45-50	393.3	947.4	748.8	633.4	231.6	452.7	178.1
50-55	956.0	1208.3	878.9	1028.8	496.0	141.7	275.3
55-60			559.9		1128.7	78.0	92.1
60-65					773.4		46.6
65-70					726.2		

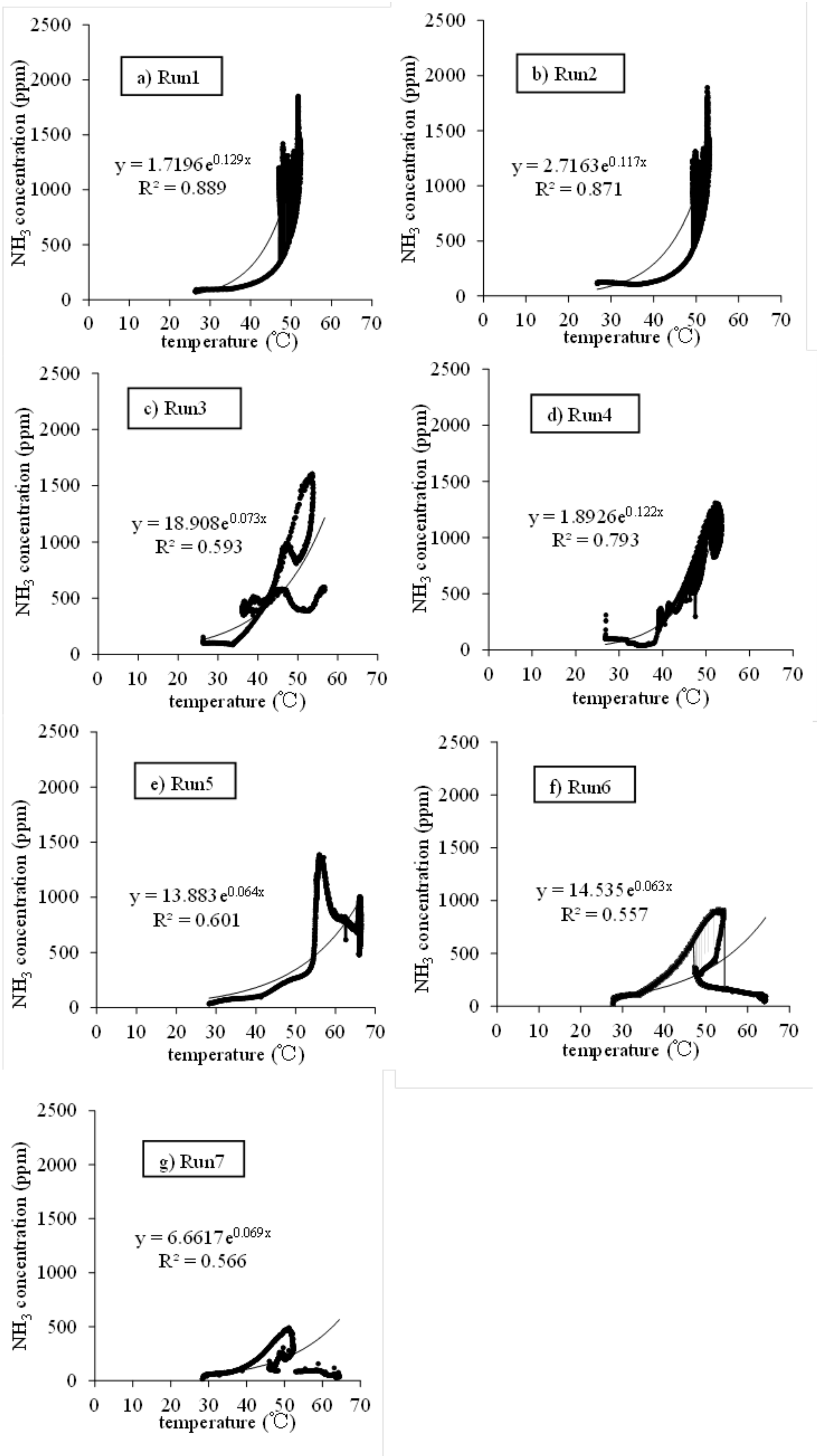


Figure 4.17 Effect of reactor temperature on ammonia emission in first experiment.

Table 4.6 The average of ammonia gas in 5 degree temperature interval in second experiment.

	Ammonia Gas(ppm)											
°C	Run1'			Run5'			Run6'			Run7'		
	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3
25-30	72.10	32.33	49.76	9.59	78.84	11.71	46.13	31.06	30.34	68.20	37.28	72.52
30-35	119.36	65.22	87.55	25.38	209.14	16.06	50.15	51.17	46.18	108.28	90.18	156.14
35-40	160.57	98.36	106.31	363.98	316.17	16.13	119.67	107.35	90.33	117.16	105.43	210.69
40-45	237.73	247.31	174.05	426.10	328.48	39.54	136.36	140.73	99.23	108.19	89.92	270.13
45-50	265.13	131.97	209.58	290.15	644.21	29.64	141.24	168.08	143.79	144.86	96.99	274.81
50-55	267.49	100.50	90.69	315.07	80.88	25.90	123.97	98.74	103.26	147.75	103.23	103.62
55-60	80.33	188.93	165.28	136.31	66.83	20.08				96.53	49.52	167.30
60-65										38.35	33.41	

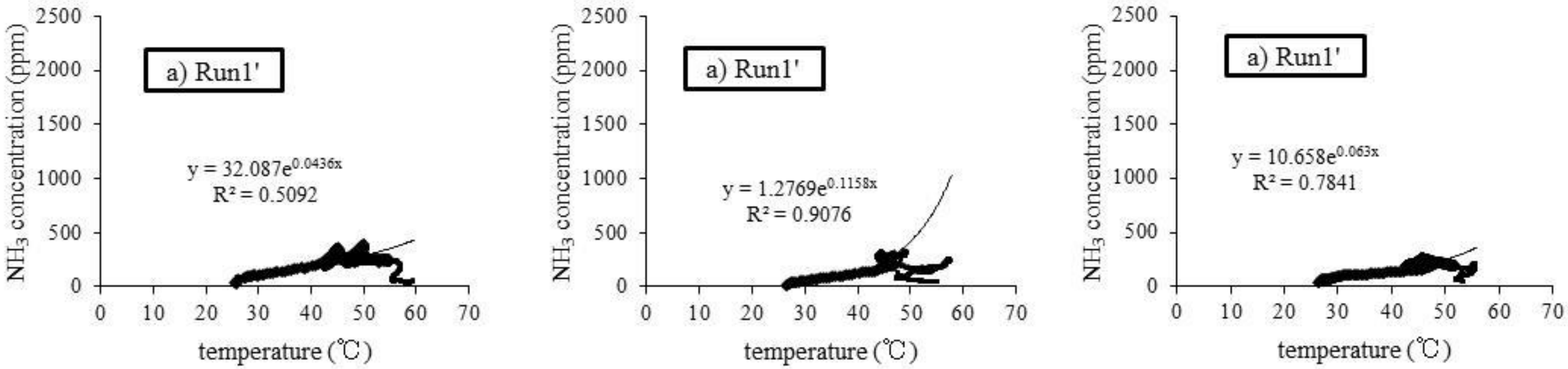


Figure 4.18 Effect of reactor temperature on ammonia emission for Run1'=CL 0%.

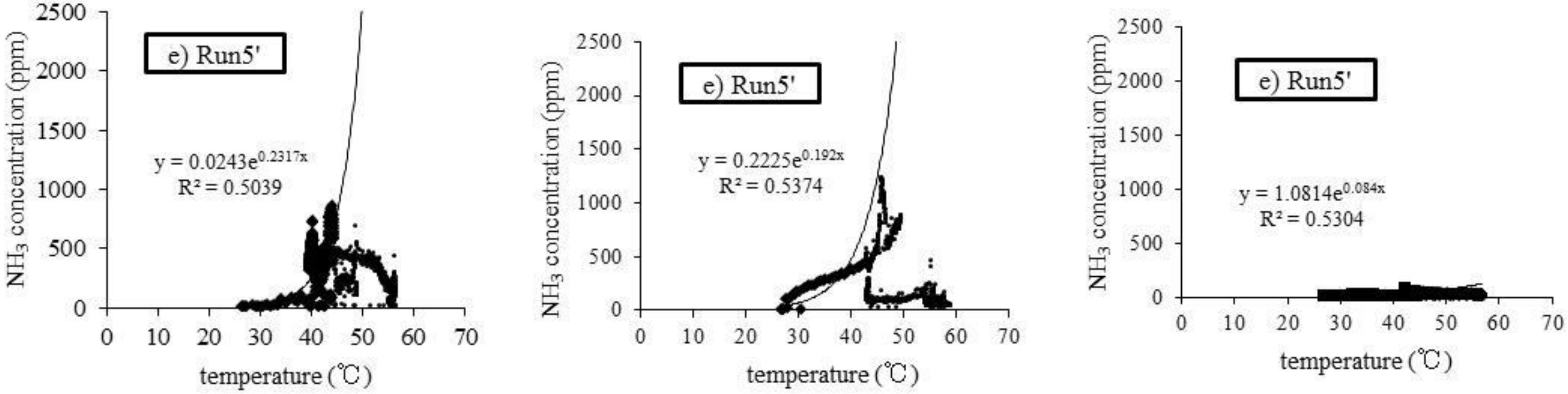


Figure 4.19 Effect of reactor temperature on ammonia emission for Run5'=CL 21.8%.

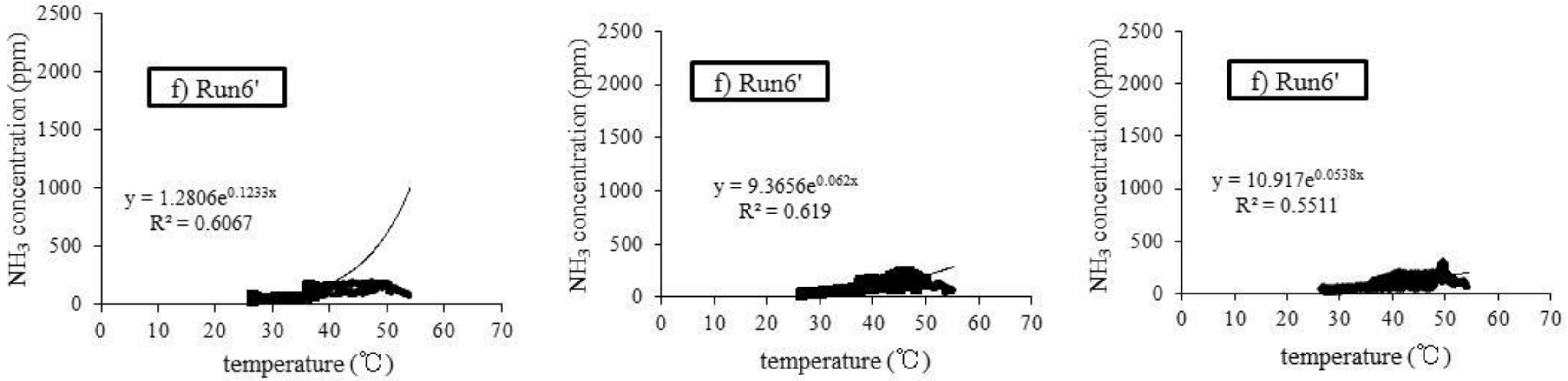


Figure 4.20 Effect of reactor temperature on ammonia emission for Run6'=CL 31.5%.

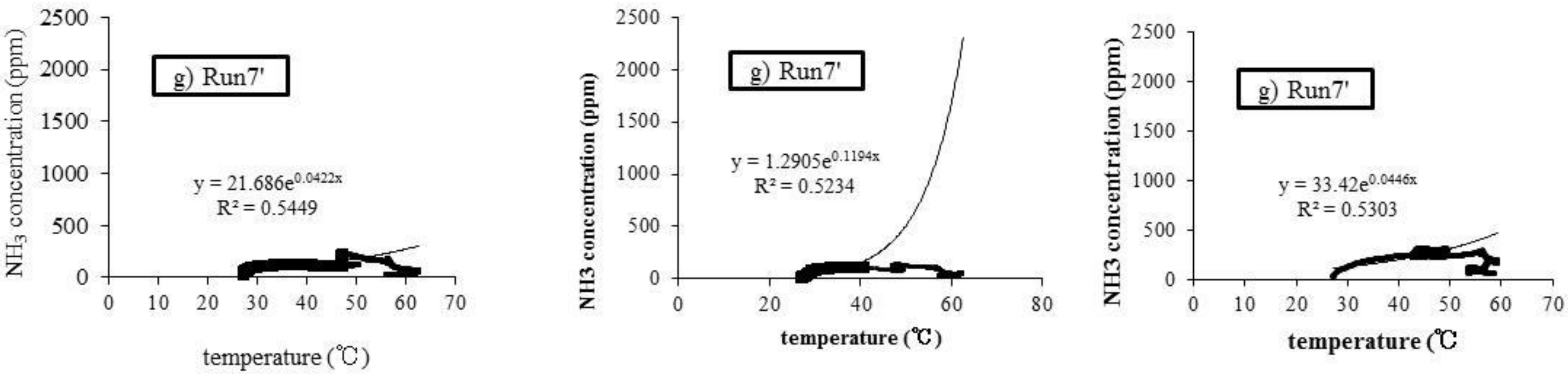


Figure 4.21 Effect of reactor temperature on ammonia emission for Run7'=CL 47.2%.

4.3.4. Zeolite effect on composting properties

Figure 4.22 and 4.23 illustrated the effect of temperature on the ammonia gas (NH_3) concentration and clinoptilolite mixing ratio. The ammonia emission rate was calculated by formula (1). The mass of emitted ammonia per degraded organic matter was calculated at 27.6, 48.3, 11.2, 16.9, 31.1, 3.27, 3.03 g/kg VS for Runs 1~7, respectively in the first experiment. For validation data in second experiment was observed average of 9.82, 25.18, 7.59, and 9.63 g/ kgVS for Run1', Run5', Run6', and Run7', respectively. The ammonia emission rate decreased with the clinoptilolite dose. Both first and second experiment were shown that, the 21.8% clinoptilolite treatment observed a higher level of ammonia emission rate in the high clinoptilolite addition groups, and also showed less stability of volatile solid degradation. In the case of Run (31.5%) and (47.2%), ammonia emission rates were less than 20% of Run (0%) that had no clinoptilolite application in the first experiment, however more than 50% was observed in the second experiment.

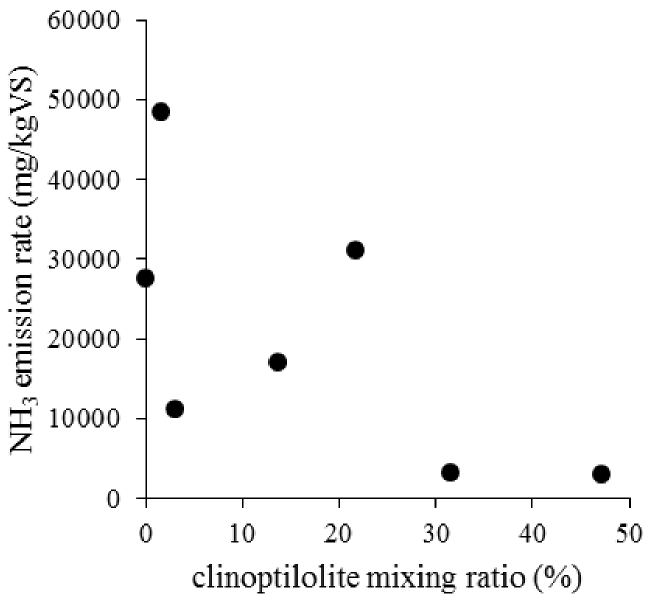


Figure 4.22 Effect of clinoptilolite mixing ratio on ammonia emission rate in first experiment.

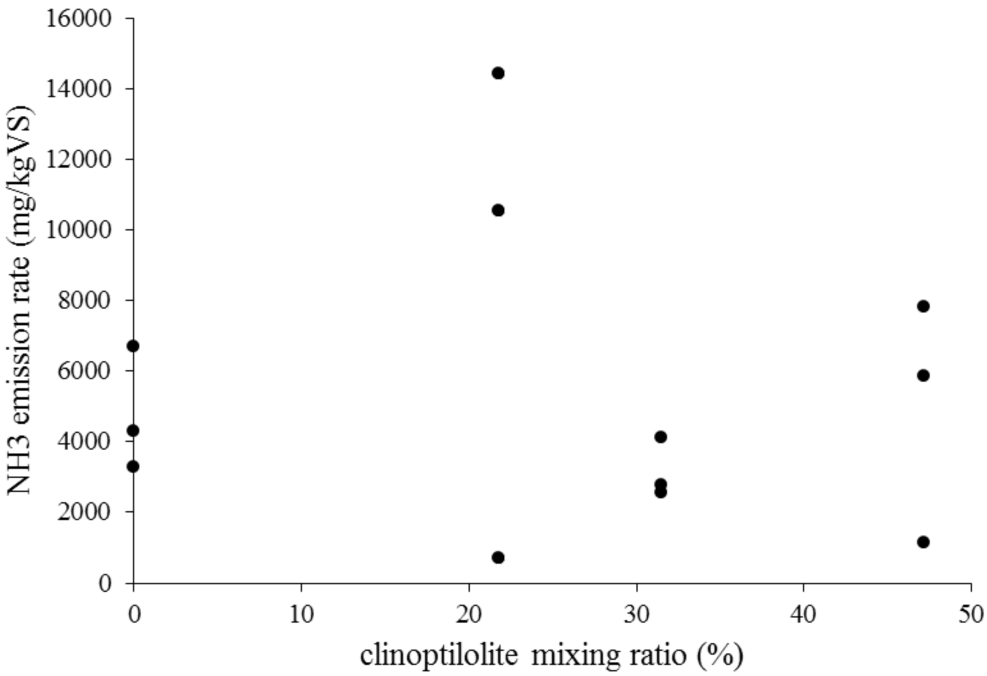


Figure 4.23 Effect of clinoptilolite mixing ratio on ammonia emission rate in second experiment.

The characteristics of composting materials before and after the 7-day composting test are shown in Table 4.7 and 4.8. The initial MC of each run varied with the dose of the clinoptilolite and the effect was maintained until the end of the 7 days of composting. After 7 days of composting of first experiment, Run 1 showed no change in the MC, VS, pH and C:N ratio. The amount of clinoptilolite increased in line with the decrease in the moisture content in Run 2~7 of first experiment and higher decreasing ratio of MC occurred in Run47.2% in of second experiment. The VS loss of first experiment varied from 9.0, 4.3, 9.1, 6.6, 6.4, 17.4, and 11.8% for Run 1~7, respectively; the higher of VS loss in second experiment occurred in Run31.5% of clinoptilolite; a possible effect identified was that the clinoptilolite improved volatile solid degradation, especially for Run 6 (31.5%) and 7 (47.2%). Values for pH tended to increase with time due to the alkalinity of clinoptilolite that has a pH value of 7.5 at the beginning of composting and after 7 day composting tend to decrease. In contrast, the pH decreased in the group of low concentrations of clinoptilolite addition (Run 2~ 5) of first experiment. Increased doses of clinoptilolite affected the decrease of ammonium nitrogen TA-N at the start in all treatments as shown in Table 4.7 by the dilution effect. After the composting test, TA-N increased except for Run 4, and Run 6 achieved the highest increased ratio of 287%. TA-N in second experiment could not be measured.

Table 4.7 Characteristics of feedstock mixture before and after composting in first experiment.

			Run1	Run2	Run3	Run4	Run5	Run6	Run7
clinoptilolite		%	0	1.6	3.1	13.7	21.8	31.5	47.2
Weight	start	kg	4.50	4.51	4.50	4.50	4.50	4.50	4.50
	finish	kg	4.15	4.17	4.11	4.16	3.95	3.79	3.95
	decreasing ratio	%	0.08	0.08	0.09	0.08	0.12	0.16	0.12
MC	start	%,w.b.	65.0	64.1	63.1	56.2	51.6	43.4	34.3
	finish	%,w.b.	65.0	62.7	62.4	55.2	44.8	38.8	26.3
	decreasing ratio*	%	7.6	9.6	9.8	9.3	23.8	24.6	32.7
VS	start	%TS	89.8	84.6	82.3	60.7	48.0	36.8	22.5
	finish	%TS	88.5	84.3	80.4	60.0	44.9	33.3	20.2
	decreasing ratio*	%	9.0	4.3	9.1	6.6	6.4	17.4	11.8
pH	start	-	5.2	5.4	5.3	5.3	4.8	4.7	4.9
	finish	-	4.5	4.4	5.2	4.7	4.8	7.6	6.4
EC	start	mS/cm	4.5	4.3	4.3	3.1	2.9	2.2	1.4
	finish	mS/cm	4.9	4.8	4.4	3.6	2.6	1.8	1.2
C/N ratio	start	-	18.6	25.9	21.7	25.5	24.5	25.2	23.2
	finish	-	20.8	23.3	19.2	23.7	25.8	18.6	21.3
TA-N	start	mg/kg	254	216	213	210	170	144	141
	finish	mg/kg	280	270	354	187	280	431	230

*Decreasing ratio of MC and VS were calclulated from total amount of them

Table 4.8 Characteristics of feedstock mixture before and after composting in second experiment.

			Rep1	Rep2	Rep3	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3	Rep1	Rep2	Rep3
clinoptilolite		%	0	0	0	21.8	21.8	21.8	31.5	31.5	31.5	47.5	47.5	47.5
Weight	start	kg	4.50	4.50	4.50	4.50	4.51	4.51	4.50	4.50	4.51	4.50	4.50	4.50
	finish	kg	3.76	4.05	4.01	3.99	4.14	3.96	4.08	4.14	4.04	3.98	4.03	4.00
	decreasing ratio	%	0.16	0.10	0.11	0.11	0.08	0.12	0.09	0.08	0.10	0.12	0.10	0.11
MC	start	%,w.b.	57.0	59.3	60.0	49.0	50.2	47.0	44.0	41.8	41.0	34.0	37.1	33.0
	finish	%,w.b.	55.0	57.1	57.0	46.0	45.5	46.0	41.0	39.5	40.0	28.0	27.0	26.0
	decreasing ratio*	%	19.4	13.3	15.4	16.7	16.7	13.9	15.4	13.0	12.5	27.1	34.9	29.9
VS	start	%TS	88.0	89.0	88.0	56.0	58.0	53.0	47.0	44.0	43.0	31.0	36.0	28.0
	finish	%TS	88.0	87.0	88.0	55.0	55.0	54.0	42.0	42.0	42.0	31.0	30.0	26.0
	decreasing ratio*	%	12.6	7.4	4.2	7.7	4.5	8.7	14.6	8.8	10.9	3.5	13.3	8.7
pH	start	-	6.08	6.47	5.63	6.19	6.47	6.68	6.71	6.47	7.86	6.42	7.26	8.44
	finish	-	5.61	5.03	4.71	4.85	4.74	4.95	5.04	5.52	5.16	7.55	5.42	6.54
EC	start	mS/cm	3.42	3.22	3.85	2.22	3.22	2.17	1.75	2.25	1.15	1.51	1.47	0.68
	finish	mS/cm	4.28	3.88	4.36	2.4	3.84	2.7	2.09	2.36	2.18	1.02	2.18	1.37
C/N ratio	start	-	28.6	24.2	30.9	29.0	25.7	34.2	25.4	29.3	31.1	24.6	25.2	23.2
	finish	-	26.0	27.0	26.0	25.0	27.0	21.0	24.0	25.0	23.0	29.0	30.0	25.0

*Decreasing ratio of MC and VS were calclulated from total amount of them

Table 4.9 Average properties of composting material in second experiment.

Parameter	Clinoptilolite Treatments			
	0%	21.80%	31.50%	47.20%
before composting				
MC(%)	58.757±1.70	48.743±1.07	42.257±1.31	34.697±2.39
VS(%)	88.333±0.46	55.667±1.33	44.667±2.13	31.667±3.68
pH	6.06 ±0.28	6.978±0.20	7.013±0.17	7.37±0.59
EC (mS/cm)	3.497±0.14	2.537±0.71	1.717±0.35	1.220±0.03
C:N	27.897±3.10	29.590±2.32	28.630±2.32	24.327±0.42
after 7 day composting				
MC(%)	56.363±1.69	45.833±0.05	40.173±0.92	26.987±1.07
VS(%)	87.667±0.33	54.667±0.14	42.000±0.10	29.000±0.69
pH	5.117±0.14	6.447±0.08	5.240±0.34	6.503±1.51
EC (mS/cm)	4.173±0.28	2.980±1.02	2.210±0.19	1.523±0.82
C:N	26.333±0.04	24.333±1.44	24.000±0.45	28.000±0.76

The average of composting properties was shown in Table 4.9, the existence of clinoptilolite in composting were caused decreasing in MC, VS, pH, C:N and only in 47.2% clinoptilolite was caused increasing in EC, and C:N.The results were classified as immature compost. Those all data was additional information as the study focuses on Effect of natural zeolite (clinoptilolite) on ammonia emissions.

4.4 Discussion

The fundamental difference of first and second experiment was the characteristic of leftover food. This was the possible reason which caused differences result between first and second experiment however the trends were same. As shown in the result section, all the test conditions provided maximum temperatures of more than 50ºC except an error of Run 5' in repetition 3. Furthermore, increases of clinoptilolite addition caused increases in the maximum temperature and decreases of ammonia emission.

The average of decreasing MC of run7 was 7.75% from start to finish. For example, as shown in Table 4.7 at Run 7 (47.2%), MC decreased from 34% to 26% during the 7 test days. Excessive low moisture less than 30% was used to restrain the fermentation; however, the results showed that the successful composting process continued. The initial pH 5.2 of the feedstock mixture still remained at lower levels of acidity of the test materials even when $Ca(OH)_2$ was added, in order to reach a pH value of 5.5~8.5 suggested as the optimum by Bertoldi et al. (1983). The material temperature in all treatments successfully reached the condition level at which the fermentation process was activated. In the case of low pH material composting, the addition of seeding compost (Miyatake et al., 2008) or pH adjusting material (Kofujita et al., 2007) achieved the composting process successfully. Hwang and Neculita (2012) also stated that zeolite had the effect of amendment for increasing pH in Food Waste-Based Compost in South Korea.

The highest of VS loss was observed in 31.8% of clinoptilolite, this indicates that at adequate temperature, the decomposition was successful coexist with low of ammonia emission. There was a tendency for the increase of clinoptilolite to accelerate/smooth ammonia emission without disturbing the decomposition process. Stentiford (1996) suggested that a temperature between 35~40ºC maximized the microbial diversity in the composting process. Conversely, Beck-Friis et al., (2001) reported that ammonia emissions started when the thermophilic temperature was higher than 45ºC. Our data showed that at temperatures between 26-45 ºC and 45-55 ºC were found the exponential correlation between temperature and ammonia emission for all composting test. This is similar to the statement of Pagans et al., (2006) that the ammonia emission pattern in the composting of five types of waste (source-separated organic fraction of municipal solid waste (OFMSW)); dewatered raw sludge (RS); dewatered anaerobically digested sludge (ADS); animal by-products (AP); and partially hydrolyzed hair (HH)) investigated strongly depended on the process temperature. As shown in Fig. 4.12, increasing clinoptilolite had the effect of moderate ammonia emission with an increase in temperature. Especially, the addition of 31.5% (Run 6) and 47.2% (Run 7) of clinoptilolite was successful in reducing the ammonia gas emitted from compost as lower levels of the ammonia emission rate were reached. These results reflected the statement of Wang et al., (2007) that clinoptilolite exhibits high selectivity for the ammonium ion (NH4+). Witter and Lopez-Real (1988) reported that the retention of ammonium and ammonia by clinoptilolite was due to the ion exchange and adsorption processes, respectively. Similarly, Villasenor et al., (2011) reported that as the concentration of clinoptilolite increased, the retention of ammonium increased and emissions of ammonia gas decreased.

The water vapor from compost that contained ammonia gas through ionization was adsorbed easily by clinoptilolite microspores as water molecules are smaller than carbon dioxide and oxygen molecules. Therefore, it can be stated that clinoptilolite added enough adsorbed ammonium nitrogen that was emitted from leftover food composting successfully.

Frequently, zeolite as clinoptilolite was used as a soil conditioner. Although it depends on the soil characteristics, the application rate of zeolite was several tons per 0.1 ha. In contrast, compost was applied to farms at the same levels as zeolite. In this study, almost the same amount of clinoptilolite as the feedstock mixture was mixed in Run 7, which observed the least ammonia emission.

4.5 Summary

The ammonia emission pattern in the thermophilic stage of composting with the presence of clinoptilolite was investigated dependently of the process temperature. Clinoptilolite application successfully supported the thermophilic stage of the composting process, as there was no indication of inhibition of the microbial activity in the hemophilic stage identified from temperature evolution. Clinoptilolite adsorbed excess nitrogen and retained ammonia during the thermophilic stage of composting. The application of 31.5~ 47.2% clinoptilolite to leftover food composting was the best doses for reducing ammonia emission. The results of this study demonstrated that clinoptilolite acted as an adsorbent and had great potential for removing ammonia from the composting of leftover food especially in granular form.

Chapter 5

Overall Summary and Conclusion

5.1 General Conclusion

The development of urban agriculture will vary from country to country and region to region depending on climatic, demographic, economic, social and cultural circumstances. Therefore, the outcome of this study would nevertheless supplement existing UA literature. Focuses on social and technology approach would lead to promote the successfully implementation of UA in developed and developing countries. Related to the UA concept, this paper was stressed the waste management in urban area.

Social approach in initiation of community-based composting in Fuchu city and technology approach in odor control of its composting were the most important issues to be discussed. This was the first goal on community based management namely investigate the establishment of collaborative committee of community-based composting in Fuchu city. Initiation of community-based composting was the first action to be able to adopt the conviction from the farmers or individuals who had 1) the common problems; 2) needs; 3) perspectives; 4) responsibility; and 5) understanding and willingness to bear the risk of co-operation. The observation have been found in this study indicated that management of organization needs to be addressed i.e. the synergy of formal and informal stakeholder in the community among government agencies, universities, research and development institutions, employers and others as it is the key factor to be able to continue well-functioning composting management system in UA. Previous discussion explained that the conviction of the farmers in Fuchu city was of interest in using compost from food waste and they confirmed its ability to improve nutrients in their fields. In the next development, this community faced various obstacles and challenges that addressed in this study i.e. risk of odor from composting facilities and unavailable of lunch servers. Thus, the obstacles were solved by technology approach in odor control. First action from researcher of TUAT was tried to manage technology i.e. starting with high quality feed stock, cutting corner for delay of fresh material, mixing between rich nitrogen feedstock and rich carbon feedstock, frequently turning of material position, shifting the smell into drainage-canal, and in active aeration. From the observation of initial characteristics of the composting material in different seasons and monitor of some physical properties indicated that the composting process was not properly and save for environment. However, within those results of ammonia gas concentration, no complain from resident about odor, as no present of odor for their environment.

A community-based management which found in Denpasar, Bali also was a problem finding which is need a recommendation on odor control approach and provide information of development of UA concept. This study has generated some essential information for the waste management situation and potential of UA in Denpasar as UA offers environmental benefits. The local authority could play role in offering technical support and providing markets and could be assisted by either a micro-enterprise or an NGO. It provided convincing evidence of the importance of the usage of wastes as medium to promote UA concept. The result of this work may have contributed to some extent to launching of the UA program in Denpasar, Bali. It also indicated some significant challenges ahead.

Another achievement in odor control was the reduction of ammonia gas by clinoptilolite in composting of leftover-food. This was the second goal and recommendation which achieved in odor control approach for urban agriculture. In particular, this study focused on the correlation between ammonia emissions and temperature at different doses of clinoptilolite in the thermophilic stage, which occurs in the early days of compost and from which ammonia gas was actively discharged. The addition of 134~ 269% clinoptilolite to leftover food composting affected the reduction of ammonia emission and the composting properties especially the pH condition. The results of this study were demonstrated that natural zeolite from Japan “Itaya Zeolite-13” acted as an adsorbent and had great potential for removing ammonia from fermenters composting of leftover food especially in granular form (<4mm).

5.2 Contribution

Based on those results above, those odor control approach is not impossible and management of community-based composting can be applied to another city in Japan, Denpasar or other city in the world. Even if some obstacles can be successfully overcome by good management, innovation, and showing commercial benefit, the social stigmas associated with waste management activities will still have to be overcome. The recent development a collaborative committee of community-based composting in Fuchu city provide a proposal “Recommendations on the basis of the model project” which was issued by the committee and two plans were introduced as i) Create a new model project which focused on kitchen garbage from households, and ii) Apply and use the active recycling devise to the educational activities at schools. This paper also could be the answers and the solutions for UA problems which might be occurred in any city anywhere in near future.

Any effort of composting will face the problem in "to how to mitigate the odor ". Technology approach in odor control and social approach in initiation of the community-based composting in this study will contribute in the future of research and development of waste management in other city in Japan, Denpasar or other city in the world. Research progresses which are developed in this study can be the guidance to continue and resolve issues related to waste management in the city. It places solid waste management at the core of society: its moral values, its social structure, its lifestyle, its economics and politics (Colon and Fawcett, 2006). Especially Denpasar-Bali is the city which just started the development of community-based composting and realized on how the importance of community-based composting to promote UA, which is different from Japan in technical management, policy and supervision.

5.3 Suggestion for Future work

By 2015~ 2020 well over half of the world’s population will be living in urban and peri-urban areas, the majority of them in developing country cities. If present trends hold, the vast majority of these people will be living in irregular settlement, without access to decent food, shelter, water and sanitation (UN-HABITAT, 2004b). The slum population, currently estimated at 1 billion, could rise to 1.5 billion by 2020 (UN-HABITAT, 2004c). Percentage of urban populations living in slums in 2001 ranged from 24 per cent in Oceania to 32 per cent in Latin America and the Caribbean, 42 per cent in Asia and the Pacific, and 61 per cent in Africa. Governments across the world have entered the 21st century with a growing recognition that cities should be given much more attention in development strategies than has been the case in most regions and countries so far. Government as a policy makers are needed to take an action to admit that better resourced and informed more inclusive and comprehensive approaches to UA development. Any resource which is belong to the city should as much as possible be an asset to the local community. It will be as a spearhead in the implementation of UA development and should take a control. If talking UA development then we will see a variety of sources useful to seek the realization of agriculture in urban areas.

Research concerning the development of UA-related issue has not come to the ending point. There is a fundamental need for improved policy and technology interventions in UA investigation, a sector of urban activity that officially remains largely unquantified, if not invisible. Data adequacy, accuracy and reliability can only be bettered if field survey data and official statistics used in scientific reports are scrutinized more often than ever, for both limitations and implication related to the next future of research and development of waste management. New research on UA development should continue to inform strategies and ground interventions to improve urban food security, livehoods, environment quality and overall social justice in our cities.

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