Diversity in food waste recycling technologies in Japan

A technographic approach to three case studies

MSc Thesis Rural Sociology

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Abstract

Food waste recycling is not yet a standard in Japan. The country produces 17 million tonnes of food waste each year. Furthermore, there have not yet been many studies that account for the diversity of food waste recycling technologies in Japan. This MSc thesis research explores socio-technical configurations of food waste recycling through three case studies to identify where the diversity comes from. Through semi-structured interviews and participant observation, this research identifies three crucial factors that shape the differences among the three cases. First, accessibility to fibrous organic matters defines the biophysical aspect of the technology. Second, objective and performance of the people involved make the three technologies distinct from each other. In Case 1, the method was established due to a series of unpredictable events. In Case 2, professional architects designed the ingenious structure of decomposing reactor, which enables the use of highly lignified organic materials for composting. In Case 3, where the degree of certainty in the technology design seems to be the highest, the plant operator's spontaneous decision-making was still premised in the plant design. Third, the study also shows that dominant narratives, people’s attitudes toward the microbial digestion process might influence the biophysical component of technology.

Key words: food waste composting, technography, expert/lay knowledge, science, decomposition

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Abbreviations

MAFF:	Ministry of Agriculture, Forestry and Fisheries
TUA:	Tokyo University of Agriculture

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1. Introduction

1-1. Food waste in Japan

Food waste recycling is not yet a standard in Japan. According to the Ministry of Agriculture Forestry and Fisheries (2011), Japan produces 17 million tonnes of food waste each year (including 6.4 million tonnes of untouched food). In the Japanese waste management system, food waste is divided into two categories based on the source. First, domestic food residue such as kitchen leftovers and spoiled food disposed of from households are categorised as household food waste. Second, industrial food waste consists of ones from various types of entities in the food chain, including restaurants, retailers and food processors. Out of the 17 million tons of total food waste, the Ministry of Agriculture Forestry and Fisheries (2011) estimates that approximately 11 million tonnes are household food waste. The rest of 6 million tonnes are industrial food waste. One reason why household food waste is nearly double industrial food waste is that the food recycling law enacted in 2000 establishes qualitative targets and measures to reduce industrial food waste but does not regulate on household food waste management (Sudou & Hishida, 2010). Thus, the rules and regulations on handling household food residue are left entirely to the municipal waste management policies. The Ministry of Environment (2018) conducted a survey to study how local authorities treat household food waste. The result reveals that out of 1707 municipalities, 84.0 % do not have segregation rules for organic waste. Put differently, most of the domestic food residue in the country is collected, incinerated, and landfilled together with other solid waste.

Composting is one of the effective strategies to treat food waste. It not only minimises organic waste that goes to the incinerator, but also provides economic benefits, improves soil properties through the application of compost, reduces use of chemical fertilisers, and environmental pollution in farmland (Voběrková et al., 2020). Furthermore, composting can play other roles in the food system. Platt et al. (2014) point out that composting resembles the way ecosystems naturally function in a way that “few resources are lost from the system, all matter that was once alive is returned to the earth to support new life […] by supporting local food production, the distance between the food producer and the eater can be narrowed” (p.8).

I consider these additional values that food waste composting offer to society might be appealing to Japanese policymakers.

In May 2021, MAFF launched a medium-long term strategy called “MeaDRI” (Measures for achievement of Decarbonization and Resilience with Innovation). In this document, the ministry announced the goal of a 30% reduction in chemical fertiliser use and a dramatic increase in the size of organic farmland in the country up to 25% of total farmland by 2050 (Ministry of Agriculture Forestry and Fisheries, 2021). Regarding these ambitious goals, food waste composting seems no less than a viable option for the country to optimise resource recovery while substituting agrochemicals.

Composting is defined as “the controlled aerobic biological decomposition of organic matter into a stable, humus-like product called compost. It is essentially the same process as natural decomposition except that it is enhanced and accelerated by mixing organic wastes with other ingredients to optimize microbial growth” (USDA, 2000, p. 15). The microbial growth is regulated by environmental factors such as temperature, pH, moisture content, aeration and some other characteristics (C to N ratio, particle size etc.) of organic waste (Jain et al., 2019).

Plenty of literature on composting already exist in the public domain. Although, as Hettiarachchi et al. (2020) notes, despite how convincing it sounds as a concept, society has not realised the full potential of composting. Hettiarachchi et al. (2020) argues that “the reason behind this discrepancy are more social-related and policy related than engineering or the sciences” (p.5). The authors blame the miscommunication between the agricultural sector as a user of compost and the waste management sector as the source of raw material, which leads to the same disconnection in the research and academia. In other words, the disconnection between agriculture science and policy makers is the underlying reason for sub-optimal practical implementation (Hettiarachchi et al., 2020). This research project, however, intends to contribute to this dialogue from a different angle by studying the existing composting initiative from a sociological perspective. Composting technology to recover food waste has been attracting growing attention worldwide, let alone in Japan. However, there have not been many integrative studies that elucidate precedent food waste composting technologies. Therefore, this lack of academic work was taken as the point of departure for this research project. The following section presents the state of the art, which discusses what is already documented about food waste composting technology.

1-2. Composting and the sciences

The lack of scientific knowledge on the socio-technical interface of food waste composting can be pictured by searching terms such as "food waste" and "composting technology" in Google Scholar, where about 1,220 results are offered (July 2021). It might seem that there is already an adequate number of academic works conducted. However, this number includes many articles that focus solely on a particular component of composting processes. For instance, Palaniveloo et al. (2020) review 136 scientific papers from biological sciences and compile findings on physico-chemical properties and structure of microbial communities during food waste composting. The authors conclude this comprehensive study by stating "the success of composting strongly depends on its microbial community" (p.23). Indeed, there is no doubt that the microbial community itself is one of the decisive factors of success in food waste composting. However, to be more practical and realistic, attention should also be paid to how these microbial activities are treated in the actual composting site. In other words, the paper overall overlooks the human component of composting technology: the use of skills, tools, knowledge, and techniques of people on the composting site.

The asymmetrical accumulation of scientific knowledge on food waste composting is also witnessed in Japan. For instance, Megumiya (2000) conducted a detailed study on the optimal turning frequency of the food waste compost pile to secure oxygen supply during aerobic digestion. Nakasaki (1999) studied the optimal temperature range for activating microbial communities in compost. Uchiyama et al. (2004) measured the nutritional value of food waste compost and its impact on soil fertility and vegetable growth.

By contrast, few social science works explore socio-ethnographic arrangements that affect the implementation and successful continuation of food waste composting technologies. For example, Taira (2019) argues a causal relationship between individual participants' environmental consciousness and community food waste composting initiatives' sustainability. Hatano (2003) summarises the socio-economic impact of small-scale circular composting initiatives in the context of national food security policy.

A similar problem has been encountered by agricultural scientists when transferring validated scientific knowledge into farmers actual practices. Even if agricultural producers adopt such validated knowledge, they typically fail to reproduce the same results on farms as in the carefully controlled environments of research stations. By contrast, some agricultural knowledge and technologies that scientists do not approve of are sometimes taken up and spread amongst farmers in the real world (Glover, 2011). Glover (2011) and Jansen and Vellema (2011) propose a technographic approach as a viable methodology to fill the gap between scientists and the real world. Technographers insist that the dilemma between science and reality arises if a researcher starts with a reductionistic assumptions of the nature of technology and neglect the diversity and dynamism that characterise people's practice in the real world.

In short, the objects of composting studies vary from the identification of microbial communities in the process to the discussion of national waste management policy. However, as far as the socio-ethnographical aspects of the technology are concerned, there is little knowledge built upon the diversity and dynamics that characterise food waste composting in the real world. Therefore, instead of looking at specific components separately, a comprehensive socio-technical analysis of what makes composting a diverse and dynamic practice is needed. Thus, this paper will intend to fill this gap by comparing three case studies in which it will cast some light on the diversity of composting practices with the help of technography as an analytical framework.

2. Conceptual framework

2-1. Technology in society

2-1-1. Nature of technology

As Fernand Braudel (1992, p. 334) wrote "In a way, everything is technology". It is increasingly difficult to identify where the boundary lies between what we call technology and any other things that exist in society (MacKenzie & Wajcman, 1999). Especially after the industrial revolution occurred, the term technology tends to refer to mechanical artefacts in general. However, some sociologists in technology studies might not agree with this narrow definition of technology as physical objects. Many other schools of thought see technology not only as physical objects but also as virtual objects, knowledge, and complex socio-technical systems (Matthewman, 2011).

Fernand Braudel remarked upon the role played by technology in mankind's great revolutionary moments, which is to gradually modify what humanity already knows and do (Matthewman, 2011). For instance, the way sailors determine their position and direction had been completely changed by navigation, and new agricultural machinery had changed the way farmers plough. Matthewman calls these processes "the gradual transformations of tools and techniques which add to the stock of accumulated knowledge" (2011, p. 8). To reflect on these transformational processes in current society, the materiality of tools and techniques might need rethinking and an update from the age of the Industrial Revolution. Sassen (2002) alerts the limitation of defining technology only by referring to fixed, stable and bounded things. She points out that the ongoing transition process predominately interacts with objects in intangible forms such as Information and Communication Technology. Put differently, digitisation is now the main driver of the shift in the materiality of things. It "liquifies" things that have been seen as fixed, immobilised and place-bounded materials. She illustrates this liquefication of things in an example of finance as a mix of digitised/non-digitised activity. The stock market is completely digitised while many financial instruments are in physical forms, including various kinds of real estate and cash. Indeed, technology studies had to expand their horizons to capture the interwoven landscape of actual and virtual objects. Latour (1988) agrees on the limitation of technology as material objects and according to him the term technology is unsatisfactory for many theorists in sociology because it has been "limited for too long to the study of the objects that take form of nuts and bolts"(Latour, 1988, p. 199).

Aside from the hardware/software definition, at least two other definitions are offered: "technology as human activity, and technology as knowledge" (MacKenzie & Wajcman, 1999, p. 3). To illustrate the human activity definition, MacKenzie and Wajcman (1999) introduce steelmaking as a technology. "but this implies that the technology includes what steelworkers *do*, as well as the furnaces they use" (p. 3, emphasis as in original). Knowledge also is arguably a component of technology. Referring to the steelmaking example, steelworkers' know hows to operate furnaces, repairmen's knowledge on overhauling the machinery, and furnace manufacturer's expertise in designing, shapes steelmaking as one coherent technology.

L. Marx (1997) pushes the research frame of socio-technical configurations even wider by bringing the above two definitions and the *technology-as-object* interpretation together. For illustration, L. Marx (1997) introduces railroad as an example. Unlike the earlier stages of the industrial revolution in which inventions of self-standing machines were the main outcome, the later years of the Industrial Revolution saw the development of large-scale, complex socio-technical systems, including the railroad. In addition to the invention of the locomotive, the operation of railroad demands many other things: (1) various kinds of physical facilities (a network of track, rolling stock, stations, bridges, tunnels); (2) a large amount of capital investment from large public/private organisations; (3) technical expertise in engineering and telegraphy; (4) services of numerous skilled workers in the construction, operation and maintenance; (5) institutional changes in society such as standardisation of track gauges and the national system of time zones (Marx, 1997, p. 973). Matthewman (2011) cites L. Marx's example of railroad and frames the technology as "a mode of social organisation" (p.11). In short, the integration of different types of objects, activities, knowledge results in a complex sociotechnical system. In this research, composting is regarded as a socio-technological system ranges from biological digestion processes of organic matter to institutionalisation of organic waste collection.

2-1-2. Science, state and market

Busch (2000) identifies at least three ways for society to solve problems of social order. In his book, Busch elucidates how faith in science, the state, and the market rest on unexamined and erroneous beliefs in society. To do so, he discusses the works of three theorists, Francis Bacon, Thomas Hobbes and Adam Smith and how their thoughts on the role of science are reflected in the modern world.

Francis Bacon, an English philosopher in the later sixteenth century, would have agreed on L. Marx's interpretation of technology as an instrument to organise society. Bacon proposed a world where only natural science can be an ordering mechanism for arriving at truth. Emotion, on the other hand, must be demolished because it is always a source of error. Busch (2000) refers to the history of social change in the United States as an example of Baconianism incorporated in capitalist nations. For the United States, the very beginning of its faith in scientific progress was in the second half of the nineteenth century, when the country saw the rise of large-scale industry empowered by scientific research institutes. Agriculture was the front runner of this shift. In 1887, congress passed the Hatch Act, which provided for necessary agricultural research to be carried by each of the states in collaboration with the United States Department of Agriculture."(I)t was justified on the ground that problems on the farm could be resolved by science" (Busch, 2000, p. 36).

Busch (2000) identifies the origin of the ideology of American technoscience in what he calls Social Darwinism. Social Darwinism "offered a comprehensive world-view, uniting under one generalization everything in nature from protozoa to politics" (Hofstadter, 1955, p. 31). In short, Social Darwinism borrows a linear worldview from Charles Darwin's natural selection theory and argues that competition was the natural ordering mechanism that things from microbes to business enterprises must endure. This logic justified the establishment of the giants in American heavy industry, including philanthropists such as Andrew Carnegie and John D. Rockefeller. These giants are committed to developing technology and organising scientific knowledge. For instance, Rockefeller financed a scientific education programme for American farmers and medical research to eliminate epidemic diseases by creating multiple institutes and organisations.

The belief in science and technology can also be observed in the history of the American education system. School boards and university governing bodies were fragmented into manageable sizes to be run by businessmen who, of course, follow efficient business principles (Callahan, 1962). American scientists, in particular, biological scientists, reconceptualised biology along mechanistic lines. Agricultural scientists in the nineteenth century focused on the manipulation and control of plant traits. Some biologists, financed by philanthropic foundations, even started to control the evolutionary process of organisms (Busch, 2000).

In sum, Busch (2000) argues that the economic and social change in the United States can be characterised by the unquestioned faith in technoscience shared in business enterprises, states, education systems, and science itself. As Rostow (1990) describes by the aeroplane metaphor, social change in the country is supposed to be strongly driven by technological development.

Another example of Baconian spirit can be found in the history of the Green Revolution. The faith in technoscience departed from western countries and expanded to the Third World nations in the post-war period. After the Second World War, most industrialised countries and their population, agriculture, commerce, and industry were devastated while the United States remained intact. Hence, one of the assignments for the country was to figure out how the former colonial nations could become economically and politically independent, being able to feed their population and, most importantly, not become a communist country. This was the Green Revolution's point of departure (Busch, 2000).

The Third World nations were not in the same situation as Europe and Japan, where trained technical personnel already existed. They were short of trained human resources, the population was mostly illiterate, infrastructure was poor and low efficient agriculture tended to be the primary source of income of the nation. As a consequence, many American aid programmes were initiated with a strong emphasis on increasing agricultural productivity. Farmer (1986) notes that the Green Revolution resulted in the use of "high-yielding varieties (HYVs) of cereals, especially dwarf wheats and rices, in association with chemical fertilizers and agro-chemicals, and with controlled water-supply (usually involving irrigation) and new methods of cultivation, including mechanization. All of these together were seen as a package of practices to supersede traditional technology" (pp. 175-176). Transition to science-based industrial farming was seen as a promising way to help those post-colonial countries to overcome hunger, insecurity and poverty.

Busch summarises the criticism for the involvement of scientists in the Green Revolution as follows:

> *Few social or environmental scientists are connected with monitoring the consequences and of the new projects, either in industrialized or developing nations. And, no one has bothered to ask the public if this is indeed what they want. Even farmers have rarely been given an opportunity to participate in determining which biotechnologies, if any, should be created and used. We are all expected to be the passive recipients of these new, undiluted goods* (2000, p. 63).

The summary above also depicts that the Baconian view on technoscience is based on expert knowledge, which tends to ignore the voice of non-expert actors in the socio-technical sphere. The paper will come back to discuss (non)expert knowledge and its impact on technology development in the following subsection.

The Baconian spirit remains in the modern world, nearly four hundred years after his decease. For instance, Wilson (1999) asserts that the social sciences, humanities, psychology and all other academic disciplines should be subsumed under the umbrella of biology as a unified science. He even notes that "all tangible phenomena, from the birth of stars to the workings of social institutions, are based on material processes that are ultimately reducible, however long and tortuous the sequences, to the laws of physics" (Wilson, 1999, p. 291). This reductionist perspective coincides with what Busch (2000) calls scientism, the conviction that the power of science and technology resolves not merely technical but moral problems. Because the conviction is highly pervasive, many who believe in it often do not even notice that they hold such belief.

Another key thinker for Busch (2000) to reflect on the modern science and technology development is Thomas Hobbes. For Hobbes, one of the founders of modern philosophy, the sovereign state is the most powerful organising mechanism to produce social order. Hobbes was concerned about how social order could be maintained in the war of each against all. Shapin and Schaffer (1985) pointed out that Hobbes believed that the truth could only be reached by looking into things produced entirely by humans. Thus, for him, geometry is an ideal way to get to the truth because it is designed based on the principle of producing certain knowledge necessary for universal assent and civil peace. Moreover, Hobbes saw state, also known as Leviathan, as an artificial man who has greater stature and strength than nature. If state was an artificial man, the sovereign was "an artificial soul" (Busch, 2000, p. 17) for Hobbes. This Hobbesian myth of state-induced social order lives on in the modern world, which is named "statism" in Busch (2000).

State takes the shape of many different forms such as totalitarian state, democratic state, capitalist state; and corporations may be seen as a private state. Arguably, no place on earth or no single human has been unaffected by the state. Statism inevitably leads to a world filled with bureaucracy. In a bureaucratic system where the same bureaucrats monitor planning and measure performance, people start to work towards the measurement. For example, in the industry, "production measures based on weight lead to ever heavier products. Trains run empty so as to fulfil the distance measure foreseen by the plan" (Busch, 2000, p. 119). Moreover, in planning, numerous paperwork and signatures are required, which prevent the prosecution of the very plan.

The third key figure in Busch (2000) is Adam Smith who created a foundation for the current fascination with the market in all forms of thoughts and action. He was not much concerned with technology as a tool to reach social order. He instead was convinced that if the state set the right preconditions, the market would serve to produce order. Smith believed that the humanity of human is derived from the interaction with society, and therefore humankind exists only through the social. The mode of production is another crucial concept in Smith's work. Observing the world in which he lived, Smith came across an increasing number of different occupations along with different modes of production – hunting and gathering, farming and industrial society – that have their own division of labour, technologies, and moral sentiments (Busch, 2000). This situation poses substantial problems for Smith's philosophical framework by questioning the origin of the market society of his day. In Smith's theory, the nature of market society is found in barter, which is the source of motivation of men to better their condition by increasing their fortune (Hirschman, 2013). However, a question arises; how could people not living in small communities learn morality? Put differently, would people living in a mass scale industrialised society where face-to-face instructions to others are limited, face moral disorder? Smith answers these questions by proposing the economy, like the state for Hobbes, as a system of power to ensure moral order. Thus, Smith insisted on the need to remove all restrictions from the market. Smith's spirit lives on in the current fascination with the market. All crucial decision making from the individual level to the matter of international politics became subject to the market laws. Business enterprises take over nearly all government functions, from welfare services to postal services.

Bacon, Hobbs and Smith shared an individualistic perspective as a unit of analysis when looking into morality. They submit that the solution to moral disorder is to identify and trust Leviathan, an external force that tells what is good and what is evil. This external force, for Bacon, was science, state for Hobbs and market for Smith (Busch, 2000). Although these three theorists lived in a society different from the current world in many ways, the work of those three should not simply be seen as outmoded and providing utterly useless arguments for the modern world. Given that they are descriptive and prescriptive simultaneously, "they were both materialised in the world and provided rhetorical icons that could be drawn on necessary, even when the names of Bacon, Hobbes and Smith were no longer conscious memories for those drawing on them" (Busch, 2000, p. 30). What Bacon, Hobbs and Smith also agreed on is that the solution to the problem of moral order is found in intellectual activity, not in democratic discourse. It was for Bacon, natural scientists and engineers, bureaucrats for Hobbes, and businessmen for Smith. Because non-experts for them cannot (or should not) execute moral judgement by themselves, and thus that has only to be done by Leviathan.

2-1-3. Expert knowledge and lay knowledge

From the perspective of scientism, professional knowledge is vital for the survival of ordinary citizens in today's highly industrialised society, to which Kleinman (2000) poses a question; what does it mean to trust an expert in the matter of science and technology if complex socio-technical configurations fundamentally shape the outcome of science and engineering? Moreover, he continues, "the matter of trusting expert is further complicated because if the actual practices of and artifacts produced and evaluated by experts are not neutral, neither are the experts themselves" (Kleinman, 2000, p. 102). Finally, of course, experts as individuals or organisations cannot escape being influenced by the network of social relationships that they are surrounded by. Put differently, experts are inevitably part of the most influential institutions in society. Therefore, it is vital to be aware of the social location of professionals who might influence their knowledge production and decision-making.

Another concern of Kleinman (2000) is that experts tend not to be cautious of the partial and fragmented character of their knowledge which is also pointed out by other authors (Busch, 2000 and Haraway, 1988 and Richards, 1989, 1993). These authors are agreed on that the quality of decision making can be improved by incorporating a wider array of knowledge outside highly professional and technical knowledge. Kleinman (2000) highlights the contributions that lay people can make in decision-making by referring to Brown (1992). According to him, lay persons can help decision making for the public good in three ways. First, lay involvement helps identify the many cases of bad science which might be against the public good. Second, lay persons can point out that science has drawbacks and challenge the appropriateness of the technology. Lastly, lay person may yield valuable data that would be unavailable to scientists without their involvement.

Nevertheless, in the field of rural sociology, non-expert knowledge must be treated with great care keeping in mind that how to treat the vagueness exists between science and local knowledge remains to be an unsolved challenge of the field (Jansen, 1998). On one hand, Richards (1993) warns that the term "local knowledge" itself is often misinterpreted by agronomists. He emphasises that "much of indigenous agricultural knowledge system is often nothing of the sort, but rather the product of improvisational capacities called forth by the needs of the moment" (Richards, 1993, p. 62). Jansen (1998), on the other hand, discusses the dualism of official discourse and local knowledge. He refers to the discussion between pro and anti-burning practices in Honduran smallholder agriculture and alarms that the conventional agronomy contrasts science-based agriculture with the traditionality and ignorance of peasant farmers. However, Jansen (1998, p. 129) points out, "if one appraises the wide array of arguments and how they reconsider these every season, producers can hardly be called ignorant". The rest of the conceptual framework will discuss the improvisational capacity of farmers from a technographic approach.

2-2. Technography

2-2-1. Technography: Objective and performance as key concepts

Technography is a methodological framework to study socio-technical configurations that revolve around farming evolved in the Technology and Agrarian Development research group of Wageningen University. Technography elucidates "how teams or networks of farmers, technicians and engineers, amongst other actors, solve problems [...] to facilitate research into the shaping, use and impact of technologies in concrete social situations" (Jansen & Vellema, 2011, p. 169). According to Jansen and Vellema (2011), there are three dimensions in technography, of which the first and the second ones are particularly relevant to this paper. First, the dimension of making is also known as "the study of performance" in Paul Richards's works (1989, 1993) and as the study of "situated action" in Lucy Suchman's works (1987, 2007). These strong emphasises on the technology at the moment of use make technography distinctive and valuable to fill the gap between technology studies and actual farming. The authors above would agree that "it is not only the intrinsic characteristics of tools and artefacts that form the basis for explanation but the process of using them to make something" (Jansen & Vellema, 2011, p. 171).

This technology-in-use perspective could serve as an analytical lens to frame what really is happening in farms far away from research centres. In particular, small-holder farmers' practices are characterised by diverse and dynamic processes of knowledge building and thereby need more attention on "a kind of knowledge that goes directly from practice to practice" (Van der Ploeg, 2002, p. 210). Glover (2011) also draws attention to the "experimental, adaptive, improvisational and inventive agency of farmers" (p.218). In the study, he revealed two contradicting views on System of Rice Intensification between scientists and farmers. On the one hand, from agricultural scientists' perspective, System of Rice Intensification tends to be seen as a kind of standardised technical package (or a set of principles) that is supposed to be installed holistically - even though there is no universal catalogue for essential practices of System of Rice Intensification available. On the other hand, from small-holder farmers perspective, the system is mere one of many ways to cope with uncertainty and contingency that they may face, which results in partial implementation of practices (or principles) recommended by the system. As such, Glover (2011) argues that System of Rice Intensification, in reality, should be understood as the outcome of farmers response to uncertain and risky situations rather than the fulfilment of detailed plan.

Referring to the same logic as Glover (2011) does, Richards (1993) criticises the overuse of "indigenous technical knowledge". He draws on an example of Nigerian farmers compensation for drought. When the Nigerian farmers have insufficient rainfall, and the first planting of sorghum failed, they replant the farm as many different seed mixes as possible to hedge the risk of another failure. It may seem that the farmer planted the designated seed mix to minimise the risk of water shortage. Richards (1993), however, argues that it is not an accurate illustration of what really happened. Farming system researchers tend to regard a particular technology in peasant farming as a result of a fixed, predetermined body of knowledge. However, the truth is, in many cases, the outcome is just a consequence of the farmers improvisation against what had happened to a particular farmer on a particular piece of land in a particular year. Thus, the outcome can only be comprehended by reconstructing the sequence of events in time. For the Nigerian farmers, the layout of mixed crops in a farm is not a farm design based on indigenous technical knowledge, but it is a result of farmers improvisation against contingency (Richards, 1993, p. 67). The existence of "fuzzy logic" (Jansen & Vellema, 2011, p. 174) in farmers' explanation of their farming-related decisions could be explained by the abovementioned reconstruction of time in farmers decision making. In sum, the first dimension of technography is beneficial for understanding smallholder farming, which is intrinsically constrained and contingent in specific agro-ecological and socio-economic settings.

The second dimension of technography is "distributed cognition" (Jansen & Vellema, 2011). It is about bringing different types of knowledge and skills from different actors together and coordinating, mobilising them effectively. Bringing inter-disciplinary knowledge is often seen as a matter of communication. Technography, however, aims to go beyond it. Indeed, Jansen and Vellema (2011) are concerned with such issues as the transmission of task-related information between actors and the exclusion and/or inclusion of actors to perform collective tasks. Just like a sailing ship moves forwards safely even though none of the sailors on board has a complete picture of how the ship operates in his/her mind, this phenomenon of distributed cognition can be witnessed in many socio-technical configurations. This second dimension of technography justifies the importance of participant observation in this research to capture the collective aspect of practices. Details of the methods will be given in the following chapter of the paper.

2-2-2. Avoiding the determinist binary

There are two divisive positions in the sociology of technology from which socio-technical configurations are investigated and theorised. The first one is what is often called technological determinism. This school of thought sees technology as the most substantial source of decisive force, and technology is the factor that shapes social relations and triggers social change (Matthewman, 2011). From this perspective, human activities are a secondary consideration. It seems that technology exists outside social relations. Another argument common in technological determinism is that technology is all about the object. Other elements that other schools of thought consider as part of technology (activity, knowledge, organisation) are perceived as the *effect* of material artefacts by technological determinists. The second one, on the other side of the spectrum, is so-called social constructionism. For them, humans are the protagonist; technology, therefore, is an effect, not a cause. In other words, society defines every aspect of technology. This is why technology, at times, "incorporate competing aesthetic, design, economic, engineering, production and marketing interests" (Matthewman, 2011, p. 19). Consequently, they argue that they need to look at the *politics of artefacts* and discuss *contingency*. At the very end of the spectrum, another worldview referred to as social determinism, where material artefacts are entirely left behind, focuses solely on the social.

Technography attempts to go beyond the determinist dichotomy and avoids such reductionistic interpretations. Jansen and Vellema (2011) quote the concept of "stratified reality" (p.175) from Jansen (2009) to equally recognise nature, technology, and society as the crucial factors. The concept enables researchers to picture bio-physical mechanisms, and social mechanisms operate at different levels of hierarchy. This alternative position can be classified as a post-humanist school in the categorisation of Matthewman (2011). To better understand the post-humanist approach, Michael (2012) gives an example on a socio-technological co-agency revolves around a lazy person in front of the TV (a so-called "couch potato" in popular term). A human watching TV on a sofa can be seen as a hybrid agency of human, sofa, TV and remote controller. All elements are necessary. Without a place to sit back, the person cannot be qualified as a couch potato, also without a remote, the person has to stand up and make his/her way to the TV to control its volume and channels. The remote control, therefore, works as an extension of the human body in a way. Although, the remote cannot take out the human's agency to be a couch potato since he/she still has to use his/her fingers to press buttons. It is also worth noting that the physical design of the TV remote is also part and parcel of the couch potato hybrid. Who possesses or controls the TV remote is also a significant concern because it depicts the power relations in a family. In this sense, the TV remote, as Michael (2012) states, "symbolizes, crystallizes and materially affects these relations" (p.105). To apply a technographic approach to this example, human, sofa, TV remotes work at a different layer of stratification, and they all codetermine a socio-technical configuration of the couch potato.

3. Research design

3-1. Research questions

As discussed in the introduction, there have not yet been many studies in social sciences that account for the diversity of composting technologies in Japan. Thus, this study aims to fill or at least decrease this knowledge gap by examining the interaction of human and material components of composting technology, emphasising performance and roles of expert/lay knowledge in design. To do so, I will look into three case studies in which comparisons of social components (history, narrative and relationship between actors) and technical components (skills, tools, knowledge and techniques) of a local community garden, a large-scale municipal organic waste recycling plant and a science-driven food waste recycling plant are made. Through these three case studies, I intend to answer the following research questions.

The main research question is as follows:

- Why do the differences exist in food waste recycling technologies used in Seseragi community garden, Midori-kan and Tokyo University of Agriculture?

From the main question, the following three sub questions were raised:

- What history precedes the technology in each case?
- Which narratives are dominant and/or less dominant in each case?
- What role does performance play in technology?

3-2. Methods

The following section of the paper describes the methods used in this research and the reasoning for selecting such methods. The data collection for this research project took place from March 18, 2021, to June 2, 2021.

3-2-1. Semi-structured interviews

One of the two main methods of this research is the semi-structured interview. 31 interviews were conducted; 18 were from Case study 1, 10 were from Case study 2, and 3 interviews were from Case study 3. The interview guide varied both in the numbers of questions and in topics depending on the position of the informant in each case study. 27 interviews were conducted in offline settings while 4 interviews were carried out online using ZOOM and Microsoft Teams. The average duration of the interview is 59.4 minutes.

Informants in Case 1 were participants of Seseragi community garden, inventor of soil decomposition method, the landlord of the community garden, a childcare worker from the neighbouring kindergarten, teachers from the neighbouring elementary school, municipality officers, the representative of Non-Profit Organisation which established the community garden, and residents of households from which the community garden collects organic residue. Informants in Case 2 are the manager of the composting plant, machine operators, a former manager of the plant, the CEO of the firm which designed the plant, and local farmers/users of the compost. Informants for the third case study are a soil researcher who designed the system, a CEO of the company which recently took over the plant and the operator of the plant. Participant observation and document analysis complemented the imbalance in data between cases. The snowball sampling method was used to recruit interviewees. Additionally, informal non-structured interviewing was combined with participant observation during the field research to build greater rapport and reveal new interesting topics that might have been overlooked (Bernard, 2017). Yielded data from semi-structured interviews took the form of audio recording and notes taken during the interview.

Jansen and Vellema (2011) draw attention to the challenge that faces technographers in data collection, which is how to avoid focusing too much on individualistic perspectives towards the socio-technical system. As discussed in the conceptual framework, distributed cognition plays a crucial role in many socio-technical systems. Therefore, the research methods in this project should not solely focus on the interviews, which tends to yield data from an individualistic perspective (Bernard, 2017).

3-2-2. Participant observation

Participant observation is the other main research method in this project. Through cautious observation, taking measurements (e.g. time, depth of tillage, the amount and proportion of organic materials) and recording the conversations among labourers, I intended to better understand how the composting technology is performed in a specific way in each case. As Glover (2011) alerts that asking retrospective questions in interviews is not effective in technographic research for learning why the farmers have come to perform such tasks, technographic observation would help by throwing light on the specific (mis)understandings, difficulties and habits that led the practise to be conducted in a particular manner. In Case 1, by participating in the activities taking place at the community garden, I was able to get to know more about the community gardeners' perceptions of composting practices. In Case 2, I participated in the daily operational works at the plant ranging from collecting leaf litter filled bags from the forest to the delivery and application of compost to local vegetable farms. In Case 3, it was not possible to participate in the operation of the plant because the plant had stopped running for relocation. To compensate, I arranged an excursion to the plant in the middle of relocation processes with a verbal explanation by a machine operator. For participant observation, the yielded data took the form of field notes, audio recording, video recording and photograph.

3-2-3. Document study

To gain extra information and reflect on the findings from the other two main research methods, I gathered various documents relevant to the three case studies. Seseragi community garden provided brochures, pictures, and newspaper articles. In addition, I obtained documents from the library located in Hino municipality office, where records of dialogue between the municipality and the community garden are available. Additionally, the community garden owns its blog, where the gardeners update their activities every week. On top of that, the website also provides a pdf version of the monthly magazine they publish. As for Case 2, I obtained a copy of architectural drawings of the plant facilities and other informative publications, including brochures published by Motegi town, articles that the former manager of Midori-kan published in academic journals, municipal policy documents, local history books, and existing academic works on the impact of Midori-kan compost on soil structure. For Case 3, the primary source of documents is scholarly articles written by the TUA researcher. The information from those documents were to complement two methods by bringing detailed technical description and broader socio-political context to the study. This complementary method is also important to avoid focusing excessively on individualistic perspectives.

3-3. Introduction to three case studies

This section is intended to contextualise the three case studies that this research draws on before going into details in the following chapter.

3-3-1. Case 1: Seseragi community garden

Seseragi community garden is located in Arai ward of Hino City, Tokyo. Hino city is one of the middle sized (27.55 km^2) suburban cities located 35 km South-West from the central district of Tokyo. The city is populated by 187,372 residents (Hino city, 2021b). The two rivers that cut right through the city are the rich water resource that makes Hino city well known for rice production. Meanwhile, the city is well connected to other parts of Tokyo by two railways, one monorail and one highway that attracted car manufacturers, heavy metal industry, and food processors to the city's northern area (Hino city, 2019). Arai ward is one of 108 subunits that comprise Hino city. Arai ward consists of 1833 households with 3829 residents (Hino city, 2021a).

Figure 1 Seseragi community garden

Photo retrieved from Hino municipality's website

Seseragi community garden lies next to Asakawa river and is surrounded by the network of irrigation channels from the river to neighbouring rice paddies. The community garden is part of an approx. 2ha of remaining farmland/rice paddy patch in the residential area. The community garden was named after the Japanese word "Seseragi" which means stream or small river. The land size is 3,700 m^2 which consists of two rice paddies, a flower garden, two small handmade shelters/sheds and several vegetable/grain fields. The land is owned and lent by a landlord who cannot continue farming for personal reasons to a civic group "Machi no namagomi ikashitai" (citizen's squad for food waste recycling), who represents the community garden. Expenses in the community garden are covered partially by a membership fee from 162 households from which the community garden collect organic waste (kitchen wastes and garden wastes).

Nevertheless, most of the revenue comes from the municipal subsidy and other private charity foundations. In order to recycle the organic waste they collect from the neighbourhood, the community garden deploys a method called "Tsuchigoto-hakko", literary translated to the soil decomposition method. Using this method, in 2020, the community garden recycled 27,552kg of food residue and 4,071kg of garden waste, meaning 31,623 kg of organic waste in total was recovered from the municipal waste disposal. They produce vegetables, flowers and rice without any agrochemical.

The participants of the community garden primarily reside in Hino city. They work during the regular working days every Tuesday and Thursday in exchange for the harvests. There is no such thing as membership or subscription to benefit from the harvest, but anyone can take the harvested vegetables or flowers as long as they come and contribute to work on the mentioned days. Another critical role that Seseragi community garden plays for the neighbourhood is to provide six neighbouring kindergartens and two primary schools with environmental educations and farming activities. The community garden also collaborates with higher educational institutions. In the last decade, at least three academic works about Seseragi community garden were published in urban planning (Shimpo et al., 2014) and in landscape architecture (Kodama & Yanai, 2013 and Shimbori, 2012).

3-3-2. Case 2: Midori-kan composting plant

Midori-kan is a municipality-owned industrial composting plant run by Motegi town in Tochigi prefecture. The plant was designed by a private composting facility designing firm called Okada manufactory in 2001. After several months of construction, Midori-kan started operation in 2002. The plant consists of seven self-standing facilities which are connected by numerous belt conveyers. First, feedstocks, organic wastes and bulking agents are added to the input hopper equipped with a large mixer underground. Second, the mix is conveyed to the primary composting reactor, where the least fibrous carbons are decomposed in the circular shaped vessel for 25 days. Third, the half-matured compost pile is transported to the second reactor, a windrow composting vessel where remaining high fibrous organic compounds are decomposed within 65 days. Fourth, the full compost is moved to a drying vessel equipped with aerating machinery to ensure the moisture content of the compost is right. The fifth building is for stocking the pile of the final product for selling it directly to local farmers. The sixth building is storage for raw bulking agents. Lastly, the seventh facility is a deodorising reactor which is filled with saw dust and bark. An air duct is connected to the primary reactor aspirates air in the vessel and filter it before release.

Figure 2 Entrance and buildings of Midori-kan

Midori-kan is run by nine machine operators and three desk workers who oversee the administrative work. All workers are employed by Motegi town. The machine operators are mainly 60-70 years old male workers who already retired from their job.

The compost named "Midori-kan compost" is made from two types of main feed stock (food residue and cow manure) and three types of sub feed stock, also known as bulking agents (leaf litter, rice husk and saw dust). Food waste is discarded from 1700 households in the town centre, covering 40% of all households in Motegi town (the other 60% are located in rural areas where most of the organic waste is composted on the spot). Cow manure comes from 5 dairy farmers in Motegi town. All bulking agents are also sourced from natural resources within the town. The compost is used mainly by local rice/vegetable farmers. The price is 5000 yen (37 euro) per 1 t for the residents of Motegi town and 8000 yen (60 euro) per 1 t for those who do not live in the town. In 2008, approximately 60 % of arable farmers in Motegi town used compost from Midori-kan (Japan Livestock Industry Association, 2008). In theory, Midori-kan can process 3,200 t of cow manure and 512 t of food residue a year. Nevertheless, the capacity fluctuates due to weather and the amount of available bulking agents.

3-3-3. Case 3: TUA fertiliser

TUA fertiliser was developed by a soil and plant nutrition researcher, Ituo Goto and his colleagues in Tokyo University of Agriculture. The production site is located on the TUA campus in Tokyo. The plant itself consists of 8 components. Each component is self-standing machinery built by different manufacturers. According to Dr Goto, the individual devices are initially designed for organic waste disposal factories but converted and incorporated into an interface where most components are connected by human labour.

First, collected food waste in a bucket is set on the inversion lift, which brings the content into the compressor in which food residue is compressed and become a fluid-like substance. Second, the substance goes to the dehydration device, which is the heart of this plant. The device was made for dehydrating sewage sludge before landfilling, but it is converted for processing food waste. The device is powered by a boiler located outside the plant. The boiler generates steam from fossil fuel. Steam circulates the pipes attached around the vessel in which the substance is heated up to as much as 80 degrees Celsius. Also, a screw inside the vessel constantly mixes the fluid while it is heated. Third, a belt conveyer carries the dried substance to an oil extractor. After oil is extracted, the substance becomes solid and is taken to the fourth step, in which it is broken down into smaller fragments. In the fifth stage, the fragments are turned into pellets before being sieved and packaged into a sack. In theory, the plant can process 500 t of food waste in a day. However, the actual capacity is limited by the labour-intensive nature of the system premises to 10 hours of operation per day. It is also incredibly important to note that this technology is not composting. Throughout the processes, every step is monitored and regulated by humans. In other words, decomposition, the natural digestion process in which organic matter is broken down by microbes is replaced by artificial devices--- compressor, dehydrator, and oil extractor in this food waste recycling technology. Therefore, the final product is not compost but fertiliser.

Figure 3The dehydrator unit at TUA plant

Photo retrieved from TUA's website

One of the characteristics of this technology is that it does not need any bulking agent nor a large in-vessel/open-air composting site. It was started as part of academic research on food waste recycling technology in urban areas with limited access to fibrous organic matters and a large composting site. The plant's design and its final product, also known as "TUA Midorikun food waste fertiliser" has been patented by Dr Goto and TUA. However, in 2020, The university announced that the plant would be relocated to a private organic waste recycling business in a neighbouring prefecture. All machinery was transported to the company in May 2021. Know hows for the plant operation are to be transmitted to the company who will fully take over the technology by the end of 2021. Before the relocation of the plant, TUA fertiliser used to be supplied to local farmers in Tokyo for free as samples. It will, however, be produced for commercial purposes by the private business after the relocation.

4. Findings

4-1. Case 1: Seseragi community garden

4-1-1. The genesis of the community garden: Relationship between citizens and policy makers

To contextualise the technology used in the community garden, I first touch upon the dynamics of citizen's involvement in Hino city's urban planning and policy making, which can also be seen as the history of Yamaboshi, the Non-Profit Organisation which started Seseragi community garden as part of their environmental activity. "Everything was started from the draft of Hino city master plan in 1995," said Isao Ito, one of the founders and the current representative of Yamaboshi. According to Japanese law, all municipalities in the country, regardless of their size, are obligated to establish and implement a "master plan" for city/town/village planning and keep it updated. In 1992, Hino municipality decided to set up a master plan drafting committee consisting of 15 citizens. Ito was one of these committee members. After three years of discussion in the committee, the draft was handed in the municipality. The paper consisted of 4 chapters - urban planning, green conservation, human welfare, and animal welfare - which were meant to cover a range of issues that Hino city was facing at that time. "To disrupt the bureaucratic nature of municipality's city planning, we wanted to make the draft as creative and comprehensive as possible," said Ito. However, he continued, "We were disappointed when we looked at the master plan finalised by the municipality because they got rid of the creativity and passion we put into the draft".

After several years of discussion between citizens and municipality, they reached an agreement, and the master plan was published. At the same time, a group of committee members, including Ito, established Non-Profit Organisation Yamaboshi. According to Ito, "the role of Yamaboshi was to initiate the realisation of what was envisioned in our draft and pave the way for policy makers through some pilot projects on various societal issues". Yamaboshi's pivotal projects were mainly around environmental issues (restoration of the river side ecosystems, farmland preservation and household waste reduction) and social welfare for people with disabilities (lobbying for improving care houses, job training for the disabled and running organic grocery shops with people with disability, etc.). In 2004, as an environmental and social welfare integrated project, Yamaboshi started a household food waste composting project with 22 households in Arai ward. A driver (Yamaboshi staff) and an employee with disability on mini-truck collected bio-degradable wastes (food residue and garden waste) along specific routes within Arai ward every Tuesday and Thursday. The collected organic waste was brought to a neighbouring dairy farm where it was mixed with cow manure and composted for a couple of months.

AA was another member of the Hino municipal master plan drafting committee together with her deceased husband. She and her husband met when they were both PhD candidates in agricultural sciences at Hokkaido University. In 1993, after getting married, they moved to Arai ward of Hino City, where they participated in various activist movements, including master plan drafting and Yamaboshi's farmland preservation project. After several months of working on a small plot next to her house, AA was offered to use approximately 1000 m^2 sized farmland by a neighbouring old rice farmer. "in the beginning, surrounding farmers were looking at my husband and me with suspicious eyes. But after several years of hard work and accumulation of small communications, I gained trust in the neighbourhood, and many aged landlords asked me to take care of their farmland," said AA. Ageing farming population is one of the largest problems that the municipality faces today. Thus, in around 2002, AA decided to take over these aged farmer's farmlands (approx. 1 ha in total) with Yamaboshi's employees with disabilities. In this farm, the food waste-cow manure mixed compost produced by Yamaboshi was applied to produce organic vegetables, grains, and rice. However, as of 2008, the dairy farmer who provided cow manure and the composting site could no longer cooperate with the composting project for personal reasons. Furthermore, in the same year, Yamaboshi decided to retreat from the organic waste recycling project due to financial difficulties. ST, the leader of Seseragi community garden, used to work for Yamaboshi as a full-time employee. However, when the organisation retreated from the composting project, she decided to quit the job and take over the project on her own. This was the very beginning of the Seseragi community garden.

4-1-2. Soil decomposition method: Objective and how its performed

ST said, "at that moment, our waste-collecting route covered 150 households in Arai, and the number was still growing. I didn't want to give up the circular system we were building just because Yamaboshi gave up". She continued, "The biggest problem was the absence of composting facility. Thus, on-site composting seems the best way to go. [...] At the same time, I also had to think about how to manage the farmland. I cannot make it a commercial farm because I am not the landlord. We were just borrowing the piece of land from aged local farmers. After a while, I came up with the idea of converting the farm to a community garden. That way, I would have sufficient workforce from the local population, which I think would be the most sustainable".

YD is an organic farmer, entrepreneur and, former extension service officer of Nagasaki prefecture, 1,000 km away from Tokyo. In the late 1990s, he started propagating a type of organic farming called Tsuchigoto-hakko, which translates to the "soil decomposition" method. He said, "I didn't invent the method. All I did is that I just coined the name, Tsuchigoto-hakko. The method itself existed from ancient times among farmers. Farmers didn't make compost back then. They just buried food residue in the soil. Even in the modern era, Japanese farmers dig a ditch and throw food waste into it." According to YD, "soil decomposition method minimises the loss of calories that organic residue contains. By incorporating raw organic material into the soil, you can directly feed microbes in the soil. Suppose you apply already composted organic material into the soil. In that case, it does not affect the soil ecosystem as much because calories are already consumed during off-site decomposition processes". In other words of YD, "the main aim of the soil decomposition method is to amplify as much soil microbes as possible by making compost on the spot".

The first contact of YD and Seseragi community garden was a personal connection between YD and ST established through the national food waste recycling conference in 2004. Since then, some members of Seseragi community garden have been practising soil decomposition in a small plot with YD's supervision. As such, in 2008, when the manure from dairy farmer became no longer available, the community garden quickly decided to switch to the soil decomposition method to process organic waste collected from 150 households.

In short, the introduction of the soil decomposition method in Seseragi community garden can be seen as the consequence of a series of spontaneous events and citizens' improvisational responses. First, an Non-Profit Organisation, Yamaboshi started a food waste recycling initiative with off-site composting facilities to realise a municipal master plan. Second, AA started borrowing farmlands from old landlords in Arai ward and gradually expanded the land to approx. 1 ha. Third, ST got to know YD and his soil decomposition method by chance. Fourth, the off-site composting facilities became unavailable, so they had to process food waste on-site.

During the 11 participant observations carried out in March, May, and June 2021, the author participated in a variety of works carried out in the community garden. The author also joined their organic waste collection work one time. On average, 19 people showed up to participate in farm work on a regular working day. Since the community garden grows more than 20 different types of crops simultaneously, there are many different types of tasks that they want to accomplish in a day. Nevertheless, they most prioritise collecting and broadcasting food waste. For instance, when the weather forecast said it would be heavy rain, the regular working day was called off a day before. However, the collection of food waste and broadcasting were carried on and seven people still showed up to carry out broadcasting of organic waste to the farm.

Figure 4 Broadcasting of food waste

The organic waste-collecting team, consisting of one driver and one collector, departs the community garden around 8 am on Tuesdays and Wednesdays. They usually come back around 10.30 am with approx. 300 kg of food residue loaded in the back of the truck. When the collecting team is on their way, other people prepare a plot for broadcasting and incorporation of food waste. The designated plot for one application is sized approx. 25m^2. The farm is divided into 55 of these small plots. One cycle of the rotation on these plots lasts seven months. The preparation starts with peeling off plastic sheets installed in advance to protect the soil from rain and make sure it is dry. Then, some other people prepare tools and materials they need, such as rakes, a gardening tiller, a bucket of rice bran bokashi and 5-7 kg of leaf litter in plastic bags.

"Leaf litter absorbs the excessive moisture content of food residue and prevents putrefaction," said SK, a 76-year-old male participant who plays a leading role in organic waste application work in the community garden. When one of the farm workers spots the arrival of the collecting team, he/she notifies others, so they pause their work and come to help. Depending on the amount of the collected food waste and the condition of the plot, 4 to 6 people quickly gather around the truck and drag down the pile using rakes. Once the pile is on the ground, they spread it evenly within the plot and level the surface. After that, rice bran bokashi is applied until the surface is covered. Next, the layer of soil, food waste, and rice bran bokashi is mixed by the tiller to ensure the aeration and to prevent purification. Then the mixture is covered with a layer of leaf litter and plastic sheets on top of all. The plastic sheet is installed and fixed with dozens of iron pegs to protect the plot from wild animals such as racoons and crows. Finally, they place another plastic sheet on the following designated plot. The same plot is mixed after three days, one week, two weeks and one month. It takes five times mixing before bed making.

Figure 5 Mixing food waste and rice bran bokashi into bed

Figure 6 The map of the community garden divided into 55 designated plots for composting

4-1-3. The dominant narrative

When the informants were asked questions about the uniqueness of the soil decomposition method they perform in the community garden and how it is different or the same compared to when they started in 2008, they tended to talk about how they learned from failures, errors and how they rectified these. "We are just a group of lay persons. [...] I was a bit concerned that you choose us as your case study because here, we do not have any scientific evidence or quantitative data set on our way of food waste recycling. [...] After all, it is us humans that make things happen, so we should learn the art (could be translated to skill or technique in this context) by doing," said SK. Indeed, out of eleven interviewees, three retired from office work, five are housewives, one is a hairdresser, one electrical engineer, and only one person has working experience in farming as a professional occupation.

HY, another male participant who is called a "technical advisor" of the community garden, said, "in my opinion, you should never count upon scientific books or textbooks when it comes to farming because their knowledge or techniques is useless in different places from where they study. The best way to learn to farm is to ask a local farmer or learn by yourself on the go". HY is so strongly opinionated that his opinion might not represent the whole. However, a lot of other interviewees agreed on the concept of learning by doing. During the interview, KA, one of the community garden participants in charge of using machinery such as tiller and mower, said, “many things have changed since I started coming here (ten years ago). For example, we did not use the leaf litter for soil decomposition, but instead, we used to cover the surface of organic matters with the garden waste we collect from households and kitchen waste. However, we noticed that it was inefficient to uncover the garden waste every time before using the tiller; otherwise, it is stuck with the tiller's blades. As such, we substituted garden waste with leaf litter which can be mixed with the tiller with no problem”. In sum, the most dominant narrative observed during participant observation and interview can be named as the “learning on the go” narrative.

4-2. Case 2: Midori-kan composting plant in Motegi town

4-2-1. The genesis: Why Midori-kan was needed in Motegi town

Motegi town is located in Tochigi prefecture, just outside the greater Tokyo area. The town is known for Twin Ring Motegi, one of the largest motor sport race tracks in the country. The land area of the town is 172,69 km^2. 64% of the land surface is covered by forest and mountains, 12% is farmland, 3% is residential area. The population of the town is 12,118 in 2020 (*Summary of agriculture in Motegi town*, 2020). The town has been facing a decrease in population since the 1980s when the post war economic boom came to an end in Japan. Since the town is situated in the middle of a mountainous district, farmers have been confronted by sub-optimal conditions for agriculture such as steep slopes and limited access to the market. Thus, rice farming, which requires flat land, is not suitable for a large part of the town (Japan Livestock Industry Association, 2008). Historically, tobacco cultivation has been the primary income source for farmers in the town. According to Motegi town (1995), tobacco leaf production peaked in the 1940s before the tobacco industry in Japan was struck by the devastation of the world war. After the war, the production gradually recovered until the 1960s when the young population started to migrate to the greater Tokyo area in search of better job opportunities and economic prosperity. One of the most extensive tobacco manufactories in the country operated a factory in Motegi town from 1904 until 1977, sourcing locally-produced tobacco leaves. After the golden era, the number of tobacco farmers gradually decreased in the last several decades due to the national government's tobacco production adjustment policy. Today, Shiitake mushroom, konjac and strawberry production are the drivers of the town's agriculture, whereas tobacco farming accounts for only a few per cent of agricultural production (*Summary of agriculture in Motegi town*, 2020).

The abundant forest is a rich pool of organic resources like leaf litter. Historically, tobacco farmers went into the forest and gathered leaf litter to make compost and seedlings in December and January. For composting, gathered leaf litter was mixed with human or animal excrement, stomped and piled for a couple of months until it adequately decomposed. Leaf litter was also used for the seedling bed. It was mixed and piled with soil inside the wooden frame and is directly seeded after a couple of months in spring (Motegi town, 1995).

Now, Midori-kan distributes refillable plastic bags (a bag can contain 20 kg of leaf litter) to local farmers and purchases leaf litter filled bags for 400 yen per bag (3 euros). In 2020, local farmers brought 200 t (10,000 bags) of leaf litter in total. Yano, the former manager of Midori-kan, said, "We took advantage of local tobacco farmers' indigenous custom for gathering leaf litter. […] we are happy because leaf litter is necessary for good compost, and local farmers are also happy because they can make pocket money in wintertime".

4-2-2. Roles of expert and non-expert: Design of the plant and performance of operators

The initial plan of Midori-kan was first brought about in the town's policy document in 2001. As already mentioned in the previous case, according to Japanese law, every single municipality has to establish a "municipal master plan" and update it regularly. Motegi town renewed its master plan in 2001. In Section 1 of Chapter 4 of the master plan named "Shining nature", the blueprint for a composting plant appeared for the first time. Moreover, the same section already states that "the new composting plant shall make good use of our town's abundant organic resources such as food residue, animal manures, leaf litter and timber to promote organic farming, forest conservation and food waste recycling in the town". According to Yano, all he was told when he was assigned to the manager of the Midori-kan construction project was to build a composting plant that uses five different organic matters mentioned in the master plan. He and his colleagues had to start everything else from scratch.

The design of Midori-kan's facilities was accomplished by Okada manufactory, a relatively small designing firm with 30 employees specialising in industrial organic waste composting plants. Suzuki, CEO of Okada manufactory, said that what makes the design of Midori-kan special is the novel structure of the primary decomposition reactor. The reactor is circularly formed with a twenty-metre diameter and three-metre depths at the deepest point. Inside the vessel, two metal arms stretch from the centre of the circle to the outside. Some say the reactor just looks like a record player. The mix of organic materials are delivered to the primary reactor through belt conveyors and broadcasted from the end of the longer arm. The shorter arm is equipped with a two-metre-long screw that keeps turning the compost pile to ensure aeration and gradually convey the pile to a hole in the centre, leading to the belt conveyer connected to the second reactor. Compared to windrow composting containers, the circular-shaped reactor can accommodate the same volume of material in a relatively smaller space, minimising the heat loss during the decomposition process. It also means that the circular reactor needs smaller deodorising equipment compared to other conventional windrow designs. Yano said, "the ingenious design of the primary reactor is the heart of Midori-kan. And this is the reason why we (municipality) liked Okada manufactory's design at first sight".

Figure 7 Inside the primary decomposition reactor

Moreover, Okada manufactory's design contributes to the unique quality of Midori-kan compost. As mentioned earlier, the plant composts five different types of organic matter at the same time. Therefore, it was a crucial task for the architects to take account of differences in the degradability of organic matters. For example, food waste and leaf litter, the least fibrous matters can be fully decomposed in approximately one week, whereas the most lignified matters, such as rice husk and sow dust, take more than two months (Adhikari et al., 2008). Thus, Midori-kan is designed to be able to adjust the length of composting by changing machine settings. In other words, the architects left room for manoeuvre in the design so the users can adapt it out of necessity. As a result, Midori-kan compost is believed to rarely cause any problems in the soil because of undegraded organic matters. KI, a local vegetable farmer in the town and a long-time user of the compost, said, "usually, I do not want to use compost made from sawdust or rice husk because it is most likely to do bad things to the soil. Nevertheless, Midori-kan compost is an exception. Their compost is fully matured. It's black, soft and very beneficial for the soil."

Figure 8 A pile of final product, Midori-kan compost

The plant workers are requested to cope with the contingency they face every day. For instance, during interviews and participant observation, the workers repeatedly told that the proportion of organic materials they add in the hopper has to be finetuned depending on humidity, temperature and quality of organic material in the day. It is also worth noting that almost all of the workers are retired (except one person) and hired by the town as temporary employers. The oldest person has been working in the plant for 15 years. In addition, 5 of them previously worked for the same camera manufactory located in a neighbouring town. These plant workers' experiences influence composting at Midori-kan. For instance, one of the workers who worked in the camera manufactory as an electrical engineer is now in charge of repairing electric systems of the plant. "we must be able to perform maintenance works by ourselves. If something goes wrong with electric systems, it takes a long time for specialists to come over and repair it because we are in a remote place. [...] I am a former electrician, so I can do professional works. But it would not be easy to teach my knowhow to others and let them do the same thing," he said during the interview.

The plant workers are well coordinated in many ways. At 8 o'clock every morning, a briefing is organised, which all machine operators and office workers on shift must attend. In the meeting, the manager explains the tasks of the day, and operators discuss the amount of feedstock they will add based on the condition of the compost pile in reactors (they do it by guessing moisture content from the colour and smell of the pile). For instance, one morning, a machine operator reported, "this morning, because of the heavy rain last night, the compost pile looks very wet. So, I propose we put 1.5 times of leaf litter, turn on the blower in the second reactor and open the curtain on the primary reactor". Operators usually work individually, but all operators again gather at lunch time (12-13) and teatime (15.00-15.30). Important information is exchanged over tea and snacks during this time. For example, if one of the machineries is not in order or the pile looks too wet or dry, the remedy is discussed during casual conversations during the break. OZ, a machine operator, said, "We always talk to each other because six eyes and three brains work better than two eyes and one brain does, don't you think?". He continued, "but the most important thing is the experience that each of us has. We have learned from many errors".

4-2-3. The dominant narrative: From farmers to municipal officers

Nagashima, the current plant manager, said, "Our boss (mayor of the town) always says that *Midori-kan is not run by operators nor office workers in the plant. Microorganisms run it*. It is a bit sad to hear that as manager, but I totally agree with him. Our job is to help them (microorganisms) work efficiently. To do so, we make sure they are healthy and comfortable by monitoring temperature, moisture content, and C: N ratio". Nagashima added, "We appreciate the design of this plant by Okada manufactory. We like how simple the structure is. Other municipal compost plants are more complicated than it is here. For example, some use gas heaters to speed up decomposition or chemicals for deodorizing. Here we don't use heaters or chemicals at all. By providing them with the right condition, microbes can warm up on their own, even in winter. As for deodorizing, we use sawdust and bark instead of chemicals. [...] We just let microorganisms work on their own".

Among workers in Midori-kan, leaf litter is seen as a source of "indigenous microorganisms". In general, leaf litter is used for composting as a carbon source, also known as a bulking agent (Adhikari et al., 2008). In Midori-kan, however, people believe that leaf litter from the local forest is an incredibly beneficial addition for composting because it contains many indigenous microbes such as lactic acid bacteria and fungi. Although all feedstock is supposed to go in the input hopper, plant workers ignore the design and directly add leaf litter into the second reactor when the pile needs more active microbes to generate sufficient heat.

Figure 9 Leaf litter gathered by local farmers

The same kind of narrative is shared by the architects who designed the plant. Suzuki, the current CEO of Okada manufactory, was the manager of Midori-kan's designing project. During the interview he repeated how important he thinks it is for a composting plant to maintain aerobic conditions during decomposition. "Humans do not do composting, but microorganisms do it. Our job as architects is to design a house in which microorganisms can comfortably live. They need oxygen to live just like humans do," said Suzuki. He also referred to simplicity in their design. "We have been exporting our technologies to the developing countries such as Philippines, Malaysia and Vietnam. Other Japanese companies tried to export organic recycling plants to the Philippines, but they failed in the end. Their technologies were too complicated [...] what I meant by complicated is things like methane gas generator. [...] We architects must not forget that it is challenging for laypeople to handle living organisms. Plant design must be therefore simple enough for them to get used to". In sum, the most dominant narrative found in the interviews with the plant workers, the current/the former managers, and the architects can be named as the "let microorganisms work" narrative.

4-3. Case 3: TUA fertiliser

4-3-1. The genesis: How the technology was developed

Development of TUA fertiliser started in 1994 when a municipality in Kanagawa prefecture asked Dr Goto to review a new organic fertiliser developed by the municipality. The prototype fertiliser developed by the municipality was made from commercial food residues discarded from within the municipality. The recipe first dehydrated food scraps by a dryer and then added water to control moisture content around 70 per cent. After five years of field experiment by TUA researchers in collaboration with local farmers, the quality of the fertiliser and its positive impact on plant growth were approved. However, there was room for improvement, including odour emission and inefficient use of energy by adding water to the artificially dried materials. Thus, the researchers started experimenting on organic fertiliser production from dried food scraps with as little energy as possible. Thus, it was, according to Dr Goto, the point of departure for the TUA fertiliser.

Figure 10 final product of TUA fertiliser

Photo retrieved from TUA's website

After several years of research and development, a prototype came about. In order to decrease C: N ratio of dried food residue to as low as 10, urea was added to the mixture (approx. 3% of the dry mass). The reason why controlling C: N ratio is so crucial is that if organic matter with high carbon content is added to soil, soil organisms consume nitrogen, making N unavailable to the plant, resulting in nitrogen deficiency. If nitrogen deficiency occurs, the plant root cannot take up sufficient nitrogen, and the plant would be suffered from the disorder. Normally, cattle manure is prone to cause nitrogen deficiency if it contains 20 times more carbon than nitrogen. However, food waste compost has a higher risk of nitrogen deficiency because of its readily degradable carbon composition. In other words, food scraps from human consumption, such as vegetables and carbohydrates, consist of organic carbons, which can be easily degraded by soil organisms (Palaniveloo et al., 2020). Dr Goto and his team managed to resolve this problem by manually adding nitrogen to the compound. In 2005, the team applied for MAFF fertiliser registration which is necessary to manufacture fertiliser for commercial purposes, but it was rejected because food residue was not authorised as a fertiliser according to Japanese law. Thus, the team had to reconsider the recipe. In 2007 they started to produce a new version of fertiliser with an oil extraction method in which carbon content is cut by extracting oil from the dried compound under high pressure and heat. This is how TUA fertiliser is produced until now.

4-3-2. The performance of a machine operator

Over the last 19 years, the plant has been operated by only one operator, ON, whom TUA initially employed as a general caretaker on campus. He said that when the plant started running in 2002, he and another caretaker were given basic training by a consultant agency in the first couple of months. However, the other caretaker left TUA after a couple of months. As a result, ON has been taking care of entire processes on his own, although the plant was designed to be run by two or more workers.

At the beginning of processes, the segregation of organic residues that are added to the compressor requires experience and improvisation. ON said, “the most important part is to get the balance right. It defines the quality of the end product. Moreover, the proportion of vegetables and carbohydrates influences the probability of machine breakdown [...] if you put too many carbohydrates or too many oily substances into the compressor, the compound is prone to block pipes between the compressor and the dryer, in that case, I have to call the technician, and it takes a whole day to unblock. It is the same as a human being. It would help if you ate a well-balanced diet. Too much oil or carbohydrates makes you sick”. In 19 years of experience, ON learned by heart the right proportion of vegetable and carbohydrate from many failures. “One time, the dryer nearly exploded because I put too many carbohydrates into the machine,” he said.

His first job each day is to separate collected food residues into three types based on compositions: vegetables, carbohydrates, and meat/fish. After the separation, he decides how much of each substance is to be added to the compressor. He continued, “I have never been taught such thing as the right proportion. Moreover, there is no handbook for it. [...] I had to figure it all out by myself. After all, there is no fixed proportion because the composition of food waste is never the same”. In other words, the smooth operation of the plant and quality of the end product largely rely on the improvisational decision making of an individual machine operator.

4-3-3. The dominant narrative: The power of science

The dominant narrative identified in the third case study is the “science as a solution” narrative. Although the number of interviews for Case study 3 was limited, this narrative was observed in two out of three interviews. First, Dr Goto, an agricultural scientist and father of TUA fertiliser, repeatedly referred to the importance of farming practices based on soil science principles. In fact, he established the “national soil association for farmers” in 1989. The organisation has been providing associated farmers with regular soil tests, technical advice by agronomists upon requests, and educational content to help the farmers better understand soil health.

During the interview, Dr Goto said, “Of course, farmers' insights and experiences are very important and essential components of farming. On the other hand, agricultural scientists can guide farmers by validating these insights and experiences of farmers because farmers misunderstand what is happening in their farm”. Furthermore, during the interview, Dr Goto stated that he was strongly against any kind of farming practices in Japan that is not based on scientific evidence. He mentioned the use of “Effective Microorganisms” (Higa & Wididana, 1991) in food waste composting as an example of how scientifically illiterate farmers could go wrong and end up with unproductive practices. Dr Goto’s stance on farming is clearly based on the findings from soil and plant sciences. The design of TUA fertiliser technology reflects this science-oriented view of Dr Goto.

As for the development of TUA fertiliser, this narrative can be summarised in the form of a question: how can we control the variables (C:N ratio, temperature, moisture content and oil content) by the power of science? Microbial decomposition is not used in the processes at all, and instead, the variables were regularly monitored and finetuned by the scientists. In other words, their approach to food waste recycling replaces the natural phenomenon regulated by microbial digestion processes with artificial dehydrating and chemical composition adjustment procedures. This mindset seems to coincide with a deep-rooted faith in natural science by Baconian and its offspring in the modern world (Busch, 2000).

Nevertheless, it has to be noted that this narrative cannot be found in the interview with ON, the plant operator. As discussed in the previous subsection, he orients himself to more experience-based knowledge acquirement. In fact, the plant consists of 8 pieces of machinery with different functions, and each is self-standing, meaning that humans have to take care of the interface. There is a contradiction between expert knowledge and lay knowledge. In other words, whereas the planning phase of the technology was predominantly regulated by the scientific expertise of Dr Goto and his colleagues in TUA, the technology is chiefly dependent upon skills, techniques and knowledge of a scientifically illiterate individual in the moment of use. Put differently, human improvisational capacity was premised in the design of TUA fertiliser technology.

5. Discussion

5-1. Why are different food waste recycling technologies used in the three cases?

Quoting "the notion of stratification" (Jansen, 2009 and Jansen & Vellema, 2011) from farming system studies, I argue that the composting technology needs to be considered as "the result of a complex set of diverse mechanisms from different strata (the physical, the biological, the social and so on)" (Jansen, 2009, p. 182). To avoid falling into the deterministic binary discussed in the conceptual framework, this research intends to cast neither material strata nor social strata as the leading actor. Technography, on which the research strategy of this project is based, instead proposes a position that views that material, social and any other possible dimensions of technology may matter and interact to co-determine outcomes (Jansen & Vellema, 2011). Thus, in the following part of the paper, biophysical factors and socio-ethnographic factors in the three case studies are explored accordingly.

First, in the bio-physical strata, accessibility of fibrous organic materials and the size of the affordable composting site affect the development of different composting technologies. In Seseragi community garden, the only bulking agent available for them was leaf litter since a neighbouring dairy farmer who had been supplying straw - mixed with cow manure – quitted. Furthermore, they could not afford a large piece of land to be allocated to on-site compost production or an adequate financial investment to build a new off-site composting facility. As such, the soil decomposition method was established as a solution that does not require as many bulking agents as normal on-site composting does, nor does any composting facilities.

By contrast, in the second case study, Motegi town has two remarkable advantages. First, the town has abundant natural resources from the forest (leaf litter and sawdust) and farming (cow manure, rice husk), on which both the design and daily operations of the plant hinge. Second, there was already a composting centre established by a tobacco manufacturer in the exact location until the 1990s, which the municipality purchased and reused partially to build Midori-kan.

In the third case, processing food waste without a single bulking agent is the biggest novelty of TUA fertiliser technology. The technology was developed to enable food waste recycling in urban areas where conventional composting is impossible due to the scarcity of fibrous organic material. Furthermore, the technology is developed to overcome the limited availability of land for composting sites. In sum, the availability of different fibrous organic materials and the size of the available composting site led to differences in the composting technologies.

Second, in the social strata, the objective and performance of the people involved make three composting technologies different from each other. As discussed above, on the one hand, the soil decomposition method was implemented in Seseragi community garden as a response to the closure of an off-site composting site which was completely unpredictable. But, on the other hand, the method was introduced with the intention of providing children with environmental education. The principal of Hino 4th public kindergarten, one of the kindergartens collaborating with Seseragi community garden, told during the interview that they incorporate regular visits to the community into the curriculum because of the soil decomposition method's impact on children's environmental consciousness. According to the principal, some parents told her that their child constantly tells how mysterious and fascinating the decomposition process is. "By letting children experience soil decomposition in Seseragi community garden, we hope children develop their curiosity in agroecology and environmentally friendly farming," said the principal.

In Midori-kan, the objective shared in the municipality office was to recycle as many different types of organic material as possible to stimulate environmentally friendly agriculture in the town. Furthermore, the diversity in feedstock was especially important for Midori-kan to be part of the town's public waste management. According to Yano, the former plant manager, by incorporating other organic wastes aside from food waste and cow manure, the municipality wanted to make Midori-kan beneficial for as many people in the town as possible. In fact, rice farmers now do not have to be worried about the disposal of rice husks in the harvest season because a truck from Midori-kan comes to them and sweep up all the rice husk within a day after the harvest. Forest owners are now relieved of cleaning up the remnants of regular maintenance works. They just need to call Midori-kan to come to collect prunings and timbers from their land.

Nevertheless, as noted in the findings, a wide range of activities in the plant operation is covered by the knowledge, skills and improvisational capacities of 9 veteran machine operators. It is also important to stress that the design of the plant co-enables such a flexibility in the machine operator's performance. Richards (1989) describes the importance of "performance" using musicians as an example. Musical performers plan many things before they play--- how to phrase a melody, coordinate entrances, pace different part of a piece. However, many of these planning may go wrong on the night. Therefore, a good musician needs other skills – how to handle nerves, how not to panic, and recover from a mistake. These are the capacity to keep going and avoid complete breakdown on the spot. Midori-kan's composting reactors were designed to be flexible on the spot. Duration of decomposition and intensity of aeration can be manually adjusted allowing the operators to change those settings depending on condition of the moment.

The TUA fertiliser technology is also on the premise that there is an operator who has adequate knowledge and techniques to perform various essential works to complement the interface of the stand-alone devices—for example, figuring out the right proportion of feedstocks and ensuring that there is a proper amount of oil content and moisture content in the drying machine requires at least several years of working experience in the plant, according to the plant worker.

5-2. Who controls decomposition – microbes, humans or science?

Given that this research assumes composting as a stratified social bio-physical system, the microbial decomposition processes can be seen as the core element of the bio-physical side of the system. Therefore, it might be worth examining how social strata intervene biological strata by reflecting on how the work of microorganisms in decomposition is treated by humans differently in three cases. To do so, the following part of the paper compares narratives in each case. In short, the degree of human intervention in the microbial digestion process seems strongest in TUA fertiliser and weakest in Seseragi community garden.

In Seseragi community garden, people tend to use words such as “trial and error” and “laypeople” to explain the uniqueness of the whole initiative, growing organic vegetables from directly incorporated food residue in pre-seeded bed. Furthermore, the leader of the community garden repeatedly told during the interview that she sees Seseragi community garden as “an arena of experimentation”. This narrative is reflected in how community gardeners treat soil microbes during decomposition. KK, one of those actively engaged in composting related activities in the community garden, said, “Here, people do not fully understand the differences between aerobic and anaerobic digestion. [...] Our method is based on continuous processes of failure and rectification. However, in my opinion, sunlight, aeration and breeze are the most decisive factors in the soil decomposition method. [...] aeration and breeze are different things. Aeration of soil is important to keep the aerobic microbes active. Whereas, breeze is important to ensure the adequate level of moisture content in composting pile”. In Midori-kan, the decomposition process is monitored by more systematic and quantitative means. A third-party company regularly checks a number of indices including temperature and moisture content of the pile (even though the plant workers perceive a change in vital indicators by their eyes, hands and nose).

As discussed in the findings, the dominant narrative in Midori-kan can be named as the “let microorganisms work” narrative. It might seem in line with what was witnessed in Seseragi community garden regarding the faithful attitudes toward soil microbes and their role in food waste composting. However, there are differences in the involvement of expert knowledge in handling microbial activities. In Midori-kan, the design of the plant was conducted by specialists. On top of that, the plant collaborates with several research institutions and laboratories to understand what is happening during the decomposition processes in the reactors. In fact, a collaborative research project is now being conducted to identify microbial communities involved in the decomposition of fibrous organic matters occurring in the second reactor.

By contrast to the narratives found in Seseragi community garden and Midori-kan, the dominant narrative observed in the TUA food waste recycling initiative coincides with what Busch (2000) calls scientism. The microbial decomposition of organic matter emits odour and causes a problem of flies. Thus, they decided to solve these problems by approaching food waste recycling from a scientific-oriented perspective. From the scientists’ worldview, the essence of composting can be reduced into two functions: reducing C: N ratio by taking advantage of bacteria which break down organic substances into inorganic matter such as carbon dioxide, sugar or water; reducing the bulk density of the pile, again, by taking advantage of bacteria. TUA fertiliser technology substitutes science and artefacts for microbial activities.

In sum, dominant narratives present in Seseragi community garden and Midori-kan contradict the one found in TUA. In the first two case studies, informants often referred to microbes as the main protagonist in the process. Although it seemed they do not have a complete picture of the aerobic decomposition process, community gardeners, machine operators, former/current Midori-kan managers, the mayor of Motegi town and local farmers share the same narrative that composting is the art of microorganisms. Thus, humans must treat them properly by regulating the temperature and moisture content in a pile. This trust in the work of microorganisms is intentionally removed in the technology developed by the researchers in TUA.

To put the discussion above in the context of Busch (2000), the rest of this subsection will examine spectres of the three key thinkers—Bacon, Hobbes, and Smith and remnants of their ideas found in the case studies. First, as discussed already, the influence of Baconian spirit, or scientism— the belief that the power of science and technology would permit humans to build an ideal society was observed in Case 3 in the form of strong faith that soil sciences should be the driver of technology change in agriculture. By contrast, this faithful attitude to technoscience as a solution to food waste disposal seems to be firmly rejected by the people involved in Seseragi community garden. The community garden is oriented toward solving the food waste problem by what Busch (2000) names "networks of democracy", which also is related to the argument that Kleinman (2000) makes about the contribution of lay knowledge in technological decision making. People who come to the community garden (chiefly ordinary citizens living in the neighbourhood) are actively engaged both in designing and performing phases of technology. Busch (2000) argues the existence of two ways in which the network of civilians can contribute to a better technology choice. First, through public deliberation and debate over new technologies. Second, through direct action by residents of affected communities. What Seseragi community garden has been doing can be seen as the latter. By performing the soil decomposition method, they try to solve the problem exist within their reach.

Second, the evidence of Hobbism, also known as statism, characterised by heavily bureaucratic decision-making processes in technology choice, was barely observed in the case studies. Midori-kan in Case 2 is a composting plant run by the local government. However, informants in Case 2 often mentioned how flexible their operations are and how important it is not to fall into bureaucratic decision making. The design of the plant was open to public debate, to which many interviewees attributed the 19 years of successful operation of the plant. The selection of Okada manufactory as the architect was based on how much the company emphasises microbial activities in the plant design.

Lastly, the influence of Marketism, the faith in free market mechanism on technology choice could not be observed in any case study. It might be because, as Busch (2000) points out, the fascination with the market is so widely fused in society that it is taken for granted and is very hard to take account of its influences on technology choice.

5-3. Technology studies and technology in the real world

By placing empirical observation at the centre of analysis, technography enabled this research project to take a descriptive attitude to be able to answer the main research question, which is an open-ended question: *why are there differences in food waste recycling technologies used in three case studies?* Furthermore, the notion of stratified reality helped this research not to develop any deductive inference on whether it is nature or human that determines technological development. To further demonstrate the fruitful but delicate nature of the technographic approach, I discuss below two challenges faced during the fieldwork in this research.

The first example is from the interviews carried out in Seseragi community garden. When asked about the equipment used in the composting site, ST, the leader, and other three participants disagreed when they did start to use the plastic sheet to cover the food waste incorporated in the soil. While ST was convinced that they used the plastic sheet from the beginning, SK, KA and TD, all of whom have more than 7 years of experience in the community garden, insisted that the plastic sheet was not used in the first couple of years. The three people agreed that before installing the plastic sheet, they used a net to protect the compost site from wild animals.

Considering ST was the most knowledgeable person who brought the method to the community garden, it seemed right to believe her memory. However, the other three agreed on every detail of the net they used before the plastic sheet, which also seems accurate. This ambiguity in community gardeners' memory implies that, as Glover (2011) notes, asking retrospective questions could be an effective approach to understand how and why a farmer performed the practice in a particular way, but it might also have limitations. In the Seseragi community garden's case, other supplemental sources such as photographs or video records could have resolved the confusion.

The other example that illuminates the role and kind of logic in informants' representation of technological practice is the discussion on tillage depth after broadcasting food waste in Case 1. An unwritten rule among the community gardeners is that 15 cm is the best depth to ensure soil aeration. Some of the community gardeners said that they were strict on the depth. However, another said that "Last week, when I was using the tiller, I was told that I should go shallower, but I am sure I was following the 15cm rule." Furthermore, according to the measurement during the observation, the length of blades attached to the tiller used in the community garden (Yanmar YK650MR) was 12 cm at the longest point. On top of that, when they use the tiller, the depth adjusting bar is lowered until the second or the third hook, meaning the actual ploughing depth is certainly shallower than 12cm. Jansen and Vellema (2011) introduce "fuzzy logic" to try to make sense of these kinds of ambiguous explanation by small holder farmers. The authors emphasise that researchers need to be aware that farmers do not always have the type of logic researchers expect when they make daily decisions. The challenge is to keep some of this "fuzzy logic" in the presentation and analysis of yielded data. This fuzziness seems to be part and parcel of farmer's improvisational decision making but it is difficult to account for its role. Bourdieu (1977) argues that the identification of reasons of farmers' decision should not be based on the assumption that reasons always direct, guide or orient actor's actions. "Agents may engage in reasonable forms of behaviour without being rational" (Bourdieu, 1977, p. 76).

6. Conclusions

This thesis shows that in the studied socio-technical systems bio-physical matters (machines, tools, environmental conditions and different organic matter resources) and knowledge, skill, technique of those who are involved in composting (citizens, machine operators, municipal officials and scientists) co-determine a unique outcome of food composting technology. This study aims to decrease the lack of knowledge in this area by examining three cases which illuminate the interaction of human and material components of composting technology by emphasising performance and the involvement of expert/lay knowledge in design.

This project intended to achieve its research objective through the following research question: *Why are there differences in food waste recycling technologies used in Seseragi community garden, Midori-kan and Tokyo University of Agriculture?* This study found three factors to which the differences in the three technologies can be attributed. First, the availability of fibrous organic materials contributes to the development of different composting technologies. Midori-kan has the richest organic resource supply thanks to the surrounding forest and farmland. Seseragi community garden has access only to leaf litter and limited land available for on-site composting, whereas TUA is the most limited as far as organic resources and land are concerned. Second, the different objectives embedded in technology design and performance at the moment of use make the three technologies distinct. In Seseragi community garden, the soil decomposition method came into being due to significant contingency in a series of events and lay persons' responses to them. In Motegi town, the composting plant was established in a more predetermined way. A professional architect firm was in charge of the ingenious design of the primary decomposing reactor, which enables the use of three types of highly lignified organic materials as bulking agents. At the same time, veteran machine operators' improvisations during the composting process play a crucial role in coping with the contingency caused by biophysical and environmental conditions. In TUA, where the degree of certainty in the technology design is the highest, the plant operator's spontaneous decision-making was still premised in the plant design. Third, the study also showed that a dominant narrative could provoke differences in technology development. There is a discrepancy in narratives that revolve around the treatment of biological digestion processes in three cases. Informants from Seseragi community garden and Midori-kan tend to have appreciative views on microbial digestion, whereas those from the TUA case study take no notice of the biological aspect of composting.

All in all, since there is no "one size fits all" technology to food waste recycling, different communities (citizens, the state and scientists) develop and perform in different ways. Technographers can contribute to the existing body of research by adding an ethnographic perspective to enrich understanding of human-technology interactions that revolves around each food waste recycling initiative.

7. Recommendations and limitations

This project suggests that more study is needed regarding the socio-ethnographical aspect of food waste composting technology. As discussed already, little existing literature from social science communities examines how composting technology is performed in the real world. Considering these socio-ethnographic approaches to food waste composting are highly context-dependent, more case studies from other parts of the world might help stimulate the discussion in this field. Hettiarachchi et al. (2020) can be seen as an example of a comprehensive analysis with various case studies of food waste composting from practice and policy studies. A technographic equivalent of the comprehensive study on food waste composting needs to be carried out.

Another suggestion for future research would be about the research strategy/methodology that this project employed. Technography needs further refinement to be a concrete methodological approach for investigating the socio-technical fabric. Currently, as Jansen and Vellema (2011) note, technography itself is indeed incapable of detecting specific types of causal relationships in socio-technical configurations. Therefore, it is left up to a researcher to connect it to a more explanatory and substantial social theory. This incomplete nature of technography brings this project the most significant limitation. To compensate for this partiality and become more analytical, I intended to anchor this research's conceptual framework in social theories around technology and in Busch's (2000) arguments on science, state, and market.

Another limitation in the more practical aspect of this research is that the number of semi-structured interviews and the time for the participant observation are limited in the third case study, which makes this project an asymmetric comparison between the three cases. Nevertheless, the information obtained through the document study sufficiently supplemented the shortage in the third case study.

(Word count: 16987)

References

Adhikari, B. K., Barrington, S., Martinez, J., & King, S. (2008). Characterization of food waste and bulking agents for composting. *Waste Management, 28*(5), 795-804.

Bernard, H. R. (2017). *Research methods in anthropology: Qualitative and quantitative approaches*: Rowman & Littlefield.

Bourdieu, P. (1977). *Outline of a theory of practice*: Cambridge University Press.

Braudel, F. (1992). *Civilization and capitalism, 15th-18th century, Vol. III: The perspective of the world* (Vol. 3): Univ of California Press.

Brown, P. (1992). Popular epidemiology and toxic waste contamination: lay and professional ways of knowing. *Journal of Health and Social Behavior, 33*(3), 267-281. doi:10.2307/2137356

Busch, L. (2000). *The eclipse of morality: Science, state, and market*: Transaction Publishers.

Callahan, R. E. (1962). *Education and the cult of efficiency*: University of Chicago Press.

Farmer, B. (1986). Perspectives on the 'green revolution'in south asia. *Modern Asian Studies, 20*(1), 175-199.

Glover, D. (2011). The system of rice intensification: Time for an empirical turn. *NJAS-Wageningen Journal of Life Sciences, 57*(3-4), 217-224.

Haraway, D. (1988). Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist studies, 14*(3), 575-599.

Hatano, T. (2003). The contribution of the organic farming to garbage recycling activities: The contributing factor in making the small-scaled spread system. *Kobe University Agricultural Economics Departmental Bulletin paper, 36*, 39-46.

Hettiarachchi, H., Bouma, J., Caucci, S., & Zhang, L. (2020). Organic waste composting through nexus thinking: linking soil and waste as a substantial contribution to sustainable development. In H. Hettiarachchi, S. Caucci, & K. Schwärzel (Eds.), *Organic waste composting through nexus thinking: Practices, policies, and trends* (pp. 1-15). Cham: Springer International Publishing.

Higa, T., & Wididana, G. (1991). *The concept and theories of effective microorganisms.* Paper presented at the Proceedings of the first international conference on Kyusei nature farming. US Department of Agriculture, Washington, DC, USA.

Hino city. (2019). Hinoshi no gaiyo [The summary of Hino city]. Retrieved from https://www.city.hino.lg.jp/shisei/profile/gaiyo/1004554.html

Hino city. (2021a). Danjo betsu chomei betsu jinko tokei hyo [The number of male, female residents and households sorted by wards in Hino city]. In.

Hino city. (2021b). Hinoshi no jinko setaisu menseki [The population, the number of households and the land size of Hino city]. Retrieved from https://www.city.hino.lg.jp/shisei/profile/toukei/jinko/index.html

Hirschman, A. O. (2013). *The passions and the interests*: Princeton University Press.

Hofstadter, R. (1955). *Social Darwinism in American Thought*. Boston: Beacon.

Jain, M. S., Daga, M., & Kalamdhad, A. S. (2019). Variation in the key indicators during composting of municipal solid organic wastes. *Sustainable Environment Research, 29*(1), 1-8.

Jansen, K. (1998). *Political ecology, mountain agriculture, and knowledge in Honduras.* Thela, Amsterdam. Retrieved from https://edepot.wur.nl/11806

Jansen, K. (2009). Implicit sociology, interdisciplinarity and systems theories in agricultural science. *Sociologia Ruralis, 49*(2), 172-188.

Jansen, K., & Vellema, S. (2011). What is technography? *NJAS-Wageningen Journal of Life Sciences, 57*(3-4), 169-177.

Japan Livestock Industry Association. (2008). Organic waste recycle plant, Midori-kan Motegi town. *Toward nature inclusive livestock farming*, 48-55.

Kleinman, D. L. (2000). *Science, technology, and democracy*: SUNY Press.

Kodama, T., & Yanai, S. (2013). The current state of community based agricultural land management in urban promotion area of a metropolitan suburb and its issues arising upon the expansion of the system to a regional level. *The journal of Japanese institute of landscape architecture, 76*, 621-626.
Latour, B. (1988). *The pasteurization of France*: Harvard University Press.
MacKenzie, D., & Wajcman, J. (1999). *The social shaping of technology*: Open University Press.
Marx, L. (1997). Technology: the emergence of a hazardous concept. *Social Research, 64*(3), 965-989.
Matthewman, S. (2011). *Technology and social theory*: Palgrave Macmillan.
Megumiya, H. (2000). Namagomi no kousoku taihika niokeru tuukiryou to kirikaeshi hindo nokouka [The effect of oxygen supply and turning frequency on fast composting of food waste] *The Journal of the Japan Society of Waste Management, 11*, 204-213.
Michael, M. (2012). *Reconnecting culture, technology and nature: From society to heterogeneity*: Routledge.
Ministry of Agriculture Forestry and Fisheries. (2011). *Shokuhin rosu toukei chousa houkoku [Report of statistical study on food loss in Japan]* Retrieved from https://selectra.jp/sites/default/files/pdf/131028_sanko2-5.pdf
Ministry of Agriculture Forestry and Fisheries. (2021). Strategy for Sustainable Food Systems, MeaDRI. Retrieved from https://www.maff.go.jp/e/policies/env/env_policy/meadri.html
Ministry of Environment. (2018). *Shokuhin haikibutsu touno hassei oyobi saiseiriyou no sokushin no torikumi ni kakaru jittai chousa [the survey on food waste reduction and promotion of food recycling]* Retrieved from https://www.env.go.jp/recycle/H30_houkokusyo.pdf
Motegi town (Ed.) (1995). *The history of Motegi town*: Gyousei publication.
Nakasaki, K. (1999). Composting of Organic Waste. *The Japanese Journal of Multiphase Flow, 13*, 117-125.
Palaniveloo, K., Amran, M. A., Norhashim, N. A., Mohamad-Fauzi, N., Peng-Hui, F., Hui-Wen, L., Kai-Lin, Y., Jiale, L., Chian-Yee, M. G., & Jing-Yi, L. (2020). Food waste composting and microbial community structure profiling. *Processes, 8*(6), 723.
Platt, B., McSweeney, J., & Davis, J. (2014). Growing local fertility: A guide to community composting. In Highfields Center for Composting, Institute for Local Self-Reliance, & Hardwick Vermont (Eds.).
Richards, P. (1989). Agriculture as a performance. In R. Chambers & L. A. Thrupp (Eds.), *Farmer first: Farmer innovation and agricultural research* (pp. 39-43).
Richards, P. (1993). Cultivation: Knowledge or performance? In M. Hobart (Ed.), *An anthropological critique of development* (pp. 61-78): Routledge.
Rostow, W. W. (1990). *The stages of economic growth: A non-communist manifesto*: Cambridge university press.
Sassen, S. (2002). Towards a sociology of information technology. *Current Sociology, 50*(3), 365-388.
Shapin, S., & Schaffer, S. (1985). Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life.
Shimbori, M. (2012). Changes of non-building like use and future directivity in Hino. *Housei University bulletin of graduate studies, 1*, 1-7.
Shimpo, N., Amemiya, M., & Yokohari, M. (2014). The organic waste recycling system based on agro-activities of urban residents A case study of a community garden in Hino city, Tokyo. *Journal of the city planning institute of Japan, 49*.
Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication*: Cambridge University Press.
Suchman, L. A. (2007). *Human-machine reconfigurations: Plans and situated actions*: Cambridge University Press.
Sudou, H., & Hishida, T. (2010). A Study on the problem about self-sufficient rate of food and food wastes in Japan. *Nagoya Bunri University Journal, 10*, 127-138.
Summary of agriculture in Motegi town. (2020). Motegi town

Taira, K. (2019). The potential of community compost for resource circulation of kitchen waste in a local area: The causes of composting participation and continuation. *Rikkyo Journal of Social Design Studies, 18*, 57-71.
Uchiyama, T., Hashimoto, T., Tanigawa, N., Inno, Y., & Sakimoto, M. (2004). Composting of school lunch left overs and its influence on the growth of several types of vegetables. *Bulletin of Agricultural, Food and Environmental Sciences Research Center of Osaka Prefecture, 40*, 5-11.
USDA. (2000). *Environmental engineering national engineering handbook*.
Van der Ploeg, J. D. (2002). Potatoes and knowledge. In M. Hobart (Ed.), *An anthropological critique of development* (pp. 221-239): Routledge.
Voběrková, S., Maxianová, A., Schlosserová, N., Adamcová, D., Vršanská, M., Richtera, L., Gagić, M., Zloch, J., & Vaverková, M. D. (2020). Food waste composting-Is it really so simple as stated in scientific literature?–A case study. *Science of The Total Environment, 723*, 138202.
Wilson, E. O. (1999). *Consilience: The unity of knowledge*: Vintage.

Appendix

See the next page.

Appendix: The summary of the semi-structured interviews

Case 1= Seseragi, Case 2= Midorikan, Case 3= TUA

No.	Date	Case	Name informant	Initial	Male/Femal	Age range	Recorded	online/o	Occupation	Codes/summary
1	04-May	1	Anonymous	AA	Female	75	45		Founder Seseragi community garden	the genesis of Seseragi relationship with Landlord "cultivate the city" waste reform (charging for trash bag) whole soil decomposition community garden
2	04-May	1	Anonymous	KK	Male	42	42		Practitioner soil farmentation method at Seseragi	empirical knowledge whole soil decomposition sunlight, soil aeration and ventilation waste reduction community building moisture content depth of tiller blades
3	06-May	1	Anonymous	SK HY AE YM	Male	76	93	38, 25, 9,	Participants, practitioner of soil decomposition method Seseragi	Sakakibara: empirical knowledge, waste reduction, driving tiller, labour intensity and aging, 3 types of soil amendment, objective of the community garden, microbial activities Hayashi: anti-science, market, ecosystem Ae: community revolves around organic waste erduction, landscape, finance, whole soil decomposition as a pillar Yamaguchi: eldery care, inter-generational communication, education, microbial activities, community building and organic waste recycling
4	06-May	1	Anonymous	WK	Female	30-40	8		Participants, practitioner of soil decomposition method Seseragi	
5	07-May	1	Mr Yoshida	YD	Male	62	49	online	Inventor soil decomposition method	differences composting and soil decomposition (microbes, energy, depth, edfinition of putrefaction & decomposition) "the world of putrefaction" Whole soil decomposition demands labour but its educational
6	09-May	1	Anonymous	SK	Male	76	42		Practitioner soil decomposition method at Seseragi	"laypersons' work" citizens involvement aging participants process of collective learning based on empirical knowledge no scientific data nor numarical evidence use of fallen leaves (foliage) performative???
7	11-May	1	Anonymous	KB	Female	60-70	67		Organic residure provider Seseragi	Ms Sato's contribution & commitment improvements in prevention of foul odor & flies no economic benefit by the initiative responsibility of citizen or municipality? Environmental consciosness of the participants environmental education to children word of mouth and bond in the neighbbourhood the community garden should focus more on the waste recycling
8	11-May	1	Anonymous	ST	Female	50-60	113		Leader of Seseragi community garden	the genesis of Seseragi landlord and inheritance taxation the role of Yamaboshi 1st recycle experiment genesis of whole soil decomposition method (the most practical way to process organic waste from 150 households) the benefit of soil decomposition method **Labour demanding nature of soil decomposition method contributes to strengthen the sense of community and solidarity** Downside of the method (ecessive potassium, pH goes up) EM and bokashi "fun" as a keyword for managing community garden responsibillity of "those who eat"
9	11-May	1	Anonymous	HK	Male/Female	60-70	21		Landlord Seseragi community garden	inheritance tax and municipality a change in Seisan ryokuchi law irrigation channel and landscape
10	12-May	2	Mr Suzuki & Mr Shimizu		Male	60-70	58	online	CEO Okada manufactory	History of the company the importance of aeration "appropriate technology" "composting is done by microorganisms, not human" construction process prevention of foul odor uniqueness of circular shaped composting plant
11	13-May	1	Anonymous	WM MO	Female	40-50	37		Participant Seseragi community garden	Ms Wakamatsu: interested in no-chemical farming because her father, apple faremr died due to cancer caused by agro-chemicals gave up household composting due to flies and odor Ms Muraoka: participated in the initial soil decomposition experiment Ms Sato "it's like a flowing river. Water keeps washing down but never stops"
12	13-May	1	Ms Komiya	KY	Female	40-50	64		Hino 4th Kindergarten	intuitive and instinct based education. public kindergartens in Hino city put emphasis on diversity and inclusion in the carriculum. focus on development of capacity of thinking, decision making and self expression through intuitive experiences . personify the microorganisms, soil and vegetables. "the microbes grow and work so hard that they generates heat in the soil". Because microbes live their life just like we do, we need to provide them air (=soil aeration). When the colony of fungus is visible on the surface, children say "Hello, nice to meet you'. they even say things like "good job" to microbes. force children keep thinking why? that is the key to provoke their curiosity. cooperation with friends, making friends with others. Shifting to the education makes children think themselves some children started crying when their parents try to cook the vegetables. reaching out and changing parents mind by educating their children (importance of transmission of knowledge in household) Change children first. start from small things like turning off room light. then they will perform it when they go home.

13	14-May	1	Mr Yamaguchi	YG	Male		33	online	Gomi-zero promotion department, Hino city	the importance of environmental education for the next gerenration It also changes the current generation's (parents) mind
14	17-May	2	Mr Nagashima 1st time	NS	Male	40-50	90		Chief soil building promotion department Motegi town office, Manager of Midorikan	the genesis of Midorikan (change in cow manure treatment law, renewal of waste incineration plant of the town lead to incorporation of organic residue as feedstock). advantage of existing leaf litter composting plant by JT. foul odor problem (design of the complex, elaborate explanation for the neighborhood). the reason why Okada was chosen as the designer of Midorikan (simple mechanism, less disturbance to the natural processes). citizens become less aware and conscious about food recycle leading to the decreasing amount of organic residue come to Midorikan. economic benefit of Midorikan as Motegi town. decreasing population and aging. "not as a waste disposing plant but as a compost manufacturing plant" is the key for citizens understanding (because there are many farmers & gardeners in the town who need compost). suger metophour. the importance of output and its quality (Do not sell compost for free of charge!) and thats why Midorikan has been doing field experiments over the last 19 years. repairment project. socio-economic factors affect the quality and process of composting (access to locally sourced timber defines the amount of organic residue they can process) follow theoretical value.
15	18-May	2	Anonymous	OZ KB	Male	60-70	26		Operator at Midorikan	2(leaf litter), 2(rice husk), 1(saw dust), 1(returning compost) per one truck of cow manure. Quality control based on their own experience in farming food residue is not left in the final product Yuzu causes problem in winter. some leftover oil from bio-diesel fuel production is added to compost on Monday the importance of leaf litter as moisture controler and host of microbes bamboo makes difference in the initial decomposition you can tell from a lot of steam coming out "the most important thing is the experience, intuition (or hunch)" improvisation is also important "the elderly make better compost than the young. because we have experience of helping copost making in childhood"(tobacco farming) there was a rocal custom in the town that in winter, farmers gather leaf litter to compost a bit of opposing attitude to office staff
16	19-May	2	Anonymous	YO	Male	60-70	30		Dairy farmer in Motegi town, cattle manure provider	slurry, barn clearner did not expect that the town would invest the large amount to Midorikan other dairy farmers were not capable of inevst in building the manure processing facilities so that helped them a lot I think it's also beneficial for the neighbours to avoid odor
17	19-May	2	Mr Nagashima 2nd time	NS	Male	40-50	130		Chief soil building promotion department, Motegi town	decreasing importance of processing manue but other objectives underlie the existence of Midorikan We need to add farmers outside town to compensate reduction of manure. But it doesn't make sence to bring manure from farmers far away. We want to stick to the recycle of local resources. if there is no longer Midorikan, operators loose their job, farmers loose income from leaflitter and the town looses the biggest promotion content. the mayor wants to continue Midorikan. public nature of Midorikan (by adding household food waste, its guaranteed). comparison to other municipalities, and other similer initiatives making use of local customs and natural resources (JT composting center, abundant forest) that leaf litter is making a huge difference in quality
18	19-May	2	Anonymous	TT	Male	50-60	86		Operator, driver	Mr Takatsu= Its a mere 1000 yen for driving more than 30 minutes to collect mushroom residue. But the main point here is not making money. It's making a good use of local organic resources. his motivation is to contribute to the locals by producing good quality compost His family used to own a tobacco farm so he knos how labour intensive it is. The hard part is to dry leave. comparison between normal home made compost and Midorikan compost (Midori compost is much clearner and purer). There is high demand for the compost so they can sell more if do more marketing. But then production would not catch up. So, we want especially, local farmers to use compost make a closed cycle in the town a large part of work is to driving a truck to collect feedstock operator as a job (aging, but popular when hiring, enjoyeable, not very labour intensive) the key ingredient is leaf litter. I personally use 2, 3, 1, 1 rule (3 leaflitter). order= Leaf, rice husk, sow dust, leaf, rice husk, leaf, returning compost experience as engineer (in charge of repairing elecctric systems or power cables) he looks up to Mr Nishiya who learned everything quickly and being only one who can do all kinds of work in the complex Mr&Ms Hukasawa= 2 or 3 times a month disposes mushroom base. they started to use Midorikan since 10 years ago. is very helpful. they used to break mushroom base into pieses and bring it to pig farm or buried excessive ones into ground another mushroom farmer quitted due to the flood in 2019. Midorikan gathered the flooded mushroom bases to help the mushroom farmers
19	19-May	2	Anonymous	KI IS	Male/Female	65-70	37		Midori compost user & member of the town council	Mr Kobayashi produdes radish, turnip, carrot, sweet potato, potato, pumpkin, eggplant, cucumber, watermellon and sell it at the motorway service station using Midori compost to all of them when preping beds his son produces chinese chive He thinks that Midori compost facilitate uptake of fertiliers (he uses chemical/organic fertilisers) using sticker so consumers can easily tell its locally produced Mr Iso uses the compost every year for vegetables and rice production. high reputation of the rice and it taste much better Midori compost helps root growth and makes rice plant more stable and tolerant to falling down how he knew about the compost was the promotion by mayor "We all used to produced tobacco, so we used tobacco residue as compost for rice" both of them know very detailed information about other farmers living in the town. farmers produced Konjac after tobacco prices fell. but Konjac price also fell because Gunma pref. produces a large amount. so now vege farmers like us depend on the store in service station. everyone thrives thanks to Midorikan

20	20-May	2	Anonymous	KW	Male	40-50	28		Midori compost user, vegetable farmer in Motegi town	produces leek, eggplant. Approx. 1ha. Know little about soil tupes and other baisic kowledge abhout farming. soil of the farm is clay he uses Midori compost since he took over his parents farm sence of contribution to the closed loop of organic resources satisfied with the quality of Midori compost aging of farmers in the area. he is the last eggplant farmer in the area. he sells his product partially at the service station broadcasting service is helpful because he does not know how to drive such vehicle
21	20-May	2	Anonymous	NY	Male	40-50	44		Chief officer/operator Midorikan	his experience in previous waste processing plant in Mashiko town How he got used to work in Midorikan how to moisture control (sow dust, adding leaf litter from the secondary plant) is the most important thing to let machines work right heat conrol in the circular plant comlpains of machinary and how the workers compensate it by empirical knowledge (broken aeration blower, there are too many belt conveyers which break down often, corrosion of building frame, no water sprinkler) desire to see what new composting plants look like nowadays the key to make good compost is timing to use bamboo powder (for the sake of odor prevention), also he thinks using bamboo powder helps improving quality of the compost itself the decleasing amount of manure is a challenge we need to overcome. that depends on local farmers if we use more food residue to compensate manure, the compost would be no longer same quality. there are many things that you have no idea if you only look at blueprint. and we also have to overcome issues caused by the degradation of facilities
22	20-May	2	Mr Yano		Male	60-70	95		Former manager soil building promotion section	Motegi town had progressive policies and wanted to promote recycling even before the time of Midorikan. Then "soil building promotion division" was established in the town office in 2001. "producing is different from disposing". We wated to produce compost not dipose manure and food residue. the town's progressive waste management policies helped us to gain understanding of citizens. I lobbied establishment of Midorikan in town concil by saying "running cost can be payed off by the reduction in waste disposal cost". compost has to be used by farmers for "circularity", which means it has to be high quality. involve thousand people to this loop (dairy farmers, vege/rice farmers, local citizens who gather leaf litter, households in city centre etc.). the initial ieda of comosting plant was on the municipality basic plan of the town. From there, I put it into concrete plan. I started from "why we need compost?" he made experimental composting box in much smaller scale to test by himself. Before Midorikan, he worked for establishing the service station. That experience was the reason why I was chosen as the first manager of Midorikan. the reason why they choose "circular plant" and types of feedstocks they use. they have to take into account socio-economic affairs (timber scarcity caused by biomass power plants). how politics affect composting (national subsidising scheme, changes in municipal basic plan). the municipal basic plan can not be changed easily aside renewal in every ten years. the municipal basic plan is made base on citizens opinions. Environmental policy and its nesecity in current society. "microbes play a leading role. however, it is really difficult to handle microbes for us humans" the mindset we had was "we will make the best compost in the country" that makes us the longest running compost centre in Japan
23	22-May	1	Mr Ito	IO	Male	60-70	215		Chairman/representative NPO Yamaboshi	the genesis of Yamaboshi and its environmental planning advocacy and support for the disabled his working experience in care home for the disabled leads to the realisation that the society has to change to accept the disabled The disabled also have to contribute to society by being part of solving society problem. environmental issues in Hino the disabled are not only those who marginalised in society. environment is also marginalised. therefore, we wanted to create symbiotic society in which all kinds of people and nature thrive Our motto is "Birds are in the sky, fish in the sea and people in the community" disabled poeple should also be part of the ecosystem in society (by working, getting payed, living in a neighbourhood) "Environmental activists are separated into silos. they do not care things outside their interest" "focusing only on Seseragi isn't enough. we have to have macro view point for inclusive and sustainable community building" Yamaboshi= 500 million yen, 130 enployees, 16 offices. it's now hard to manage environmental planning in 1994 diversity in people and make sure "no one is left behind" Seseragi farm as part of "no aru machidukuri" project submitted a proposal for establishing a distributed system of organic waste composting his ambition to create distributed composting system p.6-8 how to create "social capital" he admires Seseragi's power to attract people but he emphasis volunteer isn't sustainbale.
24	25-May	1	Anonymous	KH	Male/Female	30-50	25		Tachibana class, Hino 8th elementary school	Tachibana class= 20 children in special needs study they visit Seseragi once/twice a month members of Seseragi come to the school and teach how to build healthy soil and to grow vegetables they grow vegetable from food residue in their small garden located in schoolyard tomato, sweet potato, radish, Komatsuna, sweet corn, eggplant, okura, soybean, cucumber etc. environmental education, SDGs part of carriculum the older teach younger. they learn leardership, cooperation dietary education (grown vegetables are used in school meal) also let students take vegetables home and cook themself they do not expect students to reduce their households food waste "we want to teach students circular and organic farming"
25	26-May	1	Mr Ogasa	OS	Male	50-60	29	online	Former manager Gomi zero section Hino city	manager gomi-zero section of Hino municipal office 2008-2013 city environmental regulation in 1997 by citizens initiative "reform in waste management policy in 2000" municipality officer joined Machinama's regular board meetings the municipality did not expect the experiment to scale up and cover bigger area but they wanted to duplicate the initiative other neighbourhood in the city importance of an individual who plays a centralrole in these initiatives environmental education, children as the starting point of change in 70s and 80s, citizens and municipality didn't have a good relationship. they are oposed it changed gradually in 90s. and it became "the era of cooperation" through masterplan and city environmental regulation environmental friendly water management municipality officers learned a lot from charismatic citizens intensive and continuous discussion between active citizens and municilaity in city plannning national subsidy affected construction of waste incinirator in Hino city

26	26-May	3	Dr Goto		Male		71	68	TUA researcher, founder national soil association	how the composting research has started no four odor, easy to handle, energy efficient and slow release fertiliser MAFF didn't accept our formula to add urea to dried food waste according to law so they changed the formula and decided to extract oil from dried food waste to reduce CN ratio (food waste from school consists of 20% of oil) It is difficult to apply this formula to household food waste because its higher in CN ratio. Do not mix different organic resources. we need to find best fit method for each types of organic wastes mixing different organic wastes is also bad for soil nutritional balance. soil will be suffered from "obesity" comment on Seseragi community garden (they should bury it instead of leaving it on surface, no need to mix it with soil several times) Composting in Motegi town is only possible in rural area it's best to inrporate this plant to waste incinerator bureaucratic system in municipality prevents it from installment to incinerators TUA is also reluctant to further develpoment of the technology on the other hand, private companies are keen to install the technology, one of them was Omura shoji the core of this technology is to bypass the microbial process by controlling CN ratio artificially our research is based on the request from farmers and other practitioners. it has to do with the history of our laboratory compost and fertiliser from poerspective of soil health farmer's experience and intuitive should be recognised treatment of organic waste has to be diverse Dr Goto's view on organic agriculture, EM and microbial farming methods He also researches microbes and Bokashi (Bacillus, Trichoderma)
27	27-May	1	Anonymous	AE	Male	60-70		25	Participant Seseragi community garden	financial problem after relocation new ways to gather food waste, introducing membership? Landlord and inheritance tax bleaucratic system in municipality office change in agricultural land management law illegal state of Seseragi community garden Soil edcomposition method as a pillar ro core of the community garden subsidy from municipality **soil decomposition method is quantitative and therefore easy to report municipality how much food waste are collected!** irrigation channel and landscape sweet potato experiments by Ms Sato
28	27-May	1	Anonymous	KA	Male	60-70		14	Practitioner soil farmentation method at Seseragi	He joined Seseragi due to interest in farming, gardening his parents were farmers food waste & leaf litter compost as supplement crop rotation and Soil decomposition method (**diversity in crops and its rotation enables soil decomposition method ??**) covering the site to keep soil dry and not frozen in winter depth of mixing (https://www.yanmar.com/jp/agri/products/cultivator/minicultivator/yk450mr_yk650mr/) earthworms tell how decomposition is going the amount of leaf litter is important they mixed soil by tiller 4-5 times until its ready he recognised it is a labour intensive method to compost
29	29-May	3	Mr Omura	OM	Male		50	155	CEO Omura shoji	5 challenges and risks that they have been facing (foul odor, pests, fire, input-output balance, profitability) TUA Midori-kun fertiliser compensate some of these bottle neck of composting production (no fire risk, less odor and pest risks, more profitable than compost) biogass plant will be constructed neighbouring area which might affect how food waste is treated in this area of the city the selling point of composting and fertiliser is that returning organics into soil, giving it back to nature. also it contributes to agriculture three steps to compost (liquefy food residue into juice), mix it with shredded garden waste and returning compost and let it decomopse for four months with regular turning food waste as a promoter of decomposition he doesn't take ratio of food waste and garden waste seriously focus must be on output, not input I thinnk food waste would decrease, if farmers produces high value food. thus we want to support production of high quality food by providing good compost It is important to have a "mindset of merchant". we muct provide society value composting and fertiliser are superior to biogass production because it can be used by farmers and gardeners in a very visible way. power generation could also be used but invisible direct connections to consumers he used to throw away the compost up until 5 years ago how not to get criticised and gain trust by neighbours were the priority for them green waste 20 JPY/kg, food residue earns 30 JPY/kg (incinerator asks 21 JPY/kg) green waste 1,5 milion JPY/month, food waste 2 milion JPY/month cost 4 milion JPY/month we have other businesses and these are more proitable (municipal waste collection, removal) TUA fertiliser is easyer to sell and more calculable business model. how much it can produce and how much it can make profit/cost. alsoTUA branding is powerful don't know what users actually think about their compost (gap between what he said earlier)
30	01-Jun	1	Anonymous	TD	Female	40-50		10	Practitioner soil decomposition method at Seseragi	
31	02-Jun	3	Anonymous	ON	Male	60-65		63	Operator at TUA recycle centre	He has no previous experience in compost/fertiliser production He was tought about the machine operation by a research institution He learned from lots of failures and experiences There is no formal guidebook for quality control. It is based on his intuitive decision making How to transmit his knowhow to Omura shoji, ltd. Dr Goto doesn't do much about how to run the plant The most important thing for controling oil content in the fertiliser is to find the right ratio of different kinds of food recidue (vegetables, meat/fish and carbohydrate) Different quality day by day since the feedstock is different every time
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