ENERGY-EFFICIENT GREEN LIVING A SMALL-SCALE ORGANIC ECOLOGICAL RECYCLING SYSTEM

BY

HAITAO GUAN

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Assoc. Prof. Pisprapai Sarasalin
Examination Committee Chairperson

Prof. Eakachat Joneurairatana, Ph.D.
Member

Assoc. Prof. Pakorn Prohmvitak
Member and Advisor

Approved by Graduate School

(Prof. Suejit Pechprasarn, Ph.D.)
Dean of Graduate School
August 30, 2024

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Guan Haitao

Researcher

6407592 : Haitao Guan

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Abstract

The primary objective of this study is to meticulously explore the design principles, operational mechanisms, and potential applications of the family ecological recyclable system. Through this in-depth investigation, this research aims to shed light on the system's capacity to instill environmental awareness and foster ecological equilibrium among family members. Furthermore, it seeks to emphasize the practical and engaging ecological experiences that this system offers to households. The overarching research goal is to contribute substantive, household- level solutions to advance the realization of Sustainable Development Goals, ultimately promoting a more sustainable and eco-conscious way of living. The results underscore the practical and engaging ecological experiences offered by the system, contributing substantive, household-level solutions for a more sustainable and eco-conscious way of living.

(Total 52 pages)

Keywords: Energy Saving, Green Living, Small Scale, Organic, Ecological, Recycling

Student's Signature .... Thesis Advisor's Signature ....

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Introduction

1.1 Background and Significance of the Problem

At a global scale, climate change, environmental problems, and resource shortages have emerged as serious and interconnected challenges confronting human society. These issues pose significant threats to the well-being of both current and future generations, necessitating urgent and collective action.

The Earth's climate is undergoing profound changes primarily due to human activities, such as the burning of fossil fuels and deforestation. This has resulted in rising global temperatures, extreme weather events, sea-level rise, and disruptions to ecosystems. Climate change has far-reaching consequences for ecosystems, biodiversity, and human societies, impacting agriculture, water resources, and increasing the frequency and intensity of natural disasters. Pollution, deforestation, loss of biodiversity, and habitat destruction are key environmental problems that exacerbate the challenges posed by climate change. Industrial activities, improper waste disposal, and the extensive use of harmful chemicals contribute to air, water, and soil pollution. These environmental issues threaten ecosystems, wildlife, and human health. The growing global population and increased consumption patterns have led to resource shortages, including water scarcity, depletion of arable land, and diminishing natural resources. Over-extraction and mismanagement of resources contribute to the degradation of ecosystems and compromise the ability of the planet to sustain human life.

Addressing these challenges requires concerted efforts on multiple fronts, involving governments, businesses, communities, and individuals. The international community has recognized the need for collaborative action, as evidenced by global agreements such as the Paris Agreement, which aims to limit global warming, and the Sustainable Development Goals (SDGs), which encompass a broad range of environmental and social objectives

Sustainable practices, renewable energy adoption, conservation efforts, and the development of innovative technologies are essential components of the collective response to these challenges. Additionally, fostering environmental awareness and promoting responsible consumption habits are crucial for creating a more sustainable and resilient global society.

The pivotal role of the family, as the fundamental unit of society, is increasingly acknowledged. The actions and decisions made within the household have a direct impact on the utilization of global resources and the overall health of our environment. This recognition underscores the necessity for families to adopt sustainable practices and make informed choices that contribute positively to environmental conservation and resource efficiency. Especially in the process of pursuing sustainable development, the family has become an important molecule, which needs to reduce the environmental burden by changing the daily lifestyle. In this context, the construction of a small ecological cycle system in the family has become an important part of achieving energy saving, emission reduction and resource utilization.

In this context, the obligation to engage in proactive measures extends from individuals to entire households. The development of a sustainable and health-oriented ecological system for families transcends mere personal convenience, representing a deeper pledge towards our collective future. Establishing eco-friendly domestic environments not only significantly diminishes our ecological footprint but also sets a precedent for sustainable living practices across society. This initiative is crucial in fostering a culture of responsibility and environmental stewardship, ensuring that each action taken contributes positively to the preservation and enhancement of our shared environmental heritage.

The gravity of family resource wastage is increasingly alarming within contemporary society. Across various aspects, ranging from water mismanagement to excessive energy consumption, households contribute significantly to resource squandering in their daily activities. This profligacy not only showcases a lack of responsibility towards finite resources but also poses a direct threat to environmental sustainability. An in-depth comprehension of these challenges underscores the pressing need to address the issue of familial resource wastage.

Water scarcity is a growing problem all over the world. Parts of Africa and Asia in particular are experiencing severe water shortages. Several factors contribute to water scarcity, exacerbating the situation for millions of people and ecosystems. Changes in climate patterns, including altered precipitation and temperature levels, contribute to shifts in water availability. Climate change-induced droughts and erratic rainfall patterns can lead to decreased water supply in affected regions. The rapid increase in global population puts a strain on water resources, especially in densely populated areas. As more people compete for limited water supplies, the risk of scarcity intensifies. Inefficient water management practices, such as over-extraction of groundwater, pollution of water sources, and inadequate infrastructure for water distribution, can exacerbate scarcity issues. Mismanagement contributes to the depletion and contamination of available water resources. Certain economic activities, such as industrial processes and large-scale agriculture, can be water intensive. When not managed sustainably, these activities contribute to water scarcity by depleting local water sources. Certain regions, particularly in Africa and Asia, face disproportionately severe water scarcity due to geographic factors, including arid climates and limited freshwater sources. These regions often lack the infrastructure and resources needed to address water challenges effectively.

According to the Organisation for Economic Co-operation and Development (OECD), municipal waste refers to waste generated by households and similar waste from commercial enterprises, offices, institutions, and small businesses. This definition encompasses a broad range of waste types and includes materials such as paper, cardboard, plastics, glass, metals, food waste, textiles, and other items discarded by individuals and businesses in urban areas. It accounts for up to a third of all public spending on pollution control, although it makes up only 10 percent of total waste generation. According to a recent report, Denmark produces the most municipal waste of any OECD country. Every year, Danes produce an average of 751 kg of municipal waste per capita, of which 515 kg is household waste. The United States and Switzerland are close behind, generating 725 and 712 kg per capita of municipal waste respectively (Liu, 2023).

In China, the annual transportation volume of urban domestic waste has increased from more than 31 million tons in 1982 to more than 200 million tons in 2023, with the garbage growth rate reaching 10% (Liu, 2023). In 2023, Chinese cities' expenditure on the safe disposal of domestic waste will be close to the proportion of higher education expenditure, about 350 billion yuan. Faced with such a large amount of domestic waste and disposal costs, reduction, and resource utilization on the basis of harmless treatment have become the research focus and social development trend of China's waste treatment. Different types of garbage have different resource utilization methods, so resource recycling needs to be achieved through garbage classification.

As the main component of domestic waste, the proportion of food waste varies in different cities, accounting for about 50-60% on average (Hu, 2023), and it needs to be treated with emphasis. Due to the special nature of food waste, which is rich in organic matter and moisture, the cost of garbage collection and terminal treatment is high. The country has targeted the reduction and resource utilization of food waste by treating it on-site at the source.

Kitchen waste, according to the definition given by the China Environmental Science Association, refers to the waste generated in residents' daily life and food processing and other activities. Kitchen waste includes discarded vegetable leaves, peels, eggshells, tea residues, leftovers, bones, etc. The main sources of food waste are household kitchens, restaurants, restaurants, canteens, markets, and other industries related to food processing.

Kitchen waste has distinct characteristics compared to other types of waste. The water content of kitchen waste is as high as 70%-90%, and it is rich in organic matter such as protein and starch, as well as various elements such as N, P, and K. Therefore, it is easy to rot, smell, and pathogenic bacteria and mosquitoes can easily breed. Therefore, there is a significant duality of hazards and resources. The resource nature of kitchen waste is reflected in the reuse of organic matter and trace elements through harmless treatment. For example, composting can produce organic fertilizers, feed processing can convert kitchen waste into pet feed, and energy processing can convert it into energy gases such as methane. The recycling of food waste reduces China’s resource consumption to a certain extent. The harm is mainly reflected in the impact on the environment, human health, and the difficulty of processing. Food waste is perishable and breeds a large number of mosquitoes, leachate, and foul odours. In addition, the random consumption of food waste by livestock and poultry may lead to cross-infection of diseases between humans and animals. The transportation cost of food waste is high, and leakage is prone to occur during transportation. In the subsequent landfill treatment, multi-layer prevention and control of leachate is also required. The cost is very high when the classification is imperfect. Some studies have compared the residual heavy metal content in the products after composting waste with different degrees of separation, pointing out that the earlier food waste is separated, the less heavy metal content remains in the fertilizer.

However, at present, China faces a significant challenge in establishing a comprehensive system for kitchen waste management. Traditional waste disposal practices in the country predominantly involve the mixing of various types of garbage in landfills. As of 2023, the predominant methods of waste treatment—sanitary landfill and incineration—comprised 97.8% of the nation's facilities designated for harmless waste processing. This indicates a minimal utilization of composting, a method that remains underrepresented in China's approach to waste management. This gap highlights the urgent need for diversifying waste treatment strategies to include more sustainable practices such as composting, which can play a crucial role in reducing landfill usage and promoting environmental sustainability.

The growing waste problem around the world forces us to act, and it is the responsibility of every individual to dispose waste and conserve resources to the best of their ability. Given the huge amounts of waste, everyone can actively participate in resource recycling to dispose of waste in a more environmentally friendly and sustainable way. By encouraging individuals to adopt resource recycling schemes, we can minimize the negative impact of waste on the environment.

1.2 Research Question

1.2.1 Analyzing the Design Principles: In this section of the study, the investigation thoroughly explores the core design principles that underlie the family ecological recycling system. This involves a comprehensive examination of the foundational concepts and methodologies that inform its structural composition. The scrutiny encompasses the system's architecture, material selection, and the guiding principles orchestrating the integration of components such as trash cans, fish tanks, and flowerpots. A deep understanding of these design principles is crucial for assessing the system's efficacy in waste management and its contribution to ecological sustainability.

Additionally, the analysis extends to evaluate the system’s versatility in accommodating different household sizes, spatial layouts, and cultural contexts. It includes a detailed consideration of how design elements facilitate user-friendly interactions, ensuring the ecological recycling system can be seamlessly adopted and maintained within daily household routines. Key aspects such as spatial configuration, the interdependent relationships between components, and aesthetic factors that contribute to the system's functionality and operational efficiency are meticulously examined.

This exploration also seeks to determine how well the design principles allow for the system's customization to meet the varied needs and preferences of diverse families. By investigating these dimensions, the research aims to reveal how design can effectively promote environmental consciousness and sustainable living practices among households.

1.2.2 Examining Operational Mechanisms: The examination of operational mechanisms delves into the functioning of the family ecological recyclable system concerning waste reutilization and ecological balance. This includes a detailed study of how the system processes organic waste, the role of microorganisms in waste decomposition, and the mechanisms by which nutrient-rich byproducts are utilized by plants in the ecosystem. Operational mechanisms also encompass the monitoring and maintenance protocols required for the sustainable functioning of the system over time.

Moreover, this analysis involves understanding the feedback loops within the system, examining how waste materials are transformed into valuable resources for plant growth and how the symbiotic relationship between fish and plants contributes to maintaining ecological balance. By exploring these operational aspects, the study aims to provide insights into the efficiency and practicality of the system, offering guidance on optimal usage and potential refinements.

1.2.3 Exploring Potential Applications: The exploration of potential applications involves investigating the adaptability and versatility of the family ecological recyclable system across diverse household settings. This includes assessing its feasibility in urban and rural environments, different climatic conditions, and varying cultural contexts. The study seeks to identify the system's potential to address specific waste management challenges unique to different households.

Moreover, exploring potential applications involves considering the socio-economic factors that may influence the adoption of the system. This includes evaluating the affordability, accessibility, and scalability of the system to ensure its widespread adoption. Additionally, the study may explore the system's compatibility with various architectural styles and living spaces, further emphasizing its potential integration into diverse household settings.

In essence, the examination of design principles, operational mechanisms, and potential applications collectively contributes to a comprehensive understanding of the family ecological recyclable system. This knowledge not only facilitates the refinement and improvement of the system itself but also provides valuable insights for households, policymakers, and environmental enthusiasts seeking sustainable solutions tailored to diverse living environments.

1.3 Research Objectives

The primary object of investigation in this research is the family ecological recyclable system, and the research centers on a comprehensive examination of its structure, functionality, and impact on household sustainability. Each component of this investigation plays a crucial role in understanding the system's efficacy in promoting sustainable living practices within the context of households.

Structure: Architectural Composition: The structure of the family ecological recyclable system encompasses its physical layout and composition. This involves an in-depth analysis of how components such as trash cans, fish tanks, and flower pots are integrated into a cohesive and functional unit. Evaluating the structural design involves assessing factors like spatial arrangements, ergonomic considerations, and the overall aesthetic appeal of the system.

Material Selection: An investigation into the structural elements also includes an examination of the materials used. This involves understanding the sustainability of materials in terms of production, durability, and environmental impact. Exploring the choices made in material selection contributes to gauging the system's eco-friendliness and resource efficiency.

Functionality: Waste Management Processes: The functionality of the system is a crucial aspect, involving a detailed examination of how it manages household waste. This includes scrutinizing the processes involved in waste decomposition, the role of microorganisms, and the conversion of organic waste into nutrients for plants. Understanding the mechanics of waste management within the system is fundamental for assessing its efficiency and effectiveness.

Symbiotic Relationships: Investigating the functionality extends to exploring the symbiotic relationships within the system, particularly between fish and plants. This includes understanding how the waste produced by fish becomes a nutrient source for plants, creating a closed-loop system. The examination of these symbiotic interactions provides insights into the ecological balance achieved by the system.

Impact on Household Sustainability: Environmental Footprint: The research focuses on evaluating the overall impact of the family ecological recyclable system on household sustainability. This involves assessing its contribution to reducing the environmental footprint of households by minimizing waste and promoting recycling. Understanding the quantitative and qualitative aspects of this impact provides a basis for measuring the system's success in fostering sustainable living practices.

Behavioral Changes: Investigating the impact also includes an exploration of how the system influences household behavior and attitudes towards sustainability. This involves understanding whether the introduction of the system leads to increased environmental awareness, changes in waste disposal habits, and an overall shift towards more eco-conscious living.

In essence, by thoroughly investigating the family ecological recyclable system's structure, functionality, and impact on household sustainability, the research aims to provide a holistic understanding of its role in promoting sustainable practices at the micro-level of households. This comprehensive examination not only sheds light on the system's strengths and potential areas of improvement but also contributes valuable insights to the broader discourse on sustainable living (Du, 2022).

1.4 Research Expectation

The expectations for the study "Energy-saving green living: small-scale organic ecological recycling systems" are manifold and involve several key results. Here are what to expect from this study:

This research is expected to provide a comprehensive and detailed understanding of the design principles, operating mechanisms, and potential applications of home eco-recyclable systems. This includes a detailed understanding of its structure, function, and the symbiotic relationships between its components.

The main objective of this study is to provide substantive household-level solutions to advance the achievement of the SDGs. We expect the results of this study will provide practical insights into how household eco-recyclable systems can play a role in achieving broader sustainability goals.

The study is expected to provide practical recommendations for families, policymakers and practitioners interested in adopting or promoting sustainable living practices. The recommendations include guidance on implementing and maintaining home eco-recyclable systems in different home environments.

The study aims to highlight the role of home eco-recyclable systems in inculcating environmental awareness and promoting ecological balance among family members. It is expected that the research will highlight the educational and behavioural aspects of the system and contribute to a more environmentally conscious lifestyle.

This study is expected to demonstrate the innovation and novelty in eco-recyclable systems for homes. This involves highlighting how integrating everyday items into a holistic recycling system represents a fresh and creative approach to waste management and sustainable living.

The research is expected to make a meaningful contribution to academic knowledge and practical applications. This may involve increasing theoretical understanding of sustainable living practices while also providing practical solutions that can be implemented by households seeking to reduce their environmental impact.

The study goal includes providing strong empirical evidence gathered through research methods such as literature reviews, case studies, and practical experiments. The study is expected to provide an informed basis for its conclusions and recommendations.

The study is expected to have a clear, coherent structure that follows a logical progression that leads the reader to explore design principles, operating mechanisms, potential applications, and overall impact. A well-organized presentation can enhance the accessibility and understandability of research results.

Overall, this study is expected to make a valuable contribution to the sustainable living discussion, providing actionable insights that can be applied at the household level to achieve a more eco-conscious and energy-efficient lifestyle (Fu, 2023).

Chapter 2

Design Research

2.1 Conceptual and Keywords Analysis

In the pursuit of sustainable development, the relationship between human society and the natural environment stands at the forefront of global concerns. This chapter delves into the core concepts of "Ecology" and "Ecological Civilization," pivotal themes that encapsulate the essence of this research.

Faced with the daunting challenges of climate change, environmental degradation, and resource scarcity, the notion of ecological civilization represents a paradigm shift towards aligning human advancement with ecological sustainability. The objective of this chapter is to dissect the complex design principles and operational mechanisms that underpin this shift, shedding light on how design can act as a bridge to sustainable living.

Central to this exploration is a detailed examination of ecological principles and their practical application within the context of a family ecological recycling system. Through an analysis of architectural composition, material choices, and the symbiotic interactions within this system, the chapter aims to reveal how households can contribute to the overarching goals of ecological civilization. This investigation encompasses the system's impact on household sustainability, including waste management processes, the cultivation of green lifestyles, and the enhancement of environmental awareness.

By articulating the theoretical underpinnings and practical ramifications of ecological civilization, this chapter lays the groundwork for understanding its critical relevance in the modern world. It highlights the imperative for collective reevaluation of our interaction with the natural environment, advocating for design strategies that encapsulate sustainability, efficiency, and harmony. In this context, the chapter enriches the dialogue on environmental sustainability, providing a roadmap for embedding ecological considerations into everyday life.

As we confront the complexities of the 21st century, the insights from this examination of ecology and ecological civilization offer a pivotal perspective on the role of design in forging a sustainable future. This chapter invites readers to consider the transformative power of design research in cultivating an ecological ethos, charting a course towards a more resilient and sustainable global community.

Ecology and ecological civilization

"Ecology" refers to natural ecology and is often used to discuss the relationship between humans and nature. Civilization refers to the general term for all material and spiritual achievements achieved in human practical activities, reflecting the degree of development of human society. Ecological civilization is a form of civilization that is currently under construction. It is the sum of the results achieved by combining human development and ecological construction. Ecological civilization emphasizes the relationship between humans, nature, and society. Ecological civilization requires humans to actively follow the laws of nature in practice, and at the same time grasp the laws of development of human society. Ecological civilization is the result of mankind's profound reflection on the ecological crisis and is a symbol of the progress of social civilization.

The focus of ecological civilization construction is not only environmental construction, but also the construction of human lifestyles, consumption patterns and spiritual values. All in all, the construction of ecological civilization penetrates into all aspects of development.

For example, from the perspective of cultural values, clearly understand the ecological value of the natural environment and establish values and codes of conduct that cherish nature.

From the perspective of economic development, it is necessary to transform the traditional economic development model, establish an industrial structure dominated by green industries, and realize the ecologicalization of social production.

From the perspective of lifestyle, people are required to establish a reasonable consumption concept, advocate diligence and thrift, oppose profligacy and waste, and form a green lifestyle that can meet their own needs without damaging the natural environment.

From a political perspective, the construction of ecological civilization should be integrated into the formulation of various policy systems and the construction of social structures, coordinate the relationship between man and nature, and protect a good ecological environment from the perspective of system construction.

Building ecological civilization is not simply environmental governance but requires changing the traditional economic development model and adhering to the path of green development. The purpose and focus of ecological civilization construction is to build a new civilization model that is different from the human civilization model based on healing the ecological gaps in the industrial civilization model, that is, to create an ecological endogenous economic development model.

Green development

As the level of civilization continues to improve, "green development" has transformed from a simple academic concept into a consensus on human development. Green development is derived from popular concepts such as circular economy, sustainable development, and low-carbon economy. It is a comprehensive summary and high-level summary of the above vocabulary. Green development involves the reform of traditional systems, and its essence is to promote economic and social development on the premise of ecological sustainability. On the one hand, green development not only focuses on development, but also pays more attention to environmental protection and resource conservation, placing the carrying capacity of resources and the environment in a more important position in economic development (Li, 2023).

While promoting development, we must always adhere to the maintenance of ecological and environmental safety. On the other hand, green development requires long-term economic and social development, which reflects the coordination and sustainability of development. Coordination and sustainability of development refer to the balance between population, resources, and the carrying capacity of the environment. We must consider not only contemporary development and utilization, but also the sustainable utilization of future generations to fully meet human needs. The core of green development is sustainable development, taking environmental factors as an intrinsic element of economic growth, maintaining the harmonious relationship between economy, society, and ecology through green development, and promoting the greening of the development model. Green development pays attention to the fairness of social development and the coordination of economic development and environmental protection, and ultimately aims to achieve people's happiness.

Organic ecological recycling systems are a sustainable approach to agriculture and ecosystem management that aim to maximize the use of natural processes and resources and reduce dependence on external inputs while minimizing negative impacts on the environment. The design goal of such a system is to establish an interdependent and coordinated development ecosystem so that various biological and ecological processes promote and support each other. Nanjing Agricultural University conducted a study on small-scale farmland ecosystem design. The research team chose to conduct experiments in the Nanjing area (Luo, 2022). The main purpose was to build an organic ecological recycling system by introducing a variety of plants and organic fertilizers. The core goal of the research is to optimize the ecological benefits of farmland and improve the quality of agricultural products. In this study, the team adopted a multi-plant cultivation strategy to introduce different types of plants to promote biodiversity within the ecosystem. At the same time, they focus on the use of organic fertilizers, avoid synthetic pesticides and chemical fertilizers, and advocate more natural agricultural management methods. This helps improve soil structure and soil fertility, thereby creating a more ideal environment for the growth of crops. This research is committed to establishing a closed-loop organic ecosystem so that resources can be recycled more effectively within the system. This includes the processing and conversion of organic waste into organic fertilizer, thus reducing agriculture's dependence on external resources. Through this sustainable design, the research team hopes to improve the ecological sustainability of small-scale farmland, while enhancing the quality of agricultural products and injecting more environmentally friendly and efficient elements into agricultural production.

The small home organic ecological recycling system is a method to achieve sustainable agriculture and resource recycling in a limited space. Such systems often include elements such as plant cultivation, organic waste disposal, and natural fertilizer production to promote food self-sufficiency and environmental friendliness in households (Wang, 2023).

Organic waste treatment is a key environmental practice that aims to effectively utilize organic waste generated in household life, such as fruit peels, vegetable residues, etc. The process includes waste sorting and composting, providing households with a sustainable approach to waste management. First, organic waste needs to go through a sorting step to distinguish compostable organic matter from other waste. This can be achieved through segregation bins or containers at household level, where organic waste is collected separately. This process is not only simple and easy, but also can minimize the pollution of other garbage by organic waste, providing purer raw materials for subsequent processing. Subsequently, the sorted organic waste can be converted into organic fertilizer in the organic composting process. A home compost bucket or compost bin is a highly effective way to allow family members to easily dispose of organic waste in a home environment. During the composting process, microorganisms break down organic waste to form nutrient-rich organic fertilizer. This organic fertilizer has good soil improvement and plant growth promotion effects, helping to improve soil fertility and water retention capacity. Through organic waste processing, households can reduce their burden on traditional landfills while also being able to recover and reuse the nutritional content of organic waste. This environmentally friendly practice not only benefits individual households, but also contributes to broader ecosystem health and sustainability.

2.2 Case Analysis

Composting technology is an effective method for resource utilization of biomass waste and has become a common process around the world.

After composting, the volume of food waste will be reduced by 30%-50%, which can achieve reduction. The industrialization of composting in foreign countries started earlier and has a variety of processes. For example, the United States is divided into treatment facilities for municipal sludge, food waste, garden waste, etc. based on different raw materials, with a total of more than 8,000 composting facilities (Chen, 2022).

Figure 2.1 Compost bucket type

Source: Researcher

China's compost industry is in a stage of steady development, and it is proposing applications in line with national conditions based on combining foreign technologies, including the application of composting microbial inoculants and the proposal of rapid composting processes. As the country pays attention to the composting industry, the development of composting technology has become more rapid. Accelerated research on the principles and processes of composting technology will also be conducive to its promotion and application.

Research on the principles of composting technology.

1) Aerobic composting is a process of food waste composting technology, which relies on aerobic microorganisms to decompose organic solids and transform them into humus, ultimately achieving harmlessness and stable decomposition to produce organic fertilizers. Organic fertilizer is dark brown in color, loose in texture, and has good fertilizer efficiency. During the composting process, when microorganisms decompose organic matter, the temperature of the pile will change accordingly, first rising and then falling. Temperature changes will affect the growth and reproduction of microorganisms, thereby affecting the speed of composting. At this time, ventilation, stirring, heating, etc. can be used to adjust the temperature and thereby regulate the composting process. The temperature change process of aerobic composting can be divided into three stages: warming, high temperature and cooling stages. In the early stage of composting, the internal temperature of the pile rises from room temperature to about 55°C to 60°C, which is also the optimal high temperature for composting. At this time, the decomposition efficiency of compost is the highest, and most pathogenic microorganisms can be killed, mainly affected by most thermophilic microorganisms. Moisture content, organic matter content and oxygen content affect the temperature rise rate. At the same time, when the temperature of the pile must not be too high (>70℃), timely heat dissipation is required. In the decomposition stage, the metabolic capacity of mesophilic microorganisms increases, and organic matter that is difficult to degrade in the high temperature stage will be gradually decomposed to form humus (Su, 2023).

2) Anaerobic fermentation means that food waste is converted into fertilizer under the metabolic decomposition activities of anaerobic microorganisms, and CO2 and methane will be produced during the fermentation period. Anaerobic fermentation can be divided into different types of fermentation processes based on different perspectives such as temperature and feeding methods. Different types of anaerobic fermentation processes are basically divided into early hydrolysis and fermentation stages, mid-term hydrogen production and acetic acid production stages, and final methane production stages. The first stage is the hydrolysis and fermentation stage, which means that anaerobic microorganisms hydrolyze large organic molecules and break their chains to form small molecular substances such as monosaccharides and amino acids. Acidogenic bacteria then further decompose small molecule substances and generate acetic acid, hydrogen, and other substances. Finally, the soluble nitrogen-containing compounds and organic acids produced are further decomposed to produce ammonia, nitrogen, carbon dioxide, methane, hydrogen, and other substances. Carbon dioxide can also be reduced to methane by hydrogen, and methane is also one of the main resources for energy utilization (Su, 2023).

The purpose of raw material pretreatment is to adjust the moisture content, C/N ratio, porosity, etc. of food waste, and to add bacteria that promote decomposition and fermentation. The general method is to add fluffing agents such as sawdust and straw, control the particle size to less than 50 mm through crushing, and finally adjust the moisture to about 55%, the pH value is 6.8~7.2, and the C/N is 25:1~30:1. At present, EM bacteria are a common and relatively mature compound bacterial agent. After pretreatment and inoculation, a fermentation is entered. In this stage, the compost temperature can rise to about 60°C, the moisture content decreases, and various inorganic nutrients are released, the organic materials become loose and dispersed, and harmful microorganisms such as pathogenic bacteria are killed, achieving the purpose of harmlessness. During primary fermentation, you need to start controlling the humidity, temperature, and oxygen content of the pile. On the one hand, forced ventilation is used to create a global aerobic environment and evaporate water at the same time; on the other hand, the fermentation materials are fully mixed through stirring, and the general stirring frequency is 4~8r/min (Luo, 2022).

After the first compost fermentation, the remaining organic matter needs to be further decomposed and stabilized, that is, the secondary fermentation, so that the garbage can be fully decomposed for subsequent fertilizer production. The main method is to pile the primary fermentation materials to a height of 1~2m and continue to use pile turning or ventilation to speed up the composting rate. Li Yuhua believes that different ventilation methods should be used in different stages. Forced ventilation is suitable for primary fermentation, and natural ventilation is suitable for secondary fermentation stage. After a composting cycle, when the compost is basically mature, the volatile matter and solid phase C/N ratio decrease significantly; the temperature remains around 30°C, and the oxygen consumption gradually stabilizes. At present, some institutions have developed a system for online real-time monitoring of compost oxygen, aiming to determine the end of the composting cycle through automated control methods.

To sum up, composting is a technology that uses microorganisms to convert kitchen waste into organic fertilizer, and it also has the function of sterilization and disinfection. Miniaturized and specialized container composting equipment is the future research and development direction. The Seattle Solid Waste Utilities Bureau planned to use composting technology to process yard waste and kitchen waste in 1986, which meant the beginning of home composting. In 2005, some European cities promoted complete sets of household food waste composting equipment. At the end of the last century, Japan began to develop and promote household food waste composters, and in 2000, Japan also promulgated a food waste recycling law to promote the use of household composters (Su, 2023).

In China, it was only after the 20th century that food waste composting technology began to be systematically studied and processes and results consistent with Chinese characteristics were gradually developed. For example, Shao Lei conducted multiple experiments through the control variable method and obtained different optimized process parameter combinations for household composting of kitchen waste. The Key Laboratory of Jiangnan University uses solar energy to realize intelligent control to provide energy to insulate and ventilate the designed compost bin. Wei Xinzhu designed a convenient and resource-based sustainable system for the utilization of kitchen waste based on residents' behavior in dealing with kitchen waste and the structure of home kitchens. A professor from Hunan University designed a household food waste composter based on the environmental characteristics and kitchen waste characteristics of Changsha. The Guangdong Provincial Modern Agricultural Equipment Research Institute has intensified its research to give existing food waste compost tanks without power systems automatic control functions and has promoted it in Shengshi Village in conjunction with the "balcony vegetable garden" plan. Zhao Yinghui improved and designed a garbage recycling and processing system based on residents' daily garbage classification habits and the Posica composting method of food waste, including garbage classification bins and compost bins with pre-stored food waste (Yang, 2021).

It can be seen from this that more and more scholars and experts are investing in the research field of household kitchen waste composting. At the same time, it can also be seen that the research direction of household composting of kitchen waste is not only the research in the technical field of composting. Compost products are also gradually designed with the user as the center. If composting can be carried out at the source under appropriate conditions and time, it can alleviate the pressure on the collection, transportation, and treatment of urban domestic waste in China and reduce costs to a certain extent.

Chapter 3

Question Research and Question Summary

3.1 Mixed Research Methodology

Questionnaire questions cover users' basic attributes, daily processing habits, and opinions on household ecological recyclable systems. A total of one hundred and twenty-one (121) valid questionnaires and twelve (12) invalid questionnaires were collected in this questionnaire survey.

The characteristics of the subjects were determined through age and family structure to ensure that the survey subjects of the questionnaire belong to the target user group of this article. In terms of age, 93.39% of the subjects meet the target user age group; in terms of family structure, 62.81% of small family users have options of one person, two people and three people. The occupations of users in this age group are mainly office workers and stay-at-home spouses, of which 68.6% are office workers. Under the setting of three conditions, the pertinence of this questionnaire is guaranteed to a certain extent.

Table 3.1 Age information of surveyed users

Generation	Number of people	Proportion
Under 20 years old	0	0%
21-30 years old	69	57.02%
31-40 years old	15	12.4%
41-50 years old	29	23.97%
Over 50 years old	8	6.61%
Number of valid entries for this question	121	

Table 3.2 Occupational information of surveyed users

Profession	Number of people	Proportion

Work	83	68.6%
Housewife/husband	36	29.75%
Retirees	2	1.65%
Number of valid entries for this question	121	

Table 3.3 Family structure information of surveyed users

Family size	Number of people	Proportion
One person	2	1.65%
Two people	22	18.18%
Three people	52	42.98%
Four people	26	21.49%
More than or equal to 5 people	19	15.7%
Number of valid entries for this question	121	

The questionnaire was conducted to investigate residents' knowledge and opinions on household ecological recyclable systems. The survey results show that 78.51% of users have a conceptual understanding of the home eco-recyclable system, 6.61% of users said they have tried to use the home eco-recyclable system, and 14.88% of users have no idea about it. This data shows that the promotion and application of household ecological recycling systems needs to be improved and there is a lot of room. And perceptions about the behavior of using home eco-recyclable systems at home.

Among the subjects, 61.16% of users valued resource utilization, saying that the home ecological recycling system can produce fertilizer and save the cost of purchasing fertilizer; 31.4% of users value the convenience of problem solving, saying that the home ecological recyclable system can solve the hygienic problem of storage, and can also achieve volume reduction, reduce the number of times and operations of personal daily disposal of kitchen waste, and provide convenience. To this end, the final design of the subsequent household ecological recycling system provides two directions, namely resource utilization and convenient disposal. In this survey, nine users expressed their unwillingness to use the home ecological recycling system, believing that the home ecological recycling system is more troublesome.

Table 3.4 Surveyed users' understanding of household ecological recycling systems

Users' understanding of home eco-recyclable systems	Number of people	Proportion
Never heard of	18	14.88%
Heard of it but never tried it	95	78.51%
Heard of it and already using it	8	6.61%
Number of valid entries for this question	121	

Table 3.5 Surveyed users' opinions on household ecological recyclable systems

Users' understanding of home eco-recyclable systems	Number of people	Proportion
Willing to use. The household ecological recyclable system can achieve resource utilization, conform to personal interests in growing flowers and grass, and can also save the cost of chemical fertilizers.	74	61.16%
Willing to use. The household ecological recyclable system can solve the hygiene problem of storage and achieve volume reduction, which can reduce the number of personal discards and operations.	38	31.4%
Unwilling to use. Home ecological recycling system is more troublesome	9	7.44%
Number of valid entries for this question	121	

Based on users' views on the home ecological recyclable system, the questionnaire further investigated the four aspects of the user's functional characteristics, human-machine operation, composting effect, and appearance of the home ecological recyclable system. Sort by importance. Functional characteristics are the most important, followed by operability, effect, and finally appearance. Based on the ranking results of importance, users pay more attention to issues related to home ecological recycling systems. That is, issues such as deodorization, drying, sterilization, classification, convenient disposal, and mobility. The application of household ecological recycling systems is an added-value function of garbage disposal for users. Therefore, only by dealing with the storage and disposal issues related to kitchen waste will it be more conducive to the application of household ecological recycling technology and its integration into the daily life processing process of users. The storage and disposal issues related to kitchen waste are solved according to the functional priorities mentioned above.

Table 3.6 Ranking of the functional importance of household ecological recycling systems by surveyed users

Functions of home eco-recyclable systems	Average overall score
Features	3.35
Operability	2.78
Effect	2.23
Appearance	1.64

Based on the comprehensive research findings detailed in previous sections, the realization of food waste recycling at the source necessitates a dual-faceted approach. This strategy involves, firstly, the design of household ecological recycling system equipment and, secondly, the development of a conceptual framework for a fertilizer circulation service platform. Each of these perspectives plays a pivotal role in ensuring the effective recycling of food waste, contributing to the broader goals of sustainability and ecological balance. In conclusion, the design criteria for household ecological recycling system equipment are categorically organized into three primary tiers: hygiene, controllability, and ease of use.

Hygiene: This fundamental aspect underscores the necessity for the system to meet stringent hygienic and health standards, incorporating features such as sterilization, deodorization, and leak prevention during the waste handling process. Ensuring the hygienic processing of food waste is crucial for user acceptance, as it directly impacts the health and safety of the household environment.

Controllability: Controllability pertains to the simplicity and intuitiveness of operating the household ecological recycling system. This involves designing the system in such a manner that users can easily manage and control the recycling process, making the technology accessible and user-friendly. The objective is to demystify the technology, enabling users to engage with the system confidently and effectively.

Ease of Use: Ease of use extends beyond simple operational aspects to include the optimization of functions that address kitchen waste hygiene concerns. This involves streamlining the system's interface and functionalities to ensure that users can effortlessly navigate and utilize various features, thereby enhancing the overall user experience.

Hygiene serves as the foundation for user adoption of food waste treatment equipment, establishing the essential conditions for a clean and healthy home environment. Meanwhile, controllability and ease of use significantly contribute to improving the user experience with the household ecological recycling system equipment. By prioritizing these design requirements, developers can create an ecological recycling system that not only addresses the technical challenges of food waste recycling but also aligns with the daily needs and preferences of users, fostering a more sustainable and eco-friendlier lifestyle.

3.2 Qualitative Research

The researcher executed an in-person questionnaire survey by visiting various public spaces such as parks, squares, and supermarkets to interview diverse individuals (Figure 3.1). The analysis of the questionnaire responses indicates a contemporary emphasis among the public on environmental safety concerns.

Figure 3.1 Photos from the interview

Source: Researcher

Through the analysis of the data collected from the questionnaire survey, it has been discerned that a significant majority of respondents express a willingness to implement the family eco-cycle system (Figure 3.1). This indicates a positive reception and a potential readiness among households to adopt sustainable waste management practices within their daily routines. Furthermore, a considerable portion of the survey participants offered constructive suggestions for the development of a new family ecological cycle system (Figure 3.2). These recommendations provide valuable insights into the expectations and preferences of potential users, highlighting areas for innovation and improvement in the design and functionality of the system. The feedback underscores the importance of user-centric design principles in the development of ecological recycling systems, ensuring they meet the practical needs and environmental values of households. This collective willingness and the proactive engagement of participants in suggesting enhancements demonstrate a growing awareness and commitment towards environmental sustainability and the pivotal role of individual actions in fostering ecological balance.

Questionnaire Survey (A total of one hundred people were interviewed.)

Figure 3.2 Photos from questionnaire feedback form

Source: Researcher

Following the questionnaire survey, in-depth interviews were conducted with two individuals to garner further insights into their perspectives on the family eco-cycle system, as illustrated in Figure 3.3. The primary aim of these interviews was to delve deeper into the actual needs, concerns, and suggestions of potential users regarding the implementation and functionality of the eco-cycle system. This qualitative approach allowed for a more nuanced understanding of customer attitudes and expectations, providing valuable context to the quantitative data previously collected.

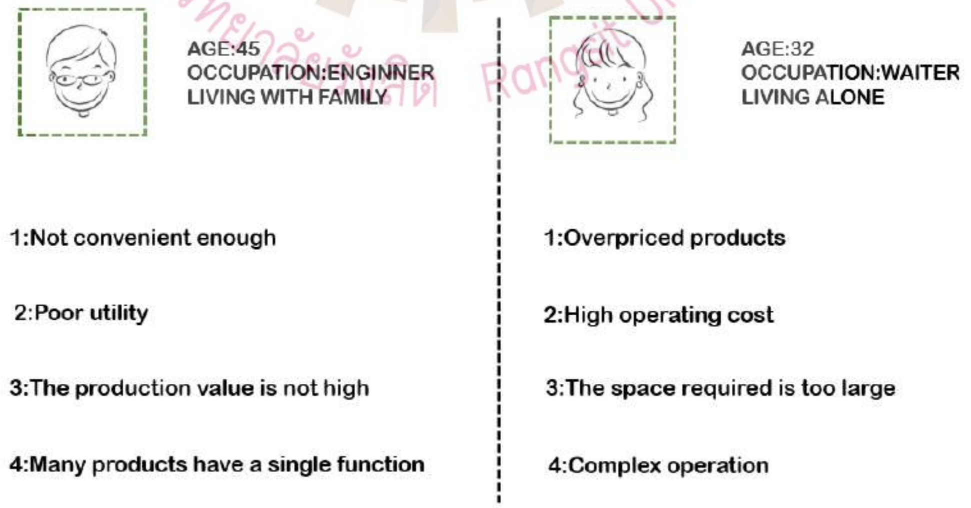

Figure 3.3 In-depth interview information summary

Source: Researcher

Through comprehensive research conducted, the design concepts for the family eco-cycle system have been categorized into three distinct parts, as depicted in Figure 3.4. This strategic division serves to streamline the focus on essential components of the system, ensuring a thorough examination of each aspect in relation to its contribution to sustainability, user-friendliness, and ecological balance. In an effort to innovate and refine the system, various combinations of these design ideas were experimented with. This approach allowed for a creative exploration of potential synergies between different elements of the system, aiming to enhance its overall efficiency and appeal to users.

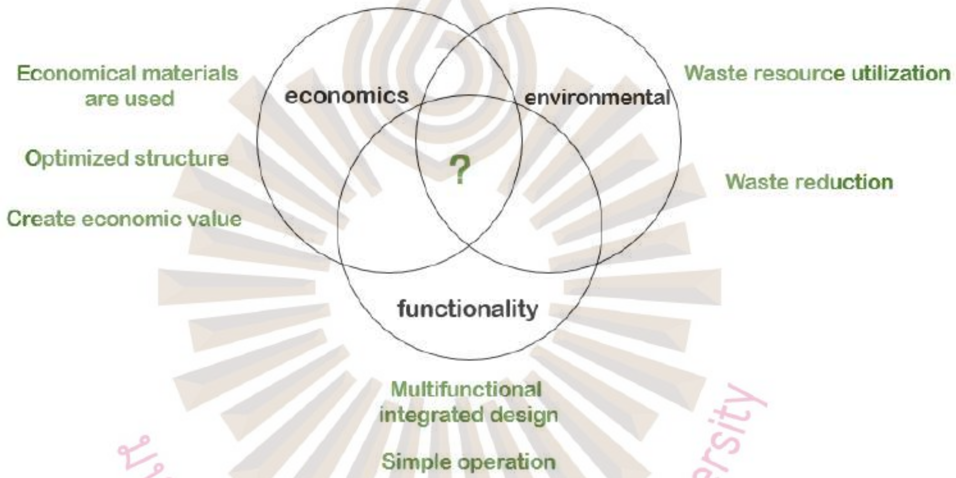

Figure 3.4 Attempt 1 of design ideas

Source: Researcher

Building on the comprehensive research conducted, the design concepts for the family eco-cycle system were systematically segmented into three primary categories, as illustrated in Figure 3.4. This categorization was instrumental in isolating critical facets of the system, thereby facilitating a focused analysis of each segment. In pursuit of innovation and enhancement within the system, various combinations of these design ideas were experimented with.

The price and operating costs of the product are too high for everyone.

The prevailing high pricing and operational expenses associated with many products pose constraints on their universal adoption across households, particularly among economically disadvantaged segments. The substantial initial investment and ongoing operational costs present challenges for certain families in embracing advanced technologies. The imperative lies in ensuring equitable access to eco-friendly solutions irrespective of a family's financial standing. Manufacturers are anticipated to address this challenge by optimizing production costs and employing cost-effective materials to lower product pricing. Simultaneously, governments can institute enhanced economic incentives, such as tax incentives or subsidy initiatives, to facilitate a broader spectrum of households incorporating these environmentally sustainable technologies. This approach facilitates the plausible extension of family ecological cycle systems across diverse socio-economic strata, catalyzing societal progress toward sustainable development objectives.

The reuse rate of waste is low, and the input cost is higher than the output value. The household ecological recycling system is faced with a series of challenges, which are characterized by unsatisfactory recycling rates, and the inability to dispose of waste effectively and accurately, and the input cost exceeds the corresponding output value. Inadequate reuse of waste impairs the overall efficiency of the system, while the economic burden of rising input costs poses a significant obstacle to its viability.

Addressing the issue of singular functionality and enhancing the product's convenience for resource recycling.

In order to surmount the challenge posed by a singular product function, it is imperative to establish a holistically integrated ecological cycle system. Through profound integration of diverse functionalities encompassing waste treatment, water management, and energy utilization, the objective is to forge a comprehensive and highly efficient system. This integrated framework endeavors to tackle waste-related issues through diversified approaches, elevating reusability, while concurrently minimizing environmental impact via advanced water management and energy utilization technologies. The system's design prioritizes user-friendliness, facilitating seamless participation of family members in the resource recovery process, thereby concurrently advancing sustainable development, and enhancing overall quality of life.

Chapter 4

Design Process

4.1 Design Concept

The integrated household recycling system is designed with a holistic approach to address environmental concerns while prioritizing user-friendliness, economic viability, and operational efficiency. The following key features and principles embody the design concept:

Resource Efficiency and Waste Minimization: Employ advanced sorting and separation mechanisms to maximize resource recovery from household waste. Integrate smart sensors and AI algorithms for precise sorting, minimizing contamination and ensuring higher material purity. Emphasize the reduction of single-use materials through education and incentives for sustainable packaging.

Optimized Waste Reuse: Facilitate easy identification and separation of reusable items within the waste stream. Include designated compartments for reusable materials, promoting a circular economy within the household.

Advanced Waste Treatment Technologies: Integrate state-of-the-art waste treatment technologies such as composting units, anaerobic digesters, and bioconversion systems to process organic waste efficiently. Implement technologies for the safe disposal and recycling of hazardous waste, minimizing environmental impact.

Water Resource Management: Utilize water-saving features in the system, incorporating technologies like water filtration and purification for safe and efficient water reuse. Implement a closed-loop water recycling system to reduce the overall water consumption within the household.

Energy Efficiency and Renewable Energy: Prioritize energy-efficient components and systems to minimize the carbon footprint of the household recycling system. Integrate solar panels or other renewable energy sources to power the system, reducing reliance on traditional energy grids.

User-Friendly Design: Design an intuitive interface for easy operation, ensuring that users of all ages can actively participate in recycling efforts. Provide informative feedback on recycling habits and environmental impact, fostering a sense of responsibility and awareness.

Affordability and Economic Value: Strive for cost-effective materials and manufacturing processes to ensure the affordability of the household recycling system. Highlight the economic benefits, such as potential savings on waste disposal fees and reduced environmental impact, to attract a wide range of consumers.

Environmental Education and Awareness: Include educational features within the system to inform users about the environmental impact of their actions. Promote sustainable living practices and eco-conscious behaviors through interactive guides and notifications. By combining these principles, the integrated household recycling system aims to not only enhance environmental sustainability but also make a positive impact on users' lives by promoting economic efficiency, ease of use, and environmental awareness.

4.2 Design Attempt

The initial model iteration, as showcased in Figure 4.1, presents a design concept that utilizes aquarium wastewater for plant irrigation. This design, characterized by its simplicity, embodies a foundational approach to integrating waste recycling within household ecosystems. However, its functionality is notably singular, focusing exclusively on the redirection of nutrient-rich water from fish tanks to support plant growth.

While this concept capitalizes on the symbiotic potential between aquatic and terrestrial systems, its practical applicability faces certain limitations. The model's singular function, though innovative, may not fully address the broader spectrum of household waste management needs or the complexities of achieving a balanced ecological cycle within a domestic setting. The design's simplicity, while advantageous for ease of use and initial implementation, may restrict its capacity to engage with a wider array of organic waste types or to significantly impact the household's overall sustainability practices.

This initial design attempt highlights the critical balance between simplicity and functionality in the development of ecological recycling systems. It underscores the need for further innovation and design exploration to enhance the system's practicality and broaden its ecological impact. Future design iterations could explore multi-functional systems that incorporate additional forms of waste recycling, advanced filtration techniques, or modular components that allow for customization based on specific household needs. By expanding the scope and capabilities of the system, the design can evolve to offer a more comprehensive solution for sustainable household waste management.

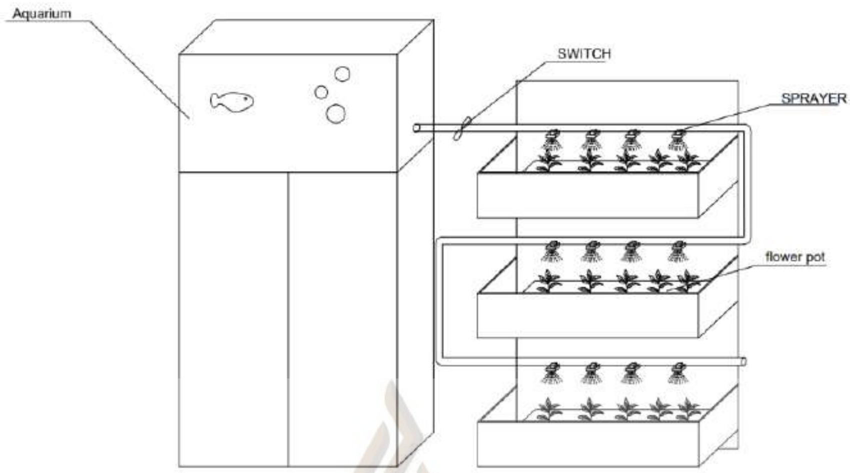

Figure 4.1 The first version of the model

In the progression of design exploration, the second version of the model, depicted in Figure 4.2, represents a more integrated approach by combining a fish tank, a flowerpot, and a trash can to form an ecological cycle system. This iteration aims to create a more cohesive ecosystem within the household, leveraging the natural symbiotic relationships between aquatic life, plants, and organic waste decomposition.

However, this version encounters operational challenges that limit its effectiveness and user experience. The integration of different components, while conceptually innovative, results in a system where interconnectivity and ease of use are not optimally achieved. Users find the operation of the system inconvenient, indicating a disconnect in the seamless flow between the system's components. Furthermore, the model's design does not facilitate a high degree of resource utilization, failing to capitalize fully on the potential for recycling and reuse within the household ecological cycle.

The feedback on this model iteration underscores the importance of user-centric design principles in the development of ecological recycling systems. For a system to be effective and embraced by users, it must not only embody the principles of ecological sustainability but also prioritize convenience, ease of operation, and the efficient use of resources.

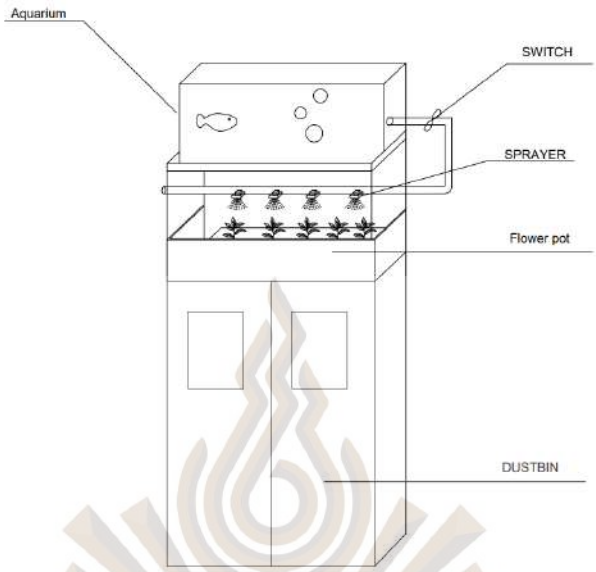

Figure 4.2 The second version of the model

4.3 Usage Scenario Display

The household recycling system has different functional requirements for different usage scenarios, including the scenarios when users put in kitchen waste, take out fertilizer, and dispose of excess fertilizer.

1) Feeding scene display

In the feeding scenario, it mainly involves the placement of kitchen waste, the placement of packaging bags and other garbage, and the addition of bacterial litter. When placing garbage, it is necessary to ensure the simplicity, ergonomics, and consistency of the user's actions. In the design of this plan, the height of the composter is 37cm, which is higher than ordinary traditional trash cans, which reduces the user's bending action and also solves the user's need for kitchen waste classification. Compared with the previous solution, both categories of trash cans adopt a sealed flip-top design to improve the hygiene of garbage disposal. In addition, in order to facilitate users to add strains, this solution designs the position of the strain box on the top floor, making it convenient for users to complete relevant operations directly after adding it. The functional design related to the feeding scenario of this solution can effectively solve the garbage classification needs of urban small family residents and the convenience of the composting process.

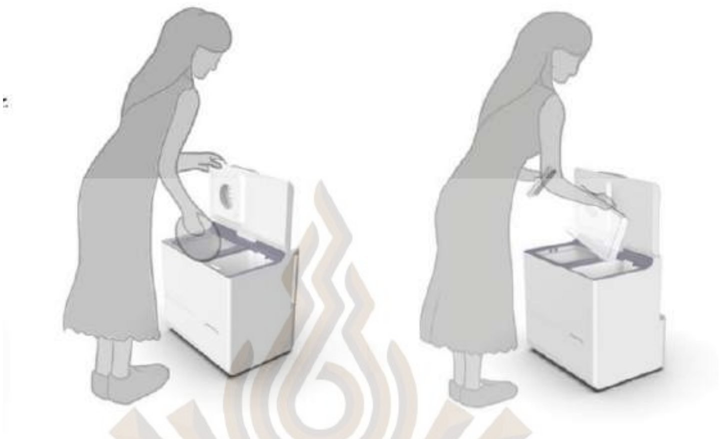

Figure 4.3 Garbage placement scene (a), strain addition scene (b)

2) Material collection display

The feeding method of this product is different from that of household recycling systems. It adopts the feeding method of top in and bottom out to avoid the mixing of fresh materials and active fertilizers in traditional compost barrels. At the same time, the top-in and bottom-out design can ensure that users can put in food waste every day. In the material retrieval scenario of this product, it mainly involves the design of the material retrieval port and fertilizer storage box. The main consideration in the design of the feeding opening is the location and size of the opening, to ensure that users can easily take out suitable fertilizer. The material discharging port adopts a push-type buckle design, and the user can easily open the material discharging port to take out materials. In addition, the removal direction of the storage box is consistent with the direction of the material inlet, which reduces the space occupation rate of the composting equipment. At the same time, it can ensure that the user can complete the action at the same position when performing the material retrieval operation, ensuring the continuity of the process. The design of the storage box effectively solves the problem that users need to prepare additional storage bags or boxes to store fertilizer when using traditional compost buckets.

Figure 4.4 The material retrieval scene diagram

3) Mobile scene display

Since the scenarios where food waste is generated are inconsistent with the scenarios where fertilizer is used, there is a need to move equipment or fertilizer. Considering the power supply and other conditions, the user can directly take out the modularly designed compost barrel and move it to the required place for use. The modular design of the compost bucket is shown in the figure below, and the handle connection is used as a fixing device for the compost bucket. At the same time, the compost bucket has its own material inlet, which uses a push button to switch the material inlet, and the inside of the bottom adopts an inclined design, which solves the pain point of difficulty in digging fertilizer inside the bottom on the market. The inclined space can be used for heating wire and fan systems. In addition, the use of top-in and bottom-out methods and the shortening of the aerobic composting cycle improve the output rate of active fertilizers. For small household users in first- and second-tier cities, excluding the fertilizer required for the cultivation of flowers, fruits and vegetables, the high output rate leaves a surplus of fertilizer. In this case, excess active fertilizer can be donated to community greening or farms in need, which can effectively expand the circulation channels of organic fertilizers.

Figure 4.5 Compost bucket moving scene diagram

4) Product usage environment display

The usage environment of the product is shown in the figure below, which is mainly used in the kitchen and balcony.

Figure 4.6 Kitchen environment display diagram

Figure 4.7 Balcony usage environment display

4.4 Final Design

Integrate the product into a seamless ecological cycle, amalgamating collection, processing, and utilization into a unified system.

Figure 4.8 Analysis of household waste recycling machine

Source: Researcher

The designed product incorporates a trash can in the lower-left section, strategically divided into two compartments: one for organic waste collection and another for non-decomposable waste. The organic waste section at the bottom is covered with soil to create a habitat for earthworms. These earthworms play a crucial role in breaking down organic waste naturally. Additionally, the product features two drawers for convenient cleaning and maintenance purposes, ensuring efficient waste management and promoting a sustainable and user-friendly design.

Figure 4.9 Product detail drawing

Source: Researcher

In the upper section of the product design, there is a fish tank situated above the trash can. Positioned above the fish tank is a U-shaped flowerpot. To facilitate water management, a faucet has been installed in the lower right section of the fish tank, allowing for the efficient removal of wastewater. Simultaneously, water can be imported into the system through the gap located in the upper left corner of the fish tank. This integrated water circulation system ensures the proper maintenance of the aquatic environment and supports the overall ecological balance within the product.

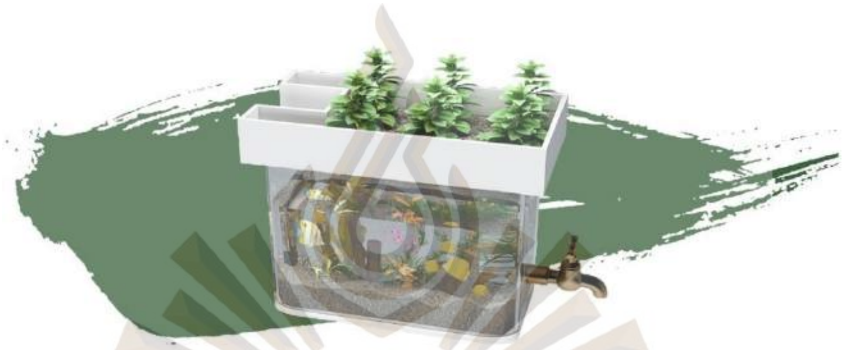

Figure 4.10 Product detail drawing

Source: Researcher

To enhance the waste management system, a composter is positioned on the right side of the trash can. The composter is strategically designed to create a ramp that connects to the trash can, facilitating the smooth flow of decomposing garbage into the composter. This interconnected design streamlines the disposal process, allowing organic waste to fall seamlessly into the composter. Furthermore, the composter benefits from a mixture of water sourced from the fish tanks, enhancing the decomposition process with the assistance of earthworms. This approach promotes a more efficient and integrated waste recycling system within the product.

Figure 4.11 Product detail drawing

Source: Researcher

Positioned above the composter is an innovative area housing both a hand generator and a water wheel designed for electricity generation. The water wheel is strategically positioned to harness the impact of water flowing from the tap, effectively converting it into electricity. Simultaneously, a hand generator, equipped with a manual handle, provides an alternative method for electricity generation. This dual-purpose approach maximizes the utilization of limited resources, ensuring a sustainable and efficient energy generation system within the product.

Figure 4.12 Product detail drawing

Source: Researcher

In the upper right area, a water pump and lighting unit are strategically placed. The water pump is responsible for circulating the mixture of waste water and organic waste from the composter, serving as a nutrient-rich irrigation solution for the plants in the pot. Simultaneously, the electricity generated by both the water wheel and the hand generator is harnessed to power the integrated lighting system, ensuring a sustainable and interconnected functionality within the designed product.

Figure 4.13 Product detail drawing

Source: Researcher

In the endeavor to develop products that epitomize the sustainable use and reuse of resources, the focus has been placed on creating systems capable of processing organic waste and wastewater. This initiative is grounded in the transformative concept of converting waste into valuable resources, thereby not only mitigating environmental impact but also generating economic benefits for households. The driving philosophy behind this product design is to embody the principle of "turning waste into treasure," aligning with broader objectives of environmental stewardship and sustainability. This approach heralds the adoption of a green economic model, which is meticulously designed to enhance resource efficiency and minimize the reliance on virgin resources. By integrating mechanisms for the treatment and repurposing of organic waste within household operations, the product seeks to establish a closed-loop system. This system is intended to recycle nutrients and water, providing a sustainable source of inputs for domestic agriculture or landscaping, thus illustrating a practical application of circular economy principles in everyday life.

The economic benefits derived from this model are twofold. Firstly, it reduces household expenditure on fertilizers and water for gardening purposes by supplying nutrient-rich compost and reclaimed water. Secondly, it potentially offers an avenue for households to engage in small-scale production of organic produce, further aligning with the ethos of self-sufficiency and sustainability. Furthermore, this green economic model contributes significantly to sustainable development by reducing the environmental footprint of households. It does so by diverting organic waste from landfills, thereby mitigating methane emissions, and by conserving water, a critical resource increasingly under stress from overuse and climate change.

In essence, the design of such products embodies a holistic approach to sustainability, weaving together the threads of environmental conservation, economic viability, and social well-being. Through innovative design and practical application, it aspires to not only redefine household waste management practices but also to inspire a shift towards more sustainable lifestyles, contributing to the global efforts in sustainable development.

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

In conclusion, the integration of design innovations in waste management, composting, energy generation, and eco-recycling within this small ecosystem demonstrates an exceptional level of versatility and ingenuity. The concerted efforts in transforming waste into valuable resources, coupled with the efficient treatment and reuse of organic waste, contribute to the establishment of a sustainable and eco-friendly model.

The incorporation of energy generation devices, including water wheels and hand generators, not only adds a dynamic facet to the ecosystem but also addresses the crucial need for sustainable energy sources. This holistic approach not only fosters energy self-sufficiency but also establishes a green living environment within the confines of a home.

The promising results achieved by this system underscore its efficacy in promoting waste recycling and paving the way towards a more sustainable future. By exemplifying a harmonious coexistence between human activities and the environment, this small ecosystem serves as a beacon of inspiration for communities and individuals seeking environmentally responsible solutions.

As we move forward, the lessons learned from this innovative model can guide future endeavors in creating self-sustaining ecosystems that not only manage waste effectively but also harness renewable energy, fostering a balance that aligns with the principles of a circular and regenerative economy. Through ongoing commitment to such initiatives, we can collectively strive towards a greener, cleaner, and more sustainable world for generations to come.

5.2 Recommendations

To enhance the practical application of this small ecosystem, several key improvements can be implemented. Firstly, the waste sorting system requires further optimization to ensure a more precise separation of organic and non-organic waste, thereby enhancing the overall efficiency of waste treatment. By fine-tuning this aspect, the ecosystem can better capitalize on its potential for resource recovery and recycling.

Secondly, the performance of the water wheels and hand generators should undergo careful adjustments and enhancements to ensure that the energy generated can consistently meet the power needs of the home. This entails refining the technology to maximize output and reliability, ensuring a seamless integration of sustainable energy sources within the system.

Consideration should also be given to the integration of an intelligent control system, enabling automatic monitoring and regulation of the entire ecosystem. This step not only streamlines the operational processes but also elevates the overall intelligence of the system, making it more adaptive to varying conditions and user requirements.

Furthermore, to better serve the needs of the family, the ecosystem can explore the incorporation of convenient functions such as intelligent reminders and remote monitoring. These additions not only improve the user experience but also foster a more user-friendly interface, encouraging widespread adoption and acceptance.

With ongoing development and refinement, this small ecosystem holds the potential to evolve into a comprehensive solution for sustainable living. By addressing these areas of improvement and incorporating user-friendly features, the system can better cater to the diverse needs of families, offering a completer and more convenient framework for embracing sustainable lifestyles. As we continue to refine and expand upon this innovative model, it serves as a testament to the boundless possibilities of integrating eco-friendly practices into our daily lives for a brighter and more sustainable future.

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Appendix

Parent-child toys

1. Awareness and Motivation

Question: How familiar are you with small-scale organic ecological recycling systems?

Follow-up: What motivated you to learn about or implement such systems in your daily life?

2. Current Practices

Question: What energy-saving and green living practices are you currently implementing in your home or community?

Follow-up: How do these practices contribute to your overall environmental goals?

3. Benefits and Challenges

Question: What benefits have you observed from using a small-scale organic ecological recycling system?

Follow-up: What challenges have you encountered in implementing these systems?

4. Environmental Impact

Question: How do you believe these systems impact environmental safety and sustainability?

Follow-up: Can you provide any specific examples or data to support your view?

5. Community Engagement

Question: How important is community involvement in the success of ecological recycling systems?

Follow-up: What steps have you taken to engage your community in these initiatives?

6. Technological Integration

Question: What technologies have you found most effective in enhancing the efficiency of your recycling system?

Follow-up: Are there any new technologies you are considering for future use?

7. Educational Efforts

Question: What educational resources or programs have you found helpful in understanding and implementing green living practices?

Follow-up: How do you think education on these topics can be improved for the general public?

8. Policy and Regulation

Question: What role do you think government policies and regulations play in promoting energy-saving and green living initiatives?

Follow-up: Are there specific policies you believe could better support small-scale ecological recycling systems?

9. Economic Considerations

Question: How do cost factors influence your decisions regarding energy-saving and green living practices?

Follow-up: Have you found any cost-effective solutions or financial incentives that support these initiatives?

10. Future Outlook

Question: What are your future plans for expanding or improving your ecological recycling system?

Follow-up: How do you see the role of small-scale recycling systems evolving in the next 10 years?

Biography

Name	Haitao Guan
Date of birth	October 25, 1994
Place of birth	Fujian/Nanpin China
Education background	Yuannan University
	Bachelor of Environment design, 2022
	Rangsit University
	Master of Fine Arts in Design, 2024
Address	Sihe street, Yanping district, Nanping City, Fujian Province, China
Email Address	1623574018@qq.com