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How South Korea's waste management system becomes a model for the world: What Indonesia can learn from South Korea's experience

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Abstract

This article explores South Korea's waste management system, focused on effective food waste management, a key factor contributing to the country's overall success in waste management. The effectiveness of the South Korean system has made it a case study model for government officials in other countries since the issue of waste management has become one of the prominent challenges for many countries to this day. This article used qualitative method, relying on journal references from the Scopus database with additional references obtained through Harzing's Publish or Perish. The data analysis used Nvivo 14 and VOSviewer to map and visualise the findings across all the compiled references. The findings showed that South Korea's renowned efficient waste management system focuses on key aspects such as government initiatives, waste segregation, pay-as-you-throw system, recycling facilities, waste-to-energy plants, public awareness, education, enforcement, and penalties. Indonesia here needs to explore and adopt several initiatives and strategies for efficiently managing various types of waste. This imperative arises particularly in light of the UNEP Food Waste Index 2021 report, which reveals that Indonesia has emerged as the Southeast Asian country with the highest food waste production.

Keywords: Indonesia; management; system; South Korea; waste

1. Introduction

The waste is a problem faced by all communities in various environments (Hendra 2016). The waste or rubbish produced might come from personal consumption and other activities such as office operations, laboratories, and other activities (Utama, Ambariyanto, and Samudro 2018). The waste problem increases along with population growth and urbanisation, making it easy for trash bins to fill up, making waste management ineffective (Roy et al. 2022). Increasing waste and its inappropriate management, in turn, can endanger human health and the environment (Hutajulu et al. 2022). The problem of waste and its management is serious in many countries, requiring them to issue various policies to overcome the problem (Khair, Rachman, and Matsumoto 2019). One of these countries is South Korea.

As a developed country, South Korea always requires large amount of energy sources, also causing an increase in waste produced from various kinds of intensive activities in urban areas to agricultural activities (Nam and Konishi 2019). The increase in industrial activities in South Korea means more and more waste are produced, making it difficult for Korea to deal with it (Kim and Phae 2022). From 1998 to 2017, household waste production in Korea increased rapidly, so the government prioritised waste management, especially recycling household waste (Jung et al. 2021).

To overcome the waste problem, the South Korean government issued various policies, such as a policy that requires people to sort waste that can be recycled, pay waste management fees according to the number of scales of waste produced, as well as a policy requiring every company to collect and recycle their waste, especially waste from paper products, plastic, glass, cans, batteries, lubricants, and electronic products (Saraswati 2023). For this reason, South Korea's efforts to overcome the waste problem have shown good results. According to data from the Organization for Economic Cooperation and Development (OECD), Korea has the highest recycling rate among other member countries, with the highest recycling percentage being food waste from 2% to 95% (Chang et al. 2022). Apart from requiring materials that are easy to decompose and recycle, Korea also implements multi-functional containers to anticipate and reduce food packaging waste. This is done because South Korea experiences a rapid growth in the food delivery industry, which sparks government concerns about increasing food packaging waste (Jang, Nam Kim, and Woo 2023).

To overcome the problem of food waste, a solution is needed that does not merely focus on dealing with existing waste. The government needs to change priorities that also centre on prevention, such as reducing waste sources, recovery, and recycling, including by converting waste into other energy using technology (Richa and Ryen 2018). South Korea is trying to implement this prevention by encouraging

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the conversion of food waste into biogas, as done by China, England, France, and Germany (De Clercq et al. 2017).

South Korea is currently considered capable of meeting the waste challenge, especially food waste in urban areas. This country has become a smart city model with best practices in building its cities through strong policies and regulations regarding waste management, thereby successfully increasing recycling and reducing waste (Yi and Yoo 2022). Several countries, such as Japan and the United States, are interested in Korea's way of dealing with waste and are then exploring alternative possibilities for recycling (Kim 2023).

Based on this, this research aims to explore the waste management system in South Korea with special attention to food waste management, as well as whether Indonesia can adopt the main keys to Korea's success in overcoming this waste problem.

2. Methodology

This article used qualitative research method with the main data collection technique being the Scopus database. Some additional data were collected using Harzing's Publish or Perish application. The data were collected from a number of journals relevant to this article's topic.

This article used Nvivo 14 to code and organise the data imported from RIS files for data analysis. The authors employed a framework matrix to facilitate the analysis of relevant data for discussing their findings. Additionally, VOSviewer was used to create data visualisations, displaying co-occurrence relationships among keywords. This step was crucial for mapping relevant topics related to the issue. All collected references were converted into a single RIS file using Mendeley to produce these visualisations. The RIS data were then processed by VOSviewer, which generated a network of related keywords, as shown in Fig. 1.

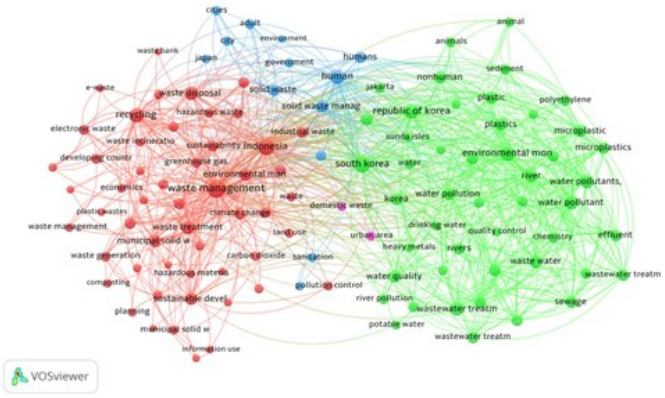

Fig. 1. Co-occurrence of waste management in Indonesia and South Korea

3. Results and Discussion

3.1. Comprehensive waste management system in South Korea

South Korea considers food waste as a critical problem. This is proven by continuously reviewed policies and assessments in the effectiveness of policies on reducing waste and recovering energy and materials from waste (Um et al. 2018). The Korean government realizes that dealing with waste is not simple; therefore, it is trying to prioritise waste reduction by giving responsibility to producers and consumers through a comprehensive waste management system (Marshall 2022). Here are some important aspects of South Korea's waste management system:

3.1.1. Waste sorting

South Korea emphasises selecting waste based on its source, and the public must sort waste into categories such as food waste, recyclable waste, non-recyclable waste, and hazardous waste (Park 2018). The government also pays great attention to this waste separation, providing various trash bags for every kind of waste. These trash bags are also different in each district; people must use them according to their environment (Summer School Hanyang 2022). Waste sorting is divided into three categories: general waste, food waste, and recyclables such as paper, iron, plastic, cans, vinyl, styrofoam, and glass (M. Lee, Choi, and Koo 2017). General waste will be burned or buried, including tissue, sanitary napkins, shoes, and used clothes (Defitri 2022).

Meanwhile, food waste has a more specific sorting process and will be processed through composting or anaerobic digestion to produce fertilisers. Moreover, food waste is used as animal feed. Therefore, when disposing of food waste, it is necessary to take action such as washing, separating, and disposing of dangerous substances from the food, then putting it in a standard plastic waste bag that has been determined (Migration to Asia Peace 2022). Apart from that, food waste is processed into biomass or organic methane elements, the results of which are very similar to the analysis of actual solid methane elements (Lee et al. 2016). South Korea uses advanced technology, using waste-derived fuel from waste to produce artificial diesel fuel from synthesis gas (Nam and Konishi, 2019).

Furthermore, recyclables such as paper, iron, plastic, cans, vinyl, styrofoam, and glass are collected, sorted, and sent to recycling facilities to be reprocessed into new products. This practice significantly decreases the demand for virgin materials, conserving natural resources and reducing energy consumption. Through these waste management strategies, communities can mitigate environmental pollution, enhance resource efficiency, and foster a more sustainable future. With this, a new alternative is created for the South Korean government to solve the problem of increasing energy needs and waste management.

3.1.2. Pay-as-you-throw system

Apart from sorting waste types, South Korea also implements a waste payment system based on the amount of waste or volume. Before Seoul adopted this system in 2013, the initial waste disposal fee system based on the amount of garbage was tested in the Jung-gu commercial area in 1995, where the government provided waste bags in the sizes of 2, 3, 5, 10, 20, 30, 50, 75, and 100 litres. Usually, a 20-litre bag costs approximately KRW 340 and 400 (Yoo 2014). The greater the production of community waste, the greater the costs must be incurred (Rijayanti et al. 2020). In other words, the waste produced by the community and collected into trash

bags must be purchased by the community.

This waste fee system also influences recycling performance in South Korea, which has received a high ranking from the OECD organisation (Park 2018). Government policy effectively addresses the problem of reducing household food waste in South Korea because incentives to households for waste make them plan their purchases in advance and only buy what they need rather than buying in large quantities from stores (Wang, Kim, and Kim 2023). In other words, reducing purchases that cause waste can also minimise waste recycling activities.

3.1.3. Food waste recycling facilities

Not only does the government sort waste according to type, but the government also requires people to carry out the recycling process. A simple example is separating and returning the bottles of drinks purchased and exchanging them for a security deposit according to the purchase price of the drinks (Rijayanti et al. 2020).

Apart from that, in supporting the community to participate in reducing the generation of food waste and recycling, the government has facilitated apartment residential complexes with special trash bins that use Radio-Frequency Identification (RFID) technology to calculate the costs of various waste that must be paid for (Lee and Jung 2018). For apartment residential complexes, waste management is regulated in a special policy. Previously, waste management used a group incentive system for residents living in apartments, where they paid the same price by dividing the total waste costs between each apartment resident. However, because it was less effective in reducing waste, the government then changed its policy by requiring each apartment resident to bear the cost of their waste according to the number of scales measured using RFID (Lee and Jung 2017). RFID is an influential innovation in reducing household waste production because the system accurately measures the waste volume and the total costs charged to each household (Rijayanti et al. 2020).

South Korea also has factory infrastructure facilities to complete the recycling process of collected food and plastic waste. This country is building a number of environmentally friendly facilities that minimise waste and carbon emissions through recycling and applying AI technology to produce high-quality polyethene terephthalate (PET) or PET plastic (Lee 2022). As for food waste, apart from having a mobile (conventional) waste collection system, Korea also has an automatic pipe-based vacuum collection system, which has only been tested in several densely populated areas. The collection system with pipes, called as Automated Pipeline-based Vacuum Collection (AVAC), have been created for reasons other than reducing costs; the application of AVAC is also efficient, hygienic, and environmentally friendly (Oh et al. 2016).

Food waste is collected and processed in biogas facilities, which produce methane gas and anaerobic production, such as chemical oxygen and nitrogen (DJ Lee et al., 2017). Food waste is also recycled for composting and making animal feed (Padeyanda et al. 2016).

3.1.4. Waste power plants

Not only does it provide facilities to make it easier to recycle waste, but the government is also investing in processing waste into electrical energy. South Korea utilises every chemical discarded in waste volumes to be processed into electricity generation, the output of which contributes 0.6% to South Korea's total electricity needs and is estimated at around 8% for district heating needs (Bourtsalas et al. 2019).

Dense urban areas require the increasing renewable energy. South Korea seeks to provide urban energy from solid waste management, known as Waste-to-Energy (WTE), and District Heating and Cooling (DHC) systems, where the use of these systems is expected to increase energy recovery to secure the long-term district energy needs (Ham and Lee 2017).

This Waste-to-Energy system is driven to achieve the goals of energy efficiency, circular economy, and economic development through sustainable resources from waste; where to realise this, an environmentally friendly energy community has been formed to process local waste using bio gasification to convert food and agricultural waste into biogas that is distilled into city gas or electricity (UN ESCAP 2019).

3.1.5. Public awareness and education

Public awareness is an important thing that needs to be highlighted in waste management strategies in South Korea. The government's achievements in reducing waste will not separated from public awareness and participation in government policies. Since the early 1990s, it has been difficult to build a landfill in South Korea because the public strongly rejected it, resulting in the "'not-in-my-backyard (NIMBY)" phenomenon, which complicated procedures for securing a landfill site (Cho et al. 2017).

Since 1998, the government has made a waste reduction master plan, where the government first only demanded the collection of food waste from residential areas. In 2005, the policy was changed by prohibiting food waste from being disposed of carelessly in landfills, and it was even tightened in 2010 with collaboration from the Ministry of Environment and Forestry. Agriculture, Ministry of Forestry and Maritime Affairs, Ministry of Food, Ministry of Health, Family Welfare (Administrator 2019).

The community has started to be more orderly in waste management since the implementation og pay-as-you-throw system policy as they do not want to spend much on waste collection (United Nations 2011). Public awareness has increased, especially since the 2013 law introduced special rubbish bins for disposing of food waste and using only biodegradable or biodegradable rubbish bags (Borsi and Murdie 2023). The facilities the government provides to manage waste are also one of the reasons why the community has become cooperative. Positive achievements related to recycling have received a positive response from the community, where recently, there has been a high interest in building and managing waste recycling (Park et al. 2019).

3.1.6. Enforcement and punishment

The government enforces waste management regulations and sanctions individuals or businesses that violate the laws. This is done to maintain compliance and encourage

responsible waste management practices. The South Korean government has a number of environmental regulations that its people must comply with; these regulations include the Act on the Control and Aggravated Punishment of Environmental Offenses (APEO), the Water Environment Conservation Act (WECA), the Waste Control Act (WCA), and the Act on the Transboundary Movement of Hazardous Wastes and Their Disposal (ATMHW)(Lee et al. 2021).

The government also fines those who do not use the designated trash bags. Residents can be fined up to around US$900 for throwing away rubbish that is not put in official plastic bags. Here, CCTV has been installed at rubbish dumps in many cities to catch violators (UNESCAP 2019). Food or drink waste, such as used drink bottles, must be in a separate trash bag. The fine for this violation will continue to increase, up to KRW 100,000 for the first violation, then increasing to KRW 200,000 for the second violation, and so on (Yoon 2021).

Strict policies, such as those carried out by the Korean government, are deemed important for waste reduction. The policies, thorough monitoring to detect violators, and fines imposed due to violations can produce more compliance from the community so that they are more orderly in managing their waste (D'Amato et al. 2018). Korea has also made violating or destroying environmental sustainability as a criminal offence, so every citizen must be responsible for the environment's and society's health (Hwang 2022).

3.2. The possibility for Indonesia to adopt the key aspects from South Korea

Similar with Korea, Indonesia is also facing waste management problems. Waste management in Indonesia generally is carried out daily because existing waste continues to increase (Khanza, Dachyar, and Farizal 2021). Apart from waste generation, which continues to grow, another problem is that waste management sites (TPA) in Indonesia are one of the main causes of nitrite, nitrate, and heavy metal pollution in groundwater (Pratiwi et al. 2021). This occurs because every week, the estimated waste thrown away specifically for food alone is around 10 million pieces of bread and other food, equivalent to 292,000 tonnes of carbon dioxide emissions (Susilo et al. 2021). Not to mention the generation of plastic waste and other waste, which means Indonesia needs creative solutions to overcome this urgent waste problem.

In overcoming the waste problem, Indonesia has made many efforts to create better waste management, but existing efforts are still far from expectations (Suhardjono et al. 2021). It is said to be far from expectations because in 2022, at the DPR RI Working Meeting, the Minister of the Environment was asked to immediately take steps to overcome the problem of uncontrolled waste generation. The Member of Commission IV DPR RI, Suhardi Duka, said that Indonesia's waste generation continued to increase from the previous year, with a total of 68.5 million tons in 2021, then rising to 70 million tons in 2022, and an additional 16 million tons that were not managed (Administrator 2017). Even in the 2021 Food Waste Index belonging to the United Nations Environment Program (UNEP), Indonesia was ranked first in Southeast Asia with the highest food waste production of 20.93 million tons (Haryanti 2023). Therefore, Indonesia urgently needs steps to solve the existing waste problem.

Waste management efforts in Indonesia involve the formal and informal sectors. The formal sector includes city government agencies and formal business entities that carry out waste bank management, composting, recycling, and biodigester energy source processes (SIPSN 2021). Meanwhile, the informal sector includes individuals, small businesses, and groups that carry out unregistered and not formally regulated waste collection, which usually refers to recycling activities by mobile waste collectors or scavengers (Aprilia 2021). This sector is a small business unit used as an alternative for people who want to set up a business, usually based on low capital and skills, so they collect waste that can be recycled and then deposit it at the recycling factory (Nugroho 2021).

However, it must be acknowledged that the main problem is that there is no control from the government to the community over the waste volume. As a consequence, people are free to throw away as much rubbish as they can without being charged. In addition, waste management in Indonesia is still focused on transporting waste from its source to temporary waste storage areas and landfills (Aprilia 2021). Waste management for household waste is carried out by the central government, regional governments, and business actors, where the process includes waste handling, recycling, and reuse (Defitri 2023). However, only 10% of waste management is used, and most of the rest is immediately thrown into the landfill (Hendra 2016). As a result, the uncontrolled waste generation in the landfill pollutes the environment. Also, it has a potential to explode, such as what happened in 2005 at the Leuwigajah landfill, which exploded and a landslide buried two village settlements and caused the death toll of 157 people (Mahendra and Luthfiana 2023).

To overcome the waste problem, one aspect of the success of Korea's Pay-as-you-Throw system can be used as an example by Indonesia. So far, the efforts have only focused on handling landfill waste (Sutana 2021). The pay-as-you-throw system implemented by the Korean government is a right method to reduce waste generation because this system focuses on fundamentally reducing waste sources. When testing the pay-as-you-throw system in the 1990s, Korea experienced a fairly large reduction in food waste production by 10 to 30% (Yu 2017).

Certainly, positive results cannot be achieved just like that. For Indonesia, to follow in Korea's footsteps in reducing waste, strong political will and demands from society are required to create a healthier and cleaner environment (Shankar IAS 2018). This is done by several cities in American states, namely Austin, Berkeley, Seattle, and Portland, because this system is considered as a control tool by the government that is most effective in reducing waste sources (AFP 2022). When this system is implemented, households tend to reduce the amount of their waste quickly; for example, in Massachusetts, the results of implementing pay-as-you-throw reduced the waste by 30% in 2020 (Pollans 2022).

According to the European Commission, the implementation of the pay-as-you-throw system can be adopted in various forms according to the individual's

identification in collecting waste (European Commission 2021), for example:

a) Waste volume-based scheme. Waste fees are charged based on the size of the wastebasket/container emptied.
b) Sack based scheme. Waste fees are charged based on the total number of trash sacks used
c) The scheme is based on a combination of weight and volume of waste. Waste fees are charged based on waste baskets' frequency and volume.

However, it must be acknowledged that the main problem is that there is no control from the government to the community over the waste volume allowing people to be free to throw away as much rubbish as they want.

Several forms of pay-as-you-throw can be adopted; basically, pay-as-you-throw is a system that encourages people to throw away less waste and be more careful because there is a cost to their waste. Indonesia can try one of several forms above. The Reason Foundation says pay-as-you-throw is a good policy study and the only way to get people to act to reduce waste, increase recycling, and ultimately benefit the environment (Ecube Labs 2020).

4. Conclusion

Waste management is a significant environmental challenge for Indonesia due to its large population and diverse geographic characteristics. However, some Korean waste management methods above can provide useful insights for Indonesia and other countries struggling with waste problems. Korean regulations has given Indonesia an idea of how efforts to control public waste are seriously taken by the government.

Korea's waste management in the form of a pay-as-you-throw system is one of several key aspects of Korea's success that Indonesia can emulate. Applying incentives to households for waste is one solution to reduce waste sources. Pay-as-you-throw system can also be a step for the Ministry of the Environment to control the public from throwing away the excessive volumes of waste. Moreover, following Korea's example, the pay-as-you-throw system is an effective way to control households over their shopping. It makes them to plan their purchases by buying what they need rather than buying in large quantities and producing a lot of food waste.

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