Review of the Status and Treatment Method of Organic Waste in Korea

Hee Jung Kim, Ji Ye Yoo, and Chan Jin Park

***Abstract*—Increasingly organic wastes (environmental residues) are increasingly being generated, and research on how to recycle these wastes into resources is essential. The purpose of this study is to investigate the recycling of organic wastes, which have been attracting attention worldwide, and to investigate the amount of organic wastes generated in Korea. The subjects of the survey were waste water sludge, water treatment sludge, animal and vegetable residue and livestock excretions generated in the workplace and sewage treatment sludge, food waste and excretions treatment sludge generated in the living environment. The treatment methods include incineration, landfill, Composting, and energy (anaerobic digestion).**

This study also compared the results of analysis for countries operating organic wastes energy facilities in Japan or Europe with similar conditions.

***Index Terms*—Organic, waste, treatment.**

I. Introduction

In In modern industrial societies, lifestyles are changing into mass production and consumption forms, and the wastes generated in the process are also becoming social problems that can't be solved only by auto purification effects such as massive waste, refractory waste, and malicious waste. In other words, wastes that can't be cleansed by nature can be disposed of through disposal facilities such as landfill and incineration facilities. In this process, problems of local egoism and huge facility investment are caused, resulting in socioeconomic problems. It is urgently required Eco-friendly treatment plan. [1] Waste and environmental residues in Korea are managed under the laws such as the 「Waste Management Act」, 「The Water Quality and Aquatic Ecosystem Conservation Act」, 「The Livestock Manure Management and Utilization Act」, and 「The Sewerage Act」. First, "waste" as defined in 「The Waste Management Act」 defines waste such as waste, combustible slag, sludge, waste oil, waste acid, waste alkaline, and dead bodies of animals Means a substance that is not necessary for the life or business activities of a person. "Municipal waste" refers to wastes other than waste from the workplace. "Waste from the workplace" means wastes generated at the workplace where the discharge facility is installed or operated in accordance with the 「Air Quality Preservation Act」, 「The Water Environment Conservation Act」, or for 「The Noise and Vibration Control Act」 and any other workplace designated by the Presidential Decree. The term "livestock manure" as defined in the 「The Livestock Manure Management and Utilization Act」 refers to the mixture of feces and urine excreted by livestock and water used in the livestock raising process. . The term "sewage" as defined in the 「Sewerage Act」 means sewage (hereinafter referred to as "sewage") mixed with liquid or solid substances due to human life or economic activity, and site of buildings, roads and other facilities Rainwater or groundwater that flows into the sewerage system. However, except for the cultivation of crops. "Manure" refers to any liquid or solid contaminants (including residues that arise from the cleaning process of a private sewage treatment facility) collected in a collection toilet. Wastes are classified into industrial wastes generated in the workplace and municipal wastes generated in the living environment, and they are classified into organic wastes and inorganic wastes in terms of the characteristics of constituent materials. The standard wastes that distinguish organic and inorganic wastes are defined as organic wastes with an organic content of 40% or more on a dry weight basis.

Recently, organic wastes are turning into resources that must be circulated in the material to be treated. Korea is a resource poor country and can be safely circulated to resources without environmental adverse effects of waste in order to build a resource circulation society to improve resource security and self-sufficiency. There is a need for research on how to do this. [2]

II. Organic Waste

Waste is first classified as solid waste and organic waste. Also solid wastes are classified into domestic municipal wastes and work wastes depending on the source. Organic wastes are waste biomass subject to the 「Waste Management Act」 and are divided into organic and organic wastes in the living and business areas. Food waste, living waste wood (waste furniture), and waste cooking oil belong to the living system. Business sites include organic sludge, organic vegetable residues, waste wood, and waste cooking oil. And

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「The Livestock Manure Management and Utilization Act」 on the Management and Use of Livestock Manure is also classified as organic waste. [3]

A. Sewage Treatment Sludge

In a sewage treatment process such as an activated sludge process, raw sludge of the first settling basin and waste sludge in the final settling basin are generated. Waste sludge is used to transport the bioreactor, such as aeration tank, to maintain proper microbial concentration and is expressed as recycle sludge. In addition, when a chemical phosphorus removal process is introduced for advanced treatment, coagulated sediment sludge containing coagulant components such as aluminum salts is generated. In addition, screen contamination, sediment and sediment deposited on the gypsum, and scum accumulated on the surface of the aeration tank are also included in sewage sludge in a broad sense. In the general sewage treatment, the first settling sludge and the excess sludge are mostly used. In the sewage or wastewater treatment process, substances formed by separating solids from the liquid body and sewage sludge sediments are generally called sewage and they are treated and disposed separately.

B. Food Waste

It refers to the food waste that is produced in the manufacturing and distribution process of the food waste before the food is cooked in the home or the restaurant, the food waste left after eating. [4]

C. Livestock Excretion

The livestock excretion is a liquid or solid pollutant collected in the collection toilet, and the liquid or solid pollutant excreted by the livestock is called livestock excretion. Liquid excretion is a mixture of livestock, urine and livestock feed, straw, and cleaning water, and it has various water contents depending on the conditions. Liquid excretion is a liquid substance with a moisture content of 85% or more, which is composted in an anaerobic state or in an aerobic state by aeration or agitation, and the decomposition is terminated and stabilized. [5]

III. Treatment Characteristics of General Organic Wastes

A. Incineration

In a waste incineration facility, organic matter in the waste is burned when the material reaches the required ignition temperature and comes into contact with oxygen. During the incineration due to the oxidation (combustion) of combustible materials in solid and liquid wastes, the exhaust gases CO_2 , CH_4 and N_2 O, which contain most of the energy available as heat, are discharged, and the types of waste incinerated are municipal solid waste, Site wastes, designated waste, sewage sludge, etc. [2] Waste is usually a very heterogeneous material consisting essentially of organic matter, minerals, metals, and water. The purpose of waste incineration is to reduce the volume of final waste to be disposed of, to remove harmful substances and to recover recyclable materials as an intermediate process. [6]

B. Landfill

Reclamation is the most commonly used waste disposal method for dents and burrows, and has explosion and water pollution problems due to methane gas and leachate. Monitoring and disposing and compressing the incoming wastes, ash, soot, sludge, slag, and the environmental monitoring and control facilities of the landfill. The landfill is used for wastes that do not contain wastes that can cause damage in the living environment, ie stable wastes. Finally, managed landfills are not harmful but can generate pollutants that can cause damage to the living environment, which can pollute groundwater and public waters. Wastes are used for landfilling of waste which is decomposed after landfilling and which is likely to be contaminated secondarily (animal carcasses, wood carvings, scraps of paper, scraps of waste, fiber scraps). Waste buried for the preservation of living environment and natural environment, the leachate should be discharged directly to the outside, so that it does not pollute the surrounding environment, and there should be no odor. From the viewpoint of economic efficiency and environmental conservation, it is preferable to reduce the amount of leachate and the occurrence of high-quality methane gas.

C. Feeding

In the case of feed conversion, feed conversion is not permitted because it is directly consumed by animals and the like, which may cause diseases such as animals. According to the criteria for the range of harmful feeds, sewage sludge discharged from the sewage treatment plant is restricted to feed-use restricted substances.

It is mainly characterized by a drying or fermentation method and a mixture thereof, which is faster than the case of composting. Feeding can be a fluidized-bed drying method, a high-speed drying fermentation method, or a high-speed fermentation method. In addition, according to the present state of the art, the current feedstuffs are treated with feedstuffs from food wastes, vegetable residues, and process sludge (food and beverages) and are consumed by animals. Therefore, foodstuffs and feedstuffs from animal or plant- Is expected to proceed. [2]

D. Composting

Composting is a process in which organic matter is usually decomposed and stabilized by microorganisms. The final material should not adversely affect the environment, should be usable for the soil, biochemical processes that convert it into a material that is corroded enough to be stored, or a continuous biological treatment of the organic components of the solid waste under anthropogenic conditions.

The composting facility consists of a pretreatment operation that regulates moisture by adding various additives, a first fermentation step of decomposing organic matter using aerobic microorganisms, a second fermentation step of stabilizing the activated organic matter, a manufactured step of sieve separating and packaging. The most important of these processes is the primary fermentation stage, and the decomposition of organic matter depends on the process control at this stage. The use of quality composts improves

the physical, chemical and microbial properties of the soil, creating a good environment for crop growth.

E. Energy Conversion

Waste energy is an effective means of replacing fossil fuels and reducing greenhouse gas emissions. Renewable energy is currently being generated mainly from waste energy. The energy of the waste can solve the energy problem and become the treatment method of the waste, so that the efficient energy can maximize the proper treatment of the waste. [7] Refers to an industry that produces and sells energy such as heat and electricity with methane gas generated through thermochemical and biological reactions of organic waste accurately. The basic principle of energy production using organic waste is anaerobic digestion. The use of solid fuels, liquids, and wastewater can be achieved through the use of techniques such as the oiling of pyrolysis waste, the production of solid fuels, the production of flammable gases by gasification, and the heat recovery by incineration, Fuel, gas fuel, waste heat, etc. [8]

IV. Generation of Organic Waste

'The classification of wastes in Korea' is shown in Fig. 1. First, waste is divided into municipal waste and workplace waste, and workplace waste is classified as workplace general waste, designated waste, and construction waste at the workplace. Workplace general waste is divided workplace municipal waste and waste discharge facility waste. And designated waste is medical waste. [9]

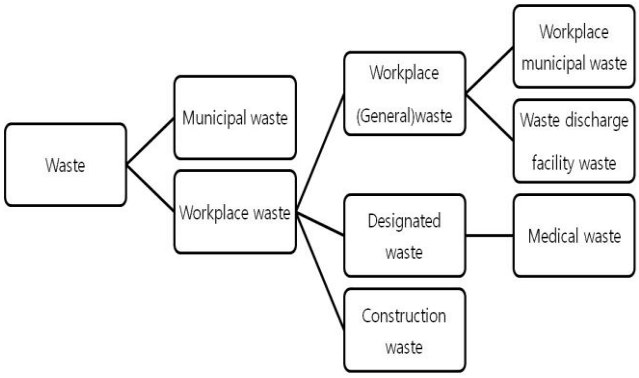

Fig. 1. Classification of waste in Korea.

TABLE I: Annual Amount of Waste Generated in Korea

(Unit: ton/day)

Division	Municipal waste	Workplace waste	Construction waste	Total
2007	50,346	114,807	172,005	337,158
2008	52,072	130,777	176,447	359,296
2009	50,906	123,604	183,351	357,861
2010	49,159	137,875	178,120	365,154
2011	48,934	137,961	186,417	373,312
2012	48,990	146,390	186,629	382,009
2013	48,728	148,443	183,538	380,709
2014	49,915	153,189	185,382	388,486
2015	51,247	155,305	198,260	404,812

Below Table I shows 'Annual amount of waste generated in Korea'. The annual amount of waste generated in Korea is increasing from 337,158 tons / day in 2007 to 404,812 tons / day in 2015 as shown. Looking more closely, workplace waste and construction wastes occurred at similar level, and municipal wastes showed the least amount.

Organic wastes include wastewater treatment sludge, water treatment sludge, animal vegetable residues, livestock excretion, sewage treatment sludge, food waste, and excretion treatment sludge. The wastewater treatment sludge is the sludge that is generated when treating wastewater generated in the workplace. The sewage treatment sludge is the sludge that is generated when municipal waste is treated and abandoned.

'Annual amount of organic waste generated in Korea' is shown in Table II.

TABLE II: Annual Amount of Organic Waste Generated in Korea

(Unit: ton/day)

Division	Workplace				Municipal		
	Wastewater treatment Sludge	Water treatment Sludge	Animal and vegetable Residue	Livestock excretion	Sewage treatment Sludge	Food Waste	Excretions treatment Sludge
2008	7,050	602	2,388	128,143	7,962	1,116	527
2009	7,318	410	2,551	135,761	6,422	417	606
2010	7,780	356	3,005	135,653	7,538	243	485
2011	8,402	124	2,750	128,621	6,299	273	469
2012	8,827	204	2,936	177,105	6,086	172	397
2013	9,336	130	3,369	173,052	6,091	162	360
2014	7,892	139	4,159	175,651	7,573	476	384
2015	8,539	106	4,184	173,304	8,357	1,120	958

First, wastewater treatment sludge occupied the largest portion of the waste in the workplace, and the sewage treatment sludge was the most of the waste in the municipal.

Water treatment sludge of workplace is gradually decreasing from 602 tons / day in 2008 to 106 tons / day in 2015. Thus, the amount of water treatment sludge was reduced by about 82%.

Animal and vegetable residue is gradually increasing from 2,388 tons / day in 2008 to 4,184 tons / day in 2015. Thus, the amount of generation increased approximately twice.

Sewage treatment sludge of municipal has been decreasing until 2012, but it has been increasing since then. The amount of sewage treatment sludge the average values is 7,000 tons /day.

Food waste is decreased by about 60% from 1,116 ton/day in 2008 to 417 ton/day in 2009, which is one year later. But it increased rapidly to 476 ton / day in 2014 and 1,120 ton / day in 2015.

Finally, excretion treatment sludge is shown a steady decline since the slight increase in 2009, but it increased rapidly to 958 tons / day in 2015.

V. Methods of Treating Organic Wastes

Generally, the organic waste disposal methods used in Korea include landfill, incineration, reuse, and ocean dumping. The organic waste generated division in Table II above is used to investigate each treatment method and treatment status.

'Trend of disposal method of wastewater treatment sludge'

is shown in Fig. 2. The wastewater treatment sludge is treated by landfilling, incineration, reuse and ocean dumping. In 2008, landfill was processed at a rate of 12.79%, incineration was 15.59%, reuse was 33.23%, and ocean dumping was 38.39% of the total. But in 2015, landfill is treated at 16.07%, incineration at 28.63%, reuse at 49.72%, and marine dumping at 5.57% of the total.

'Trend of disposal method of water treatment sludge' is shown in Fig. 3. The water treatment sludge is treated also by landfilling, incineration, reuse and ocean dumping. In 2008, landfill was processed at a rate of 55.32%, incineration was 5.32%, reuse was 30.56%, and ocean dumping was 8.82% of the total.

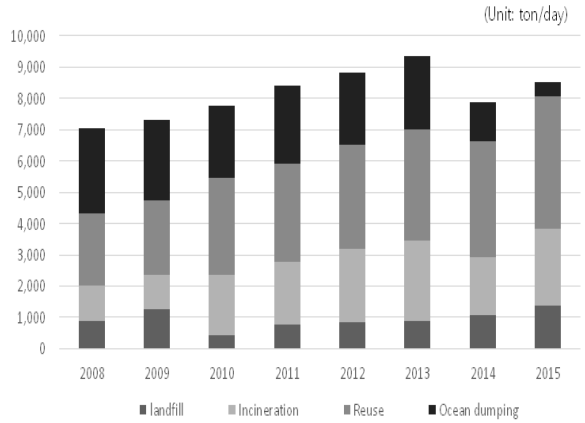

Fig. 2. Trend of disposal method of wastewater treatment sludge.

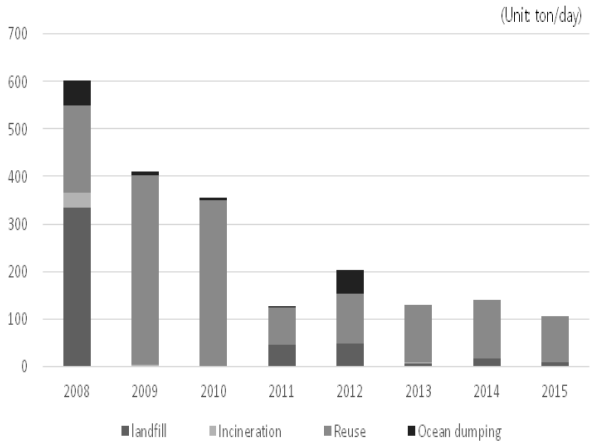

Fig. 3. Trend of disposal method of water treatment sludge.

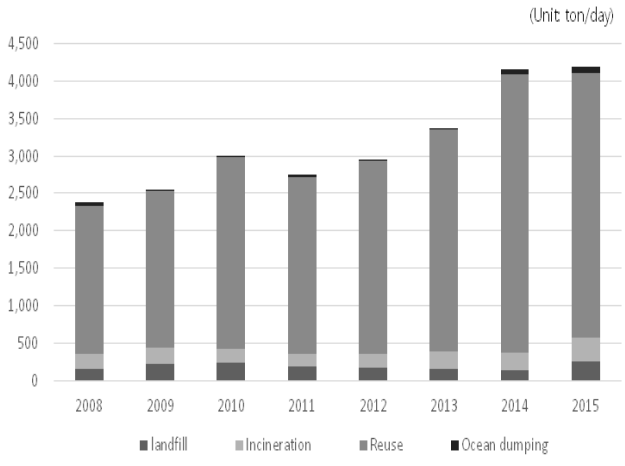

Fig. 4. Trend of disposal method of animal and vegetable residue.

But in 2015, landfill is treated at 7.55%, incineration at 0.94%, reuse at 90.57%, and ocean dumping at 0% of the total. The ratio of landfill and incineration was reduced, and the ratio of reuse was greatly increased. Ocean dumping of industrial wastewater and wastewater sludge will be completely banned in 2014, and the treatment rate for ocean dumping is 0%.

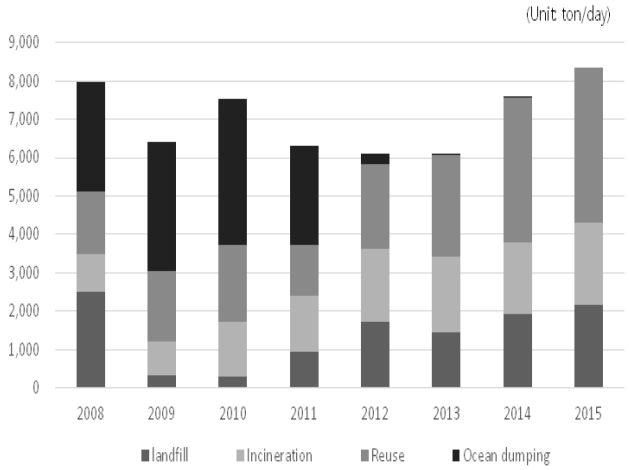

Fig. 5. Trend of disposal method of sewage treatment sludge.

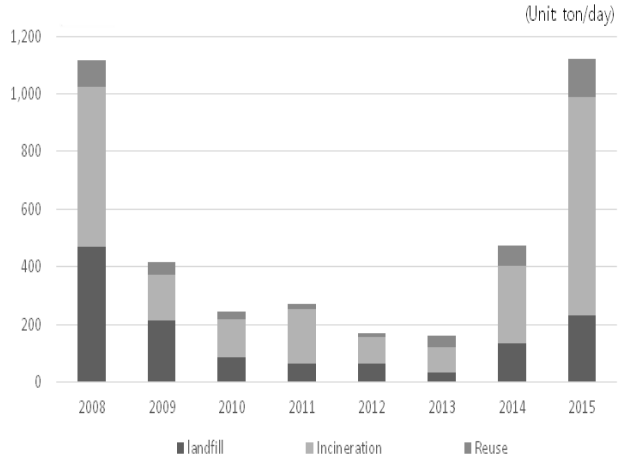

Fig. 6. Trend of disposal method of food waste.

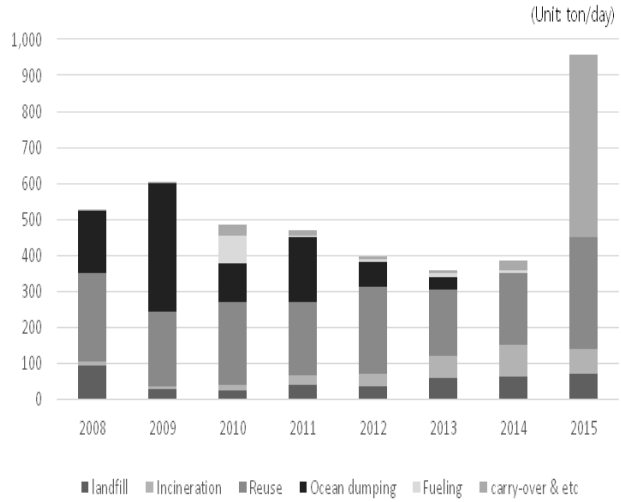

Fig. 7. Trend of disposal method of excretion treatment sludge.

'Trend of disposal method of animal and vegetable residue' is shown in Fig. 4. Animal and vegetable residue is

treated also by landfilling, incineration, reuse and ocean dumping. In 2008, landfill was processed at a rate of 6.57%, incineration was 8.29%, reuse was 82.75%, and ocean dumping was 2.42% of the total. But in 2015, landfill is treated at 6.02%, incineration at 7.50%, reuse at 84.61%, and ocean dumping at 1.88% of the total. The ratio of treatment methods from 2008 to 2015 is almost the same.

'Trend of disposal method of sewage treatment sludge' is shown in Fig. 5. Sewage treatment sludge is treated also by landfilling, incineration, reuse and ocean dumping. In 2008, landfill was processed at a rate of 31.22%, incineration was 12.64%, reuse was 20.27%, and ocean dumping was 35.88% of the total. But in 2015, landfill is treated at 25.86%, incineration at 25.61%, reuse at 48.53%, and ocean dumping at 0% of the total. The ratio of treatment methods from 2008 to 2015 is almost the same. The incineration and reuse was increased, as in the case of the water treatment sludge, and the ocean dumping banned in 2014, and the treatment rate for ocean dumping is 0%.

'Trend of disposal method of food waste' is shown in Fig. 6. Food waste is treated by landfilling, incineration and reuse. In 2008, landfill was processed at a rate of 41.94%, incineration was 49.73% and reuse was 8.33% of the total. But in 2015, landfill is treated at 20.54%, incineration at 67.77% and reuse at 11.70% of the total.

'Trend of disposal method of excretion treatment sludge' is shown in Fig. 7. Excretion treatment sludge is treated by landfilling, incineration, reuse, ocean dumping, fueling and carry-over & Etc. In 2008, landfill was processed at a rate of 17.84%, incineration was 2.09%, reuse was 46.49%, ocean dumping was 32.83%, fueling was 0% and carry-over & Etc. was 0.76% of the total. But in 2015, landfill was processed at a rate of 7.41%, incineration was 7.20%, reuse was 32.57%, ocean dumping was 0%, fueling was 0% and carry-over & Etc. was 52.92% of the total. Treatment methods of excretion treatment sludge show a decrease in landfill and reuse, increase in incineration, 0% in ocean dumping and fueling, and a sharp increase in carry-over & Etc.

VI. Domestic Case of Organic Waste Disposal

A. Food Waste Leachates

One of the most representative methods of treating food waste leachates is biogas (methane) production through anaerobic digestion. Conventionally, anaerobic digestion methods have been applied to organic wastes such as sewage sludge, livestock excretion, and septic tank excretion. Recently, however, techniques for producing biogas by anaerobic digestion with mixed food waste leachate have been actively developed. [10]

In Korea, Gwangju Metropolitan City sewage treatment plant uses biogas production through anaerobic digestion. In detail, the food resource facility located in the second sewage treatment plant produces bio-methane through the high temperature anaerobic digestion process. The digestion gas of about 30 m 3 per 1 ton of food waste leachate is generated, and the methane content of digestion gas is 56 to 69% (Average 62.5%), with an average daily production of 2,438㎥ of methane. Methane produced is used as a fuel in the facility, and about 40% of the LNG consumption per day is replaced by methane gas produced to reduce costs. In addition, food wastes are processed by dry feed method, and feeds produced are supplied to feed mills free of charge. [10]

B. Sewage Treatment Sludge

The byproducts from the drying (fueling) method of the treatment facilities in Suwon are used as raw materials for cement and are also used as auxiliary fuel for the Western Power (Taean Thermal Power Plant) in Korea. The water content of sewage sludge can be lowered to less than 10% and mixed with bituminous coal in a thermal power plant to be used as an auxiliary fuel. Suwon City has been supplying sewage sludge building materials as auxiliary fuel for thermal power generation since October 2010 for the first time in Korea since the western part of Korea has completed the facility to incinerate mixed bituminous coal and organic solid fuel which is the construction material of sewage sludge. In April 2010, Suwon City and Korea West Power signed a Memorandum of Understanding on the supply of renewable energy to utilize the construction of sewage sludge. Through the agreement, Suwon City will be able to supply up to 130 tons / Sludge dry matter will be supplied as fuel and the annual sewage sludge disposal cost is saved through this. In addition, Korea's West Power has secured a stable supply of energy sources and is importing more than 45,000 tons of bituminous coal annually. [10]

VII. Foreign Case of Organic Waste Disposal

A. Germany

Located in the German capital Berlin about 2 hours and 30 minutes away, Schlöben is a biogas production facility using livestock manure to cover the heating and electricity of the villagers, as well as selling surplus energy to earn income. The German federal government annually sees three villages as bio-energy villages. In Schlöben, alternative energy produced by the bioprocessing plant covers 60% of the total energy used in the village. Above all, alternative energy using livestock manure. It is where production is happening vigorously. [3]

B. Japan

Since the early 1990s, Japan has been studying the feasibility of applying biogas plants to feed farming farms in Denmark and Germany. The Kyoto Prefecture Yagicho Plant, which was completed in 1998, is the first livestock manure biogas plant. The operation method of this livestock manure biogas plant is introduced in a way that solves the problems of commercialization and generalization by carrying out additional studies on the technology after many technologies are introduced in Europe, Digest technology itself and develop it into new technology. In addition, new incineration technologies for organic wastes in Japan are mainly concentrated on gasification and melting methods. Recently, industrial wastes are also being used for the purpose of improving the economic efficiency of newly constructed facilities. [11]

C. Hong Kong

Hong Kong is also carrying out weight-based measures and focuses on green policies centered on the composting of food waste. The Hong Kong Government has selected the environment protection industry as one of the six new growth engines of Hong Kong. It has provided environment-friendly facilities, water conservation and pollution management, environmental consulting services, air pollution and odor management, waste management and disposal, And the policy of the United States. In particular, since the landfill of food waste has reached a saturation point, a system for composting through food separation and recycling steps has been established. Especially, due to the geographical characteristics of Hong Kong, which has many hills, it collects food by using various special vehicles at the time of collection of garbage, and the collected garbage is sent to a special factory to operate a composting system.

VIII. Conclusion

Organic waste has high water content in terms of properties and a high content of decomposable organic matter can lead to problems in storage, transportation, intermediate treatment and final treatment because of its high perishability do. Therefore, these organic wastes should be first identified and recycled as to whether they contain constituents or harmful substances. [2]

Korea is currently seeking various ways to treat organic wastes in an environmentally friendly manner, as in many other countries, such as composting, feed conversion, landfill materials, solid fuel, and bio-gasification. However, it is thought that the development of this technical part is necessary as well as the institutional part.

In the three countries mentioned above, after completing the legislative system for establishing a recycling society in the process of establishing eco-friendly treatment of organic waste, the amount of waste generated decreased as a result of regulations. In addition, due to changes in social conditions, individual laws are enacted and regulations are being enacted. [12]

Through these best practices, Korea should be better treated by supporting the legal and institutional aspects of the government.

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