



A Recycling Method of Food Waste by Drying and Fuelizing

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Abstract: *Background/Objectives:* Since food waste was prohibited from being buried in the ground, each municipal government has installed food waste treatment facilities, and has treated the food waste by a method of making compost or feeds. *Methods/Statistical analysis:* However, in case of compost, salt could not be removed, accordingly the compost acted as a factor in withering the crops or hampering their growth. In case of making feeds, a problem of killing livestock was caused because it was not possible to remove toxicity that might be contained in the food. Therefore, a vicious circle was created, where food waste that could not be used as compost or feeds became waste again even after being treated. *Findings:* As a result, we got 4431kcal/kg as a heating low value from the dried food waste, so after heating around 400°C, the exhausting gas can be used as a fuel. Also we got the useful components ratio of 0.42%(N), 0.02%(P) and 0.4%(K) from condensate water, so this condensate can be used to liquid compost. *Improvements/Applications:* Therefore, this paper suggests measures for recycling the dried food waste into feeds or compost, reducing fuel costs by recycling the dry remainder into fuel, recycling the carbonized residues into cover soil, and utilizing condensate generated in this process as deodorant, external carbon source and liquid fertilizer.

Keywords: Carbonize, Condensate Water, Dryer, Food Waste, Recycling

Introduction

The output of food waste of Korea is 4,821,000tons/year, Ministry of Environment (2014). As burying food waste in the ground has been prohibited from 2005, most of municipal governments have come to install food waste treatment facilities Agriculture and Rural Affairs News (2003). And there is an aspect of avoiding compost or feeds made from recyclable materials in food waste recycling and treatment facilities due to supply-demand imbalance, immaturity, salt, and toxicity, and so on. Recyclable materials remaining like this become waste again. And another treatment method becomes necessary Doohwan Kim *et al* (2005). One candidate is a trial of zero emission method Lazarev VA *et al* (2016). Also food waste cannot be thrown to sea after 2012 by London Convention. So food waste should be treated in the land Doohwan Kim *et al* (2005). Since the expansion of recycling facilities, “Food Waste Comprehensive Plan

(2004-2007)” and “Improving food culture and food waste comprehensive plan (2006-2010)” have spent a lot of policy efforts on reduction portion. Of course, while inheriting the traditional development policies, which have taken the position that can be gradually expanded to maintain the continuity of development policies Kim DH *et al* (2010). A study of sludge drying system introduced the invention relates to the deodorization cooling tower and the sludge drying machine including the same. The invention mounts the deodorization material inside the main body part of the deodorization cooling tower built-in deodorization cooling part with multiple. While the steam flowed in successively passes through the deodorization cooling part the steam is cooled and the bad smell is removed at the same time it is sterilized Choi C W *et al* (2012). Recently, Environment Affairs Agency installed food waste treatment facilities of a type that dries food waste in a hermetically sealed state and carbonizes

the dried waste under a reduced pressure, using the heat of kiln incinerator, and drew up measures for recycling after properly using waste heat and making a dried and carbonized treatment product and condensate instead of leachate.

This paper introduces a perfect recycling method of utilizing a solid as animal feeds, utilizing the condensate as deodorant or external carbon source in sewage managing plant, utilizing the dry remainder as heat source of drying equipment after drying food waste abundant in fat and protein in a hermetically sealed state and carbonizing the dried waste under a reduced pressure. The purposes of this study are minimized the extra food waste after treatment and make a new recycling mechanism by using gasifying of food waste.

Treatment Process Improvement

Problems of former managing method

With regard to a government-approved method of making compost or feeds after 2005, food waste is collected, and is saved in a hopper, and then a solid and leachate is separated through a crushing and compressing process. Leachate was mainly dumped into the ocean. However, recently, ocean disposal was prohibited. Therefore, the inland treatment of leachate costs a lot. Even so, the situation is that treatment facilities are not sufficient in Korea. The actual condition is that the government also suspends ocean disposal.

Improvements

Dried solids and condensate was made to be perfectly separated and treated in the drying equipment by just one process. In this case, fat and protein is preserved intact. So, a soft dried material that doesn't blow and condensate that contains a large amount of organic acid is made. With regard to treatment process, the drying equipment is hermetically sealed type, and a drying method by forced air circulation mode

is used. Therefore, odor emission was gotten to be fundamentally suppressed. The dry solid can be used as nutritious dry feed, and the condensate can be utilized as liquid fertilizer or can be utilized as deodorant after being mixed with methyl alcohol and so on. Besides, it was so improved that perfect recycling could be accomplished by being utilized as external carbon source in sewage managing plant.

On the whole, a drying method in hermetically sealed state and carbonizing method under a reduced pressure was used. And heat exchanger and condenser plays a major role in drying. The features of process can be summarized as follows: there is a small amount of unnecessary exhaust gas due to drying in hermetically sealed state and carbonizing under a reduced pressure by external heat. And after condensation, incineration gas is used. So, it is not necessary to treat exhaust air current. And pollutants are treated as transparent condensate [3]. Therefore, maintenance cost is low. Figure 1 shows the diagram of food waste recycling

Many kiln incinerators are installed in each municipal government. So, heat from incinerator instead of burner and vaporizer can be used. And it is deemed to be a treatment method suitable for efficiently treating organic waste such as food waste. All of the dried solid components can be consumed as raw materials of feed ingredients and all of condensate can be consumed as deodorant, liquid fertilizer and so on. Therefore, it deserves to be optimized recycling equipment. Its operation principle is described in brief in Figure 1. With regard to its heat source, steam is produced in the boiler by burning a combustible gas generated by gas generator by using the dried food waste or

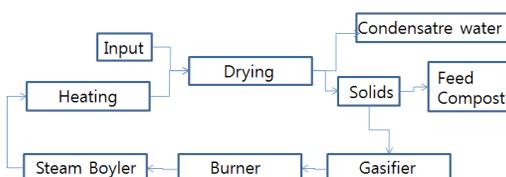


Figure 1. Diagram of Food Waste Recycling

another drying heat is steam boiler using the waste heat of kiln incinerator. And heat enters the lower part of high-speed drying equipment. And food waste coming from storage hopper is stirred and heated.

Steam generated at this time is changed into dry air with passing through heat exchanger and condenser, and then circulates to the high-speed drying equipment. The dried materials continue to be stirred and heated until their water content becomes less than 5%. Those pass through impurities removal system by vibrating screen method after being sufficiently dried. And solid ingredients are packed in 20kg sack. And condensate is stored in storage tank. On the whole, it has a hermetically sealed process. So, there is little bad smell except from storage hopper. Equipment playing a key role here is high-speed drying equipment, and it is batch-type equipment. And once the food waste is fed, the equipment is operated in a hermetically sealed state [8].

Batch-Type High-Speed Drying Equipment and Combustion Equipment for Gasification

Design of High-Speed Drying Equipment.

Batch-type high-speed drying equipment is composed of stirring device, heater, heat exchanger, condenser and internal air circulator and so on. Figure 2 shows a design example of batch-type high-speed drying equipment.

The stirring device (12) was so designed that two stirring devices operated independently in order that food waste didn't cluster on one side. Steam efficiently heats the inside of drying equipment by installing a thermal jacket (10). And in case the steam equipment didn't work, it was made possible to be electrically heated. The heat exchanger and condenser (20, 14) induces condensation by quickly cooling down high-temperature and high-humidity gas when it passes, and the condensate is discharged to the outside, and help is given in heating by recirculating the high-temperature

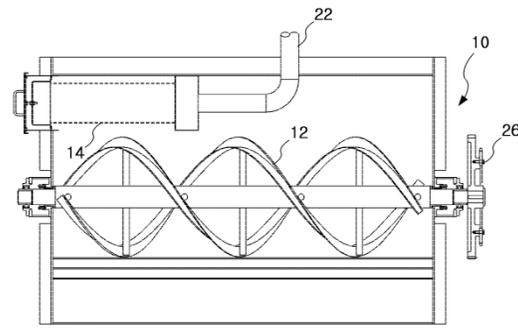


Figure 2. Speedy Dryer 10: Main Body, 10: Steam Jacket, 12: Mixer, 14: Dust Eraser, 20: Heat Transformer, 22: Inner Gas Stream Line, 26: Rotator)

and low-humidity gas to the inside. If this process is continued, the solid is dried. Internal temperature is set so that 80-100°C is maintained.

Manufacturing the Experimental Apparatus of High-Speed Drying Equipment

The experimental apparatus of 100kg/day on the basis of treatment capacity per batch was manufactured. Dregs are prevented from being stuck to the internal wall of drying equipment by making a double-spiral screw with L-shaped section in order to enable a smooth stir. Basically, electric heating was used as default. And if necessary, high-temperature high-pressure steam was used as heating source. Figure 3 shows the example of installation.

If we summarize the drying process, it can be shown as follows Doo Hee Han *et al* (2015), (2010), (2014).

- 1) A waste sorting bin for food waste is provided, and food waste is collected, and then it is transported to storage area by collection vehicle.
- 2) The food waste is put into a storage hopper from collection vehicle, and it is hermetically sealed and the food waste is stored temporarily.
- 3) The inputted and stored food waste inside the storage hopper is crushed.

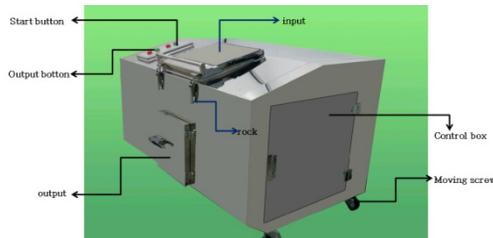


Figure 3. Sample of Speedy Dryer (100kg/day)

- 4) Food waste inside the crusher is fed to the fermentation tank through hermetically sealed feeder, and is fermented for about 8 hours.
- 5) The preheated, stored and fermented food waste is sent to high-speed fermenting and drying equipment. And water content is decreased to 5% or below.
- 6) The materials are sent to the screening equipment through the outlet, and then are automatically screened and separated.

Thermal Decomposition and Gasification Device

Hot wind from the combustion of dried combustible waste as biomass treatment and internal air emitted from putrescible waste having a high water content in the course of drying is mixed and supplied, and is used as the heat source of drying, and the dried putrescible waste is used as solid fuel again. And it is made to be used as activated carbon and soil conditioner. So, putrescible waste with high water content can be stably and economically treated without environmental pollution. Besides, there are requirements for the stability of operation, the reduction of fuel costs, economical efficiency by the production of fuel at low price, and pleasant environment by operation without environmental pollution.

Waste disposal cost is reduced by waste recycling via available biomass treatment through the stepwise single process of various putrescible wastes such as food waste, sewage and wastewater sludge and stock raising waste.

And putrescible waste is dried by using a combustible waste as heat source, and it is made possible to be used as cheap solid fuel and feeds or compost and by doing so, economical efficiency can be increased in a farming and fishing village.

Combustion Experiment

A gas generator was operated. And the produced combustible gas was burned in the combustion equipment. It was possible to verify that the gas was adequate as the heat source of boiler.



Figure 4. Sample of a speedy dryer and thermal decomposition device



Figure 5. Sample of a combustion experience

Making Compost-Feeds and Condensate

Substance after Drying

The dried materials of food water were produced through the trial operation of the food waste drying equipment. It takes about 8 hours on the basis of 100kg. The duration can be reduced according to heating temperature.

Trial Operation

The dry food waste powder was packed in 20kg sack, and was stored temporarily. Impurities such as large bones could be chosen by using vibrating screens before being packed. Table 1 shows the chemical component of simply dried food waste. In this case there is a large ratio of water, a solidifying phenomenon occurred. So, a well ventilated place was required for storage.

Figure 6 shows the appearance of dry food waste.

Condensate Making Experiment

The condenser combined with heat exchanger normally worked. In addition to this, the effect of condenser was increased by the operation of dehumidifier. The condensate coming out as product is carbon source abundant in organic acid component, and is excellent especially in deodorant effect, and can be used as external carbon source in sewage managing plant and liquid fertilizer. However, if it is discharged without permission to sewer system, a problem may be caused. This is like requiring a lot of water in order to dilute alcoholic drink such as Soju. Table 2 and Table 3 show the appearance of condensate.

Use of Condensate

Used as Deodorant and Liquid Fertilizer

What removed bad smell emitting from landfill area where a large number of poultry were buried due to avian flu was deodorant obtained from food waste. Besides, a large amount of deodorant is used in Gimpo landfill area as well. Besides, condensate can be used as liquid fertilizer, and in Japan, it has been already put to practical use. Figure 7 show an example of condensate appixation.

Utilization as External Carbon Source in Sewage Managing plant

In case there is a method making it possible to conform with standard for effluent water quality and use the existing sewage treatment plant at the same time in consideration of the overall situations of sewage treatment in Korea, it is thought that an effect of killing two birds with one stone, which can maximize the sewage treatment efficiency, is expected by reusing the existing sewage treatment plant through simple improvement work as well as reducing the cost required for installing a new advanced sewage treatment plant. The condensate can be utilized as external carbon source in sewage waste water treatment plant improving nitrogen and phosphorus removal efficiency by adding a carbon source and improving the conventional activated sludge method in the existing sewage waste water treatment plant. It is possible to contribute to mitigating the environmental pollution problem in Korea, and presenting an alternative measure for complying with tightened standard for effluent

Table 1: Ratios of Chemical Component after Drying Process

H2O (%)	Ash (%)	Source (%)						Heating Low Value(kcal/kg)	Specific(ton/m3)
		C	H	N	O	S	Cl		
17.7	10	41.2	7.1	2.51	17.9	0.45	2.24	4431	0.36



Figure 6. Sample of Food Waste Powder



Figure 7. An example of condensate water application: deodorant

Table 2: Components of Condensate Water

Test Item	Amount
TCODcr(ppm)	20337
SCODcr(ppm)	20069
T-N(ppm)	80
NH3-N(ppm)	71
NO3-N(ppm)	2
T-P(ppm)	9
Ortho-P(ppm)	8
SS(ppm)	None Detected
VSS(ppm)	None Detected
TVFAs as COD(ppm)	9337

Table 3: Components of Test Liquid Compost

Components	Ratio (%)
H2O	88.1
Fe	26.4×10 ⁻³
Ca	2,147×10 ⁻³
Na	1,998×10 ⁻³
Mg	279×10 ⁻³
Cl	1,880×10 ⁻³
Cu	0.05×10 ⁻³
Zn	4.25×10 ⁻³
N	0.42
P	0.02
K	0.4
etc.	5.6

water quality, and reducing water treatment cost by economically and efficiently removing eutrophication-causing elements such as nitrogen and phosphorus at the same time together with organic matter without adding an extra advanced treatment process in the existing sewagewaste water treatment plant through process improvement.

Conclusion

Many food waste treatment facilities were installed in each municipal government, and has treated the food waste by a method of making compost or feeds. However, in case of compost, salt should be less than 1% by government law, but reducing the salt ratio was very difficult in rural area, accordingly the compost acted as a factor in withering the crops or hampering their growth. And in case of making feeds, a problem of killing livestock was caused because it was not possible to remove toxicity that might be contained in the food. Therefore, a vicious circle was created, where food waste that could not be used as compost or feeds became waste again even after being treated. So we proposed the extra food waste which remained after composting or animal feeding should be recycled, and optimal candidate of recycling can be a fuel source by sealed drying of food waste. It was able to fundamentally prevent the bad smell in the drying process. I have shown the possibility

to make feeds effectively through standard packing. Also this method can reduce fuel costs by recycling the dry remainder into fuel, and carbonized residues can be recycled into the cover soil, and condensate water generated in this process can be used as deodorant, external carbon source and liquid fertilizer.

So, perfect recycling of food waste can be done when using evaporation with sealed type high speed dryer, and using dried extra waste as a fuel in the dryer. As a result, we got 4431kcal/kg as a heating low value from the dried food waste, so after heating around 400°C, the exhausting gas can be used as a fuel. Also we got the useful components ratio of 0.42%(N), 0.02%(P) and 0.4%(K) from condensate water, so this condensate can be used to liquid compost.

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