Feasibility Study of Biomass Waste Recycling System in University Campus

Peni Astrini Notodarmojo[1*], Yutaka Wada[2], Takeshi Fujiwara[1], and Habuer [1]

1: Okayama University, 3-1-1 Tsushima Naka Kita-Ku, Okayama 700-8530, Japan

2: Hazama Ando Corporation, 6-1-20,Akasaka, Minato-ku, Tokyo,107-8658, Japan

*corresponding author: peniastrini@gmail.com

Keywords: Regional sound material-cycle society, Feasibility Study, Biomass waste recycling, University campus

INTRODUCTION

Okayama University has an expansive campus in Japan and generates much biomass that is usually disposed of by outsourcing waste treatment to private companies. The university should tackle reducing and recycling waste within the campus as a regional society member to establish a sound material-cycle society. We evaluated the potential to recycle the biomass waste on the campus by first measuring or estimating the amount of biomass waste generated almost through a year. Secondly, we conducted feasibility studies such as analysis of methane gas and compost production, power consumption, and CO_2 emission of a methane fermentation facility and a composting facility.

MATERIALS AND METHODS

Estimation of waste generation in campus

Mowed grass and fallen leaves waste discharge in a year was estimated based on a survey from June 2016 until January 2017. The harvesting residue and inferior product not to be sold become agro-waste. We estimated the amount of agro-waste by multiplying each product's harvested amount each month (Field Science Center of Agriculture Department) with the crop by-product coefficient (Chiba Prefectural Agriculture and Forestry Research Center), otherwise estimated from crop acreage and the crop by-product coefficient. On the university campus, 529 trees of 49 species are pruned in a year. We surveyed the trunk circumference of all trees recorded and managed by the university's financial division and estimated the pruning residue. An estimation equation proposed by the Ministry of Agriculture, Forestry, and Fisheries is used for horse dung waste generation. As for kitchen waste, we interviewed the university co-op union about the amount of kitchen waste discharged from the four cafeterias in the campus.

Feasibility study of biomass treatment facility

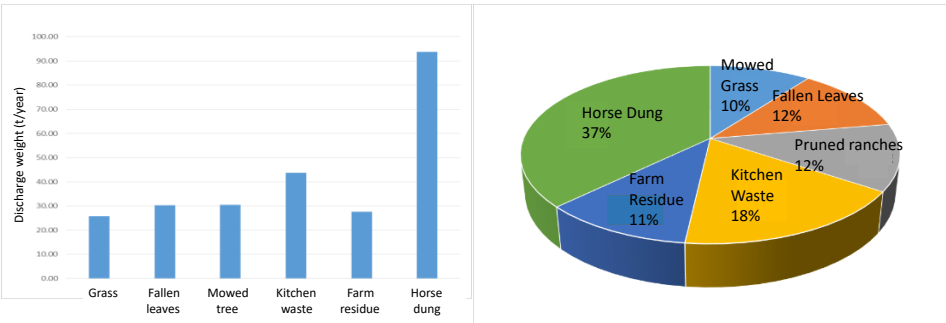
We examined a hybrid biomass treatment facility composed of the methane fermentation process (two-stage anaerobic digestion system) and composting process. The methane fermentation uses horse dung, kitchen, and agro-waste. The composting facility targets horse dung, fallen leaves, grass, and pruned branches. The solid digestion residue discharged from the methane fermentation process is also processed at the composting process. The effluent of methane fermentation circulates back to the methane reactor to reduce water usage, and the excess applies to the university farm as liquid fertilizer.

RESULTS AND DISCUSSION

Generation rate and composition for each waste

Fig. 1.1 shows the annual emissions of biomass waste targeted by the treatment facility by type, and Fig. 1.2

shows the ratio. The total amount of biomass waste on campus, excluding cow dung, was 251 tons / year.



1)Waste generation amount 2)Waste composition

Fig.1 Waste discharge by waste category

Feasibility study

1)Methane fermentation process

The average input amount to the methane fermenter was 0.33 t/day. When methane fermentation of mesophilic bacteria (37 °C) is performed, the annual amount of biogas generated is 5,826 Nm^3, the amount of methane gas is 4,020 Nm^3, the methane gas concentration is 69%, and the average generated power is 31.12 kWh/day. The generated heat and electricity are used for heating the methane fermenter and operating the facility. Since 1.06 kWh/day is required to heat the methane fermenter and 36.31 kWh/day of heat energy recovered from the gas engine's exhaust heat, 35.25 kWh/day is the surplus heat. Total power consumption is 76.22 kWh/day, not including heating. The power generated from biogas is utilized to reduce power consumption to 45.09 kWh/day. Regarding environmental impact, electricity from Japan commercial plant in 2018 generated an emission of 0.506 kg-CO_2/kWh (Climate Transparency, 2019), and based on that data, this methane fermenter greenhouse gas (GHG) emission is 8.52 tCO_2/year.

2) Composting process

Composting facility processed biomass waste 2.31 t/day. The initial C/N ratio is 30, and the mature compost C/N ratio changed to 10. Total moisture also changed from 65% to 50%. The composting process and water evaporation reduced biomass waste weight to 0.53 t/day or 194.21 t/year of matured compost.

CONCLUSION

In this study, we found that the largest amount of biomass waste generated from Okayama University Tsushima campus was horse manure, followed by kitchen waste. These two types account for 55% of the total waste. Estimated production of methane and compost from biomass waste results in a possible amount of 5,826 Nm^3 of biogas and 194 tons of compost produced per year. The energy produced from methane gas cannot meet the energy needs of the facility, so it requires an external energy supply 45.09 kWh/day. This resulted in GHG emission from methane fermentation process to 8.52 tCO_2/year.

REFERENCES

Climate Transparency. 2019. Japan Country Profile 2019. Brown to Green: The G20 Transition Towards a Net-Zero Emissions Economy. Retrieved from https://www.climate-transparency.org/wp-content/uploads/2019/11/B2G_2019_Japan.pdf