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Demonstration of Dehydration and Dryer Technology for Biosolid Reuse as Fertiliser and Fuel in Small or Medium Scale STP

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Abstract: This study aims to evaluate the performance of two innovative technologies as energy saving biosolids reusable technology for both fertilizer and fuel use. The result of comparing innovative technology with conventional technology indicated that both of innovative technologies can reduce Life Cycle Cost (LCC) or the maintenance cost. In addition, it was suggested that the energy efficiency of both innovative technologies was obviously higher than that of conventional one. Furthermore, we conducted evaluation of the quality of the dried sludge by analysing its ingredient in order to confirm the compliance with the standard in the Fertilizer Regulation Act for fertilizer use and with the standard of JIS Z7312 BSF-15 for fuel use. As a result, both innovative technologies fulfilled these two standards for fertilizer and fuel.

Keywords: Biosolids reuse, Utilization of sewage sludge, Life cycle cost (LCC)

Introduction

Sewage sludge, has been disposed of in landfill as a waste, but now is expected to be various biomass resources such as biogas, sludge fuel, fertilizer, and so on. In Japan, the energy potential of sewage sludge is equal to the electricity consumption of approximately 1.1 million households. From the viewpoint of resources, sewage sludge contains phosphorus equal to 10% of its import from abroad. In 2015, biomass utilization rate in Japan was as low as about 26%. Thus, MLIT (Ministry of Land, Infrastructure, Transport and Tourism) considers sewage sludge as a resources made in Japan in its Productivity Revolution Project and aims to improve utilization rate to 40% by 2020 through thorough utilization. On the other hand, it is difficult for the small or medium scale sewage treatment plant (STP) to introduce the high-cost facilities because of their severe financial status. NILIM (National Institute for Land and Infrastructure Management) is implementing B-DASH project in order to promote spreading of innovative technologies with guidelines. We conducted demonstrative study of two innovative technologies. One is ‘Demonstration of sewage sludge conversion to fertilizer and fuel with dehydration and drying system’ (Dehydration and Drying Technology). Another is ‘Demonstration of high efficiency heat pump dryer for sewage sludge based on self-heat recuperation’ (Self-heat Dryer Technology).

Outline of full scale demonstration technology

1. Dehydration and Drying Technology

Schematic flow and appearance of Dehydration and Drying Technology is shown in Figure 1 and Figure 3. Dehydrated sludge of fine particulate and low adhesion is generated by inside double coagulation type centrifugal dehydrator and then dried by circulating flash dryer. This combination enables moisture content of dried sludge to be controlled from 10% to 50%, suitable for various utilization.

2. Self-heat Dryer Technology

Schematic flow and appearance of Self-heat Dryer Technology is shown in Figure 2 and Figure 4. This technology incorporates a heat pump system which enables highly efficient heat collection by recovering the latent heat of the exhaust gas.

Demonstration methods

1. Evaluation of cost saving effect

We evaluated the benefit of innovative technology through estimating the initial cost, maintenance cost and LCC in case of installing innovative technology in small or medium scale sewage treatment plant by using cost functions[1].

2. Estimation of the energy efficiency

We estimated the energy efficiency of both innovative technologies. The conventional technology with many introduction cases and of the same type of heating was selected for comparison with each innovative technology. The conventional technology of hot air rotating dryer is selected for comparison with Dehydration and Drying Technology. The conventional technology of indirect heating dryer is selected for comparison with Self-heat Dryer Technology. Calculation conditions of energy balance are shown in Table 1. Calculation formula of energy efficiency is shown in Table 2.

3. Evaluation of quality as fertilizer and fuel use

We measured the amount of assurance component and harmful component in dried sludge and confirmed that it satisfies the standard value in the Fertilizer Regulation Act for fertilizer use. We also measured total calorific value and moisture content of dried sludge to confirm that it satisfies the standard value of JIS Z7312 BSF-15 for fuel use.

Results and Discussions

1. Evaluation of cost saving effect

Result of LCC comparison between Dehydration and Drying Technology and conventional one is shown in Figure 5. LCC of the innovative technology decreased by about 24% than that of the conventional dehydration and dryer system. Comparison result of maintenance cost between Self-heat Dryer Technology and conventional one is shown in Figure 6. The reducing ratio of LCC is about 42%. Result of maintenance cost comparison between Self-heat Dryer Technology and conventional one is shown in Figure 6. Maintenance cost of the innovative technology decreased by about 62% than that of the conventional dryer.

2. Estimation of the energy efficiency

Estimation result of energy efficiency is shown in Table 3. It is indicated that the energy efficiency of both innovative technologies are obviously higher than that of conventional one. Especially in case of Self-heat Dryer Technology, because input heat energy is lower than required heat energy for evaporation of water, the energy efficiency exceeded 100%.

3. Evaluation of quality as fertilizer and fuel use

The result of ingredient analysis of dried sludge as the fertilizer use and the fuel use is shown in Table 4. The quality of the sludge satisfied the standard value of Fertilizer Regulation Act for fertilizer use and JIS Z7312 BSF-15 for fuel use.

Conclusions

From the above result, both of innovative technologies were successfully proved to low cost and energy saving dehydration and dryer system for fertilizer and fuel use. Future work is verifying stability to seasonal variation.

References

1) The manual of basic plan for Biosolids application in Japanese, Japan Sewage Works Association, 2004

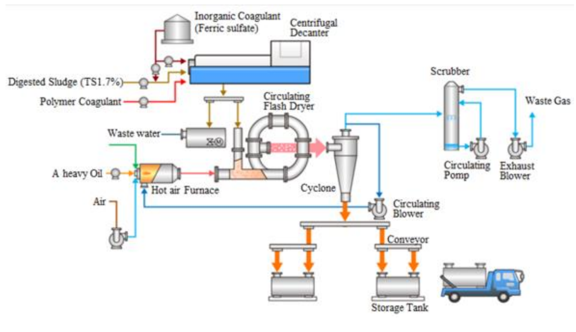

Figure 1 Schematic flow of dehydration and drying process
(Dehydration and Drying Technology)

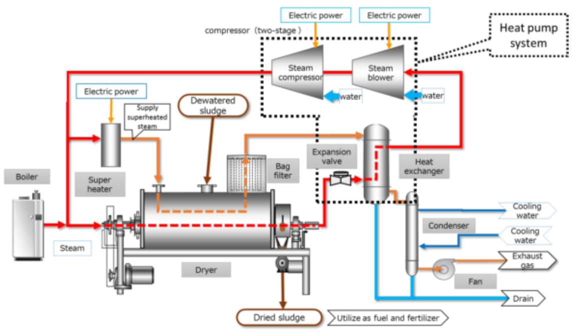

Figure 2 Schematic flow of drier process
(Self-heat Dryer Technology)

Figure 3 Appearance of full-scale demonstration plant
(Dehydration and Drying Technology)

Figure 4 Appearance of full-scale demonstration plant
(Self-heat Dryer Technology)

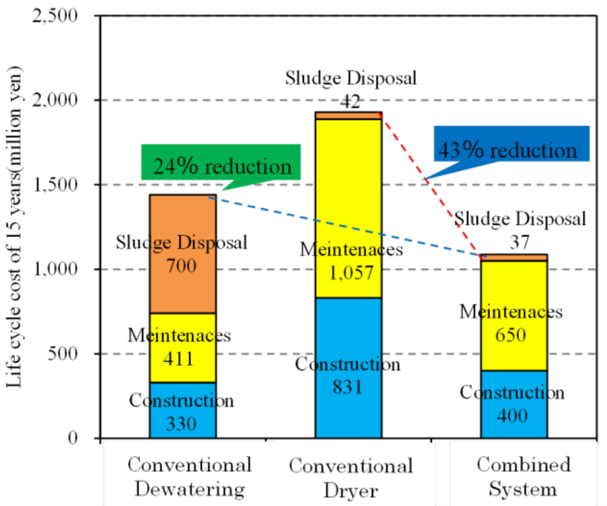

Figure 5 Comparison of Life Cycle Cost (LCC)
(Dehydration and Drying Technology)

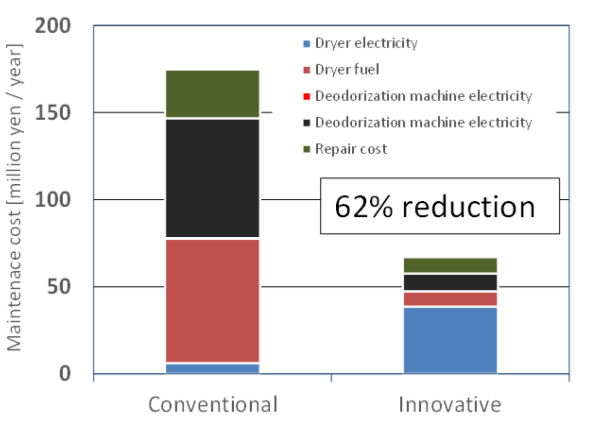

Figure 6 Comparison of maintenance cost
(Self-heat Dryer Technology)

Table 1 Calculation conditions of energy balance

	Dehydration and drying	Self-heat recuperation
Heating system	Direct	Indirect
Conventional technology	Rotary dryer with stirrer	Indirect heating dryer
amount of dewatered sludge[kg/h]	304	1,300
Dewatered sludge water content[%]	76	72
Dried sludge water content[%]	30	20
Air temperature[℃]	15	10

Table 2 Calculation formula of energy efficiency

$$\text{energy efficiency}[\%] = \frac{W \times (hv - hl)}{E} \times 100$$

W: Evaporated water quantities [kg/h]
hv: Specific enthalpy of water vapor at dried sludge temperature [MJ/kg]
hl: Specific enthalpy of water at atmospheric temperature [MJ/kg]
E: Input energy [kJ/h]

Table 3 The result of estimation of energy efficiency

	Dehydration and drying (Innovative)	Rotary dryer with stirrer (Conventional)	Self-heat recuperation (Innovative)	Indirect heating dryer (Conventional)
Heating system	direct	direct	indirect	indirect
Energy efficiency[%]	73	45	167(74※)	61

Table 4 The result of ingredient analysis of dried sludge as the fertilizer use and the fuel use

		Contents	Unit	Dehydration and Drying Technology (digested sludge)	Self-heat Dryer Technology (dewatered sludge)	Tolerance
Fertilizer	Assurance components	Nitrogen	%	6.2	5.6	-
		Phosphoric acid	%	4.3	2.4	-
		Potassium oxide	%	0.2	0.1	-
		Copper	mg/kg	560	120	-
		Zinc	mg/kg	520	310	-
		Calcium oxide	%	1.8	1.0	-
	Harmful components	Cadmium	mg/kg	<1	<1	<5
		Mercury	mg/kg	0.5	0.2	<2
		Arsenic or the compound	mg/kg	4.2	1.6	<50
		Nickel	mg/kg	22	14	<300
		Chrome	mg/kg	27	16	<500
		Lead	mg/kg	<1	17	<100
Fuel	Total calorific value		MJ/kg	17.3	19.8	>15
	Moisure content		%	11	10.7	<20