Performance evaluation research on technology of the sewage sludge drying using an oil bath under diminished pressure

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1. Introduction

In Fukuoka Prefecture, effective use and the recycling of the sewage sludge were examined in consideration of an increase of the amount of the sewage sludge generation according to the progress of wastewater facilities. Stable disposal and the global environment maintenance of the sewage sludge were done to the examination by the purpose.

Then, Fukuoka Prefecture paid attention to the technology of the sewage sludge drying using an oil bath under diminished pressure, and executed a joint research of this technology with JIWET.

This technology dries the one that the dewatered sludge was mixed with cooking oil waste. This technology heats the sewage sludge below the atmospheric pressure, and manufactures dried sludge of about 3.0% of the rate of the include water. The calorific value can be high because oil is contained, and this dried sludge is expected to be used effectively as associate Mo material in the cement manufacturing and an alternate fuel such as coal.

The practical use research was done in 1996 fiscal year, and the design parameter of the real equipment was set. Equipment was constructed in 2002 fiscal year, and the proof driving investigation was executed as a performance evaluation research that had used equipment in 2003 fiscal year.

This time, the performance evaluation research is announced.

2. Technological outline

(1) Principle of dryness

Fig.1 shows the concept chart of the technology of sewage sludge drying using an oil bath under diminished pressure.

1) The cooking oil waste is mixed with the dewatered sludge in device.
2) It decompresses to about -40kPa in device, and the compound of oil and sludge is heated with steam. The cooking oil wastes plays heat transfer medium's role, and evaporates moisture in dewatered sludge.
3) The amount of sludge loses weight to about 1/3. (Refer to Fig. 2)

- Because it decompresses in the device, and the boiling point of water is lowered to about 85℃, the deterioration of the cooking oil wastes can be decreased, and oil is used repeatedly.

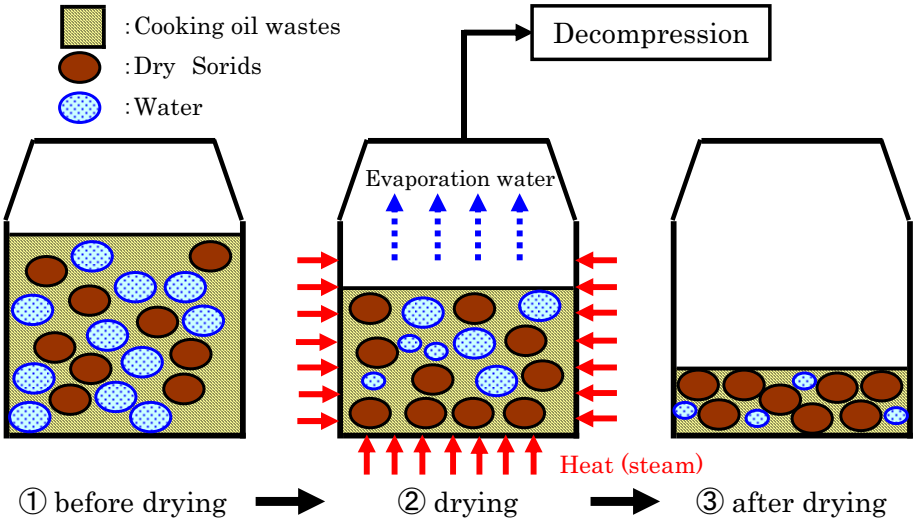


Fig.1 Image of dry principle

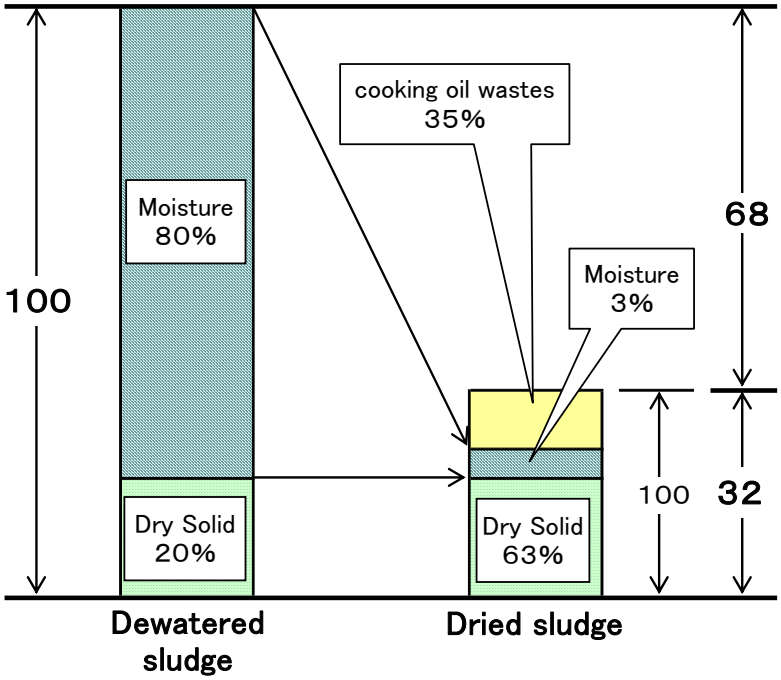
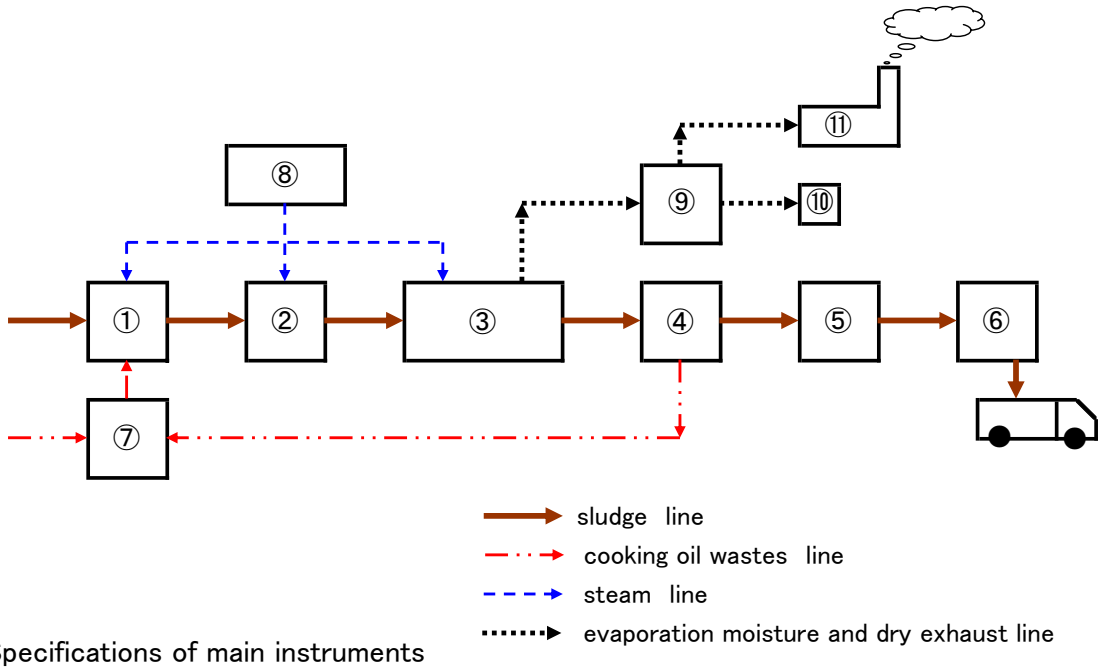


Fig.2 Volume reduction image of sewage sludge

(2) Basic flow of this equipment

Fig.3 shows the flow of the system of this technology. The processing of this technology is a batch type, the ability to process the dewatered sludge of 10 ton-wet times is possessed, and the amount of dewatered sludge disposal each day is 90t-wet/day.

1) The dewatered sludge of 10 ton-wet and medium oil 7m^3 are mixed in sludge mixing tank, oil is distributed in dewatered sludge, and it turns it on to the sludge dryer through pre-heating tank.
2) It is decompressed to -40kPa in sludge dryer, and the dewatered sludge is heated, and moisture evaporates. The evaporating moisture becomes condensation water after it cools with the condenser via mist separator, and is processed as recycle flow water.
3) The compound of dried sludge and the medium oil is separated to dried sludge and oil with oil separator. The separating oil is refined further with the oil re-separation machine, and recycled as medium oil.
4) The dried sludge after oil is separated is cooled by the cooling machine and is done to the dried sludge hopper.



Specifications of main instruments

①	②	③	④	⑤
Sludge mixing tank	Pre-heating tank	Sludge dryer	Oil separator (the 1st stage)	Oil separator (the 2nd stage)
cylinder type 19m^3	cylinder type 19m^3	oil bath evaporation under diminished pressure 90t (wet base) / Day heating surface area: 198m^2	centrifugal s eparation, basket type 4m^3 / hr	centrifugal separation 7m^3/hr

⑥	⑦	⑧	⑨	⑩	⑪
Dried sludge hopper	Oil storage tank	Main boiler	Condenser	Vacuum pump	combustion furnace
35m^3	cylinder type 29m^3	furnace tubular boiler reduced amount of evaporation: 12 t /hr	multitude heat exchanger heating surface area: 257m^2	water jet type rate of evacuation: 9.7m^3/min	direct burning with fuel combustion rate: 40 m^3/min

Fig.3 Plant equipment flow

3. Content of performance evaluation research

3.1 Dry performance

A dry performance of this equipment is investigated. Tab.1 shows the dry performance target of this research.

Tab.1 Dry performance target

Processing condition	Sludge of processed object	Digested sludge
	Moisuture content（%）	80
	Amount of processing of dewatered sludge（t-wet／batch）	10 ※
	Dry time （min）	120
	Mixture ratio of heat medium oil（m^3/t-wet）	0.6～0.8
Quality of dried sludge	Moisuture content（%）	≒3
	Cooking oil waste content（%）	30～40
	higher calorific value（kJ/kg-DS）	≒20,000

※. 90t-wet／Day

3.2 Economy

The amount of the energy use of this equipment for the driving period is arranged, and the utility cost and the administrative and maintenance cost per the turning on dewatered sludge are calculated.

3.3 Possibility of effective use for sewage dried sludge

Properties of the dried sludge manufactured from this equipment are compared with other biomasses, and best, effective use is examined.

4. Result of performance evaluation research

4.1 Dry performance

Tab.2 shows the investigation result of every the season. Moreover, the accumulation frequency is shown in Fig.4 about the water content of dried sludge at each time. The water content of dried sludge falls below target value (3%), and can produce dried sludge without trouble for change of the water content(79～86%) of the dewatered sludge.

Tab.2 Dry performance result

Investigation item \ Investigation result		Time			
		Apr-03	Aug-03	Nov-03	Jan-04
Processing condition	Sludge of processed object	Digested sludge			
	Moisuture content （%）	80～84	79～82	81～82	81～86
	Amount of processing of dewatered sludge （t-wet／batch）	10	10	10	10
	Dry time （min）	0.64～0.75	0.64～0.69	0.65～0.69	0.64～0.69
	Mixture ratio of heat medium oil （m^3/t-wet）	113	107	109	110
Quality of dried sludge	Moisuture content （%）	0.9～4.2	0.5～1.5	0.5～1.5	0.4～1.7
	Cooking oil waste content （%）	34	37	36	34
	higher calorific value （kJ/kg-DS）	—	20,000	—	22,100

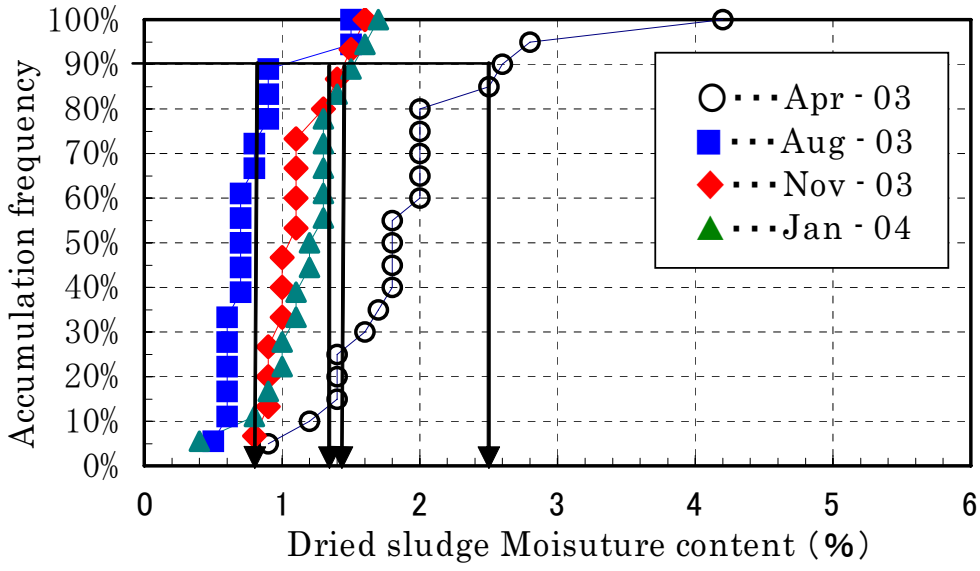


Fig.4 Accumulation frequency distribution of dried sludge moisture at the four seasons

4.2 Economy

Tab.3 shows the trial calculation result of the cost of construction and integrated maintenance cost necessary to process the dewatered sludge by 1ton-wet.

In Mikasagawa treatment center, a digestive gas of the sewage sludge origin is used as substitution of necessary kerosene for the heat source of dryness. Therefore, the utility cost can be suppressed to low.

Cost item		Cost to process dewatered sludge by 1t-wet	
		¥/t-wet	€ /t-wet
construction	Civil engineering and construction	¥1,069	7.17 €
	Plant machine	¥8,725	58.56 €
	Plant electrical	¥1,379	9.26 €
	Subtotal ①	¥11,173	74.99 €
Maintenance management	Utility	¥4,350	29.19 €
	Labor	¥2,224	14.93 €
	Normal shutdown	¥2,107	14.14 €
	Subtotal ②	¥8,681	58.26 €
Integrated cost ①＋②		¥19,854	133.25 €

※. Equipment driving time : 24hr／Day

※. The equipment life : 10Years

4.3 Possibility of effective use for sewage dried sludge

(1) Comparison with other biomasses

Tab.4 shows the result of comparing other typical biomasses of the sewage sludge system, the wood system, and the food waste system with dried sludge. The feature of dried sludge manufactured from this equipment is shown below.

○ Because this dried sludge contains oil, higher calorific value is higher than other biomasses. Moreover, higher calorific value for each supplied ash content is higher than the carbonization sewage sludge when seeing in the index of HCV/AC(3～10 times).

○ This dried sludge is high organic, and meets a quality as the fertilizer and an official standard of Japan concerning safety.

Tab.4 Comparison with other biomasses

Biomass \ Analysis result		Higher calorific value		Moisuture content	Ash content	Chlorine content	HCV／AC※
		kJ／kg-DS	kcal／kg-DS	%	%-DS	mg／kg	kJ／kg
Sewage sludge	Dried sludge※	20,000～22,000	4,770～5,270	0.4～4.2	22.7	500	881～969
	Carbonization sewage sludge	8,000～8,200	1,911～1,959	－	74～85	－	94～111
Wood waste	Carbonization woods waste	9,460～11,135	2,260～2,660	－	0.3～3.5	39～190	2,703～37,117
	Carbonization construction waste	16,995～19,047	4,060～4,550	－	0.4～4.2	100～600	4,047～47,616
Carbonization food waste		13,521～15,991	3,230～3,820	－	38.1～41.8	13,000～17,000	323～420
Coal (reference value)		26,000	6,211	9.05	20	－	1,300

※. HCV／AC： Higher calorific value／Ash content

※. Dried sludge： Sewage sludge processed by sludge drying using a oil bath under diminished pressure

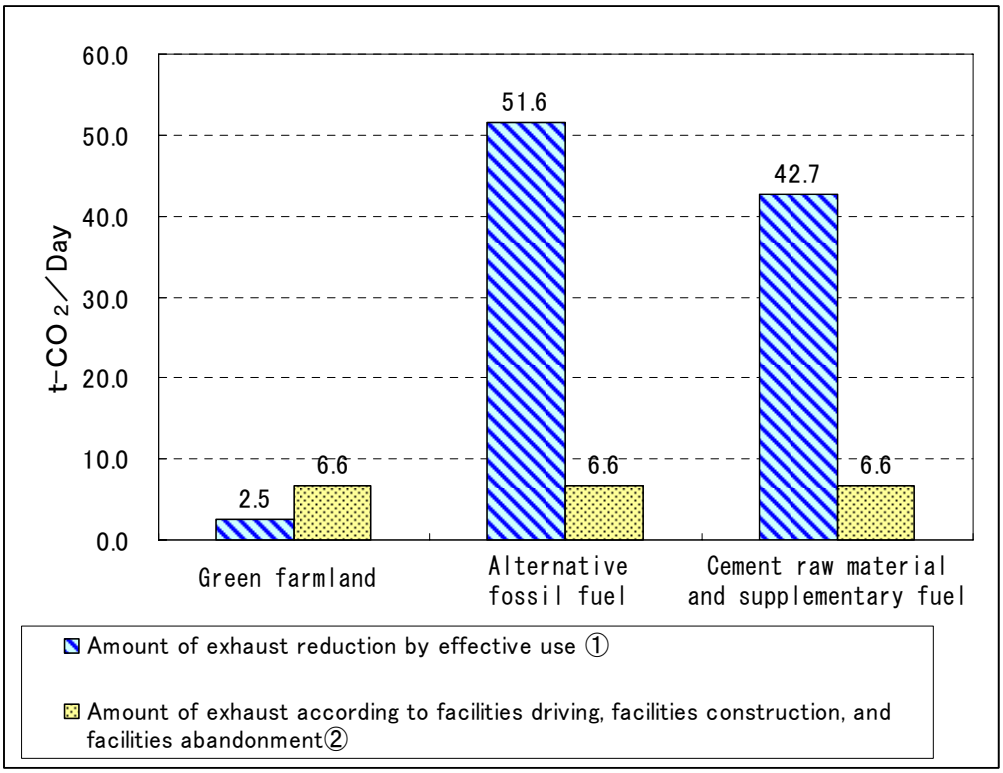
(2) Effect of heat-trapping gas reduction

At first, the profit use as a biomass fuel has been paid to attention as for the research beginning in recent years though this dried sludge put use in the cement manufacturing process as associate Mo material in view.

Therefore, the effect of the reduction of the heat-trapping gas of three methods (the green farmland use, the alternative fossil fuel use, and the cement raw material and supplementary fuel use) was provisionally calculated. Fig.5 shows the trial calculation result.

○ The amount of the exhaust reduction is a little because the heat-trapping gas of about 11ton-CO_2/ day is generated to manufacture dried sludge at the green farmland use, and the amount of the exhaust increases.

○ The amount of the reduction is large because it is assumed the substitution of the resource with large amount of the heat-trapping gas exhaust such as the fossil fuels if it uses it as the alternative fossil fuel use, and cement raw material and supplementary fuel use. Therefore, the amount of the heat-trapping gas reduction exceeds the amount of the heat-trapping gas exhaust when driving and constructing it. (Reduce by the alternative fossil fuel use during 45ton-CO_2/day. Reduce by the cement raw material and supplementary fuel use during 36ton-CO_2/day.) However, because the amount of the heat-trapping gas exhaust according to manufacturing dried sludge increases when a digestive gas is not used, the effect of the reduction becomes small. Therefore, effective use for a digestive gas is important to enable the effect of the reduction of a bigger heat-trapping gas.



Effective usage / Amount of heat-trapping gas (t-CO_2／日)	Green farmland use	Alternative fossil fuel use	Cement raw material and supplementary fuel use
Amount of exhaust reduction by effective use ①	2.5	51.6	42.7
Amount of exhaust according to facilities driving, facilities construction, and facilities abandonment②	6.6	6.6	6.6
Amount of integrated heat-trapping gas exhaust(②－①)	4.1	−45.0	−36.1

Fig.5　Effect of heat-trapping gas reduction

5. Summary of performance evaluation research

To achieve the heat-trapping gas reduction target of Japan in the Kyoto Protocol*, energy conservation, new energy, and the progress of other reduction strategies are needed more than before. Then, to achieve the target, the RPS law * was enforced in Japan. The RPS law is a content in the law enforced aiming at the new energy spread in 2003 that obligates more than a constant ratio to be used against an electric entrepreneur as for the electricity obtained from new energy etc. Especially, the amount of the introduction of crude oil conversion 19,100M liter is expected about new energy in fiscal year 2010. (integrated resource energy investigation committee report in July, 2001)。

New energy etc. that become objects are a photovoltaic generations, wind power

generation, biomass power generations, small-scale hydro-power, and the geothermal power generations. This dried sludge is a biomass with the usage to many fields like a green farmland, thermal energy, and the cement raw material and associate Mo material, etc. as well as other biomasses. Especially, because the cooking oil waste (medium oil) is contained, calorific values are higher than other biomasses. Moreover, the mineral is few. Because it is a carbon neutral, the reduction in the amount of the heat-trapping gas exhaust can be expected. Therefore, it is a biotechnology solid fuel excellent as the substitution of the fossil fuel. The above-mentioned background exists, and attention is paid to this dried sludge by the electric power entrepreneur. Power generation that uses the fuel that mixes coal with this dried sludge in Matsuura coal-fired power station (J-POWER) is done now. The mixture ratio of this dried sludge to coal is 1%, and power generation is done without trouble. Two equipment of output 1,000MW is set up in the Matsuura coal-fired power station, and consumption is about 4.4 million tons a year. Therefore, this approach has reduced the consumption of the coal of about 44,000 tons a year. That is, the heat-trapping gas of about 110,000 tons a year will have been reduced. (Conversion value of CO_2)

There is a big role that wastewater facilities are a hydrologic cycle. Wastewater facilities in addition to the role is expected to reduce sewage sludge collected from each home to the society as a biomass energy resource.

It is expected that this research can contribute to the effective profit use of the sewage sludge.

※ Kyoto Protocol(Kyoto Protocol to the United Nations Framework Convention on Climate Change) ：The Kyoto Protocol is a protocol resolved in Kyoto Conference on Climate Change (the 3rd Framework Convention on Climate Change Conference of the Parties and COP3) opened in Kyoto City (Japan) in 1997 based on Framework Convention on Climate Change.

※ RPS law(Renewable Portfolio Standard law)：In the law enforced aiming at the new energy spread in 2003, it is a content that obligates more than a constant ratio to be used against an electric entrepreneur as for the electricity obtained from new energy etc.

Performance evaluation research on technology of the sewage sludge drying using an oil bath under diminished pressure

Japan Institute of Wastewater Engineering Technology
1st Research Department
Researcher SHIGERU IKARUGI

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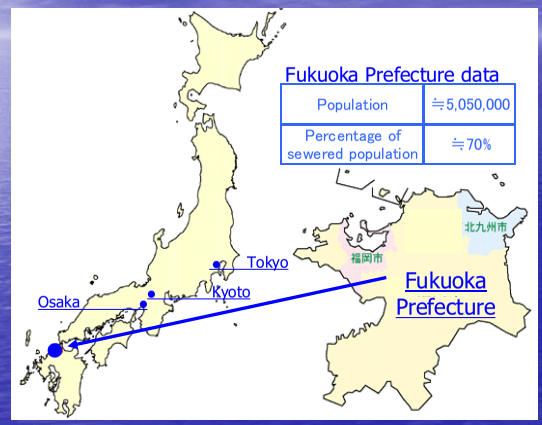
1.Introduction

(1) Fukuoka Prefecture position



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1 Introduction

(2) Background

Examination problem in Fukuoka Prefecture

An increase of the amount of the sewage sludge generation according to the progress of wastewater facilities

The technology of sewage sludge drying using an oil bath under diminished pressure

- ○ Possibility of Stable sludge disposal
- ○ Possibility of recycling sewage sludge
- ○ Contribution to global environment

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1.Introduction

Start of a joint research in MIKASAGAWA treatment center

The technology of sewage sludge drying using an oil bath under diminished pressure

Fukuoka Prefecture

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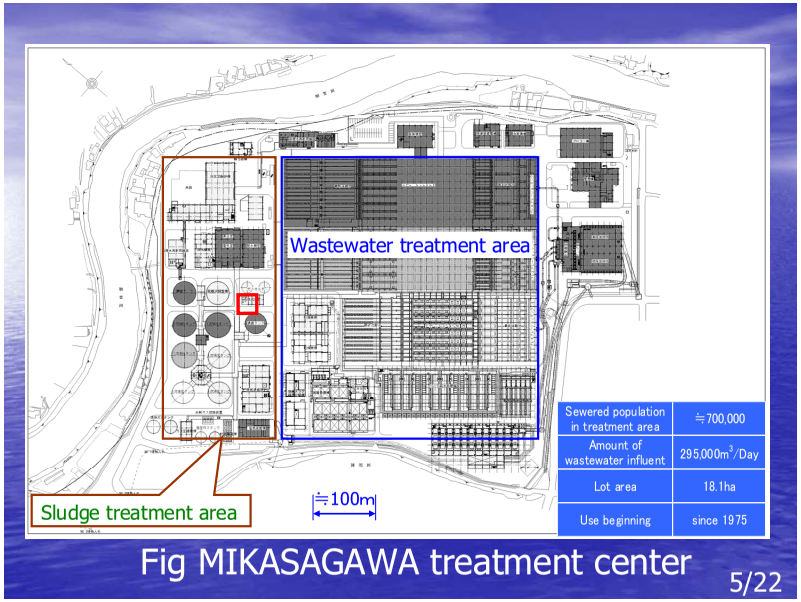

Fig MIKASAGAWA treatment center

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2.Technological outline

(1) Principle of dryness

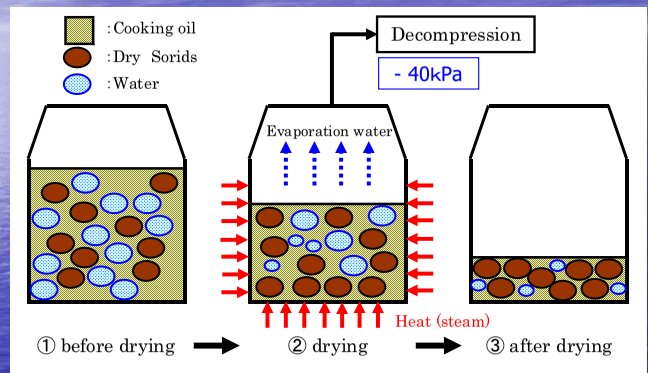

Fig.1 Image of dry principle

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2 Technological outline

(2) Volume reduction image

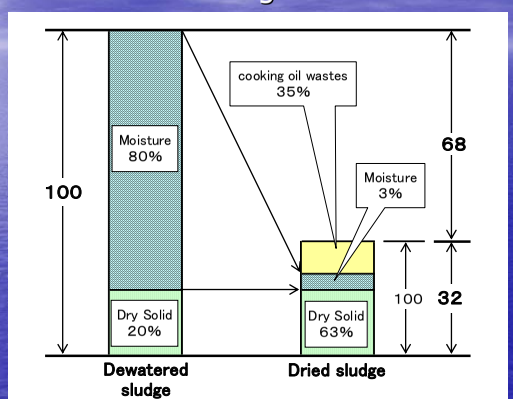

Fig.2 Volume reduction image of sewage sludge

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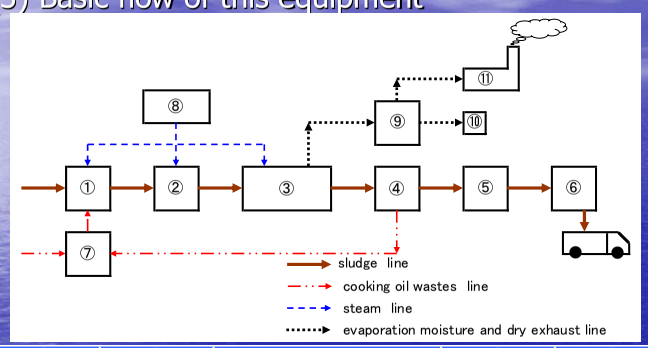
2.Technological outline

(3) Basic flow of this equipment



①	②	③		④	⑤
Sludge mixing tank	Pre-heating tank	Sludge dryer		Oil separator (the 1st stage)	Oil separator (the 2nd stage)
⑥	⑦	⑧	⑨	⑩	⑪
Dried sludge hopper	Oil storage tank	Main boiler	Condenser	Vacuum pump	combustion furnace

Fig.3 Plant equipment flow

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2.Technological outline

Spec

Model of dryer	oil bath evaporation under diminished pressure
Heating surface area	198m2
Processing object	Digested dewatered sludge
Amount of processing	90ton-wet / Day (10t-wet / batch)
Driving time	24hr / Day (9batch / Day)

Fig. Sludge dryer

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2.Technological outline

Quality of dried sludge

Moisuture content (%)	≒3
Cooking oil waste content (%)	30~40
higher calorific value (kJ/kg-DS)	≒20,000

Fig. Dried sludge

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3. Performance evaluation research Content

3.1 Dry performance

3.2 Economy

3.3 Possibility of effective use

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3. Performance evaluation research Content

3.1 Dry performance

Tab.1 Dry performance target

Processing condition	Sludge of processed object	Digested sludge
	Moisuture content (%)	80
	Amount of processing of dewatered sludge (t-wet／batch)	10 ※
	Dry time (min)	120
	Mixture ratio of heat medium oil (m^3/t-wet)	0.6～0.8
Quality of dried sludge	Moisuture content (%)	≒3
	Cooking oil waste content (%)	30～40
	higher calorific value (kJ/kg-DS)	≒20,000

※.90ton-wet/Day

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3. Performance evaluation research Content

3.2 Economy

Trial calculation of cost

(1) Construction cost

(2) Maintenance management cost

(3) Integrated cost

3.3 Possibility of effective use for sewage dried sludge

(1) Comparison with another biomasses

(2) Effect of heat-trapping gas reduction

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4. Performance evaluation research result

4.1 Dry performance

Tab.2 Dry performance result

Investigation item	Investigation result	Time				Target value
		Apr-03	Aug-03	Nov-03	Jan-04	
Processing condition	Sludge of processed object	Digested sludge				
	Moisuture content (%)	80～84	79～82	81～82	81～86	80
	Amount of processing of dewatered sludge (t-wet／batch)	10	10	10	10	10
	Dry time (min)	113	107	109	110	120
	Mixture ratio of heat medium oil (m^3/t-wet)	0.64～0.75	0.64～0.69	0.65～0.69	0.64～0.69	0.6～0.8
Quality of dried sludge	Moisuture content (%)	0.9～4.2	0.5～1.5	0.5～1.5	0.4～1.7	≒3
	Cooking oil waste content (%)	34	37	36	34	30～40
	higher calorific value (kJ/kg-DS)	—	20,000	—	22,100	≒20,000

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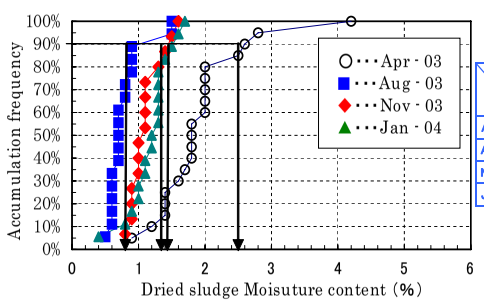
4. Performance evaluation research result

4.1 Dry performance



	Dried sludge moisuture content(%)			
	50% Occupation value	90% Occupation value	Min value	Max value
Apr '03	1.8	2.6	0.9	4.2
Aug '03	0.7	0.9	0.5	1.5
Nov '03	1.1	1.4	0.8	1.6
Jan '04	1.2	1.5	0.4	1.5

Fig.4 Accumulation frequency distribution of Dried sludge moisture at the four seasons

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4. Performance evaluation research result

4.2 Economy

Tab.3 the trial calculation result of the cost

Cost item		Cost to process dewatered sludge by 1t-wet	
		¥/t-wet	€/t-wet
construction	Civil engineering and construction	¥1,069	7.17 €
	Plant machine	¥8,725	58.56 €
	Plant electrical	¥1,379	9.26 €
	Subtotal ①	¥11,173	74.99 €
Maintenance management	Utility	¥4,350	29.19 €
	Labor	¥2,224	14.93 €
	Normal shutdown	¥2,107	14.14 €
	Subtotal ②	¥8,681	58.26 €
Integrated cost ①＋②		¥19,854	133.25 €

※. Equipment driving time : 24hr／Day

※. The equipment life : 10Years

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4. Performance evaluation research result
4.3 Possibility of effective use for sewage dried sludge

Tab.4 Comparison with other biomasses

Biomass \ Analysis result		Higher calorific value kJ／kg-DS	Higher calorific value kcal／kg-DS	Moisuture content %	Ash content %-DS	Chlorine content mg／kg	HCV／AC※ kJ／kg
Sewage sludge	Dried sludge※	20,000～22,000	4,770～5,270	0.4～4.2	22.7	500	881～969
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Wood waste	Carbonization woods waste	9,460～11,135	2,260～2,660	–	0.3～3.5	39～190	2,703～37,117
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Coal (reference value)		26,000	6,211	9.05	20	–	1,300

※. HCV／AC： Higher calorific value／Ash content

4. Performance evaluation research result
4.3 Possibility of effective use for sewage dried sludge

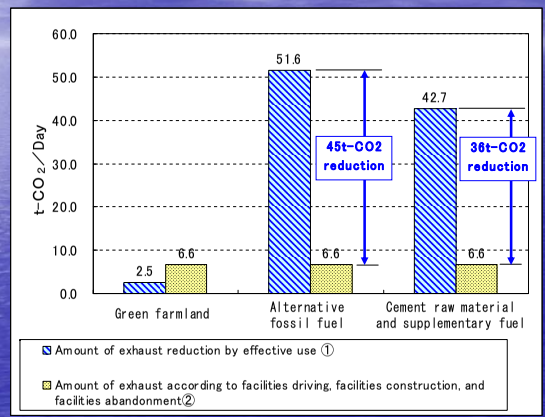


Fig.5 Effect of heat-trapping gas reduction

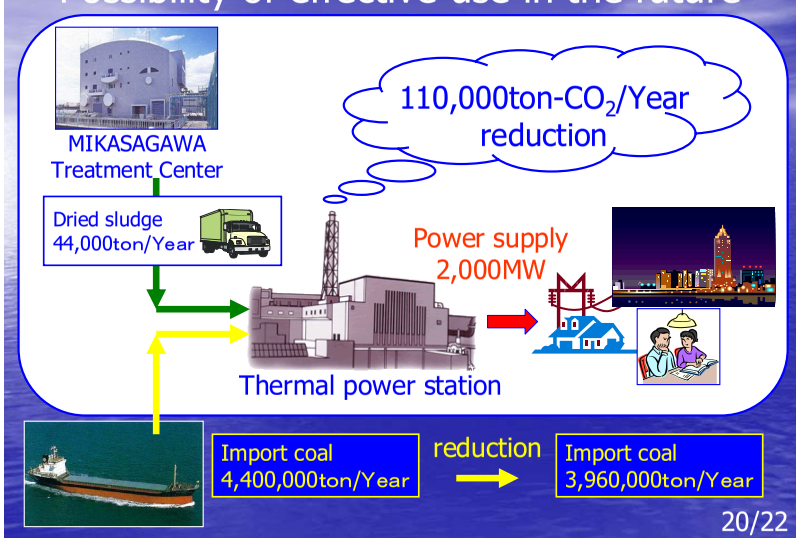
5. Summary of performance evaluation research

○ The performance target was able to be satisfied

○ The amount of the heat-trapping gas exhaust can be reduced

○ The stable operation of equipment can have been done

Possibility of effective use in the future



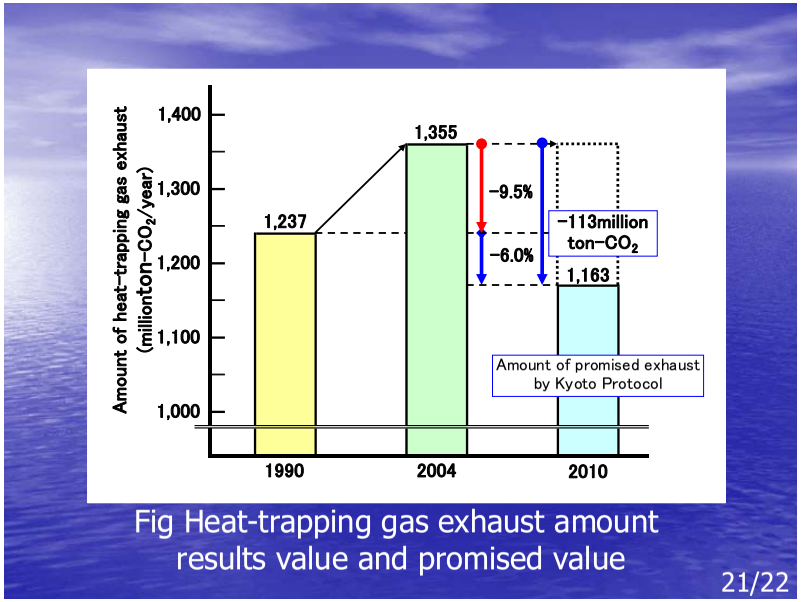


Fig Heat-trapping gas exhaust amount results value and promised value

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Thank you for listening !

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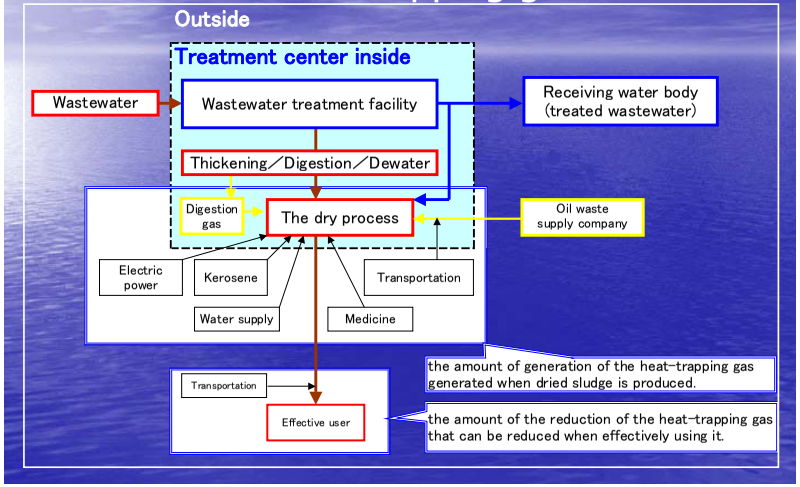
The technology of sewage sludge drying using an oil bath under diminished pressure

reference

Range of trial calculation of amount of heat-trapping gas exhaust



Range of trial calculation of cost

Cost item		
construction	Civil engineering and construction	
	Plant machine	
	Plant electrical	
Maintenance management	Utility	
	Labor	
	Normal shutdown	

Electric power / Kerosene / Digestion gas / Water supply / Oil waste / Medicine

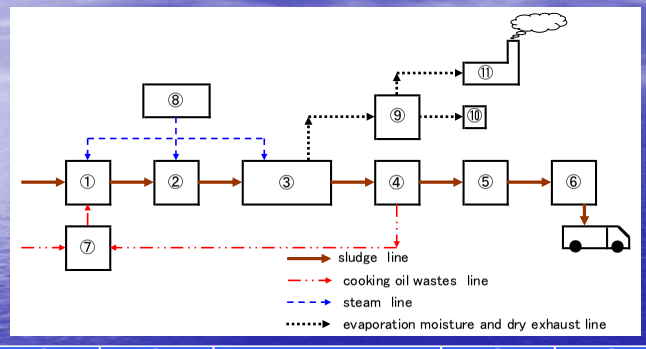
6 full-time people and 2 night shift people

Legal check of boiler / Periodical repair of dryer / Analysis expense(water quality and stink) / Consumption material purchase expense

Trial calculation unit price

Electric power ¥8.2/kWh　Kerosene ¥33.6/L　Digestion gas Free
Water supply ¥565/m^3　Oil waste ¥26/kg　Clean can medicine ¥1,229/kg
Boiler water processing medicine ¥1,428/kg

Basic flow of this equipment



①	②	③		④	⑤
Sludge mixing tank	Pre-heating tank	Sludge dryer		Oil separator (the 1st stage)	Oil separator (the 2nd stage)
⑥	⑦	⑧	⑨	⑩	⑪
Dried sludge hopper	Oil storage tank	Main boiler	Condenser	Vacuum pump	combustion furnace

Fig.3 Plant equipment flow