Development of innovative technologies for biogas production and purification

S. Osumi, T. Kume, J. Tsubota, H. Sakamoto

Energy Engineering Dept.

Osaka Gas Co., Ltd.

Background

- Japanese green house gas reduction goal 25% by 2020, 80% by 2050 (compared to 1990)

- A new low was enforced in 2009 and requires energy companies to make effort to increase the biogas use.
- A low was revised in 2009 And requires every industries (=our customers) to make effort to save energy or to increase the renewable energy use.

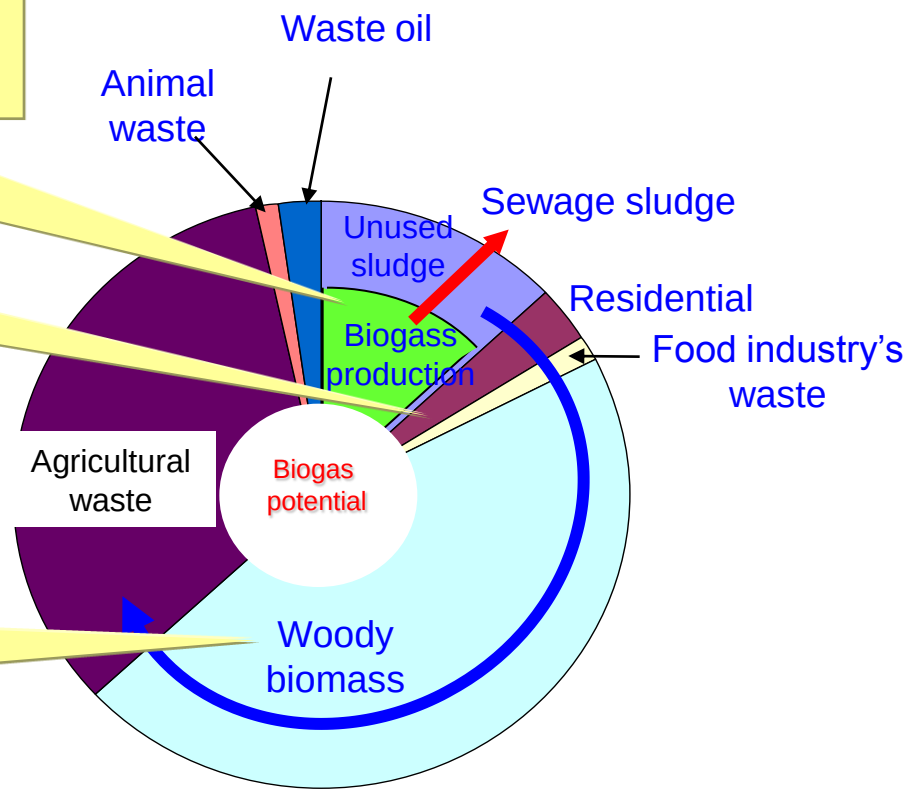
- Both of our company and our customers need to straggle to use renewable energy.

2-1. Biomass potential in Japan and status of its usage

Partly used , mostly discarded by incineration

Incinerated together with paper or plastic wastes

Exhausted sites are wide spread and far from city (pipeline)



Biomass potential in Japan
4.7 billion m3/y as 45MJ/m3 city gas

Strategy to increase biogas use in Japan

<Status>

<Strategy>

- Waste incineration plant
  - Garbage is incinerated together with paper or wastes

→ Garbage should be collected separately and produce biogas by methane fermentation

- Industrial factory
  - In bear factories, biogas is usually produced using UASB
  - In the other fields, biogas is not generally produced because of technical difficulty and economical unfeasibility

→ UASB applicable fields should be expanded by technical development

- Sewage treatment plant
  - At some plants biogas is already produced but isn't used effectively
  - Establishment of the new biogas production plant is difficult because of the economical reason

→ Biogas already produced but not utilized should be used effectively

Biogas potential from above strategies in Osaka Gas's sales area : 45 million m^3/y
(as 45 MJ/m^3 city gas)

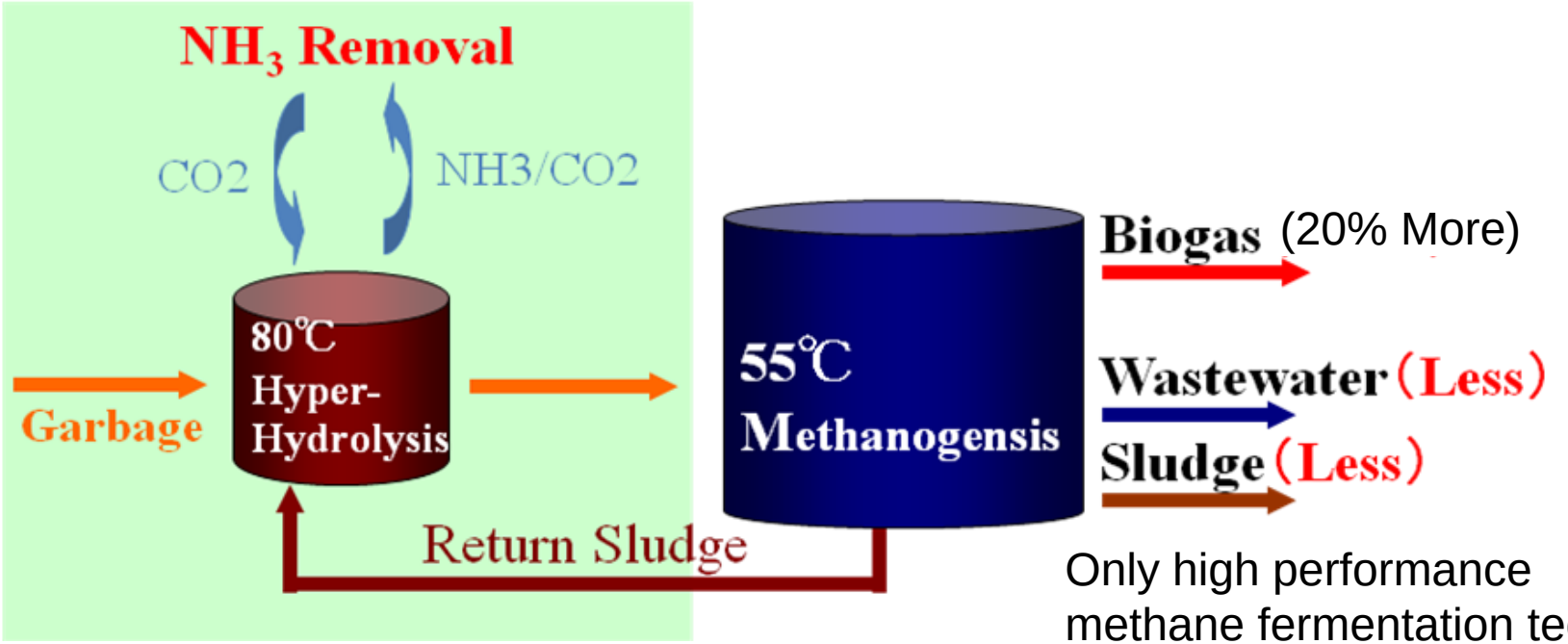
Approach to increase biogas production at wastes incineration plant approach

- Development of the high efficiency methane digestion technology
- Establishment of the new garbage collection model by using biodegradable garbage bag

Hyper-thermophilic hydrolysis

Hyper-thermophilic hydrolysis is a biological pre-treatment of MSW

- Reaction temperature: 80 ℃
- HRT : 1-2day
- Principle : microbial hydrolysis of by 55 ℃ AD sludge at 80 ℃



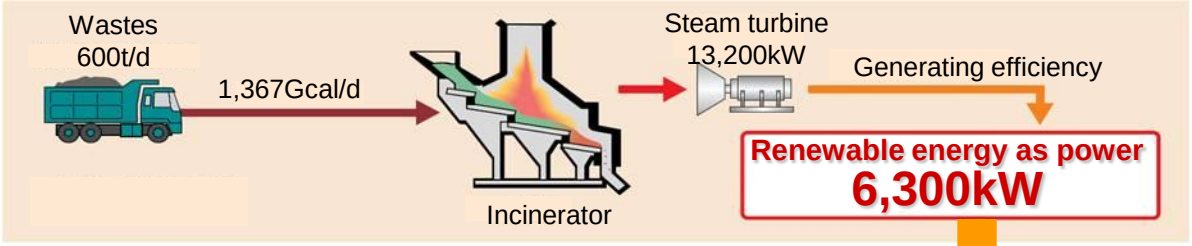
The question is …

Is this treatment also effective to biodegradable plastics ?

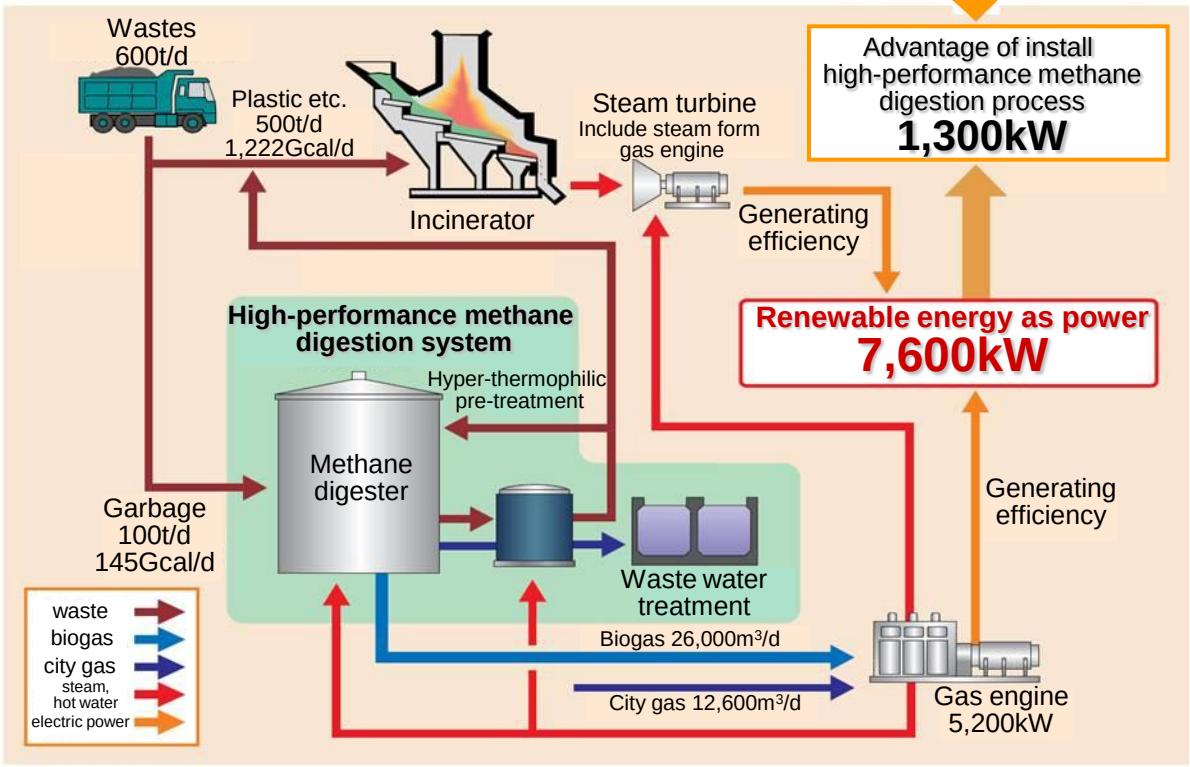
Only high performance methane fermentation tech is not enough to increase biogas production from garbage.

Garbage treatment plant with biomass energy recovery

Conventional wastes incinerating power plant



New system combined by high-performance methane digestion process



Development OF BIODEGRADABLE PLASTICS

Degradation of bio-degradable plastic under AD and Hyper-thermophilic hydrolysis condition

	AD	Hyper-thermophilic hydrolysis
Plastic A	0.49 kg/m3-day	2.8 kg/m3-day
Plastic B	0.11 kg/m3-day	0.2 kg/m3-day
Plastic C	0.57 kg/m3-day	2.5 kg/m3-day
Plastic D	0.33 kg/m3-day	2.6 kg/m3-day
Plastic E	0.49 kg/m3-day	2.6 kg/m3-day

Plastic A, C, D, E is mainly made of PLA (polylactide)
Plastic B is mainly made of PBS(polybutylsucinate)

-100ml of AD sludge at 55 mixed with 5g of commercially available plastics at 55℃ and 80 ℃ for 24 hours
- Screened solids over 0.5mm diameter weighed

Degradation of PLA with 2% ammonium carbonate at 80 ℃

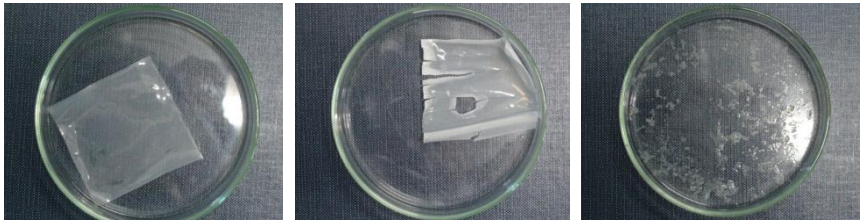
Plastic A was kept at 80℃ in 2% ammonium carbonate.

- Ammonia in AD sludge seemed to degrade PLA ester bond
- Over 70% PLA contents will be required for rapid hydrolysis

(data not shown)

- We can provide over 70% PLA contents garbage bag

(test sample)

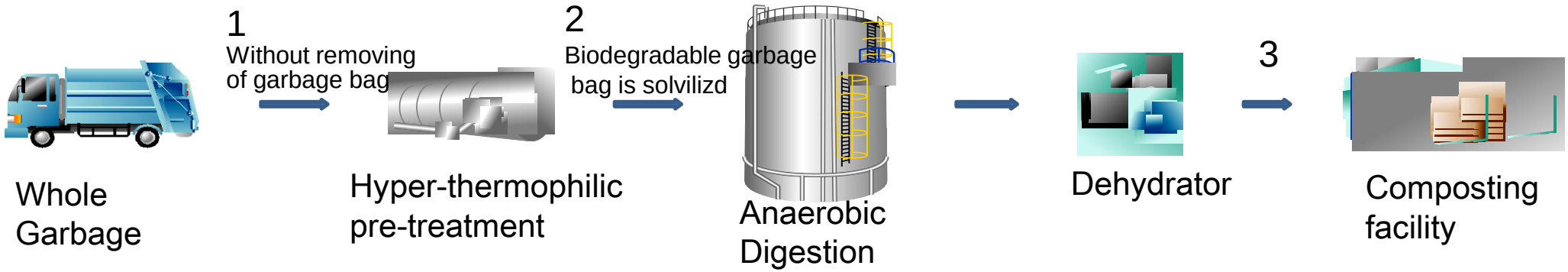


0hr 12hr 24hr

Establishment of new garbage collection model by using biodegradable garbage bag

1. MSW and garbage bag (PLA based) put into hyper-thermophilic hydrolysis reactor, mixed with AD effluent, thenhighly hydrolysed by hyper-thermophilic bacteria comes from AD effluent, polylactide of garbage bag is also hydrolysed.
2. Pre-treated MSW and garbage bag put into anaerobic digester and converted to methane.
3. Residue contains less plastics and easily process to fertilizer.

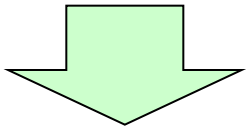
Establishment of whole Garbage (Plant-based Garbage Bag and MSWOF) methan digestion system



		AD alone		Hyper-Thermophilic Pre-treatment + AD	
Garbage input	ton/day	30	set value	30	set value
Garbage bug input	ton/day	1.5	5% of garbage	1.5	5% of garbage
Bio gas from garbage	m^3/day	6,000	200m^3 /ton of garbage	7,200	20% increase
Bio gas from garbage bug	m^3/day	0	0% digestion	980	polylactide contents 70%
Total biogas output	m^3/day	6,000		8,180	

CONCLUSION

- Establishment of new garbage collection and biogas production model
- Plant-based Garbage Bag (mainly made of polylactide) is degraded within a day by Hyper-thermophilic pre-treatment (80 degree, pH7-8).
- AD of whole garbage (garbage bag + garbage) will produce 36% more biogas.

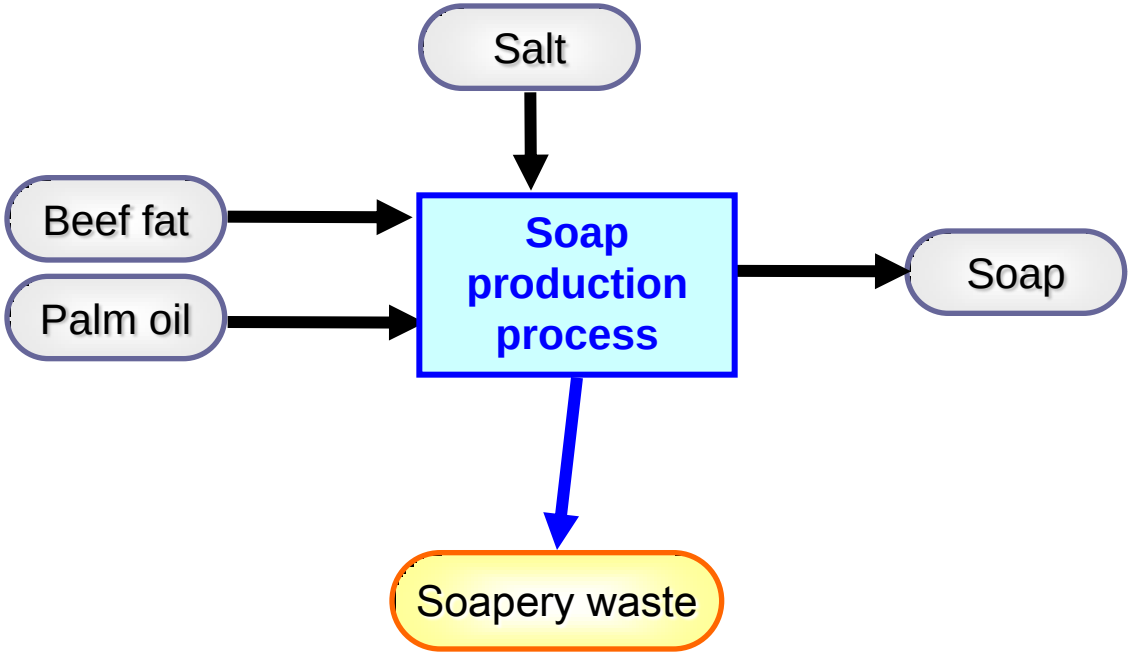


地方自治体へＰＲ

Approach to increase biogas production at industrial plants

- Expansion of the UASB application field
  - Development of the technology to apply UASB for soap factory waste

Soap production process and soapery waste



Composition of soapery waste

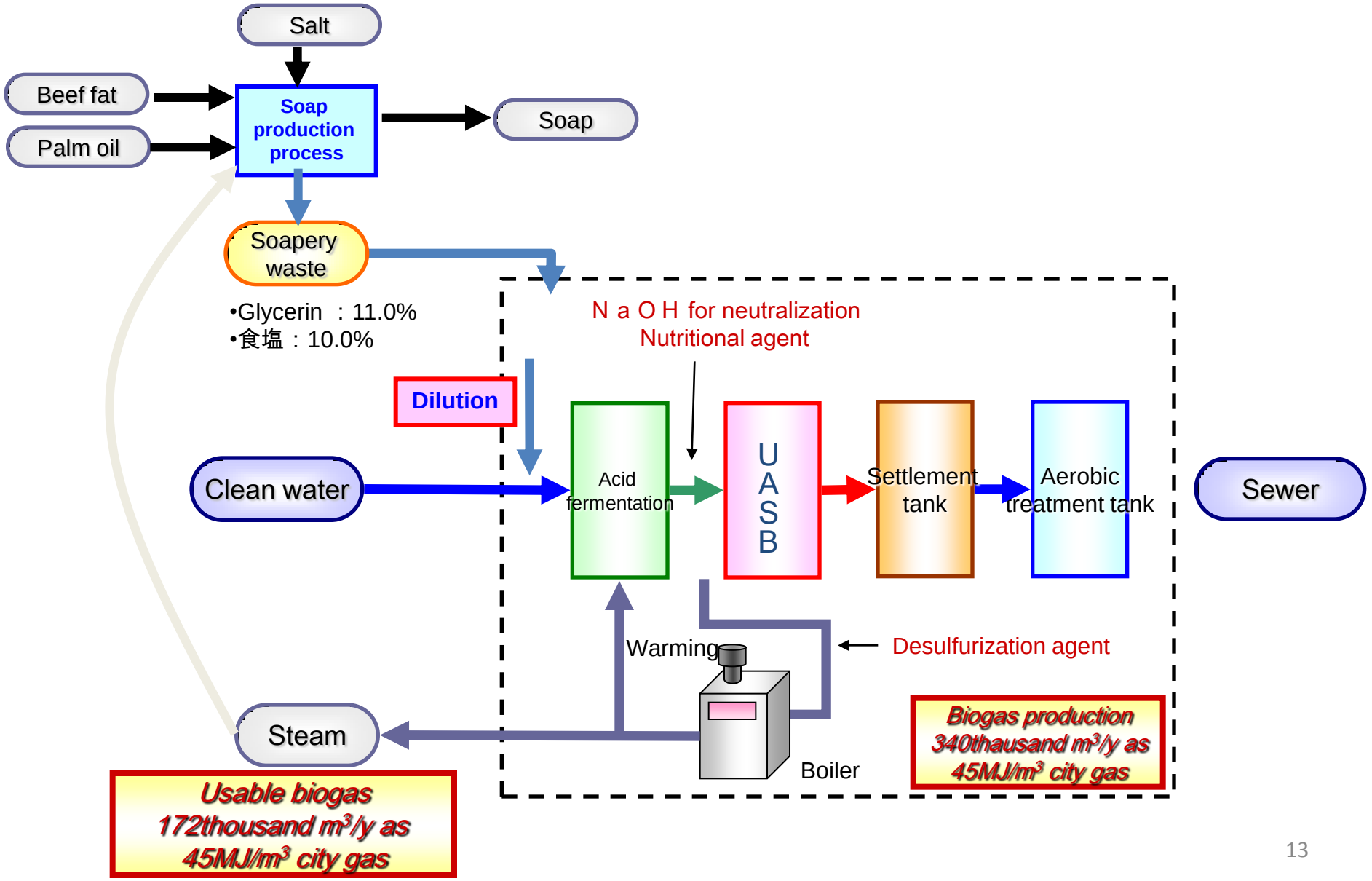
・Glycerin：10%
・COD：12万-14万mg/L

It includes a lot of organic matter originate in biomass , but・・・

・Salt：10%
・pH：13

It also includes high salinity and high alkaline, so biological treatment is difficult

Our system


Salt
Beef fat
Palm oil
Soap production process
Soap
Soapery waste
•Glycerin ：11.0%
•食塩：10.0%
NaOH for neutralization
Nutritional agent
Dilution
Clean water
Acid fermentation
UASB
Settlement tank
Aerobic treatment tank
Sewer
Warming
Desulfurization agent
Steam
Boiler
Biogas production 340thausand m³/y as 45MJ/m³ city gas
Usable biogas 172thousand m³/y as 45MJ/m³ city gas

Feature of our system

- Biological treatment can be applied by decrease the salinity into less than 1.5% by dilution.
- Alkalinity is neutralized in the acid fermentation tank by produced organic acids, and addition of a little alkaline make methane digestion possible.
- Organic matters in soapery waste can be biologically converted into biogas by UASB method.
- Produced biogas is used for steam boiler and generated steam is used to warm the soapery waste and dilution water and for soap production contributing the energy saving of the soap plant.

What's UASB

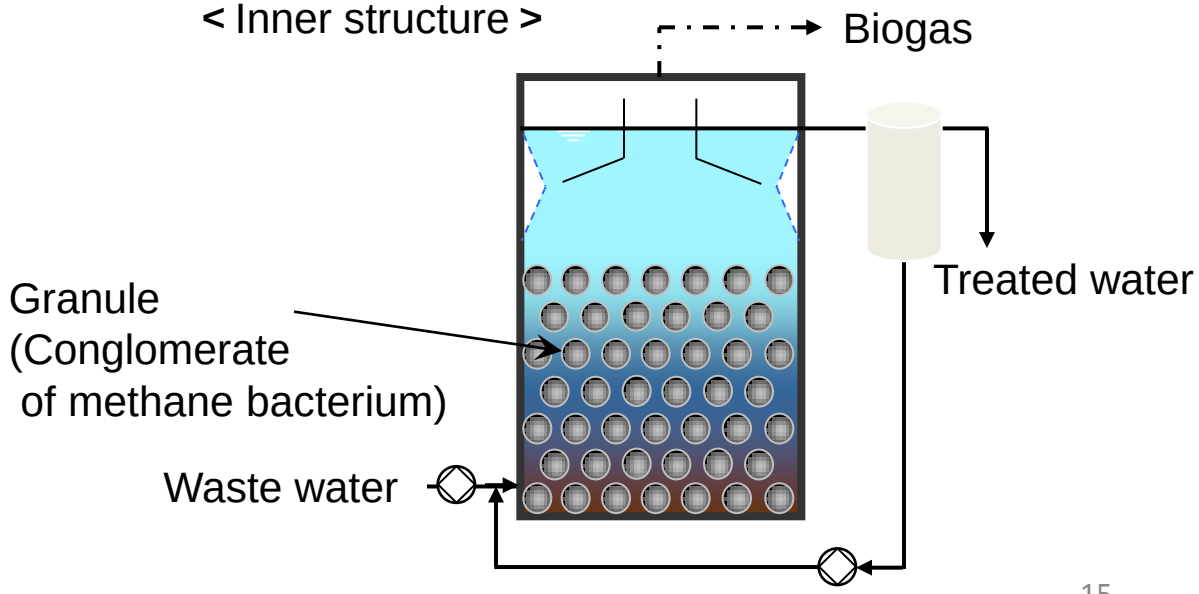
UASB method – methane fermenter for wastewater

Triple merits of biogas system

- **No aeration is necessary.**
- **Amount of sludge decrease.**
- **Biogas is generated and used as fuel.**

< Plant image >

< Inner structure >

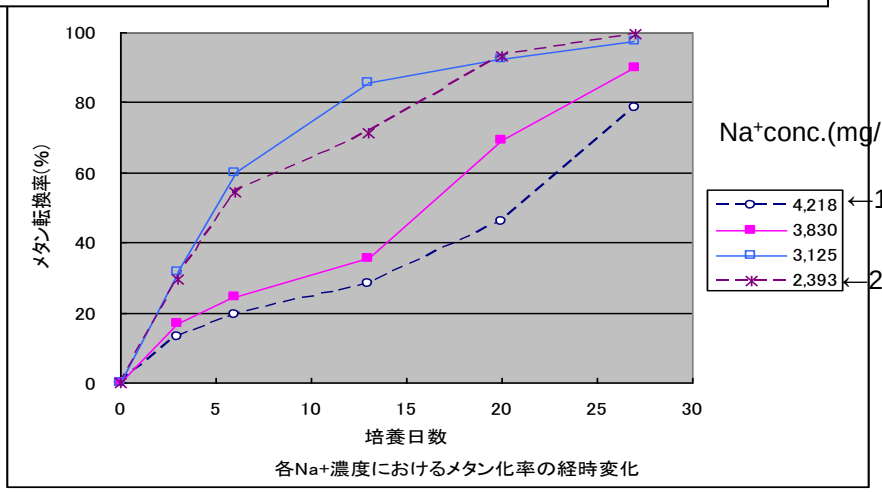


Investigation about salinity ①

- Methane digestion become to be possible by dilution

Batch experiment
for methane digestion

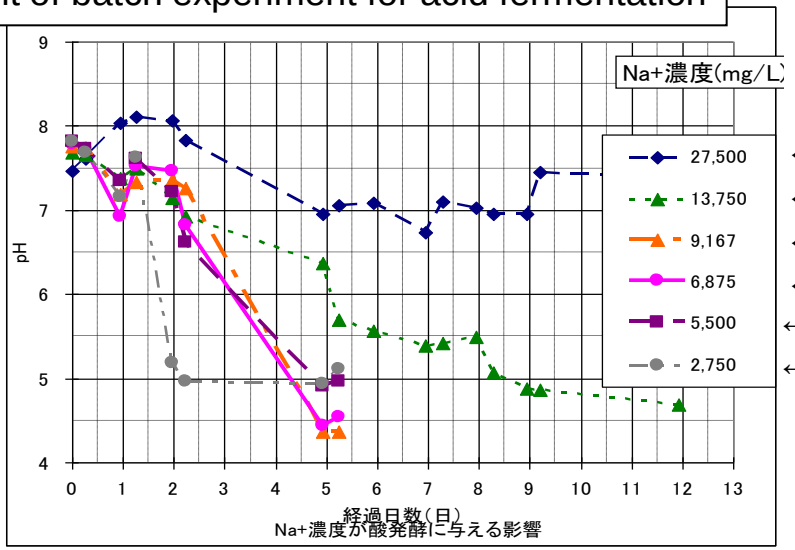
Result of batch experiment for methane digestion



- Acid fermentation become to be possible by more than 6 fold dilution.

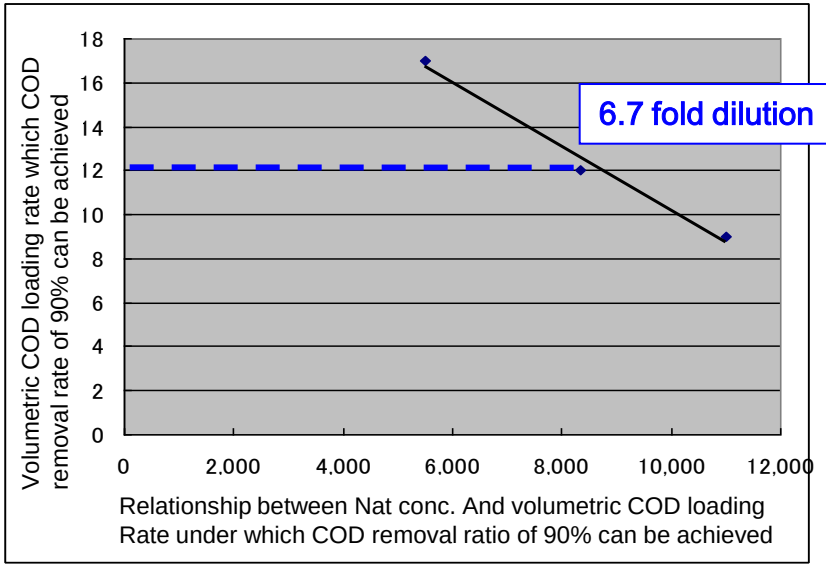
Batch experiment for
acid fermentation

Result of batch experiment for acid fermentation

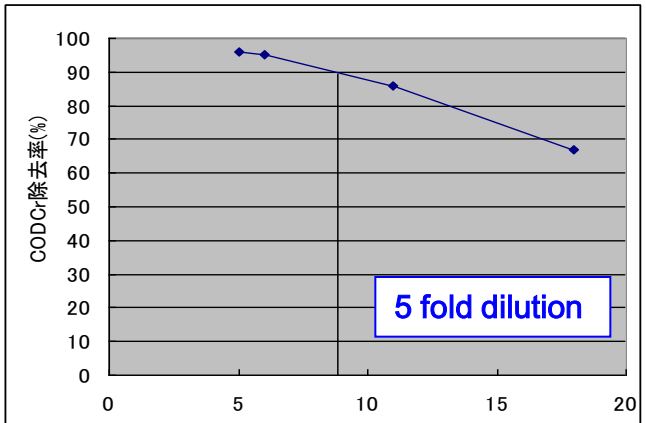


Investigation about salinity ②

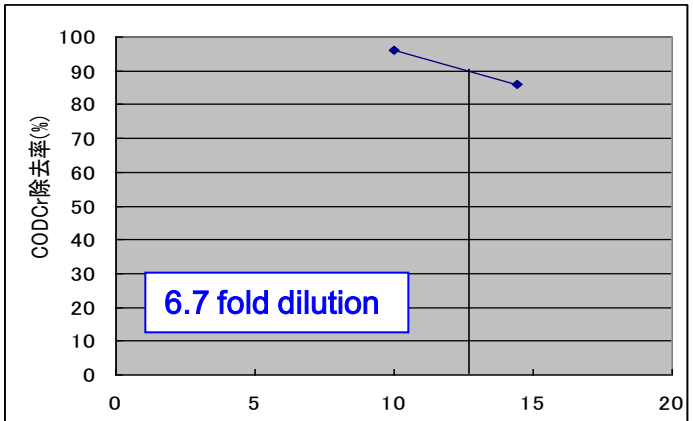
- 90% of COD removal ratio is achievable under 6.7 fold dilation and 12.5kg/m^3· d of volumetric COD loading rate



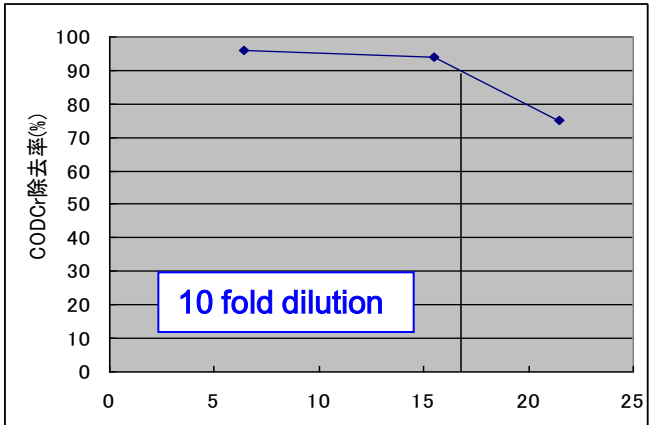
Relationship between Nat conc. And volumetric COD loading Rate under which COD removal ratio of 90% can be achieved



Relationship between volumetric COD loading rate and COD removal ratio at Nat conc. of 11 g/l

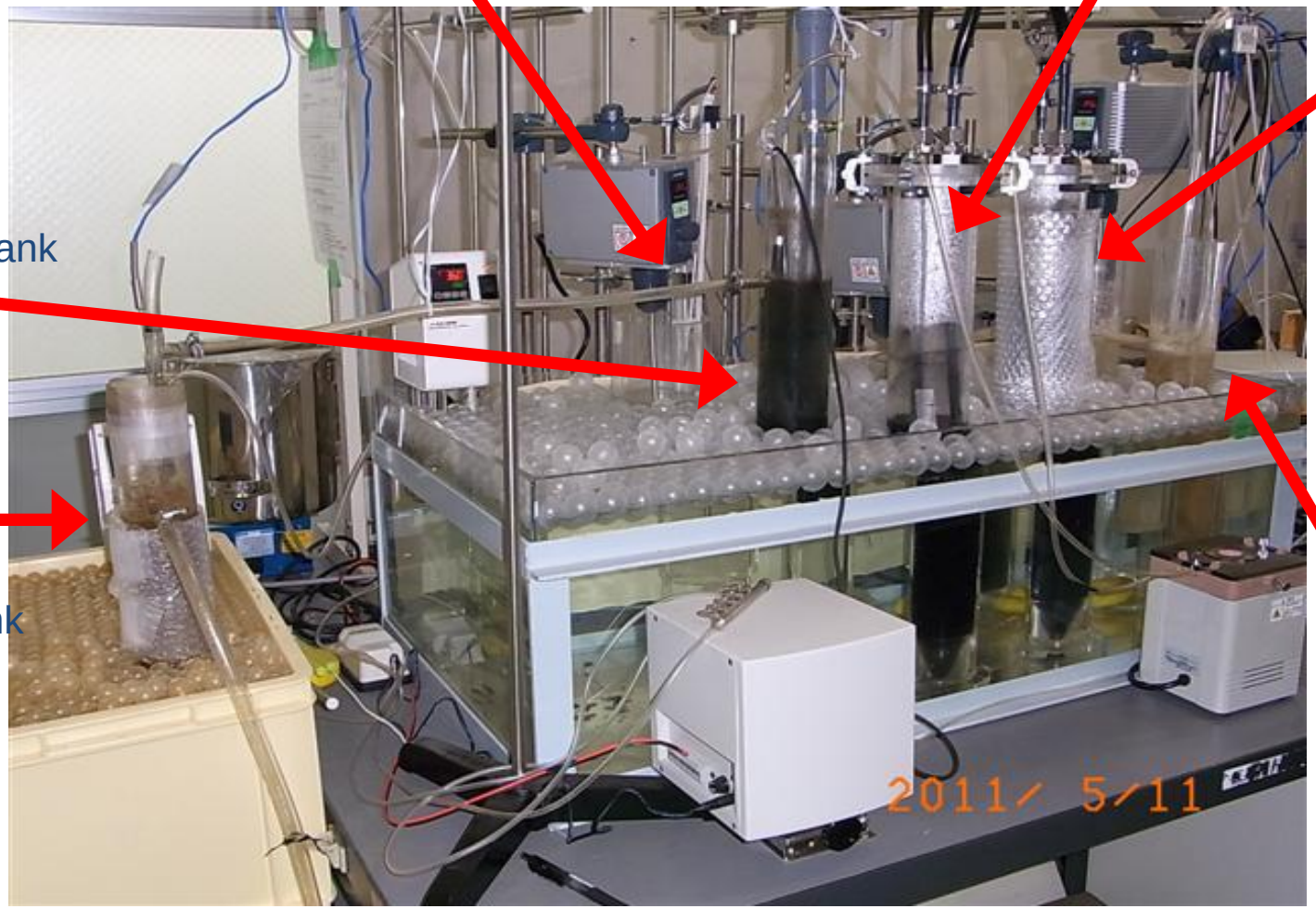


Relationship between volumetric COD loading rate and COD removal ratio at Nat conc. of 8.3 g/l



Relationship between volumetric COD loading rate and COD removal ratio at Nat conc. of 5.5 g/l

Continuous experiment equipment

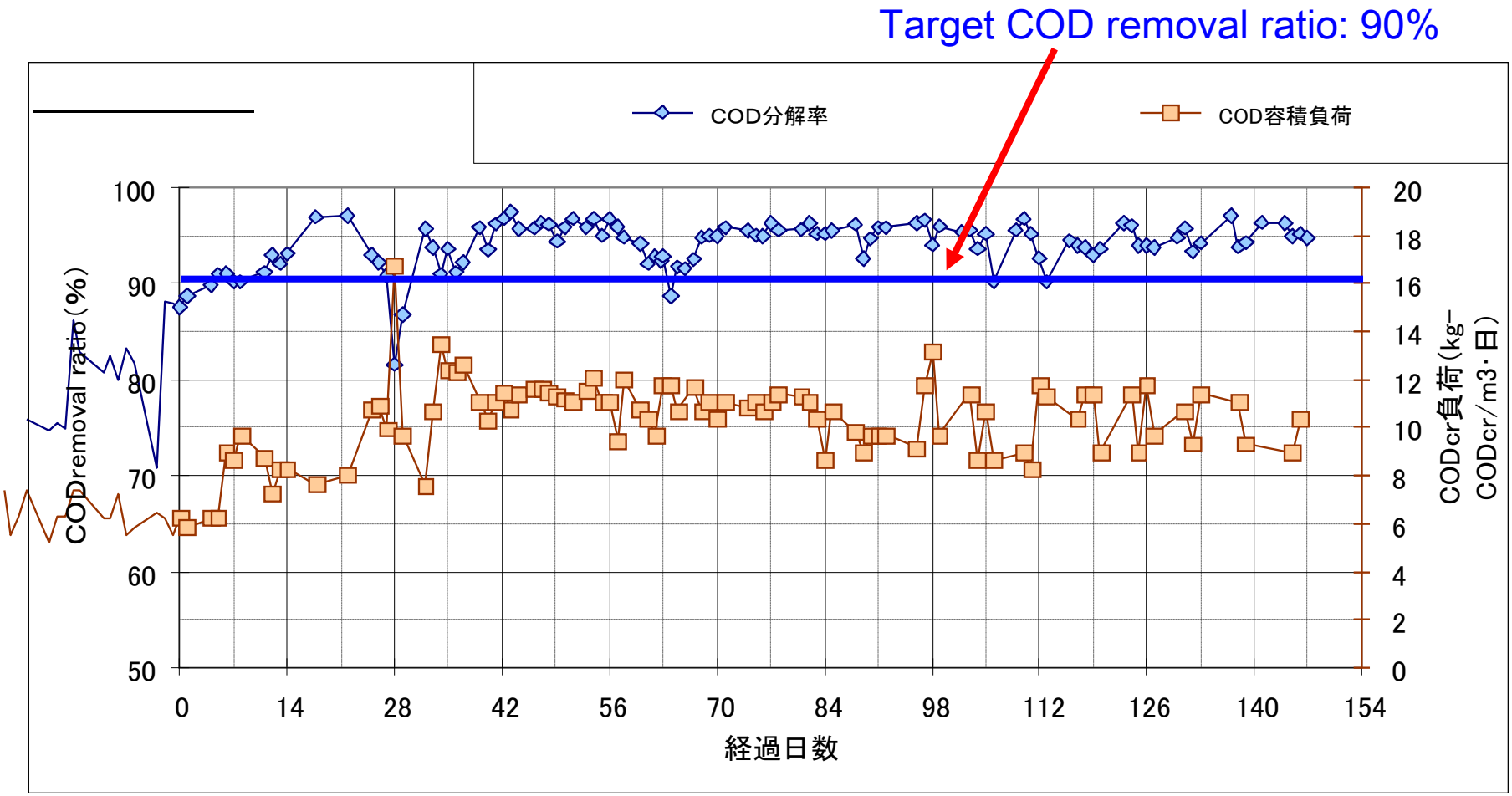


Granule

(Conglomerate of methane bacterium)

Results of consecutive experiment

Change of volumetric COD loading rate and COD removal ratio



- 90% of COD removal ratio under less than 12 kg/m^3・ d of volumetric COD loading rate is carried out for 150 days

Reduction of environmental load

【Energy saving】

Power	▲519,332 kWh/y
Gas	▲158,268 ㎥/y

14.4% of whole plants'
(3,603MWh/y)

11.7% of whole plants'
(1,348,000㎥/y)

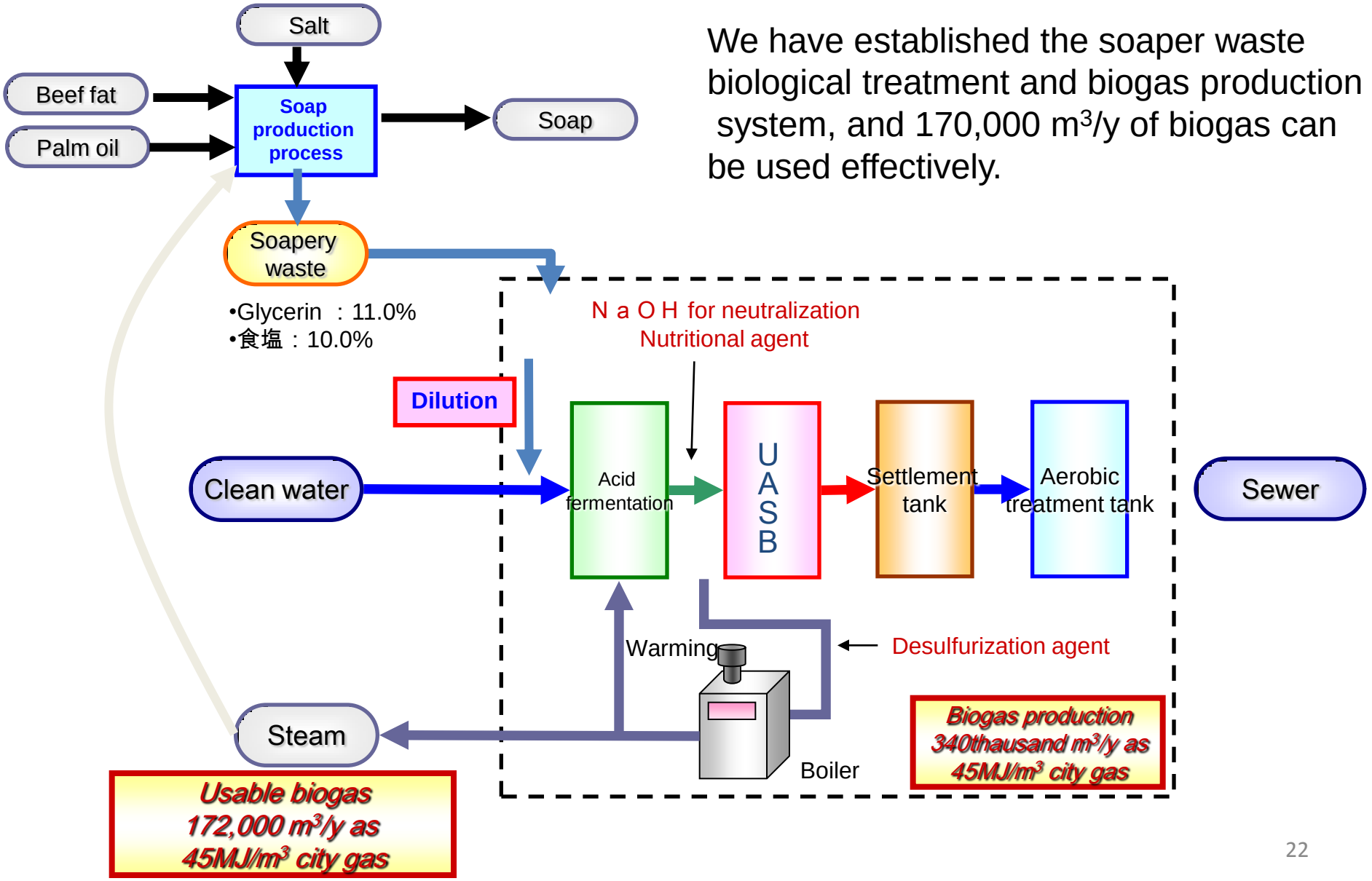
【CO_2 emission】

Power	▲288 ton-CO_2/y
Gas	▲329 ton-CO_2/y
Total	**▲617 ton-CO_2/y**

12.8% of whole plants'
(4,803ton/y)

Conclusion

We have established the soaper waste biological treatment and biogas production system, and 170,000 m^3/y of biogas can be used effectively.



Approach to increase biogas usage at sewage plant

- Transportation of unused biogas through natural gas grid

Problems for transportation of biogas through Japanese natural gas grid

1. Biogas composition Japanese city is very stable and includes few in purities because Japanese city gas is make from LNG.

2. Capacity of gas grid Some sites has small city gas emands around the biogas production site.

Existed system at sewage plant

Sewage

Sewage plant

Sewage sludge

Digestion tank

Biogas

CO_2 and H_2S removal equipment

CO_2 H_2S removed biogas

NGV

Plant use

Problems regarding to biogas composition

Items	Osaka Gas's Standard	Biogas composition at a sewage plant latter CO2 and H2S removal
Calorie	44～46MJ/m3	
H2S	≦ 1.0mg/ m^3N	≦ 0.1ppm
Total S	＜ 5.0mg/ m^3N	≦ 2mg/ m^3N
NH3	ND	
Odorant	TBM:DMS=50：50	THT 100%
Odorant conc.	12～16mg/ m^3N	9mg/m^3
H2	≦ 4vol%	
CO	≦ 0.05vol%	
O2	≦ 0.01vol%	0.4%
N2	≦ 1.0vol%	0.8%
CO2	≦ 0.5vol%	0.9%
Temp	0° C～40° C	
Siloxane	Individual consideration	≦ 1.0mg/m^3N
Moisture	Individual consideration	＜ 15.7mg/m^3
Dew point	Individual consideration	＜ -55℃

Biogas purification equipment to clear our standard

O2 removal by catalyst

O2≦0.01%

CO2 removal by PSA

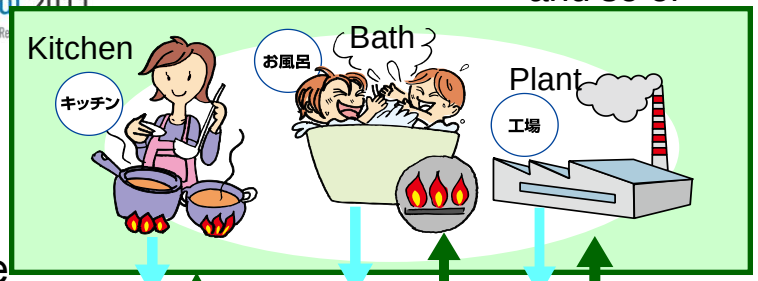
CO2 ≦ 0.5%

Calorie adjustment
Add odorant

Calorie=45MJ/m3N
Odorant conc.=12 ~ 16mg/m3N

Monitoring：calorie, temperature, pressure, gas composition（CH4，CO2，O2，T-S, etc.）, etc.

Houses, plants, and so or



Sewage

First in Japan

Biogas purification equipment

Purified biogas

Gas grid

Introduce 800,000 m3/y of biogas

Sewage plant

Local government

Manufacturer

Osaka Gas

Sewage sludge

City gas use

Digestion tank

Biogas

CO_2 and H_2S removal equipment

CO_2 H_2S removed biogas

NGV

Plant use