三木会（9月21日）

産業廃棄物下水汚泥を活用した高度炭酸利用技術

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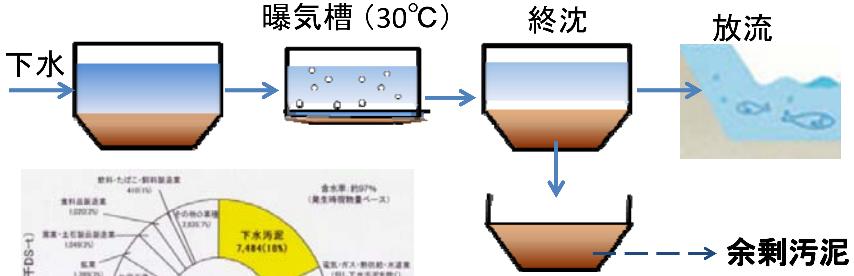
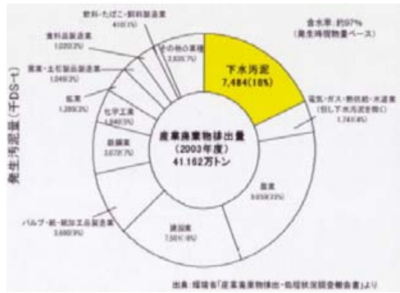
下水汚泥とは？

生物学的処理において、汚濁物質が生物の細胞体に合成されて生物汚濁となったもののうち、**<u>過剰となり不必要となった汚泥</u>**





都市型かつ集積型のバイオマス
ごみなのか？資源なのか？
日々大量に発生する
不変なバイオマス

下水汚泥の本質的問題点

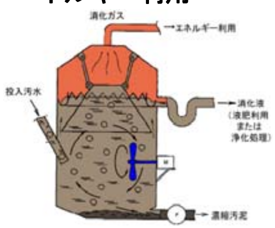
一般的な下水汚泥の処理方法 ⇒ 焼却処分

問題点

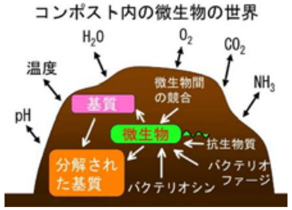
処理コスト　乾燥、運搬、焼却、埋立地確保等

環境　埋立地の確保

エネルギー利用

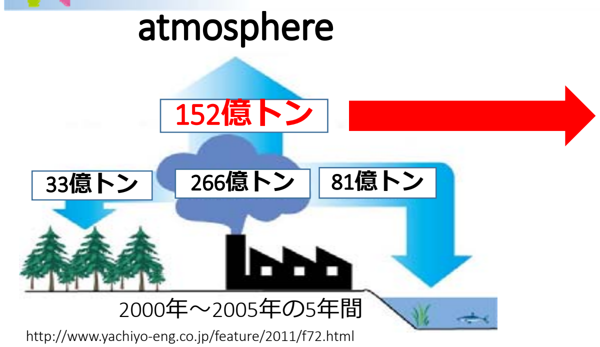


コンポスト化利用



セメント材料として利用

地球温暖化

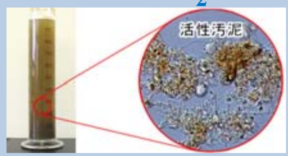


http://www.yachiyo-eng.co.jp/feature/2011/f72.html

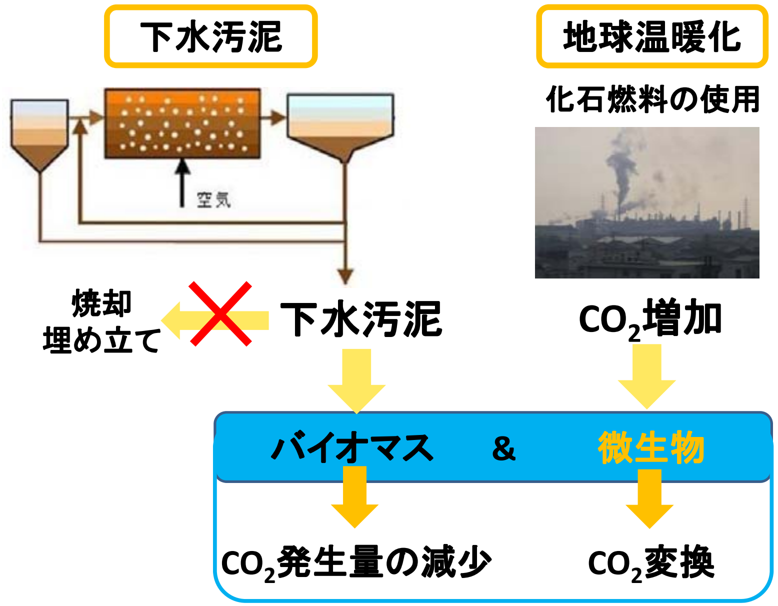
Global warming

1. Do not release CO_2

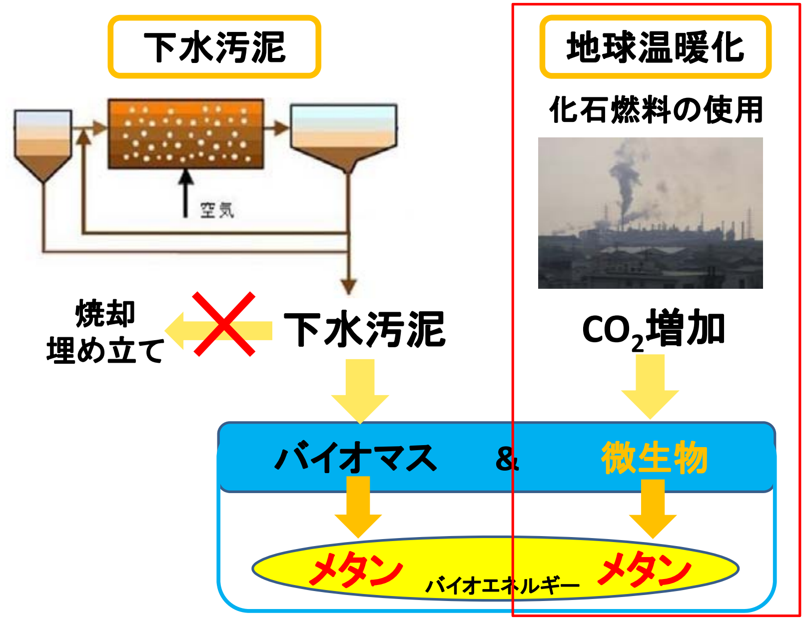
2. Utilize CO_2 as a material



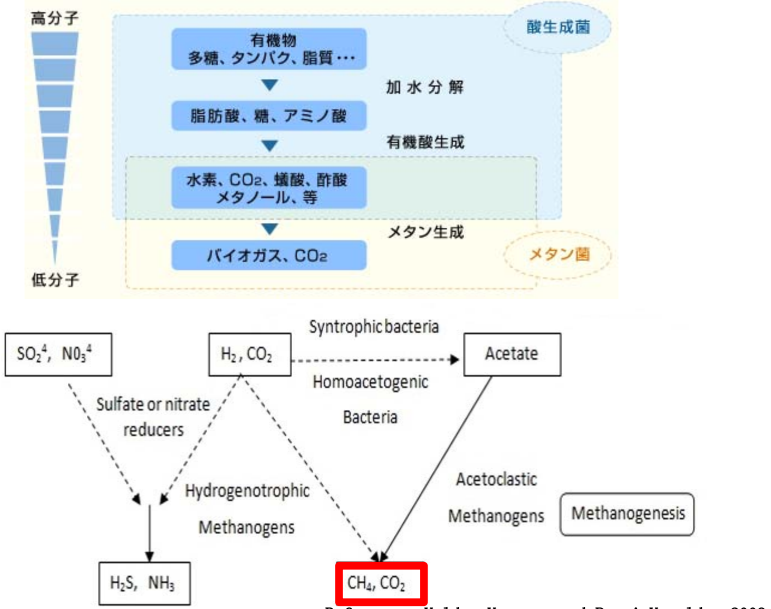
下水汚泥と地球温暖化



研究コンセプト

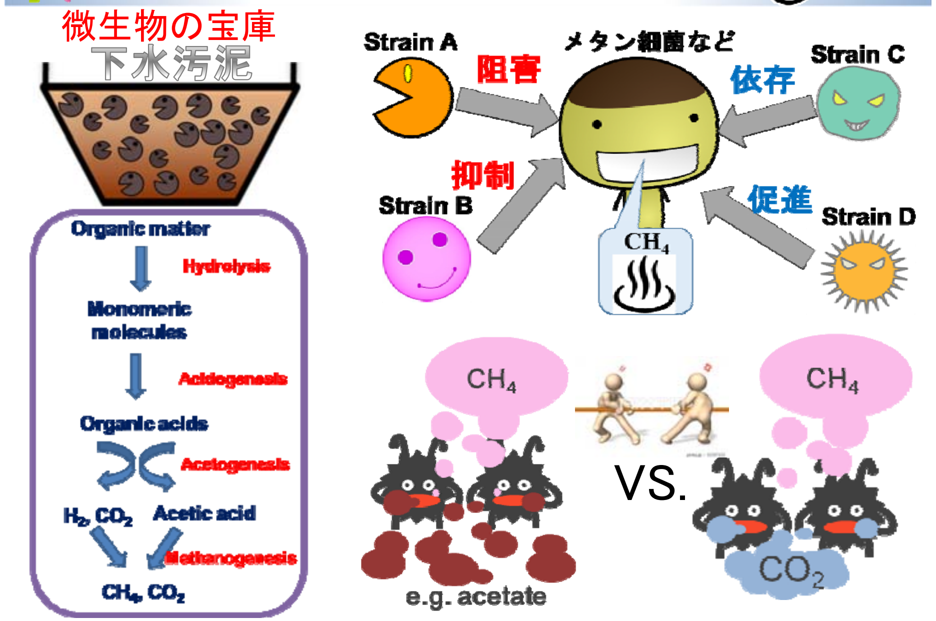


メタン生成経路



Reference: Valdez-Vazquez and Poggi-Varaldo, 2009

研究の狙い



Source: Valdez-Vazquez and Poggi-Varaldo, 2009

研究目的

下水汚泥中の微生物による綱引き

バイオマス
↓
メタン

CO$_2$
↓
メタン

通常の下水汚泥

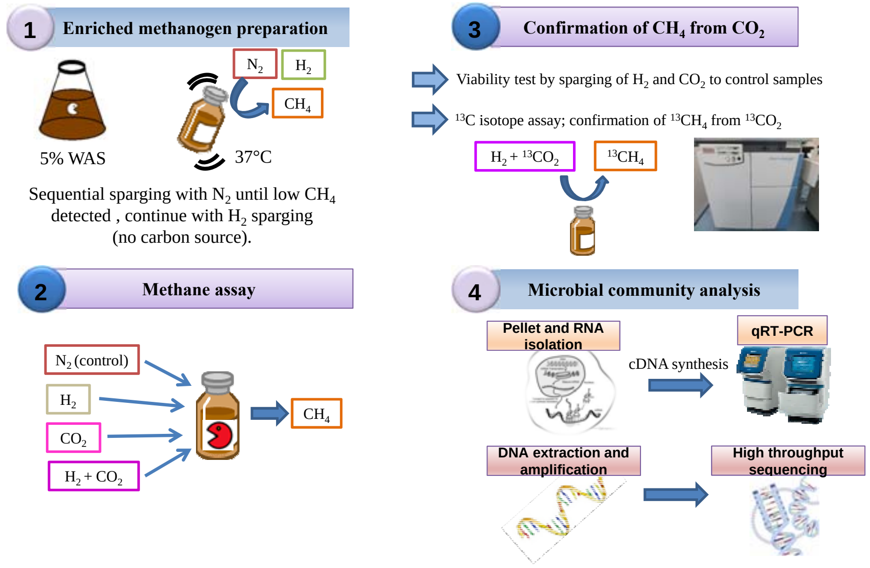
バイオマス →メタン ＞ CO$_2$ →メタン

長期培養下水汚泥

~~バイオマス →メタン~~

CO$_2$ →メタン

General Materials and Methods



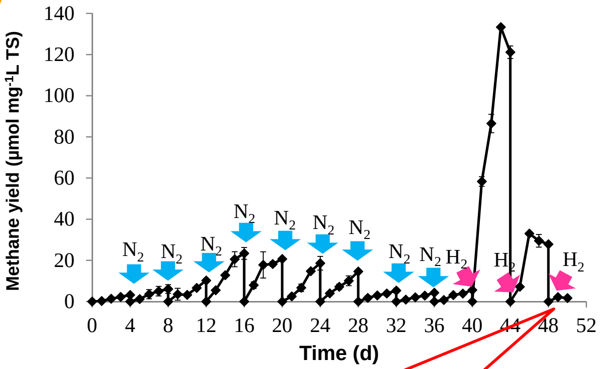
下水汚泥の長期培養

下水汚泥 (5%w/v)

37℃, 120 rpm
N$_2$(0〜39日)
H$_2$(40〜50日)

長期培養汚泥 (5%w/v)

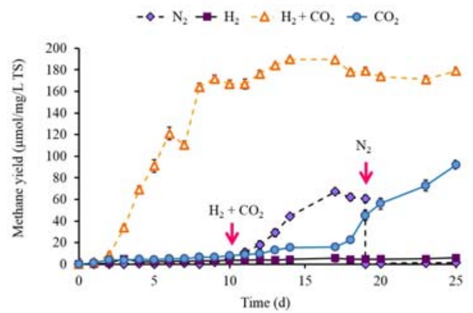
メタンガスが発生しなくなるまで！



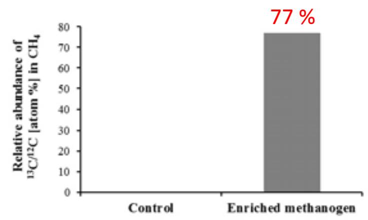
下水汚泥中の有機物を全て消費
→炭素源は残っていない

CO$_2$ sequestration for methane production

Methane assay

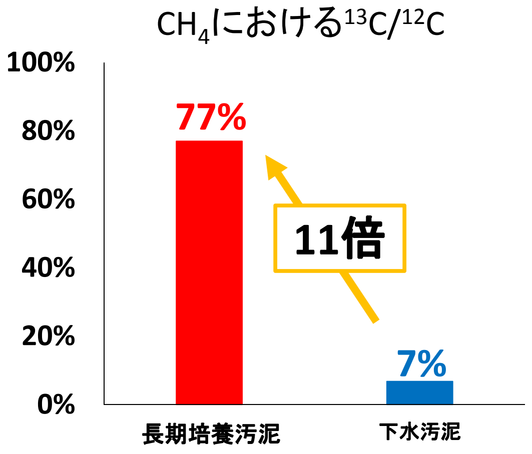


Relative abundance of ^{13}C/^{12}C in CH$_4$ from the control and inoculum enriched methanogens sparged with the mixture of H$_2$ and ^{13}CO$_2$



- **Methane drastically increased in vials sparged with H$_2$ and CO$_2$.**
- **Active methanogens in the vials tend to utilize only CO$_2$ as a sole source of substrate.**
- **77% methane come from CO$_2$ sequestration by methanogens in WAS.**

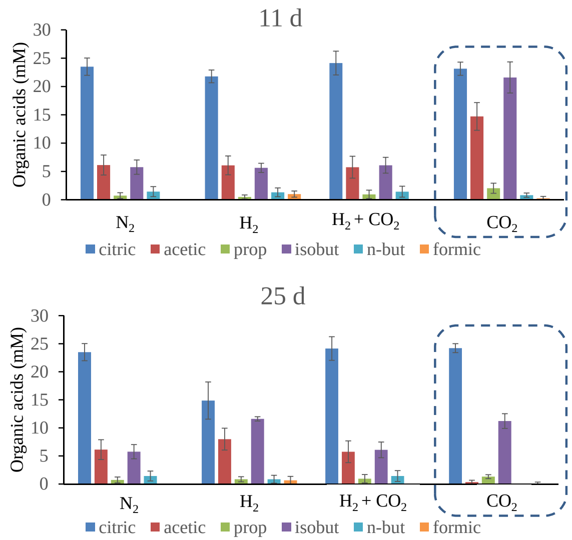
二酸化炭素変換効率



長期培養汚泥はCO_2→CH_4変換効率が良い

Organic acids profile

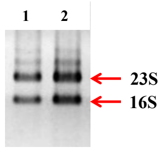
- **Acetic and iso-butyric acid formation were observed in vial purged with only CO_2.**
- **Both acetic and iso-butyric acid reduced at 25 d of anaerobic incubation.**



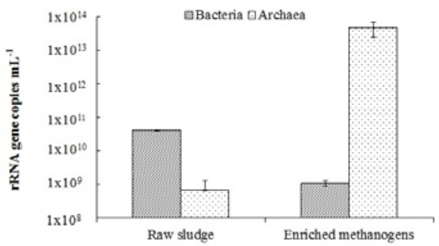
Quantitative RT-PCR (qRT-PCR) analysis of raw sludge and enriched methanogens

Target group	Primer or probes	Sequences (5'- 3')	Product size (bp)	Reference
Universal bacteria	Forward	TCCTACGGGAGGCAGCAGT	466	Nadkarni et al., 2002
	Reverse	GGACTACCAGGGTATCTAATCCTGTT		
	Probe	CGTATTACCGCGGCTGCTGGCAC		
Universal Archaea	Forward	ATTAGATACCCSBGTAGTCC	273	Lee et al., 2008
	Reverse	GCCATGCACCWCCTCT		
	Probe	AGGAATTGGCGGGGGAGCAC		

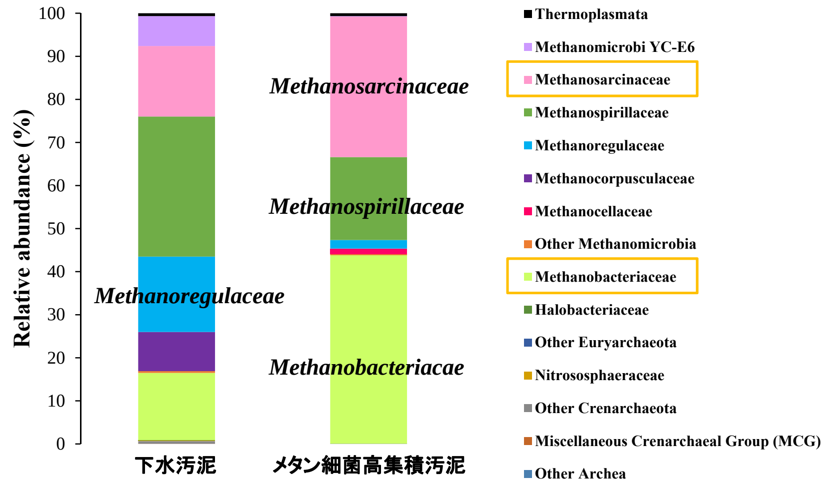
S: G or C, B: C or G or T, W: A or T



1 – Raw sludge
2 – Enriched methanogens

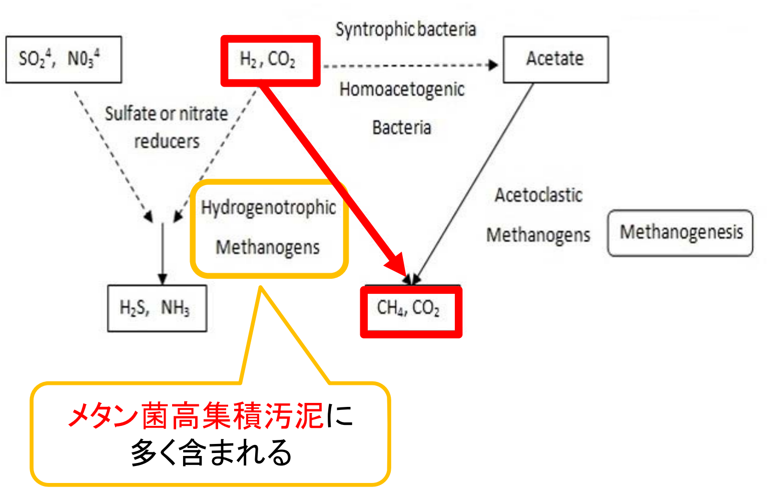


微生物群集構造解析



50日間嫌気性条件下で培養

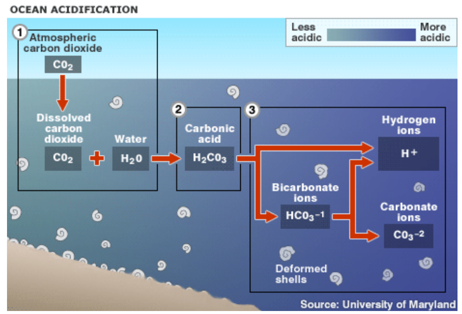
メタン生成経路の活性化



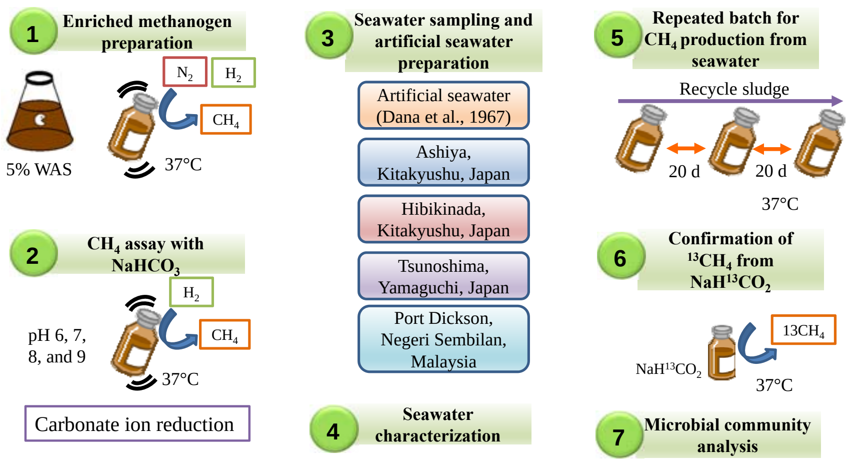
Reference: Valdez-Vazquez and Poggi-Varaldo, 2009

海水へのアプローチ

- 71% of the universe was covered by oceans (US National Oceanic and Atmospheric Administration).
- Antrophogenic effects cause ocean acidification by dissolved CO_2 through carbon cycle.

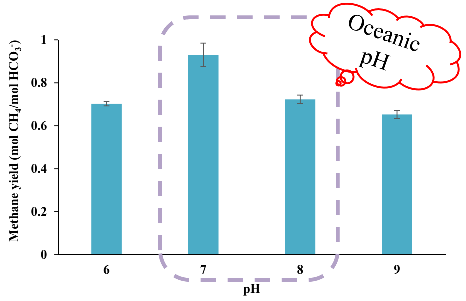


General Materials and Methods



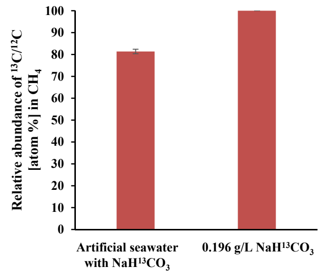
Methane production from carbonate ion sources

Effects of different pH on methane production in 0.05M $NaHCO_3$ (15 d)



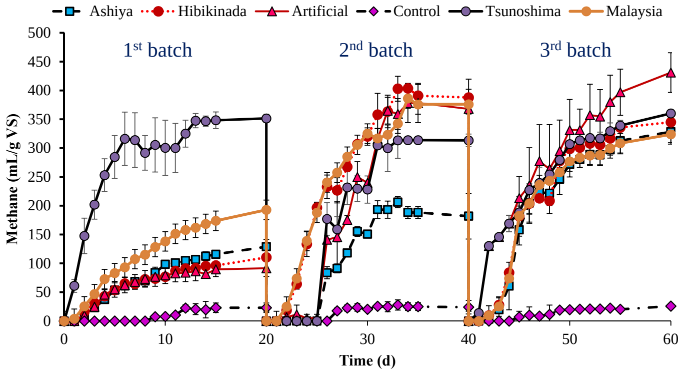
$HCO_3^- + 4H_2 + H^+ \rightarrow CH_4 + 3H_2O$

Relative abundance of $^{13}C/^{12}C$ in CH_4 from $NaH^{13}CO_3$ (20 d)



We can see the potential of methane production seawater!

Repeated batch of methane production from seawater



- Very low methane was detected in control vials (without seawater sources).
- Salinity constraint on methanogens were improved in second and third batch in all seawater sources.

Comparison of methane yield from seawater and other substrate

Substrate	Inoculum	Condition	CH_4 yield (mL/g VS)	References
Seawater from Tsunoshima, Yamaguchi, Japan	Enriched methanogens from WAS	Repeated batch culture, 37°C	351 ± 7	This study (First batch)
Seawater from Hibikinada, Kitakyushu, Japan			403 ± 4	This study (Second batch)
Artificial seawater			431 ± 34	This study (Third batch)
Algal biomass	Sludge from poultry processing industry	Batch, 40°C	9.27	Santos et al., 2014
Co-digestion of chicken manure and agricultural waste	WAS	Repeated batch culture, 55°C	695	Abouelen et al., 2014
Olive mill solid waste	Anaerobic sludge	Batch, 35°C	350	Fernández-Rodriguez et al., 2014
Oil palm frond	Saccharomyces cerevisiae	Solid state fermentation, 30°C	514	Srimachai et al., 2014

謝辞

Maeda Lab