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# Comparison of the Anaerobic Digestion of Biosorption *i.e.* A Sludge, Conventional Primary Sludge and Conventional Mixed Sludge

M. Choo-Kun<sup>a</sup>, D. Conteau<sup>b</sup>, S. Martin Ruel<sup>b</sup>, P. Camacho<sup>b</sup>, R. Gourdon<sup>c</sup> And P. Buffière<sup>c</sup>,

(a) Suez Environnement Pte Ltd, 70 Anson road, #01-10, Singapore 079905, Singapore  
(E-mail: [marlene.choo-kun@suez-env.com](mailto:marlene.choo-kun@suez-env.com))

(b) Suez Environnement - CIRSEE, 38 rue du Président Wilson, 78230 Le Pecq, France  
(E-mail: [delphine.conteau@suez-env.com](mailto:delphine.conteau@suez-env.com))

(c) Université de Lyon, INSA-Lyon, LGCIE-DEEP, 9 Rue de la Physique, F-69621 Villeurbanne Cedex, France  
(E-mail: [pierre.buffiere@insa-lyon.fr](mailto:pierre.buffiere@insa-lyon.fr))

## Abstract

Anaerobic Digestion not only enables to reduce and stabilize the volume of sludge to be disposed but also is the only way to recover energy from wastewater process-wise. The AB process developed by Böhnke *et al.* (1977) with its two stage of activated sludge leads to reduce the energy demand from the aeration on the water line and increase the methane production on the sludge line which are the key elements to reach energy self-sufficiency for wastewater treatment plants. The present work studies the anaerobic digestion of Biosorption *i.e.* A sludge from the first stage of the AB process and compares it to the digestion of conventional primary and mixed sludge. The operation of 5-Litres digesters for 100 days shows that A sludge and conventional primary sludge are equivalent in terms of sludge characterisation and behaviour through the anaerobic digestion process. They both produce about 27% more methane per VS<sub>fed</sub> than the conventional mixed sludge. Considering that A sludge represents a larger portion (85%) of the mixed AB sludge that the primary sludge (65%) does for conventional mixed sludge, the AB process does have a higher potential of energy production than conventional wastewater treatment systems.

## Keywords

Anaerobic Digestion, Biosorption sludge, A sludge, Primary sludge, Mixed sludge, Energy self-sufficiency

## INTRODUCTION

The AB (Adsorption-Biosorption) Process for wastewater treatment was developed by Böhnke *et al.* (1977). It consists in a two-stage activated sludge: A and B stages, each composed of a bioreactor and a clarifier. The A stage hosts a highly efficient biosorption process for early entrapment of the organic matter, which can be directly transferred to the digesters, maximizing the recovery of the biodegradable carbon contained in the wastewater. Around the world, a few wastewater treatment plants use this process and show a much more efficient energy balance, sometimes even positive, than conventional plants also equipped with digesters. The present study compares the anaerobic digestion process of Biosorption *i.e.* A sludge with conventional primary sludge and conventional mixed sludge, within semi-continuous 5-Liter reactors under mesophilic conditions (37°C).

## MATERIALS AND METHODS

### Experimental Setup

Three double jacketed glass reactors of 5 Litres working volume are equipped with a water bath circulator controlling the temperature at 37°C. They are fed on a daily basis thanks to a peristaltic pump. The conventional primary and mixed sludge are sampled from the conventional Water

Reclamation Plant of Kranji in Singapore. The A sludge comes from a 50m<sup>3</sup>/d AB process pilot plant on the same WWTP and treating the same raw wastewater. The digesters were inoculated with the digestate of a 3m<sup>3</sup> pilot plant digester at mesophilic conditions fed with Kranji WRP mixed sludge.

The operating conditions are the same for the three reactors with a Sludge Retention Time of 16 days and an Organic Loading Rate of 1.5 kgVS/m<sup>3</sup>/d. The three different feed sludge are thickened through centrifugation to meet the common OLR.

### Follow-up and measurement

The biogas production is monitored continuously with milligas counters (Ritter) and the biogas composition is analysed twice a week with a 490 Micro Gas Chromatograph (Agilent). Total Solids (TS) content is calculated as the amount of solids remaining after oven-drying the samples at 105°C during 24 h and Volatile Solids (VS) content is calculated as the loss of weight after igniting the oven-dried residue at 550°C for 5 h. Total COD and soluble COD concentrations, Volatile Fatty Acids (VFAs), Total Alkalinity (TA), Total Ammonia Nitrogen (TAN) are measured with kits (Hach). All these parameters are analysed from both feed and digested sludge three times a week. Biochemical Methane Potential tests were run to characterise the bioreactivity of the three substrates.



**Figure 1:** Reactor set-up.

## RESULTS AND DISCUSSION

### Characterisation of the three feed sludge

The table 1 presents a characterisation of the A sludge from the 50m<sup>3</sup>/d AB process pilot plant, the conventional primary and the mixed sludge from Kranji Water Reclamation Plant.

Table1: Characterisation of the A sludge, Primary sludge and Mixed sludge.

	TS	VM	VM	Total COD	VFA	Alkalinity	N-NH4	Methane potential
	g/L	g/L	%TS	g/L	mgHOAc/L	mgCaCO3/L	mg/L	$\frac{L_{STP} CH_4}{kg VS_{introduced}}$
A sludge	30,4	24,8	81,6%	48,3	847	784	145,6	335
Primary sludge	30,7	24,8	80,8%	50,5	1012	686	172	290
Mixed sludge	32,1	24,3	75,7%	47,9	1725	1210	474	

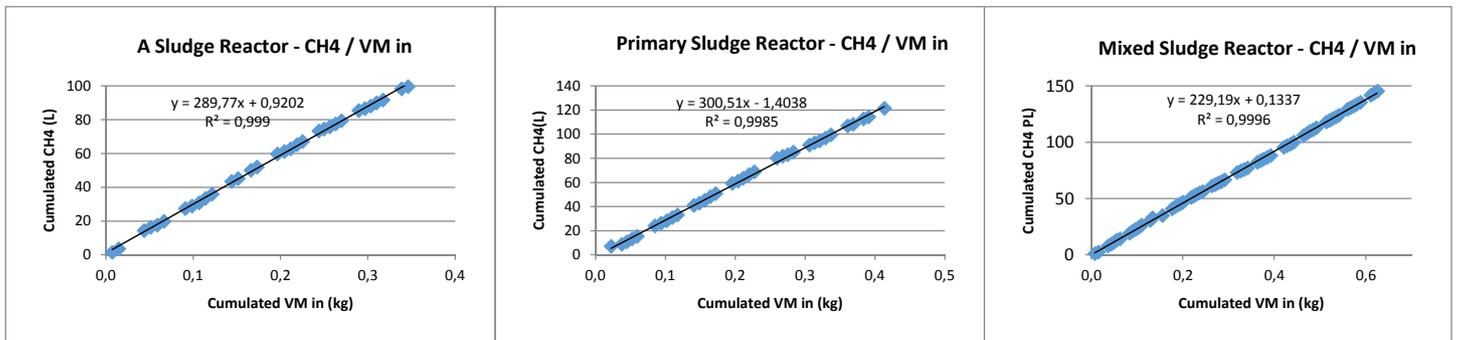
The A sludge and Primary sludge appear to be quite equivalent in terms of behaviour during anaerobic digestion. The Biochemical Methane Potential tests show about the same potential for this two sludge, with a slightly lower potential for the primary, which can be attributed to operational issues of the plant during the sampling (longer SRT of the primary clarifier affecting significantly the quality of the sludge as the clarifier temperature reaches 30°C). The Methane Potential of A sludge is 335 L<sub>STP</sub> CH<sub>4</sub> / kg VS<sub>introduced</sub>. The kinetics of the A sludge BMP test is slightly higher than the primary sludge test.

### Start-up and steady state operation

The acclimation period lasted for 3 SRTs with a first phase of 1 SRT at half Loading Rate. The methane production steadily increased without any peaks of VFA (VFA<500mg/L, VFA/Alkalinity<0.15) nor Soluble COD (<2g/L). At 2.5 SRTs, the steady state operation was reached for all the reactors with a constant methane production, VS and COD<sub>total</sub> content.

The following results were obtained during the steady state operation.

### Removal rates and specific methane production



**Figure 2:** Cumulated methane production over VS fed for the three reactors.

The primary sludge reactor and the A sludge reactor present equivalent overall performances, both in terms of removal rates and specific methane production. The specific methane production reaches 290 L<sub>STP</sub> CH<sub>4</sub> /kg VS<sub>in</sub> for the A sludge digester, and 300 L<sub>STP</sub> CH<sub>4</sub> /kg for the primary sludge digester.

The VS, COD removal rates and the specific methane production of the anaerobic digestion of A sludge are respectively 33%, 32% and 27% higher than for mixed sludge.

All the results are summarized in the table 2.

**Table 2:** Overall performances of the three reactors

	A Sludge Reactor	Primary Sludge Reactor	Mixed Sludge Reactor
VS Removal	48,5%	45,3%	36,4%
TS Removal	43,0%	40,6%	30,6%
COD Removal	42,8%	47,2%	32,5%
L biogas / kg VS <sub>in</sub>	470	494	380
L CH <sub>4</sub> / kg VS <sub>in</sub>	290	301	229
L CH <sub>4</sub> / kg COD <sub>in</sub>	150	156	112
L CH <sub>4</sub> / kg COD <sub>destroyed</sub>	345	343	336

## **Overall AB process system**

The mixed sludge produced by the AB process contains 85% of A sludge and 15% of B sludge. A conventional activated sludge wastewater treatment line produces a mixed sludge composed of 65% primary sludge and 35% of secondary sludge. It is also believed and to be proven on future experiments that the AB process produces more sludge than the conventional system. Adding to these facts that the AB sludge has a higher methane production than conventional mixed sludge, the whole AB process should enable to produce more methane, and thus energy per m<sup>3</sup> of wastewater treated, than a conventional wastewater treatment system.

## **CONCLUSION**

- The comparison of the anaerobic digestion of Biosorption *i.e.* A sludge, conventional primary sludge and conventional mixed sludge was studied with semi-continuous 5-Litres digesters at mesophilic conditions (37°C).
- The anaerobic digestion of A sludge is quite equivalent to the anaerobic digestion of conventional primary sludge, with equivalent or slightly better removal rates and kinetics (290 NL CH<sub>4</sub>/VS<sub>in</sub>).
- Future work will aim at demonstrating that anaerobic digesters treating sludge from an AB process produce more energy than the digesters associated with a conventional activated sludge process.

## **REFERENCES**

- Böhnke, B., Schulze-Rettmer, M.R., Zuckut, S.W. 1998 « Cost-effective reduction of high-strength waste water by adsorption-based activated sludge technology. *Water Engineering Management* 145, 31-34.
- Böhnke B. 1977. Das Adsorptions-Belebungsverfahren. *Korrespondenz Abwasser*, 24/2, 33-39