ANAEROBIC WASTEWATER TREATMENT TECHNOLOGY DEVELOPMENT IN THAILAND

Wastewater treatment technology has been continuously researched and developed in Thailand for over 30 years. Some of the technologies that have emerged have proven to be highly effective and have been put into commercial application, used by both local and international companies.

One of the key advantages of these locally-developed technologies is the capability of the bio-reactor to utilize highly concentrated organic wastewater (especially waste and wastewater from agro-industries and animal farms) as feedstock.

In Thailand, the widely-used anaerobic wastewater treatment technologies can be divided to 4 types - (i) Anaerobic Covered Lagoon (ACL), (ii) Upflow Anaerobic Sludge Blanket (UASB) reactor, (iii) High-Rate Anaerobic Fixed Film (HR-AFF) reactor, and (iv) High-Rate Anaerobic Hybrid Reactor (HR-AHR)\(^1\).

The industry in Thailand is especially interested in anaerobic wastewater treatment and biogas production technologies. Companies have to comply with waste management regulations and these technologies can help them. Furthermore, some of the systems that are based on these technologies enable the co-production of biogas or the co-generation of energy which can be utilized directly or sold back to utility companies. Biogas can replace fuel oil in industrial production processes. In general, 1 m\(^3\) of biogas is equivalent to 0.6-0.7 liters of fuel oil (at standard temperature and pressure (STP) and 60% of methane content).

\(^1\)Pilot Plant Development and Training Institute (PDTI), King Mongkut’s University of Technology Thonburi (KMUTT). Policy Research on an Assessment of Biomass Potential for Biogas Production in Thailand, 2007
1. Anaerobic Covered Lagoon (ACL)

An ACL is the least expensive as compared to other systems. It has been widely used in pig farms and some cassava starch production factories. Wastewater is stored in large ponds that are covered with High Density Polyethylene (HDPE) for at least 20 days. Typically, the system has a lower organic loading rate compared to other systems.

2. Upflow Anaerobic Sludge Blanket (UASB) Reactor

A UASB reactor is quite commonly found in cassava starch production operations and in the beverage industry. In this system, microbial granules are formed and suspended in the reactor tanks. These granules are not fixed to an inert media. Instead, wastewater is fed through the bottom of the reactor and flowed upward through the microbial granules. Biogas is produced and stored at the top of the reactor tank.

Papop Co. Ltd., a Thai company, has developed and constructed more than 15 UASB plants for cassava starch factories. These plants can generate approximately 80-85 m³ of biogas from the wastewater coming from the production of 1 ton of starch products. Besides Thailand, the company has also installed the UASB system in 2 factories in Vietnam. Each system can generate about 15,000 m³ of biogas a day.²

²http://www.papop.com/experiencesindex.php?language=0&pid=1

3. High-Rate Anaerobic Fixed Film (HR-AFF) Reactor

The Excellent Center of Waste Utilization and Management (ECoWaste) is the developer of the High-Rate Anaerobic Fixed Film (HR-AFF) technology. The bio-reactor in this system has the ability to handle a high organic loading rate as well as a high concentration of waste in the reactor feedstock. It also produces biogas at a much faster rate.

The HR-AFF bioreactor can be used with low and high-strength organic wastewater and has proven to be effective in a number of factory environments including rice starch and cassava starch factories as well as vegetable and fruit-canning plants.
The HR-AFF bioreactor can handle an organic loading rate (OLR) of between 2 to 10 kg COD/m$^3$/day with a biogas yield of 0.4-0.5 m$^3$/kg of COD. The biogas that is produced is composed of 60 - 70% methane. In one factory where the HR-AFF system has been used to treat cassava starch wastewater, the system is able to generate approximately 29,000 m$^3$ of biogas/day. This amount is sufficient to meet all the energy needs of the factory (or the equivalent to 9,000 litres of fuel). Furthermore, excess biogas is used to generate electricity at about 4,680 kWh/day which is sold back to the utility company.\(^3\)

**4. High-Rate Anaerobic Hybrid Reactor (HR-AHR)**

The ECoWaste has been conducting research and development on a new High-Rate Anaerobic Hybrid Reactor (HR-AHR) by combining the advantages of the UASB and HR-AFF systems. The system has been designed to prevent microbial granules from being washed out and to prevent short circuit incidents during long periods of operation. The pilot-scale HR-AHR system uses nylon fibers as the supporting media for the cassava starch and palm oil wastewater. The system holds much promise as it has demonstrated an organic loading rate (OLR) of 10 kgCOD/m$^3$/d and has a two day hydraulic retention time (HRT) with more than 80% COD removed.

### Anaerobic Wastewater Treatment Systems and Biogas Production in Thailand\(^4\)

There are currently around 2,300 bioreactor systems in operation in Thailand: 1,700 small-sized systems producing 12-100 m$^3$ of biogas and 600 medium and large sized systems. The following table shows the number of each type of anaerobic wastewater treatment system used in Thailand. These systems are found mainly on pig farms, slaughter houses, starch & cassava factories, and within the beverage industries.

<table>
<thead>
<tr>
<th>Type of anaerobic wastewater treatment system</th>
<th>Number of the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional system: Fixed Dome</td>
<td>~ 1,655</td>
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<tr>
<td>Anaerobic Covered Lagoon (ACL) reactor</td>
<td>~ 300-400</td>
</tr>
<tr>
<td>Upflow Anaerobic Sludge Blanket (UASB) reactor</td>
<td>189</td>
</tr>
<tr>
<td>Anaerobic Fixed Film (HR-AFF) reactor</td>
<td>8</td>
</tr>
<tr>
<td>Other types ex. CSTR, ABR, IC, EGSB, Plug Flow</td>
<td>~20</td>
</tr>
</tbody>
</table>

\(^3\)Professor Albert Sasson, UNU-IAS Report-Industrial and Environmental Biotechnology, Achievements, Prospects, and Perceptions, Thailand case page 18

\(^4\)Pilot Plant Development and Training Institute (PDTI), King Mongkut's University of Technology Thonburi (KMUTT), Policy Research on an Assessment of Biomass Potential for Biogas Production in Thailand, 2007

**Success Stories**

The technologies described in the previous sections have found applications in many agro-industries. Some specific examples include:
1. North Eastern Starch (NES)

North Eastern Starch (NES) is a local starch producer that has a 200 ton production capacity. The company set up an AFF bioreactor system that was designed by King Mongkut’s University of Technology Thonburi (KMUTT). Prior to using the AFF bioreactor system, it used the open-lagoon anaerobic digestion system. The old system had a retention time of more than a year and also produced unpleasant odors. With the AFF bioreactor system, the company can effectively treat the wastewater while producing biogas that has 60-65% of methane, 30-35% of carbon dioxide, and 2-3% of hydrogen sulfite. It also overcomes the odor problem.

NES invested 40 million baht for the establishment of the AFF bioreactor system. The new system allows the company to save approximately 100,000 baht a day from energy expenses, enabling the company to recover its capital investment within 3 years of the plant’s construction. In addition, the system has allowed the company to cut methane emission by 23,000 tons of carbon equivalents per year. NES has registered the project as a clean development mechanism (CDM) project.

2. Cholchareon Co.Ltd.

Cholchareon Co. Ltd. is a local cassava starch factory that produces approximately 200-250 tons of starch per day from 800-1000 tons of fresh cassava roots. The manufacturing process produces approximately 2,400 m$^3$ of wastewater a day with a COD value of about 16,000-23,000 mg per liter.

In the past, the company had to allocate over 3 hectares of land for wastewater treatment. In 2005, it invested approximately 45 million baht to establish a HR-AFF bioreactor system developed by BIOTEC and KMUTT. The savings that it achieved allowed the company to recover its capital investment in the project within 2 years. By 2008, the company was able to save approximately 95,000 baht per day on fuel cost or 23 million baht per year.

Future development of wastewater treatment technology in Thailand will be focusing on increasing biogas yield and increasing the effectiveness of the bioreactors, with the ultimate goal of achieving zero waste discharge.

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5 http://cdm.unfccc.int/UserManagement/FileStorage/N98Y6R01CFMVOL2UPHK3DQ5XITWB
6 Biogas for Food Industries in Thailand: A Case Study from Cassava Starch Factories, BIOTEC, 2009
7 http://vbn.aau.dk/tbsretriev/1492222/22/Hartmann_future_bogas.pdf