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# Development of Water Processing Technology of Tahu Industrial Waste:An Overview

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## Abstract

Tahu industry is one of those exerting overwhelmed waste water without initial processing in the disposal. Waste water exerted by tahu industry has a great deal potential to contaminate environment. Therefore, there is a need for waste water management using innovative and environmental friendly technology in order to prevent the environment from any possible contamination. This study explains the development of research on technology used for processing waste water. Anaerobic waste processing is an effective method in response to the emergence of organic wastes. The processing is mediated by facultative and anaerob microorganisms, in which no oxygen that converts organic matters into gas-related end product such as carbondioxide and methane. There are three fundamental stages in the whole anaerobic waste processing:

1) hydrolisis,
2) fermentation or asidogenesis, and
3) methanogenesis.

The Anaerobic Sequencing Batch Reactor (ASBR) process can be categorized as a suspended growth process with reaction and solid-liquid substance separation in a single reactor. ASBR is a combination between batch reactor and continue. The study concludes with an exposition of technological development of tahu processing using the ASBR reactor.

**Keywords:** tahu waste water, waste water processing technology, Anaerobic Sequencing Batch Reactor.

## Introduction

Problems related to liquid wastes are still dominant in tahu industry in Indonesia nowadays. It is possible because liquid waste disposal is not performed properly (Wagiman, 2006).

According to Perdana Ginting (2007), Indonesians still apply a conventional waste processing system only focusing on biological, or physical-chemical processing systems. Indeed, such systems have some weaknesses, such as overwhelmed chemical substances used and left unprocessed, lengthy processing, needing for spacy processing area, operation and complicated installation maintenance. To make worse, there are also lacking community awareness of latent hazard of the wastes and mud accumulation, which needs for further process.

These phenomena have, eventually, become indicators of why the liquid waste processing is expensive and ineffective. Accordingly, the liquid waste processing in Indonesian tahu industry tends to be ignored (Santosa, 2011).

Concerned parties have been putting awareness of this problem. Among them are industrial communities. However, no alternative problem-solving has been definitively found or accepted by public general. Regulations provided by the government tends to prefer particular parties at the expense of environmental hygiene. Furthermore, of all of these factors, finance has become the typical reason for the industries to be reluctant to process their wastes in a proper manner. Financial factor includes installation cost and IPAL operation that the industries consider too expensive (Perdana Ginting, 2007). In order to overcome the problem, a technological breakthrough is necessary to be made available, i. e., progressive waste water processing technology, affordable investment and operational cost, efficient processing site, and easy and simple maintenance.

Initially the strategy of environmental management focuses on leverage capacity approach. In practice, the concept is deemed too difficult to be applied because vary emergent obstacles. As time has gone by, strategic concept has changed into problem-solving efforts with end of pipe (EOP) treatment. The EOP is expected to improve the environmental quality. Indeed, environmental contamination continues to occur (Azimi, A. A. & Zaman Zadeh, 2004).

According to Han and Yang (2004) in Safitri et al. (2010), clean production technology is a combination between waste reduction technique in contaminant source (source reduction) and recycle technique. In the clean production, wastes exerted during the whole production process is an indicator of inefficiency of the production process. Therefore, process optimization may help reduce the wastes.

According to Sulasih et al. (2012), liquid wastes exerted during tahu production process derive from submersion, washing, coagulation, pressing, as well as equipment cleaning. Triatmojo (2010) writes that wastes from tahu production process in different stages have different characteristics. Soybean dilute washing, normal temperature, and non hazardous wastes, during the processes of boiling, pressing, packing and coloring, high temperature with high organic content, acid pH and hazardous wastes.

A study by A. Van Handle, Wang G. F., Guo R. Z., Cheng X., Liu Q., Zhang P. J., and Qian G. R. (2006) shows that temperature condition has a biological effect on the processing performance due to optimal activities of the microorganisms at the temperatures of 23-35 ºC. Typically, temperature may also have effect on chemical reaction, substance dissolvability in the wastes and taste and smell. Temperature variation will affect biological process as a whole. Temperatures here are categorized into mesophilic (4-39 ºC), thermophilic (40-55 ºC), and psychophilic, which is operated at below 4 ºC (Eckenfelder, 1998).

According to Khabab and Akhena (2011), acidity rate of liquid wastes exerted by tahu micro industries from coagulation and pressing process range from 3 to 5. For most bacteria, enzymatic activities are affected by pH of solution and these activities reach their maximum rate at pH 6. 5-8. 5. M. L. Davis and D. A. Comwell (2008) contends that bacteria grow well when environmental condition is in a base condition, whereas algae and fungi grow well when environmental condition is in an acid condition. The acidity rate of the wastes affects the optimization of anaerobic biological process. At the anaerobic digestion process the pH of the wastes my affect process stages in the formation of methane from tahu industrial liquid wastes.

Suspended solid is contained with organic and inorganic substances, which are suspended within the liquid wastes. The suspended solid affects *opacity rate* of the exerted liquid wastes and is a pollutant that is easily subject to sedimentation that begins with coagulation and flocculation (Del Poso R. & Dils V. & Beltran, 2000). It may give a better result because the materials are too microscopic and hardly sedimented. The coagulation and flocculation cause the sedimentation of the suspended solid more efficient. The BOD contents of the liquid wastes are beyond 4000 mg/l so that it is effective and economical to perform the anaerobic process. BOD is an empiric analysis that approaches the whole biological processes in the water. The BOD rate is determined by oxygen needed by the microorganisms to decompose all dissolved organic substances and most of suspended organic substances (M. Merzouki, N. Bernet, & J. P. Delgenes, 2005).

Key parameters of the pollutant from the previous studies are presented in Table 1. The table shows that tahu industrial liquid wastes are characterized by organic matters, i. e. COD and BOD, suspended solid, fat, protein, temperature and pH. Techniques of tahu industrial waste water processing need for technological advance, which refers to COD, BOD, suspended solid, and fat and protein koloids. To process the high COD and BOD contents, one needs a biological waste processing, whereas chemical-physical processing is used in anticipating koloid and suspended solid.

The treatment of tahu liquid wastes in Indonesia typically is simply performed by storage containers in each industry before disposed to drainage without initial processing. The wastes flow through the surface body water such as river. Such condition poses high risk of contaminants for the surface water due to increasing COD and BOD as well as decreasing dissolved oxygen in the surface water body. Accordingly, tahu liquid wastes should be disposed after processing treatment by, e. g. onsite treatment or offsite treatment. The most affordable and the simpler processing alternative of tahu liquid wastes is by biological process. This process is divided into two activities namely aerob processing with the help of oxygen and anaerob processing or biological processing without oxygen.

At the moment liquid wastes exerted by tahu micro industries are directly disposed to the river or other water bodies. The liquid wastes with high organic contents will be decomposed in 12 hours and produce bad smells. Due to its position in the housings, tahu industries have mounted serious problems. In addition to bad smells, liquid wastes also make water area dirty (Romli, Baredo, Damas, A. Bes Pia, 2004). According to Hang-Qing You, Zheng Hu, Tan-Qiu Hong, Guo-Wei Gu (2008), environmental problems in which tahu liquid wastes are found have related to health matters. Furthermore, the high organic contents within the wastes have degraded the water quality. From social aspect, industry owners are criticized by the affected inhabitants at the expense of their future reputation in the business.

**Table 1:** Characteristics of Tahu Liquid Wastes

| | Average Concentration by the Researcher | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Temperature | $^oC$ | 60 | 75 | 70 | 65 | 55 | 62 | 76 | 80 |
| pH | | 5, 5 | 4, 3 | 5, 2 | 4, 7 | 4, 5 | 4, 65 | 4, 46 | 4, 5 |
| Total BOD | $mgO_2/L$ | - | - | 2000 | - | 5000 | - | 3600 | 4200 |
| Dissolved BOD | $mgO_2/L$ | - | - | _ | _ | _ | _ | _ | 60 |
| Total COD | $mgO_2/L$ | 4065 | 4113 | 7586 | 8320 | 4040 | 5623 | 5386 | 6205 |
| Dissolved COD | $mgO_2/L$ | _ | _ | 3756 | 4132 | - | - | - | - |
| Suspended solid | mg/L | 1130 | 1020 | 2016 | 1456 | 1567 | 1110 | 1426 | 1086 |
| Oil and fat | mg/L | - | - | - | 64 | - | 56 | - | - |
| Total nitrogen | mg/L | - | - | 520 | - | 165 | - | - | - |
| Amonia-N | mg/L | 250 | - | 48 | - | - | - | - | - |
| Protein | mg/L | 162 | - | - | 150 | - | 112 | - | - |

1) Ahlem Saddoud, Mariem Ellouze, Abdehafidh Dhouib; (2007), 2) Borja, Caudia ET, Magali C Carmarota; (2002), 3) DP Cassidy and E Belia, (2005) 4) Damanhuri TP, N Hakim and S Nurtiono, (2006) 5) George Nakla, Andre Lugowski, Jounika Patel, (2006), 6) Hang-Qing Yu, Zhen Hu. Hu, Tan-Qiu Hong, Guo-Wei Gu; (2008), 7) Jae-Hoon Choi, Seak Dockko, Keusuke Fuklusi, Kazuo Yamamoto, (2002), 8) LA Nunez and B Martinez, (2009)

## Technology for Tahu Micro Industrial Processing

According to R. M. Clark and R. E. Speece (2001), the most affordable and the simpler processing alternative for liquid wastes is biological. The process consists of aerob with oxygen and anaerob without oxygen processes. Anaerob processing consists of oxidation and fermentation by which enzymes are exerted by bacteria.

Anaerob processing by anaerob microorganisms without oxygen takes place with hydrolisis, acetogenesis, and metanogenesis stages. The processing needs low energy, stable effluent, mud and low nutrition. The end result is biogas (Grady & Lim, 1980; et Lettinga, 1996) and it is applicable to wastes with high organic contents (M. Z. Halalseh et al., 2005). The technology used is simple and affordable. On the other hand, anaerob processing makes use of septic tank, Imhoff tank, anaerobic lagoon

(AL), anaerobic filter (AF), and Upflow Anaerobic Sludge Blanket (UASB). As technology advances, the processing of tahu industrial liquid wastes is currently applying an Anaerobic Sequencing Batch Reactor (ASBR).

## Anaerobic Sequencing Batch Reactor (ASBR)

The introduction of the ASBR as a new technology is supposed to be followed by information about perceived environmental risk so that the consumers will have an option to apply the proper technology. The technology must be compatible with social, cultural, economic, and environmental priorities (Sulasih et al., 2012). In case of tahu industrial waste contamination, technology to be introduced is ASBR (Anaerobic Sequencing Batch Reactor). In practice, this technology can be combined with local innovation in order to get an optimal use of the technology (Wong & Lian, 2006).

The ASBR technology performs an anaerobic without oxygen so that there is no organic substance reduction. However, separation process may involve organic substances converted as methane, exposed to the air.

According to El Shafai et al. (2007), in principle the decomposition of the organic matters with anaerob process consists of two stages:acid production and methane production. Acid production begins with hydrolisis and ends with acidogenesis and acetogenesis; methane production is a crucial tage in the COD reduction.

Anaerobic Sequencing Batch Reactor (ASBR) can be categorized as a suspended growth process with reaction and solid-liquid substance separation in a single container, similar to with Upflow Aerobic Sludge Blanket (UASB). Speece (1996) states that the succesful ASBR depends on the sludge sedimentation granulated as good as possible as that of ASBR process. During the reaction periode, the intermitten stirring for several minutes hourly is performed to obtained equal distribution between substrate and solid (Sung & Bague, 2005). The critical element of the ASBR process is the speed of the sludge sedimentation before effluent decantation. The length of sedimentation may take 30 minutes (Sind & Chan et al., 2010).

ASBR is a combination of continued reaction and batch. The sequence reactor used is a modification between batch and continued process, i. e, each stage is performed by batch. One ASBR operational cycle cycle consists of five stages:(1) fill; (2) react; (3) settle; (4) decant/draw; and (5) idle.

The change in composition and concentration of the materials in the reactor is an important factor in the liquid waste processing. This change is caused by a hydrolic transport of the materials to and from the reactor. Design of biological process typically focuses on rate of vary components of the disposed water and biomass rate from the reactor. In most biological process categorization according to kinetic rate in the reactions based on the kinetic state, which allows vary reaction order due to organism, substrate, as well as environment.

There are three methods can be used for analyzing data on reaction rate:algebra, differential, and integral (Grady & Lim, 2010). Algebric method is used for data during ASBR operation in weak condition, where reaction rate can be calculated algebrically, where the reaction rate is calculated by mass scale equation. Whereas integral and differential methods for data collection were obtained from batch reactor that expressed a direct correlation of the reaction rate as a concentration function (Grady & Lim, 2010).

Techniques that have been developed by some researchers include (1) ASBR (Anaerobic Sequencing Batch Reactor), a semi-continued fill and draw processing, sludge having enough time to be sedimented so that they did not flow with the processed waste water (D. I. Masse & L. Masse, 2001, 2001; D. P. Cassidy & E. Belia, 2005; M. Merzouki, 2005); (2) fixed film reactor (anaerobic microorganisms grow at particular medium surface preventing them from flowing with the waste water).

A study by Sin and Chang (2010) on evaluation of fundamental factors that affect solid separation in ASBR, include reactor configuration, stirring (continued and discontinued), gas formation rate, mixed liquor suspended solids concentration and bioflocculation-granulation. To determine the effect of these factors on the ASBR performance in processing the nonfat dry milk. This study used for ASBR reactors with operation capacity of 12 L and in different configuration operated at a constant temperature of 35 $^{o}$C. ASBR is a new high rate anaerobic process (U. S. Pat. No. 5, 185, 079) being developed by Dague and his colleagues at the Iowa State University. The experiment aimed at evaluating fundamental factors that affect the solid separation in the ASBR, including reactor configuration, stirring (continued and discontinued), gas formation rate, mixed liquor suspended solids concentration and bioflocculation-granulation, and to determine effect of the factors on the ASBR performance in processing the nonfat dry milk. ASBR was capable of overlapping 90% of the soluble COD reduction in synthetic milk substrate at the COD weight ranging from 2 to 12 g/L. day at HRT 48, 24, and 12 hours. The reactor configuration is important in the formation of the sludge granular. The reactor with tall-slim stature tends to select the granules better than the reactor with short-fat stature. However, the shorter reactor can accumulate the biomass concentration better than the tall one. The discontinued stirring more preferrable than that of continued from the aspect of COD or methane production disposal.

## Conclusion

The above overview and literary study, it can be concluded that:

- Tahu liquid wastes are characterized by three major problems:dissolved organic matters (BOD/COD) with high concentration and suspended solids such as fat and protein as well as pH so that all studies on tahu waste water focused on the waste problem-solving.
- The biological Anaerobic Sequencing Batch Reactor (ASBR) is an alternative and environmental friendly processing to make use of organic and waste of tahu industries. Anaerobic processing technology is directed to trap microorganisms in the reactor in order to produce biogas as environmental friendly renewable energy

This overview has not discussed strategy of tahu liquid waste processing with ecoefficiency and clean production.

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