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# Commentary on Appropriate Wastewater Treatment System for a Natural Rubber Processing Factory

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**Abstract**

In this commentary, the process performance of natural rubber processing wastewater systems was evaluated and compared. The key factors evaluated in here comprised the following: the type of wastewater, the prevention of system clogging by coagulated rubber, and the reduction of greenhouse gas (GHG) emissions. This commentary examined these variables in existing systems and in a pilot-scale reactor system for wastewater treatment. Then an appropriate wastewater treatment system was proposed.

## Keywords:

Natural rubber processing wastewater; Greenhouse gas emissions; Two stage UASB-DHS system; Sulfate reduction; Energy and resource recovery

## Introduction

The natural rubber industry is one of the most important agro-industries in South-east Asia [1]. In a natural rubber processing factory, natural rubber latex (NR latex) extracted from para rubber trees is processed into three types of rubber products: ribbed smoked sheet (RSS) rubber, technically specified rubber (TSR), and concentrated latex (CL) [2-4]. Both RSS and TSR are categorized as block rubber, which is produced by the coagulation of NR latex. Conversely, the centrifugation of NR latex produces CL.

On average, 20 $m^3$ of wastewater is discharged for each ton of rubber produced [5]. The major pollutants in the wastewater are ammonia and organic acids such as acetic acid and formic acid, used to preserve and coagulate NR latex, respectively [6]. Furthermore, CL wastewater contains high concentrations of sulfate. Sulfuric acid is used in the processing of skim latex. Currently, open-type, anaerobic-aerobic systems, such as conventional lagoon systems, are used to treat wastewater [7]. However, these systems have high environmental loading of greenhouse gas (GHG) emissions, low effluent water quality, malodor, groundwater pollution, and other negative environmental effects [8,9]. Therefore, an appropriate wastewater treatment system for the natural rubber industry is required [10]. In this commentary, the performance of both existing open-type wastewater treatment systems, i.e., the pilot-scale two-stage up-flow anaerobic sludge blanket (UASB) and the down-flow hanging sponge (DHS) reactor systems (two-stage UASB-DHS systems), were compared. Finally, an appropriate wastewater treatment system was proposed based on the findings.

## The process performance of existing open-type wastewater treatment systems in natural rubber processing factories

Tanikawa et al. investigated the process performance of four existing treatment systems for treating natural rubber processing wastewater in Thailand (one factory) and Vietnam (three factories) [11-13]. These factories applied the open-type, anaerobic-aerobic system for wastewater treatment (Figure 1). Most of the factories achieved the effluent standard or water quality in the final effluent water (in the Vietnam factories, standard B). Process performance of these systems was similar with other wastewater treatment system of Vietnamese and Malaysian natural rubber processing factories [1-5]. However, these factories consumed large amounts of electricity for wastewater treatment, particularly for the aerobic treatment of CL wastewater and in the post-treatment phase of anaerobic treatment. In case of two Vietnamese factories (factory B and C), power consumption for wastewater treatment was higher than that for natural rubber production due to the stricter effluent standard required for nitrogen compounds. Furthermore, methane and nitrous oxide were emitted as GHGs from the anaerobic treatment system; nitrous oxide accounted for 65% of the total GHG emissions (surveyed at factory D). In general, methane is considered to be the main GHG emitted from open-type anaerobic systems that treat organic wastewater. GHG emissions from natural rubber processing wastewater treatment systems were not considered because in this treatment process, the chemical oxygen demand (COD) concentration is lower than that seen in other agro-industrial wastewaters, such as palm oil mill effluent (POME) and molasses wastewater. However, the potential for the nitrous oxide to be emitted from natural rubber processing wastewater treatment systems was estimated to be approximately the same as methane emissions emitted from POME treatment. Therefore, the natural rubber industry should be considered as a target industry for clean development mechanism applications, as is the palm oil industry.

## The process performance of the two-stage UASB-DHS system for the treatment of CL and RSS wastewater

Tanikawa et al. conducted a pilot-scale experiment of a two-stage UASB-DHS system (Figure 2) for treating CL wastewater, a highly contaminated wastewater containing high concentrations of organic matter, ammonia nitrogen, and sulfate, in Thailand (at factory A) [13]. The system achieved 95.7% of COD removal at 0.8 kg COD/($m^3$.d). In the treatment of sulfate-rich wastewater, methanogenesis was inhibited by the hydrogen sulfide that was produced by sulfate reduction [14]. In the first stage of the UASB, 80% of the COD removed was degraded by sulfate reduction, with more than 90% sulfate consumption. As a result, both generation and inhibition of hydrogen sulfide were reduced

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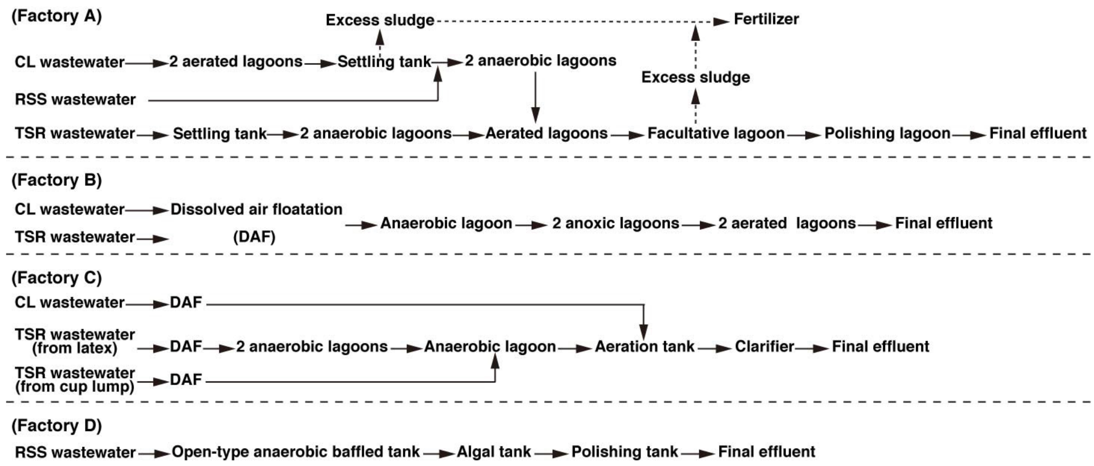


**Figure 1:** Flow chart for the existing wastewater treatment system in the natural rubber processing factories (In Thailand: factory A; In Vietnam: factory B, C and D).

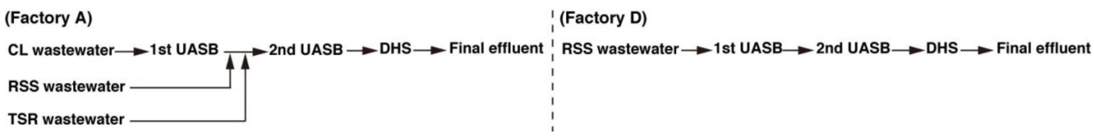


**Figure 2:** Flow chart for the two-stage UASB-DHS system installed in factory A and D.

| Waste water treatment system | CDO removal (%) | GHG s Emission (t-$CO_2$ e/m³-ww) | Power consumption (k Wh/m³-ww) |
|---|---|---|---|
| Factory A | 92.4 | 0.072 | 0.5 |
| Factory B | 97.6 | 0.192 | 9 |
| Factory C | 97.6 | 0.175 | 4.6 |
| Factory D | 94.5 | 0.157 | 0.001 |
| Two stage UA SB-DHS system | 94.9 | 0.011 | 0.05 |

**Table 1:** Process performance of wastewater treatment system in factory A, B, C, D and two-stage UASB-DHS system.

in the second stage of the UASB. Therefore, it was suggested that by separating the stages of COD removal caused by sulfate reduction, methane production, a higher efficiency of CL wastewater treatment could be achieved. Furthermore, the power consumption of the two-stage UASB-DHS system was estimated to be 95% less than that of the existing activated sludge system.

Watari et al. conducted a pilot-scale experiment of the two-stage UASB-DHS system (Figure 2) for the treatment of RSS wastewater, which contained residual rubber particles, in Vietnam (at factory D) [15]. The system achieved 94.9% COD removal at 1.5 kg COD/(m³.d). In case of RSS wastewater treatment, the system was clogged due to the coagulation of rubber particles in the wastewater. In addition, retained sludge containing rubber particles floated in the first stage of the UASB treatment due to its lower specific gravity. This material washed out in the second stage of the UASB. At this instance, the second stage of the UASB was configured as a sedimentation tank. Therefore, recovery of residual rubber particles in the wastewater should be considered to prevent system failure in RSS wastewater treatment. Regarding GHG emissions, the two-stage UASB-DHS system reduced 92% of GHG emissions compared with existing wastewater treatment system. These results indicated that a closed system can reduce nitrous oxide by recovery in addition to reducing methane emissions.

In both CL and RSS wastewater treatments, the DHS achieved a higher removal efficiency of COD and nitrogen with less aeration than the existing aerobic systems, such as aerated lagoons and activated sludge systems. Furthermore, the recovered methane was estimated to meet the standards of operation for natural rubber production wastewater treatment systems (Figure 2 and Table 1).

Table 1 shows the process performance of wastewater treatment system in factory A, B, C, D and two-stage UASB-DHS system. These results indicated that two-stage UASB-DHS system has advantages for not only COD removal, but also reduction of GHG emissions and power consumption.

## Conclusion

In the treatment of natural rubber processing wastewater, hydrogen sulfide inhibition and the clogging of the system by coagulated rubber need to be considered in the wastewater processing method used for CL and block rubber, respectively. In addition, both GHG emissions and power consumption need to be reduced in wastewater treatment. Hydrogen sulfide inhibition was prevented during COD removal by sulfate reduction and methane production in the two stage system. Both GHG emissions and power consumption were reduced by the application of a closed anaerobic system. However, coagulated rubber still clogged the system. In currently used open-type wastewater treatment systems, accumulation of coagulated rubber was confirmed at the surface and it was recovered later in the process as a rubber resource. However, GHGs were emitted from this system. Therefore, a pretreatment system for rubber recovery without the associated GHG emissions is required. Hence, a combination system of both an anaerobic baffled reactor (ABR), which is a high-rate closed anaerobic system, and a DHS (ABR-DHS system) was proposed for natural rubber processing wastewater treatment. The ABR separated wastewater treatment into phases, which included rubber recovery, hydrolysis, acidification, sulfate reduction, and methane production by compartmentalization. In addition, ABR demonstrated a high performance of solid/liquid separation. Thus, ABR can achieve rubber resource recovery, sulfate reduction, and methane recovery in a single reactor. In future, our research of the ABR-DHS system for natural rubber processing wastewater treatment will be reported.


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