Evaluation of the Decentralized Wastewater Treatment Plants in Four Provinces in Indonesia

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Abstract: In Indonesia there is a number of Decentralized Wastewater Treatment Plant or Community-based Sanitation (called SANIMAS) locations. In this study, the survey locations included Tangerang – Serang Province, Surabaya – East Java Province, Yogyakarta Province and Bali Province. These locations were selected for the following considerations: variation of influent into the SANIMAS system, ease of access to the SANIMAS manager, availability of resources and data completeness of the system and the distance to the available wastewater laboratory. Most of the SANIMAS, systems applied in Indonesia were developed by BORDA having a similar shape and size.

The study found that the typical BORDA biodigester (with a diameter of 3 meter) could work well at the loading rate of 1 kg-COD/day/m³ of biodigester, and it could reduce COD up to 3.5 kg-COD/day. If all of the removed COD was converted into biogas, it would produce 1,850 L of biogas/day, with the concentration of CH₄ in biogas of about 75%. Moreover, the SANIMAS system operation was very simple; in general, there were no obstacles in the operation of SANIMAS system, neither in communal, tofu-tempe industries, nor in treating cattle dung. However, there were several constraints/problems associated with the system performance and SANIMAS system as a whole found in this study.

Keywords: Decentralized wastewater treatment; domestic; industries

INTRODUCTION

In Indonesia, there is a number of the Decentralized Wastewater Treatment Plant or Community-based Sanitation (called as SANIMAS) locations. However, there was a lack of data on the performance of the SANIMAS. Therefore, it was needed to do a survey to evaluate its performance on various applications. The survey locations included Tangerang – Serang Province, Surabaya – East Java Province, Yogyakarta Province, and Bali Province. Survey site selection considerations included the variation of influent to the SANIMAS system, ease of access to the SANIMAS manager, the availability of resources and data completeness of the system and the distance to the available wastewater laboratory.

Most of the SANIMAS systems were developed by BORDA having a similar shape and size. For the application in small-scale industries and domestics, the system consisted of a unit of biodigester, settling chamber, and a unit of Anaerobic Baffled Reactor (ABR). As for treating the cattle dung the system consisted of a unit of biodigester and then followed by an overflow tank and a sludge drying bed. Basically, these two models of SANIMAS had the similar concept, i.e. one unit of biodigester to reduce the COD and BOD in significant quantities and produce biogas as well as post-treatment units after the biodigester. The additional post-treatment unit was intended to further treatment of effluents before being discharged directly into the environment. However, the SANIMAS for treating cattle dung were not equipped with a post-treatment unit, due to the effluent was planned to be used as fertilizers.

METHODOLOGY

This study consisted of the following stages:

Literature Study

The main focus in the literature study was for making use of various wastewater, such as blackwater (human feces), animal dung and also wastewater from home or small scale industries. These wastewater could be beneficial for producing biogas by microbial digestion inside biodigester. Various factors affecting the yield of biogas production and biogas characteristic were studied, e.g. wastewater characteristic, pH, temperature, retention time and solid fraction.
Data Collection
This stage was intended to collect various data concerning the location of existing SANIMAS units, source and characteristic of wastewater for the corresponding SANIMAS unit, type of SANIMAS system and biogas utilization. Personal interview was also performed to obtain other valuable information from the local community and SANIMAS manager.

The characteristic of wastewater and biogas were obtained by performing field survey and taking the samples directly from the corresponding wastewater treatment units. The wastewater samples were then analyzed in the available accredited laboratory nearby. Meanwhile the biogas samples were analyzed in the Department of Chemical Engineering – Institut Teknologi Bandung to obtain biogas composition.

SANIMAS Evaluation
Evaluation of the existing SANIMAS system was performed to identify potential improvement which could be done to tackle any constrains, and therefore to enhance the effectiveness of SANIMAS system, environmentally as well as economically.

RESULTS AND DISCUSSION

Brief Description of SANIMAS System in Indonesia
There are numerous wastewater treatment units which can be used to handle domestic wastewater. At first, the wastewater treatment unit shall produce an effluent which complies with the effluent standard and/or regulation for discharge into environment. Besides, this wastewater treatment unit can also be designed for the purpose of biogas production as its valuable product.

According to the source of wastewater, SANIMAS system could be classified into 3 (three) categories, they are communal toilet (commonly known as MCK++), communal wastewater treatment, small scale industries and cattle farming. Regardless their source and type of wastewater, SANIMAS system mainly consisted of a biodigester. This biodigester was typically designed by BORDA having a fixed-dome shape with a diameter of 3 meters. This type of biodigester was selected as it had been proven for handling domestic wastewater while producing the biogas, less cost as it could be constructed by the local community using common available materials (e.g. bricks), and it could be operated by the local community as it did not require special procedure, external energy nor additional chemical for maintaining its operation. However the effluent from biodigester did not comply with regulation and could not be directly discharged into environment. An additional anaerobic baffled reactor (ABR) was used in BORDA system for further treatment of biodigester effluent.

Communal Toilet (MCK++). The communal toilets were initially built to accommodate inadequate sanitary unit in the local community housing. These communal toilets consisted of about 5-6 toilets, 3-6 showers and several faucets which could cover between 300 – 400 persons in the corresponding local community. They were equipped with one unit of biodigester and additional anaerobic baffled reactor. The wastewater from toilet was directed to biodigester meanwhile the wastewater from showers and faucets were directed to the anaerobic baffled reactor. The biodigester was a fixed-dome type having a diameter of 3 meters. Meanwhile the anaerobic baffled reactor consisted of about 7 compartments which total volume of about 110 m³.

At the early days of operation, communal toilets were used by most of its local community hence its operational and maintenance costs could be covered without external subsidiary. However, recently there was a decreasing number of users. It might be caused by the improvement of communities economies, subjective social considerations, along with toilet users prefer to build their own toilet facilities in their homes, rather than using the communal. This resulted in decreased of wastewater into the communal toilet. Furthermore, it could not cover operational and maintenance cost. Recently, they were only about 50-70 persons the using communal toilet per day.
The amount of produced biogas could only be utilized by 1 (one) equal house, e.g. for daily cooking and electricity.

Communal Wastewater Treatment. These units were constructed to handle domestic wastewater generated from a local housing. These types of communal SANIMAS were depended on various factors, such as main purpose, participating household and topographic situation.

In Denpasar – Bali Province, the communal wastewater treatment unit was designed to accommodate up to 165 households or equal to 40 m³/day wastewater. It was not equipped with a biodigester, but it only consisted of an anaerobic baffled reactor having a total volume of 96 m³. It was due to the purpose of this communal wastewater treatment unit was to tackle inadequate local housing sanitary and to prevent environment pollution due to improper domestic wastewater discharge. The treated wastewater had a BOD and COD value of 20 and 52 mg/L, respectively.

Meanwhile in Yogyakarta, the communal wastewater treatment unit was designed to facilitate blackwater from 15 households and greywater from 51 households. The blackwater was treated in biodigester prior to anaerobic baffled reactor, meanwhile the greywater was directed to the anaerobic baffled reactor. The produced biogas could be only used by 2 (two) households for 4.5 hours cooking activity per day.

Tofu Industries. These types of wastewater treatment units for small industry of tofu-tempe were mostly depended on participating industries. For example, the wastewater treatment unit for tofu-tempe industry in Bantul – Yogyakarta Province was designated to facilitate 2 industries having total production capacity of 125 kg soy-bean/day. Meanwhile in Denpasar – Bali Province, the wastewater treatment unit was designed to facilitate about 6 industries having total production capacity of 1.4 ton soy-bean/day.

The wastewater treatment unit for tofu industry in Denpasar – Bali Province was equipped with one unit of digester to handle about 20 m³/day wastewater. Additional anaerobic baffled reactor with 6 compartments having total volume of 56 m³ was installed for further treatment of effluent from biodigester. Laboratory analysis for the sample taken from wastewater treatment unit showed that the BOD and COD of wastewater generated from tofu-tempe industries was 5,000 and 8,000 mg/L, respectively. Personal interview with the owner revealed that the produced biogas could be used for cooking activity continuously in 24 hours a day. Meanwhile for the tofu industry in Bantul – Yogyakarta Province, the produced biogas could be use for about 9 hours cooking per day.

The effluent of anaerobic baffled reactor gave a better community acceptance in visual and odor than its initial condition before entering wastewater treatment unit. However the laboratory analysis for the sample of treated wastewater showed that its BOD and COD values was about 300 and 500 mg/L, respectively. Hence it was obvious that the treated wastewater had not met the effluent standard for discharging into the environment. Other information given by the owner stated that the biodigester and also its anaerobic baffled reactor had not ever been cleaned for removing accumulated solid since the first time of operation (more than 3 years). Therefore, it could be concluded that the accumulated solid inside the biodigester and anaerobic baffled reactor reduced the overall performance of wastewater treatment unit.

Cattle Farming. A wastewater treatment unit for handling wastewater generated from cattle farming consisted of a biodigester. Instead of anaerobic baffled reactor, this wastewater treatment unit was equipped with sludge drying bed. These types of wastewater treatment unit were designed to handle a high load of COD and TSS. Using a typical BORDA design with a biodigester of 3 meters in diameter was not adequate to handle this COD load, hence the COD in the effluent of biodigester was still high. However, the effluent was regarded suitable as an organic fertilizer.
SANIMAS Evaluation

Following tables (Table 1, 2 and 3) show the wastewater and biogas characteristic from the SANIMAS units.

### Table 1: Influent flowrate to the SANIMAS units, based on the actual condition during field survey

<table>
<thead>
<tr>
<th>Unit</th>
<th>Influent flowrate (Liter/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communal SANIMAS</td>
<td>1,261</td>
</tr>
<tr>
<td>Tofu Industry</td>
<td>462</td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>395</td>
</tr>
</tbody>
</table>

### Table 2: Wastewater characteristic of SANIMAS units

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Communal SANIMAS</th>
<th>Tofu Industry</th>
<th>Cattle Farming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Influent</td>
<td>Intermediate</td>
<td>Effluent</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>6.2</td>
<td>6.4</td>
<td>6.3</td>
</tr>
<tr>
<td>TSS mg/L</td>
<td>482</td>
<td>60</td>
<td>60</td>
<td>946</td>
</tr>
<tr>
<td>TDS mg/L</td>
<td>652</td>
<td>816</td>
<td>314</td>
<td>5,106</td>
</tr>
<tr>
<td>BOD mg/L</td>
<td>850</td>
<td>125</td>
<td>22</td>
<td>2,310</td>
</tr>
<tr>
<td>COD mg/L</td>
<td>2,361</td>
<td>346</td>
<td>61</td>
<td>8,103</td>
</tr>
<tr>
<td>Total P mg/L</td>
<td>0.037</td>
<td>0.59</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total N mg/L</td>
<td>19.1</td>
<td>9.9</td>
<td>4.7</td>
<td>25.9</td>
</tr>
<tr>
<td>VS mg/L</td>
<td>666</td>
<td>300</td>
<td>52</td>
<td>820</td>
</tr>
</tbody>
</table>

*) not analyzed

### Table 3: Biogas characteristic from SANIMAS unit

<table>
<thead>
<tr>
<th>Unit</th>
<th>Flowrate (L/day)</th>
<th>Gas Composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CH₄</td>
</tr>
<tr>
<td>Communal SANIMAS</td>
<td>1,145</td>
<td>87.7</td>
</tr>
<tr>
<td>Tofu Industry</td>
<td>1,620</td>
<td>84.5</td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>1,583</td>
<td>72.5</td>
</tr>
</tbody>
</table>

According to Table 2, wastewater in the intermediate stream (effluent of biodigester) for communal SANIMAS was 346 mg/L. This value was not acceptable for direct discharged into environment. Therefore, additional anaerobic baffled reactor was installed to reduce remaining COD load from the effluent of biodigester. COD concentration in the final effluent was 61 mg/L, hence the wastewater could be discharged into the environment. Meanwhile COD concentration in the intermediate stream for tofu industry wastewater treatment unit was 604 mg/L. After further treatment in an anaerobic baffled reactor, COD concentration in the final effluent was 407 mg/L. This value was still not acceptable for direct discharged into environment. This fact revealed that further investigation should be performed to evaluate the overall wastewater treatment unit for tofu industry. Compared to other systems, the wastewater treatment unit for cattle farming had the highest COD load. Biodigester effluent with COD concentration of about 40,492 mg/L and also a high TSS concentration could not discharged into environment. However, a high organic and nitrogen content allowed the effluent to be used as an organic fertilizer.

In determining the performance of domestic wastewater treatment unit and biogas production, COD was selected as the main parameter in calculations. According to Table 2, the COD reduction in the biodigester for wastewater treatment of tofu industry, communal SANIMAS and cattle farming were 92.54%, 85.34% and 15.37%, respectively. Further evaluation showed that the COD load for wastewater treatment unit of tofu industry and communal SANIMAS were 3,743 and 2,978 g-COD/day, respectively. Meanwhile it was 18,895 g-COD/day for cattle farming. Using the typical BORDA design for a biodigester with 3 meters in diameter, it could be predicted that COD
reduction would vary for the corresponding biodigester. The COD loading rate per volume of digester for wastewater treatment unit of tofu industry and communal SANIMAS were 883 and 702 g-COD/m³-day, respectively. Meanwhile it was 4,455 g-COD/m³-day for wastewater treatment unit of cattle farming. An anaerobic system with mixing equipment can handle wastewater with COD loading rate between 1,000 – 5,000 g-COD/m³-day [Metcalf-Eddy, 2003]. In the other words, an anaerobic system without mixing equipment can only handle COD loading rate up to 1,000 g-COD/m³-day. Therefore, wastewater treatment unit for cattle farming gave the least COD removal since its COD loading rate was very high (4,455 g-COD/m³-day). Meanwhile the COD loading rate for wastewater treatment unit for tofu industry and communal SANIMAS gave the best COD reduction since their COD loading rate were below 1,000 g-COD/m³-day.

According to Table 3, the biogas production and composition from the biodigester for all wastewater treatment units were not significantly different. It was obvious because the shape and dimension of biodigester were typical. The value of COD removal for wastewater treatment unit of tofu industry, cattle farming and communal SANIMAS were 3,464, 2,904 and 2,541 g-COD/day. These COD removal values were not significantly different either. Hence it could be concluded that the typical BORDA biodigester being used in wastewater treatment unit of tofu industry, communal SANIMAS and cattle farming gave the same performances in reducing COD. The differences were only at COD loading rate. Moreover, methane (CH₄) concentration in the biogas of higher than 70% showed that the biodigester operated in a good condition. The comparison of the biodigester performance in COD removal of various wastewater is shown in Table 4.

Table 4: Comparison of biodigester performance in COD removal

<table>
<thead>
<tr>
<th>COD load</th>
<th>COD loading rate</th>
<th>COD reduction</th>
<th>COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>g-COD/day</td>
<td>g-COD/m³-day</td>
<td>%</td>
<td>g-COD/day</td>
</tr>
<tr>
<td>Communal SANIMAS</td>
<td>2,978</td>
<td>702</td>
<td>85.34</td>
</tr>
<tr>
<td>Tofu Industry</td>
<td>3,743</td>
<td>883</td>
<td>92.54</td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>18,895</td>
<td>4,455</td>
<td>15.73</td>
</tr>
</tbody>
</table>

CONCLUSIONS

This study found that the typical BORDA biodigester (with a diameter of 3 meter) was working well at the loading rate of 1 kg-COD/day/m³ of biodigester, and it could remove COD up to 3.5 kg-COD/day. If all of the removed COD was converted into the biogas, it would produce 1,850 L of biogas/day, with the concentration of CH₄ in biogas of about 75%.

One of the communal SANIMAS in Yogyakarta treated the wastewater of 15 households had only the loading rate of 0.70 kg-COD/day/m³ and the COD removal was 2.5 kg/day. By comparing these values with the value of the actual capabilities for a biodigester, it can be concluded that the biodigester performance and ability to handle the waste could be optimized. The results of optimization show that the communal biodigester with 3 meter diameter could serve up to 20 households.

The SANIMAS system operation was very simple; in general, there were no obstacles in the operation of SANIMAS system, neither in communal, tofu industries, nor in treating cattle dung. However, there were several constraints or problems associated with system performance and SANIMAS system as a whole found in this study, as described below:

Constraints in the Communal Toilet (known as MCK + +)

The main constraint in the communal toilet was the decreasing number of users. It might be caused by the improvement of communities economies, subjective social considerations, along with toilet users prefer to build their own toilet facilities in their homes, rather than using the communal toilet. The lesser users will affect to the sustainability of the communal toilet.
**Constraints in the Communal SANIMAS**
The survey data indicated that the biodigester with diameter of 3 m was only handling the blackwater from 15 households. However, the families who could take advantage of biogas was only 2 families, or only 13% of users. Economically, it was not a lot of benefits perceived by the 13 households who did not get benefit of biogas. But when observing the impact on the environment and sanitary conditions of society, every family seems to have substantial benefits.

**Constraints in the Tofu Industry and Cattle Farming**
The gas production tended to be decreased from time to time and it has also a high moisture content in the biogas which could clog its channel. The laboratory analysis also showed that the BOD and COD of effluent were still high having not be suitable to be discharged directly into the environment.

One possibility caused the decreased of biogas products and high content of COD in the effluent was the accumulated solids in the biodigester and ABR units. A large solids settled to the bottom of the units affected the performance of the system to produce biogas and reduce the COD. The study suggested that the knowledge of the industry owner on the system operation should be improved.

**REFERENCES**
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Introduction

- In Indonesia, there are several Decentralized Wastewater Treatment Plant or Community-based Sanitation (called as SANIMAS) locations.
- Most of the SANIMAS systems were developed by BORDA having a similar shape and size.
  - For the application in small-scale industries and domestics, the system consisted of a unit of biodigester, settling chamber, and a unit of Anaerobic Baffled Reactor (ABR).
  - As for treating the cattle dung the system consisted of a unit of biodigester and then followed by an overflow tank and a sludge drying bed.
The survey locations included Tangerang – Banten Province, Surabaya – East Java Province, Yogyakarta Province, and Bali Province.

Survey site selection considerations included:
- the variation of influent to the SANIMAS system
- ease of access to the SANIMAS manager
- the availability of resources and data completeness of the system and
- the distance to the wastewater laboratory.

example of Communal Toilet – MCK ++
example of Communal Sanimas

Tofu Industries
Basically, the two models of SANIMAS had the similar concept, i.e.

- one unit of biodigester to reduce the COD and BOD in significant quantities and produce biogas.
- the additional post-treatment unit was intended to further treatment of effluents before being discharged directly into the environment.
- however, the SANIMAS for treating cattle dung were not equipped with a post-treatment unit, due to the effluent was planned to be used as fertilizers.
Methodology

- This study consisted of the following stages:
  - literature study
    - concerning wastewater for biogas
  - data collection
    - concerning existing SANIMAS
    - wastewater sources and characteristics
    - field survey and personal interview
  - SANIMAS evaluation
    - identifying its potential improvement
    - enhancing its effectiveness
Field survey, sampling and interview
Results and Discussion

- SANIMAS overview - Communal Toilet (MCK++)
  - They were initially built to accommodate inadequate sanitary unit in local community housing;
  - Consisted of about 5-6 toilets, 3-6 showers and faucets to cover between 300-400 persons;
  - However, people started to build toilet in their own house which resulted in decreased of wastewater into communal toilet;
  - Recently they were only about 50-70 persons using communal toilet per day, hence it could not cover operational and maintenance cost;
  - The amount of produced biogas could only be utilized by 1 (one) equal house, e.g. for daily cooking and lighting.
- **Communal wastewater treatment**
  - These units were constructed to handle domestic wastewater generated from local housing.
  - Its construction depended on various factors, such as:
    - main purpose
    - participating household and
    - topographic situation.

- **In Denpasar – Bali Province**, the communal wastewater treatment unit was designed to accommodate up to 165 households or equal to 40 m³/day wastewater.
  - It was not equipped with a biodigester, but it only consisted of an anaerobic baffled reactor having a total volume of 96 m³.
  - It because the purpose of this communal wastewater treatment unit was to tackle inadequate local housing sanitary and to prevent environment pollution due to improper domestic wastewater discharge.
  - The treated wastewater had a BOD and COD value of 20 and 52 mg/L, respectively.
In Yogyakarta, the communal wastewater treatment unit was designed to facilitate blackwater from 15 households and greywater from 51 households.

- The blackwater was treated in biodigester prior to anaerobic baffled reactor.
- Meanwhile the greywater was directed to anaerobic baffled reactor.
- The produced biogas could be only used by 2 (two) households for 4.5 hours cooking activity each per day.

Tofu Industries

- These types of wastewater treatment units for small industry of tofu-tempe were mostly depended on participating industry.
  - In Bantul – Yogyakarta Province, it was designated to facilitate 2 industries having total production capacity of 125 kg soy-bean/day. The produced biogas could be used for about 9 hours cooking per day.
  - Meanwhile in Denpasar – Bali Province, the wastewater treatment unit was designed to facilitate about 6 industries having total production capacity of 1.4 ton soy-bean/day. The produced biogas could be used for cooking activity continuously in 24 hours a day.
- Laboratory analysis showed that the BOD and COD of wastewater generated from tofu-tempe industries was 5,000 and 8,000 mg/L, respectively.
The effluent of anaerobic baffled reactor gave a better community acceptance in visual and odor than its initial condition before entering wastewater treatment unit.

However the laboratory analysis for the sample of treated wastewater showed that its BOD and COD values was about 300 and 500 mg/L, respectively.

Information given by the owner stated that the biodigester and also its anaerobic baffled reactor had not ever been cleaned for removing accumulated solid since the first time of operation (more than 3 years).

Cattle Farming

A wastewater treatment unit for handling wastewater generated from cattle farming consisted of a biodigester.

Instead of anaerobic baffled reactor, this wastewater treatment unit was equipped with sludge drying bed.

These types of wastewater treatment unit were designed to handle a high load of COD and TSS.

Using a typical BORDA design with a biodigester of 3 meters in diameter was not adequate to handle this COD load, hence the COD in the effluent of biodigester was still high.

However, the effluent was suitable as organic fertilizer.
SANIMAS Evaluation

- **Influent flowrate of domestic wastewater treatment unit, based on actual condition during field survey.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Communal SANIMAS</th>
<th>Tofu Industry</th>
<th>Cattle Farming</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Influent flowrate (Liter/day)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communal SANIMAS</td>
<td>1,261</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tofu Industry</td>
<td>462</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>395</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Wastewater characteristic (in mg/L, except for pH)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Communal Sanimas</th>
<th>Tofu Industries</th>
<th>Cattle Farming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Influent Intermediate Effluent</td>
<td>Influent Intermediate Effluent</td>
<td>Influent Effluent</td>
</tr>
<tr>
<td>pH</td>
<td>6.2  6.4  6.3  3.5  6.6  7.1  6.8  6.9</td>
<td>6.8  6.9</td>
<td>6.8  6.9</td>
</tr>
<tr>
<td>TSS</td>
<td>482  60  60  946  318  346  5,760  129,770</td>
<td>5,760  129,770</td>
<td>5,760  129,770</td>
</tr>
<tr>
<td>TDS</td>
<td>652  816  314  5,106  1,948  1,482  16,300  250</td>
<td>16,300  250</td>
<td>16,300  250</td>
</tr>
<tr>
<td>BOD</td>
<td>850  125  22  2,310  215  162  17,200  12,600</td>
<td>17,200  12,600</td>
<td>17,200  12,600</td>
</tr>
<tr>
<td>COD</td>
<td>2,361 346  61  8,103  604  407  47,846  40,492</td>
<td>47,846  40,492</td>
<td>47,846  40,492</td>
</tr>
<tr>
<td>Total P</td>
<td>0.037  0.59  -  3.52  0.528</td>
<td>0.37  0.935</td>
<td>0.37  0.935</td>
</tr>
<tr>
<td>Total N</td>
<td>19.1  9.9  4.7  25.9  8.7  6.0  3,193  3,186</td>
<td>3,193  3,186</td>
<td>3,193  3,186</td>
</tr>
<tr>
<td>VS</td>
<td>666  300  52  820  560  488  10,960  88,540</td>
<td>10,960  88,540</td>
<td>10,960  88,540</td>
</tr>
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</table>
Biogas characteristic

<table>
<thead>
<tr>
<th></th>
<th>Flowrate (L/day)</th>
<th>Gas Composition (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CH₄</td>
<td>CO₂</td>
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<tr>
<td>Communal SANIMAS</td>
<td>1,145</td>
<td>87.7</td>
<td>8.0</td>
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<tr>
<td>Tofu Industry</td>
<td>1,620</td>
<td>84.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>1,583</td>
<td>72.5</td>
<td>23.6</td>
</tr>
</tbody>
</table>

Performance of SANIMAS system

<table>
<thead>
<tr>
<th></th>
<th>COD load</th>
<th>COD loading rate</th>
<th>COD reduction</th>
<th>COD removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g-COD/day</td>
<td>g-COD/m³-day</td>
<td>%</td>
<td>g-COD/day</td>
</tr>
<tr>
<td>Communal SANIMAS</td>
<td>2,978</td>
<td>702</td>
<td>85.34</td>
<td>2,541</td>
</tr>
<tr>
<td>Tofu Industry</td>
<td>3,743</td>
<td>883</td>
<td>92.54</td>
<td>3,464</td>
</tr>
<tr>
<td>Cattle Farming</td>
<td>18,895</td>
<td>4,455</td>
<td>15.73</td>
<td>2,904</td>
</tr>
</tbody>
</table>
Conclusions

- The typical BORDA biodigester (with a diameter of 3 meter) was working at the loading rate of 1 kg-COD/day/m³ of biodigester.
  - It could remove COD up to 3.5 kg-COD/day.
  - If all of the removed COD was converted into the biogas, it would produce 1,850 L of biogas/day, with the concentration of CH₄ in biogas of about 75%.

- One of the communal SANIMAS in Yogyakarta treated the wastewater of 15 households had only the loading rate of 0.70 kg-COD/day/m³ and the COD removal was 2.5 kg/day.
  - By comparing these values with the value of the actual capabilities for a biodigester, it can be concluded that the biodigester performance and ability to handle the waste could be optimized.
  - The results of optimization show that the communal biodigester with 3 meter diameter could serve up to 20 households

- The SANIMAS system operation was very simple; in general, there were no obstacles in the operation of SANIMAS system, neither in communal, tofu industries, nor in treating cattle dung.

- However, there were several constraints or problems associated with system performance and SANIMAS system as a whole found in this study.
Constraints in the Communal Toilet (MCK ++)

- The main constraint in the communal toilet was the decreasing number of users.
- It might be caused by the improvement of communities economies, subjective social considerations, along with toilet users prefer to build their own toilet facilities in their homes, rather than using the communal toilet.
- The lesser users will affect to the sustainability of the communal toilet.

Constraints in the Communal SANIMAS

- The survey data indicated that the biodigester with diameter of 3 m was only handling the blackwater from 15 households.
- However, the families who could take advantage of biogas was only 2 families, or only 13% of users.
- Economically, it was not a lot of benefits perceived by the 13 households who did not get benefit of biogas.
- But when observing the impact on the environment and sanitary conditions of society, every family seems to have substantial benefits.
Constraints in the Tofu Industry and Cattle Farming

- The gas production tended to be decreased from time to time and it has also a high moisture content in the biogas which could clog its channel.
- The laboratory analysis also showed that the BOD and COD of effluent were still high having not be suitable to be discharged directly into the environment.
- One possibility caused the decreased of biogas products and high content of COD in the effluent was the accumulated solids in the biodigester and ABR units.
- A large solids settled to the bottom of the units affected the performance of the system to produce biogas and reduce the COD.
- The study suggested that the knowledge of the industry owner on the system operation should be improved.