Analysis of biodegradation level and sludge stabilization with static and dynamic respiration index method

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Abstract. The residue must be processed to dispose or utilize the residue of the installation processing unit safely. To ensure no environmental contamination occurs, the residual/sludge must be in stable condition. The measurement of the respirometry index values, both static (SRI) and dynamic (DRI), could be used to measure the stability. The stability indicators of respirometry measure the oxygen needed to break down biodegradable organic matters. The purpose of this study is to identify the characteristics and analyze the stability of sludge/digested sample from several places based on water content approach, volatile solids, C/N ratio, SRI, and DRI values. The objective is to develop recommendations for continued processing of unstable sludge/mud/digestat. Further processing uses composting of Takakura baskets for 14 days with coconut shell bulking agents.

Keywords: dynamic respiration index; static respiration index, stability, organic

1. Introduction
According to the National Development Planning Agency, the Indonesian population in 2018 reached approximately 265 million people (Bappenas, 2013). As a consequence, this population will excrete various types of waste each year, including wastewater and sludge (United Nations, 2012). Waste utilization in Indonesia is still relatively low; most prefer to dispose waste directly into third parties.

Urban wastewater and mud contain various renewable sources such as water, organic matter, energy, and nutrients (Sperling, 2007; Sagasta, 2015). The Environmental Protection Agency (2012) defines sludge as solid, semi-solid, or liquid waste resulting from wastewater treatment plants (commercial or industrial), clean water treatment plants, or exclusive air pollution control facilities of waste from a treatment plant. Wastewater treatment is deeply related to the sedimentation of sludge, which increases with the requirements for general waste treatment. To stabilize the sludge, composting and drying can be applied to reduce pathogens and risk when disposing of the sludge. The composting process is known as aerobic decomposition through biological processes, which can be controlled (Ponsa et al., 2008). The final product of this method is a stable material that could be used as soil organic fertilizer/conditioner.

The stability indicator can be used to determine the quality of processed sludge. The stability indicator measures the extent of organic material that can be decomposed; this is known as the Respirometric Index Method. The respirometry index is recommended to determine the most
appropriate stability in measuring the decomposition of organic/biodegradable material (Sanchez, 2010). The indicator of Respirometry Stability measures the consumption of O₂ or the amount of CO₂ that forms in the reaction so that the stability assessment can be more accurate (Ponsa et al., 2008). The purpose of this study is to analyze the level of sludge stability using two approaches: static and dynamic respiration index. The difference between the two approaches is based on aeration level, which was tested. This research is important in analyzing the condition of sludge from a treatment unit, which will be treated so that it is safe for the environment and be used as new resources that are beneficial for the economy and the environment (Scaglia et al., 2000). The respirometry test will produce a stability value, which can describe the biodegradation level of a sludge sample.

2. Research Method
The study was conducted in two stages: 1) determining the characteristics and stability of the sludge, and 2) conducting further treatment to stabilize the unstable sludge. The parameters tested include dissolved oxygen value, respirometric index value, moisture content, volatile solid, C/N ratio, and visual observations of SEM (Scanning Electron Microscopy). The sludge samples were taken from various types of sludge treatment plants including domestic wastewater treatment, drinking water treatment, excrement sludge treatment, industrial wastewater treatment, and organic material treatment. Sludge samples were also obtained from different treatment units, so that the study could identify the process and the treatment unit. Table 1 describes the ten tested samples.

| Number | Type of Sludge                  | Sampling Location               |
|--------|--------------------------------|---------------------------------|
| 1      | IPAM Sedimentation Unit         | IPAM Citayam, Depok            |
| 2      | IPAM Sludge Collection Unit     | IPAM Duren Seribu, Depok       |
| 3      | IPAM Excrement stabilization unit| IPLT Kalimulya, Depok          |
| 4      | IPAL Sedimentation Unit         | IPAL Muara Baru, North         |
| 5      | Drainage Pool                  | Jakarta                         |
| 6      | IPAL Stabilization Unit         | IPAL PT Toyota                  |
| 7      | Pulp Waste                     | PT Leo Graha Sukses            |
| 8      | Pulp Residual                  | Primatama, Tangerang            |
| 9      | Anaerobik Digester Inokulum Cow | UPS FTUI, Depok                |
| 10     | Anaerobic Digester Inokulum Milk|                                 |

Water content test refers to the standard method ASTM D 2974 Method A in gravimetric. Volatile solids test refers to the standard method 2540 G in gravimetric. Carbon values test using the spectrophotometry (spectrophotometry: a method to measure how much a chemical substance absorbs light by measuring the intensity of light as a beam of light passes through sample solution). The test refers to the standard method HACH method 420, and the nitrogen test refers to the standard method HACH method 380, with Total Kjehdahl Nitrogen test method.

Samples were tested for dissolved oxygen value (DO). According to the Lasaridi and Stentiford procedure (1998), samples must be made with a suspension solution. In this test, the suspension solution consisted of 15-gram sample, which were added 500 mL distilled water. Then, each sample were added 15 mL buffer phosphate, 5 mL of CaCl₂, FeCl₃, and 5 mL of MgSO₄. The addition of buffer phosphate was intended to prevent the creation of Nitrogenous Oxygen Demand (NOD) (Lasaridi et al., 1998). After the suspension was completed, aeration was carried out for 15 minutes and 45 minutes incubation. This process was done 5 times. After that, the sample was incubated for 18 hours. Before measuring dissolved oxygen in the sample, aeration for 20 minutes is conducted. DO measurements were carried out using DO meters every minute for 2 hours. DO value checks were carried out in triplicate to obtain variations in the data for each sample.
2.1 Data Analysis

Based on the measurement of dissolved oxygen (DO), the decreasing percentage of oxygen saturation was calculated using the following equation, with 6.71 mg/L as DO calibration at 37 °C.

\[
\% \text{ saturation } O_2 = \frac{\text{DO (mg/l)}}{6.71 \text{ mg/l}} \times 100\% \quad (1)
\]

Next, a graph of \( O_2 \) saturation percentage to the time in minutes was made to get the slope value of the graph or the gradient. According to Gomez et al (2005), the gradient value used in the formula is derived from a linear graph trendline. The SRI equation that used the rules of Gomez et al. (2005) is as below:

\[
\text{SRI (mgO}_2\text{g}^{-1}\text{OM}^{-1}\text{h}^{-1}) = \frac{V \times P \times 32 \times m \times 60}{R \times T \times X \times \text{DM} \times \text{OM}} \quad (2)
\]

Where \( V \) is the air volume in the erlenmeyer (ml), \( P \) is atmospheric pressure (atm), 32 is the molecular mass of oxygen, \( m \) is the graph gradient per 100, 60 is the conversion factor from minutes to hours, \( R \) is the ideal gas constant valued at 0.08206 L atm mol\(^{-1}\)K\(^{-1}\), \( T \) is temperature (K), \( X \) is weight of wet sample (g), \( \text{DM} \) is dry matter (gDM/gX), and \( \text{OM} \) is organic matter (gOM/gDM).

The DRI values were calculated using equation (3). This formula was used because the SRI and DRI values are interrelated with a constant percentage difference and a correlation factor \( (R^2\) to describe correlation value) that is greater than the other formulas obtained, which is equal to 0.98 (p <0.01) (Adani et al., 2000).

\[
\text{DRI} = 2.64\text{SRI} + 113 \quad (3)
\]

2.2 Advance Processing

In this research, further processing aims to improve the stability of the samples tested. This study used samples from the Muara Baru WWTP and PT Toyota WWTP. The composting was done by mixing sludge samples with coconut shells. Each waste sample was mixed in a ratio of 2:3 between the fibres and coconut shell. Coconut fibres and shells act as bulking agents that can absorb moisture from the sample, increase organic stability, and deactivate parasites and pathogens in the sample (Larsen et al. 1991). Adding a coconut shell could help the composting process achieve the optimal physical and chemical conditions, including sample structure, porosity and air space, moisture content, nutrients, and C/N ratio (Ponsa, 2010). Carrying out composting in a tall, medium-sized tub lined with a trash bag. During the composting period, the tub was covered tightly with a cloth. Composting was carried out for 14 days, and parameter measurements were carried out on the 3rd, 7th, 10th, and 14th days. The parameters that were retested were DO, water content, volatile solids, carbon, and nitrogen.

3. Result and Discussion

Based on observations of the sludge sample test, nine sludge samples had a moisture content of more than 50%. The pulp and pulp residue samples decreased significantly from the initial minutes to minute 40, with a final percentage of 29% and 14%. In the milk inoculum anaerobic digestion, a very significant change occurred at the early minute 9 with oxygen saturation at 9%. These three samples’ oxygen saturation decreased significantly because there was a significant degradation of oxygen saturation due to AD digestate samples containing more organic matter; this caused decomposition to occur quickly. Volatile solids, an indication of organic material, also showed the same value, which is more than 50%. The recommended value for VS ranges from 40% to 60% were achieved only on pulp samples and pulp residues. Digestat AD inoculum of cow excrement had the highest number with 83.74%, and the smallest sample was in the IPAL Muara Baru drainage sludge with 16.20%.

Carbon (C), nitrogen (N), phosphorus (P), and potassium (K) are critical nutrients for microorganisms. In this case, the presence of C and N is important for the synthesis of the proteins that are useful to build cells and reproduction. Researchers believe that C and N are used as a barrier to efficient decomposition (Richard, 1992). The C/N interval ratio that is recommended as a requirement for optimal compost material is 15:1 to 30:1 (Haug, 1993). Low ratio values impact N, which is
changed to NH$_3$; high ratios could slow down the composting process due to the lack of nitrogen to support the activity of microorganisms. Excessive nitrogen is not recommended because it could convert ammonium into ammonia, which is a toxic compound for microorganisms (Rynk, 1992).

| Sample                        | Water Content (%) | Volatile Solids (%) | Ratio C/N | Dry Matter (%) |
|-------------------------------|-------------------|---------------------|-----------|----------------|
| IPAL Muara Baru              | 92.44             | 70.17               | 1.29      | 68.32          |
| IPAM Duren Seribu            | 78.50             | 18.24               | 0.83      | 68.58          |
| IPAL Kalimulya Depok         | 75.02             | 39.57               | 8.54      | 68.59          |
| IPAL Muara Baru Drainage     | 52.5              | 16.20               | 2.96      | 63.87          |
| IPAL PT Toyota               | 79.57             | 38.65               | 5.41      | 65.34          |
| IPAM Citayam                 | 37.43             | 18.26               | 1.36      | 54.74          |
| Pulp Waste                   | 72.17             | 52.57               | 34.93     | 64.03          |
| Pulp Residual Waste          | 68.56             | 60.88               | 25.34     | 63.90          |
| AD Inokulum Cow Excrement    | 83.15             | 83.74               | 6.92      | 68.34          |
| AD Inokulum milk             | 94.76             | 70.83               | 4.05      | 68.26          |

Notes:
- IPAL = Water Waste Treatment Plan
- IPAM = Drinking Water Treatment Plan
- AD = Anaerobic Digester

The data for dissolved oxygen (DO), which was obtained from sample measurements for 2 hours (120 minutes) with readings every minute in triplicate, was searched on average and converted into the percentage of saturated oxygen. The graphic displays the percentage of oxygen saturation and time as axis, and then the gradient value (m) for each sample used in the SRI calculation was obtained, as shown in Figure 1 and Figure 2. Both samples showing different decreasing percentage.

The comparison of SRI samples with previous studies in the form of SRI sludge with the addition of wood compost and animal residues for 0 days was 714 ± 124 mgO$_2$g$^{-1}$VSh$^{-3}$ or equal to 0.838 mgO$_2$g$^{-1}$OM$^{-1}$h$^{-1}$ (Scaglia et al., 2000). DRI results with the same category showed a reference test value for 1091 ± 124 mgO$_2$g$^{-1}$VSh$^{-3}$ or equivalent to 115,212 mgO$_2$g$^{-1}$OM$^{-1}$h$^{-1}$. In SRI sludge samples testing, all SRI sludge samples exceeded the study conducted by Scaglia et al. (2000). On DRI, the value also exceeded the study conducted by Scaglia and Adani (2000) with more than 100.

The study showed the highest SRI and DRI acquired values in the IPAL Muara Baru, IPAL PT Toyota, pulp waste, pulp residue, AD digestate inoculum of cow excrement, and AD digestate milk inoculum (Table 3). Furthermore, the IPAL Muara Baru and IPAL PT Toyota sludges were selected for composting, so the changes in the SRI and DRI values could be observed. Conversion of SRI values with mgO$_2$g$^{-1}$OM$^{-1}$h$^{-1}$ was done by multiplying the SRI values obtained with the OM variable. The results of SRI conversion (mgO$_2$g$^{-1}$DM$^{-1}$h$^{-1}$) were already suitable with the comparison made by Ponsa (2010). The information of the level of biodegradability is shown in Table 4.

According to Ponsa (2010), the sludge sample of IPAL Muara Baru Drainage is classified as wastes of low biodegradability while sludge from IPAM Citayam, IPAM Duren Seribu, IPLT Depok, and AD with milk substrate are classified as moderately biodegradable waste. The other five samples are classified as highly biodegradable waste. The analysis of the characteristics of sludge samples after composting is shown in Table 5.
Figure 1. Percentage of Oxygen Saturation to Time on IPAL Muara Baru Sludge

Figure 2. Percentage of Oxygen Saturation to Time on PT Toyota Sludge

Table 3. Result of SRI and DRI Calculation

| Sample                      | m (gDM/gX) | OM (gOM/gDM) | SRI (mgO₂·g⁻¹OM⁻¹ h⁻¹) | DRI (mgO₂·g⁻¹OM⁻¹ h⁻¹) |
|-----------------------------|------------|--------------|-------------------------|-------------------------|
| IPAL Muara Baru            | 0.384      | 0.08         | 0.33                    | 76.621                  | 315.2797                |
| IPAM Duren Seribu          | 0.1205     | 0.48         | 0.41                    | 3.0417                  | 121.0301                |
| IPLT Kalimulya             | 0.2511     | 0.25         | 0.51                    | 9.7491                  | 138.7376                |
| Muara Baru Drainage        | 0.1457     | 0.21         | 0.33                    | 10.276                  | 140.1274                |
| IPAL PT Toyota             | 0.2693     | 0.20         | 0.40                    | 16.332                  | 156.1168                |
| IPAM Citayam               | 0.2844     | 0.63         | 0.60                    | 3.7665                  | 122.9436                |
| Pulp Waste                 | 1.8408     | 0.28         | 0.89                    | 37.029                  | 210.756                 |
| Pulp Residual Waste        | 2.133      | 0.250        | 1.02                    | 31.9997                 | 197.479                 |
| Anaerobic Digester Inokulum Cow | 0.335     | 0.105        | 0.59                    | 155.59                  | 523.7675                |
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In the composting process, microorganisms need moisture to absorb nutrients of the sample, which can be done by aeration or evaporation (Gray et al., 1971). The recommended range of moisture content is 40–60% (Haug, 1993). Overall, both samples met the criteria determined by Haug (1993) to reach optimal conditions of the water content of 40–60%. The only sample from PT Toyota had a value of less than 40%. The initial measurement of the C/N ratio on the IPAL Muara Baru sludge was 1.29. After composting, the C/N ratio increased to 15.78 and it was quite stable for sludge residue. In the IPAL PT Toyota sludge, the C/N ratio was increased from 5.41 to 19.19 after composting. In volatile solids (VS), the decrease of moisture content value influenced the VS value to increase.

| Sample            | m (gDM/gX) | OM (gOM/gDM) | SRI (mgO₂g⁻¹DMh⁻¹) | DRI (mgO₂g⁻¹OMh⁻¹) |
|-------------------|------------|--------------|---------------------|---------------------|
| Excrement         |            |              |                     |                     |
| Anaerobic Digester|            |              |                     |                     |
| Inokulum Milk     | 10.191     | 0.31         | 1.05                | 355.252             |
|                   |            |              |                     | 1050.87             |

**Table 4. Conversion of SRI Value and Classification of Biodegradation Level**

| Sample            | SRI (mgO₂g⁻¹DMh⁻¹) | Classification (Ponsa, et al. (2010)) |
|-------------------|--------------------|--------------------------------------|
| IPAL Muara Baru   | 25.23              | Highly biodegradable wastes          |
| IPAL PT Toyota    | 6.54               |                                      |
| Pulp              | 32.84              |                                      |
| Residue Pulp      | 33.68              |                                      |
| AD Inokulum Kotoran Sapi | 31.74          |                                      |
| AD Inokulum Susu  | 300.40             |                                      |
| IPLT Depok        | 4.99               |                                      |
| IPAM Duren Seribu | 3.36               | Moderately biodegradable wastes      |
| IPAM Citayam      | 2.25               |                                      |
| Drainase IPAL Muara Baru | 1.25     | Wastes of low biodegradability (SRI < 2 mgO₂g⁻¹DMh⁻¹) |

**Table 5. Characteristic of Muara Baru WWTP and PT Toyota WWTP Samples**

| Sample | Days | Moisture (%) | Volatile Solids (%) | Rasio C/N |
|--------|------|--------------|---------------------|-----------|
| Muara  | 3    | 51.54        | 95.57               | 15.78     |
| Baru   | 7    | 60.01        | 90.88               | 16.70     |
| WWTP   | 10   | 39.32        | 93.72               | 13.65     |
|        | 14   | 70.68        | 83.77               | 13.03     |
|        | 3    | 47.22        | 87.62               | 5.27      |
| PT     | 7    | 32.31        | 87.50               | 19.19     |
| Toyota | 10   | 27.85        | 95.14               | 11.98     |
| WWTP   | 14   | 45.48        | 86.25               | 10.62     |

Table 5 shows the test results for moisture content, volatile solids, and C/N ratio for every sludge sampling of IPAL Muara Baru and IPAL PT Toyota. IPAL Muara Baru sludge samples have the initial moisture content value of 92.44%, which decreased during composting. The moisture content of the IPAL Muara Baru after composting for 14 days decreased to 39.32%, while the IPAL PT Toyota sample reached 45.48%. Moisture content testing is essential because it could affect the environment of the sample for the activity and metabolism of microorganisms (Sullivan and Miller, 2001). Microorganisms need moisture to absorb nutrients and to metabolize and produce new cells. Microorganisms can use only organic molecules if dissolved in water. In low humidity conditions, the composting process slows down. In high humidity conditions, the composting process can be reduced to stop the oxygen supply; microorganisms need water as part of their decomposition. Water removal could be done by aeration or evaporation (Gray et al., 1971). The recommended range for water content is 40–60% (Haug, 1993).
quite effective to meet the supporting parameters for a stability test. The values for moisture content, volatile solids (VS), and C/N ratio could be met after composting. Composting on the 7th day achieved the optimum value in this process for both IPAL Muara Baru and IPAL PT Toyota. Based on the compost stability material reference recommended by the California Compost Quality Council (2001), C/N value with ratio less than 25:1 is immature compost conditions while the ratio less than 25:1 ratio is the optimal range in determining the maturity of a composting product. These recommendations are supported by evaluations related to the stability factor of the compost, which was obtained in respirometry analysis.

Observation before and after composting (Figures 3 and 4) used the SEM (Scanning Electron Microscopy) analysis on sludge samples of IPAL Muara Baru and IPAL PT Toyota for 14 days. SEM is one of the electron beams commonly used in material characterization (Gente et al. 2007).

The size of the IPAL Muara Baru sample and IPAL PT Toyota sample before composting was bigger than after composting. The composition of both samples showed different conditions, where before composting, the samples contained only their original materials. After composting, other particles filled the samples—the bulking agent of coconut shell. Observation of both samples also showed the condition of the samples before composting. The larger size showed thicker conditions.
caused more water content in which humidity was present, especially in the IPAL Muara Baru sample. After composting, the sample IPAL Muara Baru appeared dry and brittle. The IPAL PT Toyota samples had lower moisture content than the IPAL Muara Baru samples; this showed a significant visual condition after composting in which the particles appeared drier, and the distance between materials was more tenuous.

The graph below shows the change in oxygen saturation percentage over time during composting on tofu mill waste and cow excrement samples. The samples used were the IPAL Muara Baru sludge and IPAL PT Toyota. Percentage of final oxygen saturation in the IPAL Muara Baru and IPAL PT Toyota samples was 36.16% and 70.64%. SRI values in the IPAL Muara Baru sample on the 3rd, 7th, 10th, and 14th days were relatively stable. There was no dominant spike resulting in an anomaly. The magnitude of each reduction was 12%, 18%, 24%, and 24% (Figure 5). The decreases that occurred in each sample were not less than 25%. The IPAL PT Toyota sample on the 3rd, 7th, 10th, and 14th days did not show constant stability as in the IPAL Muara Baru sample. The magnitude of each reduction, as shown in Figure 6, was 42%, 38%, 42%, and 58%. There was a fluctuation on the 10th day of composting for the IPAL PT Toyota sample, while the reduction rate on the IPAL Muara Baru sample was more constant.

![Figure 5. Alteration of Oxygen Saturation Percentage to Time on IPAL Muara Baru Sludge](image1)

![Figure 6. Alteration of Oxygen Saturation Percentage to Time on PT Toyota Sludge](image2)
Based on this study, we can conclude that:

1. The Static and Dynamic Respiration Index could assess stability by measuring oxygen consumption on sludge samples with the DO parameter.
2. Observed physical tests are visual, weight, moisture, total solids, volatile solids and observed chemical tests are carbon content (C), total nitrogen (N), and C/N ratio.
3. Comparison of tests conducted on samples with SRI and DRI values refers to SRI sludge with the addition of wood compost and animal residues 714 ± 124 mgO₂kg⁻¹VSh⁻¹ or equivalent to 0.838 mgO₂g⁻¹OMh⁻¹. DRI results with the same category show a reference test value of 1091 ± 182 mgO₂kg⁻¹VSh⁻¹ or equivalent to 115.212 mgO₂g⁻¹OMh⁻¹. The SRI and DRI values of the samples tested showed results that exceeded the reference of Scaglia (2000).
4. Biodegradability level shows:

- Muara Baru Drainage Sludge was classified as low biodegradable wastes (< 2 mgO₂g⁻¹h⁻¹).

The level of stability and maturity of composting on sludge samples from the IPAL Muara Baru and IPAL PT Toyota after composting can be adapted using the reference of California Compost Quality Council (2001) on maturity index. Stability levels could be achieved with a SOUR (Specific Oxygen Uptake Rate) value of less than 0.5 mgO₂g⁻¹VSh⁻¹. A sample of the IPAL PT Toyota met the SRI conditions until the 14th day and was classified as very stable sludge. In contrast, the value of the IPAL Muara Baru sample on the 3rd, 7th, and 10th composting days met the CCQC reference (2001) and was classified as stable sludge. On the 14th composting day, a high increase in SRI value was caused either by uneven stirring on the 10th day or the sample taken was too low where there might have been a cavity and wetter condition.

The CCME (2005) established compost quality guidelines for mature and stable compost characteristics, including the formation of fertilizer topsoil and biostabilization; the guideline’s recommendation of 0.4 mgO₂g⁻¹VSh⁻¹ could be met by the compost results of PT Toyota sludge on all composting days. The IPAL Muara Baru met this level on the 7th and 10th composting days. The graph shows an almost identical decrease for all samples on 3rd, 7th, 10th, and 14th composting days. This indicates that the purpose of composting, is to get a stable oxygen saturation reduction, could be achieved. After the values were obtained, then compared these values with the initial feedstock values of the IPAL Muara Baru and PT Toyota sludge samples to see the amount of decrease after applying the Takakura composting. Then, the level amount of decrease was related to the role of samples that are highly biodegradable wastes. On the 7th composting day, both samples reach the optimal values. A significant decrease in the SRI values after composting occurred until the decrease reached 99%. It is proven that composting is effective in reducing the SRI and DRI values of compost to be classified as mature and stable.

### 4. Conclusion

Based on this study, we can conclude that:

| Sample           | Days | m   | DM (gDM/gX) | OM (gOM/gDM) | SRI (mgO₂g⁻¹OMh⁻¹) | DRI (mgO₂g⁻¹OMh⁻¹) |
|------------------|------|-----|-------------|--------------|--------------------|--------------------|
| IPAL Muara Baru  | 3    | 0.1220 | 52.78       | 5.91         | 0.1943             | 113.5131           |
| Sludge           | 7    | 0.1650 | 67.79       | 9.20         | 0.1314             | 113.3468           |
|                  | 10   | 0.1690 | 72.15       | 4.00         | 0.2909             | 113.7679           |
|                  | 14   | 0.1299 | 54.52       | 3.06         | 0.3866             | 114.0205           |
| IPAL PT Toyota   | 3    | 0.2871 | 48.46       | 5.27         | 0.5589             | 114.4754           |
| Sludge           | 7    | 0.1142 | 39.99       | 4.89         | 0.2899             | 113.7654           |
|                  | 10   | 0.1978 | 60.68       | 3.86         | 0.4194             | 114.1072           |
|                  | 14   | 0.3679 | 41.16       | 2.10         | 2.1150             | 118.5836           |

The following table shows the results of SRI and DRI calculation after composting.
- Sample IPAM Citayam, IPAM Duren Seribu, and IPLT Depok were classified as moderately biodegradable (2-5 mgO₂g⁻¹h⁻¹).
  - IPAL Muara Baru, IPAL PT Toyota, Pulp, Pulp Residue, AD inoculum of cow excrement, and AD inoculum of Milk were classified as highly biodegradable (> 5 mgO₂g⁻¹h⁻¹).

5. Composting was carried out on a sample of Muara Baru WWTP and PT Toyota using a coconut shell bulking agent for 14 days. Samples were checked on the 3rd, 7th, 10th, and 14th days by testing the physical parameters and SRI-DRI values of samples that were more stable and mature. The composting method used was Takakura basket composting.

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