

Study of whole effluent acute toxicity test (*Daphnia magna*) as an evaluation of Ministry of Environment and Forestry Decree No. 3 In 2014 concerning industrial performance rank in environmental management

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Abstract. Only 15% of the industries in Citarum Watershed, specifically in Bandung Regency, West Bandung Regency, Sumedang Regency, Bandung City and Cimahi City, are registered as PROPER industries. They must comply to indicators as set in the Minister of Environment and Forestry Decree No. 3 In 2014 concerning Industrial Performance Rank in Environmental Management, as a requirement to apply for PROPER. Wastewater treatment and management, referencing to Minister of Environment and Forestry Decree No. 5 In 2014 concerning Wastewater Effluent Standards, must be performed to be registered as PROPER industries. Conducting only physical-chemical parameter monitoring of wastewater is insufficient to determine the safety of wastewater discharged into the river, therefore additional toxicity tests involving bioindicator are required to determine acute toxicity characteristic of wastewater. The acute toxicity test quantifies LC₅₀ value based on death response of bioindicators from certain dosage. *Daphnia magna* was used as bioindicator in the toxicity test and probit software for analysis. In 2015-2016, the number of industries that discharged wastewater exceeding the standard was found greater in non-PROPER industries than in PROPER industries. Based on the toxicity level, both PROPER and non-PROPER industries have toxic properties, however PROPER industries of 2015-2016 is more toxic with LC50₉₆ value reaching 2.79%.

1 Introduction

PROPER (*Program Penilaian Peringkat Kinerja Perusahaan/Aessment of Industrial Performance Rank Program*) as industrial rank incentive of environmental aspect is one of efforts implemented by Indonesian Ministry of Environment and Forestry (MoEF) to pursue compliance of environmental management regulations. Registered PROPER industries in Upper Citarum watershed, specifically Bandung Regency; West Bandung; Sumedang Regency; Bandung City and Cimahi City, amount to only 15% of all industries around those locations (BPLHD West Java, 2015). PROPER industry participants must comply to certain parameters in Minister of Environment and Forestry Decree No. 3 In 2014 (*PermenLKH No. 3/2014*) to be registered. In regard to wastewater, there are further tests to be conducted and effluent standards to be complied, according to Minister of Environmental and Forestry Decree No. 5 In 2014 (*PermenLKH No. 5/2014*) concerning wastewater effluent standard, including physical, chemical and biological parameters.

Wastewater quality measurements in physical parameters have burden of solid dimensions, while chemical parameters require another chemical addition. Therefore, further biological tests exposing certain dosage on bioindicators is needed to determine toxicity level of discharged wastewater.

Physical and chemical parameter assessment alone would be insufficient in pointing out pollution impacts on aquatic organisms (Ningrum, 2012). Government regulations obligates to figure wastewater acute toxicity through death responses measurement of test animals from different dosage of wastewater. Concentration that causes 50% of bioindicator death response is used to estimate LC₅₀ value in a period of observation time, according to Government Regulation No. 18 In 1999 (PP No. 18/1999). Acute and chronic toxicity is determined through toxicity tests (William and Burson, 1995). In this research, *Daphnia magna* is used as bioindicator to analyze acute toxicity, then using probit software in analysis.

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2 Methodology

Whole Effluent Toxicity (WET) tests was conducted with grab samples from registered PROPER and non-PROPER industries of 2015-2016 in Upper Citarum watershed, in Laboratory of Industrial Hygiene of Environmental Engineering ITB. Measurements of environmental parameters, namely pH, dissolved oxygen, conductivity and temperature, were conducted. Names and classification/type of industry samples is shown in Figure 1. Two liters of wastewater samples was preserved at 4°C without additional preservatives, to prevent chemical transformation and microorganism degradation.

In these toxicity tests, *Daphnia magna* was used as bioindicator due to its simple method of cultivation in the lab and its important role in the food chain and sensitivity to various pollutants (Mark, 1997). WET Tests include 7 days of cultivation phase using bottled water instead of tap water to avoid chlorine contamination, which poisons *Daphnia magna* (US.EPA, 2002). During this process bioindicators were fed with yeast powder and sanitized properly.

WET test was conducted with variation of wastewater concentration, with each combination tripled and in static non-renewal, in which test organisms are exposed to a fresh solution of the same concentration of sample, either by transferring the test organisms from one test chamber to another, or by replacing all or a portion of solution in the test chambers (USEPA, 2002).

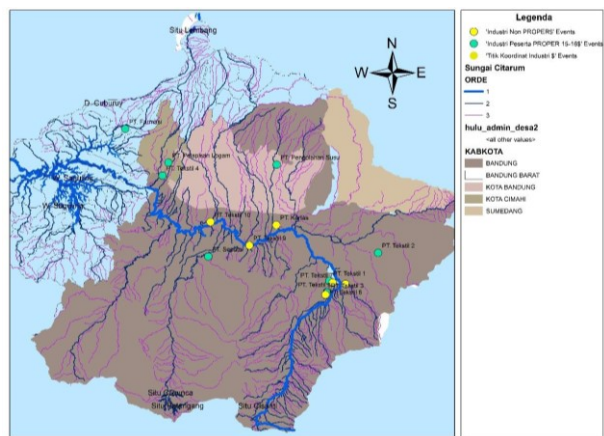


Figure 1 Location study

There are two stages in this method, namely range finding test and definitive test. Range finding test exposes test animal for 48 hours to the samples. Definitive test requires 96 hours in total, with number of death responses and environmental parameters need to be observed at each concentration every 24 hours. Standard measurement method of physical and chemical properties of the waste is shown in Table 1. In addition to those two stages of the test, samples underwent references toxicant test, which aims to determine level of sensitivity and health of test organisms over time. Mount, et al (1997) suggested that LC₅₀ reference value of a toxicity test is 4.7 g/L, which means the WET tests

are adequate to be conducted if the actual LC₅₀ value of this test are close to the reference value.

Table 1 Characteristics parameter measurement method of physical-chemical

Parameter	Measurement Method	Standard of Measurement
pH	pH meter	SNI 06-6989.2-2009
Phosphate	Spectrophotometer	SNI 6989.76-2009
COD	Closed Reflux	SNI 6989.2-2009
Hardness	Complexometry - EDTA	SNI 06-6989.12-2004
Alkalinity	Acid-Base Titration	SNI 06-2420-1991
Ammonium	Spectrophotometer	SNI 19-6603-2001
TSS	Gravimetry	SNI 06-6989.3-2004
Conductivity	Conductivity meter	
Temperature	Thermometer	
DO	DO meter	
Phenol	Spectrophotometer	SNI 06-6989.21-2004
TDS	Gravimetry	SNI 06-6989.3-2004

In the range finding test, wastewater concentrations are shown in Table 2, which involved 40 mL of wastewater sample and six (6) *Daphnia magna* in each test chamber. Range finding test resulted in minimum and maximum concentration, which later were used in the definitive test. New set of concentration in the definitive test was measured using Equation 1. By multiplying R value to the smallest range, new concentration was able to be determined for definitive test.

Table 2 Variation of concentration in range finding test

No.	Waste Concentration (%)	Wastewater (mL)	Dilution Water (mL)
1	6,25	2,5	37,5
2	12,5	5	35
3	25	10	30
4	50	20	20
5	100	40	0

$$r = \left(\frac{a}{b}\right)^{\frac{1}{n-1}} \quad (1)$$

Description: r = constant
 a = the highest concentration with mortality of 50%
 b = the lowest concentrations with mortality below 50%
 n = number of concentrations

3 Result and Discussion

3.1 Participant of PROPER 2014-2015

PermenLHK No. 3/2014 states PROPER is an evaluation of compliance and performance beyond compliance of industries or any activity in regards of pollution control, environmental impact assessments, and/or hazardous waste management. PROPER rates these performances into color-rated ranks namely black, as the least

preferred, red, blue, green, and gold, as the most preferred.

PROPER industry ranks in this study area are shown in Figure 2. There had been 51 industries participated in PROPER in 2014 and 50 industries in the following year. There was 34 blue-ranked PROPER industries, then in 2015 the number increased to 37. However, there had been declining numbers in green and gold ranks PROPER industries.

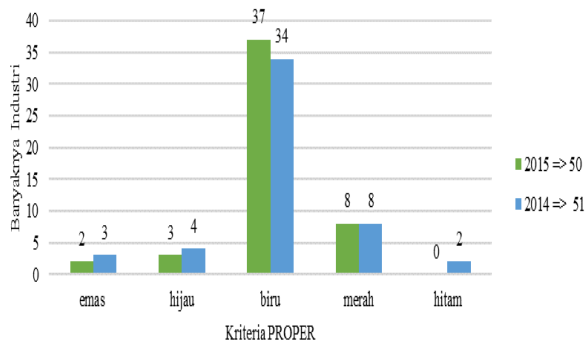


Figure 2 The Value PROPER In Citarum Hulu

Figure 3 shows PROPER industries based on their ranks around Upper Citarum area. Textile industries have the most blue-ranked industries, reaching to 10, while red-ranked were hotels with 4 hotels.

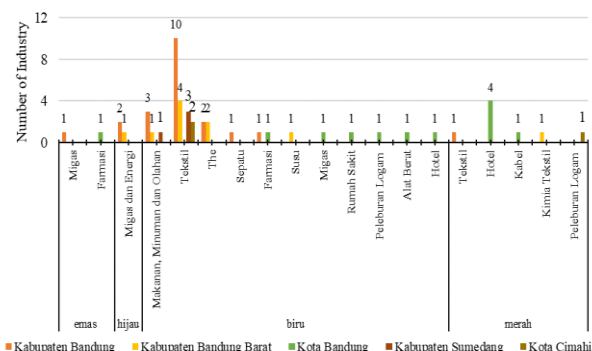


Figure 3 Type Industry Based on Value PROPER in Citarum Hulu

Blue-ranked PROPER shows that industries have conducted environmental management assessment and carry out programs as required in the policy and regulations, including wastewater discharge permit and its monitoring plans based on PermenLHK No. 3/2014. However, these control efforts had not yet reached 100%. Several of these industries had not yet been in compliance to effluent standards on PermenLKH No.5/2014 as they should.

3.2 Wastewater physical-chemical properties of PROPER registered industries in 2015-2016 and Non-PROPER industries

3.2.1 pH

pH value measures hydrogen ions, indicating the acidity or alkalinity scale of a solution. Figure 4 shows to meet the standard, pH must be within the range of 6-9, according to PermenLKH No.5/2014. Alkaline or acid water may be harmful to living organism due to its interference to metabolism and respiration system. Ideal pH for aquatic organisms varies between 7 to 8.5.

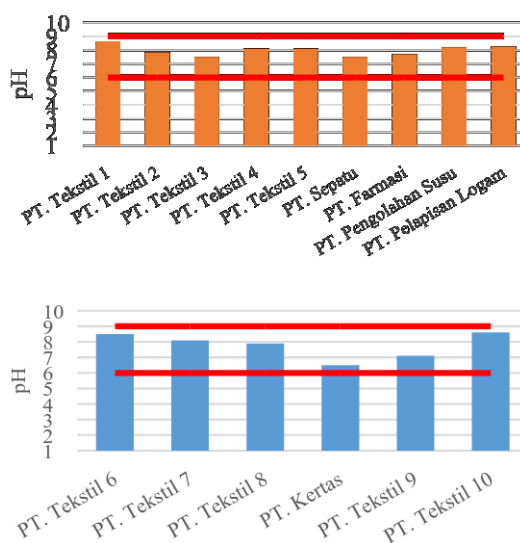


Figure 4 Concentration of pH wastewater effluent. Above: industry participants PROPER 2015 - 2016 and below: industrial non PROPER

3.2.2 Conductivity/Electric conductivity (EC)

Conductivity measures strength of a solution to pass electrical flow through conductive ion contents. PT. *Pelapisan Logam* (PT. Metal Coating) had the highest conductivity reaching 3950 $\mu\text{s}/\text{cm}$, while PT. Tekstil 4 had the smallest conductivity, which is 389 $\mu\text{s}/\text{cm}$ for PROPER industries. Non-PROPER industries have higher value with the highest reached 4030 $\mu\text{s}/\text{cm}$ (PT. Tekstil 8) and the lowest value of 645 $\mu\text{s}/\text{cm}$ (PT. Tekstil 10). Full result is shown in Figure 5. High value of conductivity in wastewater effluent means there is rich mineral content. Conductivity value depends on content of inorganic ions (Tchobanoglous, 2003).

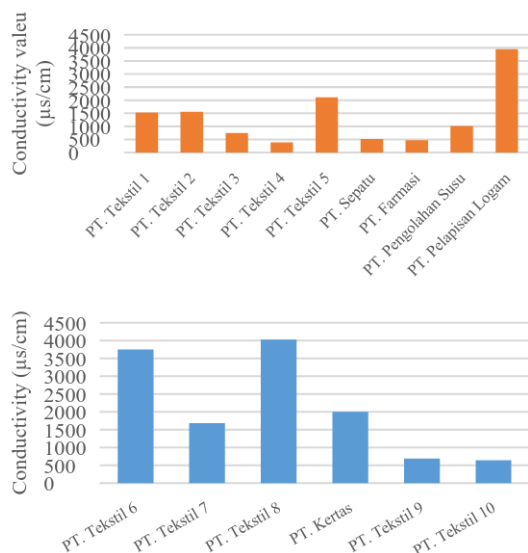


Figure 5 Concentration of Conductivity wastewater effluent. ABOVE: industry participants PROPER 2015 - 2016 and below: industrial non PROPER

3.2.3 Turbidity

Turbidity shows inorganic or organic material content in a solution or water. This inorganic or organic material can affect the ecosystem of aquatic organism. Figure 6 shows PROPER industries have the greatest value of turbidity of 135 NTU (PT. Tekstil 1), while the lowest is 19.133 NTU (PT. Tekstil 3). Non-PROPER industries have higher range on turbidity value, reaching 331 NTU (PT. Paper) as the highest and 52.2 NTU (PT. Tekstil 8) for the least turbid. Turbidity indicates fine particle contents suspended in a solution or wastewater and causing light not able to propagate straight into solutions. High value of turbidity indicates greater level of pollution in bodies of water.

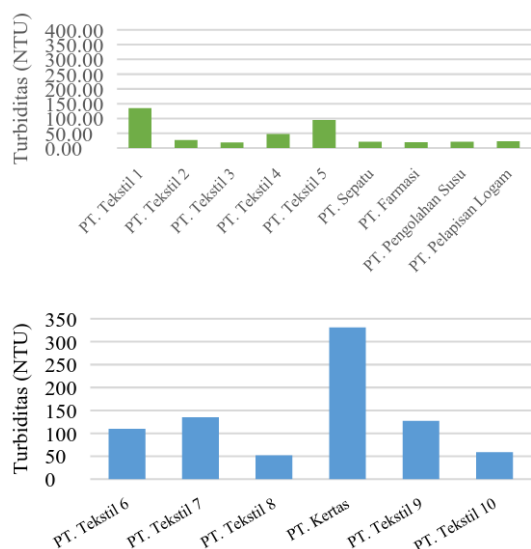


Figure 6 Concentration of Turbidity in wastewater effluent. ABOVE: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.4 Total Suspended Solids/TSS

TSS is residual total solids with maximum particle size of 2 µm or larger than the size of the colloidal particles. Figure 7 shows TSS in wastewater from PROPER and non-PROPER industries in 2015-2016. Lower range was found in PROPER industries, as 456 mg /L (PT. Tekstil 5) for the most TSS content and 86 mg/L (PT. Tekstil 2) for the least, and higher range was from non-PROPER industries with 592 mg/L (PT. Kertas) as the highest and 224 mg/L (PT. Tekstil 10) as the lowest. TSS content will reduce sun penetration into the water, affecting oxygen regeneration from photosynthesis and may cause disruption to aquatic organism growth.

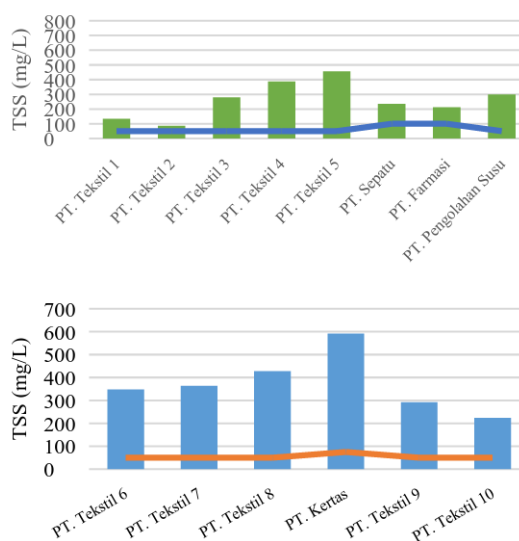


Figure 7 Concentration of TSS wastewater effluent. ABOVE: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.5 Total Dissolved Solids/TDS

TDS indicates dissolved content, whether organic or inorganic substances in liquid solution. Figure 8 shows TDS value in PROPER industries in 2015-2016 and non-PROPER industries. For PROPER industries in 2015 - 2016, the highest value was 3480 mg/L (PT. Metal Coating) and the smallest value was 144 mg/L (PT. Pharmacy). As for non-PROPER industry, the highest value was 3004 mg / L (PT. Textile 6) and the lowest was 640 mg/L (PT. Textile 10). TDS value measures inorganic materials in ion. Conductivity correlates with TDS due to the concentration of ionized dissolved solids in water.

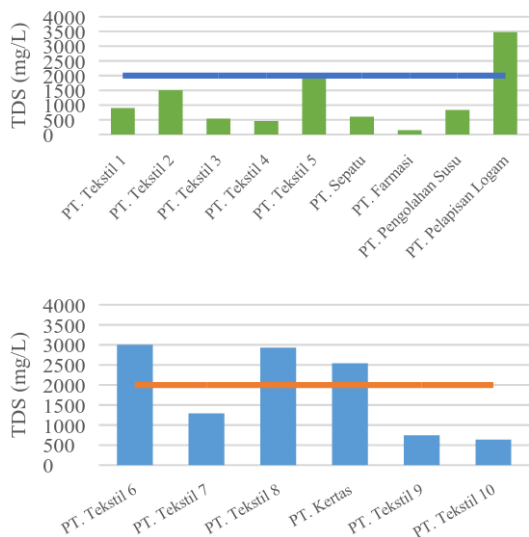


Figure 8 Concentration of TDS wastewater effluent. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.6 Chemical Oxygen Demand (COD)

COD represents the amount of oxygen required to oxidize organic substances contained in water (Boyd, 1990). Figure 9 shows COD value of PROPER industries in 2015-2016 and non-PROPER industries. All PROPER industries in 2015-2016 discharged wastewater with COD content meeting the standards in PermenLKH No. 5/2014, with the highest value of 198.4 (PT. Tekstil 1) and 121.6 mg/L (PT. Tekstil 2) as the lowest. Non-PROPER industries show relatively higher COD with wider range from 320 mg/L (PT. Tekstil 10) to 3840 mg/L (PT. Tekstil 9). Greater amount of COD in wastewater causes DO to decrease, leading to death for test animals (Effendi, 2003).

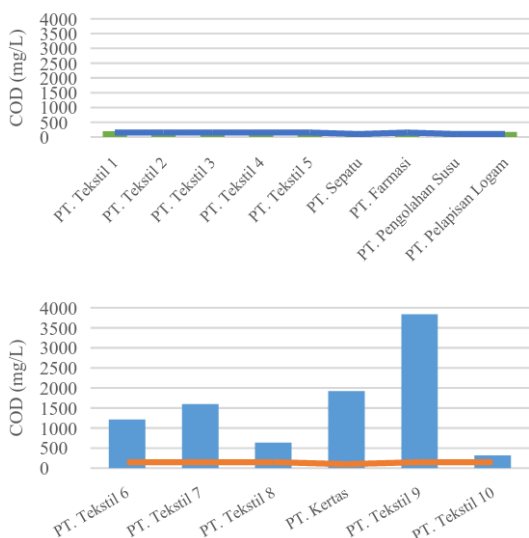


Figure 9 Concentration of COD wastewater effluent. Above: industry participants PROPER 2015 - 2016 and below: industrial non PROPER

3.2.7 Total Hardness

Total hardness of PROPER industries of 2015-2016 and non-PROPER industries (Figure 10), which is the amount of Ca^{2+} and Mg^{2+} ions, was determined by EDTA titration and used cation-sensitive indicators. PROPER industries had the range of 9.34 mg/L $CaCO_3$ (PT. Pharmacy) to 214.21 mg/L $CaCO_3$ (PT. Textiles 1), as for non-PROPER industries from 20.31 mg/L $CaCO_3$ (PT. Tekstil 10) to 253.81 mg/L $CaCO_3$ (PT. Textile 6). Based on the toxicity level, greater hardness of water may limit fish growth while low hardness can increase fish sensitivity to toxic metals.

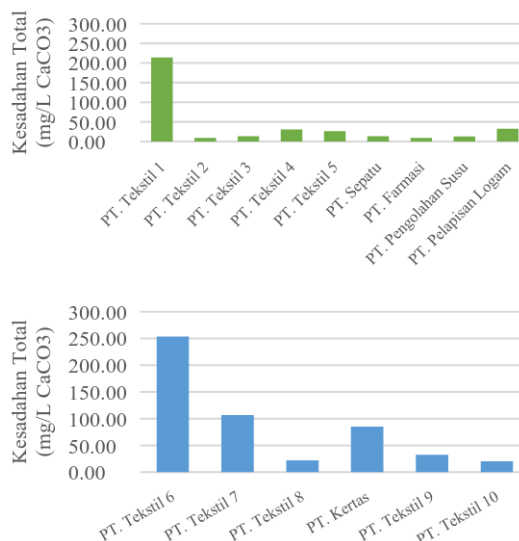


Figure 10 Concentration of Total Hardness wastewater effluent. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.8 Total Alkalinity

The alkalinity is the ability of wastewater to neutralize acid or anion quantity, which neutralizes hydrogen cations. Figure 11 shows that PROPER industries have relatively lower content of total alkalinity compared to non-PROPER industries, ranging from 35 mg/L $CaCO_3$ (PT. Metal Coating) to 970 mg/L $CaCO_3$ (PT. Textile 5). Non-PROPER industries had relatively higher value ranging from 1200 mg/L $CaCO_3$ to 3,700 mg/L $CaCO_3$ (PT. Tekstil 6) and the lowest value of 1,200 mg/L $CaCO_3$. Optimum alkalinity ranges from 90 to 150 mg/L $CaCO_3$, while lower alkalinity is limited to the value of 5 mg/L $CaCO_3$. Aquatic organisms tend to avoid high water with alkalinity, which is also proportional to hardness.

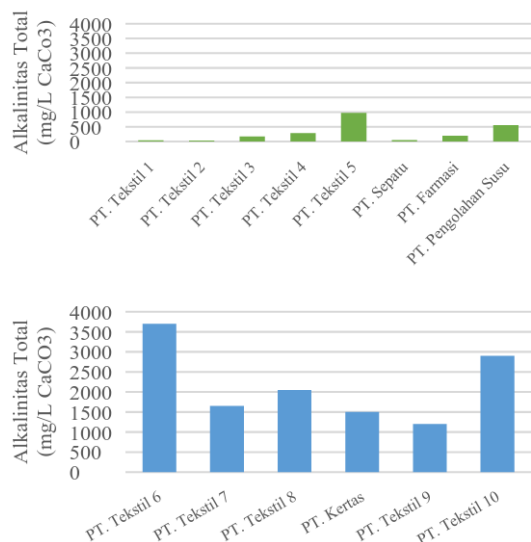


Figure 11 Concentration of Total Alkalinity wastewater effluent. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.9 Ammonium

Figure 12 shows total ammonium in PROPER industries of 2015-2016 and non-PROPER industries, with the highest content reaching 4.06 mg/L (PT. Textiles 1) for PROPER industries of 2015-2016 and 13.64 mg/L (PT. Textile 10) for non-PROPER industries. Lowest value was reaching 1.73 mg/L (PT. Textile 6) for PROPER industries and 4.35 mg/L for non-PROPER. At low concentration, high ammonium content may lead to lower rate of physical development and, accumulatively, death in fish and shrimp (Da Cruz, 2007).

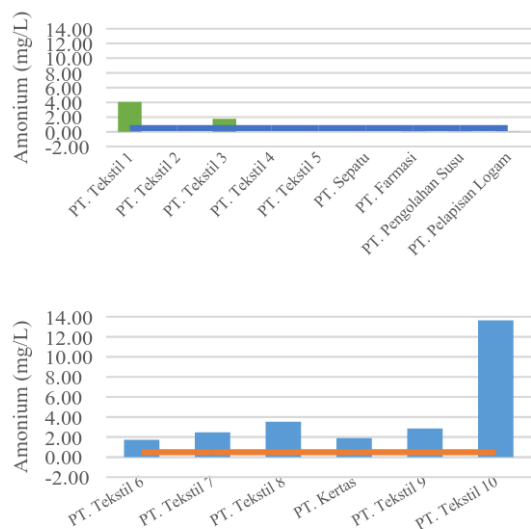


Figure 12 Concentration of Ammonium wastewater effluent. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.2.10 Total Phosphate

Phosphate is major source of potassium and nitrogen that are not soluble in water. Figure 13 shows that PROPER industries of 2015-2016 with the most total phosphate content was reaching 1.25 mg/L (PT. Tekstil 4), while non-PROPER ranged from 2.03 mg/L (PT. Textiles 9 & PT. Paper) to 0.21 mg/L (PT. Textile 8).

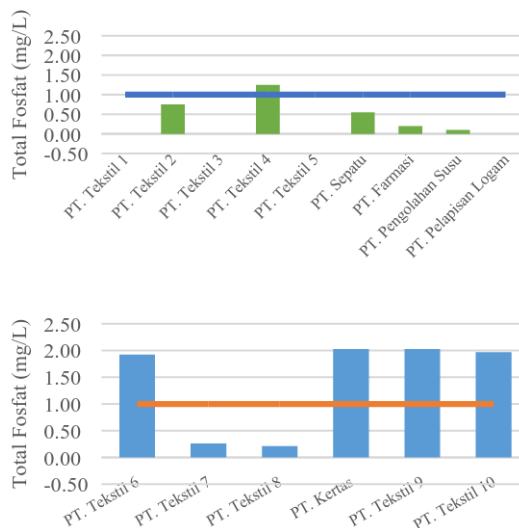


Figure 13 Concentration of Total Phosphate wastewater effluent. Left: PROPER industries 2015 - 2016 and right: non-PROPER industries

3.3 Whole Effluent Toxicity Test: Reference test

During reference test, *Daphnia magna* was exposed with NaCl for 24 hours as control reference. Concentration varied between 5 g/L, 4.8 g/L, 4.6 g/L, 4.4 g/L and 4.2 g/L. Reference test results showed 50% death of *Daphnia magna*, shown in Table 3.

Table 3 LC50 Value of The Reference Test

No.	Date of Reference Test	LC50 Value	Average	Deviation Standard
1	12 June 2016	4,903	4,685	0,584
2	16 July 2016	5,128		
3	16 August 2016	4,023		

Results shows that average LC50 from three reference tests is 4.685, which is close to the value mentioned in literatures, therefore it is adequate to do the WET test.

3.4 Range Finding Test

Results of range finding test (Table 4 and Table 5) shows the average LC₅₀ value from nine industry is 37.50% with the lowest score of 8.652% and the highest of 100%. Values closer to 100% indicates more toxic wastewater. This narrows down new combination of concentration in the definitive test.

Table 4 LC50-48 Hours Test Range Finding for Industry Participants PROPER 2015 - 2016

No.	Name of Industry	LC50 96 hour (%)	Range (%)
1	PT. Textile 1	12,023	6,25 – 12,5
2	PT. Textile 2	22,054	12,5 - 25
3	PT. Metal Coating	46,72	25 - 50
4	PT. Pharmacy	19,347	12,5 - 25
5	PT. Textile 3	10,854	6,25 – 12,5
6	PT. Textile 4	100,916	50 - 110
7	PT. Milk Processing	56,691	50 - 100
8	PT. Shoe	60,222	50 - 100
9	PT. Textile 5	8,652	6,25 – 12,5

Table 5 LC50-48 Hours Test Range Finding. For Industrial Non PROPER

No.	Name of Industry	LC50 96 hour (%)	Range (%)
1	PT. Textile 6	24,152	12,5 - 25
2	PT. Textile 7	34,351	25 - 50
3	PT. Textile 8	20,987	12,5 - 25
4	PT. Paper*	35 x 10 ⁹	
5	PT. Textile 9	43,908	25 - 50
6	PT. Textile 10*	0	

3.5 Definitive Test

Definitive test results were analyzed using probit software. LC₅₀₋₉₆ was obtained from software analysis, then reviewed to find whether there was any link between the value LC50-96 hours with PROPER value criteria. Variations of concentration in this test were obtained from result range on the range finding test, obtained by multiplying R value in Equation 1 with initial value range. Table 6 and Table 7 shows LC₅₀₋₉₆ value in definitive test.

Table 6 Value LC50-96 Hour Definitive test results. For Industry Participants PROPER 2015 - 2016

Name of Industry	LC50 96 hour Definitif Test (%)	TUa	PROPER Value
PT. Tekstil 1	6,357	15,73	Biru
PT. Tekstil 2	13,555	7,377	Biru
PT. Pelapisan Logam	20,567	4,862	Merah
PT. Farmasi	12,967	7,712	Biru*
PT. Tekstil 3	2,719	36,78	Biru
PT. Tekstil 4	88,399	1,131	Biru
PT. Pengolahan Susu	45,097	2,217	Merah*
PT. Sepatu	49,959	2,002	Biru
PT. Tekstil 5	7,585	13,18	Biru

Table 7 Value LC50-96 Hour Definitive test results for Industry Non PROPER

Name of Industry	LC50 96 hour Definitif Test (%)	TUa
PT. Tekstil 6	17,25	5,80
PT. Tekstil 7	9,96	10,04
PT. Tekstil 8	9,05	11,05
PT. Tekstil 9	9,31	10,74

According to Maryland *Department of the Environment* (2012), WET data interprets toxic in samples when generating LC₅₀ or EC₅₀ value less than or equal to 100% effluent concentration. Table 5 shows that LC₅₀₋₉₆ value of all samples from industry wastewater effluent was less than 100%, indicating they are not fit to be discharged.

3.6 Environment Parameter

USEPA (2002) recommends to conduct environmental parameter measurement for pH, temperature, DO and conductivity. These assessment is intended to monitor abrupt environmental changes due to toxicity. The toxicity in this test is measured by using *Daphnia Magna*.

3.6.1 Dissolved oxygen (DO)

Daphnia sp. lives in condition with DO content above 3 mg/l (Ebert, 2005). DO is required for metabolism. Figure 14 shows average value of DO in samples from both PROPER industries of 2015-2016 (ranges between 5.0–7.0) and non-PROPER industries (between 6.0–8.0) are in the optimum range for *Daphnia* to survive.

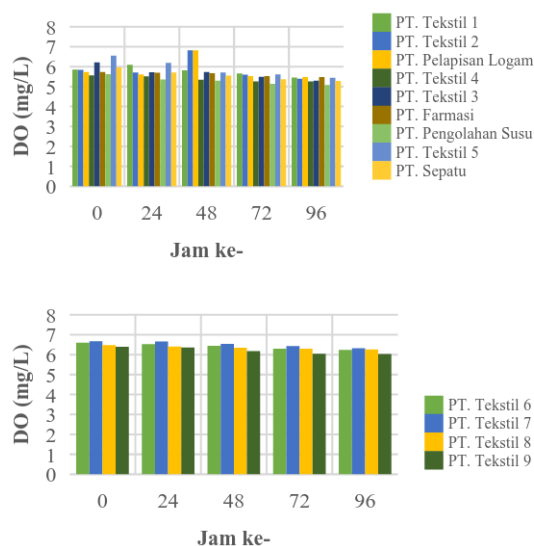


Figure 14 Measurement Parameters DO during test Definitive. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.6.2 Temperature

Optimum temperature ranges from 20-30°C for phytoplankton growth in water environment (Effendi, 2003). Temperature affects organism survival ability, for example algae grows well in the temperature range of 30-35°C and 20-30°C. Room temperature is a right condition for organism to metabolize and reproduce.

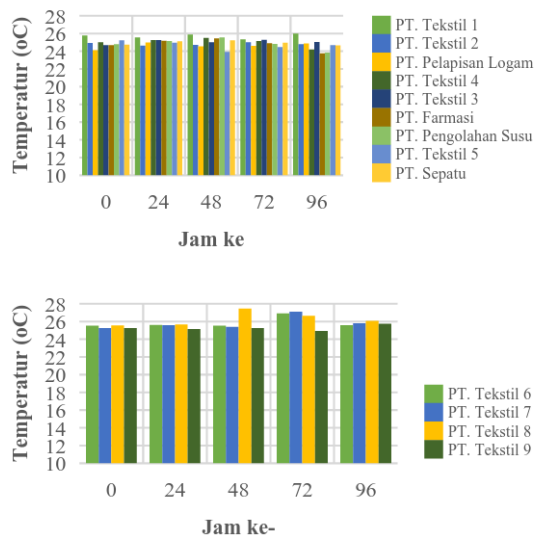


Figure 15 Measurement Parameters Temperature during Test Definitively. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

Figure 15 shows different range among PROPER industries of 2015-2016 (24-26 °C) and non-PROPER industries (24-27 °C), however, both are still among optimum temperature range for *Daphnia sp.* to live. Condition with temperature out of the optimum range will disrupt its growth and development.

3.6.3 Conductivity/Electrical Conductivity (EC)

Conductivity, which is influenced by free ion content such as heavy metal ions released by pollutants in wastewater (Fonridest Environmental, 2014), shown in Figure 16 indicates PT. Metal Coating had the highest EC value amongst all PROPER industries measurements for 48 hour (1000 - 2200 µs/cm). PT. Tekstil 8 excelled amongst all non-PROPER industries (700-900 µs/cm).

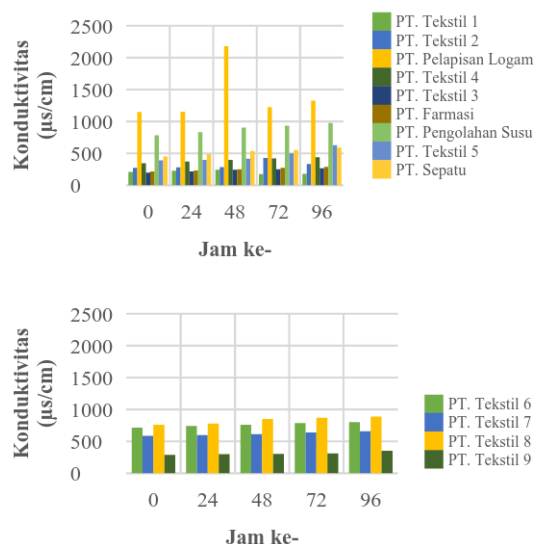


Figure 16 Measurement parameters Conductivity during Definitive Test. Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.6.4 pH

According to Pennak (1989), optimum pH growth for of *Daphnia sp.* ranges from 6.5 to 8.5. Figure 17 shows PT. Milk Processing as the highest pH (in the range of 8.90–9.20) amongst other PROPER industries, which were in the range of 8.0 to 8.7. For non-PROPER industries pH were in the range be 7.5 - 8.5. Both PROPER and non-PROPER industries had pH value in the optimum growth range for *Daphnia sp.*, except for PT. Milk Processing and PT. Tekstil. pH value above or below the optimum range growth may cause death (USEPA, 2002).

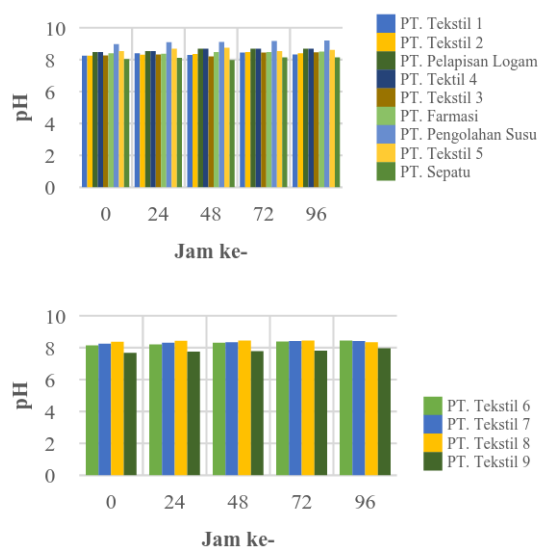


Figure 17 Measurement parameters pH during Definitive Test, Above: PROPER industries 2015 - 2016 and below: non-PROPER industries

3.7 Evaluation of PROPER 2015 – 2016 Criteria Based Value Acute Toxicity and Industrial Wastewater Physical-Chemical Characteristics

The smaller LC₅₀ value points out more toxic properties in the wastewater. Figure 18 shows acute toxicity proportion for blue-category PROPER, indicating LC₅₀₋₉₆ value below 100%. PT. Tekstil 3 had the least LC₅₀ value reaching 2.719%, which had not met reference standard of LC₅₀₋₉₆ value based on Maryland *Department of the Environment* (2012). Based on this result, blue-category PROPER received by industries would not indicate low toxicity level, because toxicity test standards have not been included into indicator of environmental assessments.

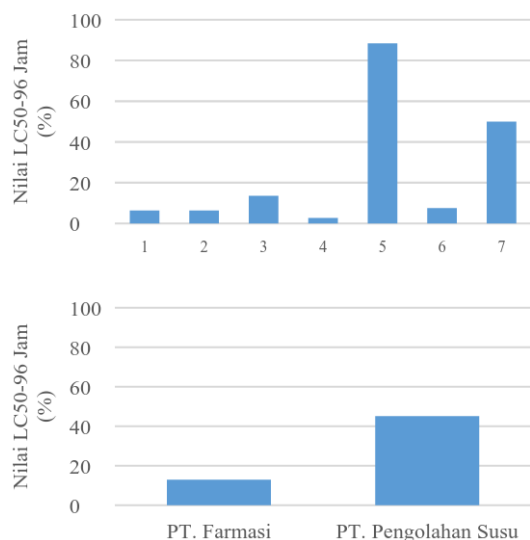


Figure 18 Value Acute Toxicity Criteria LC50-96 hours against PROPER. Left: Industry Participants PROPER and Right: New Participants PROPER Industry 2015 - 2016

Both graphics on Figure 18 contains information on all 9 PROPER industries of 2015-2016 with 2 new industries registered as PROPER industries in 2016 based on their current report, namely PT. Farmasi (blue-category PROPER) and PT. Pengolahan Susu (red-category PROPER). Figure 18 shows lower LC₅₀₋₉₆ value for PT. Farmasi than PT. Pengolahan Susu. Better ranking, such as blue-category PROPER, did not indicate lower toxicity in the wastewater. Different raw material from both industries may be a contributing factor to this condition, considering chemicals is mostly used for PT. Farmasi.

Figure 18 also shows both blue and red category of PROPER have LC₅₀₋₉₆ value less than 100%, pointing out toxicity level of the discharged wastewater. This result draws one example of blue-category PROPER, that have implemented environmental assessment and management as regulated in PermenLHK No. 3/2014, contrarily discharged toxic wastewater. The figure is also drawing red-category PROPER example that also discharged toxic wastewater, despite the undergoing efforts in environmental management. Physical and chemical parameters of environmental monitoring

standards still did not met the standard in PermenLKH No. 5/2014 even as the toxicity tests are ruled out.

4 CONCLUSION

PROPER and non-PROPER industries of 2015-2016 discharged wastewater with some of its parameters exceeding the standard regulated in PermenLKH No. 5/2014. These following physical-chemical parameters in PROPER industries of 2015-2016 wastewater were exceeding the standards regulated in PermenLKH No. 5/2014, namely COD (67% of the industries), TSS (100%), TDS (22%), phenol (78%), ammonium (22%) and phosphate (11%). Several non-PROPER industries of 2015-2016 had parameters exceeding standard as well, namely COD (100% of the industries), TSS (100%), ammonium (100%), phosphate (67%) and TDS (50%).

LC₅₀₋₉₆ value results from Whole Effluent Toxicity (WET) tests shows 100% wastewater from all industries are toxic. PT. Tekstil 3 and PT. Tekstil 8 were the most toxic wastewater with TUA value of 36.78 and 11.05.

Blue-category PROPER industries, which are 78% of all PROPER industries of 2015-2016, still discharged toxic wastewater. Higher rank on PROPER categories did not indicate low toxicity of wastewater.

Several PROPER-registered industries discharged wastewater with parameters exceeding the standard, as regulated in PermenLKH No. 3/2014.

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