

Decreasing Organic Containers in Slaughterhouse with Photocatalyst Method using TiO₂ and UV-C Rays

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Abstract—The slaughterhouse waste generally contains blood, protein, grease and suspended solids which cause the burden of high organic materials that can contaminate the rivers and environment. Therefore, efforts should be made before the waste with this high organic content in order not to pollute the environment. primary and secondary processing has been done to process slaughterhouse waste. AOPs (Advanced Oxidation Process) is one of several alternatives to degrade the organic compounds content in the slaughterhouse waste. In this research, we have tested the ability of TiO₂ photocatalyst to reduce the content of BOD and COD in slaughterhouse waste. The purpose of this research is to get the dosage of probe and the optimum exposure distance in the removal of BOD and COD content in the slaughterhouse waste water. From result of research obtained dose affixing and optimum exposure distance to decrease BOD content that is at dose of affixing 4.5 gram with exposure distance 15 cm at optimum condition is obtained percentage decrease 64%. While at removal of COD content was found optimum condition at dosage of 4.5 gram with exposure distance 25 cm with percentage of decrease 68,2%.

Keywords—RPH; Photocatalyst; TiO₂; BOD; COD

I. INTRODUCTION

The need for meat is increase everyday, slaughterhouses (RPH) as meat providers in practice should pay attention to sanitation-related factors in the RPH environment or the surrounding environment. RPH generally contain a solution of blood, protein, grease and suspended solids which cause the load of high organic material that can contaminate rivers and water bodies [1]. The slaughterhouse waste will cause changes of the colors, pH, total dissolved solids, suspended solids, grease content, BOD₅, ammonium, nitrogen and phosphorus in the water quality [2]. Management efforts need to be done before the waste is polluting the environment. Both primary and secondary treatment have been done to process animal slaughterhouse waste, such as electrocoagulation, flocculation coagulation, aerobic-anaerobic biological treatment, and biofilter utilization. but all the processing is still lacking, it needs further processing so that the waste can reach the quality standard which has been determined. *Advanced Oxidation Process*

(AOPs) is an alternative to degrade organic content contained in RPH liquid waste. AOPS work by forming radical hydroxyl compounds (*OH) which is very reactive. In this study, the advanced oxidation process will be done by photocatalyst method, where the organic compounds in RPH waste will be degraded by semiconductor TiO₂ with the help of UV C rays with variations of dosage and exposure spacing.

The main waste of RPH is liquid waste comes from both small and large scale industry. Waste generated in the form of liquid waste comes from slaughter, removal, and cleaning. The RPH liquid wastewater contains blood, protein, grease and suspended solids, which are contributors to the high organic and nutrient content in RPH waste. The high amount of dissolved organic matter will provide a contaminating effect for rivers or bodies of water [3].

COD is one of the environmental pollution indicator in the water. The presence of COD is influenced by the organic matter content in it. Household and industrial wastes are major contributors for high concentrations of organic matter. COD is the amount of oxygen required to oxidize organic substances contained in the liquid waste. COD is also the amount of oxygen needed to decompose all the organic matter contained in water. BOD is a measure of the amount of oxygen used by microbes contained in the waters as a response of incoming and decomposable organic material [4]. When BOD in high waters then dissolved oxygen in these waters are low, this may affect the survival of the biota present in these waters. The process of oxidation of organic matter takes a relatively long time, this process usually takes 20 days. Determination of BOD for 20 days is considered too long.

BOD can be determined for 5 days, and for those 5 days of incubation period is estimated 70-80% of organic matter undergoes oxidation [5]. Basically, BOD and COD could have the same amount, but BOD cannot be bigger than COD, so COD is a total depiction of the amount of organic material available [6]. So, the COD number is always greater or equal to BOD.

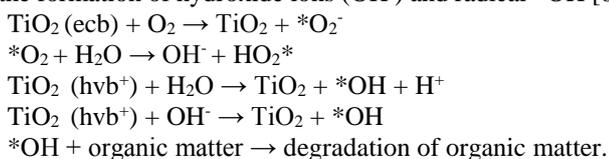
TiO₂ is often used in various types of organic material degradation method, one of them is photocatalysis with the help of UV C rays. Photocatalysts occur when a semiconductor receives photon energy from rays. TiO₂ with anatase crystalline

structure having a gap energy of 3.2 eV when given the photon energy derived from UV rays with a wavelength greater than 3.2 eV then the ray will be able to excite the e-electrons from the valence band to the conduction band, so as to form e⁻ and h⁺ pairs. If the couple absorbs water and dissolved oxygen then the water will be oxidized by a positively charged hole and split into *OH (hydroxyl radical) and H⁺.

Whereas because oxygen is a compound that is easily reduce, the reduction of oxygen by the compound of e⁻ will produce a superoxide anion radical (O₂⁻).

In principle, the oxidation reaction occurs in semiconductors running through electron donation. The greater the oxidation potential possessed by h⁺ in the valence band is therefore good in producing the hydroxyl group. The hydroxyl radical is a strong oxidizer and has a redox potential of 2.8 volts sufficient to oxidize most of the organic material into water and carbon dioxide.

The photodegradation reaction indirectly occurs through the hydroxyl radical (*OH) generated due to the interaction of holes with water or with hydroxyl ions (OH⁻) [7]. Here is the reaction of the formation of hydroxide ions (OH⁻) and radical *OH [8].



II. RESEARCH METHODS

Materials:

- Wastewater of IPAL outlet RPH
- TiO_a catalyst

Tools:

- UV-C 36 watt lamp
- Alumunium Foil
- Photocatalyst reactor

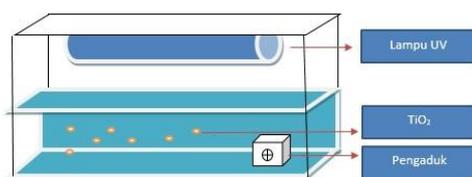
(50 x 15 x 16,7 cm³) = Irradiation distance 10 cm

(50 x 15 x 21,7 cm³) = Irradiation distance 15 cm

(50 x 15 x 26,7 cm³) = Irradiation distance 20 cm

(50 x 15 x 31,7 cm³) = Irradiation distance 25 cm

- Submersible pump (mixer)
- Analytical Scales



Information :

- 5 pieces of reactor made of glass in accordance with the variation of the distance of exposure are 5 cm, 10 cm, 15 cm, 20 cm, 25 cm

- The outside of the reactor is covered with aluminum foil and equipped with 3 mixer at each reactor
- Determined variable were the volume of waste (8 liters), 36 watt UV rays power, and 3 hours of exposure time
- The treatment variables were doses of TiO₂ ie 1.5 gram, 2.5 gram, 3.5 gram, 4.5 gram, 5.5 gram, and a distance 5 cm, 10 cm, 15 cm, 20 cm, dan 25 cm.

A. Research Procedure

Each reactor with variation of exposure distance filled with waste and add TiO₂ catalyst with weight according to variation with exposure time for 3 hours. Then the waste in the reactor is stirred with a mixer. Then after 3 hours sampling is done for analysis of BOD and COD parameters.

III. RESULT AND DISCUSSION

The study about decreasing organic containers in slaughterhouse with photocatalis method using TiO₂ and UV C rays have been done in laboratory scale. The slaughterhouse wastewater used is wastewater from the IPAL outlet of Krian's slaughterhouses, then put in jerry cans. The study was conducted within 5 days considering the parameters in the analysis is organic material so that research should be run immediately. In this study, BOD and COD analyzes on wastewater to known the levels of early BOD and COD. The initial value is the value before it is processed with photocatalis methods along with the quality standards of slaughterhouse wastewater according to Minister of Environment Regulation no 05 Year 2014, that can be seen on table 1.

TABLE I. WASTEWATER INITIAL VALUE OF RPH AND QUALITY STANDARD

Parameter	Initial value (mg/L)	Quality standards (mg/L)
BOD	385,4	100
COD	1283,84	200

(Source: Laboratory Analysis, 2018)

Slaughterhouse wastewater taken from IPAL outlet then processed using TiO₂ photocatalyst method that has been done in Environmental Engineering Research Laboratory with two variations of treatment, e the distance of exposure 5 cm, 10 cm, 15 cm, 20 cm and 25 cm, with a 36 watt UV C rays and a dose of TiO₂, 1,5 gram, 2,5 gram, 3,5 gram, 4,5 gram and 5,5, gram, to obtain the ability to eliminate the content of BOD and COD.

A. Acidity (pH)

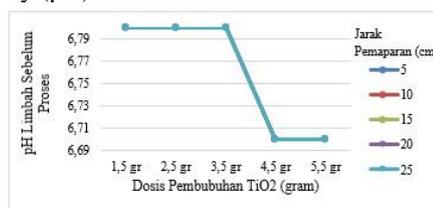


Fig 1. Influence of dosage probe and exposure distance to pH of wastewater before process

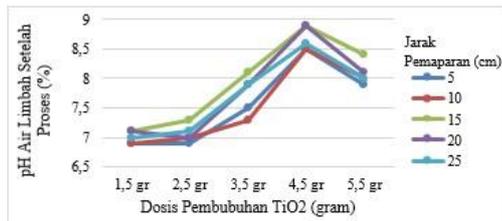


Fig 2. Influence of dosage probe and exposure distance to pH of wastewater after process

Figure 2 illustrates that in the process of TiO_2 photocatalyst there is a rise in pH in line with the addition of the dose of affixing and exposure distance, this is because the photocatalyst is essentially a process in which the reaction produces hydroxyl radicals $\cdot OH$ as the main ingredient used to degrade organic matter in wastewater, so it is expected that the photocatalyst process will produce as much as hydroxyl radical possible. However, when the largest dose of pH of waste water decreases are reversible. According to the theory of arrhenius the compound is alkaline if the solution releases hydroxide ions (OH^-), whereas according to Bronsted-Lowry theory a positively, negative or neutral substance including base if it has a free electron pair which can bind to the H atom, ie $NH_3, CO_3,$ and OH^- . The photocatalyst itself produces OH^- at the time of reaction that occurs in the conduction band of e^- [9]. The alkaline atmosphere is due to much of OH^- resulting from superoxide radion anion reactions that react with anchored water molecule [8]. So the more likely the photodegradation occurs the more alkaline the wastewater conditions.

At a dose of 4.5 grams of photodegradation that occurs greater than the dose of 5.5 grams of affixing. This is because at the dose of 5.5 grams of the solution is too thick so that block the incoming rays, making the photocatalyst process less efficient [10].

B. Influence of Dosage of TiO_2 and Exposure at COD Waste Water Supply

TABLE II. EFFECT OF DOSE OF TiO_2 AND EXPOSURE DISTANCE ON TiO_2 PHOTOCATALYST PROCESS IN COD REMOVAL PERCENTAGE

Exposure distance (cm)	COD removal percentage (%)				
	Dose of TiO_2 (gr)				
	1,5	2,5	3,5	4,5	5,5
5	23,5	36,8	41,2	49,2	49,2
10	35,3	38,2	47,1	61,9	55,5
15	41,2	47,1	58,8	68,2	61,9
20	17,6	25,0	29,4	42,8	42,8
25	11,8	22,1	23,5	30,1	23,7

(Source: Laboratory Analysis, 2018)

Table 2 shows the results of COD content removal by photocatalyst method TiO_2 and 36 watt UV rays on variation of exposure distance and dose of TiO_2 . The highest COD content removal at the dose affixed TiO_2 4.5 gram with the distance of 15 cm exposure that is equal to 68,2% from the initial COD content. While for the lowest COD content removal occurred at dose 1.5 gram with 25 cm exposure of 11.8% of the initial COD. This is shown in Figure 3 of the relationship between

the dose of TiO_2 with exposure distance to the removal of COD content in the slaughterhouse waste as follows.

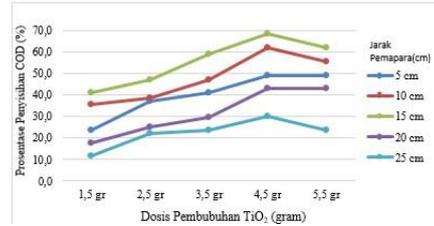


Fig 3. Percentage of COD removal with Photocatalyst of TiO_2 to dose of probe and exposure distance

COD value is one of the parameters that indicates the pollutant load of a waste. COD is the amount of oxygen required to oxidize all types of organic matter contained in wastewater which means the amount of oxygen that is chemically calculated to oxidize all organic matter in the waste water. The value of BOD are influenced by the small amount of organic material present in the waste water. The higher the organic matter also make COD value higher, and vice versa.

Figure 3 explains that the removal ability of COD content is increasing until the optimum dose of 4.5 gram at 15 cm exposure in 3 hours with 36 watt UV light, which is 68.2% of the initial COD content. However, at the dose of 5.5 gram of provision the percentage of allowance decreased compared to the dose of affixing 4.5 grams. This occurs because the addition of dosage of 5.5 gram causes the solution is very thick so that cause turbidity in waste water. Increased turbidity will lead to blocked penetration of UV rays into all parts of the solution which makes the production of holes (h^+) or electron (e^-) pair decrease and result in decreased efficiency of degradability [3]. The degradation ability of the photocatalyst is influenced by the large absorption of photon energy absorbed by the catalyst to execute electrons from the valence band to the conduction band. The condition that causes a positive hole or hole + is more and more, the hole + which then reacts with H_2O or hydroxyl ions form a hydroxyl radical which is then used to break down organic compounds in wastewater [11].

Photocatalyst treatment at 15 cm exposure spacing with a dose of 4.5 grams proved to be effective in degrading COD content in wastewater. Compared with 5 cm, 10 cm, 20 cm, and 25 cm, exposure spacing, the 15 cm exposure spacing is the most suitable exposure range to degrade COD content in wastewater with a variation of 1.5 grams, 2.5 grams, 3.5 grams, 4.5 grams and 5.5 grams. At the highest exposure exposure distance of 5 cm the percentage degradation of COD content tends to decrease, this is because the solid TiO_2 in the suspension causes a lot of UV light that is reflected or not absorbed. Given the maximum intensity of irradiation is not always effective for each treatment, there is an effective time and the need for appropriate irradiation distance in order for the photocatalyst to be effective in generating free radicals [12]. At 25 cm spacing also decreases on the graph, the same cause at the maximum intensity of 5 cm, requires appropriate irradiation in the production of free radicals, so that at a distance of 25 cm the photons that can be received by the catalyst on the reactor lips tend to be less.

C. Influence of Dosage of TiO₂ and Exposure at BOD Waste Water Supply

TABLE III. EFFECT OF DOSE OF TIO₂ AND EXPOSURE DISTANCE ON TIO₂ PHOTOCATALYST PROCESS IN BOD REMOVAL PERCENTAGE

Exposure distance (cm)	BOD removal percentage (%)				
	Dose of TiO ₂ (gr)				
	1,5	2,5	3,5	4,5	5,5
5	15,3	13,7	57,6	62,6	54,8
10	26,7	25,7	54,4	63,4	44,8
15	17,5	18,5	50,3	60,0	59,4
20	28,2	32,7	57,4	61,7	59,0
25	35,9	34,8	57,8	64,0	63,5

(Source : Laboratory Analysis, 2018)

Table 3 shows the results of COD content removal with TiO₂ photocatalyst using 36 watt UV lamp and 3 hours exposure time with variation of dosing and exposure spacing. In Table 3 the highest decrease of BOD content was found at variation of 4.5 gram with 25 cm exposure at 64% from the initial BOD content, whereas the lowest decrease of BOD was occurred at 2.5 gram variation with 5 cm exposure, ie 13, 7% of baseline BOD content. The following is the relationship of dose affixing with the distance of exposure to the removal percentage decrease in BOD content.

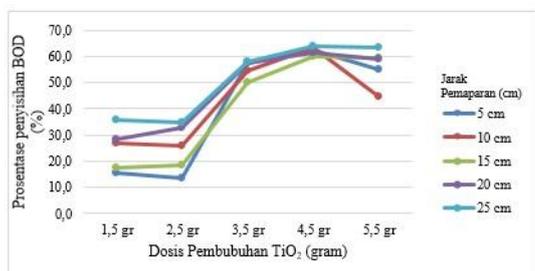


Fig 4. Percentage of BOD removal with Photocatalyst of TiO₂ to dose of probe and exposure distance

The BOD value indicates the amount of oxygen needed by microorganisms to decompose dissolved organic matter and some of the organic matter suspended in water. BOD is also a common parameter used to determine the pollutant load contained in waste water. The amount of BOD value in wastewater is determined by the composition of organic content that is biodegradable. Air limbah yang mengandung bahan organik *biodegradable* akan menghasilkan nilai BOD yang lebih tinggi. In Figure 4 shows that the more doses of added additions the higher BOD content removal is at 4, 5 gram. However, at the added dose of 5,5 grams, this is due to the excessive amount of TiO₂ catalysts in the suspension in the reactor causing blocking of incoming rays, resulting in absorption of rays by imperfect catalysts [10].

Radiation with a distance of 25 cm in BOD removal is most effective in decreasing biodegradable organic content, this is because in the allowance of BOD, decomposers also help in the process of degradation of organic matter. Due to the presence of UV rays that have antimicrobial power, the intensity

of UV light is very influential in decreasing the amount of microbes contained in the waste water, so the closer the UV lamp to the solution, the microbes will diminish [8]. This causes the best BOD content removal to occur at the farthest exposure distance of 25 cm.

At first COD and BOD found a difference in terms of its analysis. In the COD analysis, the sample was reacted with potassium iodide to be further titrated using potassium dichromate. While the BOD was measured by incubating at room temperature for five days, to then reacted with MnO₂ and then titrated with TiO sulfate. In the BOD analysis only biodegradable organic material types are detected, whereas in COD analysis all types of organic matter are detected, there is also a possibility of biodegradable organic material. This also causes the optimum distance difference in COD and BOD analysis. At a distance of 25 cm exposure of decomposing organic matter is a type of biodegradable organic material, while at a distance of 15 cm exposure and the intensity of the rising rays then all types of nonbiodegradable or biodegradable organic materials decompose.

IV. CONCLUSION

Based from the results of research and discussion conducted, then got the following conclusion:

1. Based on experiments that have been done, it can be concluded that the optimum dosage of TiO₂ in the removal of BOD and COD is 4.5 gram, the efficiency of removal is increased when the addition of TiO₂ dose to reach optimum is 4.5 gram, after exceeding the dose the allowance will decrease due to increased turbidity inhibiting the entry of UV rays to all parts of the solution. At the exposure range, the optimum exposure range at COD removal was 15 cm, while the BOD removal was 25 cm. This occurred because in the COD removal, the organic material can only be degraded nonbiodegradable, thus requiring sufficient light intensity to produce the oxidant compound. While at BOD removal, the degradable organic material which is microorganisms also participate in helping decomposition, so the intensity and distance of UV is very influential.
2. Photocatalyst TiO₂ as a natural oxidizer capable of removing BOD and COD levels in slaughterhouse wastewater. Initial BOD and COD in wastewater were 385,4 mg/L and 1283,84 mg/L, after the photocatalytic process of TiO₂ BOD and COD decreased to 138,7 mg / L and 408, however still did not meet the established quality standard (100 mg/L for BOD and 200 mg/L for CO).

V. RECOMMENDATION

Based on the conclusion of the above research, the suggestion that can be submitted for further research:

1. Further development of factors affecting the performance of photocatalyst such as exposure time, lamp power intensity, etc.

2. Using other agitators more effectively in order to make homogeneous wastewater conditions with semiconductor catalysts, such as magnetic stirrers.
3. Using RPH waste taken prior to IPAL slaughterhouses to find out how far the ability of TiO₂ photocatalyst in degrading the organic content of RPH waste.
4. More variations of TiO₂ photocatalysts such as pH settings and sampling time settings are required.

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