

Organic disinfectant using coconut shell liquid smoke in the chicken slaughterhouse wastewater treatment plant

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Abstract. Wastewater treatment in Chicken Slaughterhouse is absolutely necessary because it has a very positive impact on environmental preservation and helps remove pathogenic organisms in wastewater before being discharged into the environment. Currently, wastewater treatment still uses chlorine as a disinfectant. However, chlorine has a bad effect on the environment, the purpose of this research is to use an alternative organic material that functions as a disinfectant as coconut shell liquid smoke. This study also observe the effect of using liquid smoke on the value of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) on the output of wastewater.. This experimental research method uses a chemical method by taking samples of wastewater and adding two different doses of liquid smoke and testing for BOD and COD values. With a dose of 0.5% can reduce the COD value by 35% but increase the BOD value by 234%, and a dose of 1% it increases the BOD value by 195% and increases the COD value by 170%. This will allow for further research with the appropriate dosage to understand its relationship to water quality and its connection to environmental sustainability.

1 Introduction

The need for food consumption in today's society continues to increase, one example is the need for chicken meat. One of the fastest growing livestock sectors is poultry, especially in developing countries. Market demand, population growth, income, and urbanization are expected to increase annual poultry production to 37 billion by 2050 [1], [2]. A large portion of the final product's supply chain, which includes the activities of feed manufacturing, poultry farming, packing plants, and product distribution to retailers, is handled by this industry. Because it can kill 13,000 birds per day, it is regarded as medium-sized when it comes to animal confinement and large-sized when it comes to slaughter [3]. This encourages entrepreneurs to create a Chicken Slaughterhouse. This is a very good thing to do because with the construction of this Chicken Slaughterhouse the government and the community can better control the standardization of the chicken slaughter process and monitoring wastewater.

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However, if the slaughtering process is carried out in traditional markets or in mobile chicken traders, it will be difficult to control hygienic, halal and chicken slaughtering waste in the form of feather blood and other solids which if disposed of directly will pollute the environment [4]. Wastewater generated at the Chicken Slaughterhouse, among others, comes from the the process of slaughtering chickens that produces chicken blood waste and drain water from the process of dipping the chicken into hot water and the process of wetting the chicken in the feather removal process. Also from discharge water from the process of taking chicken innards and washing them. Discharge water from washing equipment, floors, walls, and runoff water from domestic waste. The process of wastewater treatment in chicken slaughterhouses uses a biological system that uses bacteria to treat waste. The stages of organic wastewater treatment are grease trap, equalization, pre-settling tank, anaerobic, aerobics, final settling tank, and disinfectant tank.

Disinfectant commonly used in swimming pool and in effluent of wastewater treatment plant is calcium hypochlorite $\{Ca(OCl)_2\}$. Calcium hypochlorite is disinfectant which is used in the cleaning of water due to a searchable, inexpensive and contain approximately 70% chlorine [5]. However, if used in improper amounts, it will produce toxic and hazardous Trihalomethane (THMs), haloacetic acids (HAAs), halogenated acetonitriles (HANs), and other compounds that may be harmful to human health [6], [7]. The risks of disinfection byproduct (DBP) generation were evaluated in a case study of 15 wastewater treatment facilities (WWTPs), with a focus on the recently regulated inorganic byproduct in the EU, chlorate and the haloacetic acids (HAAs) and trihalomethanes (THMs) [8]. The research showed that the coliform bacteria content in the wastewater of Tugurejo General Hospital, Semarang, and "X" Hospital in Samarinda decreased after the administration of different doses of chlorine [6], [9]. Demonstrating that the coliform bacteria in the wastewater had been eliminated or killed after the varying doses of chlorine were applied.

Coconut shell liquid smoke is a product from the condensation process of smoke originating from the coconut shell combustion process in the pyrolysis tank [10]. The compounds contained in the liquid often are phenolic compounds, carbonyl and other organic acids that play an important role in the organic disinfection process. Liquid smoke is an organic antibacterial which is related to phenolic compounds and acetic acid. Phenol compounds can damage the cytoplasmic membrane, causing the membrane to leak which will interfere with the growth of bacteria, and can even cause the death of bacteria. While acetic acid compounds have an important role as anti-bacterial because acetic acid can destabilize the function and structure of cell components in bacteria [11]. Testing of the chemical components of crude liquid smoke and redistillate includes phenol and carbonyl levels, both of which use a Shimadzu 1601 UV-Vis spectrophotometer and acidity using the titration method [12], [13], [14]. In general, coconut shell liquid smoke has a strong/sharp, sour aroma, smells like burnt, resembles the smell of disinfectant, or smells like medicine [15], [16], [17]. Various raw materials have been used for the production of liquid smoke, including organic waste, coconut shells, palm oil, palm oil shells, empty palm oil bunches, palm oil stalks, pelawan wood, and pine sawdust [18], [19]. Coconut shells can be made into liquid smoke which has antioxidant and antibacterial activity [18], [20], [21].

According to research, liquid smoke formed from the pyrolysis of biomass such as coconut shells does not leave dangerous chemical residues in the environment, as opposed to chlorine, which can produce byproducts such as Trihalomethanes (THMs) and Chloramines. These chlorine byproducts have long-term environmental and health implications, including water contamination and harmful impacts on aquatic life. The natural breakdown of organic chemicals in liquid smoke, such as phenolics and acids, allows it to be absorbed or decomposed without inflicting long-term damage to ecosystems. This aligns with sustainable waste management practices as the production of liquid smoke from coconut shells utilizes agricultural waste, making the process resource-efficient and reducing environmental impact

[21], [22], [23]. Using coconut shell liquid smoke as a replacement for chlorine in wastewater treatment offers significant environmental benefits. One of the primary advantages is the reduction of chemical pollution. Liquid smoke, derived through pyrolysis of coconut shells, contains natural compounds like phenols and acids, which have antimicrobial properties, making it an effective disinfectant. [24].

Coconut shells, a byproduct of coconut agriculture, are abundant in tropical regions and provide a sustainable raw material for liquid smoke production through pyrolysis. This process turns waste into a valuable product, reducing reliance on synthetic chemicals like chlorine-based disinfectants. The sustainable sourcing of coconut shells highlights their role in promoting a circular economy and reducing environmental impacts linked to waste disposal [25], [26]. Moreover Chlorine-based disinfectants have been shown to cause oxidative stress and damage to submerged macrophytes, affecting their photosynthetic systems and leading to ecological harm. This includes changes in the plants' antioxidant responses and metabolic processes, which negatively affect growth and ecosystem health. In contrast, liquid smoke, derived from natural sources like coconut shells, is biodegradable and poses fewer risks to sensitive aquatic environments, making it a more sustainable alternative for reducing chemical pollution in water bodies. [27], [28], [29].

The aim of this research is to compare the BOD, COD, TSS, and pH values with the addition of chlorine and coconut shell liquid smoke. If the BOD, COD, TSS, and pH values do not show a significant increase or decrease and meet the liquid waste quality standards required by the government, then coconut shell liquid smoke can be used as an organic disinfectant to replace chlorine. From the BOD, COD, and TSS data, the correct dosage for the use of coconut shell liquid smoke as an organic disinfectant can be determined. This will allow for further research with the appropriate dosage to understand its relationship to water quality and its connection to environmental sustainability.

2 Material and methods

2.1 Tools and materials

The materials used are sample of liquid waste from wastewater of Chicken Slaughterhouse as much as 20 liters, five grams of chlorine powder 60%, 75 ml of coconut shell liquid smoke, and 1 liter of clean water. The tools used are 14 liter capacity plastic bucket, 20 liter plastic jerry can for sampling, five liter plastic jerry can to send sample results of the experiment, and Measuring cup. Also agitator or mixer to mix test fluids.

2.2 Methods of preparation

The first steps of this research are take a sample of wastewater at the Chicken Slaughterhouse Wastewater Treatment Plant from the final settling tank as much as 20 liters, then separate five liters of liquid waste and put it in a five liter jerry can to be tested for BOD, COD, TSS and pH values which serve as the basis for quality standard values and we name it Waste Sample 1. Five grams of 60% chlorine powder dissolved in 250 ml of clean water, then mix it with 4.75 liters of waste sample and stir with an agitator or mixer for five minutes. We put it in a five liter jerry can to test the value of BOD, COD, TSS, pH and Free Chlor which serves as an observation with the addition of chlorine and we name it Waste Sample 2. Then 50 ml of coconut shell liquid smoke dissolved with five liters of waste sample and stir with an agitator or mixer for five minutes. Put it in a five liter jerry can to test the BOD, COD, TSS and pH values which serve as observations with the addition of coconut shell liquid smoke at a dose of 1% and we name it Waste Sample 3. For test use coconut shell liquid

smoke, 25 ml of coconut shell liquid smoke dissolved with five liters of waste sample and stir with an agitator or mixer for five minutes. We put it in a five liters jerry can to test the BOD, COD, TSS and pH values which serve as observations by adding coconut shell liquid smoke at a dose of 0.5% and we name it Waste Sample 4. Then test the value of the liquid waste quality standard in the laboratory and make observations on the results.

3 Result and Discussion

From the test results to the four samples above, the results obtained are as follows:

Table 1. Value of BOD, COD, TSS, and pH in wastewater test results

Parameter	Unit	Result	Test Method
BOD ₅	mg/L	<20.3	APHA,5210-B 2017
COD	mg/L	212.2	SNI 6989-73:2019
TSS	mg/L	<17.90	SNI 6989-3:2019
pH	-	6.74	SNI 6989.11:2019

The table above shows the test results of untreated wastewater as the baseline for comparison.

Table 2. Value of BOD, COD, TSS, and pH in wastewater test results mixed with 1% chlorine

Parameter	Unit	Result	Test Method
BOD ₅	mg/L	<20.3	APHA,5210-B 2017
COD	mg/L	29.5	SNI 6989-73:2019
TSS	mg/L	<17.90	SNI 6989-3:2019
Free Cl ₂	mg/L	<0.05	G-LAB/IK/17
pH	-	7,50	SNI 6989.11:2019

The table above shows the test results of wastewater with the addition of 1% chlorine as a comparison value for the increase in BOD, COD, TSS, and pH.

Table 3. Value of BOD, COD, TSS, and pH in wastewater test results mixed with 1% coconut shell liquid smoke

Parameter	Unit	Result	Test Method
BOD ₅	mg/L	39.5	APHA,5210-B 2017
COD	mg/L	360.7	SNI 6989-73:2019
TSS	mg/L	<17.90	SNI 6989-3:2019
pH	-	6.98	SNI 6989.11:2019

The table above shows the test results of wastewater with the addition of 1% liquid smoke as a comparison value for the increase in BOD, COD, TSS, and pH, compared to the results of tests without any treatment and with the addition of 1% chlorine.

Table 4. Value of BOD, COD, TSS, and pH in wastewater test results mixed with 0,5% coconut shell liquid smoke

Parameter	Unit	Result	Test Method
BOD ₅	mg/L	47.4	APHA,5210-B 2017
COD	mg/L	137.9	SNI 6989-73:2019
TSS	mg/L	<17.90	SNI 6989-3:2019
pH	-	7.12	SNI 6989.11:2019

The table above shows the test results of wastewater with the addition of 0.5% liquid smoke as a comparison value for the increase in BOD, COD, TSS, and pH, compared to the test results without any treatment, with the addition of 1% chlorine, and with the addition of 1% liquid smoke.

To strengthen the data that coconut shell liquid smoke is an organic disinfectant, tests were conducted on raw water suspected of being contaminated by *E. coli* bacteria, primarily from animal waste. From the data of raw water testing and raw water mixed with 0.3% coconut shell liquid smoke in the laboratory, a reduction in *E. coli* from 79 MPN/100mL to 0 MPN/100mL was observed using the APHA test method, 9221.E:2012. Wastewater Quality Standards set by the government through the East Java Government No. 22 of 2012 are as follows:

Table 5. Liquid waste quality east java government standart

Parameter	Maximum Value (mg/L)
BOD ₅	100
COD	200
TSS	100
pH	6 to 9

Based on the results in the laboratory test result data table above, we can compare the differences in each test result according to the BOD, COD, TSS, and pH comparisons of each test result.

3.1 Comparison of BOD value

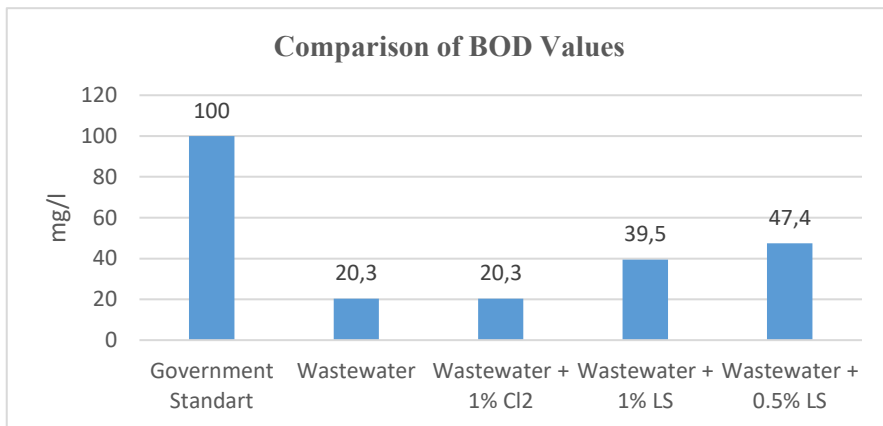


Figure 1. Comparison of BOD Value Chart

From the graphic data above, we can observe that the wastewater and the addition of 1% of chlorine to five liters of sample wastewater did not show an increase in the BOD value. While in sample 2 which used coconut shell liquid smoke with a dose of 1%, it showed an increase in the BOD value from 20.3 ppm to 39.5 ppm, which was 94%. In sample 3 which used coconut shell liquid smoke with a dose of 0.5%, it showed an increase in the BOD value from 20.3 ppm to 47.4 ppm, which was 133%. The addition of 1% chlorine, 1% liquid smoke, and 0.5% liquid smoke to wastewater still meets the government's quality standards.

3.2 Comparison COD value

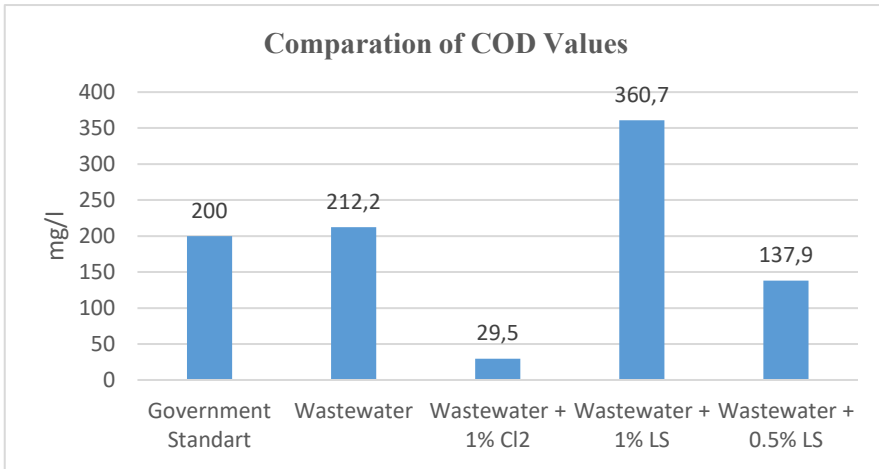


Figure 2. Comparison of COD Value Chart

From the graphic data above, we can observe that the wastewater and the addition of 1% of chlorine to five liters of sample wastewater shows a decrease in the COD value from 212.2 ppm to 29.5 ppm, which is 86%. While in sample 2 which used coconut shell liquid smoke with a dose of 1%, it showed an increase in the COD value from 212.2 ppm to 360.7 ppm, which was 70%. In sample 3 which used coconut shell liquid smoke with a dose of 0.5%, the COD value decreased from 212.2 ppm to 137.9 ppm, which was 35%. The COD test results on wastewater show values slightly above the government standards. The addition of chlorine and 0.5% liquid smoke can reduce the COD value to meet the government's quality standards. However, the addition of 1% liquid smoke increases the COD value, making it not meet the government standards.

3.3 Comparison TSS value

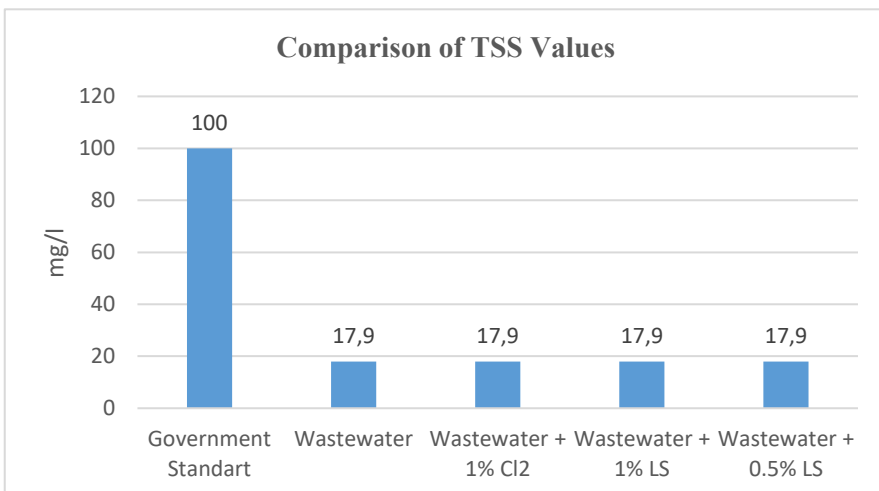


Figure 3. Comparison of TSS Value Chart

From the graphic data above, we can observe that the test results did not show a change in the TSS value because the TSS value was strongly influenced by the sedimentation and filtration system. All the TSS test results are below the government quality standards.

3.4 Comparison pH Value

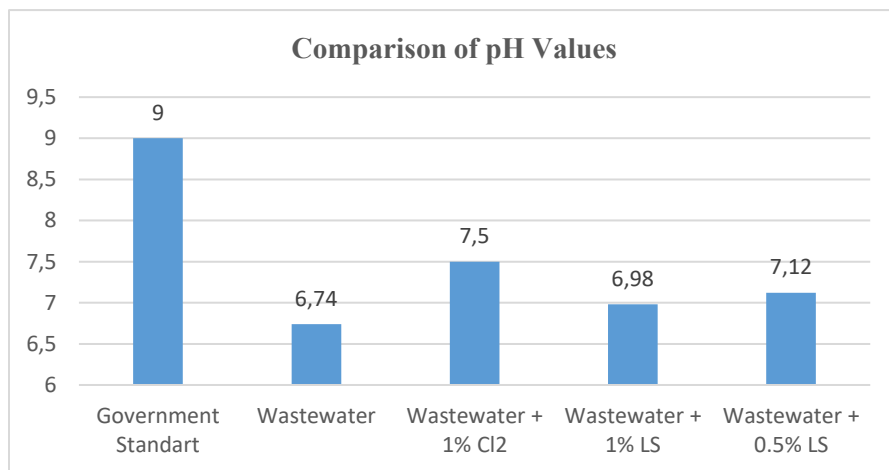


Figure 4. Comparison of pH Value Chart

From the graphic data above, we can observe that in wastewater and the addition of 1% of chlorine to 5 liters of sample wastewater, it shows an increase in the pH value from 6.74 to 7.5, which is 12% towards alkaline. While in sample 2 which used coconut shell liquid smoke with a dose of 1%, it showed an increase in the pH value from 6.74 ppm to 6.98 ppm, which was 3% towards alkaline. In sample 3 which used coconut shell liquid smoke with a dose of 0.5%, it showed an increase in the pH value from 6.74 ppm to 7.12 ppm, which was 6% towards alkaline. All the TSS test results are below the government quality standards 6 to 9.

Based on the results of testing the addition of chlorine and liquid smoke in the wastewater treatment process, the addition of chlorine at a dose of 1% with a resulting free Cl₂ < 0.05 mg/L can reduce COD values but does not affect BOD, TSS, and pH values. In contrast, the addition of liquid smoke at doses of 0.5% and 1% significantly increases BOD values compared to the addition of chlorine but decreases pH values, while TSS values remain unaffected. This is because the addition of liquid smoke increases the amount of organic compounds available for microorganisms in the wastewater, resulting in increased oxygen consumption for the decomposition process, thereby raising BOD values. The addition of liquid smoke at doses of 0.5% and 1% also increases COD values compared to the addition of chlorine but decreases pH values, while TSS values remain unaffected. This is because liquid smoke increases the quantity and complexity of organic compounds in the wastewater, which in turn increases the amount of oxygen required for the total chemical oxidation of all these organic substances, thereby increasing COD values. TSS value did not change because to reduce TSS requires a filtration system process aimed at filtering particles to lower the suspended solid content in the wastewater.

4 Conclusion

Coconut shell liquid smoke can be used as an organic disinfectant but it will make BOD quality standard value will increase between 94% - 133%. And COD quality standard value will increase by 74% at a dose of 1% and a decrease in the COD quality standard value by 35% at a dose of 0.5%. Chlorine can be used as a disinfectant and also can reduce the value of BOD and COD quality standards, with the proper dosage to avoid negative effect. The value of TSS quality standard and pH did not have a significant change in the value. Coconut shell liquid smoke can be used as an organic disinfectant to replace chlorine. However, if the BOD and COD values show a significant increase or decrease relative to the wastewater quality standards required by the government, this research should be continued with a variety of samples and more diverse doses.

The usage of liquid smoke made from coconut shells is a part of a global movement to replace synthetic chemicals with natural, environmentally friendly materials. To maximize liquid smoke's effectiveness in different waste processing scenarios and guarantee its safety in large-scale industrial applications, more study is required. Industries need to be persuaded of the efficacy, affordability, and environmental advantages of liquid smoke before it is extensively used as a chlorine alternative.

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