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Implementation a combination of bio-desulfurization and trickling filtration technologies with a variety of coconut shell charcoal filter media in reducing the content of H_2S and TSS in the leather-based clothing industry

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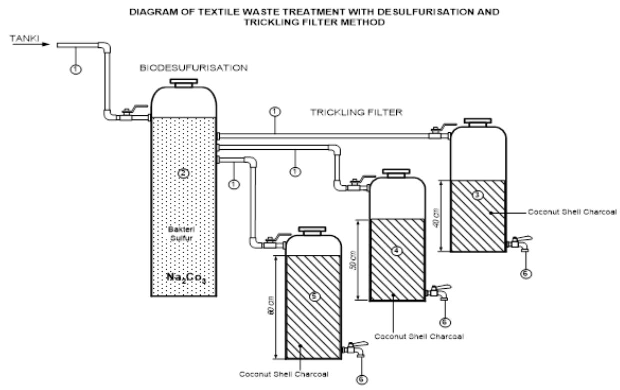
Graphical abstract



Abstract

Waste generated as a result of the leather processing industry can be in the form of solid, liquid and gas waste. Waste generated from the textile industry made from clothing H_2S and TSS which if not treated properly, will be very dangerous for health and the environment. One of the efforts to overcome this problem, is offered in the form of a simple, inexpensive and efficient H_2S and TSS waste treatment technology, namely by using a combination of bio-desulfurization and trickling filtration methods as a means of treating liquid waste in the leather-based textile industry, especially for parameters, H_2S and TSS. Bio-desulfurization is a sulfur removal process by utilizing the metabolism of microorganisms, namely by converting hydrogen sulfide into elementary sulfur, and trickling wastewater filtration is a treatment process by spreading wastewater into a pile or media bed consisting of Coconut Shell Charcoal to reduce H_2S and TSS content in leather-based clothing industry wastewater. The results of the study for H_2S parameters in wastewater treated in bio desulfurization reactor and trickling filter with Coconut Shell Charcoal filtering media, the biggest decrease was in filter media with a thickness of 60 cm with a contact time of 30 minutes of 4.43 mg/lt or 88.84%. Likewise, the largest decrease in TSS parameter content was found in a 60 cm filter media thickness with a contact time of 30 minutes of 47.67 mg/lt or 82.54%.

Keywords: Bio-desulfurization, trickling filter, coconut shell charcoal, H_2S and TSS

1. Introduction

The leather industry includes the leather tanning industry, the shoe/padding industry, and the leather goods industry. Waste generated as a result of the leather processing industry can be in the form of solid, liquid, and gas waste. Some of these wastes are generated from the effects during the tanning process stage, there is also waste generated after the leather tanning process is complete. Especially for the waste generated as a result of the tanning process, it will produce different kinds of waste and its composition.

One of the wastes generated from the leather-based textile industry is H_2S and NH_3 as a result of the unavailability of dissolved oxygen, so that the atmosphere will become aerobic and result in decomposition of organic matter with gases that produce a very pungent smell. Hydrogen Sulfide (H_2S) gas is a colorless gas, smells like rotten eggs, is toxic, corrosive and can cause irritation. Dissolved organic matter can deplete oxygen in sewage and will cause unpleasant tastes and odors in the supply of clean water. The soil environment that is used as a place for waste disposal from the tanning process will occur layered piles on the soil which can cause odors from decaying organic matter.

Other chemical constituents generated as a result of the production of the leather-based textile industry are TTS (Total Suspended Solid), the impact of TSS on water quality can cause a decrease in water quality. This condition can cause disturbance, damage and danger to all living things that depend on water resources. TSS causes turbidity and reduces light that can enter the water, the effects of which can be felt, namely acute poisoning and chronic poisoning.

To overcome those problem, is offered in the form of a simple, inexpensive and efficient H_2S and TSS waste treatment process technology, namely by using a combination of bio-desulfurization and trickling filtration methods as a means of treating liquid waste in the leather-based textile industry, especially for H_2S and TSS parameters. Bio-desulfurization is a sulfur removal process by utilizing the metabolism of microorganisms, namely by converting hydrogen sulfide into elementary sulfur, and trickling wastewater filtration is a treatment process by spreading wastewater into a pile or media bed consisting of coconut shell charcoal to reduce the content of H_2S and TSS in leather-based textile industry wastewater.

2. Materials and methods

The research design that will be carried out in this study is a laboratory scale experiment with a group comparison design, posttest with control design. In this design, a comparison of the reduction in levels of Hydrogen Sulfide (H_2S) and Total Suspended Solid (TSS) will be carried out after processing in a sewage treatment plant using control as a comparison. This type of research is a field-scale experimental study with the aim of seeing the reduction in levels of Hydrogen Sulfide (H_2S) and Total Suspended Solid (TSS) after processing in a combined waste treatment equipment of bio-desulfurization and trickling filtration, with the conceptual framework as follows:

2.1. Materials

The steps taken in the implementation of this research include:

1. Preparation of Equipment and Materials for Making Bio Desulfurization Reactor and Trickling Filtration to treat textile waste.
2. Making filter media made from coconut shells
3. Make sulfate reducing insulation (SRB) consisting of:

a. Rice based Local Microorganism (LMO)

b. Coal briquette solution that has been pulverized and then dissolved in water samples from the textile industry.

c. The coal solution is filtered, and the filtered water is added to the rice mol for 24 days (until microbes grow in the rice mol) so that black sulfate bacteria will form.

d. The bacteria formation process is carried out in a bio-desulfurization tube to which 11% Na2CO3 has been added (Figure 1).

4. After forming a black colony, then the bacteria are inserted/cultured into a glucose solution and allowed to stand for 14 days, so that a biofilm is formed (seeding process). The seeding process is the process of growing on the media, and acclimatization is the process of adjusting microorganisms to live in the reactor.
5. Next stage, the wastewater is channeled into a bio-desulfurization tube and a trickling filter tube containing activated coconut shell charcoal, then allowed to stand for 30 minutes.
6. Take a sample of wastewater for further examination of the content of H_2S and TSS
7. Preparation of H_2S and TSS examination tools and materials in the Environmental Health laboratory.

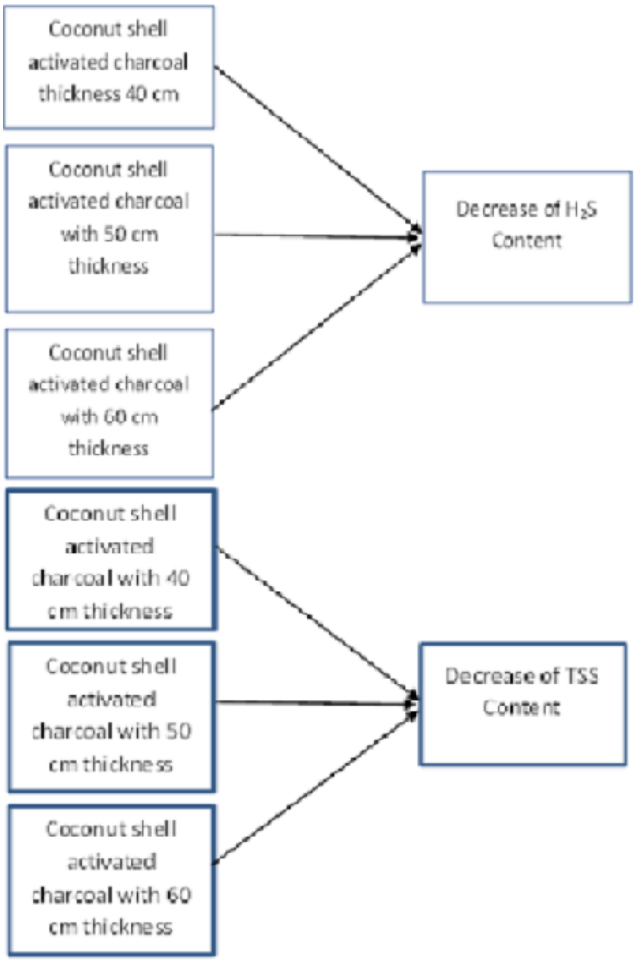
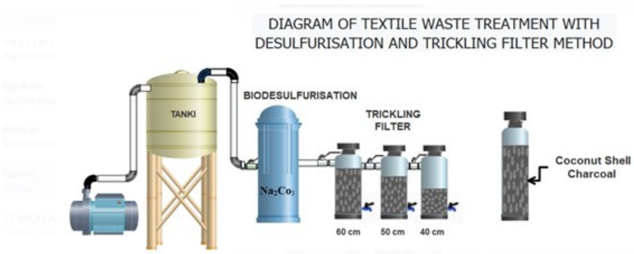


Figure 1. Research concept framework



Picture of Bio Desulfurization Reactor and Trickling Filter

How the tool works:

- Wastewater originating from the final stage of processing (outlet) of the leather-based clothing industrial waste treatment plant is accommodated in a holding tank with a capacity of 1000 liters of waste.
- Wastewater from the holding tank is then channeled into a bio-desulfurization tube which has been filled with sulfur reducing bacteria (SRB) made from rice's mol and 11% $NaCO_3$ added. The biodesulfurization tube functions as a sulfur reducing tube (sulfur removal process) through the process of utilizing microorganisms.
- The next process is the wastewater that has been put into the bio-desulfurization tube, to then flow into the trickling filter tube. The trickling filtration tube contains coconut shell charcoal filter media with various thicknesses. The trickling filtration tube consists of three tubes, where the first tube contains filter media with a thickness of 40 cm, the second tube contains filter media with a thickness of 50 cm and the second tube contains filter media with a thickness of 60 cm.
- Wastewater is then flowed into 3 trickling filtration tubes based on the thickness of the filter media and given a contact time of 30 minutes. After 30 minutes the wastewater was then taken samples for examination of H_2S and TSS levels.

2.2. Methods

The population in this study is all liquid waste in the textile industry at leather-based clothing companies in the West Java Region. Meanwhile, the number of wastewater samples required for the examination of this research is the requirement for chemical wastewater sampling is 2 liters. The sample size was calculated based on the number of treatments and the number of repetitions in the study. With a completely randomized design formula and using 3 kinds of treatment, namely the thickness of the coconut shell charcoal filter media of 40 Cm, 50 CM and 60 Cm.

The sample size of this study was to do one treatment, namely by looking at the decrease in H_2S and TSS levels before and after treatment. Based on the sampling formula, the number of samples of wastewater in this study was 6 repetitions multiplied by 3 treatments = 18, plus 5 controls, the number of samples required was 24. For each treatment, 39 liters of wastewater were needed, so a sample of wastewater was required as much as 39 x 24 = 936 liters of wastewater sample, while sampling for 1 repetition examination is 200 ml, so the amount of waste required for examination in the laboratory is 200 ml x 24 = 4800 ml.

The sampling technique in this study was done by grab sampling, namely samples taken at certain times in one location and the sample was able to represent the overall medical waste recycling material. Data were collected from the analysis of the decrease in levels of Hydrogen Sulfide (H_2S) and Total Suspended Solid (TSS) after processing through bio desulfurization and trickling filtration with Coconut Shell Charcoal Media.

3. Results and discussion

3.1. Results

The following are the results of H_2S inspection after processing in a bio-desulfurization tube and combined with filtering in a trickling filter tube with coconut shell activated charcoal filter media, can be seen in Table 1 below:

Table 1. The results of the measurement of H_2S levels after flowing into the Bio desulfurization reactor and Trickling Filter with coconut shell activated charcoal filter media

Repetition	Control	H_2S Content (mg/l)					
		40 cm	%	50 cm	%	60 cm	%
1	40,11	10,99	72,60	8,18	79,61	5,78	85,59
2	39,20	10,93	72,12	8,15	79,21	5,74	85,36
3	40,11	10,85	72,95	8,07	79,88	5,72	85,74
4	39,20	9,77	75,08	7,44	81,02	3,17	91,91
5	40,11	9,91	75,29	7,40	81,55	3,15	92,15
6	39,20	9,85	74,87	7,36	81,22	3,03	92,27
Average	39,65	10,38	73,82	7,77	80,42	4,43	88,84
Max	40,11	10,99	75,29	8,18	81,55	5,78	91,91
Min	39,20	9,77	72,12	7,36	79,21	3,03	85,36

Based on Table 1, it can be seen that the highest level of H_2S reduction after being processed in a waste treatment equipment which is a combination of a bio-desulfurization reactor and a trickling filter using coconut shell activated charcoal filter media, is at a filter thickness of 60 cm on average. the average decrease in H_2S content was 4.43 mg/l or 88.84 %.

The following is a graph of the decrease in H_2S after the waste is processed into the biodesulfurization reactor and trickling filtration:

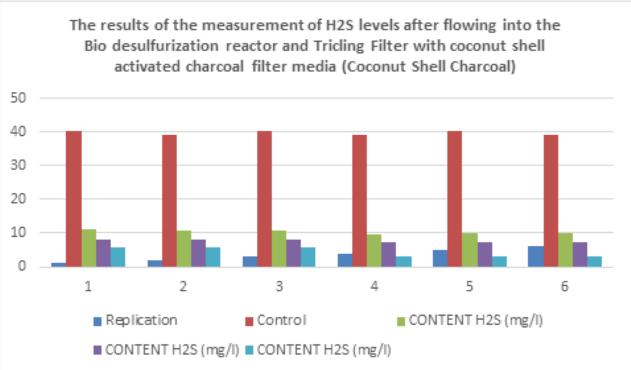
Based on Graph 1 above, it can be seen that the highest decrease in H_2S levels was at a filter thickness of 60 Cm. The following are the results of the TSS examination after processing in a bio-desulfurization tube and combined with filtering in a trickling filter tube with coconut shell activated charcoal (Coconut Shell Charcoal) filter media, can be seen in Table 2 below:

Table 2. The results of the measurement of TSS levels after flowing into the bio desulfurization reactor and trickling filter with coconut shell activated charcoal filter media (*Coconut Shell Charcoal)*

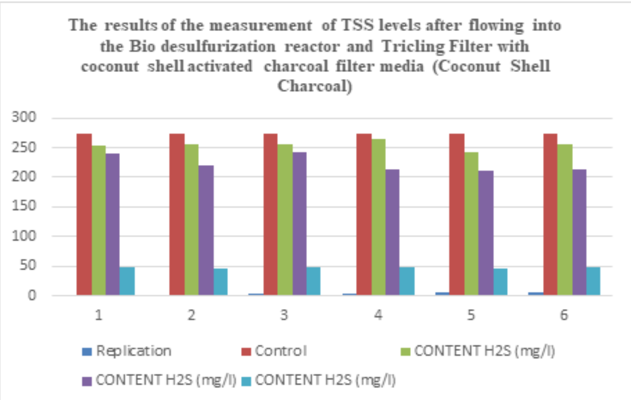
Repetition	Control	TSS Content (mg/l)					
		40 cm	%	50 cm	%	60 cm	%
1	273	253	7,33	240	12,09	49	82,05
2	273	255	6,59	220	19,41	46	83,15
3	273	256	6,23	243	10,99	48	82,42
4	273	265	2,93	214	21,61	48	82,42
5	273	243	10,99	210	23,08	47	82,78
6	273	255	6,59	214	21,61	48	82,42
Average	273	254,50	6,78	223,50	18,13	47,67	82,54
Max	273	265	10,99	210	23,08	46	82,05
Min	273	243	2,93	243	10,99	49	82,78

Based on Table 2, it can be seen that the highest level of TSS reduction after being processed in a waste treatment equipment which is a combination of a bio desulfurization reactor and a trickling filter using coconut shell activated charcoal filter media (Coconut Shell Charcoal), is at a filter thickness of 60 cm on average. the average decrease in TSS content was 47.67 mg/l or 82.54%.

The following is a Graph 2 of the decrease in TSS after the waste is processed into a biodesulfurization reactor and trickling filtration:



Graph 1. Reduction of H_2S After flowing into the waste treatment plant, bio desulfurization and trickling filter



Graph 2. Reduction of TSS After flowing into the waste treatment plant, bio desulfurization and trickling filter

Based on the graphs above, it can be seen that the highest decrease in TSS levels was at the filter thickness of 60 cm.

Following are the results of data analysis on the effectiveness of waste treatment equipment in a bio-desulfurization tube and combined with filtering in a tricling filter tube with coconut shell activated charcoal (Coconut Shell Charcoal) filter media with a thickness of 40 cm, 50 cm and 60 cm in reducing H_2S and TSS levels in textile waste can be seen in Table 3 below:

Based on Table 3, the results of data analysis using the Kruskall Wallis test to see the average decrease in H_2S by using a waste treatment tool in a bio-desulfurization tube and combined with filtering in a trickling filter tube with coconut shell activated charcoal filter media (Coconut Shell Charcoal) with thickness of 40 cm, 50 cm and 60 cm with a p value of < 0.05, i.e. P value 0.000, thus there is a significant difference in the mean effectiveness of the waste treatment equipment in the bio-desulfurization tube and combined with filtering in the trickling filter tube with filter media of coconut shell activated charcoal (Coconut Shell Charcoal) with a thickness of 40 cm, 50 cm and 60 cm to reduce H_2S and TSS levels.

Table 3. Kruskal Wallis Test Results

	Kruskal Wallis	df	Sig.
H_2S	21.600	3	**.000**
TSS	**15.059**	**3**	**.001**

3.2. Discussion

Based on the data above, the decrease in the H_2S content in the filter media with a thickness of 60 cm with the time detention of 30 minutes in the trickling filtration process can reduce H_2S by 4.43 g/l or 88.84%. This is in accordance with the research conducted by Miscbahul Munir, et al regarding the recovery of sulfur from H_2S exhaust gas in PLTP activities with the Bio-desulfurization process using the bacteria *Rhodococcus sp*. with the results obtained can reduce H_2S as much as 87.86% with a contact time of 180 minutes. So it can be concluded that research using a combination of bio-desulfurization methods with trickling filtration using coconut shell charcoal screening media can reduce H_2S content for 30 minutes, which is faster than previous studies.

While the filtration process in the trickling filter is in accordance with the research of Sri Moertinah, *et al.* about improving the performance of activated sludge with the addition of activated carbon in textile wastewater treatment in reducing dyestuffs and sulfur, the results obtained with the addition of 2250 mg/l activated charcoal, can reduce sulfur dyestuffs to below the threshold value according to Central Java regional regulation (PERDA Jawa Tengah) No. 10 years 2004 (Sri Moertinah *et al.*, 2014).

From the results of the three treatments, namely filtering using Coconut Shell Charcoal with a thickness of 40 cm, 50 cm, and 60 cm, it can be seen that only a filter thickness of 60 cm can reduce the TSS content below the threshold value set by the Minister of Agriculture. LH No. 5 of 2014, which is 47.67 g/l or can reduce TSS as much as 82.54%. Furthermore, according to Shihao Sun, etc. that bio trickling filtration with two filtration systems can reduce H_2S by 86.1%, this is due to the degradation mechanism of VOCS bacteria in the two bio-filtration filtration systems (Shihao Sun, etc, 2019).

TSS (Total Suspended Solid) are all kinds of solids from total solids that are retained on a sieve with a maximum particle size of 2.0 µm and can settle (Widyaningsih, 2011). Turbidity in water is closely related to the TSS value because turbidity in water is caused by the presence of suspended solids. Suspended substances in water consist of various substances, such as fine sand, clay, and natural mud which are inorganic materials or can also be organic materials floating in the water (Alaerts and Santika, 1987).

The bio-desulfurization process functions to separate or remove sulfur by utilizing sulfate-reducing bacteria, namely by converting hydrogen sulfide into elementary sulfur with the catalyst of an enzyme produced by certain types of sulfur microorganisms, without changing the hydrocarbon compounds in the process stream. Meanwhile, in the trickling filtration process, which contains coconut shell activated charcoal (Coconut Shell Charcoal) and allowed to stand for 30 minutes, is a treatment process by spreading wastewater into a pile or media bed consisting of coconut shell activated charcoal. In the trickling filtration process, microorganisms multiply and attach to the surface of the buffer media in the form of dust which functions to decompose pollutant compounds, in this case H_2S and TSS, which are found in leather-based clothing industry wastewater.

In line with Arik Agustina's research that sewage treatment with trickling filter system has been effective in reducing TSS content, this occurs due to the retention of solid particles by the biofilm which causes the amount of solids in fish processing waste to decrease. The biofilm media is able to restrain the rate of wastewater so that there is an interaction between the waste and the microorganisms contained in the biofilm where the filtering begins with the containment and binding of suspended solids so that it can reduce the TSS value.

4. Conclusions

Based on the results of the research on the effectiveness of the use of coconut shell charcoal filter media with a combination of bio desulfurization and trickling filtration technology in reducing the content of hydrogen sulfide (H_2S) in the textile industry, the following conclusions can be drawn:

- After processing using Coconut Shell Charcoal Filter Media with a Combination of Bio Desulfurization Technology and Trickling Filtration with coconut shell charcoal filter media, the biggest decrease in H_2S content is in the trickling filtration reactor at a filter thickness of 60 cm with the time detention of 30 minutes, which is 4.43 mg/lt or 88.42%.
- After processing using Coconut Shell Charcoal Filter Media with a Combination of Bio Desulfurization Technology and Trickling Filtration with coconut shell charcoal filter media, the biggest reduction in TSS content is in the trickling filtration reactor at a filter thickness of 60 cm with the time detention of 30 minutes, which is 47.67 mg/lt or 82.54%.
- Based on the results of statistical tests, there is a significant difference in the average decrease in H2S levels with a p-value of 0.000, and a decrease in TSS levels with a p-value of 0.001, namely p-value < 0.05

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