

## Kinerja Biofiltrasi Tempurung Kelapa dan Limbah Plastik Tempat Telur pada Pengolahan Limbah Cair Medis

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### ABSTRAK

**Latar belakang:** Pengelolaan limbah cair medis dari fasilitas pelayanan kesehatan memegang peran penting bagi lingkungan dan keamanan masyarakat luas. Pencemar yang terkandung di dalamnya harus diolah terlebih dahulu sebelum dibuang ke lingkungan. Penelitian ini bertujuan untuk menunjukkan hasil dari pengolahan limbah cair medis (IPAL) dengan menggunakan tempurung kelapa dan plastic bekas tempat telur sebagai media biofiltrasi untuk menurunkan kadar BOD dan COD di Puskesmas Siantan Hulu.

**Metode:** Penelitian ini merupakan jenis quasi-eksperimen. IPAL yang diaplikasikan adalah *continuous flow* dengan volume 2000 liter dan dibagi menjadi 4 tahapan, yaitu pengendapan awal, bak anaerob, bak aerob dan bak pengendapan akhir. Proses pembiakan mikroorganisme dilakukan secara alami dengan membiarkan media direndam dalam bak anaerob dan aerob selama 14 hari. Penelitian ini dilakukan secara kontinyu dengan lama tinggal 6 hari sesudah melewati ketebalan media tempurung kelapa dan plastic bekas yang berbeda, yaitu 20:40 cm, 40:40 cm dan 60:20 cm. Hasil dianalisis menggunakan uji t berpasangan dan uji One-Way Anova serta rumus efisiensi penurunan parameter.

**Hasil:** Diperoleh hasil bahwa ada perbedaan kadar BOD dan COD sebelum dan sesudah melewati media biakan lekat ( $p=0,000$ ) dengan berbagai ketebalan media. Berdasarkan waktu tinggal, tidak ditemukan perbedaan yang signifikan terhadap kadar BOD dan COD ( $p=0,985$  dan  $p=0,142$ ). Hasil penelitian menunjukkan bahwa di antara kombinasi anaerobic dan aerobic, aplikasi 20 cm tempurung kelapa dan 60 cm plastic bekas selama 6 hari menghasilkan penurunan tertinggi, yaitu dengan efisiensi rata-rata 94,3% dari rata-rata 130 mg/l menjadi 6,2 mg/l dan COD 96,6% dari rata-rata 217,2 mg/l menjadi 7,3 mg/l.

**Simpulan:** Penelitian ini menghasilkan kadar BOD dan COD yang sesuai ( $<NAB$ ), menjadi 6,2 mg/l dan 7,3 mg/l. Modifikasi ini menurunkan BOD dengan rata-rata efisiensi 94,3% dan COD 96,6%. Disimpulkan bahwa ketebalan media yang terbaik adalah 20:60 cm tempurung kelapa dan plastic bekas dan waktu tinggal 1 hari.

**Kata kunci:** tempurung kelapa; plastic bekas; BOD; COD; limbah cair medis.

### ABSTRACT

**Title:** Biofiltration Performance of Coconut Shell and Plastic Waste Made from Egg Holders for Medical Wastewater Treatment

**Background:** Health facilities waste water management is a crucial environmental and public safety issue. These pollutants should be treated by the proper treatment before release to the municipal drainage. This study aims at presenting the results of waste water treatment modification which used coconut shell and plastic as biofiltration media to decrease organic pollutants (BOD and COD) at Public Health Center of Siantan Hulu.

**Methods:** This study is a quasy experiment. The type of wastewater treatment that is used in this research is a continuous flow which has total volume 2000 litter and divided into 4 zones, i.e presedimentation, anaerob zone, aerobic zone and post sedimentation zone. Seeding microorganism has done naturally by letting media in anaerob and aerob zone for 14 days. The main research were conducting by continuous operation under 6 days retention time after treated by different media depth of coconut shell and plastic, i.e 20:60cm, 40:40cm and 60:20cm. The results analyzed by paired sample t-test, one-way anova, and also proportional efficiency formula.

**Results:** It obtained that there was difference of BOD and COD level before and after through various bed depth of media ( $p=0,000$ ). Based on retention time, it was not found any difference towards BOD and COD content ( $p=0,985$  and  $p=0,142$ ). The result of experiment shows that within the combined anaerobic and aerobic process using 20 cm coconut shell and 60 cm of plastic media under condition 6 days retention time, the average of removal efficiency of BOD reached to 96,6% from 130 mg/l into 6,2 mg/l and COD 94,3% which 217,2 mg/l down to 7,3 mg/l..

**Conclusion:** Application of coconut shell and plastic waste media filtration for medical wastewater treatment resulted appropriate BOD and COD content, into 6,2 mg/l and 7,3 mg/l respectively. This modification decreases BOD with the average of percentage efficiency stood at 94,3% and COD at 96,6%. It was found to be the best media with an appropriate coconut shell:plastic waste bed depth of 20:60 cm with 1 day of retention time.

**Keywords:** coconut shell; plastic waste; BOD; COD; medical wastewater

## INTRODUCTION

Public Health Center is one of the health facilities that cannot be separated from the community and its existence is expected by the community to maintain their health. Infact, it also release amount of wastewater which contains organic compounds, chemical compounds (an-organic) and pathogenic microorganisms (infectious which can endanger the ecosystem).<sup>1</sup>

The Health Facility Research in 2011 showed that 33.2% of the Non-Inpatient Community Health Centers did not provide waste water treatment plant, while those that had a number of waste water disposal facilities (66.8%), but those that met requirements of 26.2% only.<sup>2</sup>

As the Ministry of Health Regulation Number: 75 of 2014 concerning Public Health Centers, with the requirement to conduct environmental health management and based on Environmental Ministerial Regulation number 5 of 2015 concerning Waste Water Quality Standards which require that each health service facility must treat wastewater hence it meets the permitted standard. As a matter of fact that the most common problem is that the existing technology is still quite expensive, while on the other hand there is limited funds to build the wastewater treatment unit.

The Public Health Center of Siantan Hulu is one of the Non-Inpatient Health Centers located in the North Pontianak which in its operations produces liquid waste from sinks, bathrooms and laboratories with an average discharge of 21 litter/hour with operating hours of 7 hours per day. Waste is discharged directly into the ditch in front of the building without flowing through the treatment process. The results of measurements on parameters of BOD levels 167 mg/l and COD levels of 230 mg/l.

In accordance with Minister of Environment Regulation No. 5 of 2014 concerning waste water quality standards it is known that BOD levels of 50 mg/ and COD are 80 mg/l, therefore this liquid waste exceeds the threshold value determined by the applicable legislation.<sup>3</sup> A high BOD level will cause foul odor, since high level BOD means dissolved oxygen is low and its impact to degradation of waste

will take place anaerobically. Anaerobic process is an oxidation without oxygen, moreover it will produce a compound of  $\text{NH}_3$ ,  $\text{H}_2\text{S}$  and  $\text{CH}_4$  that smells bad. The high BOD and COD and low DO cause animals and aquatic plants cannot develop properly.

To overcome this problem, it is necessary to develop efficient and affordable wastewater treatment technology. Deciding coconut shells and egg plastic holders as media filter is taken since its avability in the area. Furthermore, previous research showed that coconut shell was able to reduce BOD and COD reaching 98.81% .<sup>4</sup> A modification of plastic waste of egg holders are chosen as the material has a very good porosity of the flow of water, it will avoid blockages. In fact, one study proved that the plastic coating media was able to absorb Methylen Blue pollutants in textile waste.<sup>5</sup> It strengthen the hypothesis that another kind of plastic have potency as the organic compounds removal.

The objective of this study is to apply submerged medium by utilizing coconut shell and plastic waste of egg holders as media bed filter for the treatment of medical wastewater. The possibility of using coconut shell and plastic waste of egg holders as media filter bed with different depth is hoped to decrease BOD and COD level was investigated.

## MATERIALS DAN METHODS

The design of this study is a quasi-experimental design with pre and post-test. As the study population is waste water in Siantan Hulu Public Health Center. The sample of this study is the certain amount of wastewater for measuring the levels of BOD and COD parameters with the number of samples based on Federer's formula.

The research variable is the combination of coconut shell and plastic waste from egg holders with various depth, i.e 20:60 cm, 40: 40 cm and 60:20 cm. Dependent variables are BOD and COD levels.

Collected data is then analyzed descriptively and statistically. While to test the hypothesis will be analyzed by paired t test and one-way anova. The effectiveness of decreasing BOD and COD is calculated using the following proportional formula:

$$\text{Efficiency} = \frac{\text{Pretest (A)} - \text{Posttest (B)}}{\text{Pretest (A)}} \times 100 \%$$

The following steps are carried out in this study, which includes the manufacture of wastewater treatment , breeding and sampling.

1. The process of buiding wastewater treatment plant  
Excavation of land with a size of 120 cm x 100 cm x 180 cm was carried out by 2 pieces with a capacity of 2000 liters or 2 m3. Furthermore, making fiber tub foundation, fiber tub installation, plumbing and coconut shell media and plastic from egg holders. The scheme of medical wastewater treatment process can be seen in the following figure.

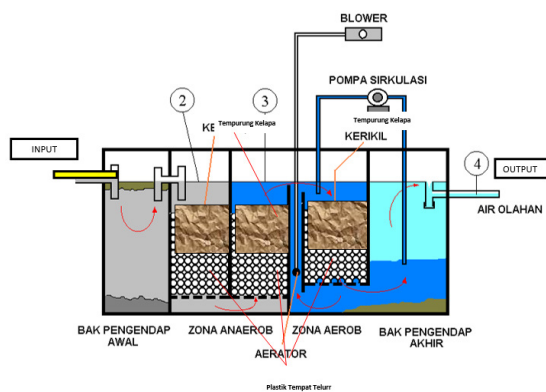


Figure 1. Process of wastewater treatment

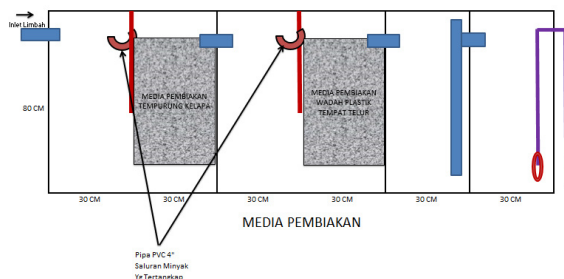


Figure 2. Side view of wastewater treatment

2. Breeding

The breeding stage has done naturally, without the intervention of seeding seeds of certain microorganisms. For 14 days, it was estimated that microorganisms naturally had begun to stick, grow and reproduce in wastewater as liquid waste which would be processed in the study.

3. Sampling of waste water

The main research is reactor operation with a retention time of 1, 2, 3, 4, 5 and 6 days. Waste water samples were taken from influent and effluent point of wastewater treatment which had been installed in advance. Wastewater is put into a winkler bottle and ensures that there are no air bubbles in the sample water. Sampling was done 6

times per treatment. Parameters such as pH, Biochemical requirement of oxygen (BOD) and Chemical requirement of oxygen (COD) were measured of the samples in laboratory.<sup>6</sup>

RESULTS AND DISCUSSION

This study used medical liquid waste at the Public Health Center of Siantan Hulu, which located in North Pontianak District. This research was carried out by using bacterial adherent method on anaerobic and aerobic coconut shell and plastic egg holders.

The characteristics of the waste to be processed are as follows.

Table 1. Characteristics of wastewater in the Public Health Center of Siantan Hulu

No	Parameters	Unit	Result
1	pH	-	7,5
2	BOD	mg/l	130
3	COD	mg/l	217,2

In the preliminary study, measurements of wastewater parameters were carried out at the study site, which included the conditions of pH, BOD and COD. It is been shown that the concentrations of BOD and COS exceeded the allowed limits (BOD <80 mg/l and COD <50 mg/l). In this term, proper treatment is a must before releasing wastewater to environment.

Deciding plastic waste from egg holders as media is based on the fact that it has a regular shape and wider surface area compared to the coconut shell. Recent study shows that the plastic used as a growth media is quite effective as a place for attaching bacteria with 87.30% porosity and effective surface area of 514.40 m2 / m3.<sup>7</sup>

Attached microorganism bioreactor is a zone where microorganisms grow and develop on a medium that can be made of plastic or stone. Waste water through plastic media by forming a layer of mucus to attach to the surface of the media, thus forming a layer of biofilm.<sup>8</sup> Broadly speaking, the biofilter process can be carried out under anaerobic, aerobic or anaerobic and aerobic conditions.<sup>7</sup> Plastic media is used both in aerobic and anaerobic processes, provided that it meets the criteria of high inertity, high volume fraction, large surface area, hydraulics.<sup>7,9</sup>

The experiment was performed using different arrangement of coconut shell:plastics bed, i.e. 20:60 cm, 40:40 cm and 60:20 cm. Declining the value of BOD and COD parameters is the contribution of microorganisms that grew in adhesives media in aerobic and anaerobic zone. The microorganism have grown naturally in the media for 14 days.<sup>10</sup>

The following are the results of laboratory measurements of BOD and COD levels before and after the intervention in the 1<sup>st</sup>-6<sup>th</sup> days.

Table 2. Results of BOD and COD measurement

Retention Time (Days)	BOD (mg/l)			COD (mg/l)				
	Pre-test	Post-Test			Pre-test	Post-Test		
		P I	P II	P III		P I	P II	P III
1	145	2	16	19	223	3	8	9
2	132	7	13	21	204	9	11	10
3	124	8	17	23	214	8	13	11
4	130	9	14	17	232	11	10	14
5	122	8	19	22	221	7	11	12
6	127	3	18	24	209	6	9	8
Average	130	6,2	16,6	21,2	217,2	7,3	10,3	10,7

Table 2 shows average value for the characteristics parameters of the Siantan Hulu Public Health Center. The average value (BOD and COD) before treatment = 130 mg/l and 217.2 mg / l. From the standards, this value higher than threshold value. After treatment, the lowest BOD and COD content fell to an average of 6.2 mg / l and 7.3 mg / l in depth media 20:60 cm coconut shell and plastic; so that the effectiveness of a waste water treatment with a microorganism growth media system is quite effective to use in the depth of the coconut shell: plastic= 20:60 cm

These results are similar to other studies where the application of plastic and sand media as the most effective filtration media in reducing BOD and COD

levels is 60:20 cm. Thus it can be a reference that the thicker the plastic media layer, the better it is to grow microorganisms that degraded organic pollutants in wastewater.<sup>11</sup>

Overall, it can be seen that the ratio of decreasing levels of BOD and COD at Treatment 1, 2 3 during the retention time of 1-6 days gives better final results compared to without biofilter media.

The results of previous studies of jeans washing industry wastewater treatment with anaerobic-aerobic biofilter process using long-stay variations are useful to determine the exact duration of microorganism planting media installation. Little time of retention in the biofilter reactor could give the smaller of removal efficiency.<sup>8,12</sup>

Table 3. Results of statistical analysis of differences between independent variables with levels of BOD and COD

No	Variables	Mean	t	Standard Deviation	p-value
1	BOD				
	Pre-test – post-test P1	109,000	26,971	9,8994	0,000*
	Pre-test – post-test P2	113,833	29,430	9,4745	0,000*
	Pre-test – post-test P3	122,667	30,249	9,9311	0,000*
2	COD				
	Pre-test – post-test P1	209,833	50,072	10,264	0,000*
	Pre-test – post-test P2	206,833	47,087	10,759	0,000*
	Pre-test – post-test P3	206,500	57,018	8,871	0,000*
3	Retention time (One-way Anova)				
	BOD	14,44	-	6,819	0,985**
	COD	9,44	-	2,617	0,142**

\* paired t test \*\* One Way Anova Test

The results of the statistical test in table 3 below show the results of statistical analysis of differences in levels of BOD and COD before and after going through WWTP with biofiltration media from coconut shells and plastic waste of egg holders.

It is obtained a probability value of 0,000 on all variables, therefore it can be concluded that there are significant differences in the content of BOD levels before and after treatment, both after flowing through media with a thickness of 20:60 cm, 40:40

High BOD levels in wastewater indicates the low value of dissolved oxygen due to the high concentration of oxygen needed by microorganisms to

cm and 60:20 cm. similar trends was found in case of the previous study, where biofiltration media from used plastic bottles has a significant effect in reducing BOD levels reach to 84.85% .<sup>11</sup>

It is also found a significant difference in COD levels between before and after treatment.

This result contrasts with the previous study which stated there was no difference, and it was only able to reduce COD by 31.73% .<sup>11</sup>

degrade dissolved organic pollutants in the water.<sup>8,9</sup> After a few days, the surface of the filter media will grow microorganism film layers. These

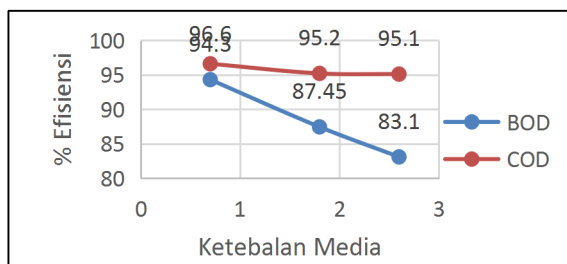
microorganisms will decompose organic substances that have not been able to decompose in the initial settling basin.<sup>12</sup>

Adherent growth bioreactors are used as attached bioreactors where microorganisms grow and develop on a medium by forming a layer of mucus to stick above the surface the media, thus forming a biofilm layer.<sup>13</sup> Microorganisms that grow predominantly in plastic media are assumed to be *Pseudomonas stutzeri*, *Pseudomonas Pseudoalcaligenes* and *Peinococcus radiopugnes*.<sup>14</sup>

The plastic surface of the egg holders which have regular shape and a wider surface area than the coconut shell, becomes the place for the formation of biofilms where the biofilm is a place to attach microorganisms that will degrade organic substances in the liquid waste.<sup>15</sup>

Wastewater that still contains organic matter that has not been decomposed in settling bodies if through this mucus layer will undergo a biological decomposition process. The efficiency of the biofilter depends on the extent of contact between the wastewater and the micro-organisms attached to the surface of the filter media. The wider the contact area, the greater the reduction in the concentration of organic matter (BOD).<sup>13</sup>

The COD parameter is crucial since it is an indicator of the level of pollution in a waters. The greater the value of COD, the higher the level of pollution in the waste, which can be seen from wastewater sample before processing reached 217.2 mg/l which describes the amount of organic compounds contained in wastewater and after going through a treatment, the COD content is equal average of 7.3 mg/l, hence the effectiveness of wastewater treatment plant by using a growth microorganism media system in reducing liquid waste COD content in the Pontianak City Health Center Siantan Hulu by 96.6%, and this be found in 20:60 cm depth media, as shown in the following graph.



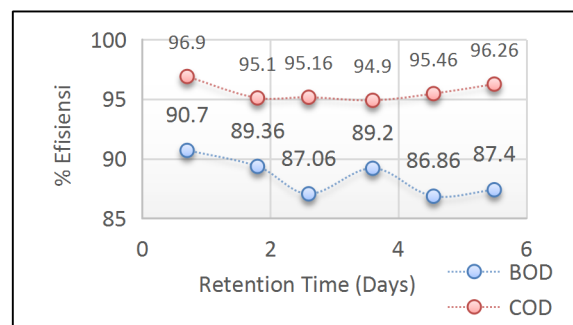
Graph 1. Efficiency of Decreasing BOD and COD Levels Based on Depth of Media Filter Bed

The efficiency of reducing the level of BOD and COD between each treatments after passing through a wastewater treatment plant with different arrangement depth of media did not make a major difference. BOD tends to decrease steadily even though it is noted that there is a decrease in

effectiveness of media bed of 40:40 cm and 60:20 cm. Likewise on the COD chart.

In case of 20:60 cm application, effluent quality became the highest reduction of BOD and COD than others. The application of 40:40 cm and 60:20 cm coconut shell and plastic bed in term of BOD and COD experienced lower than 20:60 cm. It could be seen that application of 20:60 cm is optimum depth media which could produce effluent at low BOD of 94,3% reduction and COD of 96,6%.

The process of reducing COD by using microorganism growth media is intended for COD derived from organic substances with high biogradable content, this process is carried out by aeration and anaerobes. In the process of aeration COD is reduced by breaking down organic compounds in water. These bacteria are called heterotrophic bacteria that degrade organic compounds with the contribution of oxygen. In term of biofilm layer, organic compounds are decomposed by aerobic microorganisms, thus COD value step down.



Graph 2. Efficiency of Decreasing BOD and COD Levels Based on Various Retention Time

The performance of submerged media filter was also examined using different retention time of 1, 2, 3, 4, 5, and 6 days. This was to determine the duration time of media filter required in contact-filtration process. The system was initially operated at a debit of 18 liter/hour using anaerobic, aerobic and aeration system. Chart 2 shows the performance of submersed coconut shell and plastic waste bed in term of BOD and COD removal efficiency after treated by different arrangement submerged bed filter. It could be seen that application of 1 day of retention time stood at average 96,9%. Meanwhile 2-4 days of retention time has decreased of COD removal efficiency. The next day, the performance of filter by measuring effluent COD improve steadily, however it stood at point where lower than the first day.

Similar trend was found in case of COD removal. In case retention time of 1 day, the best performance as shown the chart (90,7%), consequently then COD efficiency dropped to around 86-89%.

Based on statistical results (table 3), it proved that there was no significant difference in the levels of BOD and COD with variations of retention time of

submerged bed filter. Referring to the results of graph 2, it is fact that the optimum conditions are based on the best retention time, i.e if the bioreactor conditions are stable (efficiency of increasing BOD and COD is regulated).<sup>8</sup> Reported from the operation of wastewater treatment plant by utilizing coconut shell and plastic waste of egg holders to reduce the concentration of organic compounds are carried out in 6 stages, i.e with retention time of 1-6 days, confirming that at the duration of 1 day is the optimum period in which the average parameter conditions achieved in that period can be seen in graph 2.

These results cannot be concluded that the longer of the contact time between organic material and microorganism in biofilms, the more chance that microorganism can degrade organic compounds for their metabolism.<sup>8</sup> For this reason, further studies are needed regarding the seeding methods to be applied in this research.

Overall, it can be seen that the efficiency of the removal of organic compounds (BOD and COD) in this wastewater treatment plant is determined by the surface area of the growth media for microorganism. In addition, the length of time the growth media in water (measurement time) also affects the efficiency of removal.<sup>13</sup>

## CONCLUSION

This study concluded that there was a difference in both BOD and COD levels between influent and effluent after flowing through the submerged growth media filter with different depth of coconut shells:plastic waste of egg holders. None difference in BOD and COD levels with variation of retention time. The highest decrease in BOD and COD levels occurred in the treatment of 20:60 cm coconut shells:plastic waste from egg holders. The optimum period of retention time in reducing BOD and COD levels is 1 day.

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