Degradation of phosphate in laundry waste with biosand filter method

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Abstract. The most active ingredients in laundry waste such as clothes softener and detergent are ammonium chloride, linear alkyl sulfonate (LAS), sodium dodecyl benzene sulfonate, sodium carbonate, sodium sulfate, alkylbenzene sulfonate. These materials are not biodegradable. This study aims to reduce the phosphate and surfactant content with the biosand filter method which uses activated carbon as adsorbents with the laundry to nutritional waste mixtures ratio of 100%: 0, 75%: 25%, and 50%: 50% (%volume) with anaerobic process. The parameters analyzed were Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Volatile Suspended Solid (VSS), pH everyday and Phosphate and Surfactant before and after anaerobic processes. The pH for this study is set in the range of 6.9-7.5. The largest volume was at 50%: 50% (v/v) mixture of laundry waste and nutrients obtained 76.61% TSS, 63.55% VSS, 53.67% COD, 74.32% phosphate and 53.54% surfactant. Reduction of phosphate and surfactant values is caused by the presence of a dirty layer (biofilm) in the tank so as to produce phosphate and surfactants that have met quality standards based on the Government Regulation of the Republic of Indonesia No. 82 of 2001.

1. Introduction
According to Indonesia’s Government Regulation number 82 of 2001 concerning the quality standard of domestic waste water, domestic waste water is from real state business or activity, restaurants, offices, commerce, apartments and dormitories [1]. Domestic liquid waste is divided into two categories, domestic liquid waste derived from laundry water, such as soap, detergents, oils and pepticides and domestic liquid waste from latrines, such as soap, shampoo, feces and urine [2]. Laundry waste is included in the category of domestic liquid waste.

The laundry business is using detergent and soap as a washing material. The dominant laundry waste comes from clothes softener and detergent. The most active ingredients in clothes softener and detergent are ammonium chloride, linear alkyl sulfonate (LAS), sodium dodecyl benzene sulfonate, sodium carbonate, sodium sulfate, alkylbenzene sulfonate. These materials are not environmentally friendly (non-biodegradable) [3]. Liquid laundry waste produced by high phosphate-containing detergents derived from sodium tripolyphosphat in detergent functions as a builder which is the most important element after surfactant because of its ability to deactivate hardness minerals in water so that detergents can work optimally [4]. If the phosphate content in laundry waste water is higher then this will affect the environment around the water body, which causes eutrophication where the water body becomes containt of dissolved nutrients, decreases in dissolved oxygen content and the ability to support the body of water to aquatic biota.
There have not been many special efforts to deal with the problem of water pollution caused by detergents in Indonesia. Some efforts have been made, one of which is to replace branched chains from Alkyl Benzen Sulfonate (ABS) into a straight chain biodegradable Linear Alkyl Sulfonate (LAS). This detergent can be damaged by microorganisms [5]. Another treatment that has been done to deal with pollution problems caused by laundry waste is the Biosand Filter method. Biosand Filter is a filter with the concept of slow sand filter which is specifically designed for household scale. The advantage of biosand filter is the existence of biofilm growth on the surface of the top media which is able to degrade taste, smell and color. Biosand Filter uses medium of fine sand, coarse sand and gravel and the addition of microorganisms as an aid in reducing the organic content in laundry waste. The addition of activated carbon serves to improve efficiency in reducing levels of organic materials and to reduce the concentration of surfactants dissolved in laundry waste before being discharged from the aquatic environment before this method was only used for drinking water treatment only [6]. Biosand Filter is very similar to a slow sand filter in the sense that the majority of filtration and turbidity removal occurs at the top of the sand layer due to the decreased pore size caused by the decomposition of grain particles. This technology can reach 99.99% of typhus virus removers. The advantage of this technology is that it is cheap, requires little maintenance and operates in a gravitational manner [7].

2. Experimental

2.1. Phosphate degradation of waste laundry

The raw material is laundry liquid waste and other additives, called Molasses and Urea as sources of nutrients during the acclimatization process. Acclimatization is carried out on tanks containing gravel and sand with 20 cm for each height. The process before purifying laundry liquid waste using biosand filter tank and activated carbon tank, analysis of laundry liquid waste is done first, namely analysis of Phosphate, Surfactant, pH, COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), and VSS (Volatile Suspended Solid). After initial analysis, laundry liquid waste is then put into a tank that has a volume of 8 L with a comparison of variations in the composition of laundry liquid waste: nutrition is 100%

\[\text{Mg VSS/l} = \frac{(A-B) \times 1000}{\text{Volume (ml)}}\]  

3. Result and discussion

3.1. Profile of pH in biosand filter tank

pH is a very important parameter in determining living conditions microbes in the tank during anaerobic fermentation take place and are factors that greatly influence the growth of microorganisms in anaerobic organic degradation [8].
Figure 1. Effect of time and pH in biosand filter tank.

Figure 1 shows pH value fluctuates in each liquid waste sample laundry with nutrition that is in the comparison ratio of 100%: 0, 75%: 25%, and 50%: 50% (in% volume) from day 1 to ± 30 days. The most fluctuating pH value with a pH range of 8.3-7.5 is at a ratio of 75%: 25% on day 14, at a ratio of 100%: 0 fluctuating with a pH range of 7.6 - 6.9 on the day to 22 as well as for a ratio of 50%: 50% with a pH range of 8.0 = 7.8 on the 15th day. Decreasing the pH value of wastes containing detergent indicates the occurrence of Linear Alkyl Sulfonate biodegradation [9]. This can also be influenced by the addition of urea solution given as a nutritional source of microorganisms in growing the biofilm layer so that the pH of the water becomes alkaline [10].

3.2. Profile of COD in biosand filter tank

COD is also an important parameter in determining the microbial life conditions in the Biosand Filter tank as long as the anaerobic fermentation process takes place because COD (Chemical Oxygen Demand) is the total amount of oxygen needed to oxidize organic matter chemically, both which can be degraded biologically and which are difficult to degrade biologically into CO$_2$ and H$_2$O [11].

Figure 2. Effect of time on COD in biosand filter tank.

Figure 2 shows COD degradation in the biosand filter against the time in the variation of the comparison between laundry liquid waste and nutrition is 100%: 0, 75%: 25% and 50%: 50% (in% volume) from day 1 to 30th day. The COD most degraded is the variation of the ratio of 50%: 50%,.
namely the initial COD value of 296 mg/l to 105 mg/l on day 26, at a ratio of 75% / 25% experiencing degradation, namely 296 mg/l to 114 mg/l on the 26th day as well as the 100%: 0 ratio degraded by 296 mg/l at the beginning to 132 mg/l on the 26th day. From the results of the study it can be seen that sand height used as a variable for the measurement of COD has an effect on the decrease of COD. The higher the sand used then the bigger the COD will decrease. This is because the microbes contained in wastewater experience considerable contact with sand biofilter media which affects the decrease in the COD. If the higher the sand used, the contact time between microbes and sand and waste water becomes longer because the waste will often experience circulation. This resulted COD decreases become greater [12].

3.3. Profile of VSS in biosand filter tank
Volatile suspended solid (VSS) is the amount of organic material from suspended solids (TSS) which is removed through furnace combustion at 550°C for 2 hours and ash content calculation.

Figure 3 shows the effect of time on volatile suspended solid (VSS) can reduce VSS levels during the filter process in the biosand filter with variations in comparison between liquid waste laundry with nutrients that is 100%: 0, 75%: 25% and 50%: 50% (in% volume). At a ratio of 100%: 0 the value of volatile suspended solid (VSS) on day 1 was 265.5 mg/l which dropped to 96.82 mg/l on the 30th day. At a ratio of 75%: 25% the value of volatile suspended solid (VSS) on day 1 was 271.5 mg/l decreased to 97.34 mg/l on the 26th day. Likewise in the ratio of 50%: 50% with the value of volatile suspended solid (VSS) on day 1 was 271.2 mg/l decreased to 95.8 mg/l on day 26.

Microbial growth can be seen from the value of volatile suspended solid (VSS), at research on VSS values in liquids has decreased. The decrease in VSS in the liquid does not prove that there is no microbial growth or microbial growth or not in the biosand filter tank. Microbial growth or not in the biosand filter tank can be seen from the decrease in phosphate content in wastewater. According to the theory, the decrease in phosphate levels by using biological methods by utilizing activities microbes can reduce phosphate levels in wastewater. The decrease in VSS value can be caused by the retention of solids or suspended particles in the pores of the sand grains so that the solid or particles do not easily penetrate the surface of the sand media. One factor that plays an important role in reducing VSS content in wastewater is the height of the media in the screening process. So that the higher the media used, the higher the VSS
value will decrease. Another factor that plays an important role in reducing VSS content is the use of media used because the function of the media is as a place to grow from microbes.

3.4. Profile of phosphate in biosand filter tanks
Phosphate in wastewater can be organic phosphate, inorganic orthophosphate or as a complex phosphate. Organic phosphate can also come from bacteria or phosphate-absorbing plants [13]. Phosphate-containing detergents can cause stimulation of plant growth and surfactants in detergents can be toxic [14].

![Figure 4. Effect of time on phosphate degradation in biosand filter tank.](image)

Figure 4 shows the effect of time can reduce phosphate levels during the filter process in the biosand filter with a variation comparison between laundry liquid waste with nutrients that is 100%: 0.75%: 25% and 50%: 50% (in% volume). At a ratio of 100%: 0 the initial phosphate value is 19.1 mg / l to 5.2 mg / l on the 30th day. At a ratio of 75%: 25% the initial phosphate value is 19.1 mg / l to 4.8 mg / l on day 26. Likewise in the ratio of 50%: 50% the initial phosphate value is 19, mg / l to 4.3 mg / l on day 26. According to theory, decreasing phosphate levels by using biological methods by utilizing microbial activity can reduce phosphate levels in wastewater.

Bioreactor with attached culture or biofilter is a reactor equipped with media (support) as the place for microorganisms to grow, which is an attached growth reactor. The buffer media can be in the form of gravel, sand, plastic and activated carbon particles which can be partially or completely submerged in operation, or only through water. The function of media is as a place for the growth and development of microorganisms directly involved in wastewater treatment. These microorganisms will coat the surface of the media to form a thin mass layer called a biofilm [15][6].

4. Conclusion
The pH, COD and volatile suspended solid (VSS) and phosphate which are best decreased by the biosand filter tank in the laboratory scale are variations in the ratio of laundry liquid waste and nutrition 50%: 50% at pH 7.1 with an initial COD value of 296 mg / l to 105 mg / l and the initial VSS value was 271.2 mg / l to 95.8 mg / l with a phosphate reduction of 19.1 mg / l to 4.3 mg / l then the experiment by the biosand tank filter laboratory scale has potential for being developed.
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