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The Effectiveness of Silica and Activated Carbon Sand Filters in Reducing BOD, COD, and TSS Levels of Liquid Waste at Boalemo Regency Farmers and Fishermen Hospital

Putri Prisilya Bau[1]*, Herlina Jusuf[2], Moh. Rivai Nakoe[3]
[1,2,3]Jurusan Kesehatan Masyarakat, Fakultas Olahraga dan Kesehatan
Universitas Negeri Gorontalo, Indonesia.

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ABSTRACT

Hospital liquid waste is waste from medical activities in the form of liquids containing organic compounds, toxic chemicals, and pathogenic microorganisms that are harmful to health and the environment. The BOD, COD, and TSS parameters can be used to measure the content of organic and inorganic matter in hospital liquid waste. This study aims to determine the effectiveness of silica sand and activated carbon filters in reducing the levels of BOD, COD, and TSS of liquid waste at the Boalemo Regency Farmers and Fishermen Hospital.

The type of research is Quasi Experiment with a Pre Test-Post Test Group design. The sampling technique is Grab Sample. Wastewater samples were taken from a single reservoir (inlet) and analyzed before and after silica sand and activated carbon filtration. The data analysis technique uses the Paired Sample T Test.

The results showed that the BOD and COD levels of hospital liquid waste before and after filtration using silica sand and activated carbon with three filters were obtained as a result of a reduction in BOD levels of 94 mg/L (75.32%) and COD of 95 mg/L (78.21%). Meanwhile, TSS levels increased by 312.1 mg/L caused by saturation of filtration media. This media has been shown to be effective in reducing BOD levels with p-value = 0.000 and COD with p-value = 0.000. However, there was no difference in TSS levels before and after the filtration of silica sand and activated carbon with p-value = 0.109.

The Boalemo Regency Farmers and Fishermen Hospital is advised to monitor liquid waste and to further researchers to modify silica sand and activated carbon filtration media with other media to increase its effectiveness.

Corresponding Author:
Putri Prisilya Bau
Jurusan Kesehatan Masyarakat, Fakultas Olahraga dan Kesehatan
Universitas Negeri Gorontalo, Indonesia.
prisilyabauputri@gmail.com

INTRODUCTION

Hospitals are complex organizations, units and capital-intensive, technological and problematic, as well as the problem of dense waste produced by hospitals that can endanger public health. The hospital itself is designed as a place for public health services that are operated and must be maintained by paying attention to every aspect of human health and the environment which includes physical hygiene, solid waste and liquid waste, clean water, and insects or pests (Makaraung et al., 2022).

Hospital liquid waste is waste from the rest of medical activities in the form of liquids that contain materials that are harmful to the environment. Hospital liquid waste is one of the sources of potential environmental pollution. Hospitals that are located in the middle of residential areas or densely populated areas can sometimes cause their own problems in the community around the hospital environment. Wastewater from hospital activities is one of the sources of very dangerous water pollution. This is because

hospital wastewater contains organic compounds with a fairly high concentration and may contain other chemical compounds and pathogenic microorganisms that can cause disease to the surrounding community. Liquid waste containing chemical substances will not be able to be neutralized properly, so it is very dangerous for residents around the hospital. The main disease content seeps through the soil and directly into wells that are commonly used as a source of water consumption (Sari, 2020).

The BOD, COD, and TSS parameters can be used to measure the content of organic and inorganic matter in hospital liquid waste. The measurement parameter of BOD (Biological Oxygen Demand) is the amount of oxygen needed by bacteria to decompose almost all organic substances that are dissolved and absorbed in wastewater, if the BOD level in the waste remains high and is discharged into public water sources, the aquatic biota living in it will die because the bacteria in the wastewater absorb the oxygen needed by the biota to live, to decompose the organic matter in it. COD (Chemical Oxygen Demand) is the amount of oxygen needed to oxidize organic matter in wastewater using dichromate as an oxygen source. TSS (Total Suspended Solid) is a substance that is suspended in water and consists of organic and inorganic substances that cause turbidity in the water (Kurniajati et al., 2023).

Based on the pre-lab results conducted at the UPTD of the Gorontalo Provincial Regional Health Laboratory with the Grab Sample method, the results of the liquid waste (inlet) examination were obtained with a BOD value of 209 mg/L, COD of 247 mg/L, and TSS of 67.85 mg/L. The BOD, COD, and TSS values obtained did not meet the quality standards of the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016 concerning water quality standards domestic waste, which sets the standard quality standards for BOD of 30 mg/L, COD of 100 mg/L, and TSS of 30 mg/L. Therefore, it is necessary to carry out proper handling of wastewater treatment.

Boalemo Regency hospitals that serve the community, such as the Farmers and Fishermen Hospital, produce liquid waste that requires proper handling. One of the processing methods that can be used is with silica sand and activated carbon filters. Silica sand can be used effectively in water filtration, in addition to filtering water, silica can separate water and mud from other particles contained in water (Atma, 2022). Silica sand has granules with pores and crevices that are able to absorb and filter particles in water. The function of silica sand is to remove physical properties such as moss, turbidity, and odors in the water. When used in conjunction with activated carbon filter media, silica sand has the effect of reducing dissolved solids, turbidity, and color. It can be concluded that silica sand has uniform granules and is heavier compared to other media (Triana & Ariana, 2023).

Activated carbon is an amorphous compound produced from materials containing carbon or charcoal that are specifically required to obtain high absorption power. Activated carbon has a carbon content of about 85-95% which is produced from carbon-containing materials by heating at high temperatures and the activation process. Activated carbon has a considerable absorption capacity, which is 25-100% of the weight of activated carbon. Activated carbon has an abundant porous structure and strong adsorption capacity, widely used in a wide range of industries, including in the separation, removal of dyes and pollutants from wastewater, and in the water purification process (Lubis et al., 2020).

The combination of silica sand and activated carbon is effective in water filtration. Activated carbon has greater removal efficiency because activated carbon has a greater porosity and surface area of 0.78 so that the filtration process is improved. While silica sand has a role in filtering smaller particles, this is because the surface of silica sand is smoother and its absorption is also lower, but with the increasing area of media space. With the size of the media space, the existing pores will be more numerous, so that their absorption ability will be higher (Utari et al., 2022)

METHOD

The research was conducted for 3 months from December 2024 to February 2025. The sampling location at the Boalemo Regency Farmers and Fishermen Hospital was taken from an inlet. The treatment location was at the Public Health Laboratory of Gorontalo State University and testing of BOD, COD, and TSS samples at the UPTD of the Gorontalo Provincial Regional Health Laboratory Center. This type of research is a Quasi Experiment with a Pre Test-Post Test Group design. The sample in this study is 1500 ml of liquid waste obtained using the Grab Sample technique. Samples were analyzed before and after filtration using silica sand and activated carbon by three times of filtration. The data was then analyzed using the Paired Sample T Test.

Result
Univariate Analysis Results
BOD levels in hospital liquid waste before and after silica sand and activated carbon filtration.

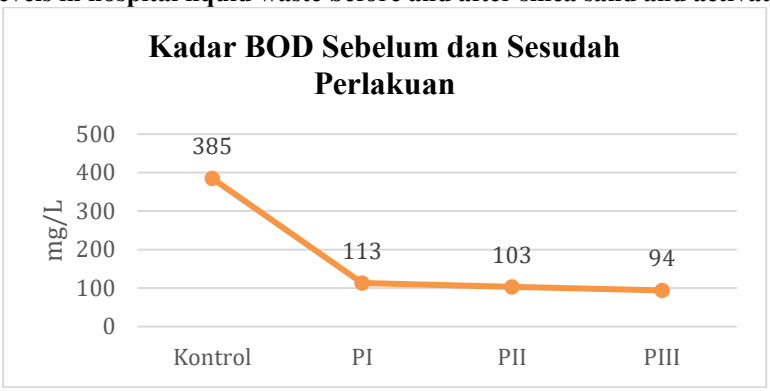

Figure 1 BOD levels before and after treatment
Source : Primary Data, 2025

Based on Figure 1, after the filtration treatment using silica sand and activated carbon, it is known that the BOD level decreased with an effectiveness of 75.32%. This can be seen from the trend line which shows a decrease from the starting point (control) of treatment of 385 mg/L to 94 mg/L.

COD levels in hospital liquid waste before and after through silica sand and activated carbon filtration.

Figure 2 COD levels before and after treatment
Source : Primary Data, 2025

Based on Figure 2, after the filtration treatment using silica sand and activated carbon, it is known that COD levels decreased with an effectiveness of 78.21%. This can be seen from the trend line which shows a decrease from the starting point (control) of treatment of 436 mg/L to 95 mg/L.

TSS levels in hospital liquid waste before and after through silica sand and activated carbon filtration.

Figure 3 TSS levels before and after treatment
Source : Primary Data, 2025

Based on Figure 3, after the filtration treatment using silica sand and activated carbon, it is known that COD levels have increased. This can be seen from the trend line which shows an increase from the starting point (control) of treatment of 54.55 mg/L to 312.1 mg/L.

Bivariate Analysis Results

Analysis of BOD level data on hospital liquid waste before and after through silica sand and activated carbon filtration.

Data Normality Test

Table 1 Data Normality Test

Parameters	Variable	*p-value*
BOD	Before screening	0,942
	After screening	

Source : Primary Data, 2025

Based on Table 1, the results of the normality test of BOD parameter data using the Shapiro-Wilk test obtained a p-value = 0.942 > 0.05, meaning that the data is normally distributed.

Paired Sample T Test

Table 2 Test Paired Sample T Test

Parameters	Variable	*p-value*
BOD	Before screening	0,000
	After screening	

Source : Primary Data, 2025

Based on Table 2, it is known that the results of the Paired Sample T Test BOD parameters were obtained with a p-value = 0.000 < 0.05, so it can be said that there is a difference in BOD levels in hospital liquid waste before and after silica sand and activated carbon filtration.

Analysis of COD level data in hospital liquid waste before and after through silica sand and activated carbon filtration.

Data Normality Test

Table 3 Data Normality Test

Parameters	Variable	*p-value*
COD	Before screening	0,843
	After screening	

Source : Primary Data, 2025

Based on Table 3, the results of the normality test of COD parameter data using the Shapiro-Wilk test obtained a p-value = 0.843 > 0.05, meaning that the data is normally distributed.

Paired Sample T Test

Table 4 Test Paired Sample T Test

Parameters	Variable	*p-value*
COD	Before screening	0,000
	After screening	

Source : Primary Data, 2025

Based on Table 4, it is known that the results of the Paired Sample T Test COD parameters were obtained with a p-value = 0.000 < 0.05, so it can be said that there is a difference in COD levels in hospital liquid waste before and after the filtration of silica sand and activated carbon.

Analysis of TSS level data on hospital liquid waste before and after through silica sand and activated carbon filtration.
Data Normality Test

Table 5 Data Normality Test

Parameters	Variable	*p-value*
TSS	Before screening	0,008
	After screening	

Source : Primary Data, 2025

Based on Table 5, the results of the normality test of TSS parameter data using the Shapiro-Wilk test obtained a p-value = 0.008 < 0.05, meaning that the data is not normally distributed.

Wilcoxon Test

Table 6 Wilcoxon Test

Parameters	Variable	*p-value*
TSS	Before screening	0,109
	After screening	

Source : Primary Data, 2025

Based on Table 6, it is known that the results of the Wilcoxon test of the TSS parameter were obtained with p-value = 0.109 < 0.05, so it can be said that there is no difference in TSS levels in hospital liquid waste before and after silica sand and activated carbon filtration.

DISCUSSION
Analyze BOD levels in hospital liquid waste before and after through silica sand and activated carbon filtration

This study was carried out to measure BOD levels before treatment in hospital wastewater samples with a result of 385 mg/L, then after filtration using silica sand and activated carbon, the results of a decrease in the first filtration of 113 mg/L, the second filtration of 103 mg/L, and the third filtration of 94 mg/L. The results obtained did not meet the quality standards of the Regulation of the Minister of Environment and Forestry Number 68 of 2016 which sets the quality standards of BOD by 30 mg/L.

Based on the results of the study in Figure 1 and Table 2 using the Paired Sample T Test to measure BOD levels carried out, it can be seen that there is a decrease in levels before and after the filtration process using silica sand and activated carbon, which affects the effectiveness of reducing BOD levels in hospital wastewater. This is because silica sand functions to separate solids from liquids by removing suspended and colloidal fine solids in wastewater. Activated carbon also functions to remove organic contaminants in wastewater.

According to Nirwana & Windraswara, (2020) silica has a negative charge at a neutral pH value so that it is able to attract positively charged particles in the form of colloidal compounds in the water to be purified. In addition, the decline also occurs due to the adsorption process. The adsorption process is zeolite and activated carbon. The adsorption process will cause physical (physisorption) or chemical (chemisorption) interactions between adsorben and adsorbate. The use of activated carbon (AC), as an absorber, has been shown to be effective in a variety of applications, including removing organic and inorganic pollutants from wastewater. Zeolite media that has been activated and modified has wider pores that can absorb organic waste optimally. Zeolite media provides habitat areas for microorganisms and supports enzymatic production so that the biodegradation of organic compounds and electron catalysis are more efficient.

This research is in line with the findings of Benyamin et al., (2020) about the reduction of BOD, TSS, and ammonia in hospital wastewater through the filtration process. In this study, the BOD level before filtration was 10.6 mg/L and then after the filtration process was 3.86 mg/L, which means that the filtration process was able to reduce BOD levels by 63.62%. So it can be concluded that the filtration process is effective in reducing the levels of BOD, TSS, and ammonia in hospital liquid waste.

Analyze COD levels in hospital liquid waste before and after through silica sand and activated carbon filtration

This study was carried out to measure COD levels before treatment in hospital wastewater samples obtained a result of 436 mg/L then after filtration using silica sand and activated carbon, the results of the reduction in the first filtration were 109 mg/L, the second filtration was 103 mg/L, and the third filtration was

95 mg/L. The results obtained in the first and second filtration did not meet the quality standards of the Regulation of the Minister of Environment and Forestry Number 68 of 2016 which set the COD quality standard of 100 mg/L but in the third screening it met the quality standard.

Based on the results of the study in Figure 2 and Table 4 using the Paired Sample T Test for COD measurement carried out, it can be seen that there is a decrease in levels before and after the filtration process using silica sand and activated carbon, which affects the effectiveness of reducing COD levels in hospital wastewater. Silica sand serves as an effective filtration medium, removing suspended and colloidal particles in wastewater. Meanwhile. Activated carbon has a high adsorption ability that allows it to attract and bind organic compounds and other pollutants in water.

According to Ronny & Syam, (2018) the thickness of a media has a great influence on the reduction of COD (Chemical Oxygen Demand) levels where the thicker the filter media, the greater the effectiveness of the process of reducing COD levels. This media has adsorbs properties, so it can be used to lower COD levels. Activated carbon can also perform ion exchange, which helps in removing harmful ions from wastewater. This process contributes to the reduction of COD by reducing the amount of organic and inorganic substances dissolved in water.

In the filtration system, a layer of silica sand is 25 cm thick and a layer of activated carbon is used to ensure an optimal water filtration process, where silica sand functions as a filter medium for coarse particles and activated carbon plays a role in absorbing organic substances, odors, and unwanted colors.

This research is in line with the findings of Izarna, (2022) regarding the reduction of liquid wastewater quality parameters in restaurants. In this study, the effectiveness of reducing the BOD parameter was 93.04% and the COD parameter was 83.86% with a thickness of silica media of 15 cm, zeolite 15 cm, activated carbon 15 cm, and filter cotton 15 cm. The decrease in COD levels is suspected to be due to a well-functioning activated carbon medium. The use of activated carbon filter media can absorb pollutants contained in domestic wastewater thereby reducing COD levels. In the filtration process, activated carbon media functions as a separator and can remove micropollutants from water such as organic substances and detergents.

In wastewater filtration systems, silica sand is composed at the most basic layer due to its crucial role in filtering fine pertiles and supporting other layers of filtration media. Silica sand, with its smooth and uniform grain size, is effective in capturing small particles that are not filtered by the media on it (Patrick, 2023).

Analyze TSS levels in hospital liquid waste before and after through silica sand and activated carbon filtration

This study was carried out to measure TSS levels before treatment in hospital wastewater samples obtained a result of 54.55 mg/L, then after filtration using silica sand and activated carbon, the results of the first filtration were obtained as much as 101.4 mg/L, the second filtration was 101.9 mg/L, and the third filtration was 312.1 mg/L. The results obtained did not meet the quality standards of the Regulation of the Minister of Environment and Forestry Number 68 of 2016 which set the standard TSS quality of 30 mg/L.

Based on the results of the study in Figure 3 and Table 6 using the Wilcoxon test of TSS measurement carried out, it can be seen that after filtration with silica sand and activated carbon, there is an increase in TSS levels in hospital wastewater. This is caused by the saturation of the filter media and the release of particles from the media. Wastewater filter media saturation is a condition when the filter media used in a wastewater treatment system is no longer able to filter, absorb, or retain contaminants such as organic matter, heavy metals, solid particles, or chemical substances because their absorption or filtration capacity has been met or saturated.

This is in line with the research of Assidiq & Hardoyo, (2023) the increase in TSS levels is due to the release of solid particles filtered by the filter media. The release of solid particles is caused by the flow pressure by the pump and the saturation of the filter media. Saturation occurs because the filter media can no longer capture the particles in the tofu liquid waste, which results in an increase in TSS concentration. Smaller silica sand is placed at the bottom, forming small cavities. This condition can cause the initial blockage of both large and small waste particles by silica media. The blockage causes unstable flow discharge so that there is an increase in TSS levels.

CONCLUSION

Based on the results of the study, it can be concluded that there is a difference in BOD levels in hospital liquid waste before and after silica sand and activated carbon filtration (p-value = 0.000). There were differences in COD levels in hospital liquid waste before and after silica sand and activated carbon filtration (p-value = 0.000). There was no difference in TSS levels in hospital liquid waste before and after silica sand and activated carbon filtration (p-value = 0.109).

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