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Effectiveness of Wastewater Treatment Plant in Reducing PO_4 and NH_3-N Pollutants at Tk. III Brawijaya Hospital Surabaya

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ABSTRACT

Hospital wastewater contains hazardous pollutants that, if untreated, can harm the environment and human health. This study aimed to evaluate the efficiency of the Wastewater Treatment Plant (WWTP) at Tk. III Brawijaya Hospital Surabaya by analyzing the removal percentage of phosphate (PO_4) and ammonia nitrogen (NH_3-N) parameters. This descriptive research collected wastewater samples from the inlet, primary, secondary, tertiary, and outlet stages of the WWTP. Laboratory analysis was conducted from September to December 2023 to measure PO_4 and NH_3-N concentrations. Results showed that the average removal percentage for phosphate was 70%, while ammonia nitrogen showed a removal rate of 33%. The concentration of PO_4 decreased from 0.01 mg/L at the inlet to 0.003 mg/L at the outlet, while NH_3-N concentrations dropped from 0.9 mg/L to 0.6 mg/L. Although the phosphate concentration met the regulatory standard, the ammonia nitrogen concentration remained above the threshold set by East Java Governor Regulation No. 72/2013 (0.1 mg/L). In conclusion, the WWTP demonstrated moderate efficiency in reducing phosphate but inadequate performance in removing ammonia nitrogen. Further improvements in aeration processes and increased retention times are recommended to enhance the treatment efficiency and ensure compliance with environmental regulations.

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INTRODUCTION

Indonesian Health Law No. 17 of 2023 states that environmental health efforts are aimed at realising the quality of ahealthy environment both physical, chemical, biological, and social which enables everyperson to achieve the highest degree of health . One of the environments that has considerable potential to be polluted by elements that can impact on public health is the hospitalenvironment. elements that can cause impact on the health of the community is the environmentof hospitals.

Every hospital that has been built will produce medical waste and non-medical waste. The waste produced must be treated first in the WWTP (Waste Water Treatment Plant) before it can be disposed again. The quality standard used is theEastJava Governor's Regulation No. 72 Year 2013 concerning Standard Quality of WasteWater for Business and/orhospital activities that require every hospital to treat wastewater to the permitted quality standard. However, there are still many hospitals that do not pay special attention to the water wastegenerated by the hospital.

Rumah Sakit Tk. III Brawijaya Surabaya built in year 1951 andis now categorised as a hospital type C, this hospital has total bedsof 111 pieces, WWTP at Rumah Sakit Tk. III Brawijaya Surabaya was built early around 2010, then underwent a complete renovation in 2019. WWTP Hospital Tk.

Brawijaya Surabaya III Hospital can accommodate a maximum wastewater discharge of 40 m^3, while the debit of wastewater generated per day is estimated at 33-34 m^3/day.

Based on preliminary studies on chemical parameters in the Hospital Tk. III Brawijaya Surabaya that has been conducted, which refers to Regulationof East Java Governor No. 72 of 2013 found that the parameter Ammonia Free (NH3-N) of 2.27 mg/L, while the quality standard that isset is at 0.1 mg/L and Phosphate (PO4) of 5.17 mg/L, while the established quality standard is 2 mg/L, then the results exceed the established quality standards, so it is necessary to conduct further analysis to calculate and determine the percentage of removal and efficiency of WWTP treatment at Tk. III Brawijaya Surabaya and provide efforts in reducing the parameters of Free Ammonia (NH3-N) and Phosphate (PO4).

The purpose of the study was to calculate and know the percentage of removal and efficiency of wastewater at the WWTP at Tk. III Brawijaya Surabaya. Measuring Chemical Parameters (NH3-N) and Phosphate (PO4) at the Inlet, primary, secondary, tertiary, outlet of WWTP Tk. III Brawijaya Surabaya hospital.

RESEARCH METHOD

This research used a descriptive method with a case study approach to evaluate the efficiency of the Wastewater Treatment Plant (WWTP) at Tk. III Brawijaya Hospital Surabaya. The descriptive approach was chosen to describe the actual conditions without any manipulation of variables, while the case study design was used to deeply understand the phenomenon in the context of real life, as described by Yin (1996). This research was conducted during the period September to December 2023.

The research location is the Wastewater Treatment Plant (WWTP) of Tk. III Brawijaya Surabaya Hospital, with supporting laboratory analysis carried out at the Laboratory Installation of the Diploma III Environmental Health Study Program in Magetan. This hospital was chosen based on consideration of WWTP capacity and the need to evaluate the effectiveness of wastewater treatment of phosphate (PO_4) and free ammonia (NH_3-N) parameters.

The population in this study is

all wastewater treated in the hospital WWTP. Samples were taken from wastewater at five strategic points that represent the stages of the treatment process, namely the inlet basin, primary basin, secondary basin, tertiary basin, and outlet basin. At each point, sampling was carried out in three replicates for each parameter tested, to ensure the validity and reliability of the results.

The parameters analysed in this study were the concentrations of phosphate (PO_4) and free ammonia (NH_3-N), two key indicators representing the quality of hospital wastewater. Measurements were conducted using the spectrophotometric method in accordance with standard laboratory procedures for water quality analysis, with the test method referring to the Indonesian national standard (SNI) related to the analysis of chemical parameters in wastewater.

Sampling was conducted using grab sampling technique at each point. Wastewater samples were immediately stored in sterile containers and analysed in the laboratory within no more than 24 hours to maintain the stability of the chemical parameters. All parameter measurements were conducted under standard laboratory temperature conditions (25 ± 2 °C) to minimise external influences on the results.

Measurement data were analysed quantitatively. The average concentration of PO_4 and NH_3-N at each stage of the WWTP process was calculated, then the treatment efficiency was calculated using the formula:

$$\text{Persentase Removal} = \left(\frac{\text{Konsentrasi Inlet} - \text{Konsentrasi Outlet}}{\text{Konsentrasi Inlet}} \right) \times 100\%$$

The treatment efficiency is assessed based on how much the concentration of both parameters decreases from the inlet basin to the outlet basin. The wastewater quality standard used as a reference is East Java Governor Regulation No. 72 of 2013, where the maximum concentration limit of PO_4 is 2 mg/L and NH_3-N is 0.1 mg/L.

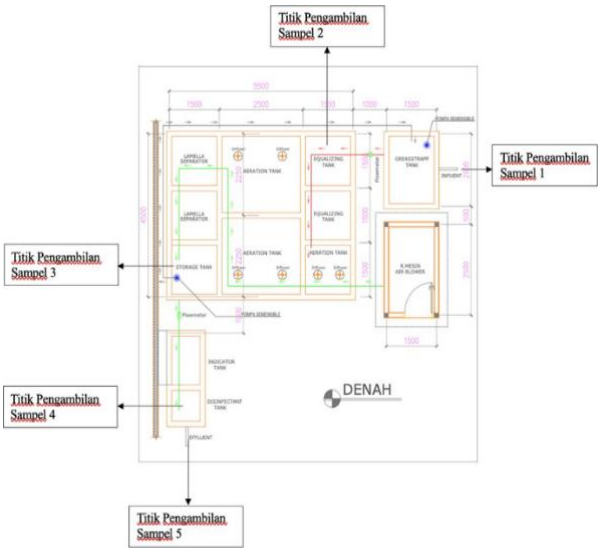

Figure 1
Sampling Location Points

RESULTS AND DISCUSSION

Table 1
Measurement Results at the Inlet Tub of the Hospital WWTP

Parameter	Point 1			Total	Average
	Replication				
	1	2	3		
Phosphate	0.02	0.01	0.01	0.04	0.01
Free Ammonia	0.9	0.8	1	2.7	0.9

Measurements of the basin inlet were carried out for 3 times replicate samples for each parameter tested and obtained measurement results of 0,9 mg/L for the NH3-Nparameter and 0.01 mg/L for the PO_4parameter.

Table 2
Measurement Results at the Hospital WWTP Primary Tub

Parameter	Point 1			Total	Average
	Replication				
	1	2	3		
Phosphate	0.01	0.02	0.007	0.037	0.1
Free Ammonia	0.9	0.8	0.9	2.7	0.9

Primary basin measurements were carried out 3 times replicate samples for each parameter tested and obtained measurement results of 0.9 mg/L for the NH3-Nparameter and 0.01 mg/Lfor the NH3-Nparameter.

Table 3
Measurement Results at the Hospital WWTP Secondary Tub

Parameter	Point 1			Total	Average
	Replication				
	1	2	3		
Phosphate	0.006	0.005	0.007	0.018	0.006
Free Ammonia	0.9	0.8	0.9	2.7	0.9

Secondary basin measurements were carried out as many as 3 replicate samples for each parameter tested and obtained measurement results of 0,9 mg/L for parameters NH3-N and 0.011 mg/L

Table 4
Measurement Results at the Hospital WWTPTertiary Basin

Parameter	Point 1			Total	Average
	Replication				
	1	2	3		
Phosphate	0.006	0.1	0.001	0.017	0.005
Free Ammonia	0.9	0.7	0.8	2.4	0.8

Measurements of tertiary basins were carried out as much as 3 times replicating samples for each parameter tested and obtained measurement results of 0,9 mg/L for parameters NH3-N and 0,005 mg/L for parameters PO4.

Table 5
Hospital WWTP Outlet Tub Measurement Results

Parameter	Point 1			Total	Average
	Replication				
	1	2	3		
Phosphate	0.004	0.003	0.003	0.009	0.003
Free Ammonia	0.7	0.5	0.6	0.8	0.6

Testing and obtained measurement results of 0.9 mg/L for the NH3-Nparameterand 0.011 mg/L for the PO4parameter.

Table 6
Analysis of efficiency water effluent and removal percentage of WWTP Hospital

Mean	Parameter	Point 1	Point 2	Point 3	Point 4	Point 5	Removal Percentage
	Phosphate	0.01	0.1	0.006	0.005	0.003	70%
	Free ammonia	0.9	0.9	0.9	0.8	0.6	33%

Wastewater efficiency and the percentage of WWTP removal obtained from calculation percentage of removal for paramter PO4 of 70%, while parameter NH3-Nby 33%.

MeasurementResults Levels NH3-N and PO4 At the Inlet Tub WWTP HouseHospital

The inlet basin is a water collection basin that will be processed to the next basin. The inlet basin serves as a basin for sampling wastewater for chemical, physical and biological examinations.

According to Table 1, the measurement results in the inlet basin that have been carried out found the results on the PO4 parameter found the highest measurement result of 0.02 mg/L while for the lowest measurement result of 0.01 mg/L and an average of 0.01 mg/L was found.

Then for the measurement results that have been carried out on the NH3-N parameter, the highest measurement result is 1 mg/L and the lowest measurement result is 0.8 mg/L, from the measurement results an average measurement of 0.9 mg/L is obtained.

From the results of these measurements, it cannot be concluded whether the WWTP at the Tk. III Brawijaya Surabaya Hospital is efficient or not, it is necessary to measure other treatment tanks and according to East Java Governor Regulation No. 72 of 2013 the NH3-N parameter exceeds the predetermined quality standard value, so it is necessary to carry out waste treatment so as not to pollute the environment.

Measurement Results of NH3-N and PO4 Levels in Hospital WWTP Primary Tubs

In table 2, measurements have been taken at the primary basin of the hospital WWTP and the highest PO4 parameter measurement result is 0.01 mg/L and the lowest measurement result is 0.007 mg/L so that the average obtained is 0.01 mg/L.

Then for the measurement results of the NH3-N parameter at the inlet basin, the results obtained did not increase or decrease from replication 1 to 3, namely 0.9 mg/L and an average of 0.9 mg/L.

From the results of measurements that have been carried out previously (inlet basin) there is no increase or decrease in the results of wastewater treatment in the hospital WWTP, both from the PO4 and NH3-N parameters, so that the NH3-N parameter still does not meet the quality standards that have been determined in accordance with East Java Governor Regulation No. 72 of 2013.

The impact of the NH3-N parameter from the primary basin is the entry of hospital wastewater into the environment whose treatment is less than perfect will result in a decrease in water quality in receiving water bodies such as rivers, which in turn causes problems, namely damage to the ecological balance in the river flow, health problems for residents who directly or indirectly use river water can reduce public health status and increase mortality due to waterborne infectious diseases and damage to fisheries in the estuary.

Measurement Results of NH3-N and PO4 Levels in the Hospital WWTP Secondary Basin

In the measurements at the secondary basin of the Hospital WWTP in the test results table V.3, the highest measurement result was found in the PO4 parameter, which was 0.007 mg/L while the lowest measurement was 0.005 mg/L, so that from these measurements an average result of 0.006 mg/L was obtained.

Then for the measurement results that have been carried out on the NH3-N parameter in the secondary basin there is no change in the measurement results in either replication 1-3, which is 0.9 mg/L so that the average obtained is 0.9 mg/L.

After measuring the secondary basin, it can be seen that there was an increase in the PO4 parameter from 0.01 mg/l to 0.006 mg/l, while the NH3-N parameter did not increase or decrease, it is necessary to increase the aeration process and add chemicals to reduce ammonia levels (Sampe, 2013).

Ammonia (NH3) is a colourless gas, corrosive, and has a pungent smell. The corrosive and exothermic nature of ammonia can cause damage to the eyes, mouth, oral mucous membranes and respiratory tract. Different concentrations of ammonia (NH3) have different impacts.

Ammonia content comes from laundry, operating theatres, bathrooms, laboratory equipment washing and kitchens. Phosphates are in wastewater in organic form. As inorganic orthophosphates or as complex phosphates. Complex phosphates represent approximately half of urban wastewater phosphates and originate from the use of synthetic detergent ingredients. Complex phosphates undergo hydrolysis during biological treatment to form orthophosphate (PO4)

Measurement Results of NH3-N and PO4 Levels in Hospital WWTP Tertiary Tubs

From the results of measurements in the tertiary basin that have been carried out in table V.4, it is found that the highest measurement result for the PO4 parameter is 0.01 mg/L and the lowest result is 0.001 mg/L, from the measurement results an average of 0.005 is obtained.

As for the NH3-N parameter that has been measured, the highest measurement result is 0.9 mg/L while the lowest measurement result is 0.7 mg/L, then an average of 0.8 mg/L is obtained.

After measuring the tertiary basin, it can be seen that there was a decrease in the PO4 parameter from 0.006 mg/l down to 0.005 mg/l, while for the NH3-N parameter there was a decrease in the tertiary process from 0.9 mg/l down to 0.8 mg/l but the decrease that occurred in the NH3-N parameter still did not meet the established quality standards. Increasing the waste residence time to 2x24 hours or more is in accordance with the results of monitoring carried out, because the wastewater flow rate and waste residence time affect the increase in ammonia levels (Pramaningsih et al, 2020).

Ammonia (NH3) levels in domestic wastewater, because it is found in almost every water body in various forms. Nitrogen can exist in water bodies in various forms. These forms include: N2, NO2- (nitrite), NO3- (nitrate), and NH3 (ammonia), the form of these elements depending on the degree of oxidation. Ammonia in surface water comes from urine and faeces, as well as from microbiological oxidation of organic matter.

Measurement Results of NH3-N and PO4 Levels in Hospital WWTP Outlet Tubs

In Table 5, measurements have been made of the PO4 parameter and the highest measurement result is 0.004 mg / L while for the lowest measurement of the PO4 parameter in the outlet basin is 0.002 and an average measurement of 0.003 mg / L is obtained.

Then measurements were taken for the NH3-N parameter and the highest measurement result was 0.7 mg/L while for the lowest measurement was 0.002 so that the average measurement obtained was 0.6 mg/l.

After measuring the outlet basin, it can be seen that the PO4 parameter measurement results have decreased from 0.005 mg/l down to 0.003 mg/l, then for the NH3-N measuring parameter in this process also decreased from 0.8 mg/l down to 0.6 mg/l, from the decrease that occurred in the NH3-N parameter it still did not meet the quality standard requirements set by East Java Governor Regulation No. 72 of 2013 so that further evaluation needs to be done to reduce NH3-N levels so as not to pollute the environment.

Analysis of Wastewater Efficiency and WWTP Removal Percentage

According to the researchers in table 6, it is known that the PO4 treatment process at the Tk. III Brawijaya Surabaya Hospital WWTP has decreased the treatment results in the sewage treatment process.

According to the results of the wastewater efficiency analysis, the percentage of total removal in the PO4 measuring parameter, the highest percentage of removal occurs in the calculation of the efficiency of the inlet basin - outlet basin, which is 70%.

Phosphate can also be a medium because phosphate reacts with a number of substances to form compounds that are not dissolved and easily absorbed by plants, where the concentration of dissolved organic phosphate in most waters is constant. Although a small amount of phosphate is dissolved in natural wastewater and when the amount increases it becomes harmful to aquatic life. An increase in phosphate concentration is a sign of pollutants in the water. Increased phosphate levels can be caused by the number of patient visits so that activities also increase with different activities. When phosphate levels increase within 24 hours if it exceeds the hospital waste quality standard (2 mg/L), it will affect human health, which can cause bone disorders. (Barus, 2019)

Then for the NH3-N measuring parameter seen from table V.6, the results of the efficiency analysis show that the NH3-N treatment process has also decreased in the wastewater treatment process at the WWTP.

According to the analysis of wastewater efficiency, the highest percentage of removal in the calculations carried out by researchers occurred in the calculation of the efficiency of theinletbasin-outlet basin, which was 33% and the resulting outlet results in the NH3-N measuring parameter were 0.6 mg/l, which means that the NH3-N treatment results at the Tk. III Brawijaya Surabaya Hospital WWTP exceed the predetermined quality standard of 0.1 mg/l.

According to Marsono, the NH3 removal efficiency is 90-95%. So it can be concluded that the condition of the Hospital WWTP is not efficient in treating liquid waste so that odour pollution occurs at the outlet of the WWTP. The maximum limit of NH3-N allowed according to East Java Governor Decree No. 72 of 2013 before discharge is 0.1 mg/l. This shows that the results of the NH3-N laboratory examination and the calculation of the average quality of the hospital's inlet and outlet WWTP effluent do not meet the requirements, resulting in odour pollution at the outlet of the WWTP.

Based on research conducted by Pramaningsih, it is stated that testing ammonia parameters at the inlet and outlet uses a 24-hour residence time with a conventional WWTP unit. The special treatment carried out is by increasing aeration and adding chemicals to help the waste degradation process, especially ammonia. If ammonia levels increase, the waste residence time in the WWTP is extended 2 times 24 hours or more according to the results of monitoring ammonia content (Pramaningsih *et al.*, 2020).

Sukadewi conducted a study to obtain the results that a decrease in ammonia levels occurred in an aerobic contracting basin where microorganisms decompose organic substances in wastewater by growing and sticking to the surface of the media and then expected a decrease in ammonia parameters in the chlorination process, namely giving chlorine water which functions to kill microorganisms in wastewater (Sukadewi *et al.*, 2020).

CONCLUSION

This study shows that the Wastewater Treatment Plant (WWTP) at Tk. III Brawijaya Hospital Surabaya is able to reduce the concentration of phosphate (PO_4) and free

ammonia (NH_3-N) pollutants in wastewater, although the effectiveness still varies. The average treatment efficiency for PO_4 parameters reached 70%, while for NH_3-N parameters it was only 33%. The average PO_4 concentration at the outlet basin was recorded at 0.003 mg/L, which is already far below the quality standard, while the NH_3-N concentration was 0.6 mg/L, still exceeding the threshold set in East Java Governor Regulation No. 72 of 2013.

These results indicate that, although the WWTP is effective in controlling phosphate levels, the free ammonia treatment process is still less than optimal and needs to be improved. Optimisation can be done through increasing the residence time, improving the aeration process, or using additional treatment methods such as biofiltration or nitrification-denitrification systems. Regular evaluation and upgrading of the treatment system is important to ensure that the discharged wastewater meets applicable environmental standards and minimises the impact of pollution on aquatic ecosystems.

SUGGESTIONS

Further improve the treatment of wastewater and increase the time of the aeration process and length of stay process treatment of wastewater. Can further explore the problem and provide treatment (experiment) use reduce parameters NH3-N which still meets quality standards.

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