IJDES
International Journal of Dynamics in Engineering System
Faculty of Engineering, Halu Oleo University
e-ISSN: xxxx-xxxx. Open Access at: https://ijdes.uho.ac.id

Improving Water Pollution Control from Hospital to Protect Ground Water Contamination in Wangi-Wangi Island, Indonesia

Uniadi Mangidi [1], Ranno Marlany Rachman [2], Agustan [2], Anafi Minmahddun [2], Erich Nov Putra Razak [2]

[1] *Department of Civil Engineering Halu Oleo University, H.E.A. Mokodompit Street, Kendari, 93232, Indonesia*
[2] *Department of Civil Engineering Halu Oleo University, H.E.A. Mokodompit Street, Kendari, 93232, Indonesia*

ARTICLE INFORMATION

Received: February 00, 00
Revised: March 00, 00
Available online:April 00, 00

KEYWORDS

Hospital WWTP, Performance, WWTP capacity, redesign

CORRESPONDENCE

E-mail: u.mangidi@uho.ac.id

A B S T R A C T

The hospitals are required to manage their waste to meet the required wastewater quality standards. This condition does not work properly at one of the government hospitals in Southeast Sulawesi. This study aims to evaluate the performance of hospital WWTPs and provide design recommendations. Evaluation of the WWTP building is carried out based on the discharge of wastewater obtained from the number of patient beds and the number of workers. The results show that the existing WWTP building is insufficient to accommodate the 36.484 liters of wastewater produced per day. Apart from that, leaks in the collection tanks and pipes are other reasons for the bad performance of WWTPs. The limestone soil also accelerates the process of seepage of wastewater, so it has potential to contaminate the soil and groundwater. Significance and impact study: To improve the function of the WWTP, a design was carried out with an anaerobic-aerobic biofilter system. This system consists of several parts with the following capacities: oil separation tank 3 m3, equalization tank 28 m3, initial settling tank 4.5 m3, anaerobic biofilter tank 25.2 m3, aerobic biofilter tank 13.95 m3; final settling tank 8.44 m3, and chlorination tank 1.584 m3.

INTRODUCTION

Hospitals are an essential component of the public health care system. Hospital operations generate waste, both liquid and solid, which, if not adequately managed, can contaminate the soil and groundwater [1]. The Indonesian Constitution on Environmental Protection and Management regulates all waste-generating activities to manage waste in the context of protecting environmental functions [2]. Since hospitals are typically located in the center of cities, the potential impact of hospital waste on the surrounding community is significant. Therefore, every hospital is required to have a good liquid waste management system [3].

Wakatobi Hospital is the only hospital in Wakatobi Regency, which is located on Wangi-Wangi Island. The hospital serves a huge number of patients because it is the referral center for all health centers in Wakatobi Regency, which has an impact on the amount of waste produced. Wakatobi Hospital has a Wastewater Treatment Plant (WWTP), but the condition is not proper because it does not meet the specifications. The dimensions of the existing WWTP chamber (50 cm x 100 cm) are insufficient when compared to the amount of waste that will be generated. Too many partitions are used in the WWTP tank, making it inefficient. In addition, there is no filter, so the existing waste will immediately settle and seep into the ground.

The position of the outlet pipe in the control tub is higher than the inlet pipe, so the wastewater does not flow, which causes an odor around the control tub. There are many leak points in the pipes, so much of the wastewater does not reach the main tanks. This condition was seen during field investigations where the storage tanks were empty. From a security perspective, the WWTP building is not equipped with a guardrail and is only covered with a thin steel plate.

https://doi.org/10.55679/xxxxx

The objective of this research is to redesign the WWTP in Wakatobi Hospital based on the required criteria. The redesign includes determining the dimensions of the fat separator tanks, equalization tanks, initial settling tanks, anaerobic and aerobic filter tanks, final settling tanks and chlorination tanks.

Second Level Heading

Second level heading must be written boldface and italics using upper and lower cases. You must set your second level heading left aligned.

Third Level Heading

Third level heading follows the style of the *second level heading*. Avoid the use of headings that have more than three levels.

Use reference manager such as Mendeley, Zotero or EndNote in citing works of others. Use the IEEE style. Citations put in the beginning of a sentence are also written using numbers within brackets. IJDES highly recommends the use of Mendeley in preparing references. Mendeley is preferred since it is free to download and use. IJDES also prepared a guidance in using Mendeley as a referencing tool.

METHOD

Calculation of Maximum Wastewater Discharge

The dimensions of the WWTP are determined by the volume of liquid waste generated by the hospital. Liquid waste is calculated based on the number of available beds and the need for clean water based on the hospital type, referring to the regulations of the minister of health [4]. Wastewater discharges are 70 % clean water discharge.

Calculation of WWTP Dimension

Design fat separation tank

The fat/oil separator tank is used for pre-treatment of waste. Separation of oil and fat is carried out using the physical method and handled manually, namely by settling the wastewater for some time so that the oil or fat or other impurities in the form of scum or others can float to the surface of the water. Wastewater flows slowly in an up flow and underflow manner from the first partition to the end of the tank, which aims to trap the contaminants. The dimensions of the fat separation and equalization tank are calculated using the following equation [5].

$$V_{max} = Q_w \times T_s \tag{1}$$

$$w = 30\% \times h_w \tag{2}$$

$$e = 10\% \times h_w \tag{3}$$

$$h_w = \frac{V_{max}}{L \times W} \tag{4}$$

$$h = h_w + e + w \tag{5}$$

Where:

V_{max} : Maximum volume of separation tank (m^3)
T_s : Settling time (s)
Q_w : Wastewater discharge (m^3/s)
Hw : Height of wastewater (m)
L : Length of tank (m)
W : Width of tank (m)
w : Freeboard (m)
e : Deposit height (m)

Design equalization tank

The equalization tank is a place for mixing all the wastewater from all over the room. Wastewater that was originally of various types (heterogeneous) will become similar (homogeneous). From the equalization tank, the wastewater will then flow into the initial settling tanks, where the settling process will occur. Calculation of the dimensions of the equalization tank uses equations 1 to 4 by changing the waiting time in the equalization process.

Design initial settling tank

The purpose of the initial settling tank is to precipitate suspended particles of silt, sand, and organic contaminants. It serves as a settling tank, as well as a tank for decomposing organic compounds in the form of solids and sludge (sludge decomposition), and as a sludge reservoir. Calculation of the dimensions of the equalization tank uses equations 1 to 4 by changing the settling time.

Design biofilter

The function of an anaerobic-aerobic biofilter tank is to reduce the content of biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) from processed products in accordance with environmental quality standards. The volume of the biofilter tank is the ratio between the waste load in the water and the allowable waste load [6].

Design chlorination tank

The function of the chlorination tank is to treat water from the settling tank so that it does not contain harmful substances before being released into water bodies. This process is done by adding chlorine. Calculation of the dimensions of the chlorination tank uses equations 1 to 4 by changing the settling time.

https://doi.org/10.55679/xxxxx

RESULTS AND DISCUSSION

Design Capacity of WWTP

In designing a WWTP, several things must be considered, including the fact that the system must be able to treat wastewater produced by the hospital. The capacity of a WWTP is determined based on the need for clean water used by patients and the number of hospital workers. Referring to Regulation of the Minister of Health No. 7 of 2019 [4], the patient's water needs for type C hospitals are 200 liters per person per day, and for staff, it is assumed to be 60% of the patient's needs. The large demand for clean water in hospitals is as follows:

$$Q_c = (Total\ bed \times 200) + (Total\ staff \times 120)$$
$$Q_c = (74 \times 200) + (311 \times 120)$$
$$Q_c = 52.120\ L/day$$
$$Q_w = 70\% \times Q_c = 0.00042\ m^3/s$$

Calculation of WWTP Dimension

Dimension fat separation tank

The settling time required for the oil separation process is assumed to be 1 hour [7], length and width of the tank is assumed to be 2 m and 1 m respectively. Calculation of the fat separation tank using equation 1-5 are as follows:

$$V_{max} = 0.00042\ m^3/s \times 3{,}600 = 1.512\ m^3$$
$$h_w = \frac{1.512\ m^3}{2\ m \times 1\ m} = 0.756\ m\ (L\ and\ W\ is\ assumption)$$
$$w = 30\% \times 0.756\ m = 0.227\ m$$
$$e = 10\% \times 0.756\ m = 0.075\ m$$
$$h = h_w + e + w = 1.058 \approx 1.5\ m$$

Based on the analysis, the dimension of fat separation tank can be seen in Figure 1.

Dimension equalization tank

The settling time required for equalization process is assumed to be 12 hours [7], length and width of the tank is assumed to be 4 m and 2 m respectively. Calculation of the equalization tank using equation 1-5 are as follows:

$$V_{max} = 0.00042\ m^3/s \times 43{,}200 = 18.144\ m^3$$
$$h_w = \frac{18.144\ m^3}{4\ m \times 2\ m} = 2.268\ m\ (L\ and\ W\ is\ assumption)$$
$$w = 30\% \times 2.268\ m = 0.680\ m$$
$$e = 10\% \times 2.268\ m = 0.227\ m$$
$$h = h_w + e + w = 3.175 \approx 3.5\ m$$

Based on the analysis, the dimension of equalization tank can be seen in Figure 2.

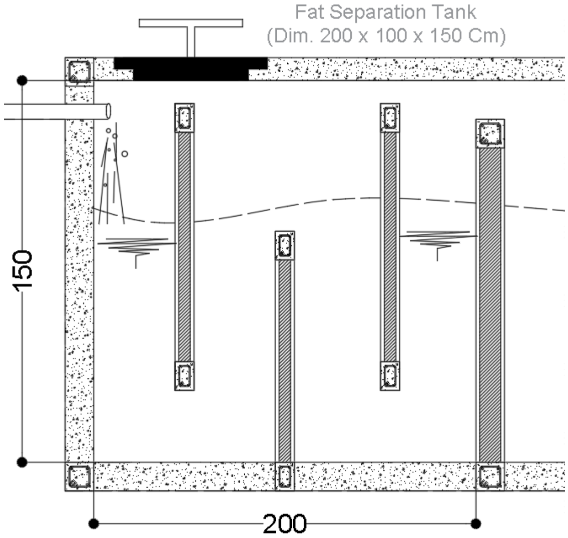

Figure 1. Fat Separation tank dimension

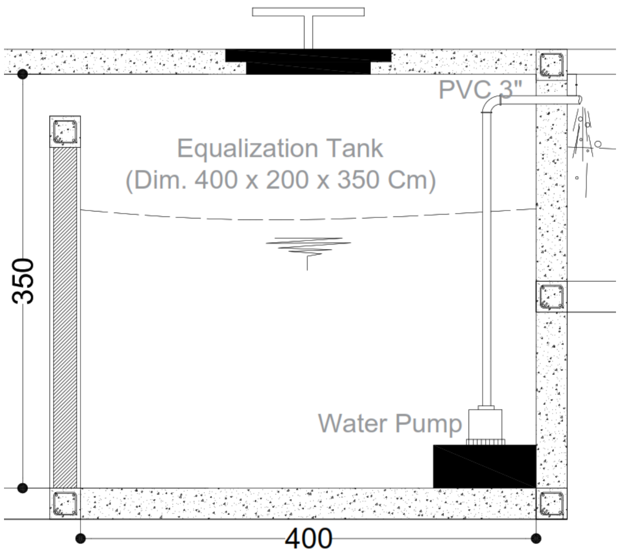

Figure 2. Equalization tank dimension

Dimension initial settling tank

The settling time required for initial settling process is assumed to be 2 hours [8], length and width of the tank is assumed to be 3 m and 1.5 m respectively. Calculation of the initial settling tank using equation 1-5 are as follows:

$$V_{max} = 0.00042\ m^3/s \times 7{,}200 = 3.024\ m^3$$
$$h_w = \frac{3.024\ m^3}{3\ m \times 1.5\ m} = 0.672\ m\ (L\ and\ W\ is\ assumption)$$
$$w = 30\% \times 0.672\ m = 0.202\ m$$
$$e = 10\% \times 0.672\ m = 0.067\ m$$
$$h = h_w + e + w = 0.941 \approx 1\ m$$

Based on the analysis, the dimensions of initial settling tank can be seen in Figure 3.

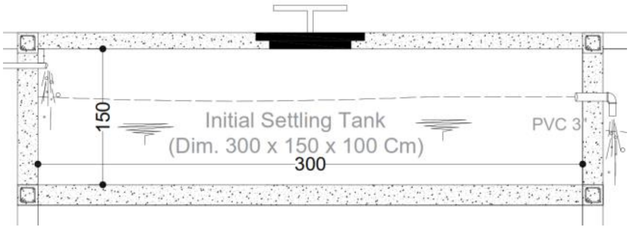

Figure 3. Initial settling tank dimension

Dimension anaerobic biofilter

For wastewater treatment with an anaerobic biofilter process, the BOD waste load is 225 gr/m^3. The standard BOD load per media volume for liquid waste in hospitals is 0.75 kg/m^3d, so the required media volume (Vm) and the reactor volume (Vr) are follows:

$$V_m = \frac{36.484\,m^3/day \times 0.225\,kg/m^3}{0.75\,kg/m^3 d} = 12\,m^3$$

$$V_m = 50\% \times V_r$$

$$V_r = 24\,m^3$$

Based on the volume requirements, the dimensions of the reactor and biofilter media are respectively 4 m x 3 m x 2.1 m and 4 m x 3 m x 1 m as seen in Figure 4.

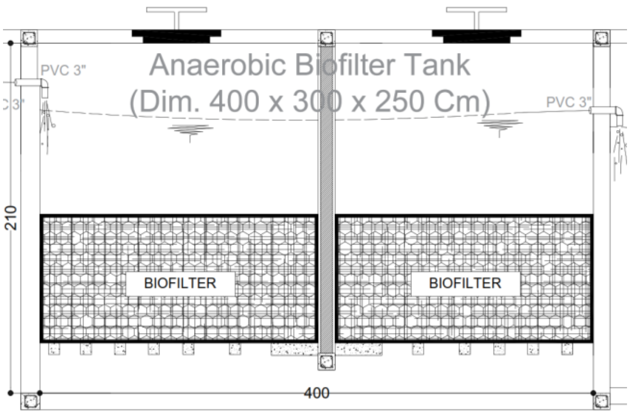

Figure 4. Anaerobic biofilter tank

Dimension aerobic biofilter

For wastewater treatment with an aerobic biofilter process, the BOD waste load is 75 gr/m^3. The standard BOD load per media volume for liquid waste in hospitals is 0.75 kg/m^3d, so the required media volume (Vm) and the reactor volume (Vr) are follows:

$$V_m = \frac{36.484\,m^3/day \times 0.075\,kg/m^3}{0.75\,kg/m^3 d} = 4\,m^3$$

$$V_m = 40\% \times V_r$$

$$V_r = 10\,m^3$$

Based on the volume requirements, the dimensions of the reactor and biofilter media are respectively 3 m x 1.5 m x 3.1 m and 2 m x 1.5 m x 1.35 m as seen in Figure 5.

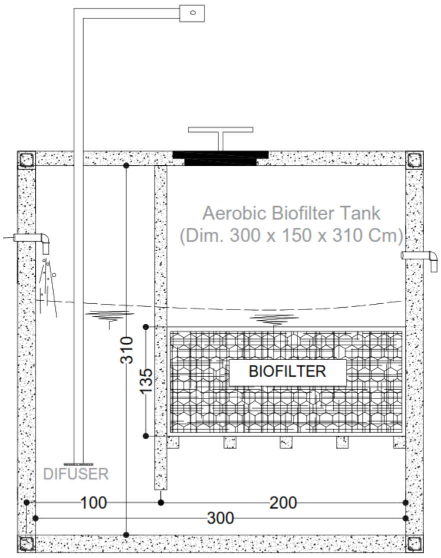

Figure 5. Aerobic biofilter tank

Dimension final settling tank

The settling time required for final settling process is assumed to be 4 hours [7], length and width of the tank is assumed to be 2 m and 2 m respectively. Calculation of the initial settling tank using equation 1-5 are as follows:

$$V_{\max} = 0.00042\,m^3/s \times 14{,}400 = 6.048 m^3$$

$$h_w = \frac{6.048\,m^3}{2\,m \times 2\,m} = 1.512\,m\,(L\,and\,W\,is\,assumption)$$

$$w = 30\% \times 1.512\,m = 0.454\,m$$

$$e = 10\% \times 1.512\,m = 0.151 m$$

$$h = h_w + e + w = 2.11 \approx 2.5 m$$

Based on the analysis, the dimensions of the final settling tank can be seen in Figure 6.

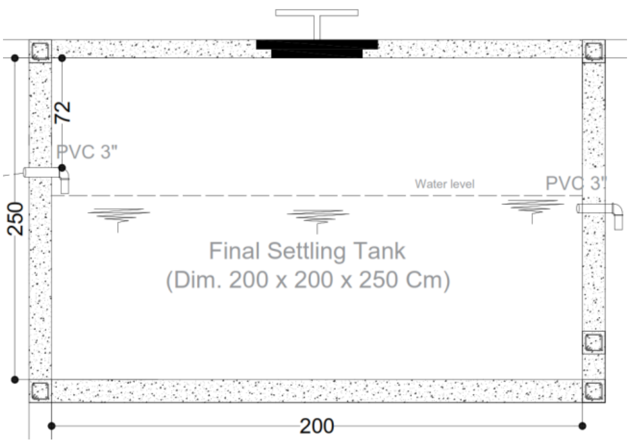

Figure 6. Final settling tank dimension

https://doi.org/10.55679/xxxxx

Dimension chlornitation tank

The settling time required for chlorination process is assumed to be 15 minutes [7], length and width of the tank is assumed to be 2 m and 1.5 m respectively. Calculation of the initial settling tank using equation 1-5 are as follows:

$$V_{\max} = 0.00042\,m^3/s \times 900 = 0.378\,m^3$$

$$h_w = \frac{0.378\,m^3}{2\,m \times 1.5\,m} = 0.168\,m\,(L\,and\,W\,is\,assumption)$$

$$w = 30\% \times 0.168\,m = 0.050\,m$$

$$e = 10\% \times 0.168\,m = 0.017\,m$$

$$h = h_w + e + w = 0.235 \approx 1.8\,m$$

Based on the analysis, the dimensions of chlorination tank can be seen in Figure 7.

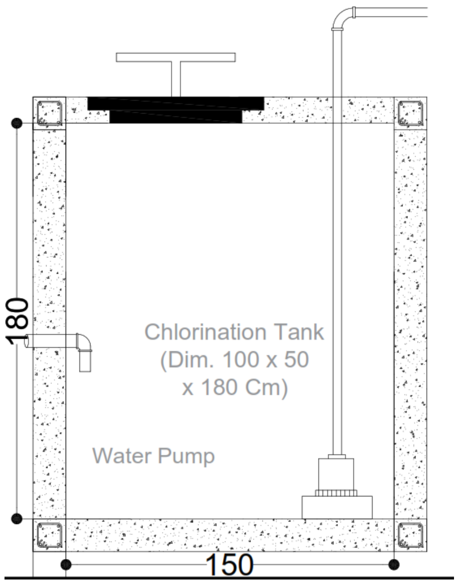

Figure 6. Chlorination tank dimension

Discussion

The results of the ideal WWTP dimensions according to the total waste generated by the hospital show that the conditions of the existing WWTP are far from ideal. From the aspect of WWTP capacity, the existing WWTP only contains partitions with dimensions of 50 cm by 100 cm, which are unable to accommodate the discharge of waste that will be generated by the hospital. From a functional aspect, the existing WWTP building does not have a clear path for managing waste. Wastewater is only allowed to settle without a filter that can decompose the waste before being released into water bodies. In addition, the base of the WWTP building has many cracks, so the wastewater seeps into the ground, thus contaminating the soil.

The WWTP building should be designed and built properly according to specifications, considering that hospital waste is a potential source of water pollution because it contains quite high levels of organic and chemical compounds [9], [10]. Hospital wastewater originating from domestic and clinical wastewater generally contains quite high levels of organic pollutant compounds. To manage Wakatobi Hospital waste, the recommended WWTP buildings can be seen in Figure 10.

Wastewater before being released into water bodies will go through several processes, such as initial settling to precipitate solid particles before entering the biofilter tank. Before being released into water bodies, the waste will go through a final stage by adding chlorine to ensure that the water to be released does not contain hazardous substances. To prevent leaks in the WWTP building, the walls and floors will use reinforced concrete materials to minimize the risk of seepage, which can contaminate the soil.

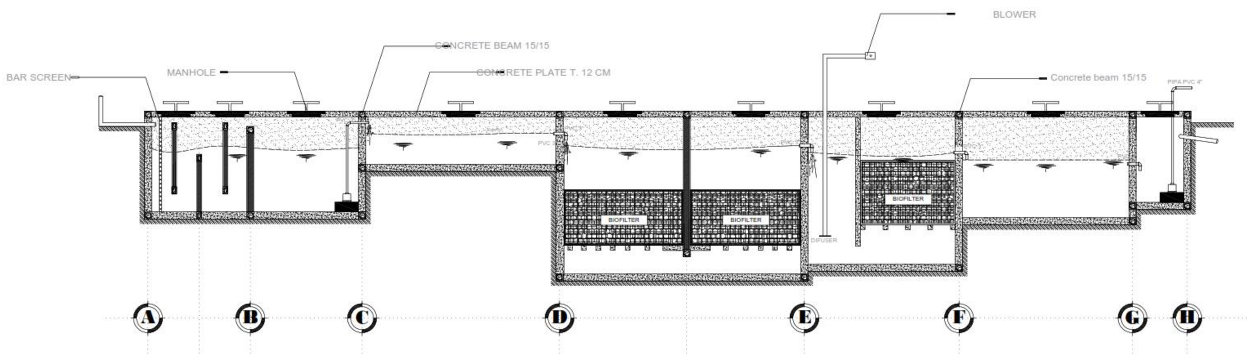

Figure 8. WWTP building plan

CONCLUSIONS

The results of the analysis show that the WWTP at Wakatobi Hospital is not functioning properly. This can be seen from the existing dimensions of the WWTP building, which are insufficient to accommodate the waste generated from hospital activities. In addition, the condition of the WWTP building, which was damaged at several points, was the cause of the WWTP not functioning properly. The results of the analysis of WWTP building space requirements show that the required volume for building grease separator tanks, equalization tanks, initial settling tanks, anaerobic biofilter tanks, aerobic biofilter tanks, final settling tanks, and chlorination tanks, respectively, 1.512 m^3, 18.144 m^3, 3.024 m^3, 1.512 m^3, 12 m^3, 4m^3, 6.048 m^3 dan 0.378 m^3.

ACKNOWLEDGMENT

The authors express gratitude to the Institution of Research and Community Service of Halu Oleo University and the Regional Government of Wakatobi Regency for financing contribution and providing access to the data needed for this research.

REFERENCES

[1] D.R. Sari, "Evaluasi Pengolahan Air Limbah dengan Sistem Extended Aeration di Runah Sakit X," Undergraduate Thesis, Universitas Negeri Semarang, 2015.
[2] Pemerintah Indonesia, "Undang-Undang Republik Indonesia Nomor 44 Tahun 2009 tentang Rumah Sakit, Sekretariat Negara," Sekretariat Negara, 2009.
[3] Pemerintah Indonesia, "Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup," Sekretariat Negara, 2009.
[4] Pemerintah Indonesia, "Peraturan Menteri Kesehatan Nomor 7 Tahun 2019 tentang Kesehatan Lingkungan Rumah Sakit," Sekretariat Negara, 2009.
[5] I. G. A. Sastrawijaya, "Perencanaan Instalasi Pengolahan Limbah Cair Rumah Sakit Wirabuana Kota Palu," Undergraduate Thesis, Universitas Tadulako, 2017.
[6] S. A. Zuhria, "Laju Penurunan BOD dan Karakteristik Limbah Cair Perebusan Kedelai Pembuatan Tempe Hasil Penanganan Fitoremediasi Eceng Gondok," Undergraduate Thesis, Universitas Tadulako, 2017.
[7] N.I. Said dan W. Hidayat, "Teknologi Pengolahan Air Limbah Rumah Sakit dengan Proses Biofilter Anaerob-Aerob," Pusat Teknologi Lingkungan Balai Pengkajian dan Penerapan Teknologi, 2013.
[8] A. Muzakky, "Evaluasi Dan Desain Ulang Unit Instalasi Pengolahan Air Limbah (Ipal) Industri Tekstil Di Kota Surabaya Menggunakan Biofilter Tercelup Anaerobik-Aerobik," Undergraduate Thesis, Institut Teknologi Sepuluh Nopember, 2016.
[9] Asmadi, "Pengelolaan Limbah Medis Rumah Sakit," Goysen Publishing, 2013
[10] M. Rosidi, "Perancangan Instalasi Pengolahan Air Limbah (IPAL) Pabrik Kertas Halus PT.X Sidoarjo," Undergraduate Thesis, Institut Teknologi Sepuluh Nopember, 2017.

NOMENCLATURE

Meaning of symbols used in the equations and other symbols presented in your article must be presented in this section.

ρ	meaning of ρ
E	meaning of E
J_c	meaning of J_c

AUTHOR(S) BIOGRAPHY

Author(s) Name
Author's biography must be short and concise (100 words maximum).

APPENDICES

Only materials supporting your article can be considered for appendices. Appendices must be presented after Authors Biography. Appendices cannot be more than 4 pages. If your appendices have tables, figures or equations, number them in sequence.

https://doi.org/10.55679/xxxxx