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Performance of Microalgae *Chlorella sp.* to Remove Phosphate in Domestic Wastewater Using Oxidation Ditch Algae Reactor (ODAR)

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ABSTRACT

Domestic wastewater contains high organic and inorganic materials. One alternative treatment that can be used is to use Oxidation Ditch Algae Reactor with microalgae *Chlorella sp*. The reactor is expected to reduce the concentration of phosphate in domestic wastewater. This study aims to determine the effectiveness and role of microalgae *Chlorella sp* in degrading phosphate in domestic wastewater. The variations used in this study were variations in the ratio of the volume of waste to microalgae (1: 0 and 1:2) and variations in conditions (oxic and oxic-anoxic). This research was conducted for five days each time running. The optimum yield of phosphate removal occurred under oxic-anoxic conditions with a volume ratio variation of 1:2, which was 78.81%. This study indicates that the microalgae *Chlorella sp* is effective for removing phosphate in domestic wastewater.

Keywords: Oxidation ditch, Chlorella sp, phosphate, oxic, anoxic

Introduction

Domestic wastewater to be released into the environment still has high inorganic and organic concentrations. Therefore, it is necessary to do good processing, one of which is the use of microalgae. The use of microalgae is more efficient than other methods, and besides that, it also requires less space and higher photosynthesis compared to other plants (Gilbert & Ashraf, 2018). The use of microalgae is more efficient and safe for the environment when compared to conventional methods because it does not cause additional pollution. Microalgae are also capable of assimilation with nitrogen and phosphorus (Wang et al., 2012).

In addition to reducing the content of harmful substances, processing with microalgae also utilizes wastewater as a medium. Microalgae will take up nutrients in wastewater for growth. Microalgae that are often used in wastewater treatment processes are *Chlorella sp*. *Chlorella sp* is a single-celled green alga with a photosynthetic efficiency of 6-7.1% (Gilbert & Ashraf, 2018). Previous research explained that *Chlorella sp*. could remove phosphorus. The use of Chlorella for sewage treatment is not a new idea. Researchers have also developed techniques to increase nutrient disposal capacity as well as ways to exploit *Chlorella sp*., which grows rapidly (Wang et al., 2012).

One of the domestic waste treatment methods using the microalgae *Chlorella sp* is the Oxidation Ditch Algae Reactor (ODAR). An oxidation ditch is a reactor that has high removal efficiency. This reactor utilizes microorganisms suspended in it and also air contact. Applying the brush aerator in this reactor minimizes the occurrence of the microorganism deposition at the bottom of the reactor. Oxidation ditch also produces less sludge than other reactors (Nurrohman, 2016).

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In addition, the use of Oxidation Ditch Algae Reactor (ODAR) can be varied between the volume of waste and oxic-anoxic conditions. In oxic conditions, the waste in the Oxidation Ditch Algae Reactor will be processed by utilizing aerobic microorganisms, using oxygen as energy for the metabolism of these bacteria. Pollutants will be broken down by microorganisms to produce carbon dioxide, energy, water and new cells for the metabolic processes of microorganisms such as respiration, oxidation, and growth. Meanwhile, during anoxic conditions, a denitrification process will occur. It is hoped that with the variation of these conditions, it is possible to know how the comparison is made for the oxidation of the Ditch Algae Reactor process in reducing phosphate parameters.

A previous study explained that dissolved oxygen (DO) in gray water and artificial wastewater could increase with the use of Oxidation Ditch Algae Reactor, which was 37.5% and 23.7%, respectively. This is certainly influenced by the existence of important variables that play a role in supporting the growth of microalgae, such as chlorophyll and also the ability of the Oxidation Ditch Algae Reactor to work (Ardhiani et al., 2016). With 24-hour aeration, ODAR can also reduce phosphate (PO_4^{3-}) with the best removal result of 38% (Putra & Farahdiba, 2018).

This research will be conducted to learn more about the effectiveness and role of microalgae Chlorella sp in degrading phosphate in domestic wastewater using an Oxidation Ditch Algae Reactor.

Research Method

This research was conducted at Jl.Cisedane No.20, Darmo, Wonokromo, Surabaya City. It was carried out on a pilot scale using domestic wastewater samples at Rusunawa Penjaringansari 2, Pandugo, Surabaya. The method used is biological treatment using Oxidation Ditch with microalgae *Chlorella sp* with a batch system. The analyzed parameter is phosphate.

The research was carried out with several variations, including the comparison between the volume of waste with microalgae and variations in oxic (24 hours) and oxic-anoxic (7 hours on and 3 hours off) conditions in the Oxidation Ditch Algae Reactor (ODAR). Each variable was run for five days.

Result and Discussion

Preliminary research

Seeding and acclimatization process

Seeding is done by culturing pure *Chlorella sp* seeds. Seeding is done by mixing pure *Chlorella sp* seeds with zero TDS water in a ratio of 1:2 into a container. Aeration, wood nutrition, and adequate lighting are required during the seeding process. The irradiation process is carried out using a lamp. The container is closed with a clear transparent lid to minimize the insects entering the container. The seeding process lasts for 5-7 days. During seeding, the pH must be maintained in the 8-9 range. The growth of microalgae in seeding can be physically observed by changing the color of the algae from a clear green to a darker green. The darker the green color of the algae, the higher the amount of chlorophyll-a. The increasing chlorophyll-a concentration also indicates that algae grow in the Oxidation Ditch Algae Reactor (Nurrohman, 2016). The concentration of chlorophyll-a in algae of 0.6 mg/l can be used for the next process.

At the acclimatization stage, it is done by adding domestic wastewater little by little into the container that has been filled with microalgae. This step aims to see to what extent microalgae can adapt and survive in a new environment. Acclimatization is done by adding 3.5 liters of domestic wastewater gradually for five days into a container filled with 3.5 liters of microalgae *Chlorella sp*. During the acclimatization process, temperature, DO, and pH were checked. The results of checking are temperatures in the range of 27-29^{0}C, DO in the range of 5-8.5, and pH in the range of 8-8.9. The acclimatization stage will end when the color of the *Chlorella sp* microalgae, originally fresh green, becomes brownish-green, which means that the *Chlorella sp* microalgae can no longer accept higher concentrations of wastewater (Farahdiba et al., 2020).

Main research

The study was conducted with a deep batch system for 5 days. The research was conducted with different volume variations of wastewater and microalgae, namely 1:0 and 1:2. The rotation speed of the brush aerator used in the Oxidation Ditch Algae Reactor is 60 rpm. Each variation will be conditioned into two different conditions, namely oxic and oxic-anoxic. The existence of these conditions is expected to know the comparison for the process of Oxidation Ditch Algae Reactor in reducing phosphate parameters in domestic wastewater. The use of a brush aerator in this reactor minimizes the occurrence of microorganism deposition at the bottom of the reactor so that it produces less sludge than other reactors (Nurrohman, 2016). Stirring in the reactor will also facilitate the mixing of nutrients evenly. Preliminary test results for domestic wastewater Rusunawa Penjaringansari 2, Pandugo, Surabaya can be seen in Table 1.

Table 1. Results of analysis of domestic wastewater characteristics

No	Parameter	Unit	Test Result
1	pH	-	7,4
2	Temperature	^{0}C	27
3	Phosphate	mg/l	3,35

Source : Analysis results, 2021

Initial analysis for domestic wastewater Rusunawa Penjaringansari 2, Pandugo, Surabaya obtained the phosphate content in the wastewater is3.35 mg/l. The microalgae expected can use it as a nutrient to survive and reproduce. Phosphate in the waters is in the form of orthophosphate (PO_4), indicating fertility in these waters. However, if the phosphate content is too high, it will also be dangerous and cause many algae to grow so that less sunlight enters the waters. When algae die, bacteria will break them down using dissolved oxygen in the water (Patricia et al., 2018).

After five days of experiment with determining variations and conditions, the data and graphs of the percentage of phosphate removal are obtained from the analysis results. The data from the oxic condition phosphate analysis results can be seen in Table 2. The results of the oxic-anoxic condition phosphate analysis can be seen in Table 3. Meanwhile, the graph of phosphate removal in oxic conditions can be seen in Figure 1. The graph of the phosphate removal rate in the oxic state. Anoxic analysis results can be seen in Figure 2.

Table 2. Results of analysis of phosphate concentration in oxic conditions

Condition	Variation of Wastewater: Microalgae	Sampling Time (days)	Phosphate (mg/L)	Percent Removal
Variation of Speed 60 rpm	1 : 0	0	3,35	0
		1	3,07	8,36
		2	2,94	12,24
		3	2,78	17,01
		4	2,34	30,15
		5	1,97	41,19
	1 : 2	0	3,35	0
		1	3,25	2,99
		2	2,18	34,93

To be continued

		3	2,05	38,81
		4	1,74	48,06
		5	1,56	53,43

(Source: Analysis results, 2021)

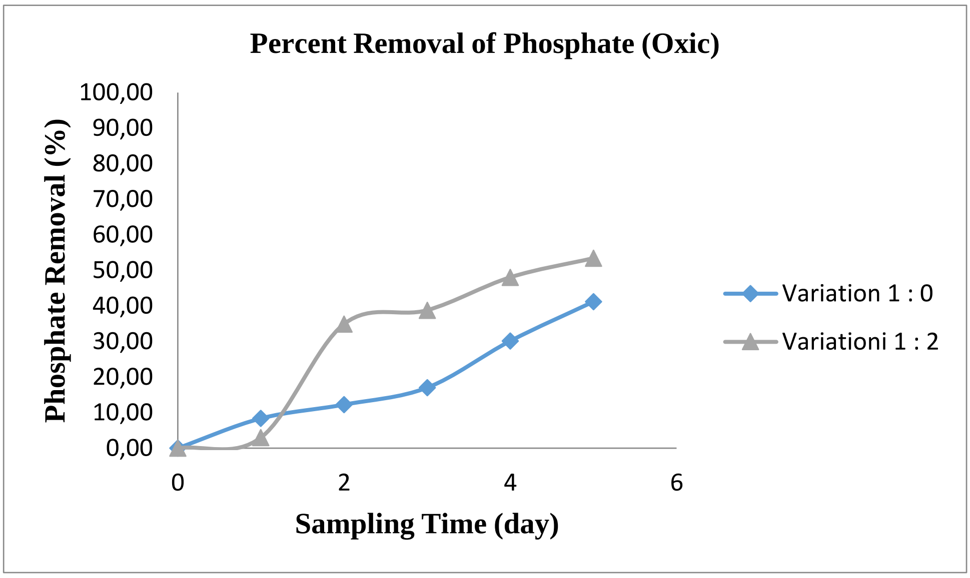

Figure 1. Relation of Variation in Comparison of Volume and Sampling Time and Oxic Conditions on Phosphate Reduction

From figure 1, we can see data on the decrease in phosphate on volume variables, and oxic conditions in domestic wastewater were obtained using a brush aerator speed of 60 rpm. Based on the observations from the first day to the fifth day, the highest percentage of phosphate removal was found in the 1:2 variation, which was 2.99%; 34.93%; 38.81%; 48.06%, and 53.43%.

Table 3. Results of analysis of phosphate concentration in oxic-anoxic conditions

Condition	Variation of Wastewater: Microalgae	Sampling Time (days)	Phosphate (mg/L)	Percent Removal
Variasi Kecepatan 60 rpm	1:00	0	3,35	0
		1	2,41	28,06
		2	1,64	51,04
		3	1,05	68,66
		4	0,83	75,22
		5	0,98	70,75
	1 : 2	0	3,35	0
		1	2,75	17,91
To be continued		2	2	40,3

		3	1,02	69,55
		4	0,88	73,73
		5	0,71	78,81

(Source : Analysis results, 2021)

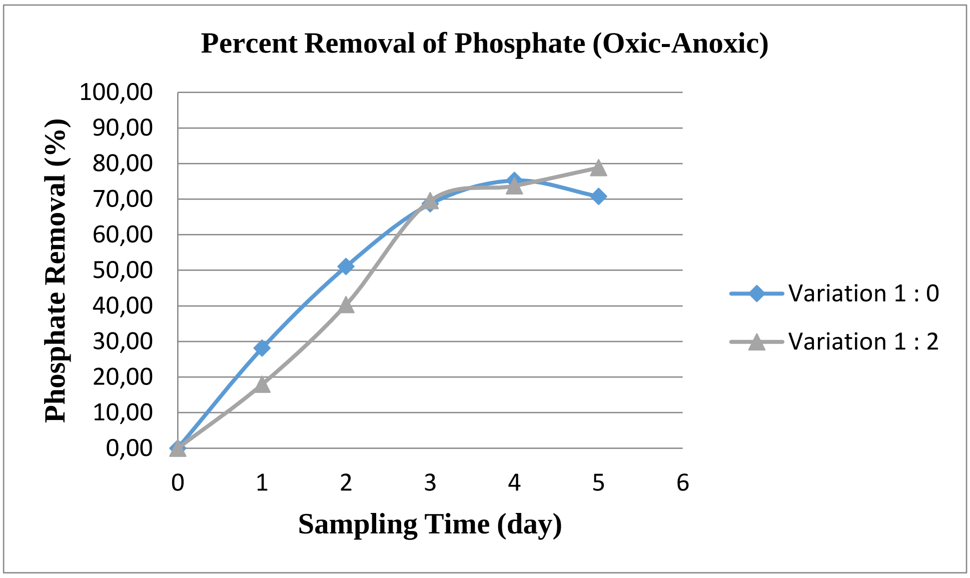

Figure 2. Relation of variation in comparison of volume and sampling time and oxic-anoxic conditions on phosphate reduction

From Figure 2, we can see that the data on phosphate reduction on volume variables and oxic-anoxic conditions in domestic wastewater was obtained using a brush aerator speed of 60 rpm. Based on observations from the first day to the fifth day, the highest percentage of phosphate removal was found at a 1:2 variation of 17.91%; 40.30%; 69.55%; 73.73%, and 78.81%.

In Figure 1 and Figure 2, it can be seen that the highest percentage of phosphate reduction in domestic wastewater occurred when the oxic-anoxic conditions varied 1:2, which was 78.81%. In oxic states, the bacteria will get energy from the hydrolysis of polyphosphate, releasing Pi. In anoxic conditions, PAO bacteria (polyphosphate accumulating organism) will return polyphosphate through phosphate taken from domestic wastewater as energy. It makes the process of denitrification more optimally than the nitrification process. So that PAO bacteria that work in the denitrification process will be more optimal in removing phosphate under oxic-anoxic conditions (Sang et al., 2020). Bacteria belonging to PAO and capable of reducing phosphate include *Aerobacter*, *Acinetobacter*, *Mycobacterium*, and *Beggiatoa* (Yadaturrahmah & Hendrasarie, 2021).

Another factor that affects the decrease in concentration is volume variation. Microalgae can secrete mucus to capture calcite (a natural mineral with high phosphate adsorption) and form crystals on the cell surface. Calcite caught and attached to the cell surface will become EPS (extracellular polymeric substance). EPS plays an important role in absorbing phosphate in microalgae *Chlorella sp* (Haiying et al., 2016). Therefore, if the volume of *Chlorella sp* microalgae increases, the EPS produced will also increase so that the decrease in phosphate concentration will be higher.

Conclusion

Based on the results, we can conclude that Microalgae *Chlorella sp,* in collaboration with PAO bacteria (Polyphosphate Accumulating Organism), can remove phosphate with a maximum removal reach 78.81% in oxic-anoxic conditions in domestic wastewater using Oxidation Ditch Algae Reactor (ODAR).

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References

Ardhiani, R. R., Farahdiba, A. U., & Juliani, A. (2016). Performance of Oxidation Ditch Algae Reactor (ODAR) for organic compound removal of grey water. *Icsbe: Fourth International Conference on Sustainable Built Environment 2016.*

Farahdiba, A. U., Hidayah, E. N., Zara, D. W., & Linh, N. T. T. (2020). The feasibility of algae treatment treating fecal sludge wastewater at Surabaya, Indonesia. *Asian Journal of Water, Environment and Pollution, 17*(3), 1-6. Doi: 10.3233/AJW200027

Haiying, L., Feng, Y., Wu, Y., Yang, L., & Shao, H. (2016). Phototrophic periphyton techniques combine phosphorous removal and recovery for sustainable salt-soil zone. *Science of The Total Environment, 568*. Doi:10.1016/j.scitotenv.2016.06.010

Nurrohman, R. (2016). Oxidation Ditch Algae Reactor (ODAR) dalam pengolahan nutrien limbah greywater perkotaan. *Undergraduate Thesis.* http://hdl.handle.net/123456789/2663

Patricia, C., Astono, W., & Hendrawan, D. I. (2018). Kandungan Nitrat dan Fosfat di Sungai Ciliwung. *Prosiding Seminar Nasional Cendekiawan 2018 Buku 1.* Doi: http://dx.doi.org/10.25105/semnas.v0i0.3373

Putra, A. H., & Farahdiba, A. U. (2018). Performance of algae reactor for nutrient and organic compound removal. *Proceedings of the International Conference on Science and Technology (ICST 2018).*

Randrianarison, G., & Ashraf, M. A. (2018). Microalgae Plant *(Chlorella Sp.*) for wastewater treatment and energy production. *Ekologi, 27*(106), 1455-1465.

Sang, W., Li, D., He, Y., Zhan, C., Zhang, Q., Li, C., & Singh, R. P. (2020). Sludge reduction and pollutants removal in anaerobic-anoxic-oxic reactor with 2450 MHz electromagnetic wave loading on returned sludge: Performance and mechanism. *Process Safety and Environmental Protection, 147*(7054), 68-79. Doi:10.1016/j.psep.2020.09.027

Wang, C., Yu, X., Lv, H., & Yan, J. (2012). Nitrogen and phosphorus removal from municipal wastewater by the green alga *Chlorella sp. J Environ Biol. 32*(2), 421-5.

Yadaturrahmah, I. R., & Hendrasarie, N. (2021). Pengaruh penambahan impeller pada fase aerobik terhadap efisiensi kinerja sequencing batch reactor pada limbah cair industri tahu. *Jurnal Envirotek, 13*(1), 115-120. https://doi.org/10.33005/envirotek.v13i1.102