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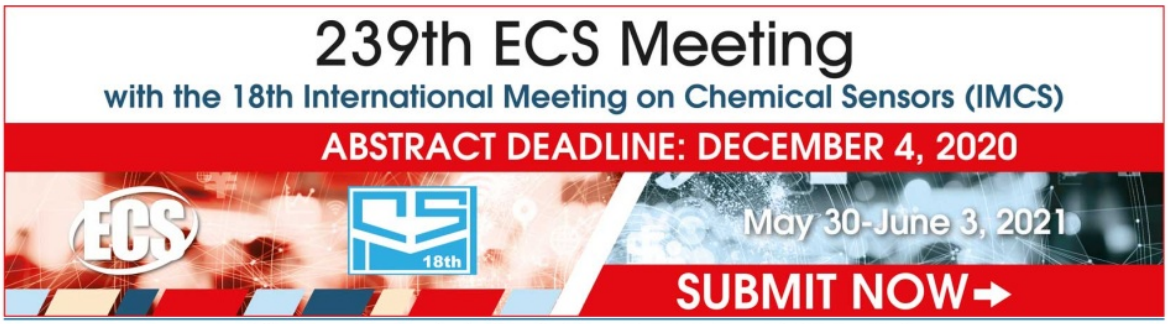

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Effect of Rotation Speed on Phosphate and Nitrate Removal from Domestic Wastewater in The Oxidation Ditch

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Abstract. Oxidation Ditch (OD) has been widely used for domestic wastewater treatment technology, especially in Indonesia. In its operation, an OD uses a rotor to increase oxygen concentration. This rotational speed of the rotor will be valuable in OD performance for decreasing contaminants, especially nutrients. Remaining high concentration of nutrients at the end of the processing unit might generate environmental issues. This study analyses the effect of rotational speed on pilot scale OD. Rotation speed conducted were 45 rpm and 60 rpm. The study was conducted for five days by measuring nitrate, phosphate, dissolved oxygen, temperature and pH. The difference between 45 and 60 rpm on nitrate reduction was not significant. The decrease in total P at 45 and 60 rpm tended to increase steadily until the fourth day but experienced a slight decrease on day 5. The complexity of N and P processes in OD pilot scale units were much noticable. Efficient removal of nitrate concentrations was influenced by the lack of anoxic conditions to enable the denitrification process. Supplementary wastewater treatment unit was needed to reduce nutrient levels.

Keywords: oxidation ditch, nitrate, phosphate, bacteria

1. Introduction

Domestic Wastewater must be treated to protect public safety and environmental quality [1]. Oxidation ditch applied in the world for treating domestic wastewater has a high nutrient removal ability [2][3]. The ditch is a trench-shaped tub used for treating wastewater by utilising oxygen (aerobic conditions) within an anoxic condition in several parts of the ditch. This oxidation pond is utilised in wastewater purification process after a preliminary process. [4].

Aeration management is one of the critical factors that could enhance removal efficiency in the oxidation ditch performance [2][5]. Previous studies concluded that aeration could practically affect nutrients removal performance in the wastewater treatment plant within the nitrification and denitrification process [6]. According to [4], an oxidation ditch has a removal ability of up to 85% to 90% and less sludge is produced compared to other reactors. Moreover, the use of a pedal or brush aerator can prevent the deposition of microorganisms at the bottom of the reactor. The deposition of microorganisms can reduce the efficiency of the reactor.

Mixing different states of aeration could affect the dissolved oxygen in the reactor e.g. when the surface aeration is different from the diffusive aeration system [7]. Previous study presents the urgency of oxygen consistency with simulation to predict the performance of biological processes [1],

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[2], [5]. This study aims to remove most nitrate, such as total phosphate and nitrate within several mixing (aeration) conditions.

2. Materials and methods

2.1. Analytical methods

Wastewater components were immediately filtered using 0.45 µm filter paper in the soluble form. Daily analyses of nitrate (NO3-N) and phosphate (PO_4^{3-}) using a spectrophotometer were done based on standard methods [8]. The environmental conditions including Dissolved oxygen (DO) and pH were measured by a DO meter by Lutron and a pH meter by Trans instrument.

2.2. Experiments set-up and operation

An initial analysis was carried out on domestic wastewater characteristics including total P and nitrate. This research was conducted on a pilot scale with a processing capacity of 300 litres and is located at Universitas Pembangunan Nasional Veteran Jawa Timur in East Java, Indonesia. The ditch was 2.08 m long and 1.08 m wide.

The processing equipment design consists of an open field in the form of a running field equipped with a dynamo to drive the propeller. There is also a speed regulator to adjust the speed of the rotating propeller. The waste was then gradually fed into the reactor and the brush aerator was turned on with predetermined speeds, at 45 rpm and 60 rpm. The wastewater was then processed for 5 days, within which period nitrate and total P were measured. The wastewater had a concentration of 30% domestic wastewater and 70% groundwater.

2.3. Data analysis

Data analysis was performed on data obtained after going through data collection methods. Data collection was carried out from the results of the study. The primary data obtained from the study are data on nitrate content and total P. Data analysis were performed with EXCEL (Microsoft Office Enterprise, 365). Statistical analysis was presented with Minitab 2016 for Windows.

3. Results and discussions

3.1. Removal of total phosphate concentration

Figure 1 shows the decrease in total P levels for five days. Total P decreased steadily at a speed of 60 rpm until day four but was slightly decreasing on day 5. However, the decrease on day 5 could have been due to bacteria in the wastewater that were starting to saturate and entering the dead phase. Whereas at 45 rpm, total P generally increased from day 1 to day 4 with a slight decrease on day 3. On the fifth day, however, it experienced a decline in removal. This level of decline assumes that the bacteria that assist in the complete decomposition process of P lysis.

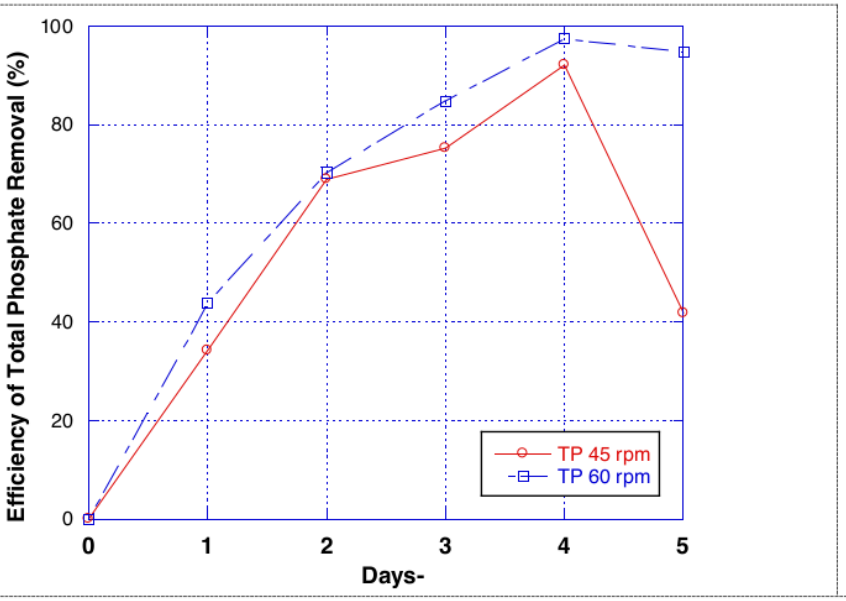

Figure 1. Performance of pilot oxidation ditch to remove total phosphate concentration

Furthermore, we could not predict whether the reactor had an anoxic zone. In the anaerobic zone, all of the raw wastewater was mixed with the return sludge. The anaerobic conditions in the contact zone are necessary to affect phosphate removal [9], [10]. Another reason could be that denitrification organisms had a stronger capability of plundering the biodegradable COD which would be easier than PAOs. Moreover, nitrate could inhibit phosphorus release by PAOs This experiment has similar performance results where oxidation ditch could remove total phosphate concentration up to 80-85% [10].

3.2. Removal of nitrate concentration

The nitrogen in liquid phase consists mainly of organic nitrogen and ammonia. Nitrogen removal is achieved through a series of biochemical reactions that convert nitrogen from one form to another such as ammonia, nitrites and nitrates [4]. The nitrification process can only take place in aerobic conditions or when dissolved oxygen content (DO) > 1 mg / l [7], [11], [12].

No significant decrease of nitrate occurred at 60 rpm. This could be due to the lack of proper denitrification process (Figure 2). What would affect the denitrification process is the lack of anoxic area, hence no decrease in nitrate. While at a speed of 45 rpm, there was an increase in nitrate removal on day 2, then a decrease on the third day and another increase on day 4. This occured because the bacteria in the reactor were in the growth stage and absorbed the oxygen needed to form bacteria that degrade organic matter bacteria [4], [6]. A declining phase on the fifth day could have been caused by the presence of the nitrification process that the denitrification would be unsuccessful in making nitrate levels rise. The low-DO-level aerobic zone (≤1 mg·L−1) would interfere with the nitrification process and accelerate denitrification before complete nitrification is achieved [1].

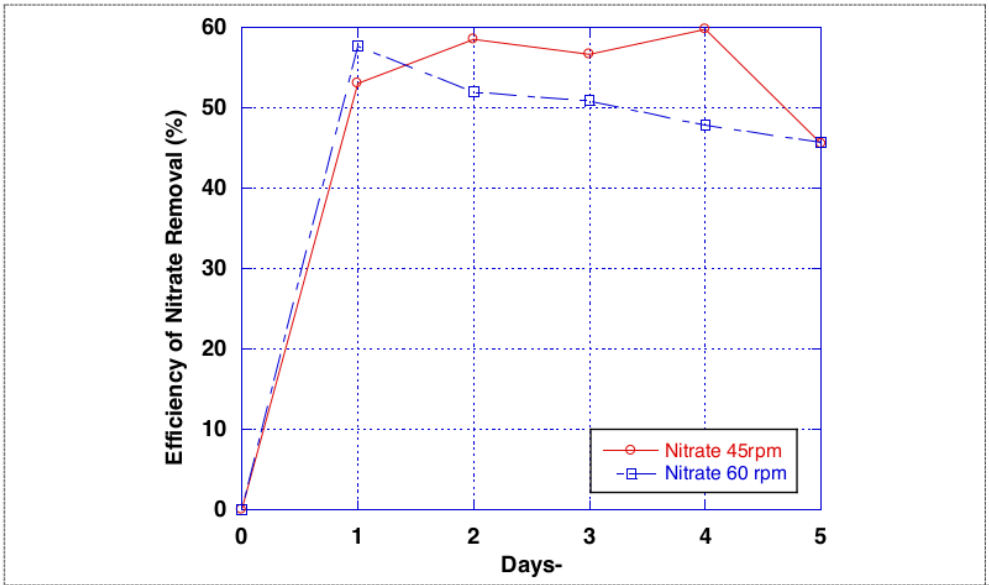

Figure 2. Performance of pilot oxidation ditch to remove nitrate concentration

Based on the results of the study, the difference in the reduction of nitrates between speeds 45 and 60 rpm was not too significant on the following days. This shows that the reduction of nitrate occured very fast in just one day [3], [5], [13]. Whereas on the next day there were fluctuates caused by biomass growth activities. It is apparent that at low loads, the rate of nitrate removal was lower than the rate of ammonia removal due to an increase in the volume of aerated zones. Several bacteria were found in the ditch system, ammonium oxidizing bacteria (AOB) (oxidation of ammonium to nitrite), and nitrite-oxidizing bacteria (NOB) (oxidation of nitrite to nitrate) [6]. Based on nitrate removal efficiency, mixing was not as strongly correlated with nitrate removal. This is similar to the results of another research while dissolved oxygen were not as strongly correlated to microbial community composition as the influent and effluent organic and nutrients compounds [6]. A statistical analysis was performed with ANOVA, where p-value = 0.331 was obtained by using alpha = 0.05. It shows that there was no significant difference between the performance at rotating speeds 45 rpm and 60 rpm.

4. Conclusions

Oxidation ditch reactor involves a much-complicated biology process. In this study, the anoxic or anaerobic condition within a reactor is not clearly stated. Meanwhile, efficient removal of nitrate and phosphate concentrations was influenced by anoxic conditions to initiate the bioprocess. Oxidation ditch process has a strong ability to perform nutrient reduction from domestic wastewater in Indonesia.

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