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Efficiency of wastewater treatment from environmental laboratory of science and technology, RMUTP using ozonation

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ABSTRACT

Wastewater from the laboratory in the Division of Environmental Science and Technology, Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon is a source of pollution without any treatment. Researchers realized that it would become an environmental problem in the future. For this reason, wastewater treatment from water laboratory would be studied using ozonation process because the researchers want to use the existing equipment in the laboratory and a simple technique that the students can do. This aims to treat the wastewater until it passes the water standard. The laboratory's wastewater characteristics were unclear based on the study. The pH values measured were 8.15, 3.35, and 2.49, respectively. COD levels were monitored of 10,480, 2,400, and 3,040 mg/L, while the measured BOD values were 4,649, 1,683, and 2,200 mg/L, respectively. Additionally, the SS concentrations were 682, 788, and 548 mg/L, respectively. Because of these characteristics using only the biodegradation process didn't work. The ozonation techniques were a good option following the research objective. The results showed that the suitable condition for the ozonation process was pH6 and the optimal time was 40 minutes. Because after 40 minutes the COD removal increase only 5% but after 60 minutes the ozonation had no effect on COD removal. This condition was applied before using biological treatment via a sequence batch reactor (SBR). Using microorganisms and 8 hours of aeration via SBR, the efficiency of COD BOD and SS removal was only 41.66, 0 and 71.82 percent, respectively. Filling ozone in rate 0.25 gram/hour/liter wastewater with SBR reactor, the wastewater treatment efficiency increased. It can remove COD, BOD and SS of 63.15, 50.00 and 72.63 percent, respectively. The advantage of this research was that the ozone generator can be applied for wastewater treatment without additional costs.

Keywords: Ozonation, Wastewater treatment, COD removal efficiency, SBR, Oxidation process

INTRODUCTION

The wastewater activities is one important problem in many university in Thailand. Division of Environmental Science and Technology, Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon tried to solve this problem to be the pilot model for other universities. Because wastewater from laboratories can be almost drained to the sink without treatment process. However, this problem shouldn't be ignored because the wastewater without a treatment process that is released into our environment is dangerous to the environment and humans. Recently, the wastewater in the laboratory in the Division of Environmental Science and Technology, Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon has almost consisted of wastewater from experiments and washing. In the laboratory, wastewater in laboratory has a low or high pH and can corrode the pipe. Because laboratory activities are involved in the different effluent characteristics. Not only was the resource of wastewater for study in the classroom from different area such as from resident areas, or industry but also from different activities in the classroom such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), nitrogen or heavy metal analysis. Each activity required a different chemical substance. Now, the wastewater is collected in the big tank. And when the wastewater was full, it was sent to the wastewater treatment company.

It can be good when we can save on this cost. And the ozone generator is a good option because it is a basic device used for studying in a student class. The ozonation process was widely used in wastewater treatment systems. In addition, ozone is a strongoxidizing agent for organic or chemical material removal in wastewater [1]. According to the water standard in Thai law, the pH of the wastewater released from the

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building, the pH is in range [5-9]. The BOD is less than 20-40 mg/L, and the SS is less than 30-50 mg/L depending on the type of building [10]. The characteristics of wastewater, such as COD and BOD, that contact the ozone can be reduced in a short time [2]. Not only save the time, but also it can save the cost too. Moreover, it can be oxidized the hard bio-degradable or toxic substance by oxidation process in some cases [3].

In this research, we try to use the ozonation process to treat the wastewater in the classroom. The ozonation process is a good option because the equipment is easy to use. The study parameters in this research were pH, BOD, COD and SS. However, using only the ozonation process in the wastewater treatment wasn't enough [4]. In this research SBR (Sequencing Batch Reactor) was used after the ozonation process to remove BOD, COD and SS in the final to pass the law of wastewater standard in Thailand. The advantage of this work is that the ozone ozone generator that is available in the laboratory can treat the wastewater. It can be applied without additional cost. This practice will be the pilot model for other universities or some organizations because almost every wastewater laboratory has this ozone generator.

MATERIALS AND METHODS

Experimental setup

A schematic diagram in Figure 1 was helpful in comprehending the experimental setup. And the details were described below.

Wastewater characteristics

The wastewater was from a classroom in the wastewater pollution laboratory. It was almost from the Bang-Khen Canal near the university. And some wastewater was collected from the wastewater treatment plant at the palm oil factory in Chonburi. The wastewater was used for the study almost exclusively for the wastewater parameter analysis. After that, it was collected until it was full. It was sampled three times and measured the parameters such as pH, BOD, COD and SS.

Ozonation process

The ozonation process was studied. The ozone generator brand "incorporate ozonizer" model "FA1000" from Fisher Scientific company was used and adjusted at maximum level. Firstly, the ozone filling rate was investigated and secondly, the optimal conditions such as ozonation time and pH were investigated. The ozone was generated from the ozone generator shown in Figure 2. COD was studied as a parameter to investigate the optimal conditions for testing ozonation time between 0-120 min and pH between [4-10]. The COD was measured following the standard method 5220D [6].

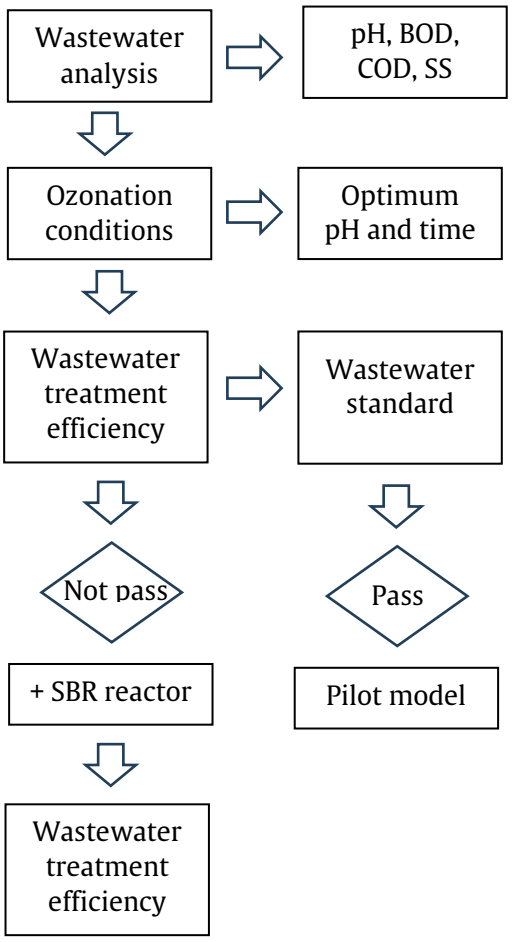

Figure 1 schematic diagram for the experiment setup.

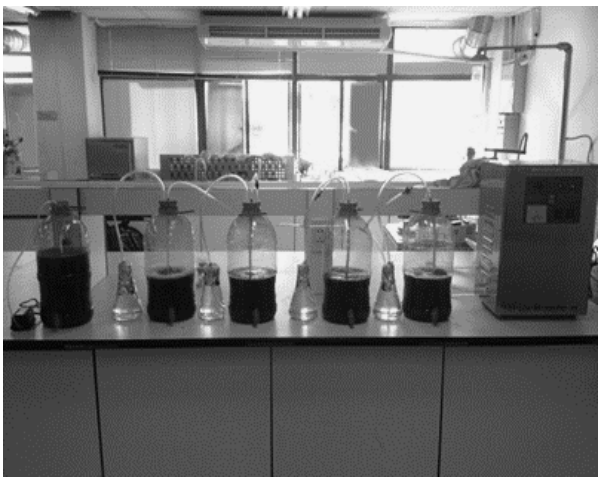

Figure 2 Wastewater treatment using the ozonation process.

Wastewater treatment using ozonation and SBR

Firstly, the wastewater was treated with ozone at various times. In this experiment, the ozonation time of 10, 20, 30 and 40 minutes with an optimal pH at room temperature was tested. After that, the wastewater was left for 24 hours for ozone volatilization. The SBR (Sequencing Batch Reactor) was used after that. The aerobic process uses aeration and filling inoculum from a wastewater treatment plant for 8

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hours and 48 hours for precipitation. The efficiency of COD, BOD and SS removal from ozonation and aerobic processes was investigated compared with a single SBR process. The COD, BOD and SS from the treatment process were compared with the wastewater standard.

RESULTS AND DISCUSSIONS

Wastewater characteristics from the laboratory

The results for wastewater characteristics are shown in Table 1. The result found that the COD was varied because the wastewater from the classroom in each period was different. The COD can be 2,400 - 10,480 mg/L while the BOD was in the range of 1,683 - 4,649 mg/L. It can be said that the oxidized matter in wastewater was also various. However, the rage from easy-biodegradable substances wasn't significantly different from COD. From sample 1, the COD was 10,480 mg/L and the BOD was 4,649 mg/L. Although the wastewater was almost bio-degradable, it consisted of chemical substances from the experiment. The wastewater in the laboratory was also sometimes composed of hard biodegradable substances. The ozonation was also a good option for wastewater treatment. Using ozone is a chemical treatment. It can treat the chemical substance in wastewater better than biological treatment. Considering the SS parameter, it wasn't significantly different either. The wastewater from the classroom in the laboratory had a difference in oxidized substances. Thus, the ozonation process would be a good option for reducing COD in the beginning step.

Table 1 Wastewater characteristics in the laboratory classroom.

Parameter	Sample 1	Sample 2	Sample 3
pH	8.15 ± 0.01	3.35 ± 0.02	2.49 ± 0.01
BOD	4,649 ± 23.52	1,683 ± 8.64	2,200 ± 13.82
COD	10,480 ± 83.52	2,400 ± 13.52	3,040 ± 25.63
BOD/COD	0.44	0.70	0.65
SS	682 ± 13.52	788 ± 14.78	548 ± 9.66

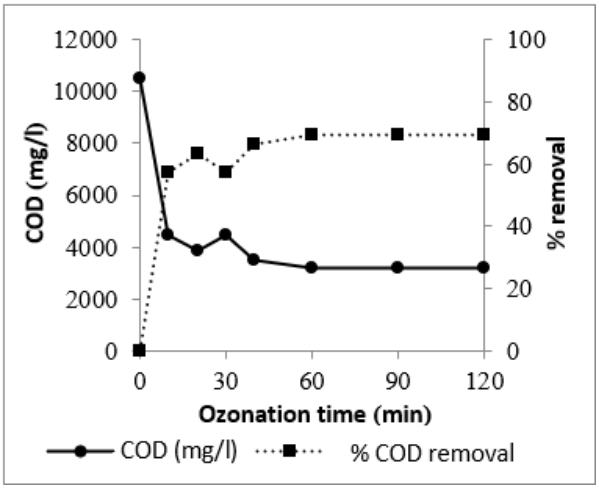

Figure 3 Ozonation time effects on COD.

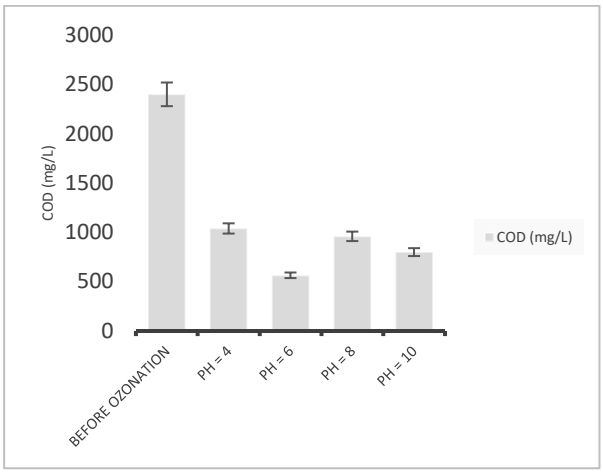

Figure 4 pH condition effecting on COD.

Optimal condition for the ozonation process

Ozone is a strong oxidizing agent. Not only organic matter but also inorganic matter such as chemical substances for wastewater parameter analysis Ozone can be used as the primary chemical process to improve the degradation efficiency of stable organic compounds in wastewater. The oxidizing agent has a high standard reduction potential (E^o) of +2.07 V. It measures the tendency of a chemical species to be reduced or its oxidizing capability. Also, it can be used to oxidize various recalcitrant organic pollutants to reduce these pollutants to smaller compounds that are less harmful to humans and aquatic environments. As a strong oxidizing agent, ozone can directly degrade pollutants in effluents or indirectly via the short-lived hydroxyl radicals (OH) (E^o +2.80 V). These free radicals will attack certain reactive groups in organic molecules to degrade them into smaller oxidation products [11].

Figure 3 and Figure 4 show the optimal conditions for the ozonation process. The result found that Ozonation process can remove COD rapidly in 40 minutes. After that, the COD removal didn't differ significantly. After 60 minutes, filling the ozone had no effect on COD removal. This result was confronted by the study of [5] that the ozonation in a long time over 1 hour hadn't influenced increasing COD and BOD removal efficiency.

The ozonation process had a cost for electricity and it took the time. Also, the ozonation time between 10 - 40 minutes was suitable. For a suitable pH, when the ozone was filled in 10 minutes, it was 6 (shown in

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Figure 4). Cañizares et al., 2007 reported that the suitable pH for ozonation process was 6 too [7]. From Table 1, the pH of the wastewater in the laboratory experiment was various. Comparing the cost of chemical substances for pH adjustment and increasing COD removal efficiency. It was worth adjusting the pH.

Wastewater treatment efficiency using ozonation and SBR process

Table 2 shows the COD and BOD efficiency of the SBR reactor compared with Ozonation and SBR reactor. In the previous study, the suitable condition for the ozonation process was pH 6, and the optimal time was 40 minutes. Filling ozone in rate 0.25 gram/hour/liter. Filling ozone in rate 0.25 gram/hour/liter. The result found that COD and BOD removal from SBR reactor are very low. It can remove the COD and BOD maximums of only 41.66 and 13.33%, respectively. It can be said that the SBR, which is a biological process wasn't suitable for wastewater from laboratories because it almost consists of hard biodegradable substances. For sample 4, using the ozonation process for 40 minutes, the biological treatment wasn't suitable for this wastewater sample. Only biological processes can't treat wastewater samples in this case. That is a reason why we used ozonation process. But when the ozonation combined with the SBR reactor is used, it can increase COD and BOD removal significantly. [9] reported that the combination process of ozone and an aerobic reactor can increase the COD and BOD removal efficiency by 112%. Because the ozonation process can reduce the COD maximum to 82.2% [8]. For the SS removal, ozone can't increase SS removal efficiency. However, the aerobic process was necessary for SS removal because of the precipitation step [9].

The mechanism of biological wastewater treatment is different from chemical treatment such as the ozonation method. The treatment of wastewater subsequent to the removal of suspended solids by microorganisms such as algae, fungi, or bacteria under aerobic or anaerobic conditions during which organic matter in wastewater is oxidized or incorporated into cells that can be eliminated by the removal process or sedimentation is termed biological treatment. Also, biological treatment is almost always applied as a secondary treatment [12].

However, the microorganisms in wastewater treatment systems are sensitive to ozone. In this study, using SBR as a secondary treatment can't increase the efficiency significantly. Although the ozonation process can increase the COD and BOD removal efficiency, the wastewater treatment system should be improved in the future.

Table2 COD, BOD and SS removal using ozonation and SBR process.

Time (min)	COD (mg/L)	COD removal (%)		BOD (mg/L)	BOD removal (%)		BOD/COD	SS (mg/L)	SS removal (%)	
		SBR	Ozone + SBR		SBR	Ozone + SBR			SBR	Ozone + SBR
0	3,040	-	-	2,200	-	-	0.72	548	-	-
10	1,440	25.00	52.63	1,300	13.33	40.90	0.90	125	70.02	77.01
20	1,440	25.00	52.63	1,050	4.54	52.27	0.72	120	70.08	73.36
30	1,280	11.11	57.89	1,000	11.11	54.55	0.78	124	70.11	63.14
40	1,120	41.66	63.15	1,100	0	50.00	0.98	112	71.82	72.63

CONCLUSION

In this study, the wastewater treatment from the laboratory in the Division of Environmental Science and Technology, Faculty of Science and Technology, Rajamangala University of Technology Phra Nakhon using the ozonation process is suitable in this case. While the aerobic process wasn't suitable for wastewater from laboratories because the wastewater consisted of toxic or hard-degradable substances. The suitable condition for the ozonation process was pH 6, and the optimal time was 40 minutes. Filling ozone at a rate of 0.25 gram/hour/liter of wastewater can remove COD, BOD, and SS of 63.15, 50.00, and 72.63 percent, respectively. It can be concluded that the wastewater in the laboratory consisted of hard-digestible, biodegradable substances. Sometimes it consisted of an oxidized chemical substance. And ozone can be a good oxidizing agent.

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