Laboratory scale ozone-based post-treatment from textile wastewater treatment plant effluent for water reuse

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Abstract. Conventional treatment such as sedimentation, aeration and activated sludge are only capable to remove organic matter. The color removal in the waste water treatment required as post-treatment at the end of the process. Dye can reduce the aesthetic value of a water body. Dye containing are not included in the textile industry's quality standards in Indonesia. The subjective of this study is to improve the quality of waste water for textile waste water treatment plants using the ozone oxidation process. Real waste water from the waste water treatment plant were used and treated by biological processes. The ozone treatment reactor has 2 L volume and flowed with ozone at a dose 0.05 and 0.5 mg/minute. The main parameters that is removed in this study are color and COD. Efficiency of colors removal reached 92% and 93%, whilst efficiency of COD removal reached 78% and 83.5%. Based on the quality standards of textile waste water in Minister of Environment Regulation No. 51/2014 and Government Regulation of Republic of Indonesia No. 82/2001 (Class 4 designation) parameters COD, BOD_5, total phenol, and total ammonia (NH_3-N) have met the quality standards.

1. Introduction

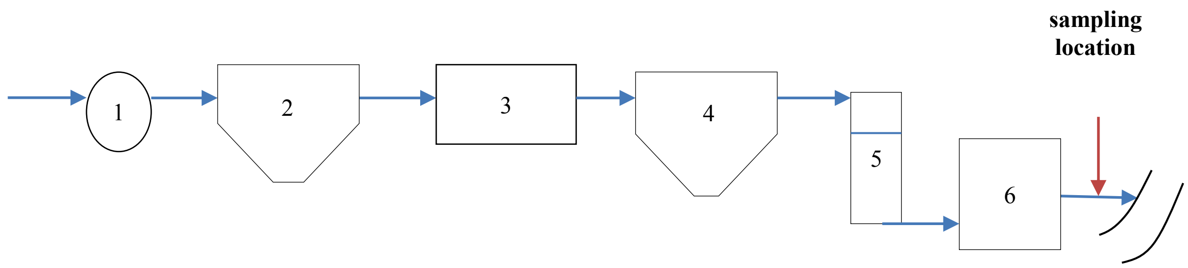
The textile industry produce waste water derived from various processes. Textile manufacture is the process of removing starch (desizing), releasing wax (scouring), bleaching, mercerising and dyeing. The characteristics of waste water produced by textile industry depends on materials used in textile manufacturing process [1]. Textile dye waste water is very difficult to eliminate because of fluctuations in pH, color, temperature, total dissolved solids (TDS), and total suspended solids (TSS) [2]. Textile waste water usually contains COD, BOD, and some metals along with complex dyes which are quite complex so of researchers demand to conduct hybrid research in order to increase quality of effluent and water reuse [3].

Textile waste water contains a large number of non-biodegradable organic materials [4]. Colored waste water released to environment cause environmental disfunctions [5, 6]such as eutrophication, production of hazardous and toxic products through chemical reactions such as oxidation, hydrolysis, and also bad impact to environmental aesthetics and water quality. Therefore, the treatment of waste water contaminated with dye has an important role not only in environmental pollution but also for technology application effectively. Color matters in textile waste water incapable degraded by aerobic biodegradation and processed by conventional biological treatment easily [7, 8]. The reason that colors are non-biodegradable is the lack of enzymes required for color degradation in the environment. Physical and chemical waste water treatment methods such as adsorption [9], coagulation, sedimentation and oxidation can be applied in colored waste water treatment. However, the application of these method require further treatment, high costs, and produce anorganic residuals [7]. Reactive colors containing poly-aromatic molecules that is soluble in water. In some studies, activated sludge used as a sorbent to remove reactive colors under anoxic condition [10]. Absorption process depends on environmental conditions of pH, types of dye and color concentration.

Ozone is a strong oxidizer that smells very strong and is of three O atoms are very unstable [11]. Ozone before or after reacting with other elements will always produce oxygen (O_2) so that ozone technology is very environmentally friendly. Ozone is the most powerful oxidizer after radicals (OH*), which can oxidize dissolved heavy metals in water, degrade organic compounds (including organochloride and aromatic compounds), and remove color. Ozone can used as a pre-treatment [10, 12, 13] or post-treatment [8] in textile waste water treatment. The purpose of this study is to improve the quality of waste water treatment plans along with quality standards of reuse water.

2. Method

2.1. Textile Waste water Treatment Plant (WWTP) Characteristic
Raw materials in industry including dyes, detergent and starch solution. Waste water from textile industry comes from the sizing, dyeing, washing, finishing and wet scrubbing process. The waste water sample had been treated using sedimentation and aerobic biological treatment. Effluent of waste water treatment plant discharged into the river. In this study that effluent of WWTP was sampled for ozone post-treatment.



Information: 1. Well collectors, 2. Preliminary sedimentation, 3. Biological aeration, 4. Sedimentation, 5. Filtration, 6 .Lagoon

Figure 1. Flow chart of textile WWTP and sampling location

2.2. Reactor and material
Volume of ozone reactor that is used in this study was 2 L. The reactor in the system carried in batches system. The acrylic reactor had one sample port that used to take samples after ozone post-treatment. Air containing ozone is flowed using an ozone generator. The ozone dose used in this study was 0.05 g/minute and 0.5 g/minute. During ozone post-treatment, ozone residues were flowed into KI 5% solution for safety.

2.3. Experimental procedure
Pollution parameter measurements carried out on the characteristics of color and chemical oxygen demand (COD). Yellow color was calculated at λ max 460 nm according to SNI 6989.80: 2011. Whereas COD values measured at λ600 nm based on SNI 06-6989.14-2004. Ammonia Total (NH_3-N)

periodically analysis by the standard method of phenate method based SNI 066989.30-2005. TSS, phenol total, Cr total, Sulfide (as S), Oil and grace, and pH analysis with standard method before and after ozone post-treatment.

3. Results and discussion

3.1. Color removal

Effluent of textile WWTP operated with ozone post-treatment within 120 minutes. Waste water color measurement carried out at λ max 460 nm based on Pt-Co unit. The measurement results showed that efficiency of waste water color removal at 120 minutes reached more than 90% (Fig. 2). Rate color degradation for pseudo first-order reactions were 0.22/min (ozone dose 0,05 g/min) and 0.0226/min (ozone dose 0,5 g/min). Those rate color degradation were lower than Zheng et al (2016) study [14]. Another alternative that used in the color removal process as tertiary treatment is adsorption or membrane process [9, 15].

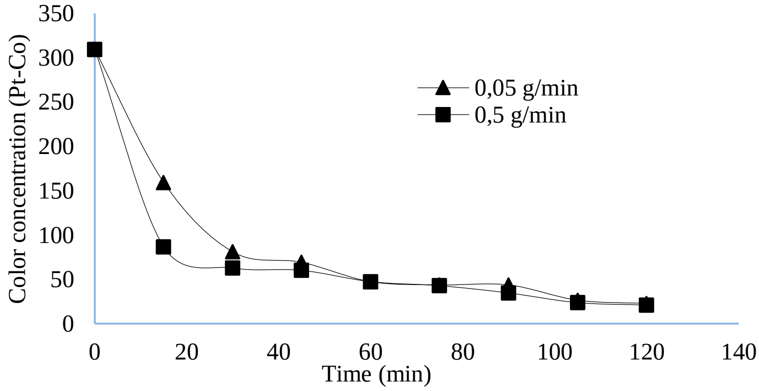


Figure 2. Results color measurement (λ maks = 465 nm) and color removal efficiency of effluent textile WWTP with ozone post-treatment.

Figure 3 shows peak at initial λmaks465 nm. After 60 minutes of ozone post-treatment that peak did not form but λ maks appeared at 300 nm, indicating that there was still organic matter left in the waste water. Absorbance at wavelength 490-510 nm decrease faster than absorbance at wavelength 300-320 nm due to the oxidation reaction [16]. Sastra widana conducted experiment that is treated textile waste water used biological treatment and showed that there was no λ maks at 520 nm and new absorption peaks appeared at 215 nm [17].

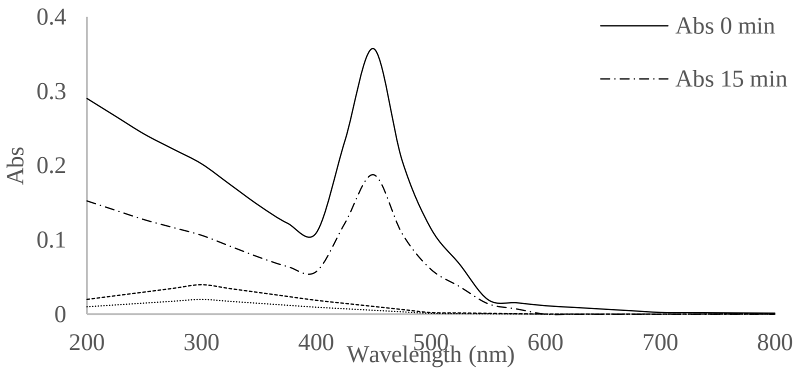


Figure 3. Changes wavelength during ozone treatment dose 0.5 g/min at 0; 15; 60; and 120 min.

3.2. COD removal
Degradation of organic matter in textile waste water in the form of COD can be degraded and reached efficiency as 55% (Fig. 4). Bilins kaetal. (2016) study has similar result of COD removal efficiency with our study [18]. COD measurement results qualified to quality standard of Minister of Environment Regulation No. 5/2014 and Government Regulation of Republic of Indonesia No. 82/2001. Therefore, waste water was safe to discharge into water bodies. The result of this study showed that ozone treatment can be used in tertiary treatment of textile WWTP to reduce color and concentration of organic contaminants [19]. Furthermore, ozone can be used as pre-treatment to increase biodegradability or BOD/COD ratio [12].

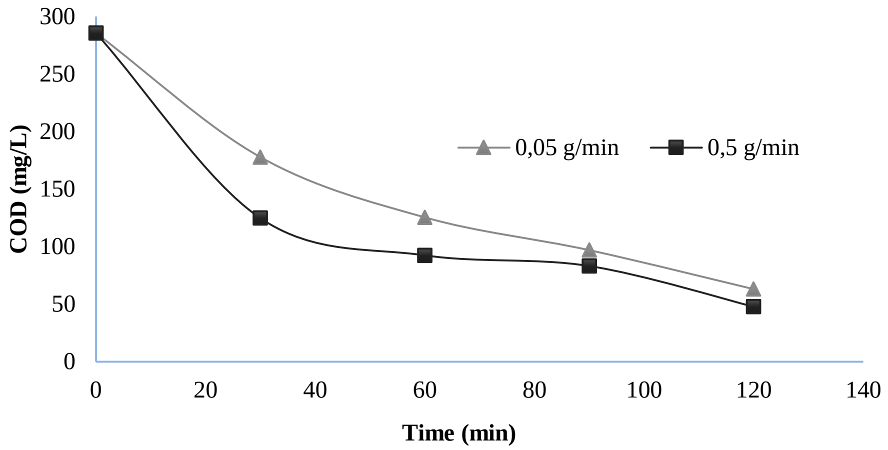


Figure 4. The results of COD values periodically in textile WWTP with ozone post-treatment

3.3. Ammonia (NH_3-N) removal
The measurement of ammonia-N was shown in Figure 5, indicating the amount of ammonia that is qualified by the quality standard. The efficiency ammonia-N removal in this study were 46% and 62% respectively. Aprilia (2016) showed the efficiency of ammonia removal in textile waste water was 13% [20]. Ammonia removal efficiency in Luo et al study was more than 85%, which was ammonia transformed into NO3 less than NO2 and colud not be transformed into N2 [21]. Following is Ozone and ammonia removal reactions [22],

$$NH_3 + 4O_3 \rightarrow H^+ + NO_3 + H_2O + 4O_2 \qquad (1)$$

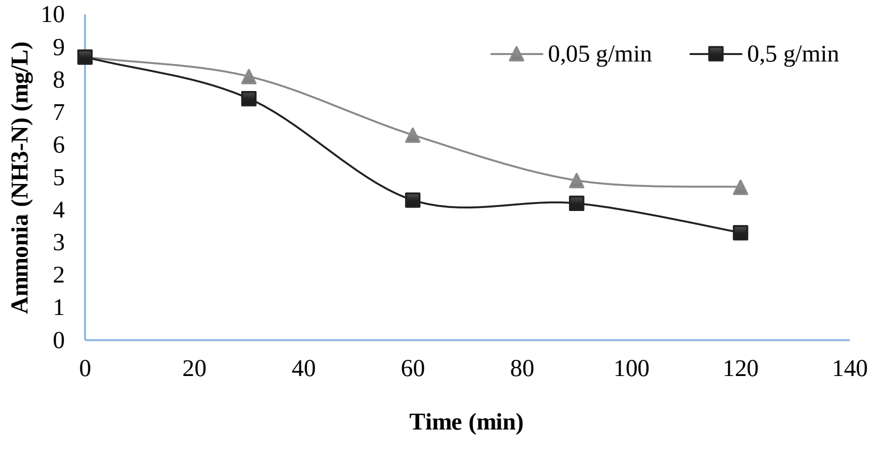


Figure 5. The results of NH_3-N values periodically in textile waste water with ozone post-treatment

3.4. Water quality standard

Efficiency of BOD_5 removal in textile WWTP was 88% and qualified into quality standard of water reuse Class 4 (Table 1). The efficiency of BOD_5 was higher than COD's efficiency. Phenol compounds are toxic compounds that are difficult to remove and mostly produced by textile industry. The dye molecule is a combination of unsaturated organic matter with chromophore as a color carrier and auxochrome as a color binder with fiber.

Table 1. Comparison of quality standards for textile WWTP after ozone post-treatment

No	Parameters	Treatment process		Unit	Efficiency	Standard[2]	Standard[3]
		Before ozone treatment	After ozone treatment[1]				
1	BOD_5	67	8	mg/L	88,0%	60	12
2	COD	285	47	mg/L	83,5%	150	100
3	TSS	23	23	mg/L	-	50	400
4	Phenol total	0,52	0,36	mg/L	30,8%	0,5	-
5	Cr total	nd*)	nd*)	mg/L	-	1	0,01
6	Ammonia Total (NH_3-N)	8,7	3,3	mg/L	62%	8,0	-
7	Sulfide (as S)	nd*)	nd*)	mg/L	-	0,3	-
8	Oil and grace	nd*)	nd*)	mg/L	-	3	-
9	pH	7,8	7,6		-	6-9	5-9

[1] After 120 min ozone treatment with dose 0,5 mg/min
[2] Ministry Environment Regulation No. 5/2014 (Appendix XLII)
[3] Government Regulation of Republic of Indonesia No. 82/2001 (Class 4 designation)
*) - indicates the parameter concentration value not detected

Unsaturated organic substances found in dyes are aromatic compounds such as aromatic hydrocarbons and their derivatives (phenols) and also their derivatives as nitrogen-containing hydrocarbon compounds. The results of phenol measurement shows at Table 1. Efficiency of phenol removal was 30.8%. This value is lower than the result of phenol removal conducted by Isyuniarto et al [23] with phenol content in initial waste water was 6.57 mg/L and through ozone treatment at optimum time became into 2.91 mg/L with efficiency as 55.75 %.

Ozone as a post-treatment shows the possibility of water reuse for textile industry. The result of ozone post-treatment has classified into Quality standards class 4 in Government Regulation of Republic of Indonesia No. 82/2001. Quality standard class four can be to irrigate the plantations and or other designation which requires the same water quality.

4. Conclusion

The ozone post-waste water treatment can improve the quality of waste water and has met quality standards. The color parameters are well removed and showed as decreasing of spectra absorbance. Organic materials in the form of COD and BOD_5 have met the waste water quality standards. Other parameters that can also be eliminated in the ozone process are total phenol and total ammonia, which the efficiency of removal reached 30.8% and 62%.

5. References

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