Effect of operational time on the chemical oxygen demand performance of sequencing batch reactor treating disperse dye synthetic wastewater

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Abstract. This work examines the effect of operational time of 6 hours on the removal of disperse dye from synthetic textile wastewater. Experiments were conducted daily at fill, react, settle, draw, and idle phase at 1 h, 1 h, 2 h, 1 h, 1 h respectively. The results showed that the highest removal efficiency of COD reached 77%. Short operational time resulted in low COD removal efficiencies of disperse dye. The findings also revealed that when applying optimum operational time, sequencing batch reactor will achieve the highest growth of the bacteria responsible for the degradation of COD. When operational time increases, degradation becomes the dominant removal mechanisms of COD.

1. Introduction

Synthetic dyes are the largest contributors to environmental pollution caused by the rapid development of textiles, pharmaceutical, plastic, food and others industries. Currently, dyeing wastewater causes serious environmental problems due to high levels of colour and high chemical oxygen demand (COD) [1]. According to previous study [2] dyes dealt with colour pollution, there are thousands of tons of dyes released daily to the environment. This has a strong psychological impact on the water ecosystem, the aesthetic nature of surrounding and as well as on human beings. According to previous studies [3], the discharge of dyes contains a high content of pigments and other additives may cause changes in oxygen and pH levels. It may also inhibit the penetration of light that causes water to disturb aquatic ecosystems, and is even potentially contain toxic and mutagenic characteristics to negatively affected aquatic flora and fauna. There are numerous physiochemical methods such as ozonation, coagulation/flocculation, sequencing batch reactor, membrane filtration and biological treatment. According to previous study [4] the sequencing batch reactor (SBR) treatment gets a lot of attention because of the single unit process.
SBR treatment is also easily handled and maintained. It also has been proven from previous studies to achieve higher removal efficiencies.

2. Composition of ICEB

2.1 Wastewater

Wastewater was fed to the laboratory scale SBR. A known concentration of disperse dye of 20 ppm were utilized. Sludge collected from Shorubber Sdn. Bhd. is employed in the reactor with the ratio of feed volume (Vf) to remaining volume (Vo) is 1:1. SBR was initiated and operated at room temperature of 23-26 °C.

2.2 SBR

The SBR reactor with a working capacity of 2 L were made out of perspex (Fig. 1). The SBR were run in aerobic cycle with sequencing batch mode to remove organics from synthetic wastewater. The reactors were run in batch mode. One cycle was composed of a feeding stage (1 hour), reaction stage (1 hour), settlement stage (2 hours), decant stage (1 hour) and idle stage, preparation for the next cycle (1 hour). Aeration pumps were used to supply oxygen in the reactor. Of Malaysia in 1999, the natural silica sand grade of Peninsular Malaysia contains 97.38%-99.88% SiO₂ and 0.001%-0.11% Fe₂O₃ [19].

![Figure 1](image)

Figure 1. Diagram of experimental system.

2.3. Analysis

The chemical oxygen demand (COD), and sludge volume index (SVI) were determined after 30 minutes of reaction, in accordance to the methodology depicted in the American Public Health Association (APHA). In addition, some operational parameters, including pH, temperature and dissolved oxygen (DO) were measured using HANNA instrument.

3. Results and discussion

In this research, the reactors were administered to investigate the effect of operational time on the COD performance. To evaluate the performance, when operated at 6 h.

3.1 COD removal of disperse dye from wastewater

Overall, the COD removal of disperse dye on day 1 is at 71 % removal. Unfortunately, on subsequent days, COD removal of 20 ppm disperse dye was at less than 20% from day 3 to day 27 (Fig 2). COD removal was gradually increased after day 26 with COD removal performance of 38 % on day 30. It has been investigated that the SBR exhibits excellent performance at the beginning of the study, but when 20 ppm of disperse dye was introduced, there was a limited effect on COD removal. This is maybe due to high concentration of disperse dye introduced to SBR system after preliminary studies was done. Kapdan et al. [5] states that when the initial concentration of the dye is high the removal efficiency of COD will decline. Kapdan et al. [6] in his study affirms that higher concentrations of pollutants will lower COD elimination performance.
In order to determine a suitable cycle length, this research will only utilize cycle time of 6 hours.

![COD Removal Graph](image_url)

**Figure 2.** Effect of disperse dye concentration on COD removal.

### 3.2 Turbidity removal

The obtained turbidity removal is shown in Figure 3. The results showed the maximum turbidity value reached to 0.44 NTU on the 9th day and the minimum value is at 0.29 NTU on the 18th day. During the initial stage of operation in SBR, the turbidity value is high due to washout of light sludge. Fortunately, the turbidity value ranges from 0.13 NTU to 0.44 NTU.

Throughout the study, sludge was found to be in good condition. Referring to the overall results obtained, turbidity does not exceed 1 NTU and is not considered as "High Turbidity" as reported by other study [7]. It shows that only a small amount of sludge enters the effluent.

![Turbidity Graph](image_url)

**Figure 3.** Impact of disperse dye concentration on turbidity.

### 4. Conclusions

This study concludes that COD removal from wastewater with cycle of 6 hours is possible. Even though, the results showed that 20 ppm of dispersed dye introduced to the SBR system depicted lower removal rates. However, after day 26, removal performance increased gradually. This study revealed, with optimal concentration of disperse dye and operational time SBR reactor can be utilized successfully if it was selected properly.
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References
[1] El-wafa MA, 2010 Flexural Behaviour of lightweight ferrocement sandwich composite beams J. of Sci. & Technol. 15(1) pp 3-16
[2] Sarvajith M, Reddy G K K, and Nancharaiah Y V. 2018. Textile dye biodecolourization and ammonium removal over nitrite in aerobic granular sludge sequencing batch reactors. Journal of Hazardous Materials 342: p. 536-543.
[3] Markandeya, et al. 2017. Statistical optimization of process parameters for removal of dyes from wastewater on chitosan cenospheres nanocomposite using response surface methodology. Journal of Cleaner Production 149: p. 597-606.
[4] Jamee R and Siddique R. 2019. Biodegradation of Synthetic Dyes of Textile Effluent by Microorganisms: An Environmentally and Economically Sustainable Approach. European journal of microbiology & immunology 9(4): p. 114-118.
[5] El-Gohary F and Tawfik A. 2009. Decolorization and COD reduction of disperse and reactive dyes wastewater using chemical-coagulation followed by sequential batch reactor (SBR) process. Desalination 249(3): p. 1159-1164.
[6] Kapdan I K and Ozturk R. 2005. Effect of operating parameters on color and COD removal performance of SBR: Sludge age and initial dyestuff concentration. Journal of Hazardous Materials 123(1): p. 217-222.
[7] Kapdan I K and Oztukin R. 2006. The effect of hydraulic residence time and initial COD concentration on color and COD removal performance of the anaerobic–aerobic SBR system. Journal of Hazardous Materials 136(3): p. 896-901.
[8] Ashraf S N. et al. 2021. Impact of turbidity, hydraulic retention time, and polarity reversal upon iron electrode-based electrocoagulation pre-treatment of coal seam gas associated water. Environmental Technology & Innovation 23: p. 101622.