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EXTENDED ABSTRACT

Treatment of Model Wastewater Containing Aromatic Organic Compounds, Dyestuffs, and Heavy Metals by Aerobic Biological Process

Amirreza Rezaei [a], Soheil Aber [a,*], Katayoun Nofouzi [b]

[a] *Applied Chemistry Department, Faculty of Chemistry, University of Tabriz, Tabriz, Iran*
[b] *Pathobiology Department, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran*

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1. Introduction

The present work studies the capability of an aerobic biological (Ae-Bio) and a combined aerobic biological-advanced oxidation (Ae-Bio/UV-H_2O_2) process in the treatment of a toxic model wastewater composed of organic aromatic compounds, dyestuffs, and heavy metals. The coexistence of organics with heavy metals causes a high level of toxicity that raises the need for the successful adaptation of microorganisms to the wastewater before biological treatment processes. In each of the Ae-Bio and Ae-Bio/UV-H_2O_2 processes, the sludge was first adapted to the wastewater and then, the adapted sludge was used for the removal of COD and methylene blue in the wastewater.

2. Methodology

A toxic synthetic wastewater including organic compounds (phenol, indole, thiourea, thioacetamide, acetanilide, ethylene glycol, methylene blue, and acid red 14) and heavy metals (lead oxide, copper nitrate, cadmium chloride, chromium nitrate, and zinc sulfate) was used in this study. The activated sludge was prepared from Pegah Dairy Industries of Tabriz, Iran, and then it was cultivated in the laboratory.

2. 1. Ae-Bio process

The sludge was adapted to the wastewater, first. For this purpose, the increasing concentrations of the wastewater were contacted with the sludge for 57 days. Nutrients (sucrose and urea) and phosphate buffer (KH_2PO_4/K_2HPO_4) were added to the adaptation mixture. The volume ratio of sludge to the wastewater was 1:2. pH, temperature, and solution volume were, 7, 29^{o}C, and 1.5L, respectively, and the mixture was aerated at a rate of 60L/min (2 hr of aeration and 0.5 hr of rest intervals) in the dark. The adaptation was performed in 13 steps. At the end of each step, the supernatant was removed and replaced with a fresh mixture of wastewater, buffer, and nutrients. During the first step, the sludge was in contact with a solution without the wastewater. From the second step onwards, the toxic wastewater was added to the mixture.

The adapted sludge was then used to treat the model wastewater at the same conditions mentioned for the adaptation process however, the total treatment time was 96 hr.

* Corresponding Author
E-mail addresses: rezaeiamirreza@yahoo.com (Amirreza Rezaei), s_aber@tabrizu.ac.ir (Soheil Aber), nofouzi@tabrizu.ac.ir (Katayoun Nofouzi).

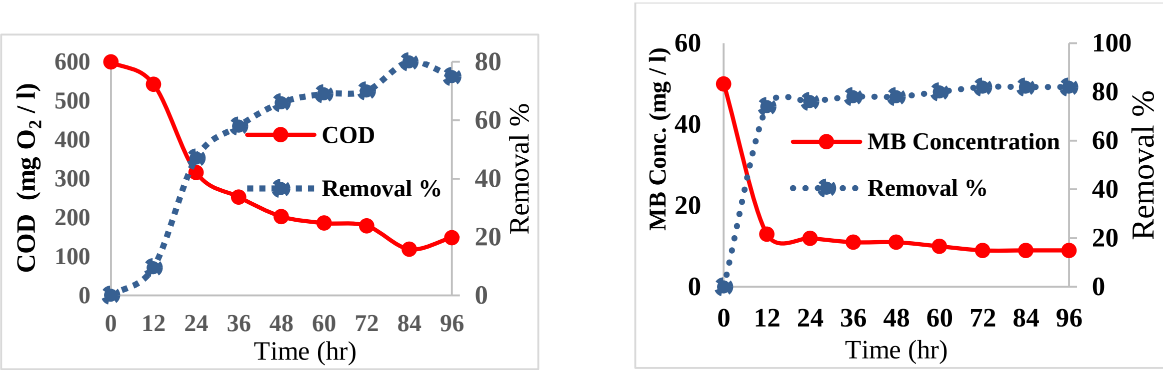
2. 2. Ae-Bio/UV-H_2O_2 process

The synthetic wastewater pre-treated by the UV-H_2O_2 process, first. In pretreatment, pH, temperature, and wastewater volume were, 3, 29°C, and 1 L, respectively, and a certain amount of H_2O_2 was added to the mixture and then, it was exposed to UV light. The pre-treated wastewater was then used to adapt the sludge in a 65-day process including 15 steps. The adaptation process was the same as the Ae-Bio process. With increasing the number of adaptation steps, the concentration of wastewater was increased and as a result, the H_2O_2 concentration and UV irradiation time of each step were changed depending on the wastewater concentration.

The adapted sludge was then used to treat the model wastewater. First, the pretreatment step was performed on the wastewater at pH, temperature, solution volume, H_2O_2 concentration, and UV irradiation time of 3, 29°C, 1L, 462mg/l, and 80min., respectively. The pretreated wastewater went through an aerobic biological step at conditions the same as the Ae-Bio process.

3. Results and discussion

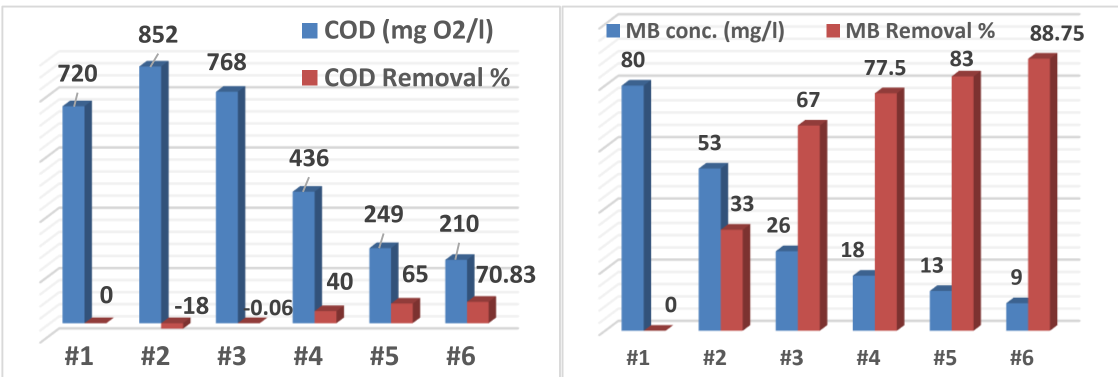
The adaptation process increases the capability of microorganisms to handle environmental and chemical shocks (Xu et al., 2013). According to Fig. 1, the removal rate of COD and methylene blue in the wastewater after 96 hours was 75% and 82% in the Ae-Bio process, respectively.



(a) (b)

Fig. 1. Changes in: a)COD, b) MB concentration against time in Ae-Bio process (pH=7, T=29°C, aeration rate=60L/min., total volume=1 L wastewater+0.5 L sludge)

According to Fig. 2, the removal rate of COD and methylene blue in the wastewater after 96 were 71% and 89%, respectively in Ae-Bio/UV-H_2O_2 process. The initial COD value of 720mg O_2/l was increased to 852mg O_2/l after the UV-H_2O_2 step due to the degradation of the organics to more degradable compounds (Muruganandham, 2004).



(a) (b)

Fig. 2. Changes in: a) COD, b) MB concentration against time in Ae-Bio/UV-H_2O_2 process (UV-H_2O_2 step: UV irradiation time=80 min., pH=3, T=29 °C, [H_2O_2]=462 mg/l, volume=1 L; Ae-bio step: pH=7, T=29 °C, aeration rate=60 L/min., total volume=1 L wastewater+0.5 L sludge). #1: Sludge solution, #2: After UV-H_2O_2 step , #3, #4, #5, #6: After UV-H_2O_2 step for 24 h, 48 h, 72 h, and 96 h, respectively.

Gram test results were revealed that in the initial sludge and the sludges after adaptation processes, the gram-positive bacteria constituted the majority.

The presence of heavy metal ions in the wastewater can show two contradictive effects. They are toxic for the bacteria and should decrease the biodegradation efficiency however, they may trigger the Fenton-like reactions in the wastewater (Bokare and Choi, 2014; Kim et al., 2018), too which will lead to a better advanced oxidation performance.

4. Conclusions

This study proved that the aerobic biological treatment and its combination with advanced oxidation processes are capable of the treatment of toxic wastewaters; and in proper conditions, the sole biological process may produce better outcomes than combined methods.

5. References

Bokare AD, Choi W, "Review of iron-free Fenton-like systems for activating H_2O_2 in advanced oxidation processes", Journal of Hazardous Materials, 2014, 275, 121-135.

Kim K, Lee K, So S, Cho S, Lee M, You K, Moon J, Song T, "Fenton-like reaction between copper ions and hydrogen peroxide for high removal rate of tungsten in chemical mechanical planarization", ECS Journal of Solid State Science and Technology, 2018, 7, 91-95.

Muruganandham M, "Photochemical oxidation of reactive azo dye with UV-H_2O_2 process", Dyes and Pigments, 2004, 62, 269-275.

Xu S, Zhang Y, Sims A, Bernards M, Hu Z, "Fate and toxicity of melamine in activated sludge treatment systems after a long-term sludge adaptation", Water Research, 2013, 47, 2307-2314.