# Feasibility of Combined Anaerobic-Aerobic System for Textile Wastewater Contained C. I. Acid Red 88 Dye Treatment: Hrt Effects and Functional Resilience

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**Abstract**

An integrated continuous anaerobic–aerobic system has been employed as the treatment for synthetic textile wastewater contained C. I. Acid Red 88 dye. A laboratory scale of upflow anaerobic sludge bed (UASB) flowed by activated treatment was operated at hydraulic residence time (HRT) of 24, 12, 6, and 3 h. the system showed high performance on the removal of color and COD within the HRT ranged between 24 and 6 hrs. At different organic loading rates (OLR), the chemical oxygen demand (COD) removal in the UASB was reached to 86.6% and up to 97% were obtained in the aerobic reactor. The system performance appeared to be more resilient to the inapt decrease in the HRT. The experimental analysis results indicated that the maximum methane yield was 13.2 mmol $CH_4$ g $COD^{-1}$ $d^{-1}$ at HRT 6 h, and the system is expected to have a better economic performance under HRT 12 h.

**Keywords:** UASB; Aerobic Treatment; C. I. Acid Red 88 dye; HRT; continuous mode

## 1. Introduction

In the last few years, the growth of different human activities has caused several environmental, social, economic and public health problems. One of the largest water and chemical consuming human activity is textile industries (Collivignarelli et al., 2019). Annually, over one million ton of different dyes are produced and about 50 % of that total was used by textile sectors (Singh and Arora, 2011). The most common dye was used in the textile industries is azo dyes and it is estimated that over 70% of the total dyes are azo dyes (Cinar et al., 2008). The composition of textile effluent is changed depending on different types of dyestuff and auxiliary chemicals. Generally, there are 20–50% of the applied dyes remain in the aqueous phase during the dying process, leading to harmful of the effluent in the environment. The discharge of azo-dye containing wastewater to the environment is of concern not only due to aesthetic deterioration but also the carcinogenic nature of aromatic amines generated as by-products of anaerobic azo-dye biodegradation (Isik and Sponza, 2008). Although different chemical, physical, and biological treatment alternatives have been studied to remove dyes from textile wastewaters, biological methods are commonly considered to be the most effective and environmentally safe. Under anaerobic conditions, azo dyes are used as electron acceptors and are readily cleaved generating aromatic amines (Isik and Sponza, 2008). Contrary to the azo-dyes, aromatic amines are generally stable under anaerobic conditions whereas they are aerobically biodegradable (Cinar et al., 2008). Consequently, this study aims to evaluate anaerobic and aerobic bio-system for the treatment of azo-dye containing synthetic wastewater. The study not only aims at optimizing its removal performance but also the functional resilience during long term operation under different operational conditions.

## 2. Materials and Methods

### 2.1. *Continuous experiment*

Continuous Methane production experiment was conducted in an upflow anaerobic sludge bed (UASB) flowed by activated treatment. The medium for anaerobic treatment was constituted of the following (mg/l): 230 $NH_4CI$, 0.35 $HBO_3$, 0.5 $MnCI_2.4H_2O$, 0.05 $ZnCI_2$, 37 $K_2HPO4$, 67 $KH_2PO_4$, 2000 $NaHCO_3$, 0.164 $Na_2SO_3.5H_2O$, 0.05 $(NH_4)6Mo_7O_{24}$•$4H_2O$, 22 $CaCI_2$•$2H_2O$, 15 $MgCI_2$, 0.038 $CuCI_2$•$2H_2O$, 5 $FeCI_3$•6H2O, 0.09 $NiCI_2$•$6H_2O$, 0.09 $AIC_3$•$6H_2O$,11 $CoCI_2$•$6H_2O$, 1000 Glucose, 100 C.I. Acid Red 88, 200 CMC, 1500 Starch. The reactor was operated at 37 ± 1 °C by water circulating through water jacket for over 120 days with an effective volume of 5 l and a hydraulic retention time (HRT) of 24, 12, 6 and 3 h.

### 2.2. *Analytical methods*

The percentage of $CH_4$, carbon dioxide and nitrogen in the biogas was determined by a gas chromatograph (Shimadzu 8A). The organic acids and ethanol were analyzed by a gas chromatograph (Shimadzu GC-1700). The volatile suspended solid (VSS), volatile solid (VS), protein and chemical oxygen demand (COD) were measured according to the procedures described in the Standard Methods (APHA, 2005).

**Table 1**. UASB reactor performance at different HRT

| HRT (h) | OLR (g CODL-1 d-1) | pH | VFA (mg L-1) | COD removal (%) | CH4 (%) | Bioenergy productivity (L CH4 L-1 d-1) | Methane yield (L CH4 g CODadd-1) |
|---|---|---|---|---|---|---|---|
| 24 | 3.24 | 7.4 ±0.12 | 180.6±8.17 | 77.3 | 55.4 | 1.43±0.24 | 0.44±0.01 |
| 12 | 6.49 | 7.4 ±0.11 | 316.3±10.11 | 86.6 | 74.1 | 2.72±0.32 | 0.42±0.03 |
| 6 | 12.97 | 7.6 ±0.11 | 248.9±19.87 | 86.0 | 75.9 | 5.46±0.19 | 0.42±0.03 |
| 3 | 25.94 | 8.1 ±0.23 | 274.7±37.84 | 57.5 | 59.2 | 7.63±0.34 | 0.29±0.05 |
| 6 (Recovery) | 12.97 | 7.7±0.19 | 204.0±24.14 | 76.5 | 69.7 | 5.15±0.27 | 0.40±0.03 |

## 3. Results and Discussions

### *3.1 Effect of UASB treatment on energy recovery and colour removal*

The reactor showed efficient energy recovery from synthetic textile wastewater. The biogas production ranged between 1.4 to 7.6 l/l/day at HRT 24 and 3h respectively with maximum methane yield of 13.2 mmol CH4 g COD-1 d-1 at HRT 6 h. Such execution was satisfactory, as it showed the microorganism's flexibility to the utilization of a high OLR of 12.79 g-COD/l.d.

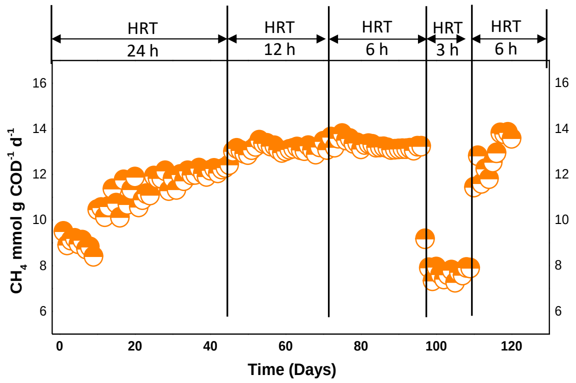


**Fig. 1.** Effect of HRT on biogas yield and system resilience

As shown in Table 1, the removal efficiencies of color and COD varied at different HRT. Generally, at this stage, up to 86.6% of COD were removed.

### *3.2. Effect of HRT on the UASB performance*

The effect of various HRT of 24, 12, 6 and 3h on colour and COD removal was investigated under mesophilic temperature (37±$^{o}$C). In general, the highest colour and COD removal were recorded at HRT of 6h with 96 and 82%, respectively. On the other hand, the reactor showed deterioration performance at HRT 3h. This drop may due to the decreasing of the contact time of wastewater with sludge granules. During the deterioration, the colour and COD removal reached 53 and 57.5%, respectively. Although the system was subjected to an inhibition period, it was able to recover again by increasing the HRT to 6h and the colour and COD removal reached 92 and 86.4%, respectively. This results suggested that the UASB reactor was non-resistance to increase OLR and dye concentration. At HRT 3h, EPS were observed within the entire granule surface. Where the presence of excessive EPS may decrease the mass transfer efficiency and lead to deterioration of reactor performance. (Zheng YM, Yu HQ. 2007).

### *3.3. Aerobic treatment performance*

The characterization of UASB effluent results indicated that the effluent still has a sufficient amount of suspended solids and organics which can deteriorate the quality of water bodies if discharged as it is (Collivignarelli et all 2019). To cope up with this issue, integration of UASB systems was successfully adopted using a post activated treatment. The experiment results showed that the colour and COD removal reached 100 and 96%, respectively. Regarding HRT effect, the reactor able to cope and treat the UASB effluent and no significant changes was recorded at HRT of 3h. Our results reported that the UASB flowed by activated treatment is an attractive technological option for decolorization Azo dyes. This operation strategy could be applied at full scale for effective treatment of high load azo dye containing wastewaters.

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