Anaerobic Treatment by UASB Reactor and Aerobic Biodegradability Test of Cutting Oil Sewage

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Introduction

Water is consumed in almost all industries. Consequently the used water is turning to a waste that usually should be treated to meet the regulated standard level prior to reuse or discharge into the environment. Cutting oil wastewater is an emulsion normally comprised of 1-10% oil and the remainder water. The main functions of this oil in industry are lubrication, friction reduction, and cooling of instrument's parts. This wastewater is classified as a toxic waste according to the existence of some additive material to prevent corrosion and bacterial growth. Breakage of the emulsion and separation of the water and the oil can alone reduce more than about 90% of the aqueous phase pollution and prepare it for treatment.

The emulsion breakage can be applied with various electrolytes. According to previous researches, calcium chloride is a suitable material from an economical and technical perspective. After separation, the oil phase can be recycled or burned and the aqueous phase should be treated before disposal or reuse. A removal efficiency of about 90% doesn’t satisfy the standard level for discharge to the environment.

Aerobic process usually applies in sewage with lower loading rates and anaerobic processes are more suitable for high loading rates. The design and application of up-flow anaerobic sludge blanket (UASB) reactors developed in the latter years of 1970s. The advantages of UASB reactors include lower area and volume requirement, lesser energy consumption, adjustment in shocking condition such as cutting off the substrate supply, and especially lower sludge production which all facilitate application in the industrial factories even inside of towns.

Possibility of the anaerobic biological treatment of the aqueous phase of the oil water emulsion in the UASB reactor and also aerobic biodegradation of the remained pollution as secondary treatment and the verification of Monod model are considered in this paper.

Materials and methods

Figure 1 shows the experimental setup and Table 1 illustrates the reactor specifications.

Experimental reactor was made by Plaxy glass. Start-up sludge volume was 1.2 lit (MLSS=170 g.lit⁻¹) which provided from a treatment plant at Tehran dairy co. Temperature during the operation retained constant at about 27±2°C which is comparable with the temperature of factories that use cutting oil. The amount of nitrogen and phosphorous in the aqueous phase is about zero; therefore, the COD/N/P ratio was controlled at 120/5/1 during the operation by the addition of K2HPO4 and NH4Cl. The aqueous phase pH and the BOD/COD ratio was kept at 7 and 0.83, respectively. A Hack spectrophotometer was used to colorimetrically measure all the concentrations using analytical kits.

In this study, sewage artificially made with the cutting oil of the Tabchem factory. The oil concentration in the emulsion is 1.5% which is the common composition for use in cutting machines. The emulsion was broken by the calcium-chloride. To fulfill this task, 1 g CaCl₂ was added to the emulsion for each percent of oil and mixed completely thereafter. This mixture was maintained stationary for one day in decanter ampoule to separate liquid phase. The liquid phase COD is equal to 2400 mg/l which diluted with distilled water.
All the experiments were carried out in two consequent 15-day periods. First volumetric loading was $L_v=0.69 \text{ kgCOD.m}^{-3}.\text{day}^{-1}$ with a 45 days retention time to adjust with the start-up sludge and in the second period loading was doubled to $L_v=1.8 \text{ kgCOD.m}^{-3}.\text{day}^{-1}$ with a 15 days retention time.

Figure 2 shows the experimental setup to assess aerobic bioassay. This test is performed in a batch reactor and the achieved results can be used in the continuous operation design. Details of this unit are stated as follow:

1. Motor & mechanical mixer
2. Plaxy glass reactor, diameter and height are 15 cm
3. Baffles to break down the vortex
4. pH meter
5. DO meter
6. Air pump
7. Circular air nozzle (aquarium type)

### Discussion of results and conclusions

Figure 3 shows the COD variation of influent and effluent during the loading periods.

As it is indicated, the average removal efficiency of the system is about 73% which implies suitable anaerobic biodegradability of the sewage. Effluent COD in the first and second period is about 290 and 350 mg.lit$^{-1}$, respectively. An increase in the volumetric loading decreases the retention time. As it can be seen in Figure 3, the removal efficiency of the system remains constant with an increase in the loading rate. This concept...
illustrates that the UASB reactor can suffer higher loading. As it was indicated in the literature, the loading rate can increase up to 40kgCOD.m⁻³.day⁻¹ which requires preparation of such reactor condition as temperature, granule concentration, hydraulic retention time, and other relevant requirement. This reactor can comparably act as a high rate aerobic reactor with less energy consumption, smaller occupied area, and without requirement to aeration equipments.

The removal efficiency of the system is reasonable; however similar to other studies, the values are above the standard limits and it cannot be discharged to the environment without a secondary treatment. Therefore, in this paper, aerobic biodegradation assay of the residual contaminates has been performed in a batch reactor to reach the environmental standard levels. This test assesses the presence of inhibitory substances and sufficient nutrients in the effluent and can also help determine the retention time and the F/M ratio for continuous reactor design. According to the UASB effluent, COD equal to 400 mg/l and initial substrate to initial biomass concentration ratio (S₀/X₀) were set equal to 2.2 and the experimental procedure is the same as the previous step. As it can be seen in Figure 4, the residual COD reaches to about 68 mg.l⁻¹ after 10 hr retention time which is an appropriate reduction. According to aforementioned discussion, design of an aerobic reactor with 10 hr retention time and S₀/X₀ ratio equal to 2.2 is possible to treat the remained pollution in the aqueous phase of an oil water emulsion.

Additionally, the measured values are in a reasonable compliance (±5%) with the logarithmic growth phase of the Monod model according to the following equation.

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S = \frac{S_a}{X_a} Y_{obs} (e^{\mu_{max}t} - 1)
\]  

(1)

**Keywords:** biological treatment, cutting oil, UASB reactor, volumetric loading.