Effect of Dodecylbenzene Sulfonate on Organic Pollutants Removal in the Intermittent Contact Oxidation Process

間欠接触酸化法における有機性汚濁物質除去へのドデシルベンゼンスルホン酸の影響

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1. Research Background and Objectives

The most important role of sewer pipe is to transfer sewage from its sources to the destination, which is often a sewage treatment plants. Tanji, et al. [1] has studied that installing porous media in sewer pipes could enhance the ability for sewer self-purification. The term "sewer self-purification" means the ability of water to purify itself of contaminants in sewer pipes. One of the methods to enhance sewer self-purification is called the intermittent contact oxidation process (ICOP). The ICOP promotes microbial growth and retention of microorganisms by installing sponge media in sewer pipes to facilitate organic pollutants removal in the intermittent flow sewage [3].

Greywater is defined as sewage from households' activities except for human excreta. It derives from bathroom, laundries, kitchen sink, showers, and accounts for 50% – 80% of the sewage volume [4]. In term of chemical contaminants, surfactants have found as the major chemical contaminant in greywater. In this study, sodium dodecylbenzene sulfonate (SDBS) is a model of surfactant which is widely used in laundry detergent [5]. The typical greywater contains anionic surfactants determined by the methylene blue method in the range of 3 – 70 mg L^{-1} [6]. Surfactants discharged into the sewer system may negatively affect microbial activities for sewer self-purification and thus purification performance due to their toxicity. To explore the potential of sewer pipes as a reactor for pre-treatment of sewage, this study assessed the possible adverse effect of SDBS on the microorganisms in the ICOP. Specifically, to examine the potential of the ICOP to remove organic pollutants under exposure to SDBS and examine the capability of the ICOP for SDBS removal.

2. Methodology

2.1 Airtight Reactor Setup

A lab-scale ICOP reactor as shown in **Figure 1** was prepared. The channel simulating sewer pipe had an inner dimension of 48.5 cm (length) × 7 cm (width) × 6 cm (depth) and a slope of around 2%. A piece of inoculated sponge media made of polyurethane sized 44 cm x 7 cm x 1 cm (BCD-2, pore cell density 6 cell/cm, Achilles Corporation Tokyo, Japan) was placed on the bottom of the channel as a habitat for microorganism. The outlet of the channel was led to the synthetic sewage tank with a working volume of 1L. The whole reactor was placed in an air-conditioned room at 20±1 ºC during the study. The channel was installed with an oxygen

sensor (ME2-O2-φ20, Winsen Electronics Technology, Zhengzhou, China). The channel was made airtight to ensure reliable oxygen consumption measurement during the experiment.

Every day, 1 L synthetic sewage with chemical oxygen demand (COD) concentration of around 500mg/L with different SDBS concentration was prepared and placed in the synthetic sewage tank. The COD of the synthetic sewage was from peptone, yeast extract, acetate, and SDBS. The recirculation pump was operated for 5 minutes every 30 minutes repeatedly at a flowrate of 200 mL/min. The air pump was operated for 5 minutes every 6 h to refresh the air inside the channel.

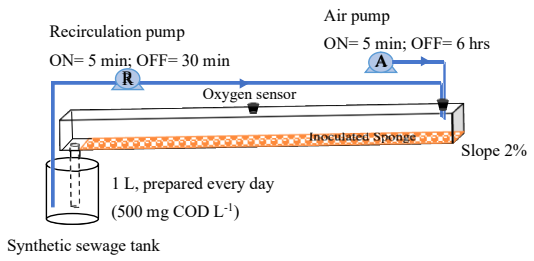

Figure 1 Airtight ICOP Reactor

2.2 Reactor Operation

Initially, microorganisms from a wastewater treatment plant were inoculated and biomass development to the sponge media for 37 days. Then, after biomass development, run 1, 2 and 3 were performed where Run 1 and Run 3 were fed with synthetic sewage containing SDBS and Run 2 synthetic sewage containing no SDBS.

Run 1 the reactor was operated under 20 – 40 mg L^{-1} of SDBS for 5 days and 60 – 80 mg L^{-1} for 6 days each condition. Furthermore, during run 2 the reactor was operated for 18 days. Run 3, under 20 – 60 mg L^{-1} of SDBS, the reactor was operated for 6 days each of condition except 80 mg L^{-1} for 9 days.

2.3 Performance Evaluation

For each day of monitoring, the samples were taken eight-times at 0, 30, 60, 120, 240, 360, 480, and 1440 minutes. The following parameters were measured: COD, methylene blue active substances, and methylene blue active substances (MBAS), and oxygen consumption rates (OCR). The concentration of COD was measured by dichromate method without mercury [7] in combination with titration. The concentration of MBAS was measured by the MBAS method. To calculate OCR, reduction rate of oxygen concentration in the reactor was calculated from the response of the oxygen sensor then standardized by the footprint area of sponge in the reactor.

2.4 Identity of Remaining MBAS

As a result, which will be explained in 3.2 it was found that removal of MBAS by ICOP was low. However, there remained a possibility that SDBS was degraded partially while remaining MBAS unchanged. To grasp the identity of remaining MBAS after treatment for 24 h, the sample was lyophilized, and analyzed by thin-layer chromatography (TLC).

3. Results and Discussions

3.1 The organic pollutant removal

Changes of COD concentration of the water in the synthetic sewage tank with different SDBS

concentrations during Run-1 and Run-2 are shown in **Figure 2**.

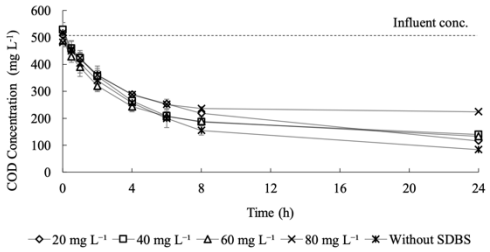

Figure 2 Changes in COD concentration in each SDBS condition in Run-1 and Run-2. Influent COD concentration was approximately 500 mg L^{-1}

Figure 2 shows that the concentration of COD decreased dramatically in the initial 4 hours after the synthetic sewage was introduced, then slowly decreased afterwards. The SDBS affected the COD removal as shown in **Figure 2**, where with increasing SDBS concentration in synthetic sewage, COD removal decreased. Compared to the condition without SDBS, the ICOP performance decreased by 8%, 14%, 12%, 34% for 20, 40, 60, 80 mg L-1 SDBS containing in synthetic sewage, respectively.

The removal performance of COD can also be evaluated from OCR in the channel as shown in **Figure 3**. In Run-1, OCR was around 9.6 g O m^{-2} d^{-1} during the period with SDBS 20 mg L^{-1} and 40 mg L^{-1}. After SDBS concentration was increased to 60 mg L^{1}, OCR remained similar level for two days, then suddenly dropped to around 7 g O m^{-2} d^{-1}. During days 51 to 60, OCR dropped about 27 % of days 38 to 49 with SDBS 20 mg L^{-1} and 40 mg L^{-1}. During Run-2 without SDBS, OCR gradually increased and came back to its original level. During Run-3, again SDBS concentration in feed was increased from 20 mg L^{-1} to 80 mg L^{-1}. However, in Run 3, the reduction of OCR was not significant: OCR during the period with SDBS concentration 60 mg L^{-1} or 80 mg L^{-1} was only 7.5% less than that of the period with SDBS concentration 20 mg L^{-1} or 40 mg L^{-1}.

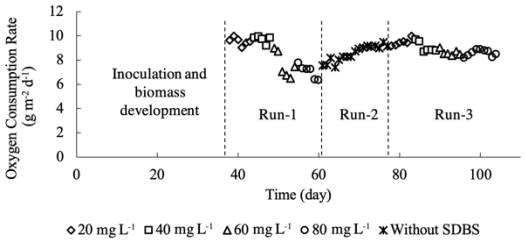

Figure 3 Oxygen consumption rate during Run-1, Run-2, and Run-3

It was thought that the COD removal decreased due to decreasing of microbial activity which related with damage of microbial cells caused by the direct interaction between SDBS and microorganisms [8]. Yin, et al. [9] reported that the toxicity of SDBS probably caused by the reduction of surface tension on the cells could inhibit microbial activity. That is, the decline of the polarity of the cellular membrane (due to the adsorption of surfactants on it) results in its malfunction substrates cannot enter the cell, and toxic substances inside cells if any cannot be removed from the cell. Both cases cause cellular decay.

3.1 The SDBS Removal in the ICOP

The concentration profiles of MBAS were collected almost every day in Run-1 and on selected days in Run-2. Findings are shown in

Figure 4.

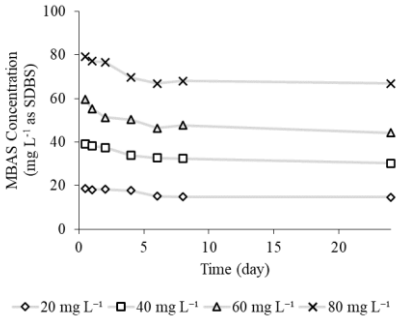

Figure 4 SDBS removal rate of various concentration. The error bar represents the standard deviation for n = 4, except for 40 mg L^{-1}. n = 5

The MBAS removal rate remained less during the ICOP ranging from 17 – 32% in a day operation. MBAS concentration decreased in the initial 8 hours, and then the removal was almost stopped. Note that MBAS concentration is not identical with SDBS concentration. SDBS maybe degraded and converted into intermediate degradation product which is still anionic surfactant. In addition, there are studies reporting generation of biosurfactants by microorganisms.

Generation of biosurfactant was measured on the selected days in the period without supplying of SDBS, the MBAS concentration was observed. The TLC analysis was conducted to examine the identity of MBAS after 24 h treatment. Findings suggested that the influent and effluent sample were not identical. It was thought the SDBS was converted to other forms by microbial activity.

4. Conclusions

Findings are provided as follow:

Increasing SDBS concentration in sewage decreased the ICOP performance. However, after microorganism were acclimatized the effect became much less. It means that the ICOP can show its COD removal performance under existence of SDBS at least up to 80 mg L^{-1}. In addition, The SDBS removal rate remained less: 17 – 32%. However, there is a possibility of surfactant remained was produced by microbes and/or SDBS itself was converted to other forms. Overall, the ICOP shows a promising performance as a pre-treatment of sewage and further study is needed.

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