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Removal of Nitrogen Compounds from Industrial Wastewater Using Sequencing Batch Reactor: The Effects of React Time

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Abstract**—**This study was performed to optimise the react time (RT) and study its effects on the removal rates of nitrogen compounds in a sequencing batch reactor (SBR) treating synthetic industrial wastewater. The results showed that increasing the RT from 4 h to 10, 16 and 22 h significantly improved the nitrogen compounds' removal efficiency, it was increased from 69.5% to 95%, 75.7 to 97% and from 54.2 to 80.1% for NH_3-N, NO_3-N and NO_2-N respectively. The results obtained from this study showed that the RT of 22 h was the optimum for nitrogen compounds removal efficiency.

Keywords**—**Ammonia-nitrogen, retention time, nitrate, nitrite, sequencing batch reactor, sludge characteristics.

I. Introduction

INDUSTRIAL wastewater could be indicated by high concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), fluctuating pH and many other toxic compounds [1]. To remove these toxic compounds from wastewaters, researchers have been using processes such as adsorption, solvent extraction, chemical oxidation, and biological treatment [2]–[4]. Though conventional biological nitrogen removal in activated sludge system has been widely practiced for its economic and technological feasibility, it has some technical constrains, such as sludge bulking, large footprint of treatment plant, easy washout of nitrifying bacteria, high production of excess sludge [5].

Activated sludge process (ASP) is difficult to maintain, costly and requires large areas [1]. One of the alternatives of ASP is the SBR. SBR operates periodically in a cycle of fill and draw. One of the main advantages of using SBR for industrial wastewaters treatment is the ability to handle periodic flows. In addition, SBR can handle the change of the environmental conditions inside the reactor in a controlled manner, as a result of that it could accelerate the enrichment of microorganisms having specific degradation efficiency. Moreover, SBR requires less operating costs. Moreover, SBR requires less operating costs. (SBR) has distinct advantages of space-saving, flexible operational mode, and auto-control capability [6], [7].

RT is considered as one of the most controllable operation parameters of SBR; it could contribute to different treatment performance and biomass characteristics [8]. The RT is the time needed for microorganisms to biodegrade the organic and inorganic compounds of wastewater. There is a lack of researches on the relationship between the RT and nitrogen compounds removal efficiency.

The present study was conducted to investigate the effects of the RT on the removal efficiency of nitrogen compounds in a SBR.

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II. Materials and Methods

A. Bacteria Source and Synthetic Wastewater

The bacteria (biomass) are mixed culture of sewage activated sludge, it was brought from Liverpool Wastewater Treatment Works, Sandon Docks, Liverpool, UK. The influent synthetic wastewater was prepared in deionized water containing: 500 mg glucose/L; 200 mg $NaHCO_3$/L; 25 mg NH_4Cl/L; 25 mg KNO_3/L; 5 mg KH_2PO_4/L; 5 mg $MgSO_4.7H_2O$/L; 1.5 mg $FeCl_3.6H_2O$/L; 0.15 mg $CaCl_2.2H_2O$/L [9], [10]. All reagents used in this study were purchased from Sigma-Aldrich, UK.

B. Setup and Operation of Laboratory SBR System

In this research, four identical reactors are used in the SBR system, R1, R2, R3 and R4. Each has a 5 L capacity. All of the reactors were filled with 3-4 L of synthetic wastewater, and 1-2 L of bacteria (biomass) for biological wastewater treatment. The treatment reactors were equipped with four electronic sensors (probes) to measure the parameters of pH, dissolved oxygen (DO), temperature and oxidation-reduction potential (ORP). The configuration of one of the four SBR reactors used in this research is shown in Fig. 1. The SBR reactors (R1, R2, R3 and R4) were operated with RT of (4, 10, 16 and 22 h), and the samples were taken and analysed from each reactor for influent and effluent respectively.

C. Analytical Methods

In this study, the analysis of influent and effluent samples of the SBR reactors was carried out after withdrawing and filtering the samples through 0.45 μm filter paper. The concentrations of NH_3-N, NO_3-N and NO_2-N were measured according to the standard methods [11].

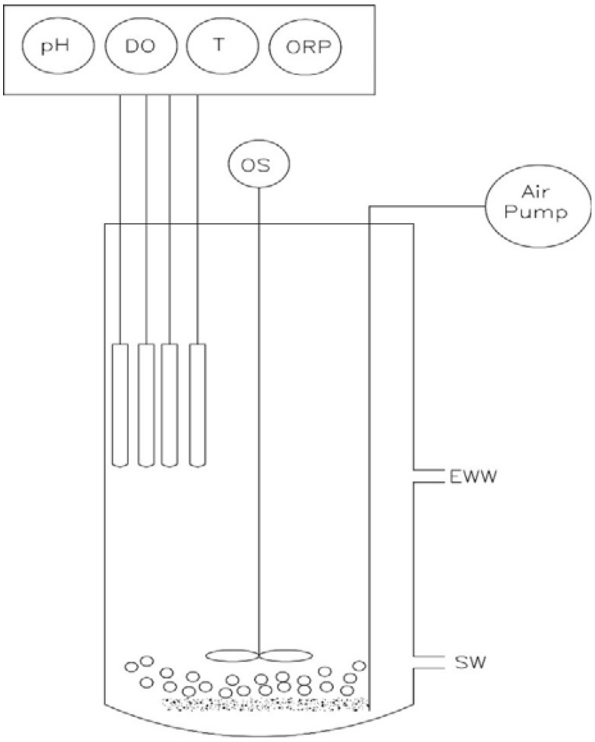

Fig. 1 The configuration of R1, one of the identical laboratory SBRs (R1, R2, R3 and R4) [DO: dissolved oxygen, T: temperature, ORP: oxidation reduction potential, OS: overhead stirrer, EWW: effluent wastewater, SW: sludge waste]

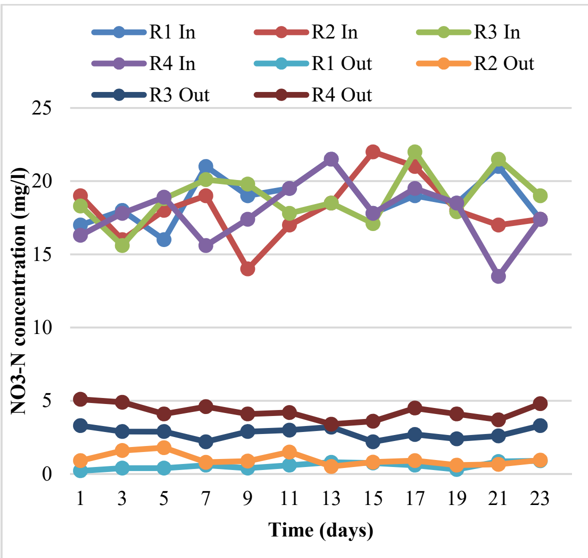

Fig. 2 The influent and effluent concentration of NH_3-N

III. Results and Discussion

A. Effect of RT on Nitrogen Compounds Removal

The influent and effluent of NO_3-N, NH_3-N and NO_2-N are shown in Figs. 2-4. The effect of RT on NH_3-N, NO_3-N and NO_2-N removal is shown in Figs. 5-7. The results showed that increasing the RT from 4 h to 10, 16 and 22 h significantly improved the nitrogen compounds removal efficiency, it was increased from 69.5% to 95%, 75.7 to 97% and from 54.2 to 80.1% for NH_3-N, NO_3-N and NO_2-N respectively. This is agreed with [13], they achieved up to 89%, 96% and 92.5% removal efficiency for COD, NH_3–N and NO_3–N respectively at the end of 24 h HRT. This is due the fact that higher HRT gives a longer contact time between biomass in the reactor and the wastewater, and thus better degradation rates [12].

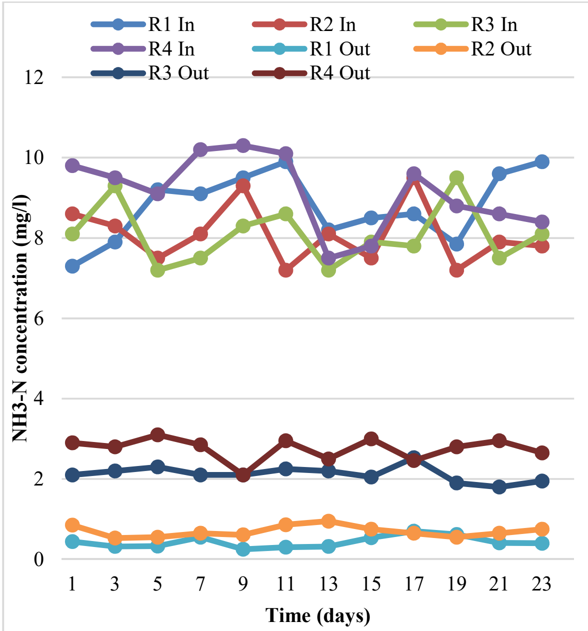

Fig. 3 The influent and effluent concentration of NO_3-N

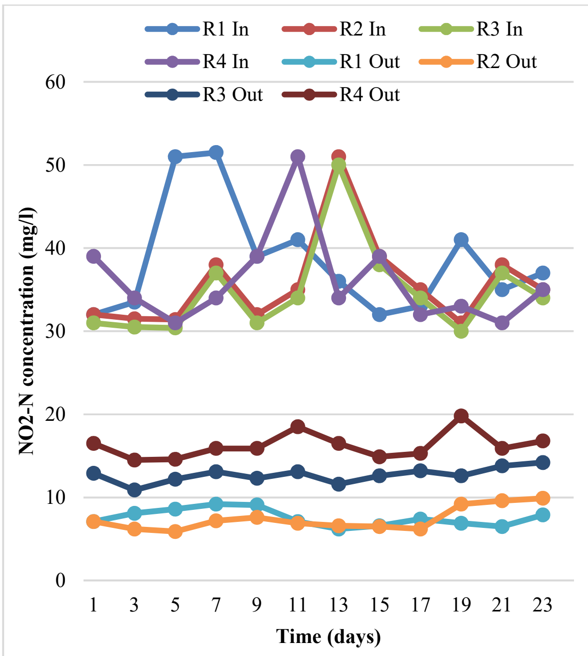

Fig. 4 The influent and effluent concentration of NO_2-N

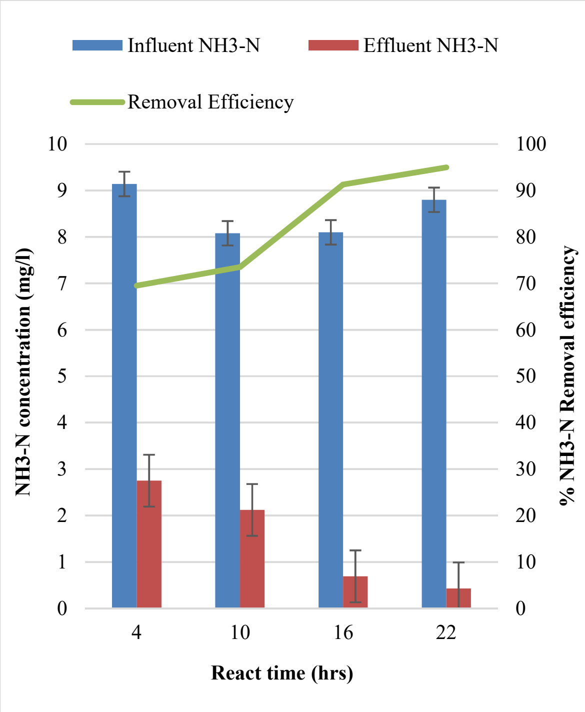

Fig. 5 The effect of RT on NH_3-N removal

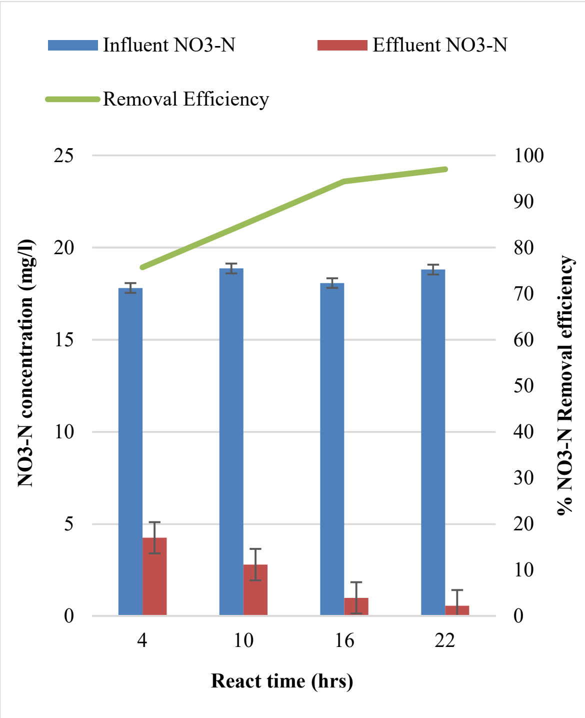

Fig. 6 The effect of RT on NO_3-N removal

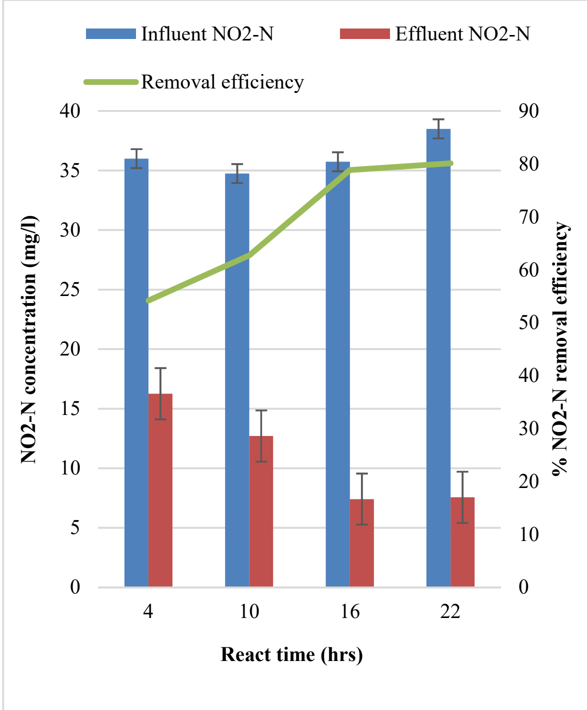

Fig. 7 The effect of RT on NO_2-N removal

IV. Conclusion

RT is one of the most significant SBR's operation parameters, which could affect the treatment efficiency. In this study, an experiment was carried out to optimise the RT and relate it to the removal efficiency of NH_3-N, NO_3-N and NO_2-N. The optimum RT obtained from this study 22 h it can reduce NH_3-N, NO_3-N and NO_2-N levels up to 95%, 97% and 80.1% respectively. For future study, 36 h and 10 h RT should be considered to find the best RT for nutrient removal.

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