Upgrading of Aerobic Sequencing Batch Reactor System with Adding Nanoscale Zero Valent Iron for Wastewater Treatment

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Upgrading of Aerobic Sequencing Batch Reactor System with Adding Nanoscale Zero Valent Iron for Wastewater Treatment

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Abstract: *The aim of this study was to investigate the effect of nano-scale zero-valent iron (nZVI) on the performance of aerobic sequencing batch reactors (SBRs) in terms of COD, phosphate removal and microbial species growth. Two lab scale SBRs were operated simultaneously for sixty days with and without adding nZVI. The reactors were fed with synthetic wastewater and acclimated with seed sludge which was taken from a full-scale municipal wastewater treatment plant in Istanbul. As a result, next generation sequencing technology analysis confirmed that the addition of nZVI in R2 promoted some bacterial types such as Xanthomonadales and inhibited others such as Clostridiales, confirming that the effect of nZVI on the bacterial growth was genera dependent. In addition, the phosphate and COD were completely removed at the end of the study and slightly enhanced with 15 % after the addition of nZVI in R2.*

Keywords: wastewater treatment; nanoscale zero valent iron; Aerobic reactors; bacterial growth

1. INTRODUCTION

Wastewater is known as water that has been struck in quality by the generated pollutants from domestic use, agricultural and industrial activities [1]. Nutrient elements of nitrate and phosphorus are among the most found elements in wastewater [2]. Exceeding the concentration of nutrient elements in wastewater to more than the acceptable levels could adversely affect human health, environment, and agriculture sector [3]. Therefore, several efforts have been made to recover the quality of household wastewater by removing the undesired elements such as nitrate, phosphorus, ammonia and COD. Biological treatment is the most used method for the remediation of household wastewater either using aerobic or anaerobic strategies. Specifically, aerobic granular sludge (AGS) has been emerged and successfully applied for the contaminates removal from wastewater [4]. Comparing with the anaerobic treatment that can cause odor problems and the formation of secondary pollutants [5], aerobic granules brought the attention of researchers over the last 10 years, due to the increased microbial growth and the superior decomposition or settling ability [6]. Therefore, the objective of this study was to investigate the effect of nano-scale zero valent iron (nZVI) on the performance of the sequencing batch reactor system (SBR) in terms of nutrient and COD removal. In addition, detect the effect of nZVI on the bacterial growth species.

2. MATERIALS & METHODS

2.1 Experimental set-up and reactor operation

Tow sequencing batch reactor were operated in sequencing batch mode with a cycle time of 6 hours divided into four phases: 60 minutes of anaerobic static feeding of the synthetic wastewater from the bottom of the reactor; 283 minutes of aeration; 2 minutes of settling; and 15 minutes for discharging. Tow liters of the seed sludge were added in each reactor and the reactors were fed with the synthetic wastewater that had the following initial substrate; COD, 500 mg L^{-1}; NH_4-N, 40 mg L^{-1}; PO_4^{3}-P, 8 mg L^{-1}.

2.2 Analytical methods

Samples were analyzed using T60UV-Visble Spectrophotometer for chemical oxygen demand (COD), nitrate (NO^{3-} , nitrite (NO_2^-–N), orthophosphate (PO_4^{3-}–P). In addition, Next Generation Sequencing (NGS)–Based Metagenomics were carried out to determine microbial community at the end of this study.

3. RESULTS & DISCUSSION

3.1 COD removal

COD was monitored in the SBR1 and SBR2 over the whole study as shown in Fig. 1. The reactors had an excellent performance in terms of reducing the concentration of COD. However, after the addition of nZVI in the influent of the SBR2 with 10 mg/L on day 24th , the removal of COD measured in the effluent of SBR2 was much better than that COD concentration in the effluent of SBR1, confirming that nZVI had a positive effect on the removal of COD.

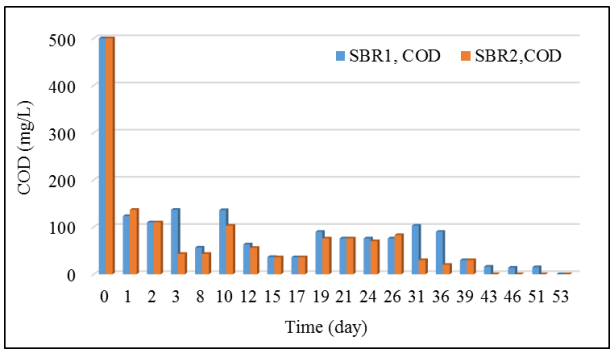

Fig. 1. Performance of the SBR1 and SBR2 in removing COD during the whole period of the study.

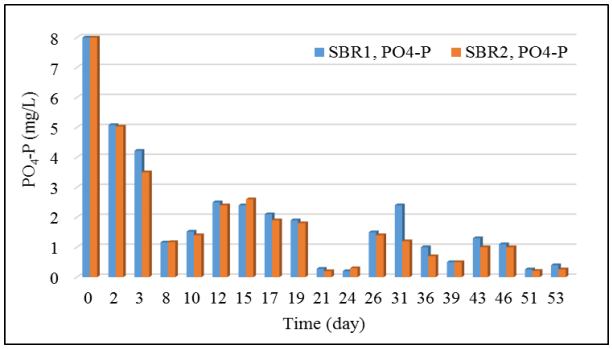

Fig. 2. Performance of the SBR1 and SBR2 in removing phosphate during the whole period of the study.

3.2 Phosphate removal

Phosphate removal was tracked in the effluent of the reactors over the entire study as shown in Fig.2. As a result, biological treatment with aerobic granulation system effectively removes phosphate from wastewater. As it observed in Fig. 2, phosphate removal progressively improved with time in the reactors. Almost a complete removal was seen the reactors at the end of the study. Phosphate removal was slightly better in the effluent of the SBR2. It was proved that the nZVI particles are one of the most efficient adsorbent materials for the removal of phosphate from water [7-10]. Additionally, nZVI particles promoted the growth of bacteria in the reactors which in turn improved their phosphate removal ability.

3.2 Bacterial growth

Bacterial growth species were estimated in the used seed sludge, SBR1and SBR2 at the end of the study. In total 38 order that commonly found in the wastewater plants [11, 12], six orders were found in the seed sludge and in the aerobic granules taken from the SBR1 and SBR2. These orders were presented in Table 2 including Rhizobiales (Rh), Clostridiales (Cl), Sphingobacteriales (Sp), Actinomycetales (Ac), Burkholderiales (Bu) and Xanthomonadales (Xa). These types of bacteria were found with different ration either in the used seed sludge or in the reactors. Next generation sequencing technology analysis showed that the growth of some bacterial species was increased in the reactors compared to the used seed sludge expect the growth of Clostridiales. The elevated microbial growth in the reactors ascribed to the trace elements in the wastewater that service as food for bacteria. However, it was noted that there is a difference in the bacterial growth in the reactors. Some orders were stimulated in the SBR2 that nZVI was added and some other were inhabited (refer to Table 1), confirming that the effect of nZVI on the bacterial growth was genera dependent.

Table: 1 Microbial population in seed sludge, R1 and R2 sludges at the end of the study.

Seed Sludge		**R1**		**R2**	
Order	**%**	**Order**	**%**	**Order**	**%**
Rh	14.7	*Rh*	23.9	*Rh*	25.1
Cl	11.1	*Cl*	6.2	*Cl*	3.6
Sp	8.1	*Sp*	1.2	*Sp*	1.2
Ac	7.6	*Ac*	8.8	*Ac*	7.5
Bu	5.3	*Bu*	5.1	*Bu*	4.9
Xa	4.9	*Xa*	12	*Xa*	13.5

4. CONCLUSIONS

This study investigated the efficiency and the visibility of the sequencing batch reactor system in the treatment of wastewater. In addition, this work investigated the effect of nZVI on the performance of the sequencing batch reactor in terms of COD and phosphate removal. we concluded that the reactors and aerobic granules had an excellent performance in removing of COD and phosphate where almost a complete removal of COD and phosphate was observed at the end of the study. The results of microbial community analysis proved that the effect of nZVI on the bacterial growth was genera dependent.

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