SBR performance for synthetic and fishery wastewater treatment

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Abstract The evaluation of a SBR performance treating synthetic and fishery wastewater was performed. Without salt addition, COD and ammonia removal rates over than 50% were obtained, indicating the occurrence of the first nitrification step and COD removal. With 0.5% salt, removal rates lower than 60% were attained, for ammonia removal efficiency probably due to ionic strength changes and cellular plasmolysis leading to inactivation of the nitrification organisms. The SBR performance was greater for synthetic wastewater, due to the inherent and controlled characteristics. For both, lower SVI were achieved as a valuable indicator towards the assessment of the aggregated biomass structure.
Keywords SBR; synthetic wastewater; fishery wastewater; settleability

INTRODUCTION

The Sequencing Batch Reactor (SBR) is one of the most interesting activated sludge process used for biological wastewater treatment allowing the control of filamentous bacteria and flexibility of the operation cycles. Nitrification process is highly vulnerable to pH, temperature and dissolved oxygen variations and it is imperious its monitoring and control in a wastewater treatment plant (WWTP). The desalination step in petroleum processing and other industrial activities, as fish-processing and chemical manufacturing, generates high saline wastewaters intervening with biological treatment efficiencies and with population structure (Moussa *et al.*, 2007). The major problems encountered in biological treatment of saline wastewater are the limited extent of adaptation, sensitivity to changes in ionic strength, reduced degradation rates and high suspended solids concentration in the final effluent (Kargi and Dinçer, 1997, 1999). The work aims to evaluate the COD and ammonia removal process and also the aggregates settlement ability in a SBR unit with and without salt addition, employing a filling strategy with symmetric pulses. Synthetic and fishery wastewater were applied for this evaluation.

MATERIAL AND METHODS

Experimental Set-up

Experiments were carried out in a SBR unit equipped with a controllable feed pump, air supply, mechanical agitator and sensors (level, ORP, pH, and DO). For data acquisition and control, the FIX-DMACS v.6.15 supervisory system (The Intellution Inc., Missouri, USA) was employed. The synthetic medium prepared with de-mineralized water presented the following composition: NH_4Cl - 76.1 mg.L^{-1}, $C_6H_{12}O_6$ - 300 mg.L^{-1}, $MgSO_4.7H_2O$ - 16.7 mg.L^{-1}, $NaHCO_3$ - 243.3 mg.L^{-1}, Na_2CO_3 - 162.2 mg.L^{-1}, $Na_2HPO_4.12H_2O$ - 46.2 mg.L^{-1}, $CaCl_2.7H_2O$ - 4.7 mg.L^{-1} and KCl - 4.7 mg.L^{-1}. For biomass maintenance, trace elements were added in lower concentrations (less than 0.2 mg.L^{-1}). The fishery wastewater was provided from PEPSI Co. industry, located in São Gonçalo – RJ (Brazil), usually processing sardine (120t/d) and tuna (15t/d). The sludge (5L), gently provided by PETROBRAS S.A., was maintained in the reactor throughout the whole experimental period. The salt concentration varied between 0 to 0.5%. Between each experiment, the biomass acclimation step was performed, allowing the conventional microorganisms to be adapted to each situation studied. Productivity results favoured a discrete fill strategy, consisting of symmetric pulses for wastewater and oxygen supply to the system (Coelho *et al.*, 2000). Sequences of aerobic and anoxic phases, throughout a total filling period of 210 minutes, allows for lower substrate levels that diminish cell inhibition. Afterwards feed was suppressed, leading to the degradation of the final compounds and the attainment of the values specified by the legislation. At the end of each SBR cycle, a period of around 30 minutes was carried out for biomass settlement, followed by the removal of the supernatant.

Analytical methods

Samples were withdrawn at the beginning and at the end of each cycle phase (every 30 minutes). Clear supernatants were analyzed for COD and ammonia concentrations. Ammonia was determined by a selective electrode (Corning), and COD was determined according to the methodology described in *Standard Methods* (1998). The sludge height variation versus time, h(t), was monitored for 30 min in a 1L settling cylinder after each SBR cycle. Total suspended solids (TSS) were determined by weight, and used to determine the sludge volume index (SVI).

RESULTS AND DISCUSSION

SBR performance for COD and Ammonia removal efficiency

The SBR performance for synthetic and fishery wastewater was evaluated through COD and ammonia removal rates for 0 and 0.5% of salt addition. The results demonstrated a complex effect of salt presence on the nitrification process and COD reduction, using different wastewater composition. Nitrification, population structures and settling characteristics are interrelated and are all directly affected by salt. COD and ammonia removal efficiencies during the employment of a filling strategy with symmetric pulses are depicted in Figure 1 for fishery and synthetic wastewater without and with salt content.

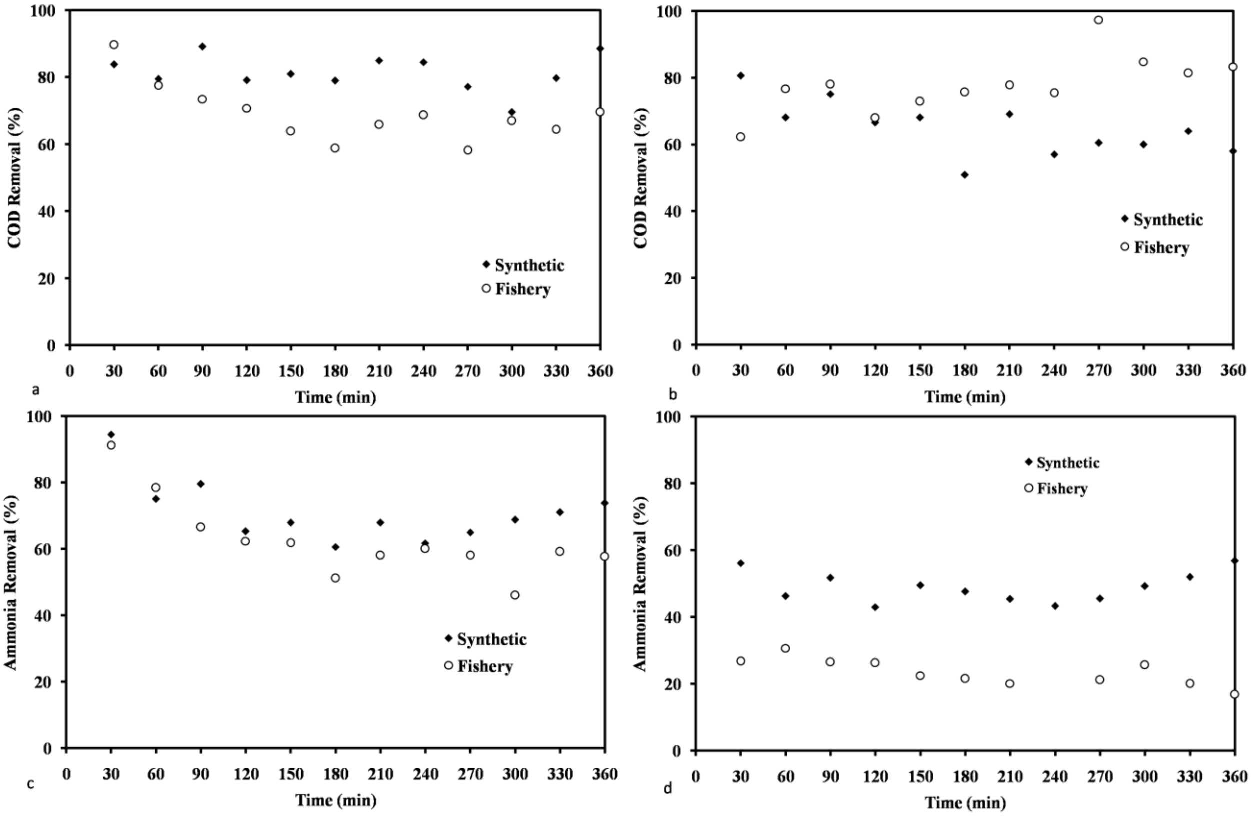

Figure 1. COD removal profiles achieved without salt addition (a) and with 0.5% salt addition (b); Ammonia removal profiles achieved without salt addition (c) and with 0.5% salt addition (d) for synthetic and fishery wastewater.

The results herein reported, show an oscillation in COD removal efficiency for both, fishery and synthetic wastewaters based on the operational strategy adopted for this study. However, higher values for COD removal efficiency (above 80%) from the synthetic wastewater are verified during this experiment without salt addition, which means that the biomass is able to reduce the organic load on the biological system (Figure 1a). From these results, it can be concluded that the symmetric pulses strategy is capable to reduce the COD concentration. The wastewater composition complexity may be responsible for the sharp drop of COD removal efficiency. When the biomass is treating a fishery wastewater, the performance of the system is lower, having different behaviour than the controlled synthetic wastewater. Nevertheless, at the end of the SBR cycle, it is observed COD removal efficiencies higher than 50%.
A salt increase (0.5%) on the synthetic wastewater led to low COD removal rate (Figure 1b) due to a drastic change in the ionic strength, similarly to the results described previously (Kargi and Dinçer, 1997). The results obtained for synthetic wastewater with 0.5% salt content, may suggest that reduced efficiencies with the salt addition could have been caused by the lack of cell metabolic recovery. Plasmolysis of the organisms resulting in loss of metabolic activity is, therefore, the most suitable explanation for this sharp decrease (Uygur, 2006). For fishery wastewater, contrasting with these results, at the end of the adopted operational strategy, COD removal efficiency is higher than 80%. The most suitable explanation is that the acclimation step allowed for the recovery of the organisms activity and COD removal and thus bacteria viability.
Ammonia removal efficiency decreased from 98 to 70% during the SBR cycle treating synthetic wastewater without salt content (Figure 1c). The salt absence allows high ammonia removal efficiency, showing the high ability of the symmetric pulses strategy for ammonia removal. Figure 1d, shows ammonia removal efficiencies lower than 60% for synthetic wastewater when the system is disturbed with 0.5% salt content. The efficiency dropped rather sharply with the salt content. Again is detected loss of cell activity at high salt contents. Nevertheless, from 210 min until the end of the experiment, there is a gradual increase of ammonia removal efficiency. These results can be attributed to the growth of surviving organisms for salt stress. The ammonia removal efficiency decreases below 30% for fishery wastewater. The regular removal efficiency shows a great response by the filling strategy with symmetric pulses. However, it can be seen higher inhibition for fishery wastewater, with the period of acclimation. These results concluded that the salt inhibition seems not be dependent only on the adaptation time but essentially on the wastewater nature.

SVI and Turbidity evaluation

The stability of the microbial aggregates in activated sludge and the effluent quality are crucial in solid-liquid separation processes. Figure 2 illustrates the SVI and Turbidity profiles for synthetic and fishery wastewater.

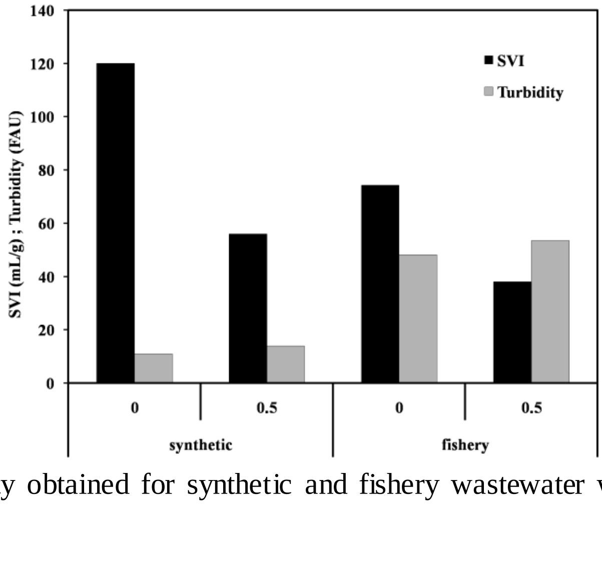

Figure 2. SVI and turbidity obtained for synthetic and fishery wastewater with (0.5%) and without salt content.

The SVI parameter indicates the morphological and settleability state of the microbial aggregates. Sometimes, high number of small aggregates and free bacteria, which do not settle, can lead to a high turbidity of the treated effluent. If they are well flocculated, they will become part of the settling matrix. If not, they will not settle and contribute to higher turbidity. SVI values were found to decrease with salt concentrations increasing for both conditions. Higher SVI values, which suggest poorer sludge compaction characteristics, were observed for 0% salt, although no signifying filamentous bulking evidence; since the value is lower than 150 mL/g, the threshold for bulking phenomenon (Jenkins *et al.*, 2003). A visible modification on the physical aggregates properties was not detected based on the SVI measurement for synthetic and fishery wastewater. The effluent turbidity enhance for both wastewaters, despite the SVI decrease, could be due to several reasons: the inhibition of WWTP regulatory action towards the dispersed bacteria due to the protozoa decline with salt contents increase; and certain species of microorganisms may collapse due to stress leading to the release of their cellular components into the bulk increasing turbidity. With salt concentrations, the higher stress on the microbial cells decreases coagulation and flocculation abilities, which may increase the effluent turbidity. The obtained results for the settleability properties suggested that SVI and turbidity are not directly related. Furthermore, it seems reasonable to assume that both measurements are complementary, and therefore turbidity can be a valuable indicator towards the assessment of the aggregated biomass structure.

CONCLUSIONS

The results indicate that the symmetric pulses strategy provides the first nitrification step and COD removal. The addition of salt is responsible for the ammonia removal rate decrease for both situations. Possibly, ionic strength changes and cellular plasmolysis led to the inactivation of the organisms and subsequent reduction on ammonia removal rates. The settleability evaluation must be analysed and consequently being an indicator variable of the aggregated biomass structure assessment. In conclusion, comparing the synthetic and fishery wastewater, the SBR performance was greater for synthetic wastewater, due to its inherent and controlled characteristics.

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