MICROBIAL COMMUNITY DYNAMICS DURING START-UP OF AN OSA PROCESS

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Abstract

A 5 L d^{-1} lab-scale pilot plant has been designed and constructed for the study of the reduction of excess sludge in wastewater treatment plants. The experimental device is similar to a conventional activated sludge (CAS) system, but includes a holding tank between the aeration tank and the settler. In this holding tank, oxygen is not supplied so that excess sludge production can be reduced by an alternating exposure of activated sludge to oxic and anoxic environments. This modification of CAS system is called oxic-settling-anoxic (OSA) system. In order to evaluate the structure of the microbial community in the start-up period in an OSA system, a CAS process was also studied as a comparison.

Keywords: pilot plant, sludge reduction, intermittent aeration, CAS system, OSA system

Introduction

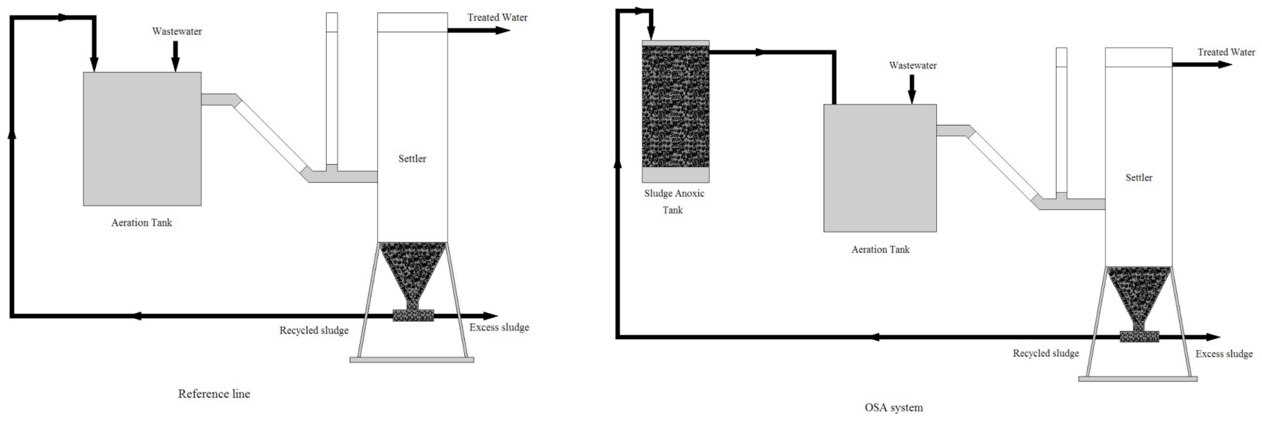
The microbial population and diversity play an essential role in sewage treatment. A high biomass concentration contributes more sewage treatment. In most biological wastewater treatment process such as conventional activated sludge (CAS) system, though they have been recognized to be effective for organic wastewater treatment, the large amount of excess sludge derived from microbial growth generates high costs in equipment, operation, and final disposal. It is necessary to develop different technologies, combined with CAS process for reducing excess sludge production. The OSA process is a modification of CAS process which can reduce sludge production by an alternating exposure of activated sludge to oxic and anoxic environments (Saby *et al*, 2003; Chen *et al*, 2003; Jung *et al*, 2006; Rodríguez-Pérez *et al* 2009, Rodríguez-Pérez *et al* 2010). However, a better understanding of the cause of the process enabling excess sludge reduction is necessary for full scale experience.

Many studies have evaluated the effects of OSA process into a variety of activated sludge processes. However, most previously conducted studies have focused on the operating conditions. After the introduction of anoxic tank to the activated sludge processes, nutrients released by cell lysis and cell debris may alter the influent characteristics of the entire system; however, there have been few in depth analyses of the biological performance and microbial communities associated with the activated sludge process when OSA system was introduced to reduce the excess sludge production.

It is now well recognized that microbial diversity is greatly underestimated by cultivation studies because most microorganisms observable in nature typically cannot be cultivated by standard techniques. In this study, microbial community structure was investigated by cell staining, in order to elucidate the biological response induced by OSA system during the start-up period.

Methods

The pilot plants are illustrated in Figure 1. The reactors had a working volume of 5 L. One of them was modified as OSA system by inserting a sludge holding tank in the sludge return circuit. The air was supplied through the reactor liquid phase using an air sparger at the bottom. DO concentration and pH value in the reactors and holding tank were measured by a DO (HQ30D Flexi, Hach-Lange) and pH (GLP22, Crison) meter, respectively. The oxygen concentration was varied during the start-up until adjusted around 5 mg L^{-1} in both reactors. The pH was maintained around 7 by phosphate buffer solution. Full mixing within the reactors and holding tank were achieved with magnetically stirrers. The feeding solution of synthetic wastewater was added to the reactors using peristaltic pumps. Seeded sludge was taken from the recirculation line of the aeration tank of the West Urban Wastewater Treatment Plant of Sevilla, (Spain). The seed mixture contained initial biomass concentrations of 3 g_{MLSS} L^{-1}, 1,5 g_{MLVSS} L^{-1}. The hydraulic retention time (HRT) was controlled at 12 h, in the aerobic reactors and at 3,5 h in the anoxic holding tank. The operation was all conducted at a room temperature (25°C).



Microscopic examination of the mixed liquors from the aerobic reactors and the anoxic tank was performed twice per week using an NIKON E200, according to the manual given by Eikelboom (2000). Filamentous index (FI) was used to evaluate the abundance of filamentous bacteria present in the samples. The dominant filamentous bacteria were identified by morphology observation together with Gram and Neisser staining reactions according to the criteria given in Eikelboom (2000) and Jenkins et al. (2004). Where possible, two independent microscopic examinations of samples were performed to confirm identifications. The difference in the structure of the microfauna in the two systems was also identified based on the morphology of the protozoa and metazoans according to Manual práctico para el studio de grupos bioindicadores en fangos activos (EMASESA, 2008).

Results and discussion

During the start-up period, removal efficiencies of COD were above 64% and 73% under control CAS and OSA system, respectively. The sludge drawn from each reactor was observed by optical microscope twice per week. The microbial population at the start-up of the cultures was the one of a typical activated sludge, including bacteria, protozoa and metazoan. After the first week of operation, the bacterial communities in the two reactors did not differ. However, after 10 days of operation, the difference in the communities increased. Under control CAS conditions, protozoa and metazoan reduced, but still large number of bacteria was present. On the other hand, under the OSA conditions, most stalked ciliates disappeared and free-swimming small flagellates became predominant, where the sludge floc was fragile and irregularly shaped. Around day 20 of the experiment, most flagellates disappeared under control condition, but under the OSA conditions free-swimming protozoa survived. It was found *Types 1851, 0961* and *0041* as group dominant filamentous bacteria and *Oxytricha sp*. as dominant protozoon in CAS control system; however, in OSA system dominant filamentous bacteria were *Nostocodia* and *Type* 0675, while dominant protozoon was *Cinetochilum sp*. These results suggest that some predators can survive under the alternated aerobic/anaerobic conditions.

Conclusions

The OSA system showed good performance for the removal of COD and cell debris, while reduce around 60% of excess sludge production, during the start-up period. The microscopic analysis revealed that bacterial communities in the processes were different. Furthermore, CAS control process contained more protozoa and metazoans than the OSA system in both number and variety. However, the microfauna in the OSA system needed approximately 15 days to adapt to the altered environment, after which it could be observed an increased of small ciliates and free-swimmings. These findings indicate that the impact of the OSA system adjust the microbial community structure, while maintaining the metabolic activity.

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