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Removal of Ammonium from Synthetic Wastewater Using Integrated Fixed Film Activated Sludge (IFAS) Include Powder Activated Carbon

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Background & Aims of the Study: High concentration of nitrogen compounds in water and wastewater can be caused various problems and diseases such as methhemoglobinemia and eutrophication. The aim of this study was investigated nitrification and denitrification from wastewater using integrated fixed film activated sludge (IFAS) includes powder activated carbon.

Materials and Methods: The laboratory scale experiments were conducted in a continuous mode. Two bioreactors containing IFAS and IFAS include powder activated carbon were utilized for evaluating of ammonium removal. Ammonia, nitrate, mixed liquor suspended solid (MLSS), Suspended solid (SS) and pH were analyzed. 2.5 g/L MLSS were inoculated in the startup time. The IFAS system was operated in HRTs 8, 12 and 16 h.

Results: The obtained results shows that utilization of powder activated carbon in the media can be cause rapid sludge production and high efficient ammonium removal process. Nevertheless, it has not effect on the carbon removal in the process.

Conclusion: According to the obtained results, utilization of powder activated carbon in the integrated fixed film activated sludge can be promoted the efficiency of ammonium removal.

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Background

The human have been contributed in environmental nitrogen pollution. For example, entry of nitrogen compounds in the forms of urine and ammonia is increasing in view of the growing world population (1). Discharge of this nitrogen into the natural waters can lead to eutrophication, oxygen depletion and fish toxicity (2). The most common treatments for removing nitrogen compounds from water and wastewater are ion exchange, electrodialysis and reverse osmosis, electrocoagulation, biological treatment (3). Although, membranes process is used effectively for removal of nitrogen compounds, various problems associated with these techniques include high-energy costs and the generation of large volumes of waste brine (4). Also, biological method was utilized for nitrogen compounds due to environmental friendly, low costs, lower operation handling, reliability and effectively. Recently some processes were applied such as simultaneous nitrification and denitrification

(SND), Modified Ludzack–Ettinger (MLE) and integrated fixed-film activated sludge (5-7). In field and pilot studies some materials have evaluated as attached growth beds such as sand and gravel, PVC, polyurethane and limestone (8). The characteristics of each materials are important factor in the adhesion properties. Jechalke, et al. (2008) was investigated biofilm development on coconut fibers and polypropylene textiles for enhancing biodegradation of low-concentration MTBE, benzene, and ammonium from groundwater in aerated treatment ponds (9). Carbon active offers a more effective means to attract biomass due to its irregular creviced, porous particle shape and ability to bind (10). Carbon active due to surface characteristics and high surface area (600-1500 m^2/g) widely is applied in treatment process. Pons et al. (2012) reported the surface roughness is affected on biofilm coverage (11). Hence, in this work, was investigated the potential of carbon active for attached growth bed by unique characteristics (such as desirable surface area and roughness), and improving the denitrification process in the IFAS systems. Based on available database and literatures, similar studies have not been reported.

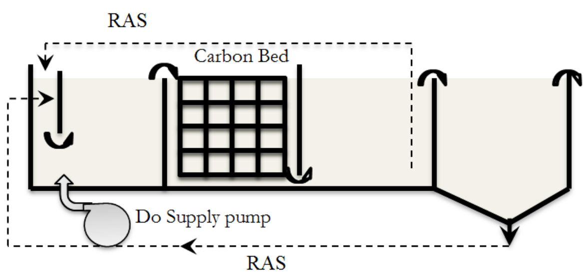

Fig. 1: Flow diagram of integrated fixed film and activated sludge

Materials & Methods

Regents

All regents and chemicals were prepared in analytical grade and purchased from Merck and Sigma Company.

Wastewater

The raw wastewater was prepared with content COD about 500 mg/L and different concentrations of ammonia 24,104, 208 and 316 mg/L. Finally, pH was adjusted in range of 6.8-7.2. The compounds of feed solution are presented in Table 1.

Table 1) Synthetic wastewater characteristics

Components	Dosage (mg/L)
Dextrose	500
Ammonium chloride	24,104, 208 and 316
Potassium dihydrogen phosphate	12
Dipotassium phosphate	16
Calcium chloride	18
Magnesium sulfate	24

Bed preparation

In order to providing the carbon active bed, first the emulsion of carbon active with ethanol was prepared. Then, the polymer ligand was added to polycarbonate bed (100 m^2/m^3) and it was placed in ethanol-carbon emulsion.

Pilot systems

In this study, the ammonia removal was studied using IFAS systems that were impregnated with carbon active bed. Bioreactors with 13-liter volume containing carbon active bed-IFAS were applied for the experiments (Fig. 1). Both reactors were filled about 30% (in volumetric) with medium. In order to enhance the nitrification, aeration with diffuser were utilized. The mixed liquor suspended solids (MLSS) were inoculated at 2.5 g/L in startup phase. At the primary experiments, IFAS system was operated in HRT 8, 12 and 16 hr and room temperature (25±1 oC). The MLSS samples were collected from the end part of the bioreactor every 7 days.

Analytical methods

All experiments (such as Ammonia, Nitrate, MLSS and pH) were performed according to Standard Methods for the Examination of Water and Wastewater (12).

Statistical analysis

All data were expressed as the mean ± standard error. Statistical analyses consisted of one-way analysis of variance conducted using SPSS software (version 19.0; IBM Company, United States). Differences were considered significant when $p < 0.05$

Results

Fig. 2 displays that change of microbial population in terms of MLSS during startup phase (5% error bar). According to results, the MLSS was decreased at primary week. Removal of 25 mg/L of ammonia at HRT_s of 8, 12 and 16 hr were evaluated. The outlet of each reactor was compared with standard discharge (3 mg/L).

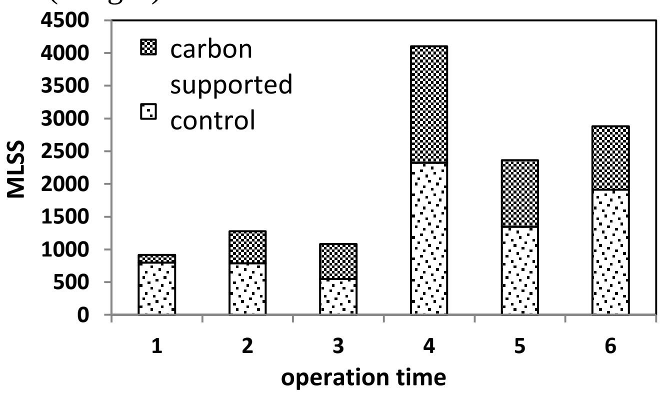

Figure 2) MLSS variation during IFAS system and startup phase

The conversion rate of ammonia at various HRT_s is presented in Fig. 3. It can be concluded that the desirable ammonia conversion occurred at HRT_s of 16 hr. In the lower HRT, removal efficiency decreased. Also ammonia higher than standard values was determined at HRT of 8 hr.

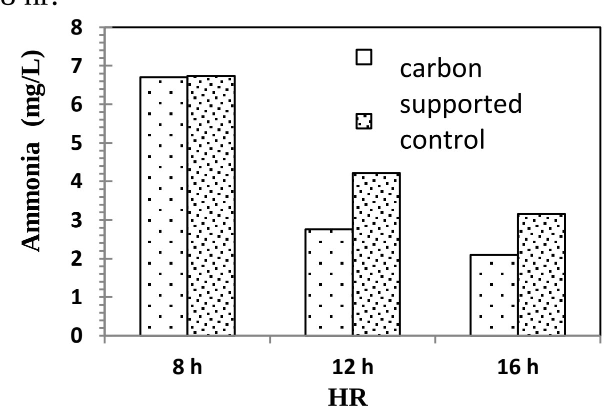

Figure 3) Ammonia removal during IFAS system at different HRT and ammonia load 25 mg/L

Fig. 4 shows the outlet nitrate from IFAS systems at different HRT_s. According to the obtained results, at HRT 16 hr in the IFAS process with carbon supported has been shown the better results.

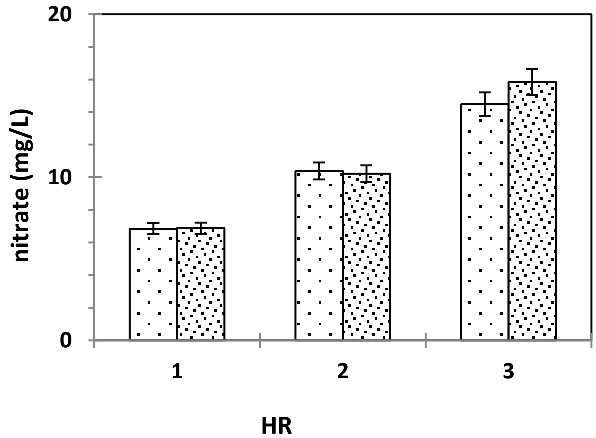

Figure 4) Outlet Nitrate from IFAS at different HRT

Fig. 5 displays the COD removal at various HRT_s during nitrification and denitrification in IFAS process. Also, effect of different levels of ammonia concentration on nitrification and denitrification was evaluated.

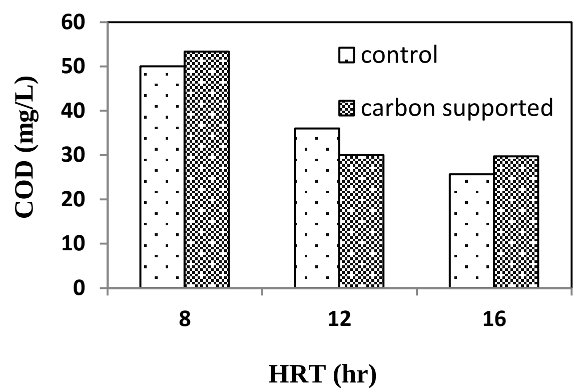

Figure 5) COD removal during nitrification and denitrification at different HRT

Ammonia removal during IFAS process at different ammonia load is presented in Fig.6. With regard to result, there is a desirable ammonia reduction at lower load of 40 mg/L. The outlet nitrate removal from IFAS process at different ammonia loading is presented in Fig. 7.

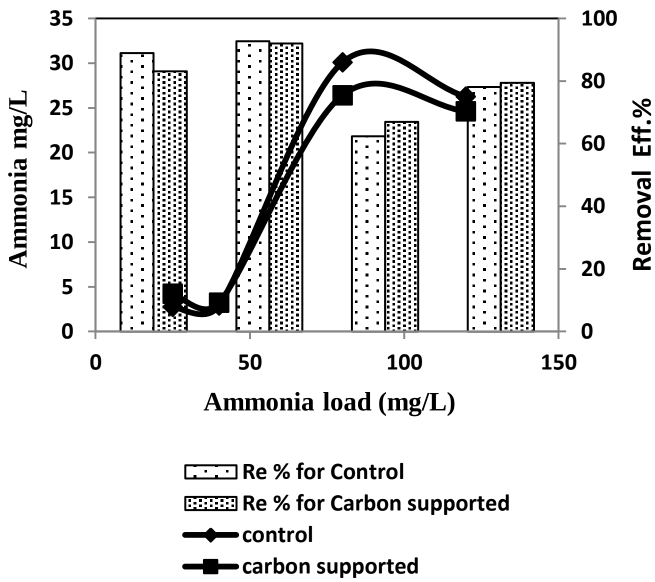

Figure 6) Ammonia removal during IFAS system at different ammonia load

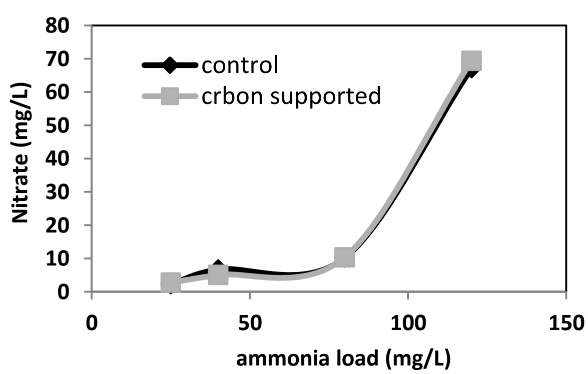

Figure 7) Outlet Nitrate from IFAS at different ammonia load

Discussion

MLSS variation

Fig. 2 shows that, the MLSS was decreased at primary week (in IFAS process include carbon powder and the control bioreactor). It can be attributed to the self-adjustment of the granules to the change of the operational mode (13). Based on the observation, the higher MLSS (mg/L) were created in term of in IFAS-carbon powder versus control condition. The average MLSS for supported and control process were determined about 820 and 900 mg/L, respectively. At the end of startup period, biomass concentration was measured in range 1000 to 2000 mg/L for supported carbon and control samples. Rutt et al. (2006) was reported the MLSS concentration average of 1,718 mg/L during two year study of IFAS (14).

Effect of HRT

Hydrolytic retention time is one of the important factors that can limit biological nitrification and denitrification. Lack of biological stabilization is occurred by decreasing of HRT. The conversion rate of ammonia at different HRT is shown in Fig. 3. It can be seen that the desirable ammonia conversion occurred at 16 hr of HRT. Generally, better condition was provided for denitrification when the carbon supported bed was applied. Fig. 4 shows the outlet nitrate in IFAS process and different HRT. At lower HRT is observed the outlet nitrate is higher in carbon supported. Sriwiriyarat et al. (2008) operated the IFAS and activated sludge processes in parallel for carbon removal and nitrification with 6, 8, and 10 hours HRTs at 4, 6, and 8 days of SRTs. The activated sludge process failed to attain steady state conditions at 10 hr HRT with 4 days SRT, whereas the IFAS system was stabilized until the SRT and HRT were adjusted at 4 days and 6 hours, respectively (15).

COD removal

According to fig. 5, it can be found the higher removal COD rate is obtained at HRT 16 hr. This may be occurred due to adequate time for biological oxidation. Maximum removal percentage was required about 50 and 53% for supported carbon and control units, respectively. Azimi et al. (2007) is believed that the reduction in COD is depended on mean residence time and the ratio of bio-carrier to reactor volume (media: reactor volume), air velocity and media specification (16).

Effect of ammonia load

Ammonia removal efficiency at different amounts of ammonia is shown in Fig.6.

Accordingly, there is a desirable ammonia reduction at lower load of 40 mg/L rather than others. Generally, the ammonia was conversed to intermediate/ N_2 products and up than 62% the ammonia was reduced at all levels. It can be concluded that the nitrate convert to nitrogen gas at lower load of ammonia, successfully (Fig. 7). But the denitrification is failed due to toxicity of ammonia at higher load. The toxicity was occurred especially at 120 mg/L. The obtained results were considered is in both carbon supported and control bioreactors.

Conclusion

Based on the results, we have reached the following conclusions:

(i) Utilization of powder activated carbon in the integrated fixed film activated sludge can be promoted the efficiency of ammonium removal.

(ii) Hydrolytic retention time (HRT) is one of the most important factors that can limit biological nitrification and denitrification. In IFAS system with low HRT, the biological conversion were losed.

(iii) Maximum COD removal efficiency was determined about 50 and 53% at 16 hr of HRT for both supported and control process.

Footnotes

Acknowledgments:

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Conflict of Interest:

The authors declare no conflict of interest.

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