Nitrification and denitrification using a single biofilter packed with granular sulfur

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Abstract This study was performed to develop a granular sulfur packed nitrification/denitrification process employing a uniquely designed single biofilter, which treated a relatively low carbon loaded domestic wastewater taken from a primary clarifier at a municipal wastewater treatment facility. The system was tested on varying experimental conditions, e.g. inflow flow, organic load and nitrogen load. Regardless of flow rate being increased, SS and COD was unvaryingly removed up to 90 and 80%, respectively. Moreover, TKN was also decomposed up to 90%. Increase in COD load gradually led to escalating level of non-biodegradable compounds observed in effluent. Nitrification was accomplished as high as 92%, whereas denitrification was achieved up to approximately 87%. For a while, nitrification and denitrification were observed at 0.65 and 0.55 kg/m^3·day, respectively. Eventually, T-N was decomposed as high as 46%. It was concluded that granular sulfur can be used for not only electron donor, but also for a media to properly treat low carbon loaded wastewater and to filter SS efficiently.

Keywords Biofilter; granular sulfur; media; sulfur denitrification

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Introduction

Because of misconnection and breakage of sewer systems in Korea, practical influent water qualities are very low compared to the design requirements for a wastewater treatment plant, which showed low C/N ratio. In other words, it ascribes to difficulty in heterotrophic bacteria growth at a conventional activated sludge process. It is thus needed that a unique biological process should be developed to efficiently remove nutrients in a carbon deficient wastewater.

Materials and methods

For that purpose, a downflow nitrification/denitrification biofilter (DNDB) packed with granular sulfur was developed. The system features that removal of organic matter and nitrification occurs in the upper part of the DNDB, while autotrophic denitrification occurs in the lower part of the DNDB packed with granular sulfur. The reactor was made by acryl, which consisted of nitrification of the upper part and denitrification of the lower part as shown in Figure 1.

Influent entered downward from the top of the reactor, while compressed air was introduced upward through the diffuser placed 40 cm above the bottom of the reactor.

Nitrification thus forced to occur in the upper part and denitrification in the lower part. An air valve was placed in a line leading to the nitrification area for critical DO control. It prevented sulfur particles from breaking and releasing into effluents. The experiment was conducted at 20°C in a temperature controlled room. As Lampe and Zhang (1999) demonstrated, granular sulfur of diameter 3 to 5 mm was packed in the reactor. Characteristics of granular sulfur are shown in Table 1.

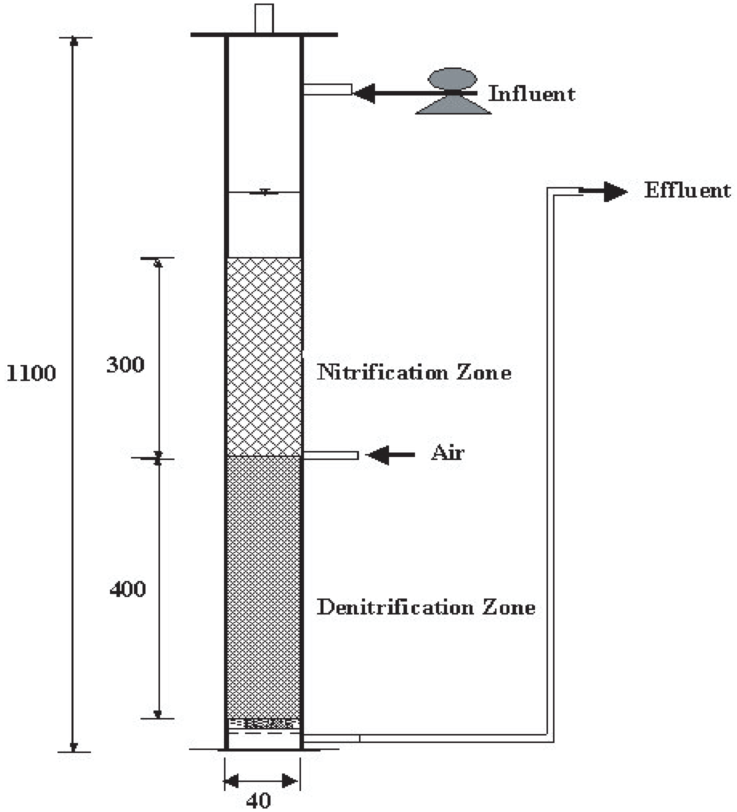

Figure 1 Configuration of Biofilter packed with granular sulfur

Table 1 Characteristics of granular sulfur

Media	Effective size (mm)	Uniformity coefficient	Porosity (%)	Packing density (kg media/L)
Granular sulfur	3.36	1.25	35.0	1.100

Analysis of water quality parameters such as NH_4^+-N, NO_3^--N, and NO_2^--N was followed as given in *Standard Methods* (1998). Prior to analysis, the sample was filtered using a 0.45 membrane (Advantec) which was then analyzed by Traace 2000 (Bran+Luebbe). Influent was prepared two ways; one taken from a primary treatment of a domestic wastewater treatment facility, the other a secondary effluent diluted with NH_4Cl to be 45 mg/L of NH_4^+-N.

Results and discussion

Analytical results of effluent taken from the primary treatment facility showed that BOD/COD ratios were low, which was attributed to industrial wastewater entering into the domestic wastewater treatment plant where industrial wastewater was simultaneously subject to be treated. As shown in Figure 2, SS was removed up to 90% showing 4 mg/L, even though influent flow was increased to 0.76 $kg/m^3 \cdot d$.

Released sulfur particles were not observed in the effluent as they were completely entrapped in the filter bed. During the test of period, COD was increased from 0.17 $kg/m^3 \cdot d$ to 2.36 $kg/m^3 \cdot d$, nevertheless, COD was unvaryingly highly removed by 70 to 80% as shown in Figure 3.

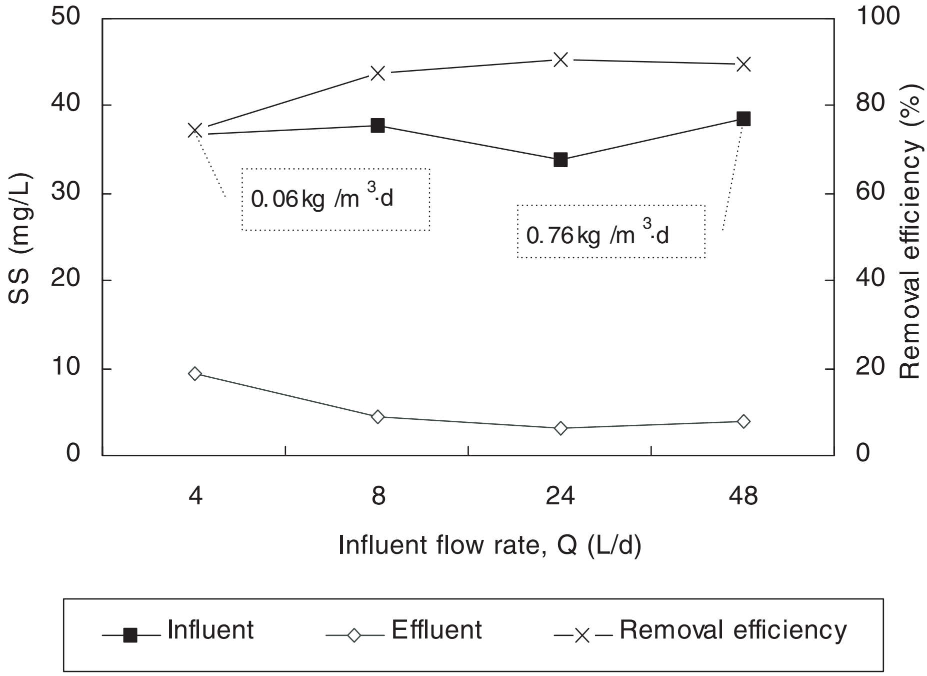

Figure 2 Removal of SS according to hydraulic loading

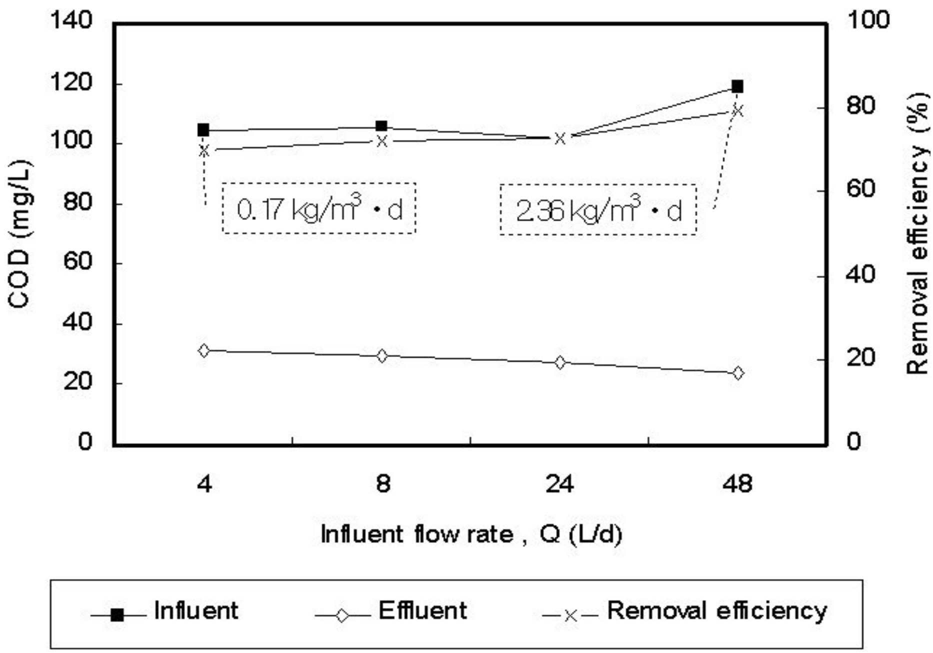

Figure 3 Removal of COD according to hydraulic loading

Nitrification was achieved up to 90% at 0.70 kg/m^3·d as shown in Figure 4. This indicates that autotrophic denitrification using granular sulfur could be performed even at aerobic conditions as demonstrated by Lampe & Zhang (1999).

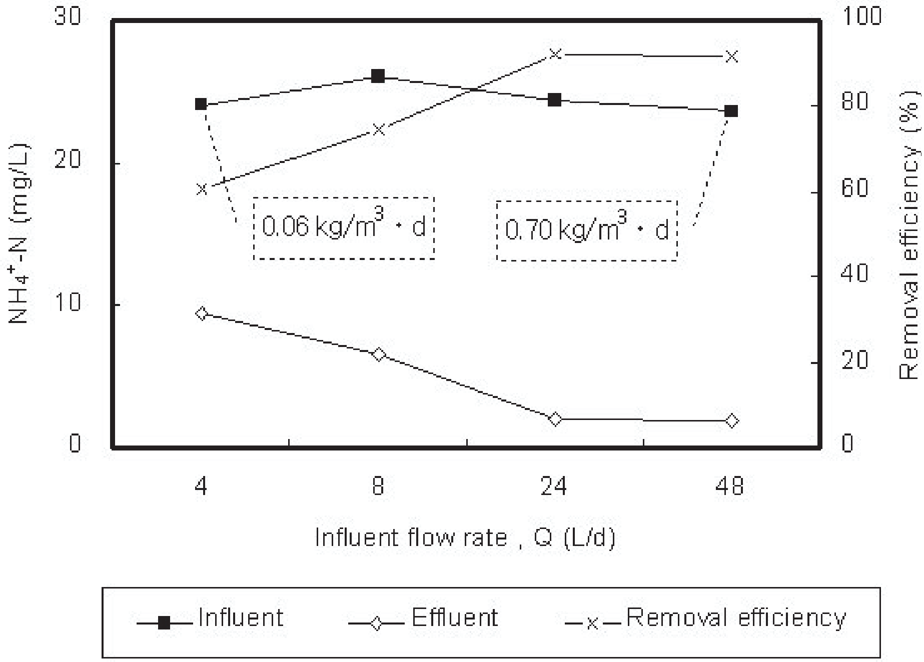

Figure 4 Removal of NH_4^+-N according to hydraulic loading

In general, nitrification and denitrification using granular sulfur consume alkalinity, so that limestone was packed in the reactor at 1:3 over the sulfur. In that condition, alkalinity was adequately observed at 185 mg/L in influent and 200 mg/L in effluent. Nitrification and denitrification were achieved more than 90% and 65%, respectively, regardless of variation given in influent flow rate of 24 L/d and 48 L/d. On the whole, TN was removed up to 45% at 0.58 $kg/m^3 \cdot d$.

Conclusion

In general, employing granular sulfur can be implemented only for denitrification, but this system can accomplish nitrification as well as denitrification in a single reactor even though low carbon concentration was present in the influent limiting the nutrient removal process. It is decided that this system of limestone and granular sulfur packed together can successfully be applied for nutrient removal in a cost effective way.

Acknowledgement

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