Applicability of sewage heat for improvement of nitrification performance of a trickling filter

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1. Preface

I presented a poster entitled above at IWA World Water Congress & Exhibition 2016 in Brisbane, Queensland, Australia from 9th to 13th October 2016.

2. Summary and Presentation

2.1 Introduction

The modified Ludzack-Ettinger process requires a high-energy input to operate blowers for aeration in a nitrification tank. To solve this drawback we developed a new biological nitrification-denitrification process with a trickling filter for nitrification and an anaerobic biological filter for denitrification. However, low temperatures less than 15℃ critically affect the bioactivity of nitrifying bacteria, which play an important role in oxidizing ammonia and nitrite. Accordingly, complete nitrification using a conventional trickling filter is difficult in winter. To prevent the inactivation of those bacteria, we focus on sewage heat. Sewage is warmer than the air in winter. In this study, we discussed an availability of sewage heat for warming the trickling filter in winter.

2.2 Material and Methods

Figure 1 illustrates the experimental set up. A pair of reactors (reactor A and B) with the same configuration was prepared for comparison. The trickling filter for nitrification consisted of an acrylic pipe with 80-mm in diameter and 1000-mm in height and 540-g of tubular filter media made of polyethylene with 15-mm in diameter and 15-mm in length (LT-15, Dainippon Plastics, Japan). The bottom end of the pipe was covered with a plastic net with a 5-mm mesh, that held up the filter media. As a sewage heat utilization system, a coil tube made of polytetrafluoroethylene with 4-mm in diameter and 6.0-m in length was installed into the reactor A alone. The influent sewage flowed into the denitrification tank via the coil tube. The coil tube was not installed into the reactor B because the reactor B was a control. The exterior of both reactors was covered with an insulation (Pipe Cover, Toray Pef Products, Japan). The denitrification tank consisted of an acrylic tank with 125-mm in height, 70-mm in width and 320-mm in depth and was filled with string-shaped and brush-like contact media (KC-30, Dainippon Plastics, Japan). Total length of the media was 1.8 m. Wastewater flowed tortuously through the contact media. The effective volume of the tank was 2.15 L. Wastewater pumped up from a sewage chamber in Ryukoku University, Japan was used for all the experiments. The operational conditions were shown in Table 1. In addition, to simulate actual sewage, the sedimentation tank was heated to around 20℃ with a ribbon heater (JH-128, Misec, Nagoya). Consequently, the temperature of effluent from sedimentation tank was fluctuated between

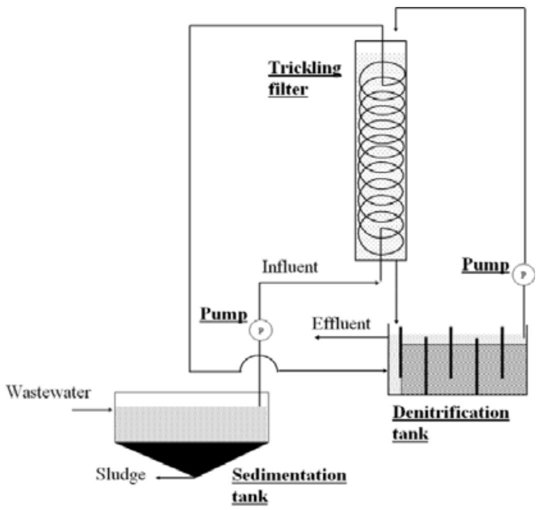

Fig. 1　Experimental setup (reactor A)

Table 1 Operational conditions

Term	Flow rate （L d^{-1}）	Circulation rate （%）	Hydraulic loading （m^3 m^{-2} d^{-1}）	Air temperature （℃）
Ⅰ 1 Oct.-26 Nov.	8.0	250	5.57	15.0-25.3
Ⅱ 27 Nov.-25 Jan.	8.0	250	5.57	4.6-14.9

20.5 ± 1.9℃ for all the experiments.

2.3 Results and Discussion

Figure 2 summarizes the changes in NH_4-N, NO_3-N, NO_2-N, and dissolved organic nitrogen concentrations over time. The averages of DN removal efficiency in term I (≥15℃) and term Ⅱ (<15℃) were 65.9 ± 17.3 % and 71.2 ± 11.6% for the reactor A, and 57.5 ± 22.2 % and 51.8 ± 15.1% for the reactor B. Although there was no significant difference in nitrogenous water qualities in the effluent between two reactors in term I, a significant difference ($p < 0.05$) was detected by the t-test in term Ⅱ. The nitrification efficiency of the reactor A was tended to increase from 51.2 ± 27.3% in term I to 62.5 ± 17.9% in term II in spite of air temperature drop to lower than 15℃ in term II, whereas that of the reactor B was tended to decrease from 39.2 ± 25.6% in term I to 20.7 ± 9.2% in term II. Accordingly, a further improvement of heating system will be required for nitrification in such a severely cold season. Figure 3 shows the relationship between the flow rate of temperature-regulated tap water and the temperature difference in the filter bed between reactor A and B. As the sewage heat utilization experiment was performed at the sewage influent flow rate of 8 L d^{-1}, it was inferred that the temperature in the filter bed of reactor A was maintained 1.3 ± 0.2℃ higher than that of reactor B and 2.5 ± 0.6℃ higher than the air temperature. Consequently, the utilization of sewage heat for warming the trickling filter was effective in enhancing the nitrification performance in winter.

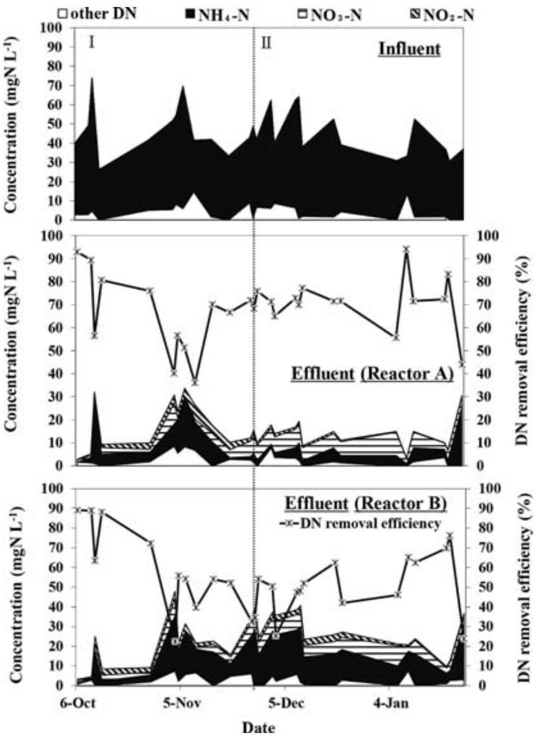

Fig. 2 Changes in DN components over time

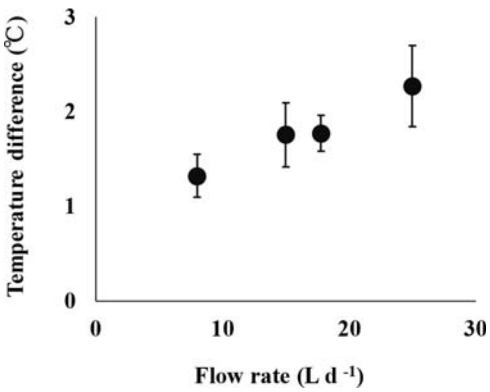

Fig. 3 Relationship between the flow rate of tap water regulated at 20℃ and the temperature difference in the filter bed between reactor A and B. The error bar shows sample standard deviation.

3. Acknowledgement

We wish to express our appreciation to Prof. N. Kishimoto for his steadfast support and encouragement. It was excellent experience for me to share my research works with many international researchers.