Micro-polluted source water treatment at low temperature by activated carbon filter biologically enhanced with heterotrophic nitrifying bacteria

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Abstract
Acinetobacter sp. Y7 and Y16, which have heterotrophic nitrification abilities at low temperature. We sought to confirm whether use of Acinetobacter strains Y7 and Y16 was practical for removing ammonium (NH₄⁺-N) from micro-polluted source water at low temperature. To test this, continuous ammonium treatment was conducted in order to evaluate the performance of a pilot-scale two-stage biologically-enhanced activated carbon (BEAC) filter, inoculated with Y7 + Y16 mixed bacteria, in removing ammonium. The filters had been running for 120 days. During the operation, the removal efficiency of NH₄⁺-N and dissolved organic carbon (DOC) were determined. The Nitrogen conversion, biomass and microbial activity in the filter were investigated. It was observed that 15.5±6.0 %, 31.3±13.1 %, and 70.0±29.4 % of NH₄⁺-N were removed using the BEAC filters at 0.9±0.2 °C, 5.9±3.3 °C, and 13.2±2.2 °C, respectively. There was no accumulation of NO₃⁻-N in the BEAC filters. About 65% of the removed NH₄⁺-N was converted to NO₂⁻-N. When the bed volum (BV) reached 14.7 m³/kg-carbon, the removal efficiency of DOC was 40.6 %. The biomass in the first stage BEAC (BEAC-I) filter and the second stage BEAC (BEAC-II) filter at 0.9±0.2 °C were both 0.5x10⁷ CFU/g-carbon, and had a 2-5 folds increase with the rise of temperature. The microbial activity in BEAC-I and BEAC-II filter increased with the rise of temperature. The results indicated that high ammonium removal efficiency of BEAC filter was due to high biomass and microbial activity. This study provides new insight into the use of biofilters to achieve biological removal of ammonium at low temperature.

Keywords
Ammonium; heterotrophic nitrifying bacteria; low temperature; micro-polluted source water; biologically-enhanced activated carbon

INTRODUCTION
Excessive amounts of NH₄⁺-N in micro-polluted source water is associated with potential hazards. Increasing concentrations of NH₄⁺-N has resulted in the need for stringent, restrictive legislation regarding NH₄⁺-N levels in drinking water. During winter, the excessive NH₄⁺-N problem is worse than it is in other seasons. Low temperature is the limiting factor in NH₄⁺-N removal when using conventional biological approaches (Huang, 2013). NH₄⁺-N removal by heterotrophic nitrifying bacteria is preferable due to the faster growth rates and strong adaptability to low temperature (Zhang, 2011a). Acinetobacter sp. strain Y7 and Y16 were isolated from the Songhua River in winter, which have the ability to simultaneously perform heterotrophic nitrification and aerobic denitrification at 2 °C. In this study, we inoculated strains Y7 and Y16 onto the surface of granular activated carbon (GAC) to develop a pilot-scale BEAC filter. The purpose was to confirm whether it is practical to use Y7 and Y16 in NH₄⁺-N removal from drinking water at low temperatures.

MATERIAL AND METHODS
The device contains two tandem BEAC filters. Filters were both 2110 mm in height and 500 mm in internal diameter, and operated in down-flow mode. The filters were filled with 250 mm grit sands
as the gravel layer, and 750 mm GAC as a carrier for the bacteria. After conventional treatment (coagulation-sedimentation-filtration), water from Songhua river enters the BEAC process. Operational conditions and influent quality of the BEAC filters is shown in Table 1.

### RESULTS AND DISCUSSION

The NH$_4^+$ and DOC removal efficiency, biomass, and microbial activity are shown in Table 2.

### Ammonium removal performance

NH$_4^+$-N removal rates at 0.9±0.2 °C and 5.9±3.3 °C were comparative and considerable. NH$_4^+$-N removal rate at 13.2±2.2 °C had a about 4-fold increase. Higher biomass and microbial activity in BEAC filters might result in higher NH$_4^+$-N removal efficiency.

### Nitrogen conversion

There was no accumulation of NO$_3^-$-N in the BEAC filter. About 65% of the removed NH$_4^+$-N was converted to NO$_3^-$-N in period a. NO$_3^-$-N was accumulated in this study because NH$_4^+$-N oxidation would be faster than NO$_3^-$-N reduction for heterotrophic nitrifying bacteria at low temperatures.

### CONCLUSIONS

Low temperature limited the growth and activity of bacteria, which affected removal efficiency and nitrification ratios. However, BEAC with strains Y7 and Y16 had significant NH$_4^+$-N and DOC removal efficiency in treating micro-polluted source water at low temperatures.

### REFERENCES
