EFFECT OF TEMPERATURE ON DENITRIFICATION AND DEOXYGENATION IN PACKED-BED GRANULAR FILTERS

Suraphong Wattanachira and Kenji Fujita
Department of Urban Engineering
The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113, Japan.

INTRODUCTION

Biological denitrification is the process which nitrate nitrogen is reduced to gaseous nitrogen by heterotrophic bacteria under anoxic condition. These organisms are able to use either nitrate nitrogen or dissolved oxygen as terminal electron acceptors. It was known that growth rate and other activities of microorganisms in denitrification process are significantly affected by temperature (U.S. EPA, 1975). The purpose of this research was to investigate the effect of temperature on denitrification rate and deoxygenation rate of biological denitrification process in packed-bed granular filter.

METERIALS AND METHODS

Laboratory scale of packed-bed upflow filters were utilized to conduct the experiments. Anthracite was used as media for supporting the growth of denitrifying bacteria. Two different media sizes of 4.00-4.76 mm (average 4.36mm) and 2.00-2.83 mm (average 2.38 mm) were tested. The media was packed to a depth of 800±50 mm from the bottom of the filter. Methanol, the commonly used carbon source, was served as an electron donor. Samples were taken from the sampling ports along the filter depth after about 20 hours of each backwashing. The characteristics of raw water fed into the filter and experimental condition used is depicted in Table 1.

TABLE 1 The Characteristics of Raw Water Fed into the Filter and Experimental Conditon Used.

Parameter	Characteristics of raw water and experimental condition used
NO_3-N	approx. 10 mg/l
NO_2-N	lower than 1 mg/l
PO_4-P	excess (approx. 6 mg/l)
DO	approx. 8.5 mg/l
pH	7-8
Alkalinity	approx. 150 mg/l as $CaCO_3$
Filtration rate	100 m/d
CH_3OH	C/N ratio excess
Temperature	varied

RESULTS AND DISCUSSIONS

Effect of Temperature on Denitrification Rate

Referring to the previous study (Suraphong and Fujita, 1989), Monod's type equation was used to represent the biological denitrification rate in packed-bed granular filter using methanol as an electron donor reported as given below:

$$dN/dZ = -\lambda . N / (k_s + N) \quad \text{------------(1)}$$

where: λ = denitrification coefficient (g/m^4)
k_s = constant (g/m^3)
= 3.7 g/m^3 for the filter with media size of 4.36 mm
= 2.9 g/m^3 for the filter with media size of 2.38 mm

In order to investigate the effect of temperature on denitrification rate , the experiments were carried out under the different controlled temperature varied from 12.8-33.0 ^{o}C with excess C/N ratio. Denitrification coefficient at different controlled temperature was determined by using equation (1) and the relationship between denitrification coefficient and temperature is shown in Figure 1. As can be drawn from this graph, it is found that the equation corresponding to the van't Hoff-Arrhenius equation could be used to describe the effect of temperature on denitrification rate as given below:

$$\lambda = \lambda_{20} . \theta^{(T-20)}$$

where: T = temperature (^{o}C)

For filter with 4.36 mm media size: λ_{20} = 24.4 g/m^4; θ = 1.032
For filter with 2.38 mm media size: λ_{20} = 32.2 g/m^4; θ = 1.022

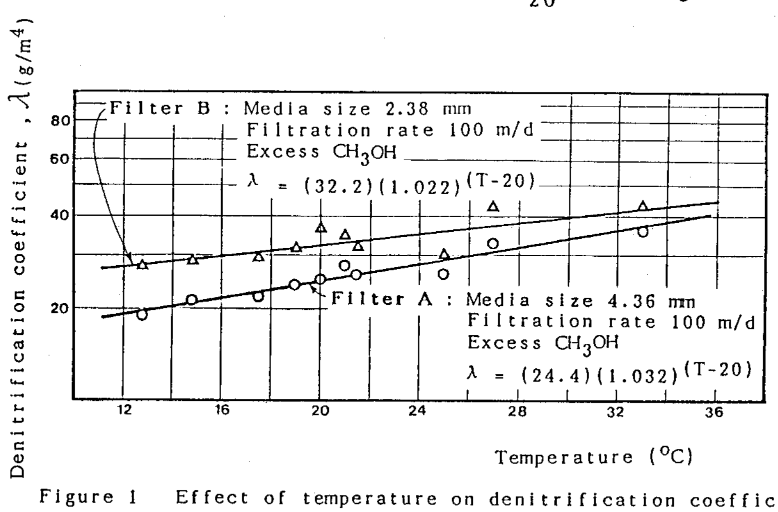

Figure 1 Effect of temperature on denitrification coefficient.

Effect of Temperature on Deoxygenation Rate

The equation used to represent deoxygenation rate in biological denitrification with granular filter has already been proposed by the authors (Suraphong and Fujita, 1988) as shown below:

$$dDO/dZ = -K.DO \quad \text{---------------------(2)}$$

where : K = deoxygenetion coefficient (m^{-1})

So that effect of temperature on deoxygenation rate could be investigated, in the experiments, filters were fed with excess C/N ratio under the different controlled temperature varied from 20 to 33 ^{o}C and the deoxygenation coefficient at different controlled temperature was determined by using equation (2). Based on the results obtained, deoxygenation coefficient was related to temperature as illustrated in Figure 2. From this graph, it can be concluded that the van't Hoff-Arrhenius's type equation is also able to express the effect of temperature on deoxygenation rate as presented below:

$$K = K_{20} \cdot \tau^{(T-20)}$$

where: T = temperature (^{o}C)

For filter with 4.36 mm media size: $K_{20} = 6.47 m^{-1}$; $\tau = 1.042$
For filter with 2.38 mm media size: $K_{20} = 13.21 m^{-1}$; $\tau = 1.016$

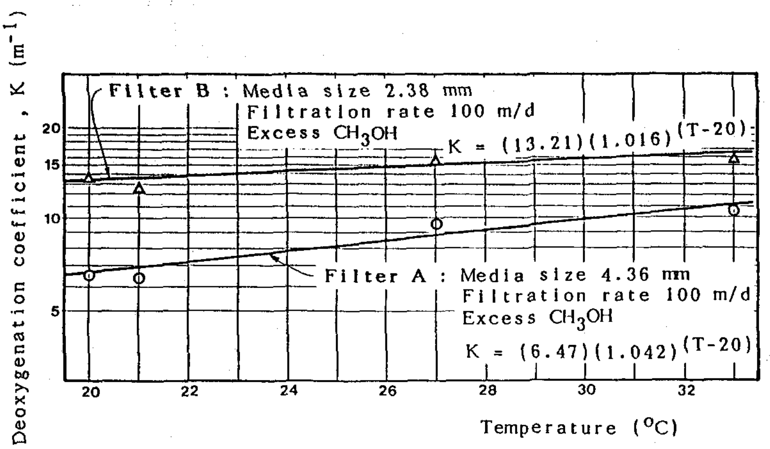

Figure 2 Effect of temperature on deoxygenation coefficient.

CONCLUSIONS

The effect of temperature on denitrification rate and deoxygenation rate could be expressed by the following equations:

For denitrification rate : $\lambda = \lambda_{20} \cdot \theta^{(T-20)}$
For deoxygenation rate : $K = K_{20} \cdot \tau^{(T-20)}$

REFERENCES

U.S. Environmental Protection Agency (1975). Process Design Manual for Nitrogen Control. Washington D.C.

Wattanachira, S. and K. Fujita (1988). Biological Denitrification in Granular Filter. Proceedings of the 2nd. IAWPRC Asia Conference on Water Pollution Control, Bangkok, Thailand, 563-569.

Wattanachira, S. and K. Fujita (1989). Packed-bed Biological Denitrification Filter with Anthracite Media. Proceedings of the 44th. Annual Conference of Japan Society of Civil Engineering, Nagoya, Japan, 2, 868-869.

ACKNOWLEDGEMENTS

This research was conducted in the Department of Urban Engineering, University of Tokyo, Japan. The authors gratefully thank Dr. Hidehiro Kaneko for his valuable comments during the course of the experiments.