II-406 Biological Denitrification of Low Nitrate Water in Granular Filters

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1. Introduction

Presence of excess nitrate nitrogen in water supplies is a serious problem. In fiscal year 1980, the results of a yearly survey by the Ministry of Health and Welfare of Japan on the raw water quality showed that nitrate nitrogen concentration exceeding the permissible level of 10 mg/L as N was found in more than one hundred water supply plants. Hence, there is a need to find a suitable nitrate removal method for municipal and communal water supplies.

2. Materials and Methods

The investigation is carried out in granular filters using anthracite media to support the growth of denitrifying bacteria. Two sizes of laboratory scale submerged filters, 0.04 m. and 0.10 m. in inner diameter, are used. A schematic diagram of the experimental apparatus is given in Figure 1. Three different media sizes of 1.00-1.68 mm., 2.00-2.83 mm. and 4.00-4.76 mm. are tested. Filtration rates, comparable to that in rapid sand filtration, are operated in upflow mode under a controlled temperature of 20 °C. Influent raw water contains approximately 10 mg/L as NO_3^--N. Methanol, a commonly used carbon source in biological denitrification, is used. The filters are operated in such a way that when the headloss exceeds 1 meter or the packed bed is lifted up from its original position due to the buoyancy of the trapped nitrogen bubbles,backwashing is done.

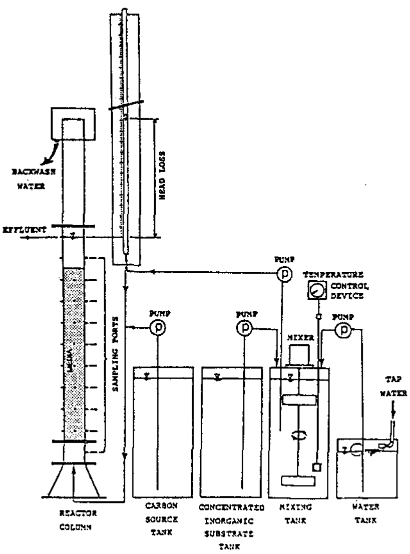

Figure 1 A Schematic diagram of the experimental appartus for operating the process

3. Results and Discussion

For ease of presentation, the discussion is divided as follows:

3.1 Effect of filter media sizes on denitrification rate

As can be seen in Figure 2, when slopes of TN line is considered denitrification rates, it is observed that the media size 1.00-1.68 mm. produces slightly higher denitrification rates than the size 2.00-2.83 mm. and significantly higher than the size 4.00-4.76 mm. This is attributed to the fact that smaller sizes provide greater surface areas. But as shown in Figure 3, a drawback in smaller media sizes is that it results in higher headloss leading to shorter filter run.

3.2 Profile of environmental parameters along the length of filter

The alkalinity produced is approximately 3.0 mg. as $CaCO_3$ per mg. of NO_3^--N or NO_2^--N reduced to N_2 which corresponds to the theoretical value.

On the other hand, the pH remains more and less constant in the range of 7.4-8.0 which is suitable for denitrification over the entire media depth.

It is apparent that the process can be operated in the presence of high dissolved oxygen (5-6 mg/L) in raw water. This is attributed to denitrification could occur in the interior of biofilm which is devoid of oxygen even when dissolved oxygen is present in the medium.

3.3 Recovery of denitrification rate after backwashing

If first-order reaction is assumed, the reaction rate constant expressed in term of -dlnTN.V/dD as a function of time after backwashing can be illustrated in Figure 4. It is found that after backwashing is done, the denitrification rates slightly drop and can recover to normal levels within a few hours. This is attributed to the denitrifying active cells which are in the interior of biofilm still attach to the media after backwashing.

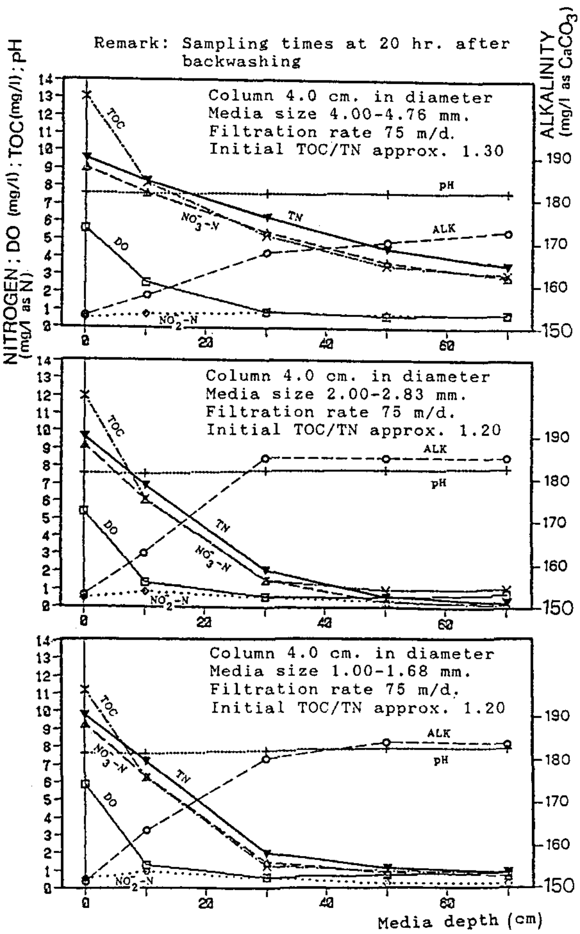

Figure 2 Variation of environmental parameters as a function of media depth

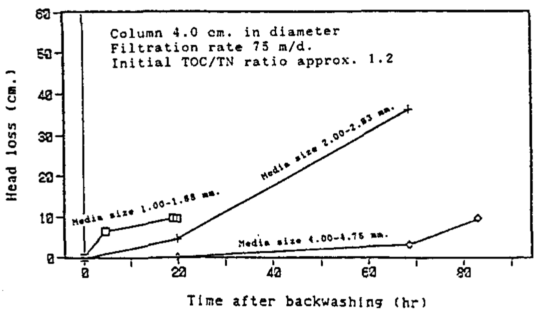

Figure 3 Head loss variation with time after backwashing

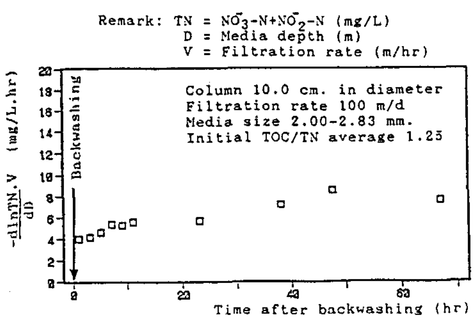

Figure 4 Total nitrogen removal rate expressed in term of $-\frac{dlnTN}{dD}$. V as a function of time after backwashing