STUDY ON NITRIFICATION PROCESS BY AERATED SUBMERGED BIOFILTER (ASBF)

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ABSTRACT

Nitrification is the first step in ammonium removal by biological nitrification-denitrification process. Submerged Aerated Biological Filter (SABF) combines different unit processes such as biological ammonium oxidation (nitrification) and filtration in one compact reactor, therefore it shows itself effective and economical tool in environmental biotechnology. In SABF the filtering material plays dual role. It retains suspended solid including active biomass, and at the same time it serves as a reaction media. In this report some results of the study on nitrification process in ammonium removal by SABF are presented. The most important parameter is treatment capacity or substrate removal rate can reach as high as 2 kg N-NH_4^+/m^3.day. Other parameters such as the relations between oxidation efficiency-substrate loading, influent's-effluent's concentrations at different retention times and temperatures were also presented. Achieved data show that SABF is very a promising technology for ammonium oxidation in drinking water treatment by its high efficiency, compactness of size and simple of operation.

INTRODUCTION

Nitrification is the process of oxidation of ammonium NH_4^+ to nitrite NO_2^-, and finally to nitrate NO_3^- by selected microbes. The conversion to nitrite is catalyzed by *Nitrosomonas* and the conversion to nitrate by *Nitrobacter*.

$$NH_4^+ + O_2 \longrightarrow NO_2^- + O_2 \longrightarrow NO_3^- (+ H^+)$$

Both *Nitrosomonas* and *Nitrobacter* are autotrophics, that means that they obtain the carbon for cell synthesis from inorganic compound (such as carbon dioxide or HCO_3^- or alkalinity). Conventional suspended-growth (activated sludge) system requires long hydraulic retention time, in some cases up to 7 days at the temperature of 20°C. Therefore, in order to increase the necessary biomass concentration to decrease the reaction time, the biological filtration methods with suitable media are used and it was proved to be highly effective among the biological methods for removing ammonium in water. This paper will show some research results of SABF used in first step of ammonium removal by biological nitrification-denitrification process.

EXPERIMENTS

Nitrification apparatus

The scheme of apparatus for nitrification experiments is shown in figure 1, and SABF characteristics are given in table 1.

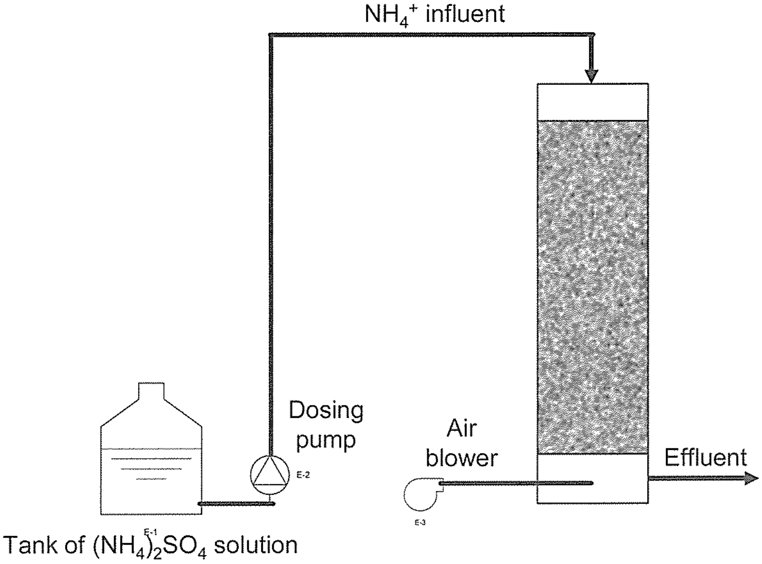

Figure 1. Scheme of experimental nitrification apparatus by SABF

Table 1- Experimental SABF parameters

REACTOR COLUMN CHARACTERISTICS	
Inner diameter	8.6 centimeters
Media (Thai Nguyen coke) height	100 centimeters
Media volume	5.8 liters
Coke size	2-3 centimeters

Experimental nitrification system

- Influent N-NH_4^+ solution tank with fixed concentration, diluted from $(NH_4)_2SO_4$ stock solution.
- Dosing pump with flow rate controller.
- Aerated equipment supplying oxygen to nitrification column through dispersion tips. Dissolved oxygen content in water is kept in the range of 6 - 7 mg/L.
- pH, DO, temperature controllers

RESULTS AND DISCUSION

Achieved results are shown in table 2. The relation between efficiency and loading capacity per unit of media are represented in figure 2.

The figure shows that:

- Temperature has considerable influence on treatment efficiency
- At the temperature of 25 - 27°C, ammonium could be oxidized completely with efficiency of more than 99% when $N-NH_4^+$ loading capacity per unit of media is under 1.5 kilograms nitrogen per cubic meter of media per day
- At the temperature of 20 - 23°C, ammonium could be removed completely with efficiency of more than 99% when $N-NH_4^+$ loading capacity per a unit of media is under 1.0 kilograms nitrogen per cubic meter of media per day

The relation between substrate utilization rate and loading capacity of $N-NH_4^+$ per a unit of media is shown in Figure 3:

The figure shows that in the range of $N-NH_4^+$ loading capacity per a unit of media from 0.5 to 2.5 kg-N/m^3.day, there is a linear increase between ammonium utilization rate and loading capacity of less than 2 kg kg-N/m^3.day. The relation between $N-NH_4^+$ influent and effluent concentrations is shown in Figure

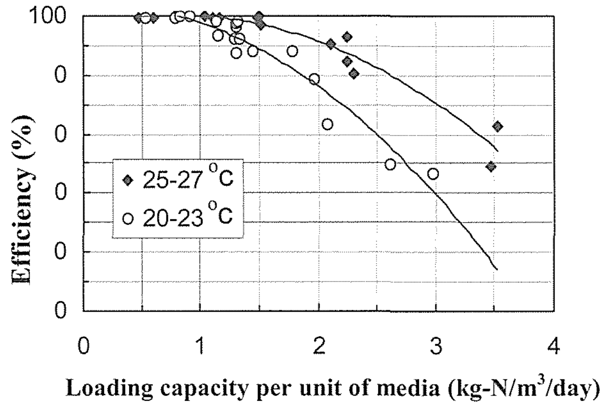

Figure 2- Relation between Efficiency and Loading Capacity

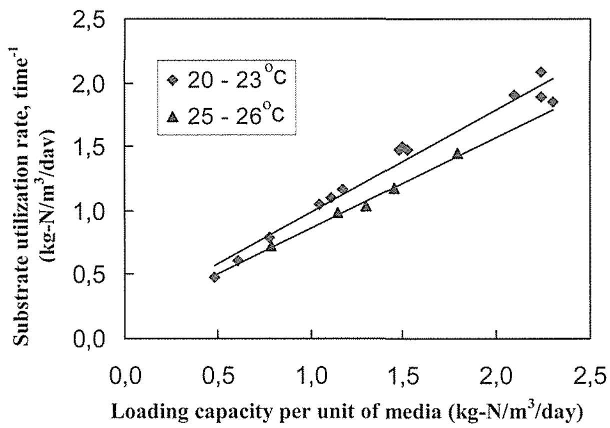

Figure 3- Relation between substrate utilization rate and loading capacity of $N-NH_4^+$ per unit of media

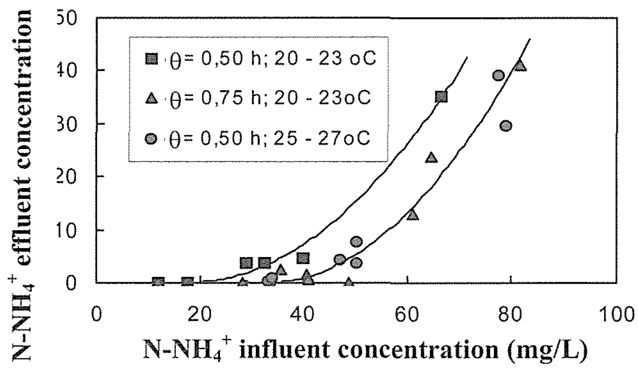

Figure 4: Relation between ammonium influent and effluent concentrations

4.

Table 2. Experiment results

Flow rate[(1)]	$N\text{-}NH_4^+$ concentration influent[(2)]	$N\text{-}NH_4^+$ concentration effluent[(3)]	Loading capacity per unit of media[(4)]	Efficiency[(5)]	Substrate utilization rate[(6)]
20 - 23°C					
7.73	35.85	2.33	1.15	93.5	0.98
10.8	39.92	4.71	1.79	88.2	1.45
	32.33	3.75	1.45	88.4	1.17
	66.48	35.30	2.97	46.9	1.28
	29.05	3.66	1.30	87.4	1.04
	18.33	0.11	0.79	99.4	0.72
25 - 27°C					
4.2	30.00	0.09	0.48	99.7	0.48
	40.00	0.12	0.61	99.7	0.60
5.8	20.00	0.02	0.78	99.9	0.78
6.9	80.71	15.90	2.30	80.3	1.85
7.5	20.00	0.02	1.05	99.9	1.05
7.73	32.50	0.13	1.17	99.6	1.17
	40.00	0.12	1.11	99.7	1.10
10.8	33.87	1.05	1.52	96.9	1.47
	50.06	7.86	2.24	84.3	1.89
	77.51	39.30	3.46	49.3	1.71
	78.88	29.50	3.53	62.6	2.21
	49.86	3.59	2.24	92.8	2.08
	30.00	0.06	1.50	99.8	1.50
	36.00	0.18	1.48	99.5	1.47
	47.31	4.40	2.10	90.7	1.91

Note:

(1) Flow rate Q (L/h)

(2) $N\text{-}NH_4^+$ concentration influent C_o (mg/L)

(3) $N\text{-}NH_4^+$ concentration effluent C (mg/L)

(4) Loading capacity per unit of media QC_o/V_d (kg-N/m^3.day)

(5) Efficiency □= $(C_o-C)/C_o$ (%)

(6) Substrate utilization rate $Q(C_o-C)/V_d$ (kg-N/m^3.day)

It was observed that when $N\text{-}NH_4^+$ influent concentration increases to a value of about 50 mg N/L, the $N\text{-}NH_4^+$ effluent concentration at first tens influent mg N/L was close to zero, then increases rapidly.

CONCLUSSIONS

1) The experiment results showed the significant efficiency of SABF with coke media in nitrification of ammonium. The relation between $N\text{-}NH_4^+$ influent and effluent concentrations, substrate utilization rate and loading of $N\text{-}NH_4^+$, efficiency and loading were presented.
2) Coke was proved to be an effective biomass cerrier in ammonium removal due to the market availability, relatively low cost and harmlessness.

References

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