[環境システム工学]

30－1 Optimization of granulation by induced precipitation in a soft water for a denitrifying upflow sludge-blanket reactor

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1. Introduction

Nitrate (NO_3) and nitrite (NO_2) contamination of natural waters can lead to serious environmental and health problems. Biological denitrification (reduction of NO_3 to nitrogen gas) has potential as an economically and environmentally favorable treatment option. The retention of essential microbial species in a reactor, however, requires a biomass carrier or support medium. In this work, optimization of an upflow sludge-blanket (USB) bench-scale reactor for treatment of a water with low levels of NO_3-N (15 to 35mg/l) using $CaCO_3$ precipitate as a catalyst for formation of biomass granules was investigated.

2. Materials and Methods

The USB reactor used in this research has a 1.70 l working volume with a 7.0cm diameter. A mechanical stirrer was routinely used to enhance sludge-gas separation. The influent wastewater consisted of varying concentrations of $NaNO_3$, ethanol, $CaCl_2$, $KHCO_3$, and supplemental nutrients. NO_3, NO_2, alkalinity, and calcium (Ca) were routinely measured. Total sludge and biomass were estimated as MLSS and MLVSS, respectively. Precipitation potential (PP) was determined as $CaCO_3$ in solution beyond its theoretical solubility limit for the given physical/chemical system (1).

3. Results

Initial start-up required about 30 days for distinct granule formation to occur. During preliminary runs, though, granulation was not sustainable and sludge retention was inadequate. Further tests were conducted (runs of 10 to 12 days, see Table 1) to investigate variables pertaining precipitation and its influence on granule formation with influent C:N=1.9 and Ca=180mg/l (Ca rendered herein as $CaCO_3$) .For the first run with a flow rate of 4.0l/hr (HRT=25min), the influent NO_3-N was 17mg/l and alkalinity was adjusted to 260mg/l with a corresponding PP of 9mg/l (both as $CaCO_3$) .Due to the denitrification reaction, an increase in pH and alkalinity in the effluent was evidenced and the PP in the reactor was determined to be 23mg/l. Despite this increase, the sludge with a mineral content of 20% still experienced excessive floating and washout and while effluent NO_3-N was consistently near zero, NO_2-N hovered around 2mg/l.

Table 1. Testing parameters and results (influent C:N=1.8 and Ca=180mg/l).

Parameter	Run-1	Run-2	Run-3	Run-4
Flow rate (l/hr)	4.0	2.0	4.0	2.0
Inf. NO_3-N (mg/l)	17	17	17	34
Inf. Alkalinity (mg/l)	260	170	170	170
Alkalinity produced (mg/l)	50	50	30	60
$CaCO_3$ precipitated (mg/l)	6	13	6	50
Eff. NO_3+NO_2-N (mg/l)	2	2	5	0

For the second run, the flow was reduced to 2.0l/hr (HRT=50min) and influent alkalinity was reduced to 170mg/l. With a pH adjustment (NaOH addition) to 7.9 it was found that with this reduced chemical input an influent PP of 2mg/l and a reactor PP of 22mg/l were possible. However, the sludge still experienced floating problems, biomass failed to increase, and NO_2-N persisted in the effluent. The third run differed from the second only in that the flow rate was doubled to 4l/hr. Again, sludge build-up was not achieved and effluent NO_2-N climbed to 5mg/l.

For the fourth and final run in this series, influent NO_3-N was doubled to 34mg/l and the flow rate was reduced to 2.0l/hr. With this scenario, sludge total mass quickly increased and effluent NO_3-N and NO_2-N dropped to zero. The key factor appeared to be the increased denitrification activity associated with the higher substrate loading at the longer HRT of 50min. Under these conditions, a pronounced loss of Ca in solution ($CaCO_3$ precipitation) and a concurrent increase in sludge mineral content to 56% occurred.

Subsequent sustained runs have been conducted with influent NO_3-N at 17mg/l. With PP conditions as before, it was found that the mineral content continued to increase to over 70% and granulation was lost; however, the sludge bed height was maintained. Ca input was then cut to about 10mg/l and mineral content gradually receded to the previous level (ca.50%) with a renewed formation of granules. Research is ongoing to optimize granule maintenance and treatment performance with minimal chemical additions. While others have suggested that denitrification with a granular USB system is only successful with a hard water (2, 3), preliminary work here has shown that such a process appears to be feasible with a relatively soft water.

1) Loewenthal R.E., Wiechers H.N.S., Marais G.V.R.: Softening and stabilization of municipal waters, Water Research Commission, Pretoria, South Africa (1986)

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3) Green M., Tarre S., Schnizer M., Bogdan B., Armon R., Shelef G.: Groundwater denitrification using an upflow sludge blanket reactor, Wat. Res., 28, 631-637 (1994)

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