Partial nitrification performance and microbial community structures in an intermittently aerated sequencing batch reactor

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1. Backgrounds & objectives

2. Methodologies

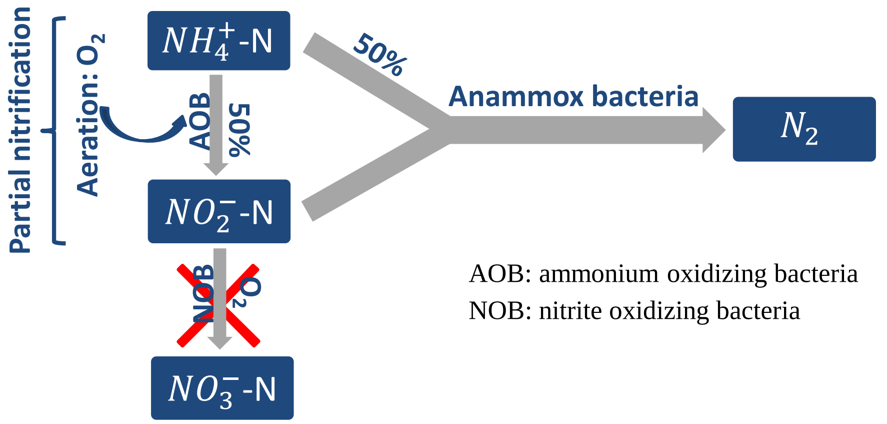
- The reactor
- Synthetic landfill leachate & seed sludge
- Sequencing operation
- Control strategies
- Molecular analysis

3. Results

- Partial nitrification performance
- Microbial community structure

4. Conclusions

1. Backgrounds & objectives



AOB: ammonium oxidizing bacteria
NOB: nitrite oxidizing bacteria

Objectives:

- ❖Long-term stable partial nitrification in an intermittently aerated sequencing reactor (IASBR)
- ❖Microbial community changes

2. Methodologies – the reactor

- ❖**Reactor:** 8 L
- ❖**Timers:** sequential operation and intermittent aeration
- ❖**Temperature:** 30℃
- ❖**Ammonium and nitrate:** real-time monitored
- ❖**Light-blocking:** stop algae growth

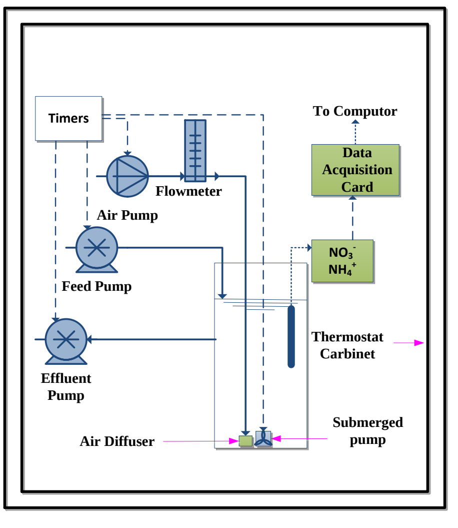


Fig.1. Schematic diagram of the IASBR

2. Methodologies – synthetic landfill leachate

Table 1. Composition of the synthetic landfill leachate.

Components	Concentration (mg/L)
NH_4^+-N start-up period	900
NH_4^+-N maintenance period	300
COD	100
KH_2PO_4	111
$MgSO_4 \cdot 7H_2O$	58
$CaCl_2 \cdot 6H_2O$	170
$NaHCO_3$	add as needed
Trace element A[1]	1 (mL/L)
Trace element B[1]	1 (mL/L)

Seed sludge: return sludge form municipal wastewater treatment plant

[1] Van De Graaf, A.A., De Bruijn, P. and Robertson, L. A., 1996. Autotrophic growth of anaerobic ammonium-oxidizing micro-organisms in a fluidized bed reactor. *Microbiology*. 142(8), 2187-2196.

2. Methodologies – sequential operation

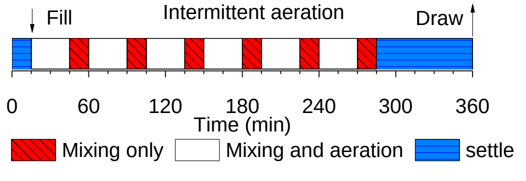


Fig.2. Sequencing operation of the IASBR

- **Four cycles per day**
- **Influent** 2.8 L/d
- **Nitrogen loading rate** 0.105 kg NH_4^+-N/($m^3 \cdot$ d)
- **COD loading rate** 0.035 kg COD/($m^3 \cdot$ d)

2. Methodologies – control strategies[2]

Start-up stage (day 0-22)

- **High free ammonia (FA)concentration:** to inhibit NOB, up to 42mg/L
- **High rate continuous aeration:** to encourage AOB, 400 mL/min

Maintenance stage (day 23-200)

- **Low FA concentration:** <6.3 mg/L
- **Low rate intermittent aeration:** 200 mL/min
- **Nitrite accumulation rate (NAR)**

$$= \frac{NO_2{-}N}{NO_2{-}N + NO_3{-}N} \times 100\%$$

[2] Li, J.P., et al., Long-term partial nitrification in an intermittently aerated sequencing batch reactor (SBR) treating ammonium-rich wastewater under controlled oxygen-limited conditions. Biochemical Engineering Journal, 2011. **55**(3): p. 215-222.

2. Methodologies – molecular analysis

Sampling & storage

- **1 mL biomass**
- **-70˚C**

DNA extraction, PCR amplification and high-throughput sequencing

- **Commercial service** (Sangon Biological Engineering Co., China)
- **Amplification:** Hypervariable V3-V4 regions of the bacterial and archaeal 16S rDNA
- **Sequencing:** Illumina MiSeq platform
- **Operational taxonomic units (OTUs):** Usearch (version 5.2.236), sequence identity threshold of 97%
- **Taxonomy classification:** Silva database

3. Results – partial nitrification performance

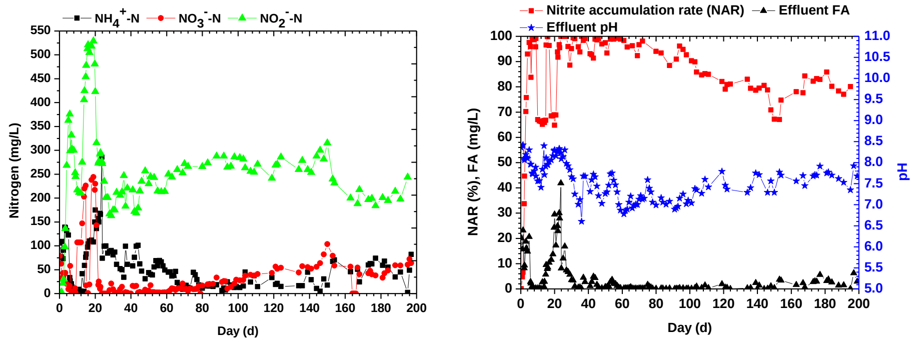


Fig.3. Partial nitrification performance of the IASBR

- **Start-up period:** NAR >93%
- **Maintenance period:** NAR 67- 99%, despite of several times of over aeration or influent feeding failure

3. Results – microbial community

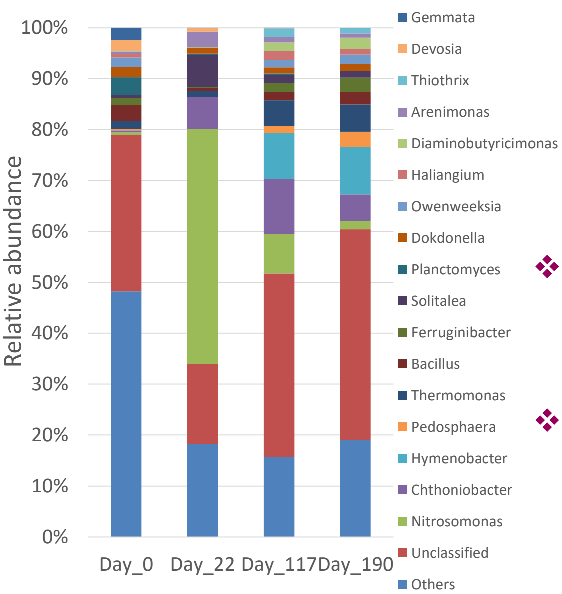


Fig.4. Dominant bacteria genera (abundance >1%) in the IASBR. The remaining genera were assigned into “others”. Sequences that could not be classified into a known group were assigned into “unclassified”.

- The start up strategies significantly encouraged the growth of nitrosomonas (AOB).
- During the whole operation, nitrosomonas (AOB) was one of the dominant bacteria genus, no dominant NOB was detected.

3. Results – microbial community

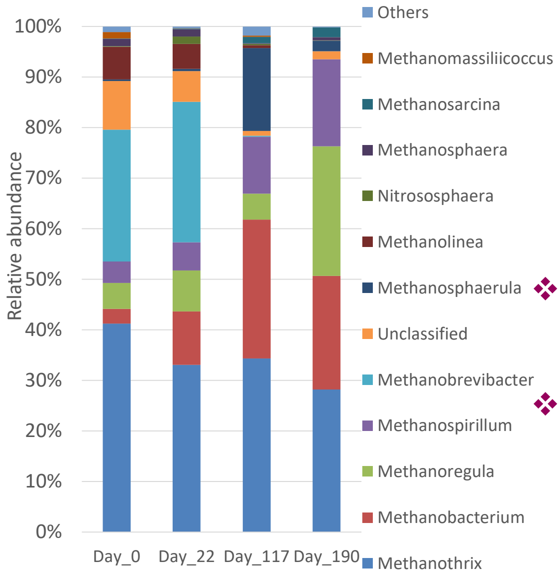


Fig.4. Dominant archaeal genera (abundance >1%) in the IASBR. The remaining genera were assigned into "others". Sequences that could not be classified into a known group were assigned into "unclassified".

- The start up strategies encouraged the growth of nitrososphaera (AOA).
- Methanogens dominated the archaeal microorganisms.

4. Conclusions

- The IASBR and strategies used were efficient in achieving long-term stable partial nitrification.
- The start up strategies significantly encouraged the growth of both AOB and AOA. During the whole operation, nitrosomonas (AOB) was one of the dominant bacteria genus, no dominant NOB was detected.
- Methanogens dominated the archaeal microorganisms.

Thank you!

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