

## Supplementary Materials

Table S1 Operational conditions for the HBR process

Items	Stage 1	Stage 2
Time (d)	1–50	51–213
Anoxic MLSS (g/m <sup>2</sup> )		14–16
Aerobic MLSS (g/m <sup>2</sup> )		6–7
DO of Anoxic (mg/L)		0–0.3
DO of 1# Aerobic (mg/L)		2.5–3.5
DO of 2# Aerobic (mg/L)		0.5–1.0
HRT (h)	8 (3.74, 2.56, 1.70)	
Total amount of carrier (m <sup>3</sup> )	68.1	
Carrier size (mm)	15 × 15 × 8	
Specific surface area of carrier (m <sup>2</sup> /m <sup>3</sup> )	709	
Carrier material and density (g/cm <sup>3</sup> )	HDPE, 0.945	

Table S2 Characteristics of the HBR process influent

Items	Value
NH <sub>4</sub> <sup>+</sup> -N (mg/L)	17.03 ± 4.50
TN (mg/L)	21.6 ± 4.6
COD (mg/L)	142 ± 80
TP (mg/L)	2.95 ± 1.98
SS (mg/L)	166 ± 102
COD/TN	6.1 ± 3.0

Table S3 Anammox bacterial abundance in actual municipal wastewater treatment processes

System	Scale	Anammox bacterial abundance	References
HBR	300 m <sup>3</sup> /d	2.89%	This research
Five traditional municipal WWTPs	–	< 0.003%	Wang et al., 2015
AAO	100 × 10 <sup>4</sup> m <sup>3</sup> /d	< 0.01%	Guo et al., 2017
AAO	25 × 10 <sup>4</sup> m <sup>3</sup> /d	0.11% (on carrier) 0.04% (in sludge)	Li et al., 2019

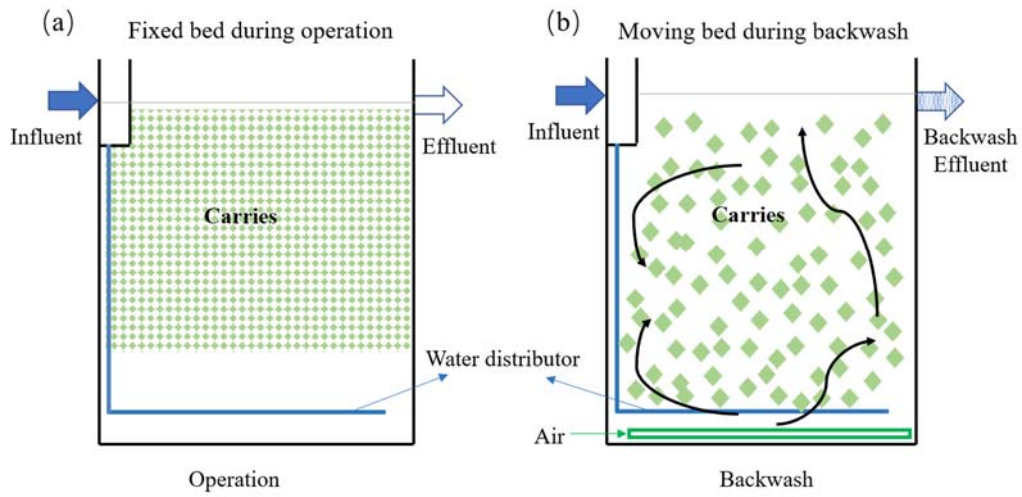


Fig. S1 Operation mode of HBR reactor (a: Normal operation mode, b: Backwash mode)

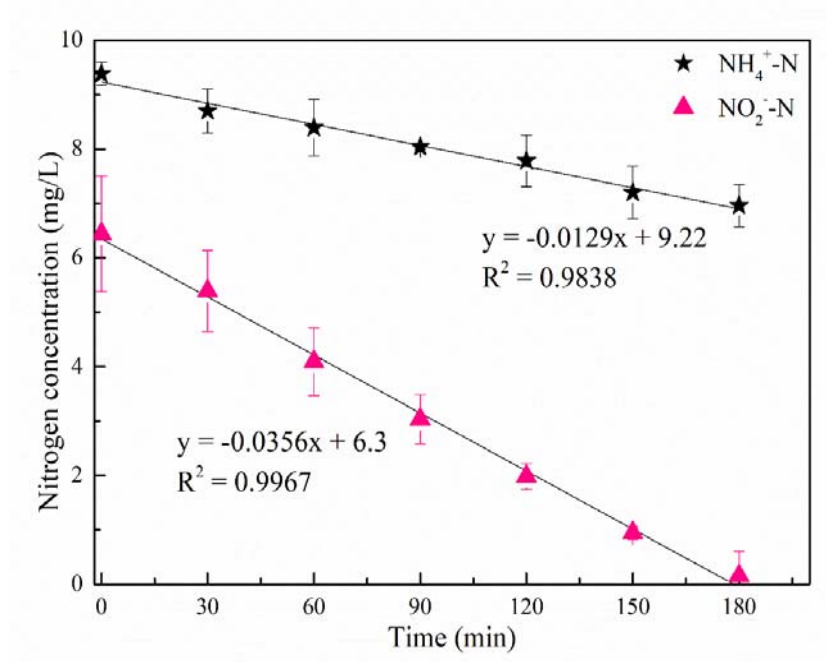


Fig. S2 Results of anammox activity test



Fig. S3 The photo of influent and effluent sample of HBR reactor

## References

- Guo J, Ni B J, Han X, Chen X, Bond P, Peng Y, Yuan Z (2017). Unraveling microbial structure and diversity of activated sludge in a full-scale simultaneous nitrogen and phosphorus removal plant using metagenomic sequencing. *Enzyme and Microbial Technology*, 102: 16–25
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- Wang S, Peng Y, Ma B, Wang S, Zhu G (2015). Anaerobic ammonium oxidation in traditional municipal wastewater treatment plants with low-strength ammonium loading: Widespread but overlooked. *Water Research*, 84: 66–75