Electronic Supplementary Material (ESI) for Environmental Science: Water Research & Technology.

Enhancing the stability and efficiency of anammox process in plug-flow integrated fixed-film activated sludge (IFAS) reactors through alternating anoxic/aerobic (A^3) conditions

Chao Liu[a], Wenlong Liu[b], Lei Wu[a], Yongzhen Peng[a,*]

[a] National Engineering Laboratory for Advanced Municipal Wastewater Treatment, Reuse Technology and Water Environment Recovery Engineering, Beijing University of Technology, Beijing 100124, PR China

[b] State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, Harbin 150090, PC China

* Corresponding author. Tel./Fax: +86 10 67392627.

E-mail address: pyz@bjut.edu.cn (Y. Peng).

Supporting Information

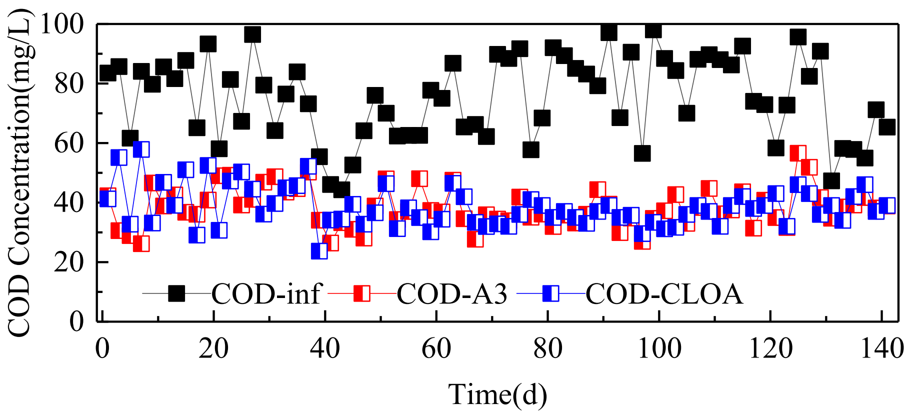


Figure S1. The variation of COD in influent and effluent of two reactors

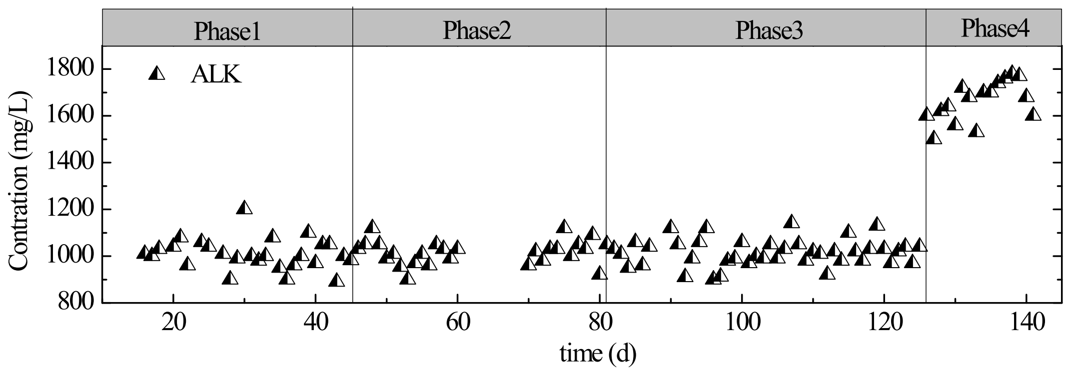


Fig.S2 The concentration of alkalinity ($CaCO_3$) in the influent

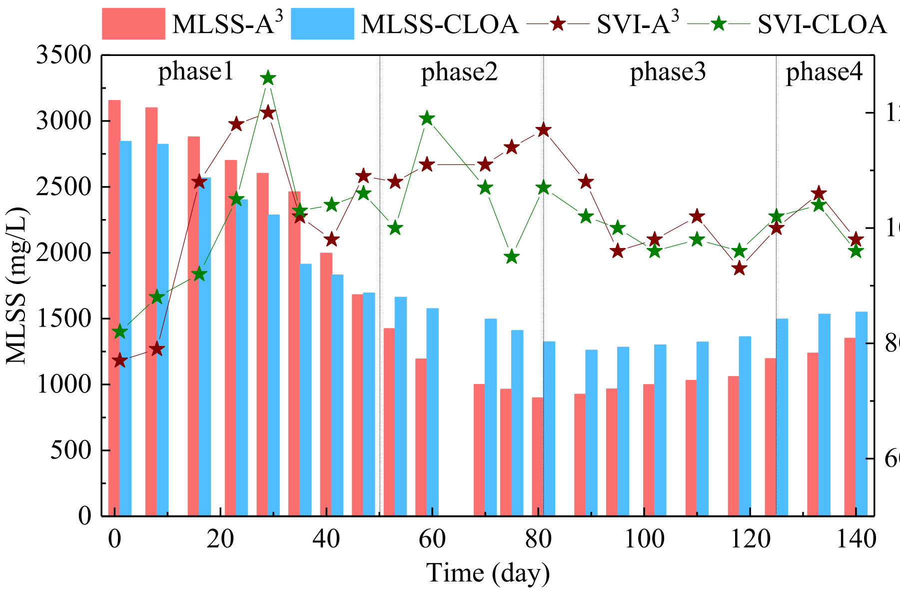


Fig. S3 The variation of MLSS and SVI in two reactors

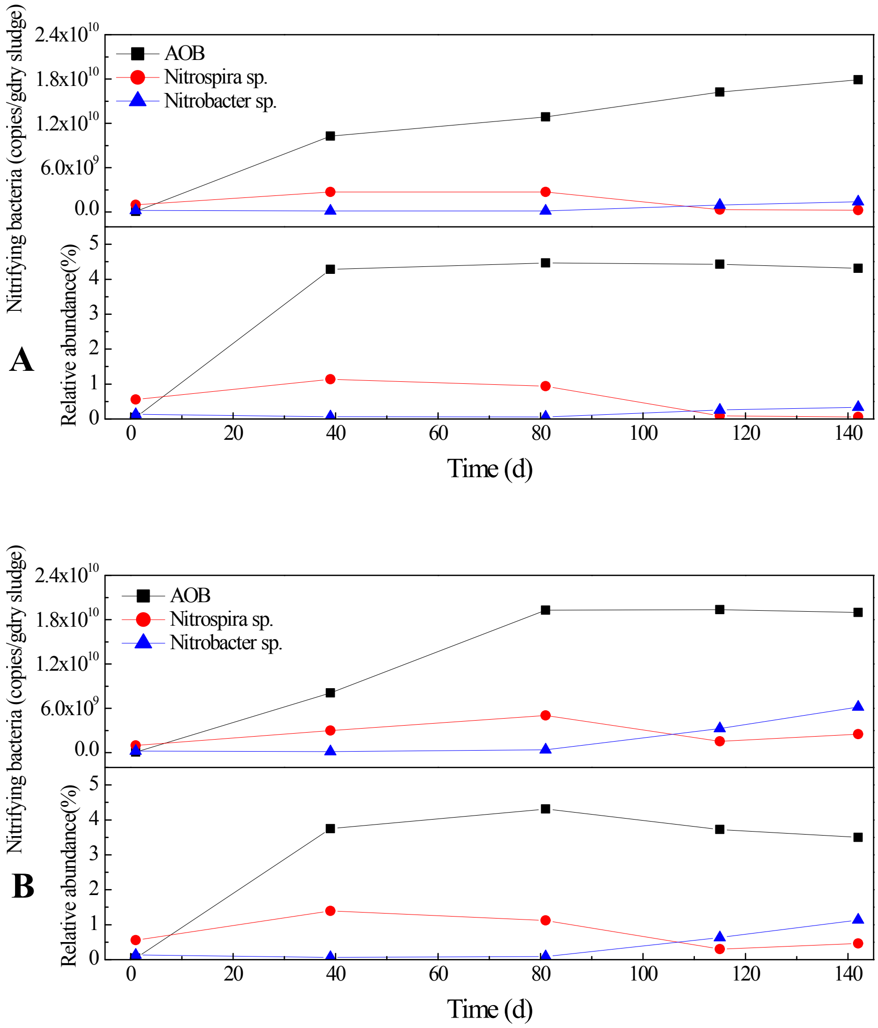
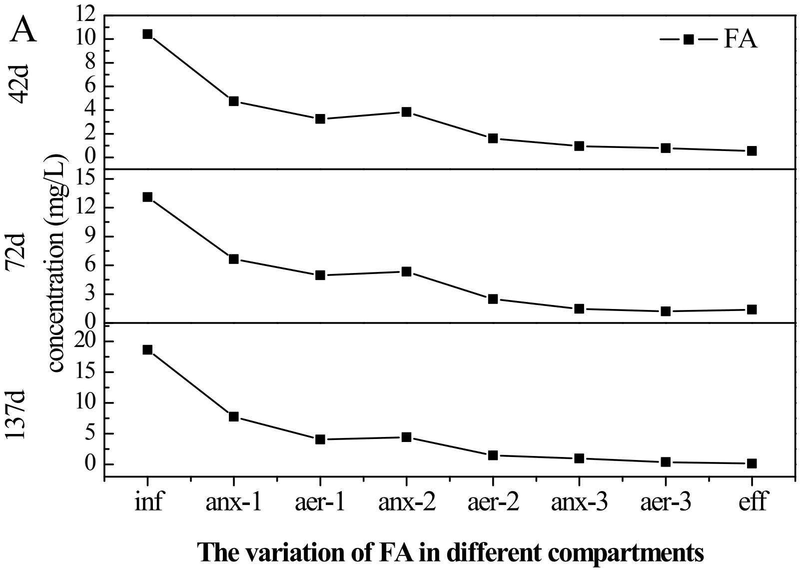


Fig.S4 Relative AOB and NOB (floc biomass) abundances in terms of qPCR at different phases: (A) is that of A^3-IFAS, (B) is that of CLOA-IFAS



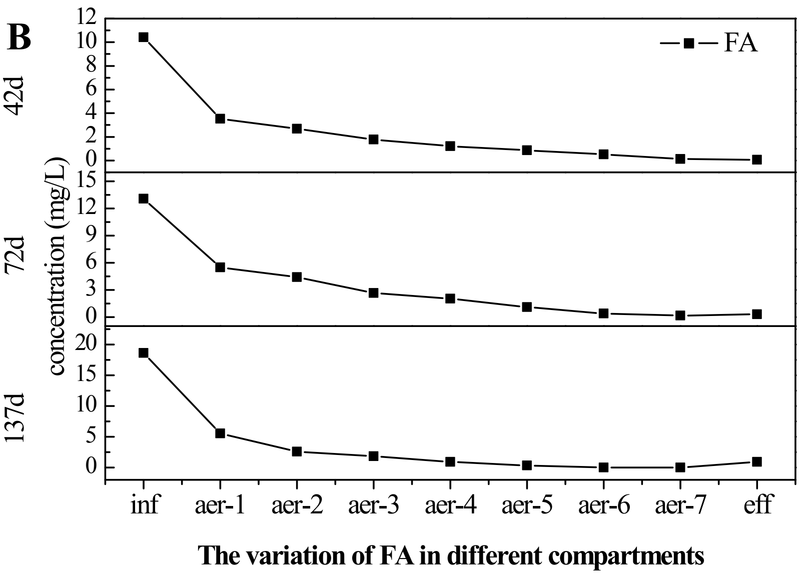


Fig.S5 The variation of FA in different compartments at 42d, 72d and 137d: (A) is the FA concentration of A^3-IFAS, (B) is that of CLOA-IFAS

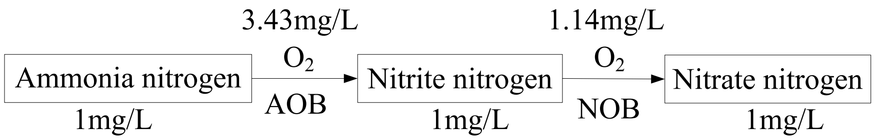


Figure S6. The oxygen consumption during nitrification

The oxygen consumption for NH_4^+-N transforming in A3-IFAS reactor:

$$\text{oxygen consumption}=300\times0.57\times3.43=586.5\text{mgO}_2/\text{mg}NH_4^+-N$$

$$=1.96\text{kgO}_2/\text{kg}NH_4^+-N$$

The oxygen consumption for NH_4^+-N transforming in A3-IFAS reactor:

$$\text{oxygen consumption}=237.2\times0.57\times3.43+68.2\times(3.43+1.14)$$

$$=775.4\ \text{mgO}_2/\text{mg}NH_4^+-N=2.58\ \text{kgO}_2/\text{kg}NH_4^+-N$$

Table S1

Fixed operation parameters of A3 reactor and CLOA reactor for different phase.

NH_4^+-N (mg/L)	COD (mg/L)	influent loading (kg·N·m-3·d-1)	influent rate (L/h)	HRT (h)	DO (mg/L)	Temperature (℃)
300±20	50-100	0.3	1.1	36	0.1-0.2	25±1

Table S2

Variable operation parameters of A3 reactor and CLOA reactor for different phase.

Phase	SRT (d)	Alkalinity resource	Alkalinity (mg/L)	pH	MLSS(mg/L)		MLVSS(mg/L)		SVI(mL/g)	
					A3	CLOA	A3	CLOA	A3	CLOA
1	20	NH_4HCO_3	1000±50	7.79±0.19	2692	2529	1862	1790	106	109
2	30	NH_4HCO_3	1000±50	7.79±0.19	1251	1545	1013	1149	92	99
3	30	NH_4HCO_3	1000±50	7.79±0.19	996	1313	727	900	84	89
4	50	NH_4HCO_3+$NaHCO_3$	1565±134	7.02±0.13	1235	1500	926	1080	93	84

Table S3

The variation of nitrogen and COD concentration in different compartments in A3 reactor

parameters	The variation of nitrogen and COD concentration in different compartments (mg/L)							
	influent	Anoxic-1	Oxic-1	Anoxic-2	Oxic-2	Anoxic-3	Oxic-3	effluent
NH_4^+-N	310.7	156.9	112.7	86.1	60.5	42.4	36.2	35.4
NO_2^--N	0.8	2.3	31	1.5	22.7	1.9	6.4	3.6
NO_3^--N	0.6	6.8	12.7	12.2	13.6	15.7	15.1	11.8
COD	65.5	41.4	35.9	27.5	30.3	30.3	28.9	28.9
ΔNH_4^+-N	--	6.2	44.2	26.6	25.6	18.1	6.2	0.8
ΔTIN	--	15.5	9.6	59.6	3	36.8	2.3	6.9

The contribution between and Heter. denitrification for the TIN removal in A3 reactor:

The consumption of NH_4^+-N in anoxic zones:

$$\Delta NH_4^+-N_{anoxic}=6.2+26.6+18.1=50.9\text{mg/L}$$

The TIN removal in anoxic zones by anammox was:

$$\Delta TIN_{anammox}=50.9\times 2.32=118.1\text{mg/L}$$

The TIN removal in A3 reactor was:

$$\Delta TIN=15.5+91.6+59.6+3+36.8+2.3=123.8\text{mg/L}$$

The contribution of Auto-Anammox was:

$$\frac{\Delta TIN_{anammox}}{\Delta TIN}\times 100\%=\frac{118.1}{123.8}\times 100\%=95.4\%$$

The contribution of Heter. denitrification was:

$$100\%-95.4\%=4.6\%$$

Table S4

The variation of nitrogen and COD concentration in different compartments in CLOA reactor

parameters	The variation of nitrogen and COD concentration in different compartments (mg/L)								
	influent	Oxic-1	Oxic-2	Oxic-3	Oxic-4	Oxic-5	Oxic-6	Oxic-7	effluent
NH_4^+-N	310.7	131.6	103.8	86.9	51.3	39.2	25.1	14.1	12.3
NO_2^--N	0.8	4.5	5.9	6.1	5.1	2.9	1.8	1.2	0.8
NO_3^--N	0.6	43.5	51.1	56.9	62.9	65.5	74.8	82.8	79.4
COD	65.5	35.7	31.1	26	26	26	23.3	23.3	27.4
ΔNH_4^+-N	--	29.9	27.8	16.9	35.6	14.1	12.1	11	1.8
ΔTIN	--	22.7	18.8	4.9	36.6	11.7	5.9	3.6	5.6

The contribution between and Heter. denitrification for the TIN removal in CLOA reactor: (The consumption of COD was considered for denitrification.)

The consumption of COD in CLOA reactor was: (sludge return ratio was 100%)

$$\Delta\ \text{COD}=(COD_{inf}+COD_{eff})/2-COD_{eff}$$

$$=(65.5+27.4)/2-27.4=19.1\text{mg/L}$$

The TIN removal by denitrification was:

$$\Delta TIN_{denitrification}=\Delta\ \text{COD}/2.86=6.7\text{mg/L}$$

The TIN removal in CLOA reactor was:

$$\Delta TIN=22.7+18.8+4.9+36.3+11.7+5.9+3.6=104.2\text{mg/L}$$

The contribution of Heter. denitrification was:

$$\frac{\Delta TIN_{denitrification}}{\Delta TIN}\times 100\%=\frac{6.7}{104.2}\times 100\%=6.4\%$$

The contribution of Auto-Anammox was:

100%-6.4%=93.6%