

Study on factors of affecting sedimentation performance of activated sludge in A-step of AB process*

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Abstract: The factors including inflow SS, pythogenous sewage, loading rate N_s , dissolved oxygen which affect sedimentation performance of A-step activated sludge were studied in the paper. The experimental results indicated: the inflow SS distinctly improve sedimentation performance of activated sludge; the pythogenous sewage easily worsen sedimentation performance of activated sludge, and canceling primary sedimentation tank and cesspool would avail to stable running of sewage treatment plant. The effect of loading rate N_s on EPS is highly remarkable, and EPS and polysaccharide are correlated evidently with sedimentation performance of activated sludge. When high loading rate N_s is 3.0 kgBOD₅/kgMLSS·d, EPS is 17.15mgEPS/gVSS and polysaccharide is 8.15mg/gVSS, which is less 40% than activated sludge of 0.3 kgBOD₅/kgMLSS·d loading rate N_s ; meanwhile the effect of dissolved oxygen on EPS is less, and dissolved oxygen does not affect sedimentation performance of activated sludge in high loading rate; the polysaccharide content of activated sludge in high loading rate does not benefit the growth of filament, and furthermore the hydrophobicity of activated sludge is good, which cause good sedimentation performance of sludge in high loading rate.

Key words: AB process; sedimentation performance of activated sludge; SS, loading rate N_s ; EPS

1. Introduction

For A-step of AB Process in which high loading rate N_s is equal to or large than 2.5 kgBOD₅/kgMLSS·d and dissolved oxygen is 0.5mg/l, when predicting sedimentation performance of its activated sludge by using tradition theory, the following results can be concluded that A-step activated sludge trend to grow dispersedly and agglomerate badly because of its high loading rate, furthermore happen low DO bulking. But the practice indicate: whenever A-step running in less or much oxygen mode, the floc of activated sludge is quite big and dense, and has good sedimentation performance whose SVI is often less than 60. So the study on factors of good sedimentation performance of A-step is very significant. How these factors including inflow SS, pythogenous sewage, loading rate N_s , dissolved oxygen affect sedimentation performance of A-step activated sludge was studied in the paper.

2. Methods and materials

2.1 Experimental setup

Plexiglass activated sludge reactors were separately consisted of a 6L working aeration tank connected to a 9L final clarifier. Air pump supply oxygen and inflow enter into reactors passing perch water tank.

2.2 Experimental methods

2.2.1 Study on effect of inflow SS and pythogenous sewage on sedimentation performance of A-step activated sludge

The experiment was performed through two phases. At first phase, parallel contrast experiments were carried out using four reactors. The running status and quality of inflow sewage of every reactor in the period of experiment were shown as Table 1. Activated sludge in the experiment was taken from a traditional treatment plant in Chongqing. Sewage used in the experiment was domestic sewage from student dormitories. The experiment was run in A-step mode: inflow water quantity $Q=300\text{ml/min}$, $\text{HRT}=50\text{min}$, $\text{DO}=0.7\sim1.2\text{ mg/l}$, $\text{MLSS}=2.5\text{g/l}$, water temperature $t=25^\circ\text{C}$. The pythogenesis time of sewage was 6h. These index including SVI, inflow and outflow COD, BOD₅ and SS was tested during the experiment.

At second phase, the reactor in which sedimentation performance of activated sludge was deteriorated after first phase experiment was run in standard A-step mode(2# reactor) to perform recovery experiment. Inflow was fresh sewage containing SS, to study the effect of SS and pythogenous sewage on sedimentation performance of activated sludge in A-step.

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Table 1 Running status and quality of inflow sewage of every reactor in the experiment

Reactor	Running status	COD /(mg/l)	COD _{soluble} /(mg/l)	BOD ₅ /(mg/l)	SS /(mg/l)
	pythogenous	621	504	342	9
	sewage filtrated	578	514	277	10
	SS . no stirring				
Reactor implement in					
1#	perch water tank and setting up 80 order strainer on it	449	399	280	8
	Fresh sewage	897	404	331	401
	containing SS. setting up stirring	815	427	347	351
Reactor implement in					
2#	perch water tank to simulate no primary sedimentation tank	549	338	354	211
	pythogenous	791	504	389	292
	sewage	748	578	392	125
	containing SS. setting up stirring				
Reactor implement in					
3#	perch water tank to simulate no primary sedimentation tank	530	449	361	131
	Fresh sewage	690	404	304	13
	filtrated SS. no stirring	627	427	303	10
Reactor implement in					
4#	perch water tank and setting up 80 order strainer on it	401	338	265	10

2.2.2 Study on effect of loading rate N_s on sedimentation performance of A-step activated sludge

Parallel contrast experiments were carried out using three reactors. The running status and quality of inflow sewage of every reactor in the period of experiment

were shown as Table 2. These index including SVI, EPS, inflow and outflow COD, BOD₅ and SS was tested during the experiment. The extraction of EPS from activated sludge used a cation exchange resin.

Table 2 Running status and quality of inflow sewage of every reactor in the experiment

Reactor	Running status	COD /(mg/l)	BOD ₅ /(mg/l)	SS /(mg/l)
	Ns=2-	884	335	375
	3.0kgBOD ₅ /kgMLSS-d,	741	306	341
Reactor Q=300ml/min, HRT				
1#	=50min, MLSS=	403	193	182
	2g/l,			
	DO=2.0~2.5mg/l			
	Ns=0.5-	418	205	204
	1.5kgBOD ₅ /kgMLSS-d	344	144	146
Reactor Q=300ml/min, HRT				
2#	=50min, MLSS=	355	163	139
	2.5g/l,			
	DO=2.0~2.5mg/l			
	Ns=0.3-	356	146	150
	0.5kgBOD ₅ /kgMLSS-d	320	150	133
Reactor Q=200ml/min, HRT				
3#	=75min, MLSS=	320	150	133
	3.5g/l,			
	DO=2.0~2.5mg/l			

2.2.3 Study on effect of DO on sedimentation performance of A-step activated sludge

Parallel contrast experiments were carried out using four reactors, and their dissolved oxygen was adjusted respectively to 0, 0.5, 1.2, and 2.5 mg/l. The reactor of DO=0 mg/l did not aerate, and only stirred to make inflow and sludge mix fully. The quality of inflow sewage and running status of every reactor in the period of experiment were as follows: COD=815-630 mg/l, BOD₅=312-191 mg/l, SS=356-273mg/l, Q=300 ml/min, MLSS = 2.5 g/l, Ns=3 kgBOD₅/kgMLSS-d, HRT=50 min. These index including SVI, inflow and outflow COD, BOD₅ and SS was tested during the experiment.

3. Results and discussion

3.1 Study on effect of inflow SS and pythogenous sewage on sedimentation performance of A-step activated sludge

3.1.1 Experiment result

The curve of SVI change of activated sludge in every reactor was shown as Fig. 1. the sedimentation curve of activated sludge in every reactor on 3rd, 10th, 20th, 30th day were respectively shown as Figs.2 to 5.

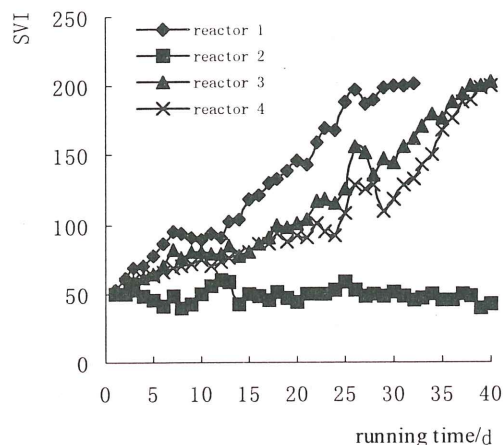


Fig. 1 Curve of SVI change of activated sludge in every reactor

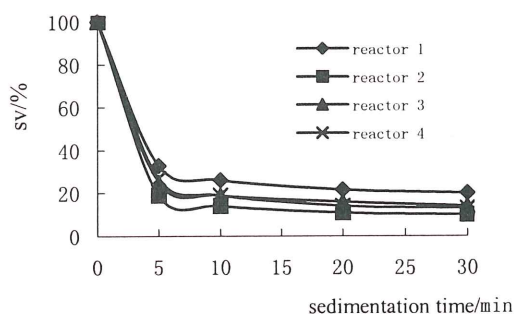


Fig. 2 Sedimentation curve of activated sludge in every reactor on 3rd day

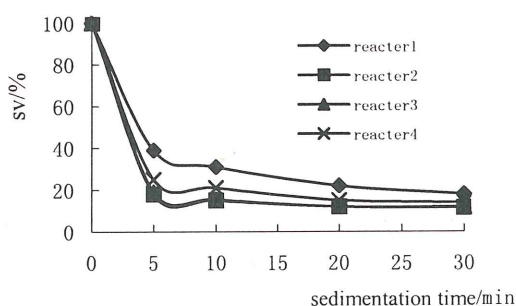


Fig. 3 Sedimentation curve of activated sludge in every reactor on 10th day

3.1.2 Discussion of experiment result

1) Experiment result analysis

Fig.1 shown: sludge bulking took place in reactor 1#, 3#, 4# during the experiment. With experimental time increasing, SVI of the sludge increased gradually and exceeded 200 respectively on 3rd,10th, 20th, 30th day, and the volume density of the sludge reduced from

20.8g/l to 4.93g/l. Only sedimentation performance of activated sludge in 2# reactor is stable, whose SVI is about 48 and volume density is about 20.8g/l.

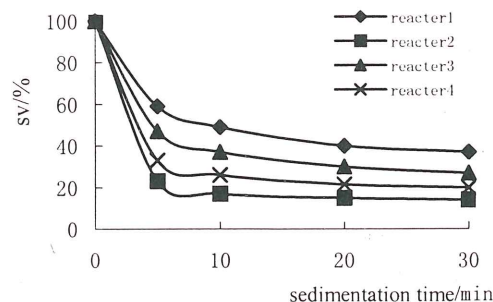


Fig. 4 Sedimentation curve of activated sludge in every reactor on 20th day

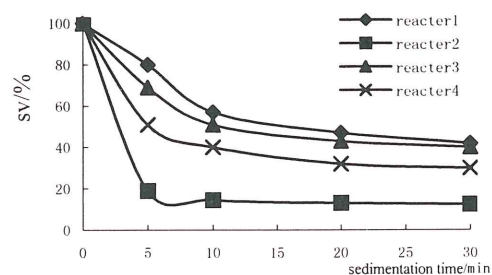


Fig. 5 Sedimentation curve of activated sludge in every reactor on 30th day

The granula of sludge floc in reactor 1#, 4# was large than that in reactor 2#. But inflow SS was less, so aggregation center was lack, which resulted in less volume density and floc proportion and worse sedimentation performance. Filamentous bulking happened in reactor 1#, 3#. There was a great deal of sulfur bacteria when observing the sludge by microscope, because inflow was pythogenous sewage in reactor 1#, 3#(table 1), and there was more soluble organics in pythogenous sewage than fresh sewage, which induce easily filamentous bulking.

The before-mentioned experiment results indicated: good sedimentation performance of activated sludge in 2# reactor was because of no primary sedimentation tank, which made inflow SS enter into A-step and improved distinctly sedimentation performance of activated sludge; part of SS adhered to zoogloea as "floc core" by extracellular polysaccharide; in the meanwhile SS also attached to surface of filamentous holding out floc, which not only obstructed filamentous bridging, but also increased floc proportion and sedimentation rate. Besides, inflow prokaryote entered directly A-step, which supplied microorganism

population and made filamentous unable to be predominated.

2) Microorganism analysis

The class of bacteria was appraised during the experiment, and the result was shown as Table 3.

Table 3 Sludge appearance and Microorganism class in every reactor

Reactor	Sludge appearance	Microorganism class
Reactor1#	At the beginning, the size of floc was equal to reactor 2# ,and it start to a Dominant bacteria change on 5th day. The floc change gradually to filamentous strip, and the was aeromonas, shape was irregular, the width of which was 0.5mm and length was 7mm; having sulfur bacteria much filament held out floc and the length of filamentous is 9680 μ m; on about 10th day , much strip sludge whose width was about 0.8cm and length was 10cm.	
Reactor2#	The floc was brown whose granule was dense; most granule was 300-800 μ m Dominant bacteria and a few was 2mm.The granule which was deep brown enwrapped SS, no was bacteria coli filament holding out floc.	
Reactor3#	At the beginning, the size of floc was equal to reactor 2# ,and it start to a Dominant bacteria change on 7th day. The floc change gradually to cake, whose granule was was aeromonas commonly 4mm. The width of the biggest floc was 2mm, length was 3cm and thickness was 1mm, some filament holding out floc.	
Reactor4#	At the beginning, the size of floc was equal to reactor 2# ,and it start to a Dominantbacteria was change on 8th day. The floc change gradually to cake whose big granule was aeromonas , having commonly 6mm, strip ,and floccus whose width was 2mm, length was 3~ sulfur bacteria 4 cm, and thickness was 0.8 mm. Some filament held out floc, and the thinner strip sludge whose width was about 5mm and length was 5cm appeared.	

3) Recovery study on sedimentation performance of bulking sludge

Recovery experiment of bulking sludge was performed from 32th for reactor 1# and 41th for reactor 3#, 4#. The curve of SVI change of activated sludge in reactor1#, 3# and 4# in recovery phase was shown as fig. 6.

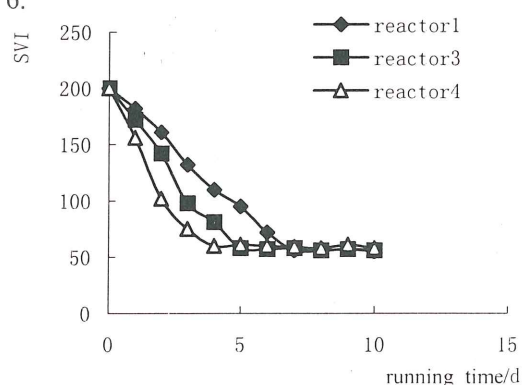


Fig. 6 Curve of SVI change of activated sludge in every reactor in recovery phase

Fig. 6 indicated: after bulking sludge in reactor1#, 3#

and 4# recovering respectively for 7 days, 5 days and 4 days, SVI reduced to 51, 51 and 50, removal rate of COD increased to 71%, 72% and 68%, and the granularity reduced gradually to 3mm~500 μ m. There was no abnormal multiplication of filamentous by microscope. The recovery experiment proved again: inflow SS distinctly improved sedimentation performance of activated sludge; fresh sewage benefited more to improve sedimentation performance of activated sludge than pythogenous sewage.

3.2 study on effect of loading rate N_s on sedimentation performance of A-step activated sludge

The experiment proceeded for 40 days. The sedimentation curve of activated sludge in every reactor in different N_s was shown as Fig. 7. Fig. 7 shown: during whole experiment, when N_s was equal to 0.30~3.0kgBOD₅/kgMLSSd in A-step, sedimentation performance and shape of activated sludge in every reactor were always relatively stable, and no

sludge bulking took place. With N_s increase from 0.30 to 3.0 kgBOD₅/kgMLSS d, SVI of activated sludge reduced from around 80 to 50 and volume density increased from 11.9 g/l to 20.9 g/l; in the meanwhile Fig. 6 indicated: EPS in activated sludge decreased from 29.22 mg/gVSS to 17.15 mg/gVSS, and polysaccharide decreased from 14.5 mg/gVSS to 8.15 mg/gVSS, which reduced around 40%. The before-mentioned experiment results indicated: sedimentation performance of activated sludge in high N_s excelled that in low N_s , and activated sludge in high N_s did not appearance dispersed growth and bad agglomeration performance, even in $N_s = 0.5 \sim 1.5$ kgBOD₅/kgMLSS d bulking extent of activated sludge process, bulking did not take place. With N_s decreasing, the content DNA and polysaccharide increased, and SVI increased; at the same time, filamentous in activated sludge also increased and some filament held out floc by microscope.

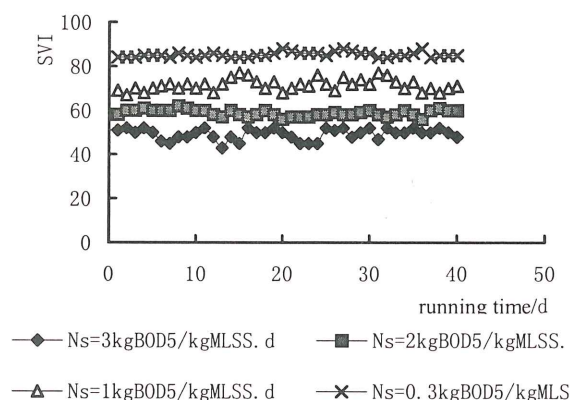


Fig. 7 Sedimentation curve of activated sludge in every reactor in different N_s

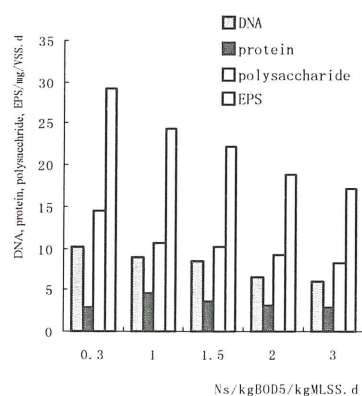


Fig. 8 Composition and content of EPS in different N_s activated sludge in every reactor

The discussion were as follows: one side, there were two reasons which made polysaccharide in EPS increase in low N_s : firstly, bacteria secreted more

extrocellular polysaccharide in low N_s ; secondly, dead bacteria increased in low N_s because of endogenous respiration, and these death bacteria autolyzed and released part of introcellular polysaccharide, which induced more polysaccharide of activated sludge in low N_s than in high N_s . At normal state, filamentous was the framework of floc, and in low N_s , they could firstly use part of polysaccharide attaching on the framework as nutriment and multiplied quickly which made for more filamentous in low N_s activated sludge, besides, the high polysaccharide content resulted in good hydrophilic capability of low N_s activated sludge; on the other hand, the low polysaccharide content resulted in good hydrophobic capability of high N_s activated sludge, moreover, because of no primary sedimentation tank and short HRT, most difficult degrading substance in inflow SS aggregated at the surface of sludge which induced more difficult degrading substance in EPS of high N_s activated sludge. Forster reported: when difficult degrading substance in EPS increased, sedimentation performance of activated sludge was improved, so difficult degradation substance improved sedimentation performance of high N_s activated sludge. Again, because of short SRT of high N_s activated sludge and long generation period of filamentous, filamentous could not became dominant bacteria.

3.3 study on effect of DO on sedimentation performance of A-step activated sludge

The experiment proceeded for 30 days. Change curve of DO—SVI—t in every reactor in 30 days was shown as Fig. 9. Fig. 9 indicated: although DO in every reactor was very different, sedimentation performance of activated sludge was good and SVI was under 60. The reason was that when reactor run in high rate ($N_s = 3.0$ kgBOD₅/kgMLSS d), the density of sludge was big, and average granularity of sludge was 500 μ m, which improved sedimentation performance of activated sludge. Although the concentration of organic substrate was enough high to make bacteria logarithmically increase and have maximal kinetic energy, DO was limited which made bacteria unable to reach zero-order reaction, especially to big granule sludge; at the same time, big granule sludge in high N_s could embedded and fixed enzyme and microorganism,

and limited microbial kinetic energy, which induced floc to have good sedimentation performance wholly.

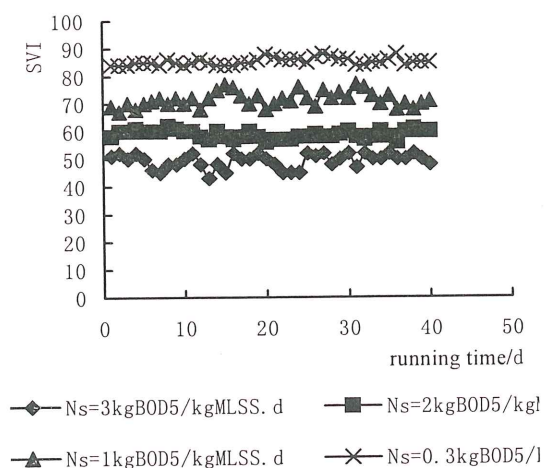


Fig.9 Change curve of DO-SVI-t in every reactor in 30 days

4. Conclusions

1) The inflow SS distinctly improve sedimentation performance of activated sludge. The pythogenous sewage easily worsen sedimentation performance of activated sludge, and canceling primary sedimentation tank and cesspool would avail to stable running of sewage treatment plant. The bulking sludge could

resume soon to normal state (10d) when the process running in A-step mode. canceling primary sedimentation tank made inflow prokaryote entered directly A-step, which supplied microorganism population and made filamentous unable to be predominated.

2) The polysaccharide content in the EPS are correlated evidently with sedimentation performance of different loading rate activated sludge in A-step. the low polysaccharide and EPS content of activated sludge in high loading rate cause good sedimentation performance of sludge in A-step.

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