高氨氮废水短程硝化过程中污泥膨胀的研究

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摘要 采用 A/O 工艺处理模拟高氨氮废水,在一定条件下实现了稳定的短程硝化(积累率 ≥80 %),污泥沉降性能良好,短程硝化后期污泥沉降性能逐渐恶化。实验结果表明,通过补充废水的 N/P 虽然能够略微降低 SVI,但是仍然不能有效的缓解污泥膨胀。当 COD 负荷 > 0.27 kg/(kg·d)时发生污泥膨胀。将 DO 控制在 1.5～2.0 mg/L,沉淀池的固液分离效果良好,并且氨氮去除率、COD 去除率和亚硝氮积累率均 > 90 %,污泥膨胀现象得到有效控制。

关键词 短程硝化 污泥膨胀 A/O 工艺

0 引言

短程硝化反硝化生物脱氮是一条新型生物脱氮途径[1],然而低溶解氧条件下的污泥膨胀是制约短程硝化在实际工程中应用的因素之一。本实验着重研究了低溶解氧条件下实现短程硝化时出现的污泥膨胀问题及相应的解决办法。

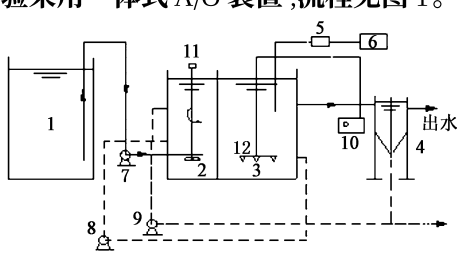
1 实验部分

1.1 实验水质和污泥状况

本实验所用高氨氮废水为模拟废水,即在自来水中加入一定量的 NH_4Cl、NaH_2PO_4、CH_3OH、以及少量微量元素,废水的 C/N 约为 3∶1,用 NaOH 和 $NaHCO_3$ 调节好氧池的 pH 值。污泥取自北京某污水处理厂。培养驯化初期污泥呈黄褐色,沉降性能良好,SV = 40 %,SVI = 98.9 mL/g,镜检时发现长颈虫、轮虫以及钟虫等原生和后生动物,污泥处于成熟期,活性较好。

1.2 实验装置

实验采用一体式 A/O 装置,流程见图 1。



1—进水箱;2—缺氧池;3—好氧池;4—沉淀池;
5—pH 调节仪;6—碱液池;7—进水泵;8—硝化液回流泵;
9—污泥回流泵;10—鼓风机;11—搅拌机;12—曝气装置。

图 1 实验装置流程

反应器由不锈钢制成,缺氧池、好氧池有效容积分别为 20、48 L。污泥回流比为 100 %,硝化液回流比为 200 %。好氧池内置悬浮填料,填料投配率为 20 %。

2 实验结果及讨论

2.1 短程硝化初期的污泥性状

系统从氨氮浓度为 48.83 mg/L 开始启动,约 1 周后氨氮去除率达 89.5 %。系统运行稳定后开始逐步提高氨氮浓度至 800 mg/L。在全程硝化的基础上控制温度为 27～30 ℃,pH 值 7.5～8.6,溶解氧 0.5～1.0 mg/L 的条件下约 1 周后逐渐形成了亚硝氮的积累(积累率 52.4 %),在此期间氨氮去除率降低到 50 % 以下。随着菌种对环境的逐步适应,稳定后的短程硝化氨氮、COD 平均去除率分别为 96.8 %、93.2 %,亚硝氮平均积累率为 90.5 %。污泥容积指数(SVI)随时间变化的曲线如图 2 所示。

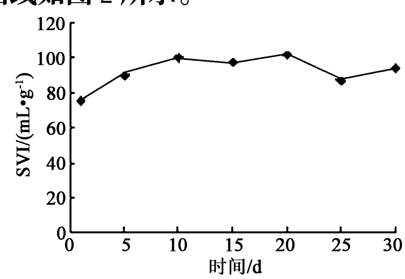


图 2 SVI 随时间变化

在短程硝化初期 SVI 值均 < 100 mL/g,污泥外观呈黄褐色,易于沉降,活性较好。

2.2 短程硝化期间污泥性状的改变

运行一段时间后污泥的 SV_{30} 逐渐高达 95 %,SVI 超过 300 mL/g,沉淀池固液分离效果差,部分污泥随出水流失,镜检发现有丝状菌,污泥发生了比较明显的丝状菌膨胀。污泥膨胀初期氨氮和 COD 去除率未受到明显影响,随着污泥的逐渐流失,污泥浓度由污泥膨胀之前的 3.5 g/L 减少到 2.1 g/L,氨氮去除率低于 90 %。这主要因为在污泥膨胀初期由于丝状菌较

大的比表面积吸附截留水中的游离细菌,有助于氨氮的降解,随着丝状菌的大量繁殖菌胶团生长受限,硝化菌和亚硝化菌也随之受到影响,因此出现了氨氮去除率的下降。这与沈耀良等人的研究结果相一致[2]。

2.3 对污泥膨胀现象的理论分析

活性污泥是一种混合培养系统。污泥絮体是由菌胶团和丝状菌组合而成。对于正常的活性污泥而言,两者之间有一个适当的比例关系。如果丝状菌生长繁殖过多,菌胶团的生长繁殖则受到抑制,使絮体松散,沉淀性能恶化,污泥体积膨胀。

一般来说,引起污泥膨胀的原因有废水水质、水温、pH 值、溶解氧、负荷率等[3-5]。

本实验在运行期间温度控制在 27～30 ℃,为了维持短程硝化 pH 值始终控制在 7.5～8.6。因此引起污泥膨胀的原因可能是废水水质和溶解氧。

2.4 采取的措施

(1) 废水水质

废水中 C∶N∶P = 300∶110∶1,可见废水中磷严重缺乏。P 是微生物新陈代谢过程中组成核酸、磷酸和辅酶的重要成分。逐渐向废水中补充磷,提高 N/P 至 30∶1。磷含量和污泥 SVI 变化如图 3 所示。

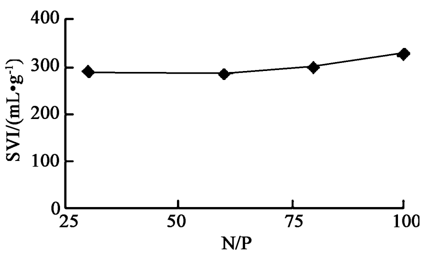


图 3 N/P 与 SVI 的变化

由图 3 可知,N/P 由 100∶1 逐渐提高到 30∶1,SVI 略有降低但仍然接近 300 mg/L,提高 N/P 对控制污泥膨胀作用不大。微生物的生命活动需要氮、磷等营养元素,但是增加其含量并不能有效改善已膨胀污泥的性状。

(2) 运行方式

污泥膨胀的发生与有机负荷有关[6]。COD 负荷和 SVI 的变化关系如图 4 所示。

由图 4 可见,当 COD 负荷 > 0.27 kg/(kg·d) 时发生了明显的污泥膨胀,因此在实际运行过程中应适当控制 COD 负荷。导致污泥膨胀的 DO 与活性污泥的有机负荷关系,如表 1 所示[7]。

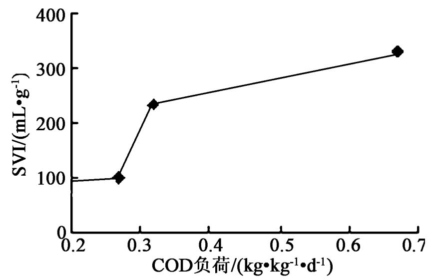


图 4 COD 负荷与 SVI 的关系

表 1 有机负荷率与"安全"DO 浓度的关系

有机负荷率/(kg·kg^{-1}·d^{-1})	"安全"DO 浓度/(mg·L^{-1})
0.30	1.0
0.50	2.0
0.75	3.0
0.90	4.0

本实验中污泥 COD 负荷增大到 0.67 kg/(kg·d),而 DO 不足 1.0 mg/L,远远低于"安全"DO 浓度。在稳定的短程硝化基础上,逐渐增大曝气量至 2.0 mg/L。DO、氨氮去除率、SVI 的变化如图 5 所示。

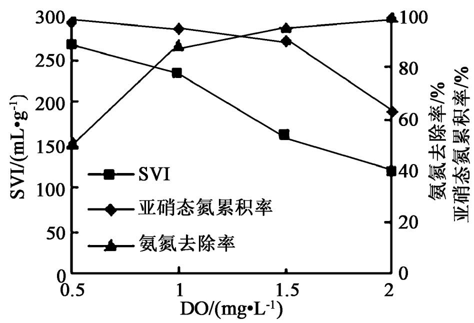


图 5 DO、氨氮去除率与 SVI 的关系

可见当逐渐增加 DO 至 2 mg/L 时,SVI 降到 118 mg/L,污泥膨胀现象得到有效的控制,但是短程硝化有向全程硝化转变的趋势。故在运行中可将 DO 控制在 1.5～2.0 mg/L,在此条件下既能有效缓解污泥膨胀又能维持亚硝氮的积累(积累率 ≥90 %)。

此外可通过排泥将反应器内积累的大量沉降性能差的污泥及时排走,这也是一种改善污泥沉降性能的手段。

3 结论

(1) 利用一体式 A/O 装置,在温度为 27～30 ℃,pH 7.5～8.6,DO 0.5～1.0 mg/L 的条件下实现了稳定的亚硝氮的积累(积累率 ≥80 %),污泥沉降性能良好。

(2) 在逐渐增加 N/P 的过程中,SVI 从 326 mL/g

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说明 Cr(Ⅵ)在球内都转变成了 Cr(Ⅲ),并以 $Cr(OH)_3$ 形式存在。因此,已使用的球可不经过脱附处理,直接磨碎后通过一定方法回收 $Fe(OH)_3$ 和 $Cr(OH)_3$,活性炭可继续用来制备微球。

3 结论

(1)利用液 - 液相分离方法制备的包埋铁粉和活性炭的微球,其内部铁粉和活性炭分部均匀,对铁粉的利用更加充分,并且加快富集在球内的 Cr(Ⅵ)和 Fe^{2+} 反应速度,对含铬废水中的 Cr(Ⅵ)有较好处理效果。

(2)静态实验结果表明:当铁粉和活性炭的包埋量为 6 %,废水初始 pH 值为 2,处理时间为 4 h,微球质量为 10 g 时,Cr(Ⅵ)的去除率达 99.7 %。动态实验结果显示:当进水流量 < 0.25 L/min 时,出水水质稳定,达国家排放标准。

(3)利用包埋铁粉和活性炭的微球处理含铬废水的方法,不存在填料结块现象,能减轻出水排渣负担,且能充分利用活性炭本身吸附性能,优于普通的铁炭内电解法。

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2007 - 11 - 07 收稿

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降低到 286 mL/g,通过补充废水的 N/P 不能有效的缓解污泥膨胀。

(3) 当 COD 负荷 > 0.27kg/(kg·d) 时发生污泥膨胀。

(4) DO 从 0.5 mg/L 逐渐增大到 2.0 mg/L 的过程中,SVI 从 268 mL/g 降低到 118 mL/g,但是短程硝化有向全程转化的趋势,本实验中最佳的 DO 应选择在 1.5～2.0 mg/L,在此条件下沉淀池的固液分离效果良好,并且氨氮、COD 去除率和亚硝氮积累率均 > 90 %。污泥膨胀现象也能得到有效控制。

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2007 - 10 - 31 收稿

Abstract The combined process of powdered activated carbon (PAC) and membrane bioreactor (MBR) was applied for treatment of municipal wastewater. The removal efficiencies of COD, NH_4^+-N and turbidity in the combined process were investigated. The result showed that the combined process may achieve better removal efficiencies of COD, NH_4^+-N and turbidity, when water temperature is above 26 ℃, DO is above 4.5 mg/L and pH is between 6 and 9. The average removal efficiencies of COD, NH_4^+-N and turbidity in the combined process were 88 %, 98 % and 98 % respectively, and was better than that of single MBR process and conventional process. The effluent COD was less than 22 mg/L and NH_4^+-N was less than 1 mg/L, turbidity was less than 1NTU. It was better than that of water for domestic reuse stated by the Ministy of Construction (CJ25.1 - 89). The fouled membrane was cleaned by water rinsing, water-acid rinsing, water-alkali rinsing, which can let its flux be restored to 43 %, 81 %, 89 % of a new membrane respectively.

Keywords powder activated carbon membrane bioreactor domestic wastewater

Abstract E. coli and Bacillus subtilis were selected to express respectively the easily and difficultly inactivated microbe, and the best irradiation time and the limit turbidity of microwave electrodeless ultraviolet (UV) irradiation were studied. In this condition, checking the disinfection of E. coli and Bacillus subtilis, and compared with mercury lamp of medium pressure. The results showed that when best irradiation time was 210 s, microwave electrodeless ultraviolet irradiation can achieve inactivation rate of 99.92 %. In order to obtain the best results of disinfection effect, the water of turbidity was below 8 NTU, the limit turbidity of disinfection was 40 NTU; microwave electrodeless ultraviolet irradiation can achieve inactivation rate of 100 % with 180 s, and the Bacillus subtilis inactivation rate of 100 % with 300 s, it is more effective than mercury lamp of medium pressure disinfection.

Keywords E. coli Bacillus subtilis limit turbidity drinking water disinfection efficiency electrodeless UV lamp

Abstract A/O technique was used to treat simulated high ammonia wastewater, the stability short-cut nitrification could be implemented by controlling the right content (accumulation rate ≥80 %), the activated sludge had good settling property, in the late of the short-range nitrification it was degraded gradually. It is showed by the experimental results that increasing N/P ratio in the wastewater can slightly drop SVI, but still can not effectively ease the sludge bulking. The bulking sludge would be occurred when COD load was above 0.27 kg/(kg·d). Controlled DO with 1.5 to 2.0 mg/L, the solid-liquid separation result is good, and the removal rates of NH_4^+-N and COD, as well as the cumulative rate of nitrite nitrogen are greater than 90 %, sludge bulking can be effectively controlled.

Keywords short-range nitrification sludge bulking A/O process

Abstract Micro-ball entrapped iron powder/activate carbon was prepared by liquid-liquid phase separation method and its effect on treating the simulation wastewater containing Cr(Ⅵ) was investigated. The results showed that the removal rate of Cr(Ⅵ) could reach 99.7 % at pH value of 2 and treating time of 4 h. The effluent could reach the discharge standard of China, the treatment operated steadily and the iron powder and activate carbon did not agglomerate in the continuous removal process. So this method is superior to the common iron-carbon micro-electrolytic method.

Keywords entrapping method iron powder activate carbon Cr(Ⅵ)

Abstract A pilot study on the treatment neoprene wastewater with integrated microelectrolysis and three-unit biochemistry process was done. The experiment results under the stable condition showed that COD removal rate was up to 97.6 %, COD concentration of the effluent could be reduced to less than 300 mg/L.

Keywords microelectrolysis three-unit biochemistry process neoprene wastewater treatment of pilot scale

Abstract The technology of catalytic oxidation is studied for degrading safranine T. The self-made polyoxometalate $Zn_{1.5}PW_{12}O_{40}$ nanotube is used as the catalyst and dioxygen is used as the oxidizer. The results show: $Zn_{1.5}PW_{12}O_{40}$ is sutiable for catalyst, with the structure of the $Zn_{1.5}PW_{12}O_{40}$ being hollowed, the type of the $Zn_{1.5}PW_{12}O_{40}$ being affiliated to the type of heteropoly acids, and the scale of the $Zn_{1.5}PW_{12}O_{40}$ being nanometer-scale; in the oxidation system of air, the optimum reaction time is 4 hours, and correspondently the degradation rate and the degradation velocity are respectively 78 % and 665 μg/h; the activity and stability are both high, and when the circulation times are four, the degradation is still 65 %.

Keywords nanotube dioxygen safranine T degradation rate circulation