

同步硝化反硝化脱氮研究

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提要 在控制 SBR 反应器保持良好的好氧状态条件下,考察进水 COD/ NH_3 比值对同步硝化反硝化脱氮效率的影响。同时也对同步硝化反硝化机理进行了初步的探讨。研究表明,进水 COD/ NH_3 比值越高,总氮去除率越高,同步硝化反硝化现象越明显。由该试验可以推断活性污泥菌胶团中异养硝化菌和好氧反硝化菌的存在。

关键词 同步硝化反硝化 好氧反硝化 碳氮比 SBR 反应器

0 概述

城市污水生物脱氮工艺中通常发生三种不同的生物反应,即有机物的好氧化、硝化和反硝化反应。大多数的生物脱氮工艺都将缺氧区和好氧区分隔开,即形成所谓的前置反硝化或后置反硝化工艺。因为根据传统的脱氮理论,硝化与反硝化反应不能同时发生,硝化反应在好氧条件下进行,而反硝化反应在缺氧条件下完成。然而,最近几年国外有不少试验和报道证明存在同步硝化反硝化现象(Simultaneous Nitrification and Denitrification,简称 SND),尤其是有氧条件下的反硝化现象确实存在于各种不同的生物处理系统,如生物转盘^[1]、SBR^[2]、氧化沟^[3]、CAST 工艺^[4]等。

同步硝化反硝化的优点如下^[5]:

(1) 硝化过程中碱度被消耗,而同时的反硝化过程中产生了碱度,SND 能有效地保持反应器中 pH 稳定,而且无需添加外碳源,考虑到硝化菌最适 pH 范围很窄,仅为 7.5~8.6,因此这一点是很重要的。

(2) SND 意味着在同一反应器,相同的操作条件下,硝化、反硝化应能同时进行,如果能够保证在好氧池中一定效率的反硝化与硝化反应同时进行,那么对于连续运行的 SND 工艺污水处理厂,可以省去缺氧池的费用,或至少减少其容积。对于仅由一个反应池组成的序批式反应器来讲,SND 能够降低实现完全硝化、反硝化所需的时间。

SND 系统提供了今后降低投资并简化生物除氮技术的可能性。然而,对于 SND 的机理还缺乏深入的认识与了解,要使该项技术实用化还有大量研

究工作有待完成。

本研究中,控制反应器保持良好的好氧状态,考察进水 COD/ NH_3 比值对同步硝化反硝化及脱氮效果的影响,探索硝化反硝化一体化工艺的规律和特性及其工程应用的可行性,同时对同步硝化反硝化的机理进行初步的探讨。

1 试验材料和方法

1.1 试验装置

试验所用 SBR 反应器为有机玻璃管制成。反应器内径为 100mm,有效容积 5L,反应器放置于 28℃ 恒温箱中,通过时间自控装置控制每一周期的反应时间。

1.2 试验用水

选用 3 种不同 COD/ NH_3 比值的人工配制污水作为进水。水质成分包括葡萄糖、氯化铵、硫酸镁、碳酸氢钠、氯化钠、氯化钙、磷酸二氢钾、氯化铁、氯化钴。进水氨氮浓度控制在 20mg/L 左右,3 种进水平均 COD/ NH_3 比值控制在约 7.9,4.6,2.3。

1.3 污泥驯化

取南京锁金村污水处理厂曝气池活性污泥 5L 进行培养驯化,驯化期间采用的操作模式为:进水 0.5h,曝气 7h,沉降 1h,排水 0.5h,逐渐增加进水的 COD 和氨氮负荷,运行约 30d 左右,活性污泥混合液的 MLSS 达 3.5g/L,在进水 COD 为 380mg/L, $\text{NH}_3 - \text{N}$ 为 40mg/L 的条件下,COD 去除率达 92%, $\text{NH}_3 - \text{N}$ 去除率达 99% 以上,至此认为污泥驯化结束。

1.4 分析监测项目与方法

COD 采用重铬酸钾法, $\text{NH}_3 - \text{N}$ 、 $\text{NO}_2^- - \text{N}$,

$\text{NO}_3^- - \text{N}$ 分别采用蒸馏滴定法,戴氏合金法,分光光度法。

1.5 试验方法

试验操作模式为:进水 0.5h,曝气 5h,沉降 1h,排水 0.5h。控制反应器中混合液污泥浓度为 1 500 mg/L 左右,同时采用 TDO-100 型溶解氧控制仪保持曝气期间较高的溶解氧水平,以维持反应器曝气阶段良好的好氧状态。反应器每周期处理水量为 3L,为反应器有效容积的 60%。考察不同进水条件下的脱氮效果。对不同进水条件下反应器中的 COD 浓度、氮元素浓度进行了轨迹跟踪。轨迹跟踪均从曝气初始起开始取水样,在之后的 5h 曝气及 1h 沉降过程中,每隔 1h 取水样一次。

2 结果与讨论

所得部分试验数据绘于图 1~图 4。

在进水 COD/ NH_3 比值为 7.9,4.6,2.3 三种条件下,沉降阶段 COD 浓度均有不同程度的回升(图 1),这可能是由进水初期微生物吸附的有机物质转化成的内碳源在停止曝气后得以释放。

以进水 1 氮元素轨迹跟踪图(如图 3 所示)为例可知,在每一工作周期的前期,硝化反应的进行使氨氮比较彻底地转化为硝酸盐氮,氨氮浓度逐渐降低,同时总氮浓度也逐渐降低。从这一现象可以得出的结论是:在这一阶段既发生了好氧硝化也发生了好氧反硝化(即同步硝化反硝化),而且导致了比较可观的总氮去除率。

图 4 表明,进水 COD/ NH_3 比值越高,出水总氮越低,总氮的去除率相应的也越高。因此,该模式下好氧反硝化现象随进水 COD/ NH_3 比值的提高而越加明显。

有研究表明,当 DO 浓度大于 2.6mg/L 时,溶解氧能完全穿透活性污泥絮体^[6~7]。本试验因不设缺氧段,并且反应过程中控制高的溶解氧水平及低的悬浮污泥浓度。因此,试验中活性污泥絮体能保持良好的好氧状态,因为宏观上的缺氧环境及缺氧微环境而引起的反硝化反应是微弱的,由此推断活性污泥絮体中存在好氧反硝化菌。这与国外有关活性污泥系统中好氧反硝化菌的报道相一致。

由 3 种进水条件下氮元素的轨迹跟踪图可知,在曝气的最初 1h 内,进水 COD/ NH_3 比值为 7.9,

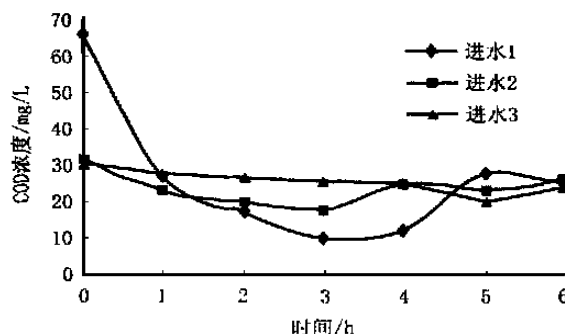


图 1 COD 轨迹跟踪测定

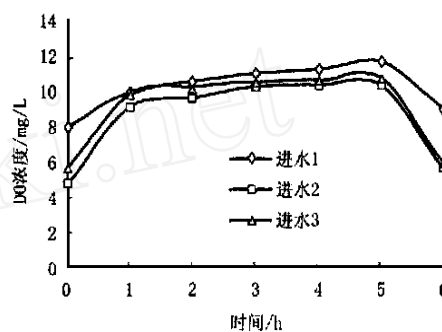


图 2 DO 轨迹跟踪测定

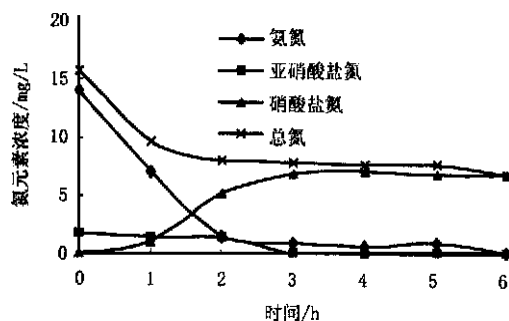


图 3 进水 1 氮元素轨迹跟踪

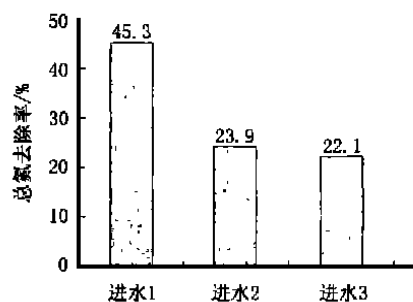


图 4 不同进水条件下平均总氮去除率

4.6,2.3 时反应器内的硝化速率分别为 7mg/(L·h), 6.14mg/(L·h), 5.18mg/(L·h) (硝化速率由公式

$Rn = - (dNH_3 - N) / (dt)$ 计算得出,数值以 N 计)。硝化速率随着进水 COD / NH_3 比值的提高而上升,这似乎与传统的硝化理论不一致。传统的硝化理论认为,硝化作用是由自养型硝化菌将氨转化为 NO_2^- 及 NO_3^- 的过程。与异养型细菌相比,硝化菌的产率低,比增长速率小,在活性污泥系统中异养菌与硝化菌竞争底物和溶解氧,使硝化菌的生长受到抑制^[7]。因此,根据传统的硝化理论,活性污泥中硝化菌的比例与污水的 BOD / TKN 值有关。 BOD / TKN 值越高,硝化菌所占比率越小,硝化速率越低。

由于传统的硝化理论不能圆满地解释以上现象,我们推断:只有在反应器活性污泥中存在着异养硝化菌,才能够解释硝化速率随进水 COD / NH_3 比值的提高反而增加的现象。最近几年,已发现许多异养微生物能够对有机及无机含氮化合物进行硝化作用^[5,8]。与自养型硝化菌相比,异养硝化菌生长快,产量高,需要的 DO 浓度低,能忍受更酸的环境。Van Niel (1991 年) 指出在很多条件下可以同时存在异养和自养型硝化菌。而且当 BOD / N 大于 6.9 时异养硝化菌对氨的氧化会起很大的作用。且由于大多数异养硝化菌同时也是好氧反硝化菌^[8],由此也进一步解释了前面所述同步硝化反硝化的现象。

3 结束语

在溶解氧浓度很高 ($> 8mg/L$), $MLSS$ 较低的情况下,经过 5h 曝气,总氮去除率因进水碳氮比不同而异,进水 COD 越高,好氧反硝化现象越明显。总氮去除率随进水 COD 的提高而增加,表明碳源对反硝化的重要性。

由该试验推断活性污泥絮体中同时存在着异养硝化菌与好氧反硝化菌。

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ABSTRACTS

Improved Technological Design of Dachang Waterworks in Shanghai Zheng Guoxing *et al* (1)

Abstract : This project of waterworks with design capacity of 400 thousand cubic meters per day is the first waterworks constructed on BOT contract in this country. In this paper the main figures of this project including the water purification process, expected quality of output water, water purification facilities with design parameters, equipment allocation, chemical dosage system and their control and online metering instruments are presented in detail. Also the particularities in process design and equipment provision are discussed.

Influence of Boundary Shape on the Partition Board Flocculation Basin Zhan Yong *et al* (5)

Abstract : By the model experiments of mixing and flocculation reactions, the effect on the flocculation can be studied under different boundary shape conditions, which turbulence plays an important role in improving hydraulic flow pattern for the partition board flocculation basin. As a result, there are reasonable energy dissipation and optimum hydraulic condition for arc sections of partition boards and basin's corner. Therefore, it is an effective way to reach a high efficiency of mixing and flocculation, especially for transforming the old technological process of water and wastewater plants.

Xianyang Road Wastewater Treatment Plant Hu Dawei *et al* (8)

Abstract : The engineering design of the Xianyang Road Wastewater Treatment Plant in Tianjin city was presented in this paper. The optimal choice of wastewater treatment process and sludge disposal are involved and some decisions of practical measures in design phase are indicated.

Research on High Quality Drinking Water Preparation by Ultra-Filtration and Activated Carbon Process Dong Bingzhi *et al* (15)

Abstract : Experiment of a combined process of ultrafiltration membrane and activated carbon adsorption was conducted for high quality drinking water preparation. The experiment results show that the performance of this highly automatic process is stable; and the prepared water is quite good to meet the requirement of the local standards of high quality drinking water DB31/197-1997 issued by Shanghai municipality. The PAN UF membrane component developed by Toray Co. was adopted. This system not only can remove bacteria and decrease turbidity effectively, but also can remove the organic compounds.

Study on Municipal Wastewater Treatment by Biotower Liu Jun *et al* (18)

Abstract : In case where the terrain feature is favorable, the biotower could be operated under condition of no or few power support, despite it is rarely applied for municipal wastewater treatment. In this paper the operating parameters and performance of biotower are presented.

Study on Nitrogen Removal by Simultaneous Nitrification and Denitrification Li Congna *et al* (22)

Abstract : By controlling the SBR reactor under aerobic condition, investigations were made into the effect of the ratio of influent carbon to nitrogen on nitrogen removal and simultaneous nitrification and denitrification (SND). In addition, the mechanism of SND was explored tentatively. It was found that a higher ratio of influent carbon to nitrogen could produce higher total nitrogen removal efficiency. Conclusion was drawn from the experimental results that there might coexist heterotrophic nitrifiers and aerobic denitrifiers inside the activated sludge flocs.

Controlled Release Disinfectant and its Application for Potable Water Deng Zhengdong *et al* (33)

Abstract : As a new approach of safe and effective disinfectants, controlled release (CR) technology has attracted attentions more and more of related professionals, and a brand-new research field is coming into being. In this article, we introduced some common knowledge of CR, analyzed the choice of disinfectant and carrier polymer in the preparation of CR disinfectant, discussed three kinds of feasible preparation methods, pointed out the advantages and disadvantages of CR disinfectant on disinfection and quality-guarantee of potable water, and predicted the future of CR disinfectant on disinfection and quality-guarantee of potable water.

New of Sulfate Removal for Anaerobic Process Fu Jianfeng *et al* (37)

Abstract : In this article, several methods were studied, summarized and assessed and a new idea has been proposed for eliminating sulfate interference to anaerobic process. This route is composed of reduction of sulfate, sulfide removal by micro-cell electrolysis and anaerobic reaction. The features of this new process are discussed theoretically. Also the existing problems and the counter-measures have been recommended.

Study on Treatment of Concentrated Wastewater of Monosodium Glutamate Production Tao Tao *et al* (39)

Abstract : A microbial flocculant *Purullans* was adopted to treat concentrated wastewater of monosodium glutamate production.