

微波无极紫外光对自来水中微生物的灭活作用*

楼朝刚 夏东升 赵帆 吕继良 曾庆福

(武汉科技学院环境与城市建设学院,湖北 武汉 430073)

摘要 选取大肠杆菌和枯草芽孢杆菌分别代表自来水中易被灭活和不易被灭活的微生物,研究了微波无极紫外光最佳杀菌效果的极限浊度和照射时间。在此条件下,考察了自来水中大肠杆菌和枯草芽孢杆菌杀灭情况,并与普通中压汞灯进行比较。结果表明:最佳照射时间为210 s,微波无极紫外光杀菌率高达99.92%;为了获得最佳的杀菌效果,原水浊度应<8 NTU,杀菌的极限浊度为40 NTU;微波无极紫外光在180 s时,对大肠杆菌的杀菌率达到100%;在300 s时,对枯草芽孢杆菌的杀菌率达到100%,明显高于普通中压汞灯产生的紫外线杀菌效果。

关键词 大肠杆菌 枯草芽孢杆菌 极限浊度 自来水 杀菌效果 无极紫外灯

0 引言

紫外消毒由于不投加化学药剂,不产生副产物,是一种符合环保要求的消毒方法。在欧洲、美国等地已经大规模使用,尤其是发现自来水中存在隐孢子虫以后,美国已将紫外消毒工艺作为自来水消毒的最佳手段写入供水法规中^[1]。

微波无极紫外光是近年来开发的一种新的消毒技术。本试验研究了浊度和照射时间对微波无极紫外光杀菌效果的影响,得出了在试验条件下其最佳杀菌效果的极限浊度和照射时间。并且考察了在此条件下自来水中大肠杆菌和枯草芽孢杆菌杀灭情况,并与普通中压汞灯进行试验比较,旨在为无极紫外灯应用于实际提供参考。

1 试验材料与方法

1.1 试验装置

微波无极紫外消毒反应器(自制)见图1,将1根U形无极灯(体积123 cm³)置于反应器(内径10.6 cm,高16.5 cm,容积1.5 L),放入改造过的微波炉之中,微波炉的输出功率500 W,频率2.45 GHz,考虑到实际工程中水量很大,水温变化较小,因此试验装置加入冷凝系统,通过调节流量,控制反应温度为30℃。

1.2 试验水样

大肠杆菌(GIM1.43, AS1.797)、枯草芽孢杆菌(GIM1.19, AS1.210)由广东省微生物所提供,使用时将这两种菌的营养肉汤培养液,经6 000 r/min的速度离心10 min,弃去上清液,将沉淀物重新溶解于一定量的无菌生理盐水中,配制成一定浓度的混合菌液。浊度物质由高岭土和无菌生理盐水配制而成。

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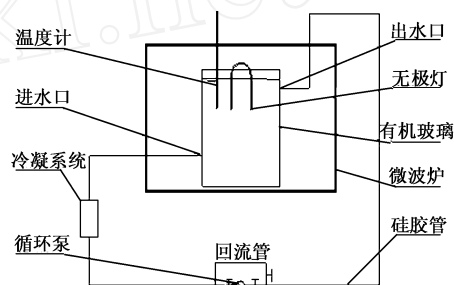


图1 微波无极紫外消毒反应器

1.3 试验方法

自配1 L水样,置于微波无极紫外消毒反应器进行反应,然后进行微生物检测,每次取样均做2次,取其平均值作为本次微生物检测结果。

细菌总数和枯草芽孢杆菌采用平板计数法测定;大肠杆菌采用多管发酵法,在37℃恒温培养箱中培养24 h后计数。

2 试验结果与讨论

2.1 影响微波无极紫外光杀菌效果的因素

在无极灯功率和强度一定的情况下,微波无极紫外光杀菌效果主要受穿透率(即原水的浊度)和照射时间的影响。照射时间越长,杀菌效果越好,但过长的照射时间会造成能源浪费。另外,若水中的浊度过高,紫外线会被大量吸收,影响其穿透率,并通过遮蔽紫外线隐藏细菌,使之具有保护细菌的作用^[2-3]。因此,要使微波无极紫外光具有最佳的杀菌效果,原水的极限浊度和最佳照射时间具有重要的实践指导意义。

2.1.1 最佳照射时间的确定

自配细菌总数为 6.0×10^4 个/mL,照射时间分别按20、50、80、110、140、170、210、360 s,8个时间梯度进行,测定微波无极紫外光出水后的细菌总数,试验结

果见图2。

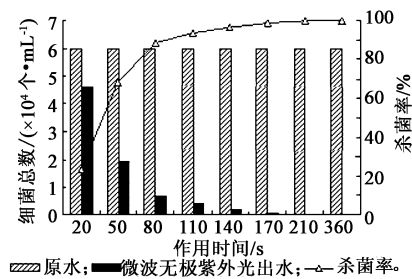


图2 微波无极紫外光在不同照射时间下的杀菌效果

由图2可知,当照射时间为20 s时,出水的细菌总数变化较小。随着照射时间的延长,细菌的杀菌率逐渐升高,当照射时间为170 s时无极紫外光的杀菌率可达到99%,但出水细菌总数仍然达到 10^2 数量级。当照射时间为210 s时,细菌总数为48个/mL,杀菌率为99.92%,出水已符合国家饮用水标准;当照射时间为360 s时,杀菌率最高,达到100%。根据实际工程中自来水出水的细菌总数100个/mL,确定微波无极紫外光的最佳照射时间为210 s。

2.1.2 微波无极紫外光杀菌极限浊度的确定

将浊度分为0.5、1.0、3.0、4.0、6.0、8.0、10.0、12.0、15.0、20.0、25.0、30.0、35.0、40.0、45.0、50.0 NTU, 16个浊度梯度进行试验。试验水样仍为混合菌液,为避免细菌本身所带来的浊度影响,试验中减少细菌个数,增加无菌土量来提高水体浊度,细菌总数为 5.0×10^2 个/mL,照射时间为210 s,试验结果见图3。

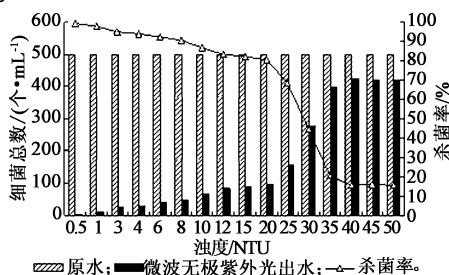


图3 浊度对微波无极紫外光杀菌效果的影响

由图3可知,当原水浊度<8 NTU时,对杀菌效果影响较小,微波无极紫外光的杀菌率保持在90%以上;当浊度>8 NTU时,浊度对杀菌效果影响较大;在浊度为0.5 NTU时,其杀菌率可达99.40%。当原水浊度<20 NTU时,经微波无极紫外光杀菌后的出水都能达国家饮用水标准,出水细菌总数在100个/mL以内。当原水浊度增加时,水中悬浮物对紫外线的吸收作用也逐渐增加,紫外线的杀菌效率急剧降低。原水浊度达到40 NTU时微波无极紫外光杀菌率达到最低

点只有15.6%。当浊度再增加时,其杀菌率变化不大,保持在16%左右,说明即使在穿透率很低的情况下,微波无极紫外光也会保持一定的杀菌率。

综上所述,确定微波无极紫外光杀菌的极限浊度为40 NTU,为了获得最佳的杀菌效率,原水浊度应<8 NTU。

2.2 微波无极紫外光和普通紫外线对不同细菌杀灭效果的研究

分别配置总数为 8.0×10^3 个/mL的大肠杆菌和枯草芽孢杆菌,浊度为8 NTU的原水。通过调节流量,控制反应温度30℃,照射时间分别按30、60、90、120、150、180、210、240、270、300、330、360 s, 12个时间梯度进行,测定无极紫外光和普通紫外线出水后的残留个数。

图4、图5为微波无极紫外光和普通紫外线对大肠杆菌杀灭情况的比较。

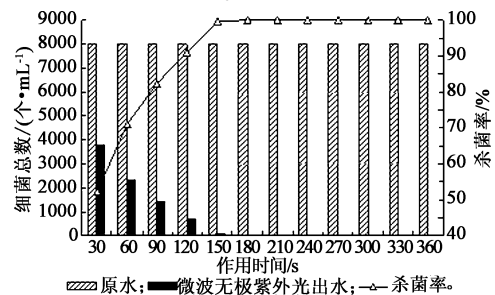


图4 微波无极紫外光对大肠杆菌杀灭效果

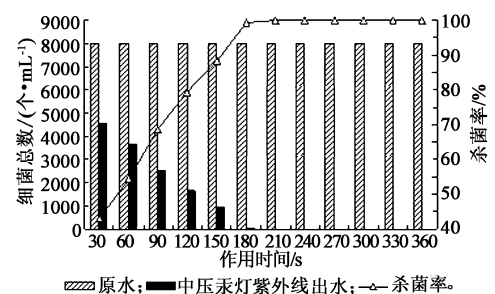


图5 中压汞灯产生的紫外线对大肠杆菌杀灭效果

从图4和图5可知,微波无极紫外光和中压汞灯产生紫外线在较短照射时间下就可达到较好的杀菌效果。当照射时间为150 s时,无极紫外光对大肠杆菌的杀菌率已达到99%以上,180 s时达到100%;而中压汞灯对大肠杆菌的杀菌率达到99%以上所需时间为180 s,达到100%所需时间为210 s。这一试验结果充分反映了2种灯产生紫外线对大肠杆菌的高效杀灭作用,同时也说明不仅对于饮用水,而且在生活污水及医院废水等对大肠杆菌指标要求非常严格的水处理工程中,紫外线杀菌仍是一种安全、可靠、高

效的手段。

图6、图7为微波无极紫外光和普通紫外线对枯草芽孢杆菌杀灭情况的比较。

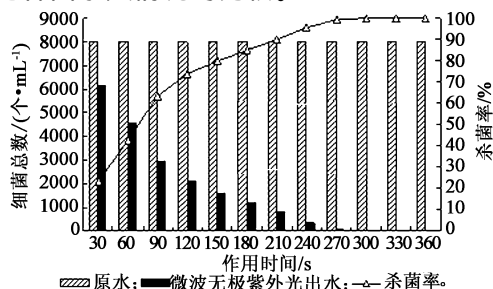


图6 微波无极紫外光对枯草芽孢杆菌杀灭效果

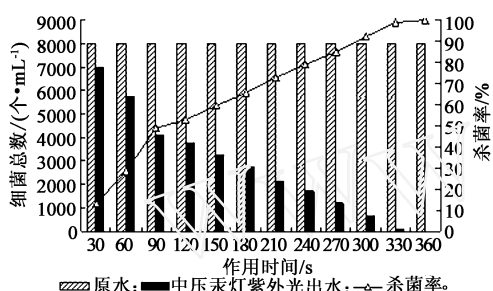


图7 中压汞灯产生的紫外线对枯草芽孢杆菌杀灭效果

从图6和图7可知,当照射时间为270 s时,微波无极紫外光对枯草芽孢杆菌的杀菌率已达98%以上,可使出水达到饮用水标准,此时大肠杆菌已经被完全去除,而中压汞灯对枯草芽孢杆菌的杀菌率达到饮用水标准所需时间为330 s。枯草芽孢杆菌对紫外线具有较高的抗性,这与枯草芽孢杆菌本身的特性有关,紫外线对其的杀灭效果要低于大肠杆菌,但通过增加紫外线照射时间,可以提高对枯草芽孢杆菌的杀菌率。

3 结论

(1)在无极灯功率和强度一定的条件下,最佳的照射时间为210 s时,微波无极紫外光的杀菌率高达99.92%。

(2)浊度对微波无极紫外光杀菌效果有一定影响,在浊度<8 NTU时,对其杀菌效果影响较小;而其杀菌的极限浊度为40 NTU。

(3)微波无极紫外光照射180 s后,对大肠杆菌杀菌率达到100%,在300 s时对枯草芽孢杆菌杀菌率也达到100%,明显高于普通中压汞灯产生的紫外线杀菌效果。因此可以很好地保证自来水的微生物学安全性。

(4)微波无极紫外光不仅在饮用水处理方面具有高效的杀菌效果,而且在废水处理方面也有很好的前景。

参考文献

- [1] Frederick W, Pontius. Regulations in 2000 and beyond. JAWWA, 2000, 92(3): 40-53
- [2] Loge J Frank, Emerick W R, et al. Factors influencing ultraviolet disinfection performance part I: Light penetration to wastewater particles. Water Environ. Res., 1999, 71(3): 377-381
- [3] Emerick W R, Loge J Frank, et al. Factors influencing ultraviolet disinfection performance part II: Light penetration to wastewater particles. Water Environ. Res., 1999, 71(6): 1178-1187

作者通信处 楼朝刚 430073 武汉市武昌区纺织路1路南湖校区
260信箱 武汉科技学院环境与城市建设学院
E-mail lcg93@163.com

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倡导绿色奥运理念——我国引进先进废气脱硫设备

为倡导北京2008年奥运会提出的绿色奥运环保理念,进一步保护大气环境,我国今年将引进先进的废气脱硫设备以用于各地发电厂的废气脱硫。

今年引进的170台最先进的废气脱硫泵设备,由全球重要泵阀制造厂家之一德国KSB集团提供。这些现代化的KWPK和KWPKC型废气脱硫洗涤泵设备,将安装在包括新建的泰州发电厂、营口发电厂、广安发电厂三期、大连庄河发电厂等热电厂中。

据了解,KSB集团对这类泵设备的制造材料,做出了进一步的改进,以适应输送带有极高研磨性和腐蚀性的重质碳酸钙液流混合物的特点,加强泵设备接触表面和叶轮的抗腐蚀抗磨损性能。

据悉,以往用于输送带有腐蚀性和研磨性液流的泵设备,都是用代价昂贵的特殊合金制造的。KSB集团近年来成功地研制出了一种具有极高抗磨损抗腐蚀性的材料,即“陶瓷聚乙烯碳化硅(Ceramik Polysic)”,并将这种新材料用于废气脱硫洗涤泵的内部表面涂层,而泵的叶轮则是由一种被称为NORIDUR的高技术合金材料制成,大大提高了这些泵设备的可靠性。

摘自“市场报”

POWDER ACTIVATED CARBON-MEMBRANE BIOREACTOR FOR TREATMENT OF MUNICIPAL WASTEWATER

Pei Liang Yao Binghua(7)

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 °C ,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 Ministry 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.

Key words powder activated carbon membrane bioreactor domestic wastewater

INACTIVATION OF MICROBE IN RUNNING WATER USING MICROWAVE ELECTRODELESS ULTRAVIOLET LIGHT

Lou Chaogang Xia Dongsheng Zhao Fan et al(10)

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.

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

STUDY ON THE BULKING SLUDGE IN THE PROCESS OF SHORT RANGE NITRIFICATION OF HIGH AMMONIA WASTEWATER

Hou Qiaoling Wen Yibo Li Linbao et al(13)

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.

Key words short-range nitrification sludge bulking A/O process

TREATMENT OF WASTEWATER CONTAINING Cr() BY PVA MICRO-BALL ENTRAPPED IRON POWDER AND ACTIVATE CARBON

Huang Yi(15)

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() was investigated. The results showed that the removal rate of Cr() 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.

Key words entrapping method iron powder activate carbon Cr()

TREATMENT OF NEOPRENE WASTEWATER WITH MICROELECTROLYSIS AND THREE-UNIT BIOCHEMISTRY PROCESS

Zhang Sheng Xu Lirong Zhu Jianrong et al(18)

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.

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

DEGRADATION OF SAFRANINE T BY THE TECHNOLOGY OF CATALYTIC OXIDATION

Wang Lijuan Huang Jiguo Dong Lili et al(20)

Abstract The technology of catalytic oxidation is studied for degrading safranin T. The self-made polyoxometalate $\text{Zn}_{1.5}\text{PW}_{12}\text{O}_{40}$ nanotube is used as the catalyst and dioxygen is used as the oxidizer. The results show : $\text{Zn}_{1.5}\text{PW}_{12}\text{O}_{40}$ is suitable for catalyst ,with the structure of the $\text{Zn}_{1.5}\text{PW}_{12}\text{O}_{40}$ being hollowed ,the type of the $\text{Zn}_{1.5}\text{PW}_{12}\text{O}_{40}$ being affiliated to the type of heteropoly acids ,and the scale of the $\text{Zn}_{1.5}\text{PW}_{12}\text{O}_{40}$ 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 $\mu\text{g/h}$;the activity and stability are both high ,and when the circulation times are four ,the degradation is still 65 %.

Key words nanotube dioxygen safranin T degradation rate circulation