

# 流化式生物膜法处理含酚废水的效能\*

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**摘要** 通过动态试验, 对自制载体的流化式生物膜法处理含酚废水的效能进行了重点考察。结果表明, 当 COD 容积负荷达  $4.0 \text{ kg}/(\text{m}^3 \cdot \text{d})$  时, COD 的去除率平均在 80% 以上, 酚去除率在 90%—100% 之间, 出水 COD 和酚可达到排放标准。自制的载体挂膜快, 膜厚适宜, 易于流化。本处理系统抗冲击负荷能力强, 具有较高的脱氢酶活性。

**关键词** 流化, 生物膜, 废水处理, 含酚废水, 载体。

流化式生物膜法技术上比较成功的是日本的 CB 载体和德国的多孔塑料<sup>[1, 2]</sup>, 国内尚未见有这方面的研究报告。以多孔塑料为载体的 LINPOR 工艺已在一些国家有所应用, 其结果表明, 该工艺不仅能去除废水中的碳类化合物, 还可在低碳、高氨时脱氮。该工艺特别适合于活性污泥法污水处理厂的改建和扩建, 在基本不增加处理设施的情况下, 可使其处理能力翻一番。但是这 2 种载体生产工艺复杂, 成品价格昂贵。本着高效、经济的原则, 笔者用自行研制的多孔泡沫塑料为载体, 进行了含酚废水的流化式生物膜法处理研究, 获得了令人满意的结果。

## 1 试验装置与方法

所用反应器为有机玻璃制成, 3 套对照运行, 规格相同。每个反应器总体积均为 12.45 L, 其中反应区为 10.89 L, 沉淀分离区为 1.56 L。每套反应器内均设一穿孔管和一多孔曝气头, 利用压缩空气进行鼓风曝气。试验工艺流程如图 1 所示。

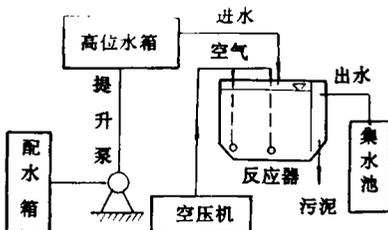


图 1 试验装置流程图

试验中对 2 种自行研制的生物载体进行了研究, 为区别起见, 分别定名为 A 型和 B 型。A 型材料选用 2 种规格, 分别为边长 10 mm 和 7 mm 的立方块。B 型材料

选用一种规格, 为边长 5 mm 的立方块。3 套反应器的载体投加量均为 3.6 L (堆积体积), 投料比为 33%。

试验所用废水为人工配制的苯酚废水, 并按  $\text{BOD}_5 : \text{N} : \text{P} = 100 : 5 : 1$  的比例补充了氮和磷, 试验在室温、 $\text{pH} 6.5-7.0$ 、进水 COD 为 500—1000 mg/L、进水酚浓度为 202—417 mg/L 条件下运行。

试验采用长春市某煤气废水处理站的回流污泥作为接种污泥。先将多孔载体、接种污泥置于反应器中, 用 COD 为 500 mg/L 左右的人工配制含酚废水进行小流量连续进水方式的曝气培养挂膜, 初期进水流量为 15 L/d。如此进行 1 周后, 逐渐加大流量。试验中发现, 进水 1 周后, 载体在停止曝气时即可全部沉下, 启动 2 周后, 载体表面肉眼已不见孔隙, 其表面生物膜光滑平整, 微生物群体附着牢固, COD 去除率可达 80% 以上, 表明挂膜过程基本完成。

研究过程中主要检测指标: COD、 $\text{BOD}_5$ 、苯酚、载体生物膜厚度、载体生物量、载体生物膜脱氢酶活性和生物膜显微镜检。

## 2 结果与讨论

### 2.1 COD、 $\text{BOD}_5$ 的降解与去除率

动态试验装置于 1994-03-30 开始启动, 载体挂膜较快, 至 04-07, 当进水 COD 浓度达到 500 mg/L 时, 其去除率已达 80% 以上, 试验装置运行初期的 COD 测

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定结果如表 2 所示。

COD 值及其去除率如表 3 所示。各反应器在正常运行

试验装置在正常运行期间(HRT 为 6 h)的进水 期的 COD 进出水变化曲线示于图 2。

表 2 运行初期的 COD 去除率

日期	进水 COD (mg/L)	1 <sup>#</sup>		2 <sup>#</sup>		3 <sup>#</sup>	
		出水 COD (mg/L)	去除率 (%)	出水 COD (mg/L)	去除率 (%)	出水 COD (mg/L)	去除率 (%)
1994-04-07	501	41	91.82	33	93.41		
1994-04-11	600			32	94.67	60	90
1994-04-17	534	96	82.02	87	83.71	90	83.15

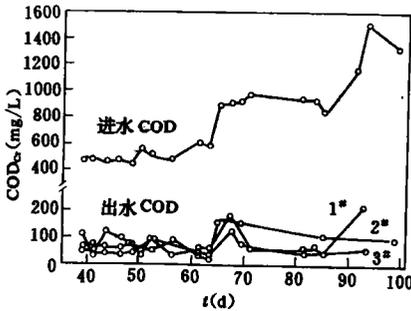


图 2 各反应器进出水 COD 变化曲线

表 3 正常运行期的 COD 去除率

日 期	进水 COD (mg/L)	各反应器 COD 去除率(%)		
		1 <sup>#</sup>	2 <sup>#</sup>	3 <sup>#</sup>
1994-05-09	497	86.7	89.3	76.7
1994-05-11	492	84.8	89.8	93.1
1994-05-13	448	85.3	73.7	90.4
1994-05-16	471	87.5	79.1	91.3
1994-05-18	450	83.1	84.0	89.3
1994-05-20	561	94.3		
1994-05-22	510	81.6	89.0	80.8
1994-05-26	480	93.8	80.8	73.0
1994-05-31	615	90.2	94.3	92.2
1994-06-02	594	90.1	96.6	94.4
1994-06-04	911	69.7	81.9	97.8
1994-06-06	923	80.3	79.0	85.5
1994-06-08	917		82.6	91.1
1994-06-10	994	93.4	82.6	
1994-06-20	943	94.0		93.6
1994-06-22	941	93.4		82.4
1994-06-24	834	95.1	86.5	
1994-06-30	1167		85.7	82.1
1994-07-02	1512	85.3		95.7
1994-07-08	1314		92.0	

由表 3 和图 2 可见,各试验系统对含酚废水的 COD 去除效果均较好,出水水质可达到排放标准。特别是当进水 COD 浓度提高至 1000 mg/L 时,其去除效果仍很理想。相对而言,在进水浓度较高的条件下,2<sup>#</sup>和 3<sup>#</sup>反应器的去除率要优于 1<sup>#</sup>反应器,它们对高负荷

冲击的耐受力较强,而 1<sup>#</sup>反应器在运行 65 d 时,由于冲击负荷影响,COD 去除率仅为 69.7%,2<sup>#</sup>和 3<sup>#</sup>却保持在 80%以上。究其原因,可能是由于载体粒径不同,造成了生物膜总表面积的大小差异,从而影响到载体的生物量,导致了微生物活性方面的差异。

流化式生物膜反应器对 BOD<sub>5</sub> 的去除效果较好,当反应器进水 BOD<sub>5</sub> 为 500 mg/L 时,出水 BOD<sub>5</sub> 为 38 mg/L,其去除率达到 92.4%。

## 2.2 对苯酚的生物降解及去除效果

含酚废水能够抑制微生物的生长繁殖,但微生物通过培养驯化以后,可以适应高浓度酚的毒性环境,并利用酚类物质作为自身生长繁殖的碳源和能源,从而使含酚废水得以净化。各反应器对酚的去除率如图 3 所示。

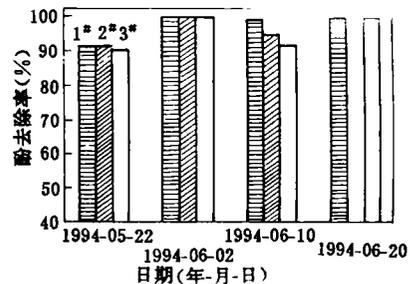


图 3 各反应器对苯酚的去除率

图 3 表明,各反应器对苯酚的去除率都在 90%以上,特别是在运行 63 d 和 81 d 时,苯酚去除率达 100%。1994-06-04 前,试验装置进水苯酚浓度在 202.27—249.27 mg/L 内,当 1994-06-04 加大进水苯酚浓度为 395.72—417.12 mg/L 后,首先是 1<sup>#</sup>反应器受冲击负荷影响,去除率明显下降至 76.54%,经 3 d 左右的适应,于 1994-06-08 苯酚去除率回升,至 1994-06-10 达到 99.76%。而 2<sup>#</sup>和 3<sup>#</sup>反应器受冲击负荷影响,其去除率在 1994-06-06 为 75.21%和 72.45%,至 1994-06-10 分别回升到 93.75%和 90.84%。

由表 4 可以看出,虽然 2<sup>#</sup>和 3<sup>#</sup>反应器对酚的去除

率低于 1<sup>#</sup> 反应器,但如果从进水酚的容积负荷和去除负荷上看,2<sup>#</sup> 和 3<sup>#</sup> 反应器均明显高于 1<sup>#</sup> 反应器,说明实际上 2<sup>#</sup> 和 3<sup>#</sup> 反应器对酚的去除效能均优于 1<sup>#</sup> 反

器,这可能与各反应器中载体所附着的生化膜量及其生化活性的高低有关。

在流化式生物膜法试验装置中,大多数有效生物量

表 4 各反应器对酚的去除效能比较

反应器	进水酚浓度 (mg/L)	去除率 (%)	进水流量 (L/h)	酚容积负荷 [kg/(m <sup>3</sup> ·d)]	酚去除负荷 [kg/(m <sup>3</sup> ·d)]
1 <sup>#</sup>	417.12	99.8	1.604	1.475	1.472
2 <sup>#</sup>	417.12	93.8	2.042	1.877	1.761
3 <sup>#</sup>	417.12	90.8	2.283	2.099	1.906

均以附着形式生长,它们对有机物的去除效能往往与载体投加量多少有关。本试验各反应器均投加载体 3.6 L, 按此计算,各反应器去除酚的质量分别为: 1<sup>#</sup>, 4.452 kg/(m<sup>3</sup>·d); 2<sup>#</sup>, 5.323 kg/(m<sup>3</sup>·d); 3<sup>#</sup>, 5.765 kg/(m<sup>3</sup>·d)。此结果可为实际工程设计提供参考。

### 2.3 COD 负荷与去除率的关系

各反应器 COD 负荷与去除率的关系如图 4 所示。由图 4 可见, COD 去除率随 COD 负荷的增加而降低,但曲线下降较为平缓,说明各反应器都具有较强的抗冲击负荷能力,当 COD 负荷达 4.0 kg/(m<sup>3</sup>·d) 时, 仍可获得 80% 以上的去除率。

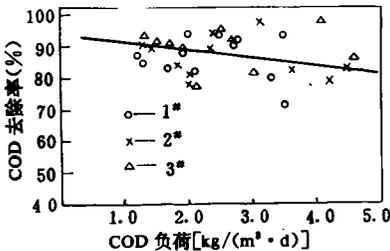


图 4 各反应器 COD 负荷与去除率的关系

### 2.4 载体的生化特性

在试验过程中,通过体积-面积折算法,对各反应器载体的生物膜厚度进行了测定。结果表明,载体表面的生物膜平均厚度为 117.3 μm。据文献介绍,生物膜厚度为 50—150 μm 时,废水中碳源的利用速率呈直线上升,而在 150—250 μm 时,该速率提高缓慢<sup>[3]</sup>。可见,试验的良好效果与载体生物膜较适宜的厚度有关。

对载体进行的生物膜镜检结果表明,微生物种类齐全。有细菌、放线菌、霉菌、球衣细菌、原生动物和小型后生动物等。在载体表面主要由丝状菌(放线菌、球衣细菌等)构成的生物膜网络结构,细菌等以菌胶团的形式填充其内。对本试验来说,之所以能够在较高负荷条件下去除大量有机物,可能与载体生物膜内有大量丝状菌存在有关,而且由于这些丝状菌大都附着在载体上,因此不会产生污泥膨胀问题。

试验过程中采用常温萃取测定法,对载体生物膜的 TTC-脱氢酶活性进行了测定,结果如表 5 所示。

表 5 载体生物膜 TTC-脱氢酶活性

反应器	比脱氢酶活性 [mg TF/ (g 膜·h)]	总脱氢酶活性 (mg TF/h)	折算酶活性 [mg TF/ (L·h)]
1 <sup>#</sup>	310.0	2173.8	199.6
2 <sup>#</sup>	225.2	4733.6	434.7
3 <sup>#</sup>	199.8	5557.3	510.3

由表 5 可见,各反应器的脱氢酶活性均处于较高状态,虽然从比脱氢酶活性看 1<sup>#</sup> 反应器较高,但由于各反应器生物膜量的差异,经计算的总脱氢酶活性则是 1<sup>#</sup> 反应器最低,3<sup>#</sup> 反应器最高。按反应器容积进行脱氢酶活性折算,也是按 1<sup>#</sup>、2<sup>#</sup>、3<sup>#</sup> 反应器顺序增高。

就反应器对酚的去除负荷看,总脱氢酶活性或折算的脱氢酶活性与其呈良好的对应关系。对 4 组相关数据的回归分析表明,脱氢酶活性与酚去除负荷之间具有显著的相关性(图 5)。

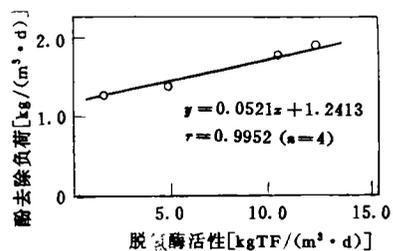


图 5 脱氢酶活性与酚去除负荷的关系

不难看出,各反应器之所以对酚的去除负荷不同,主要是它们之间的脱氢酶活性总量的不同所致,脱氢酶活性愈高,其酚的去除负荷愈大,这是反应器去除有机污染物的生化基础。

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季低温冻害,提高北方地区农作物产量。

## 2.2 不利的影响

CO<sub>2</sub> 浓度增加,虽然可以促使作物提高水分利用率,但气温升高,会使作物呼吸加快,消耗增加,导致干物质净积累减少,从而影响作物产量。同时,气候的变化,造成降水状况及作物生长季节的改变,可能严重影响粮食生产的稳定性。再者,气温升高后,使雨涝、干旱和高温等气象灾害发生率增大,也使农业病、虫害频繁和猖獗,有时还会诱发某些新的病、虫害发生。这些都不利于未来农业的发展。

高素华通过气象-产量预测模式对我国今后冬小麦、玉米、水稻等主要粮食作物产量的变化进行的计算表明,CO<sub>2</sub> 浓度加倍后,华北地区冬小麦减产,西北地区冬小麦增产,水稻的主产区将增产,华北、西北、西南和东北地区玉米增产,而华南,长江中下游地区玉米减产<sup>[16]</sup>。由此说明,气候变化对农业的影响是多方面的,对比需作更加深入的研究。

## 3 控制土壤排放温室气体的对策

(1) 抑制甲烷的排放可以通过对水田进行不排放的水浆管理,使土壤不产生强还原状态,甲烷的产生便可以大幅度降低。日本的研究数据表明,通过水浆管理,改善有机物的施用方法,并且停止施用水稻秸还田,可以抑制稻田甲烷的产生。

(2) 施肥会影响甲烷的排放与消耗。Schutz 等对水稻施尿素和硫酸铵时发现 CH<sub>4</sub> 的排放量降低。王明星等对水稻施用硫酸钾肥时也发现 CH<sub>4</sub> 排放量低于不施肥田 HC<sub>4</sub> 排放量<sup>[9]</sup>。这可能是因为肥料中的 SO<sub>4</sub><sup>2-</sup> 能刺激土壤中硫酸盐还原菌的增长,这种菌与 CH<sub>4</sub> 菌对它们共同的被用物乙酸盐进行争夺,抑制了 CH<sub>4</sub> 的产生,SO<sub>4</sub><sup>2-</sup> 还原菌可能还参与 CH<sub>4</sub> 的再氧化反应,但此

情况尚需进一步研究才能确定,不过施肥深度与 CH<sub>4</sub> 排放确有关系。表层施肥会增加甲烷排放而深度施肥则可以降低甲烷的排放。

(3) 耕地中发生的 N<sub>2</sub>O 是施氮肥的土壤因硝化过程而形成的。如果使用硝化抑制剂,可以较好地抑制 N<sub>2</sub>O 的发生。使用缓效性肥料也可以抑制 N<sub>2</sub>O 的发生,减少 N<sub>2</sub>O 的排放,还可以通过调节氮肥施用时间,少量频施氮肥,采用包衣氮肥,叶面喷施氮肥,氮肥和有机肥混合施用以及使用尿素抑制剂等方法。对于水浇地,大量、少次浇水也会导致较少的 N<sub>2</sub>O 排放。

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## 3 结 论

(1) 自制的多孔泡沫塑料载体可在短时间内完成挂膜和流化,挂膜后的载体比重与活性污泥相近,易于流化和固液分离,所需流化动力小,抗冲击负荷能力强;载体生产工艺简单,价格低廉,使用寿命较长,特别适用于对现有活性污泥法污水处理厂的改造和扩建,也适用于中小水量工业废水的生物处理。

(2) 试验装置的正常运行期,各反应器对 COD 的去除率平均在 80%以上,苯酚的去除率为 90%—

100%,出水 COD 和酚可达到排放标准。

(3) 各反应器载体表面生物膜光滑平整,附着牢固,平均厚度为 117.3 μm,膜厚适宜;载体生物膜微生物种类齐全,且主要由丝状菌构成。测定结果表明,载体上的生物膜具有较高的脱氢酶活性,并与酚去除负荷之间存在良好的相关性。

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protection. In addition, the environmental drag were used to explain the model's meaning as well as to discuss the measurement of the environmental drag.

**Key words:** social rate of return, private rate of return, elasticity of elasticity, environmental discount rate, environmental investment, environmental improvement, environmental drag.

**The Growth and Purification Function of *Eichhornia crassipes* Solms in Oil-refinery Wastewater.** Tang Shuyou et al. (Institute of Botany, Jiangsu Province and Chinese Academy of Sciences, Nanjing 210014); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 44–46

The growth of *Eichhornia crassipes* Solms in oil-refinery wastewater has been described in this paper. An influence of COD, a comprehensive index of the pollutant concentration in the wastewater, on the growth of *Eichhornia crassipes* Solms was quantitatively studied. It was found that an optimum working condition for treating oil-refinery wastewater by *Eichhornia crassipes* Solms eco-engineering is established as follows: 65 mg/L <[COD]<131 mg/L; and 262.6 mg/L of COD at effective critical point.

**Key words:** *Eichhornia crassipes*, oil-refinery wastewater, purification.

**Study on Method of Sister Chromatid Exchange in *Vicia faba* to Detect Environment Mutagen.** Kong Zhiming et al. (Dept. of Environ. Sci. and Eng., Nanjing University, Nanjing 210093); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 47–49

The experimental conditions of the Brdu-Feulgen method of SCE in *Vicia faba* root which include the content of Brdu, labelling time of Brdu, the impacts on SCE of the content of hydrochloric acid and time and temperature for hydrolysis were studied and discussed in this paper. The best experiment conditions and procedure, which overcome the short-comings of FPG method that is complicated in procedure and, hence, difficult to be popularized, were obtained. In addition, such method was compared with other genotoxicology method in order to probe into the possibility of utilizing such technology to detect environment mutagen.

**Key words:** *Vicia faba*, SCE, Brdu-Feulgen method.

**A Pulse-feed Upflow Anaerobic Sludge Blanket Reactor.** Su Yumin et al. (Dep. of Environ. Eng., Taiyuan Univeristy of Technology, Taiyuan 030024); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 50–53

The key parts of Upflow Anaerobic Sludge Blanket Reactor are gas-solids separator and feed system. The goals of this research, in which a conventional continuous feed system was replaced by an intermittent pulse-feed one, are to provide gently hydraulic mixing, to promote hydraulic selection, and to improve the contact between substrate and microorganisms. Pulse-feed method can raise the orgaine load rate as high as 27.5 gCOD/(L·d), reduce HRT to nearly 3 hrs, and quickly develop granulated sludge in 47 days. It can not cause shock load and intermediates accumulation, as every pulse only releases a small amount of wastewater (1/56 reactor volume), which can not raise the substrate concentration in whole reactor. The pulse-feed also can not cause sever wash-out of sludge, because pulse-feed mixing can effectively sepa-

rate sludge flocs and entrapped gas bubbles, and hence improve sludge settleability. The advantages of enrichment of *methanosarcina* species in the process of granulation are also discussed. At high load rate, *methanosarcina* species do appear in clumps on the granules.

**Key words:** anaerobic digestion, UASB, pulse-feed, mixing, granulation, *methanosarcina* species.

**Study on Biological Pretreatment Method-bio-ceramic Reactor Treating Micro-pollution Source Water at Low Temperature and Low Turbidity.** Hu Jiangyong et al. (Dept. of Environ. Eng., Tsinghua Univ., Beijing 100084); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 54–56

One of biological pretreatment methods-bio-ceramic reactor (BCR) was used to treat a typical source water with micro-pollution at low temperature and low turbidity. By means of in-situ experiments with the bio-ceramic reactor, it was found that: the organic matter (OC or COD), ammonia, SS in the source water could be removed about 20%–30%, 60%–70% and 80%, respectively. Removl efficiency could be reduced at low temperature. Low turbidity and high concentration of organics in the source water would be beneficial to BCR. In general, BCR would be a powerful way to purificate this kind of source water.

**Key words:** micro-pollution, source water, low temperature, low turbidity, organics, bio-ceramic pretreatment process.

**Studies on the Leaching and Species of Aluminum in Soil.** Huang Yanchu and Qu Changling (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 57–59

The leaching and chemical forms of aluminum in soil by sequential fraction procedure were studied. Solutions used sequentially to extract Al are in order of 1 mol/L KCl, 1 mol/L NH<sub>4</sub>Ac, 1 mol/L HCl and 0.5 mol/L NaOH. The spectrophotometric determination of leaching Al was performed with Eriochrom Cyamine RC. It has been found that the type of soil and the amounts of organic materials and total Al in soil have a significant effect on the amount of leaching Al. A certain amount of exchangeable Al can be leached from acid soil with 1 mol/L KCl extractant, however, it can not be leached from alkaline soil. The leaching Al extracted with 0.5 mol/L NaOH is correlated at a high level of significance with the total Al in soil.

**Key words:** soil, leaching aluminum, chemical form.

**Efficiency of Fluidized Biofilm Method for Treating Phenolic Wastewater.** Yin Jun et al. (Jilin Architectural and Civil Eng. Institute, Changchun 130021); *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 60–62

A dynamic experiment was conducted to examine the efficiency of the fluidized biofilm method with home-made carrier for treating phenolic wastewater. The experimental results have shown that COD and phenol were removed on an average over 80% and 90%–100%, respectively, while COD volumetric loading is 4.0 kg/(m<sup>3</sup>·d), and the final concentrations of COD and phenol in the effluent can meet Chinese Standard of Wastewater discharge permission. The biofilm can adhere quickly to the home-made carrier and the thickness of biofilm is suitable

to fluidize easily in the reactor. The treatment system can resist the loading fluctuation and possess high dehydrogenase activity.

**Key words:** fluidized, biofilm, treatment, phenolic wastewater, carrier.

**Development of a New Type Dispelling Smoke Silencer of Diesel Engine.** Zeng Defang (Turbine College, Wuhan University of Science and Technology of Traffic, Wuhan 430063); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 63–64

This paper introduces a kind of method of making a new type dispelling smoke silencer of diesel engine. The method includes adding a kind of solution which can clean the end gas of diesel engine to the bottom of the old silencer of diesel engine. The end gas of diesel engine can be both cleaned and silenced by passing through the dispelling smoke silencer. A comparison of new silencer with the old one under the same condition on the type 135 diesel engine has shown that the dispelling smoke silencer can reduce 80% of smoke and 14.1% of noise (from 99 dB to 85 dB).

**Key words:** diesel engine, dispelling smoke silencer, noise, end gas of diesel engine.

**A Study on Treatment of Traditional Chinese Medicine Wastewater by SBR Process.** Han Xiangkui et al. (Jilin Architectural and Civil Engineering Institute, Changchun 130021); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 65–67

Experimental results showed that at the concentration range of COD in influent from 1000 mg/L to 2500 mg/L, effluent COD can be reduced to less than 250 mg/L, BOD<sub>5</sub> and SS less than 100 mg/L. These levels conform to discharge permission standard of pharmaceutical wastewater. The variation behavior of dehydrogenase during the process of aeration is also discussed in this paper.

**Key words:** SBR process, wastewater treatment, traditional Chinese medicine wastewater.

**Dioxins in Stack Ash from PCBs Incinerator.** Ke Jiang et al. (Research Center for Eco-environmental Sciences, CAS, Beijing 100085); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 68–71

The PCDD/Fs in stack ash from a experimental incinerator for destruction of PCBs waste have been determined by <sup>13</sup>C isotope HRGC/HRMS method. Seventeen 2, 3, 7, 8-substituted toxic dioxins congeners were quantitatively measured. The TEQ value of the stack ash is 47.2 ng/g.

**Key words:** stack ash, PCBs, dioxins.

**Releasing of PAHs from Coal-ash in Seawater.** Fu Yunna and Liu Yiwen (Inst. of Mar. Environ. Prot., SOA, Dalian 116023); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 72–74

Releasing of PAHs from coal-ash in seawater was determined by fluorescence spectrophotometer. The amounts of PAHs from coal-ash soaked before and after in seawater were also analysed by reversed high performance liquid chromatography with UV or fluorescence detectors. The results show that the static state releasing and adsorption

of PAHs from coal-ash in seawater are reversible, releasing of PAHs is pool, and PAHs in the fine coal-ash dumped into sea from heat and power plant have little effect to the marine environment.

**Key words:** coal-ash, PAHs, releasing, seawater.

**Spectrophotometric Determination of Anionic Surfactants in Water with Bromocresol Green and Cetylpyridinium Bromide.** Wang Yongsheng et al. (Hengyang Medical College, Hengyang 421001); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 75–77

In this paper a spectrophotometric method has been developed for the determination of anionic surfactants in water with bromocresol green (BCG) and cetylpyridinium bromide (CPB). Sodium dodecylbenzenesulfonate (SDBS) and sodium dodecylsulfate (SDS) were determined at 614 nm and pH range of 5.5–9.0. In the concentration range of 0–80 μg/10 ml for SDBS and 0–75 μg/10 ml for SDS, both of them obey Beer's law in the presence of 86 μg CPB. The apparent molar absorptivities are 2.9 × 10<sup>4</sup> L·mol<sup>-1</sup>·cm<sup>-1</sup> for SDBS and 3.1 × 10<sup>4</sup> L·mol<sup>-1</sup>·cm<sup>-1</sup> for SDS. The proposed method has been applied to the determination of anionic surfactants in river water and wastewater. The average recovery of environmental water samples was 99.3% and the relative standard deviation was less than 3.0%.

**Key words:** anionic surfactants, bromocresol green, cetylpyridinium bromide, spectrophotometry.

**Photometric Determinations of Nickel and Copper in Wastewater by Reversed Flow Injection Analysis.** Wang Peng et al. (Department of Applied Chemistry, Harbin Institute of Technology, 150006); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 78–79

The new wastewater monitoring system by use of reversed flow injection spectrophotometry has been developed with injection of different reagents to produce similar color compounds by chemical reactions. The system has been used to simultaneous determination of nickel and copper in wastewater. The detection frequency of the method is 60 samples h<sup>-1</sup>, the minimum detection limits are 0.03 μg Ni ml<sup>-1</sup> and 0.04 μg Cu ml<sup>-1</sup> respectively.

**Key words:** environmental monitoring, flow injection analysis, nickel, copper.

**Acidification Models and Their Application to the Determination of Critical Load for Acid Deposition.** Xie Shaodong et al. (Dept. of Environ. Eng., Tsinghua Univ., Beijing 100084); *Chin. J. Environ. Sci.*, 17(1), 1996, pp. 80–84

This paper briefly discusses different models developed abroad in the study of precipitation effects to predict the long-term effects of acid deposition on soil, surface water, ground water and lakes in the past ten years. The basic methods to establish these models and the principles to apply them to the determination of critical load for acid deposition are presented based on through comparisons and analyses.

**Key words:** acidification model, critical load, acid deposition, acid rain.