邯郸市 SO_2 排放总量控制研究

方 栋 王晓东 高翔霞

（清华大学核能技术研究院，北京 100084） （邯郸市环保局， 056002）

摘要 本研究以 SO_2 长期日平均浓度为控制标准，将邯郸市区划分为工业区、文化区、居住区 3 个功能区；利用生成城市大气污染传递函数矩阵和分担率的 LEECM-Ⅱ通用程序评价邯郸市大气污染现状，在此基础上进行了大气污染物 SO_2 排放总量控制研究。给出了邯郸市的基础削减量、平权削减量、优化削减量；分析了污染治理的投资成本。研究表明 LEECM-Ⅱ程序为大气污染总量控制提供了一个方便实用的计算工具，便于中小城市推广总量控制工作。

关键词 大气污染，SO_2 排放总量控制，环境管理。

单纯的控制排放浓度既不能阻止污染源密集区的形成、也不能保证大气质量的改善。若干排放浓度达标的污染源叠加同样会使大气污染超标。大气污染物排放总量控制是在环境质量标准的控制之下，根据当地的气象条件、污染源的分布及排放方式制定允许排放总量，并合理地分配到每一个污染源，以保证控制区内大气环境质量达到预定的目标。

1 功能区划分和目标

邯郸市是我国北方一个新兴的中等工业城市，位于邯郸市远郊的峰峰矿区是我国十大煤炭生产基地之一。邯郸市区位于华北平原的边缘。建成区 47km²，人口约 60 万。市区年耗煤量为 950 万 t，其中工业用煤占 75%，民用煤占 15%。城市以煤为主要能源，城市的大气环境表现为典型的煤烟型污染。1990 年邯郸市区排放废气 5.3×10^6 万 m³，排放 SO_2 8.9 万 t，烟尘 7.2 万 t。根据监测，1990 年邯郸市大气中 SO_2 年日平均浓度为 0.097mg/m³，超过国家二级质量标准 0.62 倍，TSP 日平均浓度 0.90mg/m³，超过国家三级标准 0.8 倍。

为控制大气污染改善环境，本工作选择大气污染排放总量控制区为 56km²。按邯郸市区内现有布局将建成区划分为 3 类功能区：①工业区；②文化区；③居住区，（图 1）。并建议 3 个功能区分别执行国家相应标准。以 SO_2 为例，工业区执行国家三级标准；文化区与居住区执行国家二级标准（计算中取 SO_2 冬季日平均浓度的二级标准为 0.06mg/m³，三级标准为 0.1mg/m³）。

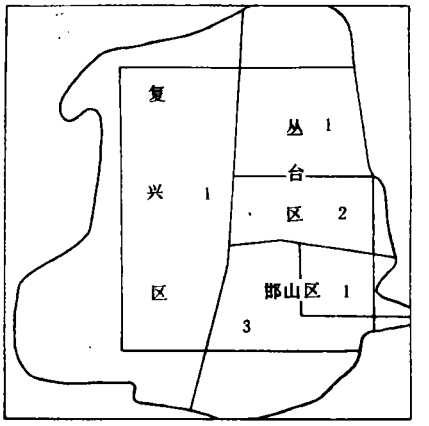

图 1 邯郸市区各功能区划分示意图

1. 工业区 2. 文化区 3. 居住区

2 传递函数矩阵、分担率及现状评价

本文采用大气污染物的长期日平均浓度标准作为控制标准。其理由是：①SO_2 等常规大气污染物对人的伤害不同于有毒有害物质，允许短时间暴露于稍高于现行标准规定的浓度之中；②在污染源分布已知的情况下，控制点的大气污染物浓度主要取决于气象条件。不同的风向、风速、大气稳定度，大气污染物的允许排放量也不同，选择个别“典型日”决定大气污染物允许排放量可能因典型日选取不当而造成较大偏差。

大气污染“传递函数 f_{ij} 是指第 i 个污染源的

1993 年 8 月 20 日收到修改稿

单位源强在第 j 个控制点上造成的污染物浓度。以 f_{ij} 为矩阵元的矩阵称之为传递函数矩阵 F。城市的大气污染表示为：

$$C = FQ \tag{1}$$

式中，C 为控制点污染物浓度列向量；Q 为城市污染源源强列向量。

大气污染分担率 r_{ij} 是指第 i 个污染源在第 j 控制点的浓度和第 j 控制点大气污染物总浓度之比。它可表示为：

$$r_{ij} = \frac{c_{ij}}{c_j} \tag{2}$$

式中，c_{ij} 为第 i 污染源排放污染物在第 j 控制点造成的浓度；c_j 为第 j 控制点的大气污染物浓度，$c_j = \sum_{i=1}^{N} c_{ij}$。

LEECM-Ⅰ程序（长期环境效应系数矩阵计算机程序第二版）[1,2]是专用于计算城市大气污染传递函数矩阵、分担率和环境效应系数矩阵的程序，它可容纳 14000 个污染源和 1800 个控制点。不仅应用于平坦地形也适用不平坦地形。LEECM-Ⅰ程序为城市大气污染评价。预测和污染控制研究提供了方便、实用的计算工具。

表 1　邯郸市各监测点年均 SO_2 实测值与计算值（mg/m³）

SO_2 浓度		监测点序号					相关系数 r	符合指数 d[5]
		1	2	3	4	5		
冬季	实测值	0.146	0.208	0.212	0.159	0.123	0.9483	0.9864
	计算值	0.109	0.174	0.186	0.146	0.108		
夏季	实测值	0.107	0.097	0.049	0.087	0.059	0.6693	0.9853
	计算值	0.069	0.076	0.061	0.060	0.046		
平均	实测值	0.098	0.126	0.103	0.109	0.067	0.8634	0.9935
	计算值	0.076	0.103	0.098	0.084	0.064		

利用 1990 年邯郸市污染源数据和气象条件，LEECM-Ⅰ得到的计算结果与实际监测数据的比较和相关分析列于表 1。比较表明 LEECM-Ⅰ程序可直接应用于邯郸市大气污染排放总量控制研究，无须修订模型和调整气象参数[3]。

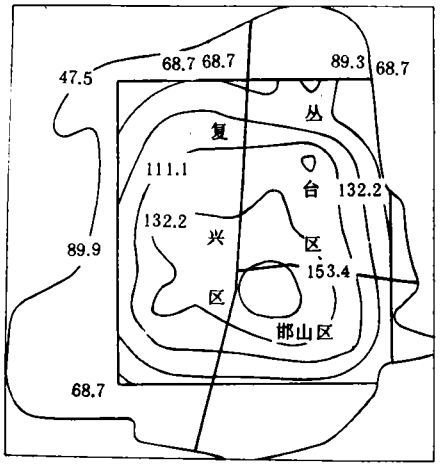

图 2　1990 年冬季邯郸市地面 SO_2 浓度分布（μg/m³）

图 2 给出的 1990 年邯郸市冬季 SO_2 浓度等值线是根据 LEECM-Ⅰ的计算结果画出的。由图 2 可见，居民集中的邯山区大气质量要比工业集中的复兴区更差，远超过国家三级标准。图 3 给出了由程序得到各行政区各部门的分担率，此图清楚地表明耗煤量仅占全市总耗煤 15%的民用耗煤在 3 个行政区中污染分担率都较大。这是由于民用耗煤设备排放条件较差所致。

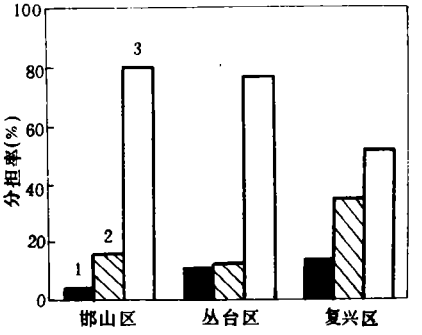

图 3　邯郸市各耗能部门对各功能区 SO_2 浓度分担率
1. 工业点源　2. 工业面源　3. 民用

3　基础削减量

按目前我国的环境政策：大气污染控制是采用浓度和排放总量控制相结合的原则。城市中每

一个污染源的允许排放量必须满足国标GB-3840规定的要求。由GB-3840的A-P方法计算得到的每一个污染源允许排放量称之为基础排放量。它与实际排放量的差值称之为基础削减量。表2给出了邯郸市主要污染源SO_2的基础排放量和基础削减量。

城市中污染源比较集中，每一个控制点上的大气污染物浓度是其周围众多污染源排放污染物的综合结果。A-P方法确定的单一污染源基础排放量并不能确保多污染源情况下大气质量达标。

4 平权削减量

根据污染控制区内各污染源按基础排放量排放污染物在各控制点上的大气污染浓度分担率确定的比例削减，其削减量称为平权削减量。平权削减符合“谁污染谁治理”的环境原则。邯郸市的平权削减量见表2。由表2可见，平权削减并不考虑实现削减的难易和削减投资成本的高低，因此，往往难以实施。

表2 邯郸市主要污染源的3种削减量(t/a)

源代号	削减前排放量	允许排放量			削减量		
		基础	平权	优化	基础	平权	优化
S_1	10508	630.72	562.65	10508	9877.28	9945.34	0
S_2	136.28	113.53	113.52	68.14	22.75	22.76	68.14
S_3	97.16	39.42	39.41	48.58	57.74	57.75	48.58
S_4	60.57	56.76	56.76	30.285	3.81	3.81	30.285
S_5	437.85	227.06	227.03	437.85	210.79	210.82	0
S_6	31.55	25.23	25.23	15.775	6.32	6.32	15.775
$S_{7\sim}$	7943.20	506.15	473.65	3971.6	7437.05	7469.55	3971.6
B_1	34969.3	1576.8	1576.8	16182.7	33392.5	33392.5	18786.6
B_2	3788.32	315.36	315.36	1894.16	3472.96	3472.96	1894.16
B_3	466.37	315.36	315.36	233.19	151.01	151.01	233.17
A_1	10128.90	3400	3400	4051.56	6728.90	6728.90	6077.34
A_2	4033.50	400	400	1613.40	3633.50	3633.50	2420.10
A_3	3529	400	400	1411.60	3129	3129	2117.40

5 优化削减量

按不同的目标进行源强优化和经济优化来分配削减量，可以较充分地利用当地大气环境自净能力，合理地确定控制区的大气排放总量和分配每一个污染源的削减量。城市中同一个污染源对不同的控制点的污染分担率往往有较大差异，因此，不同的控制点对同一个污染源要求的削减量是不同的。

5.1 源强优化

源强优化的模型如下：

$$\left.\begin{aligned} &\text{目标函数：} Z = \min \sum_{i=1}^{N} (Q_{1i} - Q_{2i}) \\ &\text{约束条件：} \sum_{i=1}^{N} Q_{2i} f_{ij} \leqslant c_{sj} \\ &Q_{1i} \geqslant Q_{2i} \geqslant 0 \quad i = 1, \ldots N; j = 1, \ldots M \end{aligned}\right\} \quad (3)$$

式中，Z为控制区内污染源的削减量之和；Q_{1i}为第i个污染源实际排放量；Q_{2i}为削减后第i个污染源排放量；f_{ij}为第i个源在第j控制点上的浓度传递函数；c_{sj}为第j控制点的大气质量目标值；下角标i为污染源序数，N为污染源总个数；下角标j为控制点，M为控制点总个数。

源强优化模型实质上是典型的线性规划问题，采用美国斯坦福大学的通用商业化线性规划软件包GAMS.在PC386/486微机上很容易给出模型的最优解。邯郸市的源强优化结果见表2。

源强优化通过传递函数考虑了污染源对控制点浓度的分担。凡污染分担率较大的污染源都要作较大的削减，同时总削减量最小。不过，源强优化并不能从经济的角度来合理地分配所应削减的污染物排放量。

5.2 经济优化

经济优化模型：

$$\left.\begin{aligned} &\text{目标函数：}G=\min\sum_{i=1}^{N}\sum_{k=1}^{L}Y_{ik}Q_{ik}\\ &\text{约束条件：}\sum_{i=1}^{N}[Q_{1i}-\sum_{k=1}^{L}Q_{ik}]f_{ij}\leqslant c_{sj}\\ &Q_{ik}\geqslant 0\\ &i=1\ldots N;j=1\ldots M;k=1\ldots L \end{aligned}\right\}\quad(4)$$

式中，G 为控制区实施削减所需的投资总数；Y_{ik} 为第 i 污染源采用第 k 种措施每削减单位排放量所需的成本；Q_{ik} 为第 i 源采用第 k 种措施的削减量；Q_{1i} 为第 i 源的实际污染物排放量；c_{sj} 为第 j 控制点的大气质量目标值；下角 i 为污染源序号、N 为污染源总数；下角标 j 为控制点；M 为控制区的控制点总数；下角标 k 为削减措施，L 为削减措施总数。

经济优化涉及到每一个污染源实际可行的 SO_2 削减技术方案和其削减单位排放量所需的投资，限于条件经济优化计算是以表3所列数据作为参考进行的。

经济优化计算仍采用上述 GAMS 软件包进行，结果如表4所示。根据表4的结果，用 LEECM-Ⅱ 程序计算了邯郸市城区经济优化削减后的冬季 SO_2 浓度分布（见图4）。削减后邯郸市的 SO_2 大气浓度将达到预定的目标值。

表3　各种治理措施的投资成本[1)]

技术措施		单位投资成本
型煤（元/t）	加石灰	84.55
	不加石灰	84.55
煤制气（元/m³）		0.115
焦炉气（元/m³）		0.012
热电联产（元/m³）		1.442
供热（元/m³）	集中锅炉房	0.992
	分散锅炉房	0.705
流化床燃烧发电（百万元/GW·h）		0.433

1）清华大学核能院。哈尔滨市经济能源环境研究课题总结报告。

表4　经济优化各污染源削减量（t/a）

源代号	排放量削减措施				
	型煤	煤气	热电联产	集中供热	分散供热
A_1	3079.2				2431.0
A_2	982.1	610.2		968.0	
A_3	1072.8		847.0		
总费用	6.52（×10⁷元）				

尽管经济优化给出了合理的满足预定目标的削减量分配，但这种分配并不公平，因为优化解把削减责任多归于投资成本低和分担率高的污染源。例如，邯郸热电厂是个排放大户，但因其烟囱高，单位削减的投资成本高，不论源强或经济优化都不要求其作削减。换言之，它对污染的责任由污染分担率高、治理投资成本低的污染源承担了，因此违背了“谁污染，谁治理”的政策原则。

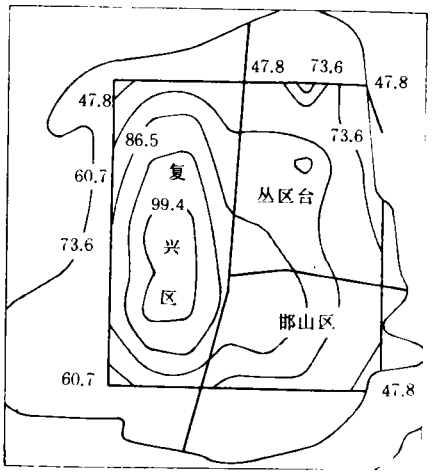

图4　经济优化后邯郸冬季 SO_2 浓度分布（ug/m³）

6　实施方案的制定

如上所述，不论基础削减、平权削减、还是源强或经济优化削减方法都有各自的不足之处，需要进行综合考虑使排放总量控制实施方案公平、合理、最优。理论上，具体实施方案可按经济或源强优化结果分配各个源的削减量，按平权削减量分配投资费用，即凡优化结果中不要求削减的污染源应按照平权削减量承担削减排放源的投资费用——进行排污权交易。实际上实施方案的制订是涉及当地社会、经济、技术诸多方面的系统工程问题，还需作进一步研究。

7　结论

（1）在当前城市发展水平上，城市大气污染治理重点应是民用污染源。邯郸市民用污染源消费燃煤仅占整个城市能源消费量的15%左右，但它对整个城市大气污染的分担率却达75%左

右。

(2)城市大气污染物排放总量控制方案的制定技术关键之一是传递函数的计算机程序。本文用的 LEECM-Ⅱ程序是一个通用、方便、可靠的计算机程序,经过多个城市的使用证明,它具有较高的精度,无须作模型和参数调整,更不用花费大量人力、物力重新建立新模型和获取非常规的参数,就能直接应用于大多数城市。它使大气污染物排放总量控制在全国城市中推广成为现实。

(3)本文所用的确定总量控制方案的方法和过程依据了文献[3]给出的方法。邯郸市应用研究表明这套方法是可行的。在对污染源进行详细的污染治理可行性研究和投资成本分析后,即可作出实施方案。

致谢 参加本工作的还有邯郸市环保科研所的魏高炬、李亚、张振珠和王晓莉等,一并感谢。

参考文献

1 方栋等. 中国环境科学. 1991,11(2):95
2 方栋等,环境科学. 1990,11(4):11
3 国家环保局等. 城市大气污染总量控制方法手册. 北京:中国环境出版社,1991:325
4 胡二邦等. 环境科学. 1989,10(6):16

· 环境信息 ·

阿拉斯加的湿地政策可能发生变化

克林顿政府在一项行政命令中,建议将"湿地无净损失"作为一项国策,并制定增加湿地面积的目标;而布什政府则从未专门将"无净损失"作为一项政策。现政府还建议废除关于开发 68 万 hm^2 阿拉斯加湿地的计划。可能要为拒绝同意开发湿地的土地所有者制定行政上诉程序;在布什政府领导下,关于拒绝接受[illegible]可证的争端,可能必须直接由法院裁决。1985 年之前布什关于免除 2150 万 hm^2 排干水和改用于农业目的的湿地控制的政策,可能没有任何变化。直到国家科学院完成标准定义,克林顿政府才会根据 1987 年陆军工程兵手册对湿地作出规定。预计 1994 年 2 月开始行动。

淮海译自 ES&T,1993,**27**(11):2261

100%清除 NO_x 和 SO_x 的二氧化钛片材

日本工业科学和技术局资源和环境研究所与富士电气公司共同开发出一种高效清除空气中 NO_x 和 SO_x 的片材。

这种片材采用 TiO_2 细粉作光催化剂,只要将片材放在阳光下,就能 100%地清除 NO_x 和 SO_x,用水洗涤其表面,片材可重复使用,研究人员准备大量生产,作为烟道和其他高浓度 NO_x 和 SO_x 场所的脱除材料。

将 TiO_2、Fe_2O_3 和活性炭混合加入作为基材的氟树脂中,然后压制成 0.2mm 厚的片材。TiO_2 是一种半导体,暴露在阳光下时,表面产生活性氧,氧与大气中的 NO 及 NO_2 反应,生成硝酸。

将一片 10cm×10cm 的片材置于阳光下,NO_x 浓度为 0.05—2.0ppm 的空气以 0.5L/min 的速度通过片材,NO_x 和 SO_x 都得到 100%的有效脱除。片材的功能可保持 10h。用水洗涤用过的片材,可回收 80%的硝酸,催化活性仍如新片材。

NO_x 和 SO_x 的脱除机理尚不明确,片材能重复使用多少次还需通过进一步的研究才能确定。到目前为止仍无良策脱净机动车废气排放到大气中的 NO_x 和 SO_x,因此人们对这种片材寄予极大的期望。

钱玲华译自 New Technology Japan October,1993

Abstracts

New Progress in Environmental Strategy. Mao Wen'yong (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085); *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 1—4

The new progresses in environmental strategy since the 1980s were discussed, which were characterized by the following aspects: (1) Environmental strategy has been expanded to cover the fields of socioeconomic development, forming a new strategy for environment and development; (2) Priority of environmental strategy has shifted from pollution control to ecosystems and resources conservation; (3) Measures for pollution control have changed from the end-of-pipe treatment of wastes to cleaner production, including the production of green products; (4) One of the primary approaches to ecological and environmental conservation has been found to be developing economy while eliminating poverty; and (5) The national strategy of a developing country for environment and development should be in combination with the global environmental strategy while taking international cooperation into account. The future environmental strategy of China, expressed by the China's Agenda 21, has been also described.

Key words: environmental strategy, pollution control, ecological conservation, cleaner production, China's Agenda 21.

Study on the Industrial Ecological Engineering in the Emei Semiconductor Materials Factory. Zhang Yizhang (Emei Semiconductor Materials Factory, Sichuan Province 614200), Chen Lujun (Dept. of Environ, Eng., Tsinghua University, Beijing 100084); *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 5—8

A study on the industrial ecological engineering (IEE) was conducted in the Emei Semiconductor Materials Factory by applying the fundamentals of ecology and the methodology of systems engineering and by following the ecological engineerings principles of integration, coordination, circulation and regeneration. The design, implementatiion and evaluation of IEE were also carried out, including the perfection of production chains and the conversion of industrial and domestic wastes to resources. The basic theories on IEE were also described in more details based on the analysis of ecological structures in industries. The results show that the realization of IEE allowed the resources and energy being most efficiently used in the factory, reducing the discharge of pollutants that in turn decreased the damage of industrial production to human beings, thus really achieving the unification of social, economic and environmental benefits.

Key words: ecological engineering (eco-engineering), industrial eco-engineering (IEE), cleaner production, pollution control.

Study on the Inhibition of Mixed Heavy Metals to Anaerobic Digestion. Wang Jusi, Zhao Lihui et al. (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085), Wang Zhenglan et al. (Beijing Institute of Solar Energy); *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 9—13

The inhibition of mixed heavy metals (copper, zinc, nickel and chromium) to the anaerobic system in a digester, and the relationship between the concentration of heavy metals daily added and the degree of their inhibition were studied. No inhibition was found when the daily addition of mixed heavy metals was less than 20 mg/L. The digestion system was slightly inhibited when the daily addition was 20—30 mg/L; was seriously inhibited when the daily addition was more than 50 mg/L; and was in normal operation when the ratio of the concentration of heavy metals daily added to that of activated sludge (dry matter) was less than 0.064% and the total concentration of dissolved, mixed heavy metals in the system was less than 1.0 mg/L. The results show that mixed heavy metals had a much stronger toxicity to an anaerobic system than each of the single heavy metals.

Key words: anaerobic digestion, heavy metal, inhibition.

Study on the Total Amount Control of Atmospheric SO_2 Emission in Handan City, Hebei Province. Fang Dong et al. (Institute of Nuclear Energy Technology, Tsinghua University, Beijing 100084); *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 14—18

The current status of SO_2 pollution in Handan City has been evaluated by using the general programme LEECM-2 which can generate a matrix of urban air pollution transmission functions and the shares of contribution. Then based on this, the total amount control of atmospheric SO_2 emission was studied. The results show that the programme LEECM-2 provides a convenient and practical calculation tool for the total amount control of air pollution, which will be helpful to promote the efforts for the total emission control in small-and medium-sized cities. The results also show that the basic reduction, equal weight reduction, source intensity optimization and economic optimization must be taken into an integrated account to develop a pollution reduction strategy for fairly and reasonably sharing the emission based on the principle of polluter pays.

Key words: air pollution, total emission control,

environmental management.

Experiment-based Evaluation of the Materials for Removal of Fluorides from Drinking Water. Qu Changling et al. (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 19—22

The optimum conditions for polyaluminum species, CF-1 and PC85-3 to remove fluorides from drinking water, such as pH value, ageing and agitation, were compared in detail and activated alumina, bone carbon and UR-3700 chelate resin were tested for their equilibrium capacity of fluoride removal, the effect of water hardness, etc. The results show that polyaluminum species, CF-1 and PC85-3 removed the excessive fluorides from drinking water to an acceptable level for drinking use but had limited applications. Activated alumina and bone carbon were more effective filters for removing fluorides from drinking water. The optimum pH values for the fluoride removal by polyaluminum species were 6—7. The eficiency of fluoride removal was the same at water temperatures ranged from 10— 30 C. The stirring time of 1—3min and agitation time of 10—15 min were satisfatory for fluoride removal from drinking water. The equilibrium capacity of fluoride removal for activated alumina was 0. 89—1. 75mg/g. The eficiency of fluoride removal was related to pH, concentration of fluoride, salinity and hardness.

Key words: fluoride removal, polyaluminum, activated alumina, bone carbon, drinking water.

Selection of the Methods for Extraction and Determination of Extracellular Polymers from Anaerobic Sludge. Liu Zhijie et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 23—26

Extracellular polymers (ECPs) were extracted from 4 kinds of anaerobic sludge by using 6 different ECPs extracting processes, i. e., sulfuric acid process, sodium hydroxide process, ethylenediaminetetraacetic acid (EDTA) process, boiling benzene process, distilled water process and steaming process, which have been used to extract ECPs from activated sludge. The concentrations of polysaccharides in the extracts were determined by both the phenol-sulfuric acid method and the anthrone-sulfuric acid method, and the concentrations of nucleic acid were also measured to examine the degree of cells damaged. The results show that the sulfuric acid process can extract more ECPs from anaerobic sludges, with a less degree of damage to cells, than other processes. The phenol-sulfuric acid method was found more suitable to measure the concentration of polysaccharide. The level and composition of ECPs in anaerobic sludges were also discussed.

Key words: anaerobic sludge, extracellular polymer, extraction method, sulfuric acid process for ECP extraction.

Levels of Mercury in Soil and Their Geographical Distribution in Tibet. Zhang Xiaoping et al. (Changchun Institute of Geography, Chinese Academy of Sciences, Changchun 130021): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 27—30

205 Samples of soil were taken from different sites in Tibet and analysed for their levels of mercury in soil. The data obtained were processed by using a method for mathematical programming statistics on a microcomputer and making some related computations. The results show that the average level of mercury in soils from Tibet was 0. 021 mg/kg and significantly lower than the average national level of 0. 04 mg/kg. The level of mercury in soil was distributed in Tibet with a total trend of gradually decreasing from the southeast to the northwest that was consistent with the direction of changes in the zonal successions of vegetation and soil in Tibet. The level of mercury was closely related to the basic attributes of soil and mercury tends to be concentrated upto the organic matter and glutinous grains of soil.

Key words: mercury, soil, Tibet.

Study on the Treatment of Dye-stuff Wastewater with an Anaerobic/Aerobic Process. Zhu Jianrong et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 31—34

The results were reported from a study on the treatment of dye-stuff wastewater by using an anaerobic/aerobic process, wherein the anaerobic stage was carried out in a UASB reactor and the aerobic stage was using a conventional activated sludge process. The results show that with a raw dye-stuff wastewater of 1150— 1300 mg COD/L and 500 fold colourity (a colour scale meant by the number of dilution times leading to a colour that seems to be the colour of tap water) under the condition of HRT 6— 10 h at the anaerobic stage, the COD removal was more than 60% and the colourity was reduced to 50—100 folds. If followed by an additional 6 h aeration treatment, the total COD removal was up to 85%— 90% and the colourity was further reduced to about 20 folds. The spectrometric analyses of influent and effluent revealed that the decolouration of dye-stuff wastewater mainly took place at the anaerobic stage and was achieved through bilogical degradation. It was concluded that the anaerobic/aerobic process was a cost-effective way to treat a dye-stuff wastewater and was of a great value of practical application.

Key words: dye-stuff wastewater, UASB reactor, activated sludge process, COD removal, decolouration.

Study on the Total Mercury and Methyl Mercury Contaminations in Fish from the Songhuajiang