



气相色谱质谱法分析挥发性有机污染物质量控制研究

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摘要 根据美国环保局合同实验室计划(US EPA CLP), 分析 5 个样品, 系统地研究了色谱质谱法分析挥发性有机污染物全过程中每个环节上的质量控制问题。此法可用来定量大部分沸点在 200°C 以下, 不溶于水的挥发性有机物。实际上对于水样的定量检测限大约是 5 $\mu\text{g/L}$, 土壤和底泥是 5 $\mu\text{g/kg}$ 。

关键词 质量控制, 挥发性有机物, 色谱质谱。

用色谱质谱法(GC-MS)分析环境样品中痕量有机污染物的质量控制(QC)研究, 是近代分析化学中一个重要的发展方向。因为只有通过 QC 所获得的数据才是可信赖和可比较的。数据是评价生态环境质量和进行环境工程设计的基础。美国环保局实验室^{1,2)}已经开展了色谱和 GC-MS 分析痕量有机污染物的质量保证/质量控制(QA/QC)的研究工作^{1,2)}。本文报道了用 GC-MS 分析挥发性有机污染物, 并通过对环境样品的实测讨论了分析全过程的 QC。

1 试剂

(1) 储备液 41 种目标化合物(target compounds)用甲醇配制成浓度为 200 mg/L 的储备液。再将储备液分别配成浓度为 20, 50, 100, 150 和 200 $\mu\text{g/L}$ 的溶液, 为 GC-MS 作标准曲线用。目标化合物清单和用于定量的特征离子列表 1。

(2) 内标物 氯溴甲烷, 1,4-二氟苯和氯苯-d₄, 每个内标物在甲醇中的浓度是 50 $\mu\text{g/L}$ 。

(3) 4-溴氟苯(BFB)标样 浓度为 25 $\mu\text{g/ml}$ 的 BFB 标样, 用作 GC-MS 的调试标准溶液。

(4) 替代标样 甲苯-d₈, 4-溴氟苯和 1,2-二氯乙烷-d₁, 在甲醇中的浓度是 25 $\mu\text{g/ml}$ 。

(5) 基质掺样标样 1,1-二氯乙烷, 三氯乙烷, 氯苯, 甲苯和苯, 在甲醇中的浓度分别为

25 $\mu\text{g/ml}$ 。

2 质量控制

质量控制贯彻在样品分析全部过程, 其中包括空白, 基质掺样(MS), 重复基质掺样(MSD)和样品分析。

2.1 GC-MS 的调试和质量标定

GC-MS 分析的有效工作时间为 12h, 从 BFB 进样分析开始计算。在标样和样品分析之前, 必须用 BFB 调试 GC-MS 系统, 使 BFB 主要碎片离子的相对丰度满足表 2 中的要求。

表 2 BFB 的主要离子及其相对丰度范围

50	基峰的 15%—40%
75	基峰的 30%—60%
95	基峰
96	基峰的 5.0%—9.0%
173	小于质量 174 的 2.0%
174	大于基峰的 50%
175	质量 174 的 5.0%—9.0%
176	大于质量 174 的 95%, 小于 101.0%
177	质量 176 的 5.0%—9.0%

2.2 GC-MS 系统的标定

为了进行定量测定, 必须对系统进行标定,

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1) U. S. EPA 40 CFR Part 136. Method 624. Oct 26, 1984

2) Van Hall. ASTM STP 686. 1979: 108—129

表 1 目标化合物和它们的特征离子

序号	化合物	m/z
1	氯溴甲烷 (内标-1)	128
2	1,4-二氟苯 (内标-2)	114
3	氯苯-d ₅ (内标-3)	117
4	氯甲烷**	50
5	溴甲烷	94
6	氯乙烯*	62
7	氯乙烷	64
8	二氯甲烷	84
9	丙酮	43
10	二硫化碳	76
11	1,1-二氯乙烯*	96
12	1,1-二氯乙烷**	63
13	1,2-二氯乙烯	96
14	氯仿*	83
15	1,2-二氯乙烷	62
16	2-丁酮	72
17	1,1,1-三氯乙烷	97
18	四氯化碳	117
19	醋酸乙烯酯	43
20	二氯溴甲烷	83
21	1,2-二氯丙烷*	63
22	顺式-1,3-二氯丙烯	75
23	三氯乙烯	130
24	二溴氯甲烷	129
25	1,1,2-三氯乙烷	97
26	苯	78
27	反式-1,3-二氯丙烯	75
28	溴仿**	173
29	2-氯乙基-乙烯醚	63
30	4-甲基-2-戊酮	43
31	2-己酮	43
32	四氯乙烯	64
33	1,1,2,2-四氯乙烷**	83
34	甲苯*	92
35	氯苯**	112
36	乙苯*	106
37	苯乙烯	104
38	二甲苯	106
39	甲苯-d ₈	98
40	溴氯苯	95
41	1,2-二氯乙烷-d ₄	65

* 标定检验化合物
 ** 系统检验化合物
 m/z: 质核比

确定各个组分的相应响应系数。先是初始标定,取 5 种不同浓度 20, 50, 100, 150 和 200 μg/ml 的目标化合物标样, 做 5 次 GC-MS 分析, 每个化合物在每次分析中的相对保留时间(RRT)必须

在 0.06 以内。每个标定检验化合物(CCC, 表 1 中打 * 的)的百分相对标准偏差(%RSD)必须小于或等于 30%。GC-MS 的系统检验工作是用 5 个系统检验化合物(SPCC, 表 1 中打 ** 的)来完成的。这些化合物的最小可接受的平均相对响应因子(RRF)是 0.300, 对溴仿是 0.250。由于它的吹扫效果很差, 初始标定必须在满足了 CCC 化合物和 SPCC 化合物的 QC 要求时才有效。

2.3 连续标定

分析样品, GC-MS 工作状态会变化, 这是因为进样口、柱前端可能受污染以及柱子或 GC-MS 系统可能产生活性点, 因此, GC-MS 系统每 12h 要重新标定一次。在分析开始之前, 必须满足 SPCC 化合物的 RRF 要求, 系统检验合格后, 用 CCC 化合物检验初始标定是否有效, 当初始标定的 RRF_i 和正在标定检验的标样 RRF_s 的百分差对每个 CCC 化合物小于或等于 25% 时, 认为初始标定仍是有效的。

2.4 空白分析

在每 12h 的有效分析过程中, 分析样品前必须进行方法的空白分析, QC 规定, 对二氯甲烷、丙酮, 甲苯和 2-丁酮不能超过 5 倍的定量限, 对其它所有目标化合物, 其含量必须小于定量检测限。

2.5 替代标样分析

每一个样品、基质掺样、重复基质掺样和空白都要加入替代标样一起吹打, 以便检验样品的处理和分析效果, 替代标样的回收率范围列于表 3。

表 3 替代标样的回收率范围 (%)

化合物名称	水	中/低浓度土壤
甲 苯-d ₈	88-110	81-117
4-溴氟苯	86-115	74-121
1,2-二氯乙烷	76-114	70-121

2.6 基质掺样和重复基质掺样的分析 (MS/MSD)

为了评价样品基质对分析方法的影响, 美国环保局给出了一组标样混合物用作 MS/MSD 分析¹⁾, 基质掺样的回收率范围列在表 4。

2.7 样品分析

表 4 基质掺样化合物的回收率范围(%)

基质掺样化合物	水	土/底泥
1,1-二氯乙烯	61-145	59-172
三氯乙烯	71-120	62-137
氯 苯	75-130	60-133
甲 苯	76-125	59-139
苯	76-127	66-142

上面所有质量控制要求都满足后,开始分析样品。

2.7.1 内标物评价

任何一个内标物的峰面积与连续标定中相应内标物的峰面积的变化范围均应落入—50%—100%以内。保留时间相差应小于 30s,系统不应被高响应值化合物所饱和,对挥发性目标化合物来说样品中被测物浓度应在 200 $\mu\text{g}/\text{ml}$,否则必须稀释。

2.7.2 定性分析

样品中各组分的鉴定,必须满足两个要求:

①未知物的 GC 相对保留时间与标准物的 GC 相对保留时间相比在 ± 0.06 以内;②比较未知物的质谱与标准谱图,标准谱图中存在相对强度大于 10%的所有离子必须在未知物谱图中存在,并且这些离子的相对强度必须在 $\pm 20\%$ 以内。

2.7.3 定量分析

鉴定出的目标化合物采用内标法定量,一般由计算机数据系统给出结果。其它推测鉴定化合物的定量是把它们的响应因子(RF)作为 1 来计算的,因为没有那些化合物的响应因子。

3 实验部分

3.1 GC-FID 检验

样品首先必须做 GC,以测定其浓度水平,如果浓度超过标定的范围,则样品需要稀释。在做 GC-MS 之前,还要检验内标物和替代标样的回收率。

实验是在 HP5890GC 配有 TekmarLSC-2 吹扫和冷阱系统上进行的,操作条件如下。

柱子初始温度:45 $^{\circ}\text{C}$;柱子初始维持时间:3min;程序升温:8 $^{\circ}\text{C}/\text{min}$;柱子最终温度:220 $^{\circ}\text{C}$;进样口温度:200 $^{\circ}\text{C}$;载气:He,30cm/s;玻

璃柱:2.4m \times 2mm 内径,装填 Carboxpak B (60/80 目,1%SP-1000 涂层)。

被测溶液是按照标定标样和替代标样的要求浓度在吹扫装置中直接配制的,吹扫装置里加入 5ml 水样,目标化合物标定溶液和 10 μl 的内标物。

3.2 色谱质谱分析

(1)挥发性有机物的分析是在 Finnigan-MAT 4023 型质谱仪上进行的,配有 SuperIncos 软件,及 Tekmar LSC-2 吹扫和冷阱系统,数据系统可连续采集、贮存和处理所有的质谱图。EPA/NIH 和目标化合物谱图库用来定性鉴定,软件系统则产生最后的定性定量结果。GC-MS 操作条件如下。

电子能量:70eV;质量范围:35—250mu;扫描时间:5 次扫描/峰;离子源温度:150 $^{\circ}\text{C}$;传送线温度:250 $^{\circ}\text{C}$ 。

(2)GC-MS 调试到满足 QC 要求后,吹扫气 He 流速调到 20—40ml/min,以使吹扫-冷阱装置获得最好的响应值。在 5ml 样品中加入 10 μl 替代物标样和 10 μl 内标溶液,配制成每种替代标样浓度为 50ng/ μl 的溶液,将装在吹扫装置上的注射阀打开,样品进入吹扫室,在室温吹扫 11min,冷阱装在 GC 柱前,然后将该装置调到解吸位置,快速加热冷阱到 180 $^{\circ}\text{C}$,解吸样品 4min 后开始气相色谱程序升温控制和 GC-MS 数据收集。基质掺样分析,要在 5ml 样品中加入 10 μl 基质掺样标样,浓度为 50ng/ μl 。

4 结果和讨论

在质量控制条件下分析了 5 个样品,包括空白、基质掺样和重复基质掺样。

4.1 BFB 调试

将 GC-MS 调试到表 2 中列出的 BFB 清单中的要求,BFB 关键离子的丰度已满足,结果见表 5。

1). Budde W L, Eichelberger J W. EPA-600/4-79-020. U. S. EPA, *Environmental Monitoring and Support Laboratory*, Cincinnati Ohio 45268, Apr. 1980

表 5 GC-MS 调试结果(BFB)

m/e	50	75	95	96	173	174	175	176	177
相对丰度 (%)	37.2	59.9	100.0	5.6	0.3(0.4)	76.3	5.0(6.6) ¹⁾	74.5(97.5) ¹⁾	4.7(6.1) ¹⁾

1)质量 174 的百分相对丰度; 2)质量 176 的百分相对丰度

表 6 初始标定数据

化合物	RRF020	RRF050	RRF100	RRF150	RRF200	RRF	RSID (%)
氯甲烷**	1.737	1.484	1.568	1.532	1.474	1.559	6.8
溴甲烷	1.579	1.429	1.471	1.436	1.407	1.461	4.9
氯乙烷*	1.897	1.629	1.701	1.674	1.669	1.714	6.1
氯乙烷	1.256	1.057	1.132	1.127	1.111	1.136	6.1
二氯甲烷	2.095	1.605	1.558	1.425	1.455	1.627	16.7
丙酮	0.950	0.799	0.652	0.553	0.567	0.701	23.9
二硫化碳	3.425	3.243	3.494	3.495	3.570	3.445	3.6
1,1-二氯乙烷*	1.050	0.944	0.979	0.984	1.004	0.992	3.9
1,1-二氯乙烷**	3.703	3.213	3.318	3.308	3.283	3.365	5.7
1,2-二氯乙烷	1.413	1.271	1.351	1.361	1.383	1.356	3.9
氯仿*	3.705	3.243	3.289	3.274	3.249	3.352	5.9
1,2-二氯乙烷	3.117	2.694	2.790	2.751	2.813	2.833	5.8
2-丁酮	0.139	0.099	0.112	0.113	0.124	0.117	12.6
1,1,1-三氯乙烷	0.683	0.598	0.622	0.620	0.621	0.629	5.1
四氯化碳	0.072	0.066	0.073	0.075	0.075	0.072	5.1
醋酸乙酯	0.783	0.683	0.704	0.688	0.719	0.715	5.6
二氯溴甲烷	0.661	0.607	0.620	0.637	0.641	0.633	3.2
1,2-二氯丙烷*	0.543	0.485	0.498	0.498	0.502	0.505	4.3
顺式-1,3-二氯丙烯	0.612	0.561	0.577	0.592	0.605	0.589	3.5
三氯乙烷	0.445	0.408	0.427	0.438	0.459	0.436	4.4
二溴氯甲烷	0.447	0.422	0.468	0.491	0.518	0.469	8.0
1,1,2-三氯乙烷	0.357	0.321	0.349	0.359	0.370	0.351	5.3
苯	1.170	1.054	1.096	1.097	1.117	1.107	3.8
反式-1,3-二氯丙烯	0.480	0.460	0.511	0.531	0.557	0.508	7.7
溴仿**	0.300	0.279	0.323	0.345	0.372	0.324	11.3
4-甲基-2-戊酮	0.820	0.599	0.535	0.539	0.523	0.603	20.7
2-己酮	0.470	0.375	0.371	0.377	0.372	0.393	10.9
四氯乙烷	0.534	0.449	0.471	0.499	0.492	0.489	6.5
1,1,2,2-四氯乙烷**	0.605	0.463	0.500	0.512	0.517	0.520	10.1
甲苯*	0.894	0.779	0.800	0.829	0.805	0.821	5.4
氯苯**	1.183	0.986	0.991	1.022	0.998	1.036	8.0
乙苯*	0.573	0.490	0.494	0.513	0.506	0.515	6.5
苯乙烯	1.088	0.947	0.974	0.987	1.041	1.007	5.6
二甲苯	0.685	0.593	0.590	0.621	0.643	0.627	6.2
甲苯-d ₈	1.327	1.307	1.255	1.314	1.306	1.302	2.1
溴氯苯	0.855	0.859	0.782	0.831	0.843	0.834	3.8
1,2-二氯乙烷-d ₂	2.704	2.644	2.518	2.495	2.544	2.581	3.5

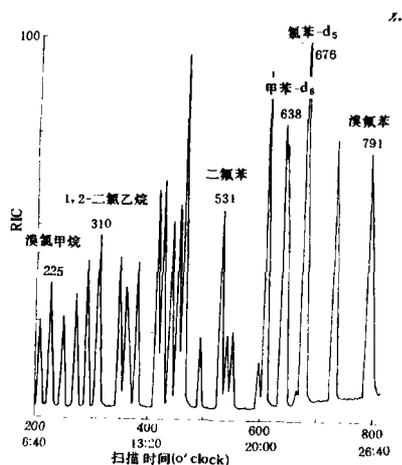


图 1 50ng/μl 的初始标定 RIC 图

4.2 初始标定

初始标定结果列于表 6, 打 2) 号和 1) 号标记的分别为 SPCC 和 CCC 化合物, 它们也都符合 QC 要求. GC-MS 的总离子流图 (RIC) 示于图 1. 该图是进 1 μl 浓度为 50 ng/μl 的标定标样产生的, 图 1 中标出相应于内标和替代标样的色谱峰。

4.3 连续标定

连续标定必须每 12h 进行 1 次, 只需进 1 次浓度为 50 ng/μl 的标样, 此次结果已满足 QC 要求, 不另表列出。

4.4 样品分析

根据 QC 要求, 应用 GC-MS 分析了 5 个低浓度水平的水样品, 以阐明此方法。首先必须检验 RIC 图中内标物的面积, 数据列在表 7。

表 7 内标面积结果

项目	1号内标面积 溴氯甲烷	保留时间 (min)	2号内标面积 1,4-二氟苯	保留时间 (min)	3号内标面积 氯苯	保留时间 (min)	
12h 标准	27940	7.50	139064	22.50	137758	17.70	
上限 ¹⁾	55880	8.00	278128	23.00	275516	18.20	
下限 ²⁾	13970	7.00	69532	22.00	68879	17.20	
VBLKOM	29380	7.53	127326	22.47	138555	17.70	
SWO1	28472	7.50	128763	22.50	136649	17.73	
SWO2	28273	7.53	127657	22.50	136732	17.73	
EPA 样品号	SWO1	27536	7.57	135229	22.50	132987	17.73
MS	SWO1	28749	7.77	132991	22.50	135934	17.73
MSD							

1) 上限 = 内标物面积 + 100%

2) 下限 = 内标物面积 - 50%

3 个内标面积都在 QC 要求的范围之内, 替代标样和 MS/MSD 回收率分别列在表 8、表 9。

对于样品分析, 替代物的回收率已落入这个范围, 但对于 MS/MSD 的回收率, 1,1-二氯乙烯未满足回收率范围的要求, 目前还没有硬性规定基质掺样化合物的回收率。

SWO1 MS 样品的 RIC 图示于图 2, 这是

表 8 替代物标样回收率结果 (%)

EPA 样品号	S1 甲苯-d ₆	S2 溴氟苯	S3 2-二氯乙烯-d ₄	超标 总数
VBLKOM	103	91	96	0
SWO1	106	104	98	0
SWO2	108	104	101	0
SWO1 MS	100	99	102	0
SWO1 MSD	95	89	96	0

一个水样品, 相应的内标和替代标样峰已指出, 表 10 给出了定量结果。

表 9 基质掺样/重复基质掺样回收率

化合物	掺样量 (μg/L)	样品浓度 (μg/L)	MS 浓度 (μg/L)	MSD 浓度 (μg/L)	MS 回收率 (%)	MSD 回收率 (%)	相对 百分差	QC 范围	
								相对偏差	回收率 (%)
1,1-二氯乙烯	50	0	73	69	146 ¹⁾	139	5	14	61-145
三氯乙烯	50	0	53	52	105	103	2	14	71-120
苯	50	0	57	54	113	108	4	11	76-127
甲苯	50	0	52	52	104	103	1	13	76-135
氯苯	50	0	47	47	94	94	0	13	75-130

1) 超出 QC 范围

表 10 SW01 MS 样品的定量结果

化合物	扫描(次)	保留时间 (min)	浓度(μg/L)
溴氯甲烷(内标-1)	227	7:34	50.0
1,4-二氟苯(内标-2)	532	17:44	50.0
氯苯-d ₅	675	22:30	50.0
丙酮	144	4:48	19.3
1,1-二氯乙烯	209	6:58	73.1
2-丁酮	310	10:20	16.5
三氯乙烯	442	14:44	52.7
苯	455	15:10	56.7
甲苯	645	21:30	51.9
氯苯	679	22:38	47.2
甲苯-d ₈	639	21:18	50.2
溴氯苯	793	26:26	49.6
1,2-二氯乙烯-d ₄	310	10:20	51.1

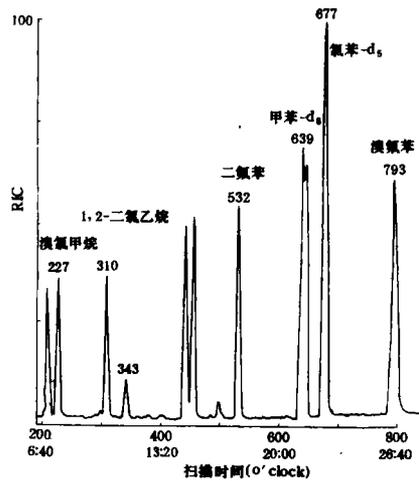


图 2 SW01 MS 样品的总离子流图

定性和定量了 14 个峰,大部分属于分析前加入的标样,一些峰是作为目标化合物鉴定的。只有一个峰,扫描号为 343,经库检索,推测鉴定为 2-甲基-2-甲氧基丙烷,浓度大约为 10μg/L。

本方法一般用来测定环境(水和土壤)样品中的挥发性有机化合物,不同的样品基质采用不同的预处理方法,此方法用来定量大部分沸点在 200℃以下,不溶于水的挥发性有机物。然而,对于很多溶解于水的化合物,定量检测限大约要高 10 倍,因为它们的吹扫效果很差。本方法的精确

度和准确度直接与分析的样品基质和污染浓度有关,实际上对于水样的定量检测限大约是 5μg/L,对土壤和底泥是 5μg/kg。

本方法需进一步完善,某些质量控制参数也有待于进一步讨论。

参 考 文 献

- 1 Provost L P, Elter R S. *American Laboratory*. 1983, 15: 58
- 2 Eichelberger J W, Harris L E, Budde W L. *Analytical Chemistry*. 1975, 47: 995

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表 9 工业废水对比测定结果(mg/L)

测定方法	糖厂	制革厂	纸厂	印染厂	化工厂	罐头厂
	废水	废水	废水	废水	废水	废水
原标准法	1.23	6.90	0.41	3.82	1.10	0.23
本法	2.15	16.51	0.71	8.54	2.46	0.44

(2)以强碱氢氧化钠混合液为吸收液,对 H₂S 吸收完全、稳定,并避免了 ZnAc₂ 为吸收液所形成的 ZnS 沉淀粘附于吸收管尖的损失。总回收率由原法 40%提高到 95%以上,减少吹气时间 25%。

(3)由于处理温度控制较低,抑制了废水中各种类型反应发生,减少了干扰作用。

参 考 文 献

- 1 国家环保局(水和废水监测分析方法)编委会.水和废水监测

分析方法.第三版,北京:中国环境科学出版社,1989:328

- 2 戴克慧等.上海环境科学.1985,4(6):27
- 3 James T P. *Am. Ind. Hyg. Assoc. J.*. 1990, 51(5): 269
- 4 《无机化学》编写组编.无机化学(上册).上海:人民教育出版社,1979:106
- 5 [日]井本英二著,孙云鸿等译.有机化学(Ⅱ).上海:上海教育出版社,1981:167
- 6 南京药学院主编.分析化学.北京:人民卫生出版社,1979: 164

of sludge clogging, liquid shortcutting and aggregation of scum have been solved. The experiment of treating aerobic excess sludge studied in 120 liter reactor at 35°C shows that the organic pollutant removal efficiency of 51.4%—58% is reached corresponding to HRT=3.53—8.57 days. When HRT is fixed at 7.5 days, the organic loading rate, COD loading rate and average organic removal efficiency are 2.97 KgSS/(m³·d), 3.89 kgCOD/(m³·d) and 55.3%, respectively. The methane content of biogas is more than 66%.

Key words: two-phase digestion, anaerobic reactor, aerobic excess sludge treatment.

Production Test on Facultative Anaerobic-AB Process in Treating Slaughterhouse Wastewater and Its Microbiological Characteristics. Zheng Dandan et al. (Chengdu Institute of Biology Academia Sinica, Chengdu 610041); *Chin. J. Environ. Sci.*, 14(4), 1993, pp. 66—70

To treat the slaughterhouse wastewater of Neijiang Comprehensive Processing Plant, facultative anaerobic-AB process was used. During the trial operation, the loading rate of facultative anaerobic regulating tank was 0.50 kgCOD_{Cr}/m³, and its removal rate of COD_{Cr} (η COD_{Cr}) was 31.15% the sludge loading rate (B_{TS}) in A-stage was 4.78 kgBOD₅/(kgMLSS·d) and η COD_{Cr}=53.37%; in B-stage, B_{TS} = 0.73 kgBOD₅/(kgMLSS·d) and η COD_{Cr} = 54.70%. There was no problem for this process in compliance with the national standards, the effluent had COD_{Cr} 103.1 mg/L (η = 88.77%), BOD₅ 32.0 mg/L (η = 94.47%), SS 36.1 mg/L (η = 89.64%), Color 26 times (η = 80.60%), and pH 7.72. When this process was put into formal operation, its effluent quality remain stable with γ = 0.48. Results indicated that this process was stable with high efficiency and low investment needed. It is an advanced process worth spreading. There was an anaerobic digestion microorganism community in the biomembrane formed on the support material in facultative anaerobic regulating tank; besides this, there were different biosystematics existing in A and B stages' aerobic tanks, A-stage is predominant in bacteria and B-stage in protozoa. The analysis of the microbiological characteristics of this process offer theoretical basis for using it to treat other kinds wastewater.

Key words: facultative anaerobic-AB process, slaughterhouse wastewater, production test, microbiological characteristics.

A Study on the Treatment of Paint Wastewater by a Sequencing Biological Batch Reactor. Zhou Yuexi et al. (Chinese Research Academy of Environmental Sciences, Beijing 100012); *Chin. J. Environ. Sci.*, 14(4), 1993, pp. 71—73

In this paper, the research was made on the treatment of paint wastewater by a sequencing biological batch reactor. The experimental results demonstrate that the biological batch system can effectively remove organic matter. With the experimental time sequence (flow-in 1 h., anaerobic 6 h., aerobic 14 h., setting 1 h. and flow-out 1 h.), the removal rate of COD is 84%—96% (influent COD is 1000—4000 mg/L).

Key words: sequencing biological batch reactor, paint wastewater.

The Effects of the UV Light on the Catalase (CAT) Activity of Several Species of Aquatic Plants. Li Hongwen et al. (Suzhou Institute of Urban Construction and Environmental Protection,

Suzhou 215008); *Chin. J. Environ. Sci.*, 14(4), 1993, pp. 74—77

By testing the volume of O₂ which is released after the CAT of the plants exposed to exceeded UV decomposed H₂O₂, the CAT activity of the exposed plants is determined. The results show that the CAT activities for three plant species, *Azolla imbricata*, *Lemna minor*, *Alternanthera philoxeroides*, obviously rose respectively after they had been exposed to exceeded UV in different hours. But the maximum values of the CAT activities for three plant species is vary with different species. There is a maximum value of the CAT activity for *Azolla imbricata* which is exposed to exceeded UV in 72 hours. There is a maximum value of the CAT activity for *Lemna minor* which is exposed to exceeded UV in 24 hours. There is a maximum value of the CAT activity for *Alternanthera philoxeroides* which is exposed to the exceeded UV in 8 hours. The CAT activities for three plant species decreased respectively in some hours after the influence of the UV had been withdrawn. This shows that there obviously are stimulative affects of the exceeded UV on the CAT active for three plants. Meanwhile, the tissues and metabolism of the exposed plants are injured by the exceeded UV. It finally leads up to decrease the CAT activity of the exposed plants. The ecological effects of various plant species on the exceeded UV are different.

Key words: Catalase (CAT). Ultraviolet (UV), *Lemna minor*, *Azolla imbricata*, *Alternanthera philoxeroides*.

Improvement in the Pretreatment Method of Samples for the Determination of Sulfides in Wastewater. Wu Yuzhen. (Nanning Environmental Monitoring Station, Nanning 530012); *Chin. J. Environ. Sci.*, 14(4), 1993, pp. 78—80

The pretreatment method of samples, known as N₂-blowing method, for the determination of sulfides in wastewater has been further studied and improved. The improvement includes the test apparatus, pretreatment procedure, acidity and temperature used in the pretreatment, and the volume of reaction bottle. Particularly, a multihole blowing ball was used to replace the single hole blowing pipet, and a mixture of NaOH, EDTA and TEA was used as the blowing-absorbing solution instead of ZnAc₂-NaAc. Then a step-wise pressure procedure has been suggested. The studies on the recovery and precision of the improved method and the comparative determination of six different kinds of industrial wastewater show that the improvement has seen an obvious effectiveness and the recovery increases from 40% for the original method to over 95% for the improved method. The blowing time is shortened by 25%. The apparatus is easy to operate.

Key words: N₂-blowing method, multi-hole blowing ball, sulfide.

Quality Control for the Analysis of Volatile Organic Pollutants by GC-MS. Sun sien et al. (The Research Center for Eco-Environmental Sciences, Academia Sinica, Beijing 100085); *Chin. J. Environ. Sci.*, 14(4), 1993, pp. 81—86

This paper described the Quality control for the analysis of volatile organic pollutants by GC-MS according to the US EPA CLP programme. The criteria of quality control in the process of analysis were presented. Five samples have been analysed in order to demonstrate the procedure. This method is used to quantify most volatile organic compounds having boiling points below 200°C and compounds are insoluble in water. The practical quantitation limit

of this method for an individual compound is approximately $5\mu\text{g/L}$ for ground water and $5\mu\text{g/kg}$ for soil and sediment.

Key words: quality control, volatile organic pollutants, GC-MS.

Risk Assessment Method for Potentially Environmental Pollution Accidents Caused by Hazardous Gases. Zhou Enyi et al. (Department of Applied Chemistry, Dalian Institute of Railway Technology); *Chin. J. Environ. Sci.*, **14**(4), 1993, pp. 87—90

A risk assessment method has been developed for the potentially environmental pollution accidents caused by hazardous gases, in terms of both extent of damage and extent of risk. The extent of damage is assessed by using those methods for environmental prediction and assessment to predict the maximum concentrations of hazardous gases escaped to where population is exposed when an accident occurs. Then the extent of damage by an enterprise is determined by the concentrations of the hazardous gases to cause an effect on human health, a damage to organisms, and a threat to the life. As for assessing the extent of risk, the method for safety management and the method for reliability analysis are used to quantify, respectively, the level of safety management and the irreliability of hazardous equipment used in an enterprise. then the danger index is calculated for the assessed hidden danger based on the relevant principles of the working safety assessment. Finally the mathematical statistics are used to determine the standards for safety limits. By comparing with the standards, it may be judged whether

a hidden danger is in the state of safety or in the state of danger, and it may be estimated to which extent such a danger can become an accident, so as to assess the risk of a hidden danger.

Key words: hidden danger, extent of damage, extent of danger.

Primal Cause for the Formation of Coal Dust in the Mount Song Coal Mining Area. Chen Zhenmin, Song Zhimin, Wei Jianming (Department of Geology, Zheng Zhou Coal Geological College 450004); *Chin. J. Environ. Sci.*, **14**(4), 1993, pp. 91—92

In the Mount Song coal mining area, there are two main minable coal seams—the carboniferous system Tai Yuan group's coal seam (I) and the permian system San Xi group's coal seam (I). Through the same mining installations and technology are used in a pit, the coal dust produced is very different. During the mining of coal seam (I), there is little coal dust, while during the mining of coal seam (I) serious pollution of coal dust is produced. The reason is that coal seam (I) has been vigorously pressed and kneaded by the Mount Song glide tectonics and the composition and construction of the seam has been destroyed resulting in the formation of powdery coal. However, coal seam (I) was not influenced by the glide tectonics, thus the composition and construction of the seam were not destroyed. Therefore it can be inferred that the primal cause for the formation of coal dust in the referred areas is the destruction of coal seam.

Key words: coal seam, coal dust, glide tectonics.