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盐度和压力对沉积物逐级分离样品吸附毒性有机物的影响*

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摘要　用化学逐级分离法对大连近海沉积物中有机组分和无机组分进行分离，考察了盐度和压力对沉积物中有机组分和无机组分吸附几种毒性有机物的影响。结果表明，有机组分对几种毒性有机物的吸附能力随盐度的升高线性递增；而无机组分的吸附能力随盐度的升高线性递减。升高压力增加了沉积物中2组分对毒性有机物的吸附能力。但随压力的升高，吸附能力增加的幅度降低。吸附系数与压力之间的关系可用指数方程描述。

关键词　盐度，压力，近海沉积物，吸附，毒性有机物。

天然沉积物是由多种成分组成的混合物。沉积物中的各种组分对毒性有机污染物的吸附能力、吸附规律不尽相同[1-4]。海洋的水质、水文等因素对沉积物中各组分的吸附行为必将产生不同的影响。盐度是海水的特征因素之一。近海海水的盐度一般在10‰－35.5‰之间。海水的盐度不同，沉积物颗粒表面的物理化学性质也不同。因此，沉积物对污染物的吸附能力也会发生变化。水压是海洋的另一特征因素。由于海水深，水柱所产生的压力必然对沉积物的吸附行为产生影响。

本文通过将大连近海沉积物逐级分离，研究盐度、压力对沉积物中2组分吸附毒性有机物行为的影响。

1　实验部分

1.1　实验材料

（1）硝基苯　1，2，4，5-四氯苯，γ-666和邻苯二甲酸二正丁酯为美国EPA标准样品，从中国环境监测总站购得。溶剂苯为优级纯，北京化工厂生产。溶剂石油醚（60—90℃沸程）为分析纯，大连旅顺东风化工厂生产。使用前重蒸馏。

大连近海沉积物样品，有机质含量2.5%。样品经逐级分离，备用。

Kester人工海水[5]。该人工海水的盐度为35‰。人工海水用蒸馏水稀释成10‰，20‰，30‰，或蒸发浓缩至40‰。用0.45 μm生物滤膜过滤，备用。

（2）主要仪器　HYA恒温摇瓶机，LG10-2.4A高速离心机，Snyder浓缩器，日本岛津GC-9A气相色谱仪配Ni^{63}的ECD。

1.2　实验方法

（1）盐度影响实验　将1.00 g原级或分级沉积物样品（原级样品含无机和有机组分，分级样品为去除有机质后的无机组分）分别加入到各自系列磨口三角瓶内，向各瓶内加入30 ml人工海水。将该沉积物/水混合体系于25℃下振荡2 h，然后加入不同浓度的毒性有机物，加盖磨口塞。在同样条件下振荡平衡8 h。将沉积物/水体系移入离心管内，高速离心15 min。准确移取10 ml上清液加入到分液漏斗，用5 ml苯-石油醚（1∶1）分2次萃取有机物。有机相用无水Na_2SO_4干燥后，用Snyder浓缩器浓缩至0.5—1 ml，重新定容，用GC-ECD测定浓缩液

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中有机物浓度，外标法定量。将测定浓度换算成平衡浓度，用差减法计算出沉积物上的吸附量。

(2) 压力影响实验　用于本实验的压力容器见图1。压力容器由不锈钢外壳加内厚壁玻璃容器组成。内体积约12 dm^3。内加10 L海水和200 g原级(或分级)样品。静止平衡48 h。加入有机物标准溶液，旋紧顶盖，旋开各气体阀门，加压。定时旋开取样阀门，每次取30 ml水样品。改变压力，重复上述操作。水样处理步骤与盐度影响实验相同。

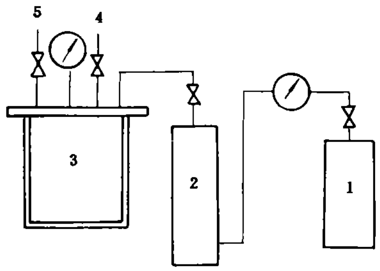

图1　压力影响实验装置
1. 钢瓶　2. 缓冲瓶　3. 压力容器
4. 取样口　5. 排气口

2　结果与讨论

2.1　沉积物化学逐级分离相关公式

沉积物经化学逐级分离后，每种组分上的吸附量用下式计算：

$$G_{1,2,\cdots n} = a_n G_1 + b_n G_2 + \cdots x_n G_n \quad (1)$$

$$G_{1,2,\cdots n-1} = a_{n-1} G_1 + b_{n-1} G_2 + \cdots + x_{n-1} G_{n-1} \cdots$$

$$\cdots$$

$$G_{1,2} = a_2 G_1 + b_2 G_2$$

$$G_1^{测} = G_1^{计}$$

$G_1^{测}$，$G_{1,2}$，$G_{1,2,\cdots n-1}$，$G_{1,2,\cdots,n}$为沉积物各分级样品和原级样品上的吸附量，通过实验测得。G_1，G_2，…，G_n为沉积物中第1，第2和第n组分上的吸附量，该值用(1)式逐项计算得到。本文中，把沉积物视为无机和有机质2组分组成，故n取2。

2.2　盐度对吸附的影响

不同盐度下，原级样品的吸附量数据$G_{1,2}$、G_1和用(1)式计算的4种毒性有机物在有机质上的吸附量(G的单位均为$\mu g/g$)，与平衡浓度c_e(mg/L)一并列于表1。前期工作表明，毒性有机物在沉积物中无机颗粒上的吸附符合Langmuir吸附等温式：

即
$$G_1 = \frac{L_0 C_e}{A + C_e} \quad (2)$$

而在有机质上的吸附符合线性吸附等温式，

即
$$G_2 = K_{OC} C_e \quad (3)$$

因此，将求得的毒性有机物在无机质上和有机质上的吸附数据用对应等温式拟合得到如表2所示的吸附等温方程。

盐度对吸附量的影响，实际上是通过改变吸附剂或吸附质的物理化学性质引起的。这种影响可通过吸附等温方程中具有明确物理含义的系数反映出来。例如，langmuir方程中L_0表示极限吸附量，该系数可表征吸附剂的吸附能力。线性方程(3)式中，系数K_{OC}表示吸附质在沉积物与水间的分配比，表征有机质对吸附质的亲合力。该2个系数与盐度S‰相关，用来表示盐度对吸附的影响(见表2)。从极限吸附量L_0与盐度S和K_{OC}与S的相关方程可知，盐度对毒性有机物在无机组分和有机组分上的吸附具有不同的影响。对确定的化合物来说，在无机质上毒性有机物的极限吸附量L_0随盐度的增高而减小；在有机质上K_{OC}却随盐度的增高而增大。对所试的4种毒性有机物，盐度在10‰—40‰内L_0变化了－22.5%～－72.8%，K_{OC}变化了11.7%－84.3%，说明盐度对毒性有机物在沉积物上的吸附具有显著影响。

2.3　压力对吸附的影响

一般河口、海湾和其他近海海水水深数10 m，沉积物表面所受到的压力为0—10 MPa之间。因此，选择的压力范围为0.1—0.5 MPa，代表着约10—50 m深处的压力。用沉积物原级样品和分级样品作为吸附剂，以1，2，4，5-四氯苯和γ-666为吸附质进行吸附实验。用(1)式计算出沉积物中无机质和有机质上的吸附

表 1　不同盐度下 4 种毒性有机物在沉积物各组分上的吸附量

盐度(‰)		硝基苯				
40	C_e	0.022	0.043	0.059	0.076	0.094
	G_{12}	0.064	0.129	0.174	0.226	0.261
	G_1	0.035	0.065	0.089	0.106	0.131
	G_2	1.21	2.63	3.48	4.92	5.32
35	C_e	0.021	0.040	0.055	0.074	0.091
	G_{12}	0.059	0.114	0.149	0.205	0.245
	G_1	0.034	0.063	0.082	0.110	0.130
	G_2	1.03	2.12	2.78	3.92	4.73
30	C_e	0.020	0.038	0.052	0.072	0.088
	G_{12}	0.569	0.110	0.140	0.193	0.231
	G_1	0.034	0.064	0.086	0.107	0.130
	G_2	0.95	1.89	2.25	3.55	4.18
20	C_e	0.021	0.039	0.050	0.072	0.090
	G_{12}	0.059	0.108	0.138	0.173	0.242
	G_1	0.039	0.071	0.088	0.122	0.155
	G_2	0.86	1.55	2.09	2.78	3.62
10	C_e	0.018	0.034	0.050	0.068	0.089
	G_{12}	0.055	0.105	0.143	0.195	0.248
	G_1	0.041	0.075	0.108	0.148	0.183
	G_2	0.60	1.26	1.53	2.02	2.98

盐度(‰)		1，2，4，5-四氯苯				
40	C_e	0.016	0.033	0.054	0.075	0.096
	G_{12}	1.68	3.52	5.58	7.82	9.68
	G_1	1.03	2.06	3.25	4.44	5.55
	G_2	26.9	60.3	96.5	139.5	170.7
35	C_e	0.017	0.035	0.055	0.075	0.097
	G_{12}	1.87	3.86	5.83	7.86	9.40
	G_1	1.15	2.36	3.50	4.63	5.79
	G_2	29.8	62.5	96.5	133.7	172.2
30	C_e	0.018	0.035	0.056	0.076	0.098
	G_{12}	1.94	3.85	5.93	8.10	10.0
	G_1	1.24	2.37	3.63	4.84	5.97
	G_2	29.2	61.8	95.7	135.3	168.5
20	C_e	0.019	0.036	0.058	0.076	0.098
	G_{12}	2.42	4.46	7.07	8.83	11.7
	G_1	1.63	3.02	4.68	5.92	7.49
	G_2	33.2	60.5	100.3	122.5	170.7
10	C_e	0.020	0.036	0.058	0.078	0.100
	G_{12}	2.50	4.49	7.20	9.37	12.2
	G_1	1.79	3.16	4.93	6.37	8.05
	G_2	30.4	56.6	95.7	126.3	157.8

盐度(‰)		γ-666				
40	C_e	0.012	0.031	0.053	0.074	0.096
	G_{12}	1.16	2.85	4.76	6.37	8.21
	G_1	0.330	0.756	1.10	1.37	1.58
	G_2	33.6	84.5	147.5	201.3	267.0
35	C_e	0.014	0.033	0.056	0.075	0.099
	G_{12}	1.34	2.94	4.84	6.44	8.42
	G_1	0.412	0.846	1.26	4.420	1.84
	G_2	37.7	85.8	144.6	202.4	265.2
30	C_e	0.014	0.034	0.057	0.077	0.101
	G_{12}	1.32	3.12	4.86	7.74	8.24
	G_1	0.451	0.928	1.38	1.59	1.90
	G_2	35.1	88.8	144.4	199.8	255.7
20	C_e	0.015	0.034	0.058	0.078	0.102
	G_{12}	1.39	2.97	4.85	6.21	8.09
	G_1	0.513	0.990	1.48	1.74	2.08
	G_2	35.5	80.1	136.2	180.5	242.6
10	C_e	0.015	0.036	0.059	0.078	0.105
	G_{12}	1.36	3.03	4.83	5.87	8.15
	G_1	0.550	1.14	1.54	1.86	2.35
	G_2	33.1	76.8	133.2	162.2	234.5

盐度(‰)		邻苯二甲酸二正丁酯				
40	C_e	0.006	0.014	0.032	0.054	0.076
	G_{12}	128.1	229.8	435.6	684.1	908.5
	G_1	65.8	82.9	95.8	98.7	100.6
	G_2	2560	5958	13688	23055	32416
35	C_e	0.006	0.015	0.034	0.056	0.078
	G_{12}	191.3	309.7	525.2	750.2	984.8
	G_1	133.0	160.9	182.3	185.3	190.1
	G_2	2464	6112	13897	22784	31982
30	C_e	0.008	0.016	0.035	0.057	0.080
	G_{12}	256.8	348.3	549.8	761.2	987.3
	G_1	184.0	200.4	218.1	220.6	223.1
	G_2	3098	6115	13488	21488	30793
20	C_e	0.008	0.017	0.035	0.058	0.081
	G_{12}	327.3	430.5	613.4	824.6	1042.5
	G_1	259.5	282.8	300.3	304.6	310.4
	G_2	2967	6192	12824	21114	29597
10	C_e	0.010	0.018	0.036	0.060	0.084
	G_{12}	407.8	492.9	667.7	878.9	1091.4
	G_1	329.6	348.5	369.8	373.3	382.1
	G_2	3458	6125	12286	20597	28755

量，所得到的 G_1、G_2 和 $G_{1,2}$值列于表 3。与 2.2 中讨论的同样原因，2 种毒性有机物在无机质上的吸附用 langmuir 等温式拟合；在有机质上的吸附用线性等温式表示。各吸附等温方程列于表 4。从表 3 和表 4 可知，随着压力的升高，2 种毒性有机物在 2 种沉积物组分上的吸附量随之升高，但升高的幅度逐渐降低。这种规律可用指数方程描述。将极限吸附量 L_0 和沉积物-

表 2 4种毒性有机物在不同盐度下的吸附等温线与 L_0 和 K_{OC}-S 相关方程

沉积物	盐度(‰)	硝基苯	1,2,4,5-四氯苯	γ-666	邻苯二甲酸二正丁酯
无	40	$G_{40}=0.75C_e/(0.452+C_e)$	$G_{40}=41.7C_e/(0.629+C_e)$	$G_{40}=3.52C_e/(0.114+C_e)$	$G_{40}=105C_e/(3.62\times10^{-3}+C_e)$
	35	$G_{35}=0.82C_e/(0.484+C_e)$	$G_{35}=42.6C_e/(0.612+C_e)$	$G_{35}=3.82C_e/(0.116+C_e)$	$G_{35}=196C_e/(2.84\times10^{-3}+C_e)$
机	30	$G_{30}=0.93C_e/(0.514+C_e)$	$G_{30}=45.4C_e/(0.636+C_e)$	$G_{30}=3.84C_e/(0.106+C_e)$	$G_{30}=228C_e/(2.02\times10^{-3}+C_e)$
	20	$G_{20}=1.21C_e/(0.629+C_e)$	$G_{20}=52.6C_e/(0.59+C_e)$	$G_{20}=4.17C_e/(0.107+C_e)$	$G_{20}=315C_e/(1.83\times10^{-3}+C_e)$
质	10	$G_{10}=1.51C_e/(0.654+C_e)$	$G_{10}=58.8C_e/(0.64+C_e)$	$G_{10}=4.54C_e/(0.11+C_e)$	$G_{10}=387C_e/(1.86\times10^{-3}+C_e)$
	L_0-S	$L_0=1.744-0.026S$	$L_0=64.6-0.615S$	$L_0=4.84-0.032S$	$L_0=486.7-8.91S$
	r	-0.9945	-0.9869	-0.9880	-0.9860
有	40	$G_{40}=59.9C_e$	$G_{40}=1.81\times10^3C_e$	$G_{40}=2.75\times10^3C_e$	$G_{40}=4.26\times10^5C_e$
	35	$G_{35}=52.3C_e$	$G_{35}=1.77\times10^3C_e$	$G_{35}=2.66\times10^3C_e$	$G_{35}=4.08\times10^5C_e$
机	30	$G_{30}=48.5C_e$	$G_{30}=1.74\times10^3C_e$	$G_{30}=2.57\times10^3C_e$	$G_{30}=3.84\times10^5C_e$
	20	$G_{20}=39.8C_e$	$G_{20}=1.70\times10^3C_e$	$G_{20}=2.35\times10^3C_e$	$G_{20}=3.65\times10^5C_e$
质	10	$G_{10}=32.5C_e$	$G_{10}=1.62\times10^3C_e$	$G_{10}=2.19\times10^3C_e$	$G_{10}=3.42\times10^5C_e$
	K_{OC}-S	$K_{OC}=22.8+0.88S$	$K_{OC}=1.56\times10^3+5.9S$	$K_{OC}=1.99\times10^3+19.0S$	$K_{OC}=3.11\times10^5+2.73+10^3S$
	r	0.9924	0.9924	0.9985	0.9854

表 3 不同压力下 2 种毒性有机物在沉积物各组分上的吸附量

压力(MPa)		1,2,4,5-四氯苯					压力(MPa)		γ-666				
0.1	C_e	0.034	0.056	0.078	0.094	0.112	0.1	C_e	0.015	0.033	0.054	0.068	0.086
	G_{12}	3.44	6.42	7.49	9.48	10.05		G_{12}	2.29	4.91	7.49	9.69	11.68
	G_1	2.36	4.52	5.04	6.26	6.43		G_1	1.54	3.08	4.95	5.81	7.12
	G_2	45.7	80.6	102.59	135.2	151.2		G_2	31.4	76.3	106.5	161.0	189.2
0.2	C_e	0.032	0.053	0.072	0.089	0.106	0.2	C_e	0.013	0.032	0.052	0.064	0.085
	G_{12}	3.86	6.35	8.10	10.46	12.08		G_{12}	2.99	7.49	9.91	13.44	16.00
	G_1	2.68	4.29	5.53	6.72	8.24		G_1	2.16	5.26	6.34	8.92	10.2
	G_2	50.1	86.6	108.3	154.2	161.8		G_2	35.6	94.4	149.4	189.8	242.2
0.3	C_e	0.028	0.050	0.068	0.083	0.099	0.3	C_e	0.011	0.029	0.051	0.062	0.079
	G_{12}	4.18	6.98	9.71	11.10	13.97		G_{12}	4.51	8.72	12.81	16.59	20.33
	G_1	2.84	4.82	6.45	7.58	8.96		G_1	2.56	5.95	8.57	10.9	13.2
	G_2	56.3	108.6	136.9	146.5	209.3		G_2	39.2	116.8	178.4	238.5	298.6
0.4	C_e	0.028	0.048	0.066	0.082	0.094	0.4	C_e	0.009	0.024	0.044	0.058	0.072
	G_{12}	4.42	7.70	10.04	12.71	13.74		G_{12}	3.81	9.58	14.94	20.46	21.91
	G_1	2.96	4.94	6.48	8.00	8.73		G_1	2.64	6.31	9.32	12.4	12.8
	G_2	61.5	115.4	148.8	196.5	209.0		G_2	49.4	137.2	234.3	334.7	379.7
0.5	C_e	0.026	0.046	0.065	0.080	0.093	0.5	C_e	0.008	0.021	0.039	0.053	0.068
	G_{12}	4.28	7.77	10.30	12.82	14.35		G_{12}	3.53	9.29	14.67	19.35	22.6
	G_1	2.85	4.94	6.65	8.10	8.96		G_1	2.59	6.17	9.98	12.20	13.9
	G_2	60.3	118.2	152.7	202.8	224.6		G_2	40.4	131.3	197.6	298.1	362.0

水分配系数 K_{OC} 与压力 P 相关，得到如下方程：

无机组分上 $$L_0 = ap^n \quad (4)$$

有机组分上 $$K_{OC} = bp^m \quad (5)$$

对 2 式取对数，得到：

$$\lg L_0 = \lg a + n\lg P \quad (6)$$

或 $$\lg K_{OC} = \lg b + m\lg P \quad (7)$$

其中 a 和 b 表示压力为 1 时的 L_0 或 K_{OC}；n 和 m 表示压力对 2 个吸附系数 L_0 和 K_{OC} 的影响程度的参数，可称压力系数。用(6)和(7)的截距和斜率可确定 a、n 和 b、m。2 种毒性有机物的 L_0 和 K_{OC} 与压力 P 的相关方程列于表 4。

表4 2种毒性有机物在不同压力下的吸附等温线与 L_0 和 K_{OC}-P 相关方程

沉积物	压力(MPa)	γ-666		1，2，4，5-四氯苯	
无机物	0.1	$G_1=28.7C_e/(0.265+C_e)$	$r=0.9927$	$G_1=45.4C_e/(0.596+C_e)$	$r=0.9658$
	0.2	$G_2=31.0C_e/(0.161+C_e)$	$r=0.9867$	$G_2=49.8C_e/(0.565+C_e)$	$r=0.9815$
	0.3	$G_3=35.2C_e/(0.141+C_e)$	$r=0.9829$	$G_3=55.7C_e/(0.524+C_e)$	$r=0.9926$
	0.4	$G_4=36.2C_e/(0.118+C_e)$	$r=0.9565$	$G_4=57.3C_e/(0.511+C_e)$	$r=0.9736$
	0.5	$G_5=37.0C_e/(0.102+C_e)$	$r=0.9920$	$G_5=58.8C_e/(0.505+C_e)$	$r=0.9627$
	L_0-P	$L_0=41.97P^{0.169}$	$r=0.9797$	$L_0=66.7P^{0.169}$	$r=0.9881$
有机物	0.1	$G_1=2.25\times10^3C_e$	$r=0.9520$	$G_1=1.40\times10^3C_e$	$r=0.9546$
	0.2	$G_2=2.92\times10^3C_e$	$r=0.9521$	$G_2=1.60\times10^3C_e$	$r=0.9455$
	0.3	$G_3=3.82\times10^3C_e$	$r=0.9694$	$G_3=1.97\times10^3C_e$	$r=0.9900$
	0.4	$G_4=5.37\times10^3C_e$	$r=0.9970$	$G_4=2.33\times10^3C_e$	$r=0.9650$
	0.5	$G_5=5.30\times10^3C_e$	$r=0.9611$	$G_5=2.46\times10^3C_e$	$r=0.9650$
	K_{OC}-P	$K_{OC}=8.12\times10^3P^{0.502}$	$r=0.9744$	$K_{OC}=3.15\times10^3P^{0.371}$	$r=0.9767$

从以上结果可知，压力对吸附行为具有明显的影响。2种毒性有机物的 L_0 和 K_{OC} 在0.1—0.5 MPa内增大28.9%—130%。可见，具有相同组成的沉积物在深的海域比在浅的海域具有更高的吸附容量。因此，对海域有机物的污染研究时，压力对吸附的影响不容忽略。

3 结论

(1) 在10‰—40‰盐度变化范围内，随着盐度的升高，沉积物中无机组分对4种毒性有机物的吸附能力呈线性降低；有机组分的吸附能力呈线性增高。其变化范围为11.7%—84.3%。

(2) 在0.1—0.5 MPa的压力变化范围内，随着压力的升高，沉积物中无机组分和有机组分对2种毒性有机物的吸附能力增高。但随着压力的增大，吸附能力增加幅度减小。这种规律可用指数方程描述。

(3) 各种因素对沉积物中各组分吸附毒性有机物的影响，可用化学逐级分离法分别描述。

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Abstracts

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A Study on the Biodegradation of Organic Substances by ATP Test. Sun Lixin et al. (Dept. of Environ. Eng., Tsinghua Univ., Beijing 100084): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 1—4

In this paper, the aerobic biodegradation of organic substances is characterized by the determination of the energy change, ATP content in microbial cells during the biodegradation. A satisfactory result was obtained under the following conditions: the initial concentration of the tested substance is 100 mg/L (as DOC), the amount of the inoculum in the biological medium is 500 mg/L (as MLSS), and the duration of test time is 14 days. The evaluating system (peak time, peak height index and IA index) is proposed to assess the biodegradability of 40 organic substances and 7 wastewater.

Key words: biodegradation, ATP, ATP test, IA index.

Effect of Salinity and Water Pressure on Adsorption of Toxic Organic Chemicals on Separated Submarine Sediment. Quan Xie et al. (Dalian Univ. of Technology, Dalian 116012): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 5—9

The organic and inorganic components of the submarine sediment from Dalian Bay were separated with a sequential chemical separation procedure. The adsorption of several toxic organic chemicals (TOCs) on the separated sediment samples and the effect of salinity and water pressure on the adsorptions were investigated. The conclusions were made as follows: (1) The adsorption capacity of organic components on the sediment increased as the salinity of water increased, but reduced for inorganic components. The relationships could be described with linear equations. (2) The adsorption capacity of both organic and inorganic components increased as the water pressure increased. The relationships could be described with exponential equations.

Key words: salinity, water pressure, submarine sediment, toxic organic chemicals.

The Influence of Diffusive Processes on Overlying Waters at the Sediment-water Interface of Lake Lugu. Wu Fengchang and Wan Guojiang (State Key Lab. of Environ. Geochem., Chinese Academy of Sciences, Guiyang 550002): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 10—12

Through the study on Ca^{2+}、K^{+}、Na^{+}、HCO_3^- and pH profiles of water column and porewater of Lake Lugu, Yunnan, a half-close and deep lake, it was found that Ca^{2+}、K^{+}、Na^{+} and HCO_3^- in the sediments could diffuse to overlying water and their diffusive flux and their influence extent on overlying water could be quantitatively estimated. At also indicates that the interreactions between sediment and water play a significant role in controlling basic chemical composition of some lakes.

Key words: diffusive processes, sediment-water interface, Lake Lugu.

The Experimental Study on Decolorization of Dye Wastewater with Pulse Corona Discharge. Li Shengli et al. (Environment Center of Science and Technology, HUST 430074): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 13—15

A new method to decolor dye wastewater with pulse corona discharge has been developed. Nonequilibrium plasma produced by high voltage pulse discharge contacts with dye wastewater and decolorization of dye wastewater can be achieved quickly. The results showed that the decolorization rate can be reached more than 95% by treating wastewater for 40 s at pulse peak voltage of 38 kV and there is influence, of pH value on decolorization rate. When pulse peak voltage is lower, the influences of pH value on decolorization rate are appeared. The decolorization rate of neutral dye wastewater is only reached about 40%—50% after treating for 40 s. However, the decolorization rate can be reached more than 80% at $pH<4$ or >7. The experimental results of adding NaCl or Na_2SO_4 into dye wastewater have showed that Cl^- is able to decrease decolorization and SO_4^{2-} just opposite.

Key words: dye wastewater, decolorization, pulse corona discharge, pulse peak voltage.

Study on the Leaching Experiments of Minor and Trace Elements in Coal and Its Burnt Products. Wang Yunquan et al. (Beijing Graduate School, China Univer. of Mining and Technology, Beijing 100083): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 16—18

The comparative leaching experiments of coal (C), ashing ash (AA), fly ash (FA) and bottom ash (BA) have been carried out under different pH conditions. The leaching behaviour of As, Zn, Pb, Ni and Sr have been investigated in detail. The results have shown that the pH values of solution, leaching time, and particularly, the properties and species of the elements existed have heavily influenced on the leaching behaviour of elements. Among the 5 elements analysed, the leaching ability of Sr is strong, Pb and As strong to middle, Ni middle and Zn weak.

Key words: coal and its burnt products, minor and trace elements, leaching experiments.

A Study on Adsorption, Desorption and Biodegradation of Pentachlorophenol by Anaerobic Granular Sludge. Shen Dongsheng et al. (Dept. of Environ. Science, Zhejiang Agricultural Univ., Hangzhou, 310029): *Chin. J. Environ. Sci.*, **17**(1), 1996, pp. 20—23

PCP degrading anaerobic sludge granules may be developed in upflow anaerobic digestion reactors (UAD) seeded with sludges acclimated to chlorophenols, the reactors are able to remove more than 99.5% of PCP in a synthetic wastewater at the concentration of 170 to 180 mg/L, volumetric loading rate up to 200 to 220 mg/(L · d), and hydraulic retention time of 20 to 22 hours. Biosorption and desorption isotherms of pentachlorophenol were determined, and the data were fitted to Freundlich equation. However, it was found that the biosorption of PCP was partly irreversible, and the Freundlich models with empirical constants determined from this study can quite well describe the partition behavior of pentachlorophenol in anaerobic upflow digestion reactor. It was demonstrated