模拟酸雨对山东主要土壤类型理化性质的影响*

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摘要 以 pH2、3、4、5的模拟酸雨, 对山东省棕壤、褐土、潮土、砂姜黑土、盐渍土等5种土壤进行1- 10a 室内淋洗土柱试验. 结果表明, 除棕壤在 pH2的模拟酸雨淋洗第4a 开始酸化以外, 其余4种土壤10a 淋滤液 pH 值均大于7; 模拟酸雨淋洗土壤10a, 土壤淋失盐基总量是褐土> 砂姜黑土> 盐渍土> 潮土> 棕壤; 盐基离子对酸雨的敏感性为 $Ca^{2+} > Mg^{2+} > K^+$、Na^+; 模拟酸雨对土壤中铝的活化作用是除棕壤 pH2出现活性铝外, 其余土壤均未出现. 对酸化棕壤施用 CaO 进行改良, 效果明显.

关键词 模拟酸雨, 土壤pH, 土壤电导率, 土壤盐基, 盐基离子, 水壤活性铝, 淋洗水柱试验, 土壤改良.

国内外对酸雨的成因, 酸雨对森林、农作物、湖泊等危害方面研究报道较多, 而酸雨对土壤物理化学性质影响及危害的研究甚少, 酸雨对我国北方土壤影响和危害的研究鲜见报道, 为此, 笔者设计模拟酸雨淋洗土柱试验, 在短期内通过模拟多年酸雨量对土壤淋洗, 来了解现实酸雨对土壤理化性质的影响和危害.

1 材料与方法

1.1 供试土壤

采集山东棕壤、褐土、潮土、砂姜黑土、盐渍土5种土壤的样品, 分析其基本性状如表1.

1.2 模拟酸雨

按山东酸雨特征, 以硫酸根与硝酸根的摩尔比为5∶1来配制模拟酸雨, 并调节 pH 为2、3、4、5, 以纯水作对照.

表1 土壤基本性状

土壤类型	采样地点	CEC /cmol·kg^{-1}土	$CaCO_3$ /%	pH	电导率 /μs·cm^{-1}	盐基离子/mg·100g^{-1}土			
						Ca^{2+}	Mg^{2+}	K^+	Na^+
棕壤	青岛市崂山	10.67		6.9	1.80×10^2	11.88	2.03	1.25	4.06
褐土	济南市王舍人镇	12.42	3.36	8.3	1.51×10^2	34.36	2.31	0.57	1.31
潮土	梁山县代庙乡	8.82	7.28	8.2	3.36×10^2	18.40	1.36	1.10	1.30
砂姜黑土	淄博市张店	18.52	2.74	7.9	2.20×10^2	14.00	4.20	0.50	6.75
盐渍土	利津县王庄乡	1.90	6.60	8.6	2.30×10^2	9.00	3.42	1.25	3.50

1.3 试验方法

盛土容器为白色空心硬质塑料管, 装置土柱直径为4.5cm 高20cm, 每柱土重400g. 各处理为模拟酸雨 pH2、3、4、5, 对照, 并重复3次.

模拟酸雨雨量以青岛市、济南市、淄博市、梁山县、利津县年平均降雨量775mm、685mm、639mm、604mm、542mm 的60% 进入土壤计算, 连续淋洗1- 10_a, 收集2、4、5、6、8、10_a 的淋滤液进行分析测定.

用 CaO 对通过模拟酸雨淋洗10a 已酸化的土壤, 进行土壤混合施用及表面覆盖的改良试验, 以确定减轻酸雨对土壤危害的对策和效果.

1.4 测定方法

用塑料瓶承接淋滤液, 分别测定以下项目:

电导率用 DDS-11A 型电导率仪测定; pH 值用 pHS-2型酸度计测定; K^+、Na^+ 用火焰光度计测定; Ca^{2+}、Mg^{2+} 用 EDTA 络合滴定法测定; 活性铝用玫瑰红三羧酸铵比色法测定. 以上

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各项测定均重复3次. 机械组成分析采用常用比重计法测定.

2　结果与讨论

2.1　模拟酸雨对山东5种土壤 pH 值的影响

5种土壤经模拟酸雨淋洗10_a 其淋滤液 pH 值变化如图1. 从图1看出, 5种土壤经 pH2、3、4、5模拟酸雨淋洗10a, 淋滤液 pH 值均大于7. 棕壤却与之截然不同, 经 pH3的模拟酸雨淋洗10_a, 淋滤液 pH 值为6.30; 用 pH2的模拟酸雨淋洗的淋滤液 pH 值由第2a 的6.15降到第4年的2.43, 最低为2.13, 说明棕壤经 pH2的模拟酸雨淋洗从第4a 开始酸化.

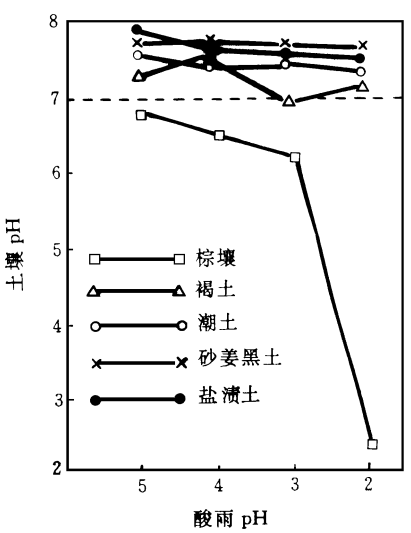

图1　模拟酸雨淋洗10a 土壤 pH 值变化

2.2　土壤淋滤液的电导率变化

山东5种土壤模拟酸雨10a 的淋滤液电导率测定结果表明, pH3、4、5的模拟酸雨淋洗5种土壤其淋滤液电导率在10_a 中变化趋势相近, 均在第2_a 电导率值增大, 从第4_a 起开始逐年缓慢降低最后稳定在一个水平上. 而 pH2的模拟酸雨5种土壤表现的差异很大, 棕壤电导率从第2a 起增加, 到第8a、第10a 达到11.30、11.20$\mu s/cm \times 10^2$. 褐土电导率是从第2a 到第6a 逐渐降低, 第8a 又猛增到$80\mu s/cm \times 10^2$, 到第10a 又降到$60\mu s/cm \times 10^2$, 成折线型. 而潮土却是第2a 淋滤液电导率最大为$32.75\mu s/cm \times 10^2$, 自第4a 以后降低并稳定到$4\mu s/cm \times 10^2$左右. 砂姜黑土电导率是第2a 最大, 达到$80\mu s/cm \times 10^2$, 第4a 又降到$42\mu s/cm \times 10^2$, 从第$6_a$ 后又呈增加趋势. 盐渍土淋滤液电导率第2a、第4a 增加第6a 以后降低.

从5种土壤经模拟酸雨 pH2、3、4、5淋洗10a 的淋滤液电导率图2看出, 5种土壤淋滤液电导率值大小为褐土> 砂姜黑土> 棕壤> 盐渍土> 潮土, 又与模拟酸雨的 pH 值成负相关, 电导率值均为 pH2> pH3> pH4、pH5.

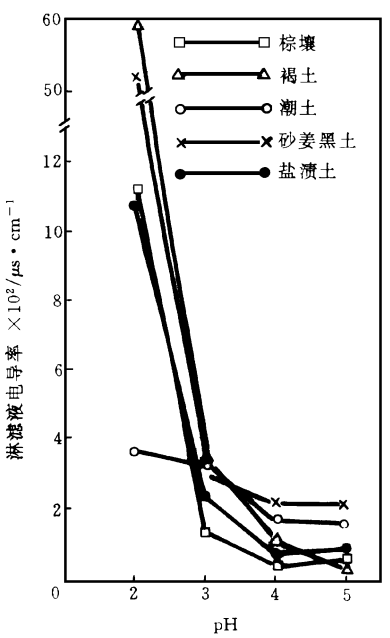

图2　5种土壤10_a 淋滤液电导率变化

2.3　模拟酸雨对土壤盐基淋溶的特性

模拟酸雨淋洗5种土壤10_a, 其淋滤液的盐基离子总量如表2所示, 由表2看出, 5种土壤的盐基淋失与降雨酸度和土壤类型有关.

(1)　模拟酸雨对盐基淋失总量的影响10a 雨量淋失盐基总量是褐土> 砂姜黑土> 盐渍土> 潮土> 棕壤, 并与酸雨的$[H^+]$呈显著正相关, 其相关系数棕壤 $r = 0.920$, 褐土 $r = 0.870$, 潮土 $r = 0.910$, 砂姜黑土 $r = 0.887$, 盐渍土 $r = 0.898$, n 均为4.

(2)　模拟酸雨对盐基离子的影响　盐基离子对酸雨的敏感性表现为: $Ca^{2+} > Mg^{2+} > K^+$、Na^+. Ca^{2+}、Mg^{2+} 最为敏感, 在 pH2－4范

围内, 淋失量随降雨酸度增加而急剧升高.

5种土壤经过 pH4模拟酸雨淋洗10a, Ca^{2+} 淋失量棕壤为 9.47mg/100g 土, 褐土为 45.95mg/100g 土, 潮土为48.06mg/100g 土, 砂姜黑土为 64.63mg/100g 土, 盐渍土为 35.06mg/100g 土, 淋雨酸度增加至 pH3和 pH2时, 其10a雨量淋失的 Ca^{2+} 棕壤增加2.8倍和10倍, 褐土增加1.4倍和9.7倍, 潮土增加1.5倍和5.6倍, 砂姜黑土增加1.4倍和6.3倍, 盐渍土增加2倍和10倍.

Mg^{2+} 的淋失量特征是: 棕壤中 Mg^{2+} 对 pH2的酸雨处理最为敏感, 模拟酸雨淋洗10a, Mg^{2+} 的淋失量为 pH3处理的4.8倍, 为 pH4处理的11倍, 而褐土、潮土、砂姜黑土、盐渍土 pH2模拟酸雨淋洗10aMg^{2+} 的淋失量为 pH3处理的1.5– 6.7倍, pH4处理的2– 7倍, 因此, 在酸雨危害的棕壤地区, 土壤由酸雨引发的缺 Mg^{2+} 不容忽视.

K^+ 对酸雨淋洗表现不太敏感, 5种土壤 K^+ 淋失量10a 均不超过9mg/ 100g 土, 其中需要注意的是棕壤, 从图3看出棕壤经酸雨淋洗10a 其淋滤液中 K^+ 总量, pH2酸雨处理的为 pH3处理的3.6倍, pH4处理的6.7倍, 是 pH5和对照处理的8倍, 所以棕壤要防止酸雨引发缺 K^+.

Na^+ 对不同处理的酸雨淋洗很不敏感, 5种土壤的 Na^+ 在模拟酸雨 pH2、3、4、5和对照处理淋洗10a 累积淋失量大体相近.

表2 5种土壤与模拟酸雨10a 盐基淋失总量关系 /mg·100g^{-1}土

土 类	pH			
	2	3	4	5
棕壤	133.69	39.09	17.97	18.14
褐土	507.08	76.07	56.65	52.97
潮土	336.62	120.28	88.30	82.06
砂姜黑土	455.52	111.39	80.89	77.22
盐渍土	405.48	85.80	46.58	43.22

2.4 模拟酸雨对土壤中铝的活化影响

山东5种土壤经模拟酸雨 pH2、3、4、5淋洗10a, 除棕壤 pH2出现活性铝外, 其余土壤均未出现. 棕壤活性铝是在 pH2模拟酸雨淋洗第2a出现的, 活性铝量为0.50mg/ 100g 土, 第4年增为1.47mg/100g 土, 第6a 为1.50mg/100g 土,

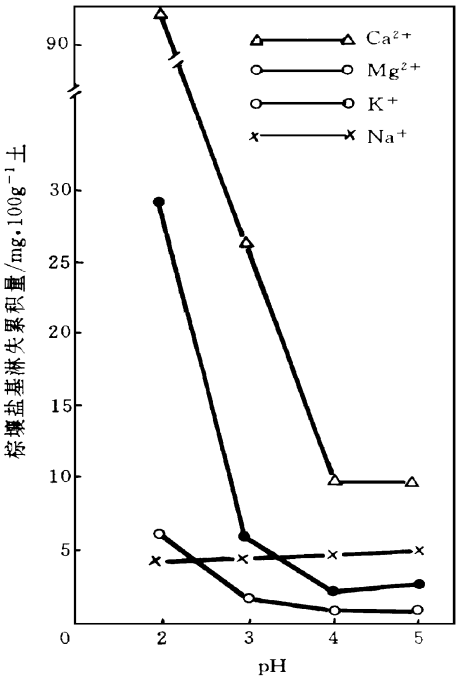

图3 模拟酸雨对棕壤盐基离子10a 淋失量的影响

第8a 为1.47mg/100g 土, 第10a 达到1.71mg/100g 土, 10a 累积活性铝量为13.30mg/ 100g 土, 棕壤活性铝量是随模拟强酸雨淋洗时间增加而增加. 说明强酸雨加速了粘土矿物的破坏, 将土壤中矿物铝转化为活性铝溶出. 土壤活性铝出现, 意味着土壤理化性质变坏, 并会通过地下水, 引起水体污染.

2.5 模拟酸雨对土壤机械组成的影响

对5种土壤经 pH2、3、4、5处理的模拟酸雨淋洗10a 的结果表明, 土壤的机械组成与对照相比, 除 pH2强酸雨对5种土壤机械组成粘粒(粒径< 0.001– 0.005mm)、粉粒(0.005– 0.05mm) 和砂粒(0.05– 1mm) 有影响, 增加或减少1或2个百分点以外, pH3、4、5处理的酸雨连续淋洗5种土壤10a, 机械组成的变化均不明显.

2.6 酸化棕壤的改良及其效果

通过不同酸度的模拟酸雨淋洗棕壤可以看出, 用 pH≤3的酸雨处理棕壤理化性状受到不同程度的危害, pH3的酸雨虽危害较轻, 但长期的累积影响明显, pH2的酸雨淋洗2a 后就使土壤的缓冲性能受到破坏, 营养物质不断释出, 有

毒物质铝的活性加大, 不断从土壤溶出, 因此对这2类酸化棕壤作了施 CaO 的改良试验. 施 CaO 的数量根据酸化棕壤消耗的碱量来确定. pH3酸雨处理的棕壤施用 CaO 为65kg/hm^2, pH2酸雨处理的棕襄施用 CaO 为900kg/hm^2, 分表施和与土壤混施2种方法, 用清水按年均降雨量的60%进入土壤, 连续淋洗8a, 测定淋滤液的结果列于表3和表4.

表3 酸化棕壤改良后不同年份淋滤液的 **pH** 值

年份	对照	pH3		pH2	
		表施 CaO	混施 CaO	表施 CaO	混施 CaO
第1a	6.68	6.30	6.57	3.41	3.40
第2a	6.80	6.64	6.36	3.84	4.42
第3a	6.84	6.38	6.54	3.96	4.68
第4a	6.83	6.56	6.58	4.52	4.94
第5a	6.87	6.62	6.64	4.70	5.24
第6a	6.86	6.68	6.70	5.74	5.94
第7a	6.85	6.70	6.72	6.42	6.60
第8a	6.86	6.74	6.76	6.46	6.64

表4 酸化棕壤改良不同年份淋滤液的盐基离子量 /mg•100g^{-1}土

年份	对照	K^+				对照	Na^+				对照	Ca^{2+}				对照	Mg^{2+}			
		pH3		PH2			pH3		pH2			pH3		pH2			PH3		pH2	
		表[1)]	混[2)]	表[1)]	混[2)]		表[1)]	混[2)]	表[1)]	混[2)]		表[1)]	混[2)]	表[1)]	混[2)]		表[1)]	混[2)]	表[1)]	混[2)]
第1a	1.71	1.48	1.60	1.06	0.55	0.86	0.49	0.62	0.72	0.47	1.93	2.19	2.18	8.26	3.04	0.61	0.51	0.46	0.71	0.51
第2a	0.16	0.14	0.13	0.27	0.44	0.09	0.05	0.05	0.05	0.03	0.33	0.33	0.30	0.30	1.09	0.09	0.09	0.08	0.08	0.14
第3a	0.15	0.14	0.13	0.30	0.16	0.07	0.03	0.02	0.02	0.03	0.33	0.33	0.30	0.30	0.67	0.09	0.09	0.08	0.08	0.14
第4a	0.14	0.11	0.10	0.20	0.11	0.10	0.03	0.02	0.02		0.33	0.33	0.30	0.30	0.38	0.09	0.09	0.08	0.08	0.14
第5a	0.10	0.08	0.07	0.07	0.05	0.04					0.33	0.24	0.21	0.21	0.24	0.09	0.05	0.05	0.05	0.06
第6a	0.10	0.08	0.07	0.07	0.05	0.01					0.33	0.24	0.12	0.12	0.14	0.06	0.05	0.03	0.03	0.03
第7a	0.07	0.08	0.07	0.07	0.05						0.19	0.14	0.12	0.12	0.14	0.04	0.03	0.03	0.03	0.03
第8a	0.08	0.08	0.07	0.07	0.05						0.12	0.10	0.08	0.08	0.09	0.01				
总计	2.52	2.19	2.24	2.11	1.46	1.17	0.60	0.71	0.81	0.53	3.89	3.90	3.61	9.69	5.79	1.08	0.91	0.81	1.06	1.05

1) 表施 CaO 2) 混施 CaO

由表3看出, pH3酸雨处理的棕壤施用 CaO 改良后, 淋滤液 pH 由6.30上升到6.74–6.76, 距对照6.86仅差0.1个 pH 单位, 与改良前相比, 提高了0.44–0.46个 pH 单位, 其中与土壤混施 CaO 的效果稍好于表施 CaO. pH2酸雨处理后的酸化棕壤改良8a 效果显著, pH 提高4个单位, 由最初的2.4左右上升到第8a 的6.46–6.64, 距对照仅相差0.2–0.4个 pH 单位, 改良后的土壤 pH 条件能适合于绝大多数作物的正常生长. 与土壤混施的效果好于表施, 因而向酸雨危害的土壤均匀施用一定量的氧化钙, 是一种预防土壤酸化或治理酸化土壤, 防止土壤理化性状恶化的可行措施.

又从表4看出, 施入 CaO 后明显地影响了盐基离子淋出. 经酸雨 pH2和 pH3淋洗而酸化的棕壤改良后淋出的 Na^+ 量均低于对照, 而 K^+ 淋出量和对照相近. 在酸雨淋溶的过程中, Ca^{2+} 是受影响的4个基盐成分中发生变化最大的离子. 4种处理中 Ca^{2+} 占淋失盐基的百分比平均值为65.71%. 在改良后的淋洗液中, 所占百分比的平均值为46.71%. 与对照相比经 pH3酸雨处理的酸化棕壤改良后淋滤液淋出的 Ca^+ 与之相近. 而经 pH2酸雨处理的酸化棕壤改良后淋滤液淋出的 Ca^{2+} 平均为对照的2.14倍. 但是这种差异表现在淋洗的最初几年, 表施 CaO 在第2a 后, 混施 CaO 在第4a 后这种差异已不复存在. 从 Ca^{2+} 淋失的总量看, 混施 CaO 的效果好于表施. Mg^{2+} 作为仅次于 Ca^{2+} 的一个重要盐基成分, 改良后淋滤液在其含量随年份变化的规律上与 Na^+ 相似, 即4个处理的酸化棕壤淋失的 Mg^{2+} 总量0.81–1.06mg/100g 土, 都小于对照1.08mg/100g 土, 但 pH2酸雨处理的酸化棕壤淋失 Mg^{2+} 量大于 pH3酸雨处理的酸化棕壤, 平均多淋失0.19mg/100g 土, 在第8a 时, pH2、pH3酸化棕壤改良的淋滤液均测不出 Mg^{2+}, 但对照中仍能测出微量 Mg^{2+}, 为0.01mg/100g 土.

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Key words: Lake East Tahu, aquatic plants, silting-up, phosphorous.

Study on Characteristics of Organics in the Eutrophic Source Water of Shaoxing City. Xiaohong Luo, Lili Cao, Zhansheng Wang (Dept. of Environ. Eng., Tsinghua University, 100084): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 13_16

Ultrafiltration was used in this study to determine the organics molecular weight(MW) distribution in the eutrophic source water of Shaoxing City. The devotion to color and UV254 of organics in each MW range was also investigated. Then the characteristics of organics in the three typical source water (Huai River, Miyun Reservoir and Shaoxing's eutrophic lake) were compared. It was found that the characteristics of organics in the water relate closely to its source. Organics in Miyun Reservoir are mainly of low MW, with MW< 3000 occupying 96.7%, while organics in Shaoxing source water and Huai River cover a more wide MW range, organics with MW> 3000 in the source water is 28.37% and 38.28% respectively.

Key words: organic, MW, SUVA, eutrophic.

The Preparation and Characterization of a New Kind of Inorganic Polymer Flocculant—— Ferric Polysilicate (FPS). Wang Dongsheng, Wu Qifang, Wei Chaohai (Department of Applied Chemistry, SCUT, Guangzhou 510641): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 17_19

A new kind of inorganic polymer flocculant —— Ferric Polysilicate (FPS) was prepared by using water glass, ferric chloride and inorganic acid as material. Several factors of preparation were discussed. The experimental results showed that FPS was best prepared at Fe/Si ratio of 1 and activation time of one hour. Compared with PFC, FPS showed better capability of turbidity removal.

Key words: inorganic polymer flocculant, activated silica, ferric chloride, coagulation mechanism.

Study on Biodegradability of Refractory Organics Under the Condition of Mixed Substrates. He Miao, Zhang Xiaojian et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 20—22

A systematic study was conducted on the biodegradability and the co-effect of refractory organics for several typical refractory heterocyclic compounds under the condition of mixed substrate. The experimental results showed that pyridine, quinoline and homologous compound have similar biodegradation and inhibitory mechanism, of which co-effect shows additive one; while the co-effect of the irreversible inhibitory substrates shows a cooperative effect, the co-effect of irreversible mixed with reversible inhibitory substrates shows a contradictory effect.

Key words: refractory organics, biodegradability, co-effect, hetorocyclic compounds, mixed substrate.

Pollution of Nitrogen and Phosphorus in the Region of Wastewater Irrigation along Kui River. Jiang Cuiling, Xia Ziqiang and Liu Ling (Dept. of Hydrology and Water Resources, Hehai Univ., Nanjing 210098), Wang Lei and Wan Zhengcheng (Xuzhou Hydrology and Water Resources Survey Section, Xuzhou 221006): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 23_25

Simulated test of wastewater irrigation in the field and chemical analysis of nitrogen and phosphorus in the soil and groundwater at wastewater irrigation area and control area showed that high contents of nitrogen and phosphorus in the wastewater had markedly improved soil fertility and the croup in irrigation area growed very well, but nitrogen and phosphorus which could pollute surface and ground water were accumulated in the soil. Ammonium ion was easily intercepted, sorbed and transformed by soil, but high concentration of ammonium ion could slowly transporte downward and accumulate in upper levels of phreatic water. Wastewater irrigation and rainfall drip can wash nitrite and nitrate ions produced by nitrification in the soil and pollute groundwater. The contents of nitrite and nitrate ions in shallow groundwater were still seriously beyond standard at condition of saturating irrigation after experience of three months.

Key words: nitrogen, phosphorus, wastewater irrigation, Kui River Area.

Study of the Effect of Simulated Acid Rain on the Physical and Chemical Properties of Main Soil Types in Shandong Province. Xiao Yuefang, Shi Yanxi, Liu Chunsheng et al. (College of Resources and Environment, Shandong Agricultural University, Taian 271018), Song Guohan (Institute of Soil and Fertilizer, Shandong Provincial Academy of Agricultural Science, Jinan 250100): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 26_29

Five types of soils i.e. brown earth, cinnamon soil, chao soil(cultivated fluviogenic soil), lime concretion black soil, salt-affected soil were leached by earth volume test with simulated acid rain of which the value of pH are 2、3、4、5, separately from one year to ten years. The results showed that the pH values of the leacheated four soil types which had been

leached for ten years are more than 7, except the brown earth which become acid under pH 2 in the fourth year. The total losses of the leached base ions are: After ten years leaching, lime concretion black soil > salt-affected soil > chao soil > brown earth. The sensitivity of base ions to acid rain are : $Ca^{2+} > Mg^{2+} > K^{+}$、$Na^{+}$. The simulated acid rain has activation to the aluminium in the soils. There is no active aluminium in the four typyes of soils except the brown earth which the active aluminium appears in pH2. It has obvious improvement effect to apply lime to the acid brown carth.

Key words: simulated acid rain, simulated earth volume test, physical and chemical properties of soil, active aluminium.

A Study on the Treatment of Black Liquor from Bamboo Pulping Process with Sequencing Batch Reactor Biological Technique. Yan Shanghua, Chen Min et al. (Guangdong University of Technology, Guangzhou 510090): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 30_ 33

In this paper, the treatment of bamboo pulping black liquor in which lignin has been separated by acid with sequencing batch reactor (SBR) was investigated. The experimental results show ed that BOD_5 and COD in black liquor is reduced remarkably with the treatment of SBR, BOD_5 removal rate is 70% —83%, COD removal rate is 54. 5% —63%, the effluent BOD_5 and COD after the treatment are 76—101 mg/L and 419—500mg/L respectively when influent COD is 1090—1170mg/L. The technology of combining internal decomposition with SBR is more efficient for treatment of black liquor, BOD_5 and COD removal rate are 67% —68% and 71. 4% —76. 9% respectively, the effluent BOD_5 and COD from this system are 33—48mg/L and 242—315mg/L respectively when influent COD is 1046—1100mg/L . It is in keeping with GB8978-88 effluent standard. The internal decomposition remarkably increase the effectiveness of follow-up SBR treatment. In addition, the kine tics of first order degradation reaction of COD was studied. The kinetic constant and undegradable COD had been calculated. Simulated data tally with experimental data well.

Key words: SBR, biological technique, internal decomposition, bamboo pulp, black liquor, biological degradation, sequencing batch reactor.

Study on the Formula of Expansion Characteristic of Three-phase Biological Fluidized Bed. Pan Tao, Wu Yangshan, Wang Shaotang (Beijing Municipal Research Academy of Environmental Protection, Beijing 100037): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 34_ 37

The formula of expansion characteristic in the three-phase biological fluidized bed has been founded in this study. When the empty-bed velocity of liquid and gas as well as the thickness of bio-film are known, the high of bed expansion is determined rather precisely, which provided basis for design. It is unusual that the expand ruler in both the two-phase bed and three-phase fluidized bed are reflected by using one equivalent function; the relationship of the dynamic in biochemical reaction and behavior of hydomechanics has been set up by the thickness of bio-film. The behavior of shrink in bed under the low velocity of gas can be reflected by this formula, and the formula in three-phase bed can be restored to one in two -phase bed when the velocity of gas is zero. The tested bed is 1. 4m of diameter and 6. 5m of high, in which the diameter of midia made of quartz sand is 0. 3—0. 5mm, using air jet for aeration inside the reactor. The test is within the bio-film thickness of 52, 80, 115, 137m, respectively. The BOD_5 concentration in the sewage tested are 47. 6-77. 2mg/L.

Key words: three-phase biological fluidized bed, rate of expansion, formula based on experimental data, equivalent function, thickness of bio-film, method for design, wastewater treatment.

Study on the Operation Characters of a Modifed Two-Phase Anaerobic Digestion System. Guo Yanghao, Men Chun, Shi Xianai et al. (Dept. of Biotechnology, Fuzhou University, Fuzhou 350002): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 38_ 40

In this work the operation characters of the two-phase anaerobic digestion system incorporated by a packed bed acidification reactor and an UASB methanorization reactor were studied. The packed bed acidification reactor started up easily and possesed of a high acidification rate and a good resistence against hydraulic impulsion and pH fluctuation. The COD volume charge was higher than 200 kg/(m^3 • d). Adopting a preadjusting alkality technology, the two-phase system could operate normally and effectively for treating brewing wastewater. Under the conditions of COD concentration 1000—7000 mg/L in the feed and COD charge 40 kg/(m^3•d), the COD concentration was less than 200 mg/L in the effluent. The system possesed also a rather good capacity for treating antibiotics wastewater.

Key words: packed bed acidification reactor, two-phase anaerobic digestion system, brewing wastewater of high concentration.

An Investigation of the Subjective Response to the Traffic Noise of an Elevated Highway or