

# 模拟酸雨下土壤中铜、镉行为及急性毒性效应

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**摘要** 本文论述模拟酸雨下红壤、黄棕壤和黑土中 Cu、Cd 行为及急性毒性效应。试验表明：(1) 模拟酸雨对添加性土壤 Cu、Cd 的淋溶有一定的影响，随着降水酸度的增大，土壤中 Cu、Cd 的淋出量增加，但增加的程度与土壤类型、添加金属的浓度和种类有关。相同酸度下，红壤中 Cu、Cd 的淋出量远大于黄棕壤和黑土，淋出率随着沉降酸度而改变的程度也最显著。酸雨对黑土中 Cu、Cd 淋溶影响最小，Cd 对酸雨淋溶的敏感性大于 Cu。(2) 模拟酸雨对土壤中 Cu、Cd 形态影响较为明显，随着酸雨 pH 的降低，黄棕壤和黑土中部分 Cu、Cd 形态明显地向着交换态转化，红壤中部分 Cu、Cd 形态明显地向着水溶态转化。(3) 模拟酸雨对土壤中 Cu、Cd 的生物毒性影响很大，但这种影响同时又受土壤类型相当大的制约，红壤中毒性影响最大，黑土中毒性影响最小，表明三类土壤的抗酸能力顺序为黑土 > 黄棕壤 > 红壤。

**关键词** 酸雨；Cu；Cd；生物毒性。

本文通过试验研究，了解模拟酸雨对土壤中重金属的淋溶、形态的变化及急性生物毒性效应，这对估价酸雨条件下土壤中重金属对农作物和其它生物的影响以及对粮食和水源的潜在迁移率是有实际意义的。

## 一、材料和方法

### 1. 供试土壤

采集未被 Cu、Cd 污染的三类非耕地表层土壤，即南京地区下蜀黄棕壤、江西鹰潭地区第四纪红色粘土上发育的红壤、黑龙江密山地区的草甸黑土。供试土壤的化学性质列于表 1，其粘土矿物组成如下：红壤以高岭石、铝蛭石为主，一定量的水云母，极少量三水铝石和石英。黄棕壤以水云母、蛭石为主，一定量高岭石和少量石英。黑土以水云母为主，少量蛭石、绿泥石、蒙脱石、高岭石。

### 2. 土壤处理

(1) 称取 1kg 风干并过 2mm 筛的土壤，按 100mg/kg ± 浓度的 Cd 添加  $\text{CdCl}_2 \cdot 2\frac{1}{2}\text{H}_2\text{O}$  溶液(蒸馏水配制)，充分拌匀，装入直

表 1 供试土壤的化学性质

土壤类型	pH	有机质 (%)	盐基饱和度 (%)	代换性盐基	代换量	代换性 A1
				(meq/100g)		
红壤	5.05	0.65	16.8	1.72	10.2	5.15
黄棕壤	7.26	0.45	97.8	17.5	17.9	0.00
黑土	5.70	5.09	69.5	20.5	29.5	0.14

径为 10cm、高 20cm 的聚乙烯塑料圆柱内，用蒸馏水调节土壤水分，红壤和黄棕壤为 35% 含水量，黑土为 40% 含水量。每类土壤设 6 个重复。最后在圆柱上口用塑料薄膜封口，以防水分蒸发，室温下放置 30 天平衡。

(2) 同上处理，按 600mg/kg ± 浓度的 Cu 添加  $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$  溶液。土壤添加 Cd、Cu 浓度是根据江西和苏南铜、镉矿附近受重金属严重污染地区的土壤污染水平而设计。

### (3) 淋溶

本试验主要突出说明酸雨  $\text{H}^+$  对土壤重金属形态的影响，没有考虑酸雨的其它复合成分，因此，经上述处理后的土壤，分别用 pH6 (蒸馏水，作为对照)、pH4 和 pH2

( $\text{H}_2\text{SO}_4$  调节) 的溶液淋溶。每个 pH-金属-土类设 2 个重复。考虑到酸雨是短期的、地区性的, 并不是重金属污染地区常年都是降酸雨, 因此, 按月降雨量为 255mm 的量淋溶土壤。淋溶时间为每天 5 小时, 每小时 100ml, 连续 4 天, 淋溶液从土柱底部渗出, 并接收渗滤液。模拟酸雨沉降结束后, 待渗滤液不再滴出为止, 倾出土柱, 风干粉碎, 按四分法取适当土样量备用。

#### 4. 测定

(1) 金属形态的测定 准确称取 1g 过 60 目尼龙筛经处理的土样置于 50ml 塑料离心管内, 按 Miller 等介绍的连续分离法测定如下五种重金属形态<sup>[1]</sup>: 第一态为水溶态, 用 10ml 去离子水振荡提取 30 分钟。第二态为可交换态, 用 10ml 1mol  $\text{KNO}_3$  振荡提取 16 小时。第三态为有机态, 用 15ml 1mol  $\text{Na}_4\text{P}_2\text{O}_7$  振荡提取 16 小时。第四态为铁、锰氧化物包被态, 用 10ml 0.1mol  $\text{NH}_2\text{OH}\cdot\text{HCl}$  振荡提取 30 分钟。第五态为硫化物, 用 10ml 1mol  $\text{HNO}_3$  振荡提取 16 小时。

Cu、Cd 含量测定均用原子吸收分光光度计。

(2) 生物毒性测定 ① 土壤酸浸液, 称取 40g 试验土样置于塑料离心管内, 加入 0.1mol  $\text{HCl}$  40ml, 在往复式振荡机上振荡提取 1 小时, 然后 4000r/min 离心 15 分钟, 取上清液过滤, 取 20ml 滤液于 50ml 烧杯中, 加 2 滴  $\text{H}_2\text{O}_2$  煮沸 5 分钟去除有机质, 加  $\text{MnO}_2$  0.2g 继续加热至 1/3 体积, 以赶尽残余  $\text{H}_2\text{O}_2$ , 冷却后过滤, 并用去离子水少量洗涤残渣, 控制滤液在 20ml 以内, 调节 pH 至 4.5 (或 5.4), 然后加 0.6g  $\text{NaCl}$  再定容至 20ml, 测定生物毒性。② 土壤水浸液, 水: 土 = 1:1, 振荡提取 1 小时。③ 土壤渗滤液, b 和 c 各取 20ml 滤液加 0.6g  $\text{NaCl}$  进行毒性测定。

毒性测定按 Bulich 介绍的稀释一倍法进行<sup>[2]</sup>。为了单独分辨出样品的毒性影响,

用公式

$$\frac{I_0 - I_{15}}{I_0} \times 100\%$$

计算样品毒性。式中  $I_0$  为经过校正的初始发光输出,  $I_{15}$  为样品与指示菌作用 15 分钟的发光输出。

生物毒性测定仪为中科院南京土壤研究所生产。指示菌为明亮发光杆菌 (*Photobacterium Phosphoreum*) T<sub>3</sub> 变种, 从澳大利亚引进。

## 二、结果和讨论

### 1. 模拟酸雨对土壤中 Cu、Cd 淋溶影响

在试验条件下, 随着淋溶液的 pH 降低, 渗滤液中 Cu、Cd 含量明显升高, 见图 1。黄棕壤 Cu 的淋出量 pH2 是 pH6 的 2.3 倍, 黑土为 1.7 倍, 红壤为 1.4 倍; 黄棕壤 Cd 的淋出量 pH2 是 pH6 的 3.7 倍, 黑土为 3.6 倍, 红壤为 1.3 倍。相对而言, Cd 对酸雨淋溶的敏感性比 Cu 强, 这一结果与汪雅谷等结果一致<sup>[3]</sup>。从绝对溶出量来说, Cu、Cd 在一定添加量下, 土壤不同溶出量有很大差异, 用 100mg/kg Cd 处理土壤, 从淋溶 pH6—2, 黄棕壤溶出量为 0.342—1.255mg/kg, 黑土为 0.202—0.734mg/kg, 两种土壤溶出率大多在 1% 以下, 而红壤溶出量为 12.596—15.998mg/kg, 溶出率为 13—16%。600mg/kg Cu 处理下, 黄棕壤溶出量为 1.47—

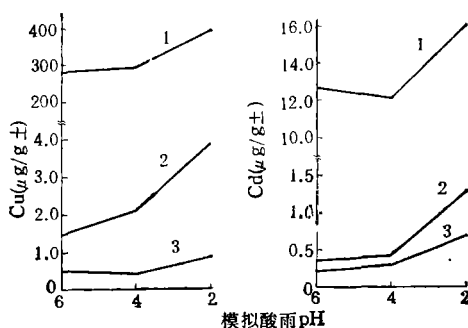


图 1 模拟酸雨对添加性土壤 Cu、Cd 淋溶影响  
1 红壤 2. 黄棕壤 3. 黑土

3.90mg/kg, 黑土为 0.49—0.85mg/kg, 两者均不足 1%, 而红壤溶出量为 279.78—391.86mg/kg, 溶出率高达 46.6—65.0%。

上述结果表明,不同土壤对 Cu、Cd 的吸附有很大差异。本研究没有做土壤最高吸附量试验,只从用 pH6 (即蒸馏水)淋溶的土壤 Cu、Cd 溶出率来分析,认为黄棕壤和黑土对 Cu、Cd 吸附性很强,在供试浓度下,几乎百分之百被土壤吸附,土壤对 Cu、Cd 的吸附表现最差。土壤吸附量的差异与土壤电荷有关。一般说,我国北方土壤的负电荷量较多,南方红壤类土壤的正电荷较其它土壤多<sup>[4]</sup>,土壤对阳离子的吸附主要决定于其负电荷。因而红壤吸附 Cu、Cd 不如黄棕壤和黑土。在同一红壤中,Cd 和 Cu 的溶出率有如此大差异,这可能与金属离子浓度有关,Cd<sup>++</sup> 的试验浓度为 100mg/kg±, Cu<sup>++</sup> 为 600mg/kg±。通常离子吸附量随着溶液浓度的增加而增大,但吸附量并不与溶液中离子浓度成比例关系,而是在不同浓度范围时,二者比值不同,到超过一定浓度后,吸附量即不因离子浓度而变<sup>[5]</sup>。因此本试验可以这样认为,有很大一部分 Cu 不是以吸附状态而是以离子溶液状态存在于土粒孔隙中,当淋溶时,这部分 Cu<sup>++</sup> 很快被淋洗下来,因而 Cu 的淋出率远大于 Cd。无论哪种土壤,随着淋溶 pH 降低,Cu、Cd 的淋出率提高,主要是酸沉降中增加了 H<sup>+</sup> 浓度,除大部分 H<sup>+</sup> 与土壤发生反应外,部分 H<sup>+</sup> 参与土壤的阳离子交换<sup>[6]</sup>,从而将一部分已被吸附的 Cu、Cd 置换出来,随着 H<sup>+</sup> 浓度的增大,置换出的 Cu、Cd 量也增加,这在红壤中特别明显。于天仁等指出<sup>[4]</sup>,土壤与阳离子的结合强度随着 pH 的降低而减弱,红壤的代换量很低,pH 的稍许改变即可引起结合能的剧烈变化。因而使吸附于土壤的 Cu、Cd 离子随着降水酸度增大,红壤的淋出量较黄棕壤和黑土显著得多。

2. 模拟酸雨对土壤中 Cu、Cd 形态影响  
由于土壤是个复杂的有机-无机复合体,

有多种粘土矿物,有分子量大小不同的有机质,有铁、锰、铝、硅等氧化物,这些组分对进入土壤的重金属离子有很强的吸附能力,因而进入土壤的重金属就以各种形态持留于土壤中。由表 2 可知,土壤中金属形态组分因土壤类型、金属元素而不同。按蒸馏水淋溶后的土壤重金属形态优势组分排列如下:

(1) Cd 黄棕壤为交换态 > 有机态 > 硫化物 > 锰氧化物包被态 > 水溶态;黑土为有机态 > 交换态 > 硫化物 > 水溶态 > 锰氧化物包被态;红壤为交换态 > 有机态 > 硫化物 > 水溶态 > 锰氧化物包被态。

(2) Cu 黄棕壤为硫化物 > 有机态 > 交换态 > 锰氧化物包被态 > 水溶态;黑土为有机态 > 硫化物 > 交换态 > 水溶态 > 锰氧化物包被态;红壤为交换态 > 有机态 > 硫化物 > 水溶态 > 锰氧化物包被态。

从总体上说,土壤 Cd 以有机态和交换态为优势,土壤 Cu 以有机态、交换态和硫化物为优势。从土壤比较而言,黑土中有机态占绝对优势。毫无疑问,与黑土中有机质含量高有着密切关系,土壤有机质含有大量配位基团,Kerndorff 指出<sup>[7]</sup>,腐殖质最显著的特点之一是它们结构中有相当高的含氧官能团,这些官能团的存在,给 Cu<sup>++</sup> 和 Cd<sup>++</sup> 形成稳定的络合物创造了条件。红壤中 Cd、Cu 均以交换态占绝对优势,它所吸附的 Cd<sup>++</sup>、Cu<sup>++</sup> 主要是交换吸附在粘土矿物及其它成分上,很易被交换剂中阳离子所置换。而在黄棕壤中,Cd 以有机态和交换态占优势,Cu 以硫化物占绝对优势,这在同一土壤中,Cu 与 Cd 形态组分有如此差异,可能与元素的化学特性有关。

由表 2 显示,模拟酸雨对土壤 Cu、Cd 形态影响较为明显。在不同酸度沉降下,Cd 和 Cu 虽然在土壤中优势形态没有变,但各形态组分有着明显的改变。在黄棕壤和黑土中,随着沉降酸度的增大,交换态 Cu、Cd 增加,从 pH6 至 pH2,黄棕壤交换态 Cd 由 48.7%

表 2 模拟酸雨对土壤 Cd、Cu 形态影响

土壤类型	淋溶 pH	Cd 形 态 (%)					Cu 形 态 (%)				
		一	二	三	四	五	一	二	三	四	五
黄棕壤	6(蒸馏水)	0.9	48.7	37.3	3.4	9.7	0.5	16.9	35.4	1.4	45.7
	4	1.2	53.2	35.0	2.8	7.8	0.7	19.0	34.6	1.2	44.5
	2	0.6	61.7	26.4	2.4	8.9	1.0	38.0	26.0	0.3	34.8
黑 土	6(蒸馏水)	1.2	16.8	70.0	0.7	10.6	0.8	4.0	73.8	0.3	21.1
	4	1.2	19.6	69.1	0.8	9.4	0.8	3.8	73.6	0.2	21.7
	2	1.5	24.5	65.6	0.7	7.7	0.6	12.4	67.9	0.2	18.9
红 壤	6(蒸馏水)	1.4	86.0	9.0	0.5	3.2	0.3	46.9	35.3	0.3	17.2
	4	6.7	79.8	8.9	2.2	2.5	0.4	48.0	33.7	0.4	17.5
	2	27.9	59.0	10.0	1.3	1.8	31.1	34.4	23.5	0.4	10.7

一为水溶态,二为交换态,三为有机态,四为氧化铁包被态,五为硫化物

上升到 61.7%, 交换态 Cu 由 16.9% 上升到 38%。黑土交换态 Cd 由 16.8% 上升到 24.5%, 交换态 Cu 由 4% 上升到 12.4%。然而该两类土壤交换态右边的其它各态基本上呈相反趋势(见表 2), 有机态最为显著, 黄棕壤有机态 Cd 由 37.3% 下降至 26.4%, 有机态 Cu 由 35.4% 下降至 26.0%, 黑土有机态 Cd 由 70.0% 下降至 65.6%, 有机态 Cu 由 73.8% 下降至 67.9%。而在红壤中, 水溶态 Cd、Cu 随降水酸度增加而增加, Cd 由 1.4% 增加到 27.9%, Cu 由 0.3% 增加到 31%, 而交换态 Cd、Cu 显著地呈相反趋势, Cd 由 86.0% 下降到 59.0%, Cu 由 47.0% 下降至 34.0%。其它形态也有不同程度的变化。总的来说, 在不同酸度沉降下, 对 Cd、Cu 形态影响显示出随着降水酸度增加, 黄棕壤和黑土中部分 Cd、Cu 形态向着交换态转移, 红壤中部分 Cd、Cu 形态向着水溶态转移。这一结果符合饭村康二曾提出的重金属在土壤中的吸附平衡模式<sup>[8]</sup>, 也符合 McLaren 所述的随着 pH 下降平衡向左移动<sup>[7]</sup>。Schnitzer 等报导在 pH = 3.8 时, Cu<sup>++</sup> 与富里酸的络合稳定常数要小于 pH = 5.0 时的络合稳定常数, 因而土壤 pH 降低, 可导致交换态和水溶态 Cu 的增加<sup>[7]</sup>。

上述结果还可看出, 随着酸雨 pH 下降, 同一金属不同形态的转化量在供试的三类土壤中, 无论 Cu 或 Cd, 均为红壤 > 黄棕壤 > 黑土, 显示红壤中金属形态转化最为活跃, 且转化形成的均为活化态(水溶态)金属, 这可能导致红壤在酸雨下所产生的金属毒性最强, 而黄棕壤和黑土转化形成的则均为亚活化态(交换态)金属, 这有可能使它们在酸雨下产生的金属毒性相对减轻。

### 3. 模拟酸雨下土壤 Cd、Cu 毒性效应 将淋溶后的土壤水浸液、酸浸液和淋溶

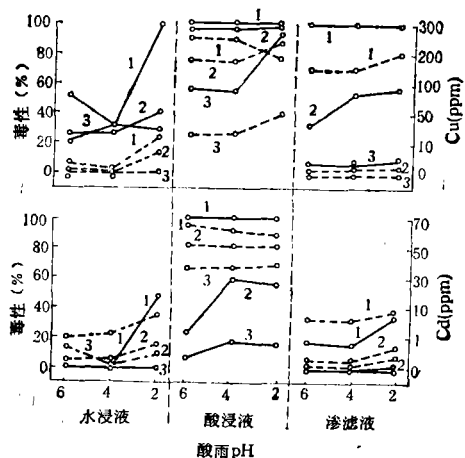


图 2 模拟酸雨对土壤 Cu、Cd 的毒性影响  
1. 红壤 2. 黄棕壤 3. 黑土  
——毒性 ——金属浓度

收集的土壤渗滤液进行急性生物毒性试验。结果见图 2。

#### (1) 土壤水浸液

随着酸雨 pH 降低, 含 Cu 土壤液对 *T<sub>3</sub>* 菌毒性显著增大, 黄棕壤的毒性由 26% 增大到 42%, 黑土由 23% 增大到 30%, 红壤由 51% 增大到 99.8%。含 Cd 黄棕壤和黑土对 *T<sub>3</sub>* 菌显示无毒, 唯在红壤中 pH2 时才显示明显毒性, 毒性达 47%。

#### (2) 土壤酸浸液

含 Cu 黄棕壤和红壤及含 Cd 红壤对 *T<sub>3</sub>* 菌剧毒而显示不出酸雨 pH 的影响。含 Cu 黑土及含 Cd 黄棕壤和黑土随着降雨 pH 降低, 对 *T<sub>3</sub>* 菌的毒性显著增大, 含 Cu 黑土毒性由 57% 增大到 94%, 含 Cd 黄棕壤毒性由 24% 增大到 56%, 含 Cd 黑土由 7% 增大到 16%。

#### (3) 土壤渗滤液

含 Cu 红壤在三种 pH 下均剧毒, 黑土毒性低, 在各 pH 下只有微小的差异, 而黄棕壤显示毒性影响, pH6 时为 31%, pH2 时为 57%。含 Cd 黄棕壤和黑土显示无毒, 唯红壤在 pH2 时显示毒性为 35%。

由上可见, 酸雨对土壤 Cu、Cd 毒性影响较大, 但这种影响同时又受土壤类型相当大的制约, 红壤反映毒性最大, 黑土毒性最低, 说明三类土壤抗酸能力顺序为黑土 > 黄棕壤 > 红壤。从图 2 土壤三液与毒性的关系看, 对 *T<sub>3</sub>* 菌的毒性反映主要是土壤溶液中

Cd、Cu 所致, 凡溶液中 Cu、Cd 含量很低者, 无论何种酸度淋溶, 对 *T<sub>3</sub>* 菌均显示无毒, 凡溶液中 Cu、Cd 含量很高者, 均反映剧毒, 在多数情况下毒性随酸雨 pH 降低而增大, 主要是 Cu、Cd 含量增加。本作者在污染物的生物毒性方面进行了多年的试验研究, 证明 *T<sub>3</sub>* 菌的发光度与污染物的浓度呈良好的线性负相关。但本文结果反映的毒性浓度范围较宽, 灵敏度没有单一金属化合物溶液反映高<sup>[9]</sup>, 因为土壤是个多相体系, 土壤溶液中还有许多其它离子, 这些离子与 Cu 或 Cd 共存, 有可能会产生拮抗作用, 也可能产生协同作用, 本试验没有一一查证, 有待进一步研究。

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#### • 环境信息 •

### 非 洲 的 长 城

中国的万里长城是唯一能从宇宙空间看到的人工建筑。非洲可能在不久的将来, 也会有它自己的有生命的长城, 一条跨越这个大陆环境最脆弱部分萨赫勒地区的绿色带。日本农业省正着眼在逐渐缩小的乍得湖和塞内加尔河之间建立这条绿色带, 该绿色带将有益于稳定这里的土地, 将最终稳定绿带内的农田。

根据日本农业省的估算, 该规划将花费大约 110 亿美元。日本农业部希望不仅仅是尼日尔河流域 9 个国家政府参与该规划, 而且也应该涉及欧洲一些国家。这项规划的研究开始于 1990 年, 1995 年前完成。仅仅这项研究预期要花费约 7 百万美元。

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**Experimental Study of Energizing Activated Sludge: Tests of Thermal Flash Pyrolysis.** Liu Lifan, Zhao Shu-chang, Den Yi-zhao, Yan Cheng-wei, Chang Yu-qin (Chemical Engineering College, Dalian University of Technology, Dalian): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 2—8.

In this paper, a fresh attempt has been made in exploring thermal decomposition of activated sludge so as to make it harmless and be resources by using flash pyrolysis process. The dried surplus sludge taken from Tianjin Sewage Plant was pyrolyzed in a heat radiating furnace and kept in a below reactor for 10 min with air being cut off. In order to provide the needed heat to sustain high temperature, a series of partial combustion pyrolysis tests were carried out in the same experiments using the same feedstock. The temperature range was 550°C to 850°C. The products obtained were combustible gas (for industrial or civil use), light oil, tar and char. According to the results of the experiments, three process designs are proposed.

**Key Words:** activated sludge, thermal flash pyrolysis, tar.

**Distribution of Particle Sizes and Polycyclic Aromatic Hydrocarbons (PAHs) Emitted from the Coal-Fired Plants and Their Mutagenic Characteristics.** Yao Wei-xi, Cui Wen-xuan, Xu Xiao-bai (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing) *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 9—13.

Reported in this paper are the discussions on distribution of particle sizes and PAHs emitted from a UG-35/39-M Typed boiler fired with coarse coal and briquettes respectively. The flue dust was collected separately into dust-fall, floating dust and smoke in accordance with particle sizes. It was showed that PAHs mostly existed in floating dust and smoke, i. e., low-number rings of PAHs distributed mainly in smoke while high-number ring ones in floating dust. The sum of mutagenicity of both floating dust and smoke was 5—6 times higher than that of dust-fall by Ames Test. When briquettes were substituted for coarse coal, the total floating dust emission would decrease approximately by 50—60% in weight. And mutagenicity of the emissions by burning briquettes were much lower than that by burning coarse coal. So the briquette combustion technology will be one of important measures for reducing air pollution.

**Key Words:** coal-fired boiler, briquette, polycyclic aromatic hydrocarbons, flue dust, mutagenicity.

**A Biochemical Index for Human Exposure to Polynuclear Aromatic Hydrocarbons (PAHs) —Urinary 1-hydroxypyrene Level of the R-**

**esidents in Different Functional Districts of Beijing.** Zhao Zhen-hua, Quan Wen-yi, Tian De-hai (Beijing Municipal Research Institute of Environmental Protection): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 13—18.

The paper reports the determination results of urinary 1-hydroxypyrene of the residents who lived in different functional districts of Beijing. The data obtained varied in different functional districts, meanwhile those of the residents themselves also varied from heating seasons to non-heating seasons. The results indicates that the level of 1-hydroxypyrene in workers' urine at the coke-oven plant is the highest of all the residents, it is about 4—25 times higher than those who lived in other districts. The order is as follow: industrial district > commercial district > residential district > scenic district. So, it is suggested that 1-hydroxypyrene be a biochemical index for human exposure to PAHs.

**Key Words:** 1-hydroxypyrene, polynuclear aromatic hydrocarbon, biochemical index.

**Research on Control of Garbage Leaching Liquor in A Landfill Site.** Liu Dong (Wuhan Municipal Institute of Environmental Sanitation): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 18—23.

By field investigation and simulated experiments, the oxidation pond beside Guozikou (a garbage landfill site) and the characteristic of leaching liquor from the dumps were examined. Its pollution characteristics and degradation as well as pollution load and distribution in the pond were studied. According to the results obtained, three measures are offered to control pollution of the liquor.

**Key Words:** garbage landfill site, leaching liquor, oxidation pond.

**The Effects of Simulated Acid Rain on the Behavior of Cu and Cd in Soils and Their Acute Toxicity.** Xie Si-qin, Zhou De-zhi, Gu Zong-lian, Wu Liu-song (Institute of Soil Science, Chinese Academy of Sciences, Nanjing): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 24—28.

The basic emphasis of this work is to research the behavior of Cu and Cd in red soil, yellow brown soil and black soil and their acute toxicity under simulated acid rain conditions. The experimental results were as follows: (1) The simulated acid rain had some influence upon leaching of Cu and Cd in soil. As the acidity of precipitation was increased, Cu- or Cd-leaching amounts were increasing. However, the increased level differed from variant soil and concentrations of the metals added to soil. Under the condition of same acidity, Cu or Cd amounts

leached from red soil were much larger than those from yellow brown soil or black soil. Leaching of Cd was more sensitive than that of Cu.

(2) The effects of simulated acid rain on speciations of Cu or Cd in soils were relatively obvious. With pH values of the precipitation reducing, a partial Cu and Cd in yellow brown soil and black soil were transformed into exchangeable speciation, and those in red soil transformed into water-soluble form.

(3) Acid rain evidently affected biotoxicity of Cu or Cd in soil. The effect of Cu- or Cd-biotoxicity was high in red soil and low in black soil.

In short, the acid resistant capacity of soils in order is black soil > yellow brown soil > red soil.

**Key Words:** acid rain, copper and cadmium, soil, biotoxicity.

**Application of the Theory of Multivariate Statistical Analysis to the Prediction of Air Pollution in Urban Environment.** Huang Guo-he (Xiamen Research Institute of Environmental Protection, Fujian): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 29—34.

A stepwise cluster analysis method toward a multitude of environmental variables was advanced for the prediction of air pollution in urban environment. The method has improved monovariate AID(Automatic Interaction Detection) algorithm. It can effectively deal with continuous and discrete variables, as well as the nonlinear relations among variables. Compared with classical modelling theories, the method provides a new way for predicting air pollution.

In a case study, the relationship between three air pollutant concentrations and four impact factors in thirty-one grid squares in Xiamen was analyzed. Cluster three concerning quantitative correlation between air quality and the distribution of relevant impact factors were derived from significant test, discriminant analysis and cluster analysis to realize the aim of predicting air quality.

**Key Words:** multivariate statistical analysis, air pollution, stepwise cluster.

**Use of the Residue after Reclamation of Protein and Chrome Salt from Leather Shavings.** Jiang Ting-da, Zhang Chun-ping (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 35—37.

This paper presents a part of the process which was developed for reclamation of protein and by-products from chrome leather shavings. After protein and chrome(III) are extracted from leather scraps, the remainder is neutralized with quick lime, and then processed into granu-

lated fertilizer. The results of tests showed that the organic fertilizer is available for flowers because of its long-term and high effectiveness.

**Key Words:** reclamation of leather shavings, residue, fertilizer.

**Analysis and Prediction of Traffic Noise in the Mountain City.** Chen Zi-ming, Lin Dong (Department of Physics, Qingdao University of Oceanography): *Chin. J. Environ. Sci.*, 12(2), 1991, pp.38—41.

This paper presents a method for analysis and prediction of traffic noise in the mountain city, emphasizing the characteristics of sloping roads. Taking Qingdao City as an instance, based on road structure, distribution of terraced buildings along both sides of the sloping roads and the conditions of motor vehicles shuttling to and fro on the roads with radiative noise, three different models have been set up for long-term monitoring, and the linear relations among varieties of vehicle noise, speeds and road slopes have been demonstrated. The results summed up correct range of noise levels caused by the road-side buildings and sloping road structure. The authors propose the method for predicting  $L_{eq}$  of traffic noise on the sloping road surface in practice.

**Key Words:** traffic noise, mountain city, prediction, model.

**Influence of Acidic Leaching upon the Contents of Organic Matter and Clay Particle in Soil.** Liu Hong-jie (Department of Geography, South China Normal University, Guangzhou): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 42—44.

This paper deals with variations of the contents of organic matter and clay particle in soil under influence of acidic precipitation. The results of simulated experiments showed that organic matter contents decreased in varying degree after acidic leaching, but acidity of leaching did not have marked influence upon the clay contents. If the contents of metals in soil solution increased to critical coagulation, efficiency of eluviation would decrease.

**Key Words:** acidic leaching, organic matter, clay particle.

**Treatment of Furfural Wastewater by Membrane Separation Process.** Chen Yu-lian, Zhou Guang-jun, Zhang He (Department of Chemical Engineering, Taiyuan University of Technology, Shanxi): *Chin. J. Environ. Sci.*, 12(2), 1991, pp. 45—49.

A new method for recovering acetic acid from furfural