

北京地区几种典型土壤吸附 Zn 的研究*

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摘要 对北京地区5种不同土壤吸附 Zn 的研究证明, 该5种土壤对 Zn 的吸附均符合 Freundlich 吸附等温线, 其吸附量与土壤 pH、有机质和 CaCO_3 的含量等土壤基本性质呈正相关。所研究的5种土壤均属于褐土类, 其中有机质含量低的褐土性土和水稻土对 Zn 的吸附量最低。

关键词 锌, 吸附量, 土壤性质。

国内外学者就不同土壤对 Zn 的吸附与固定及 Zn 在土壤中的淋溶与迁移进行了大量研究。Himes 等人的研究指出, 土壤的 pH 值及有机质含量可明显影响土壤对 Zn 的吸附强度^[1]; Follet 提出可用 DTPA 浸提全 Zn 含量相同的土壤中的有效 Zn^[2]; Shuman 指出土壤中的 Zn 可被吸持在交换位上或被吸附在固体表面^[3]; Kuo 提出可用 Langmuir 吸附等温线或 Freundlich 吸附等温线解释 Zn 被土壤吸附的现象^[4]; Gerherd Brümmer 等人用含有 CaCO_3 模式试验证明了 Mn、Fe、Al 的氧化物和腐殖酸类的物质对束缚土壤中的 ZnCO_3 能产生明显的作用^[5]; 虞琐富提出土壤对金属离子的吸附主要受土壤组成和特性的影响, 环境因素很重要^[6]; 李鼎新的研究结果认为 MAP 和 DAP 磷酸盐可影响土壤吸附 Zn 的模式^[7]。

北京地区位于褐土地带, 缺 Zn 土壤分布广, 有效 Zn 低于缺乏临界值(0.5 mg/kg)的土壤分布面积达 61%。笔者选释北京郊区县一典型区域的几种土壤研究 Zn 被吸附与土壤性质的关系, 可为改良土壤及合理施 Zn、提高其有效性提供参考。

1 实验方法

1.1 材料

5 种土壤采自北京郊区昌平区。其类型为淋溶褐土(取自低山的高处); 典型褐土(取自低

山的坡土); 褐土性土(取自平原地区); 褐潮土(取自低平原区); 水稻土(取自低洼地)。

1.2 方法

(1) 土壤样品的采集、处理与基本性质测定 对各类土壤均选择 3 点采样, 挖取 0—25 cm 的等量土壤混合为一个样品。取一定量测定 CEC, 其余的在风干后进行处理, 再测定 pH、有机质、 CaCO_3 以及 $<0.002 \text{ mm}$ 的粘粒百分数及全锌量。土壤处理与各项测定均按照《土壤农业化学常规分析方法》进行。

(2) 各类土壤对 Zn 吸附量的研究 先配制含 Zn 量为 20、40、60、80、100 mg/kg 的 0.01 mol/L CaCl_2 溶液, 然后各取 25 ml 加入装有 1 g 土壤的三角瓶内, 在 25℃ 下用 350 次/min 往复振荡器连续振荡 12 h, 再用离心机离心分离 15 min 后过滤。取滤液用原子吸收分光光度计测定其含 Zn 量, 最后计算被土壤吸附的 Zn 量并绘制曲线。

(3) 不同 pH 值对土壤吸附 Zn 的影响 先配制含 Zn 80 mg/kg 的水溶液装入三角瓶内, 按 25:1 的水土比分别将不同类型土壤加入其中, 后以 0.1 mol/L HCl 和 0.025 mol/L $\text{Ca}(\text{OH})_2$ 溶液调节土壤溶液的 pH 为 4.5, 6.0, 7.5, 9.0, 10.5 五个等级。连续振荡 12 h, 离心 15 min,

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然后测定滤液含 Zn 量。

(4) 各类土壤的基本性质及其吸附 Zn 量的相关分析

2 实验结果

2.1 供试土壤基本性质测定结果

表 1 各类土壤的基本性质

土壤类型	pH	有机质/%	CaCO ₃ /%	CEC/me · 100 g ⁻¹	全 Zn 量/mg · kg ⁻¹	<0.002 mm 粘粒/%
淋溶褐土	7.31	1.31	0.31	18.21	65.3	20.5
典型褐土	7.53	1.59	0.36	12.72	46.1	24.8
褐土性土	7.20	0.30	0.27	15.97	64.9	25.2
褐潮土	7.50	1.60	0.32	13.22	54.0	20.2
水稻土	7.41	1.27	0.22	8.71	43.8	20.8

负相关。除典型褐土外，其他土壤的全锌量随地势下降而降低，但 5 种土壤的全 Zn 量均属低水平。此外各土壤<0.002 mm 的粘粒含量均在 30% 以下，属于砂壤质土。

2.2 不同土壤对 Zn 的吸附强度比较

表 2 5 种土壤对 Zn 的吸附特征

土壤类型	介质	k	n	r(P<0.01)
淋溶褐土	水	2.6866	1.2537	0.9064
典型褐土	水	2.4923	1.3603	0.9144
褐土性土	水	2.6841	1.1061	0.9973
褐潮土	水	2.4071	1.2724	0.9712
水稻土	水	2.9194	1.0401	0.9990

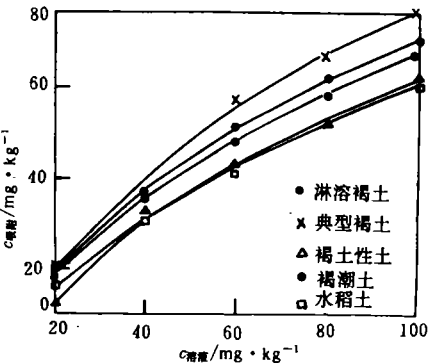


图 1 土壤吸附 Zn 和加入溶液中 Zn 浓度的关系

从表 2 和图 1 可以看出，5 种土壤对 Zn 的

供试土壤基本性质见表 1。

从表 1 可看出，各种土壤的 pH 值相差不大，属于碱性或接近碱性。有机质含量则除了褐土性土因取自生荒地而为低值外，其他土壤均属中等肥力的含量水平，且随地势下降而含量增加，统计分析结果是 CEC 与有机质含量呈

吸附均符合 Freundlich 吸附等温线。

在 Freundlich 方程 $x=kc^{1/n}$ 中， x 是每单位土壤吸附的 Zn 量($\text{mg} \cdot \text{kg}^{-1}$)， c 是平衡液中残留的 Zn 量。根据实验所得的 x 值和 c 值计算出 k 值、 n 值和 r 值。 k 为吸附容量影响的参数， $1/n$ 为吸附强度影响的参数， r 为溶液含 Zn 与土壤吸附 Zn 量的相关性。

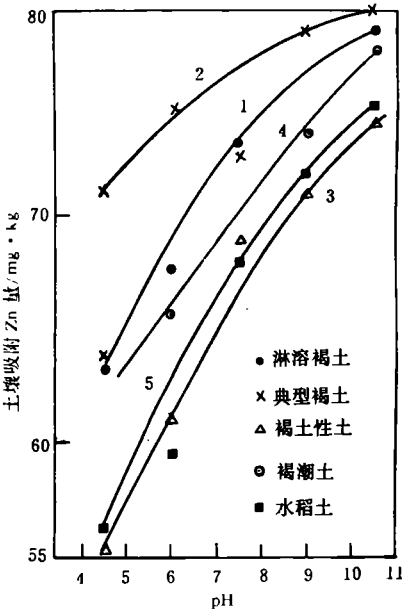


图 2 pH 值对土壤吸附 Zn 的影响

2.3 pH 值对土壤吸附 Zn 的影响

从图 2 看出，当溶液的 pH 值由 4.5 逐级升

至 10.5 时, 各类土壤对 Zn 的吸附量随 pH 上升增加, 残留于溶液中的 Zn 则随 pH 上升减少. 溶液 pH 与土壤吸附的 Zn 量呈显著正相关.

2.4 相同 pH 条件下各类土壤的理化性质与土

壤吸附 Zn 量的相关性

表 3 显示出各类土壤对 Zn 的吸附量随着有机质含量、CaCO₃ 含量、<0.002 mm 的粘粒含量及 CEC 量的上升而增加, 其中 CaCO₃ 的含量

表 3 土壤吸附 Zn 量与其各理化性质的关系¹⁾

土壤类型	吸附 Zn 量 /mg · kg ⁻¹	有机质	CaCO ₃	粘粒(<0.002 mm)		全 Zn 含量 ²⁾	CEC	
		含量/% 相关性	含量/% 相关性	含量/%	相关性	/mg · kg ⁻¹	含量 /mg · kg ⁻¹	相关性
淋溶褐土	73.1	1.3	0.31	24.8		65.3	18.21	
典型褐土	76.5	1.59	0.36	25.2		46.1	12.72	
褐土性土	69.6	0.30	0.27	20.5		64.9	15.97	
		正相关 (r=0.6257)	显著 正相关 (r=0.919)		显著 正相关 (r=0.8491)			正相关 (不显著)
褐潮土	72.0	1.60	0.32	20.8		54.0	13.22	
水稻土	68.9	1.27	0.22	20.2		43.8	8.71	

1) pH=7.5, 水土混合液中 Zn 最初含量为 80 mg/kg 2) 不相关

与其相关性最显著, 而全 Zn 量与其无关.

3 结 语

(1) 5 种土壤对 Zn 的吸附均符合 Freundlich 吸附等温线. 有机质含量低的褐土性土及水稻土吸附能力低. 对这些土壤施 Zn 时应注意选择适宜的 Zn 肥种类及施肥方法以减少淋溶迁移、提高其有效性.

(2) 各类土壤对 Zn 的吸附量均随介质的 pH 上升而增加. 这个结果显示出施用有机肥和秸秆还田的重要性, 因为有机肥在腐解过程中产生的有机酸会适当降低植物根际土壤的 pH 值, 有利于植物对 Zn 的吸收.

(3) 在相同的 pH 条件下, 土壤对 Zn 的吸附量随着土壤的有机质、CaCO₃、<0.002 mm 的粘粒含量及 CEC 的上升而增加. 这亦表明有机质低的沙壤土因对 Zn 的吸持力弱而更易缺 Zn. 对这类土壤应该定期测定其有效 Zn 的含量并及时补施 Zn 肥.

参 考 文 献

1 Himes F L and Barber S A. Soil Sci. Soc. Ame. Proc. ,

1957, 21: 368—373
2 Follett R H and Lindsay W L. Colorado Agric. Exp. Sta. Tech. Bull. , 1970, 110: 1—78
3 Shuman L M. Soil Sci. , 1979, 127: 10—17
4 Kuo S. Soil Sci. , 1979, 128(5): 274—277
5 Gerhard Brümmer. Geaderma, 1983, 31: 337—354
6 虞瑛富. 土壤, 1990, 22(3): 118—122
7 李鼎新. 土壤学报, 1991, 28(1): 24—30
8 中国土壤学会土壤农化分析专业委员会编. 土壤农业化学常规分析方法. 北京: 科学出版社, 1963: 142—148
9 Tiller K G. Aust. J. Soil Res. , 1972, 10: 151—182
10 Killer K G. Commun. in Soil Science and Plant Analysis. 1979, 10(4): 703—715
11 Shuman L M. Soil Sci. Soc. Ame. Proc. , 1975, 39: 454—458
12 John M K. Can. J. Soil Sci. , 1972, 52: 343—350
13 Kuo S and Lotse E G. Soil Sci. Soc. Ame. Proc. , 1974, 38: 50—54
14 Warncke D D. Soil Sci. Soc. Ame. Proc. , 1973, 37: 355—358
15 Saeed M and Fox R L. Soil Sci. , 1977, 124(4): 199—204
16 Barrow N J. J. of Soil Sci. 1986, 37: 311—318
17 刘铮, 朱其清等. 土壤微量元素译文集. 南京: 江苏科学技术出版社, 1981: 36—42

creasing with reaction time under conditions of 0.85 MPa and 900°C, and the conversion rate is in range of 23.5% to 42% at 120 minutes. The conversion rate is drastically growing with temperature under conditions of 1.15 MPa and 750–950°C at 120 minutes. The conversion rate was slowly and linearly increasing with pressure under condition of 860°C. Finally, the reaction mechanism was discussed.

Key words: pressurized thermogravimetric analysis, limestone, dolomite, desulfurization.

Study on the Regeneration of NaHSO_3 in the Recovery of SO_2 from Flue Gas by Bipolar Membrane Electrodialysis. Yu Lixin et al. (Department of Chemical Engineering, Tsinghua University, Beijing 100084); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 40–42

Bipolar membrane electrodialysis is adopted in the regeneration of NaHSO_3 , which is used as absorbent of SO_2 from flue gas. When cation-exchange membrane is supplemented with , both homogeneous and heterogeneous bipolar membranes which are made in our lab and by Shanghai Chemical Factory, respectively, can produce satisfactory conversion ratio (higher than 80%) in the regeneration process. The decrease of current efficiency (from approximately 80% to approximately 20%) is resulted from the increase of the concentration of proton in acid chamber. The existence of small amount of Na_2SO_4 in NaHSO_3 solution doesn't cause much effect on regeneration process. The short membrane lifetime hinders the process from getting into practical application.

Key words: bipolar membrane electrodialysis, recovery of SO_2 from flue gas, regeneration of NaHSO_3 .

Study on Characterization of Adsorption of Zinc onto five types of soil in Beijing Area. Zhou Wei and Li Jiyun (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 43–45

The results of study on adsorption of zinc onto five types of soil in Beijing area showed that the capacity of five types of soil adsorbing zinc presents positive correlation with pH value of the soil solution, contents of organism and CaCO_3 etc in soil. The adsorption data could be fitted to the Freundlich-type equation.

Key words: adsorption, zinc, soil, Beijing area.

A Study on Acclimation Technique of Activated sludge and Biological Treatment of High Consistence Cheni-thermomechanical Pulp Wastewater. Chen Min (Guangdong University of Technology, Environment & Resource Engineering Department, Guangzhou, 510090), Sung-Nien Lo and H-Claude Lavallée (Université du Québec à Trois-Rivières, Québec, Canada, G9A 5H7); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 46–49

The treatment of high consistence Cheni-thermomechanical Pulp (CTMP) pulping wastewater using activated sludge method was studied in this paper. The effect of improving technique in activated sludge acclimation on the sludge settleability and removal efficiencies was discussed. The Experiments showed that the improved technique i. e

combination of batch and continous feed in sludge acclimation process can remarkably improve the sludge settleability and removal efficiencies. The sludge volume after 30 minutes of settling was 290–320 ml/L, sludge volume index was 48–55 ml/g, the removal of COD reached to 77%–85%, removal of BOD_5 was 90%–95%, removal of TSS was 75%–89%.

Key words: batch feed, continous feed, activated sludge, acclimation technique, CTMP wastewater.

Test of Tar Emulsified Liquid as Dust Suppressant for Dirt Roads. Wu Chao et al. (Dept. of Resources Exploitation Engineering, Central South University of Technology, Changsha 410083); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 50–52

In order to control the dust raising on the dirt roads efficiently, the tar emulsified liquid with low concentration was taken as the dust suppressant. Based on a great number of experiments in laboratory, the optimum compositions of surfactants and the prepared condition for emulsifying tar were achieved, tar is 3%–6%, surfactants is 0.5% and water is 93.5%–96.5 Wt. %. The prepared temperature is greater than 70°C. Depended on a lot of tests both in laboratory and field, the results showed that the liquid is very efficient for binding dust and maintaining the dirt roads. The active time can reach more than 10 days, when the liquid is sprinkled on the road in 2.2 kg/m². A rational profit can also be achieved after it is used for years.

Key words: dust suppressant for roadway, tar emulsified liquid, field test.

Electrochemical Separation Process for Recovery of Gold, Silver and Lead from Scrap. Liang Huqi et al. (Dept. of Chem. Eng., Shanghai University, 200072); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 53–56

The electrochemical separation process for comprehensive recovery of gold, silver and lead from Au, Ag-containing scrap was investigated. The smooth and dense cathodic deposit with purity of 99% Pb was prepared by electrochemical separation process under the optimum technological conditions (electrolyte composition: 70 g/L Pb^{2+} , 100 g/L total SiF_6^{2-} ; solution temperature: 40°C. current density: 100 A/m²; concentration of β -naphthol to bone glue: 0.002 g/L and 0.5 g/L) experimentally. The current efficiency of lead was higher than 98%, the specific electric energy consumption was 117 kW · h/tPb. The recovery of Au and Ag in the anode slime were as high as 99% and 98% respectively.

Key words: recovery of Au and Ag, electrochemical separation, treatment of scrap.

Effects of Low pH Value and Aluminum on Uptake of ^{45}Ca by *Misgurnus anguillicaudatus*. Kong Fanxiang et al. (Dept. of Environ. Sci. and Eng., Nanjing University, Nanjing 210093); *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 57–59

The effects of low pH value and with or without the addition of aluminum on the uptake of ^{45}Ca by *Misgurnus anguillicaudatus* were studied. The results showed that