

污水快速渗滤处理系统对某些微量有机污染物的净化*

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摘要 利用室内大型土柱对 RI 系统中微量有机化合物氯仿、四氯化碳、三氯乙烯及苯、甲苯的净化过程进行了模拟研究. 结果表明, 系统对 3 种氯代脂肪烃具有很好的净化效果, 其浓度可从 2000—6000 $\mu\text{g/L}$ 降至 100 $\mu\text{g/L}$ 以下. 系统对苯及甲苯的净化则与淹水时间有关, 淹水初期净化效果良好, 其浓度可从进水时 1000—1700 $\mu\text{g/L}$ 降至 100 $\mu\text{g/L}$ 以下, 但随着淹水时间延续, 净化效果变差, 直至出水浓度与进水浓度基本相同.

关键词 快速渗滤, 氯代脂肪烃, 芳香烃.

污水快速渗滤处理系统(Rapid Infiltration Treatment System)已在世界各地获得了广泛的应用. 随着研究工作的深入、检测技术的提高及土壤和地下水中某些对人体健康有极大威胁的微量有机化合物的不断发现, RI 系统对微量有机化合物的净化已成为人们关注的焦点. 迄今为止, 人们对 RI 系统中微量有机物净化的研究仅停留在对其净化效果的一般性考察^[1, 2, 5], 而很少对其净化机理进行深入研究. 进入 RI 系统中的微量有机污染物种类很多, 最常见的为卤代脂肪烃及芳香烃类. 笔者重点研究这 2 类化合物, 具体种类为氯仿、四氯化碳、三氯乙烯、苯及甲苯.

试验在图 1 所示的模拟土柱装置中进行.

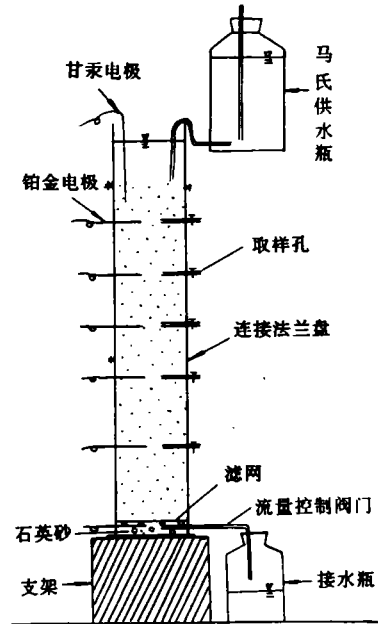


图1 模拟土柱装置示意图

土柱柱体为有机玻璃管, 外径 16 cm, 内径 15 cm. 土柱总长 240 cm, 下部 200 cm 装填土

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样,上部 40 cm 用于供水. 在土柱土体表面以下 20、50、80、110、150 及 195 cm 深处安装有取样孔. 在同样深度处分别安装有铂金电极,在土体表面安装有甘汞电极,从而可测定不同深度的氧化还原电位. 以了解系统的氧化还原条件. 土柱顶部采用马氏瓶定水头供水,淹水深度 25 cm. 土样采自北京西郊,为中细砂,阳离子交换容量 3.87 meq/100 g,比重 2.57,装填后容重为 1.50 g/cm³.

向生活污水中投放污染物配制试验用水. 生活污水中 COD 240 mg/L, NH₄-N 60 mg/L, SS 160 mg/L. 5 种微量有机污染物的投放浓度均为 10 mg/L. 污水配制后放置 1d 后使用,由

于这些化合物具有较强的挥发性,放置一定时间后其浓度将会有很大程度的下降. 试验时从土柱顶端取样,并以此结果作为各种有机物的进水浓度.

试验分 2 阶段进行. 第 1 阶段共 4 个月,主要进行土柱中微生物作用的培养,采用 5d 淹水 9d 落干的水力负荷周期,入渗速率大致保持在 4.5 cm/h 左右. 第 2 阶段共 2 个月,采用同样的运行方式,共运行 4 个周期,在各周期不同淹水时间对不同深度取样进行微量有机分析.

2 试验结果

2.1 氯代脂肪烃类

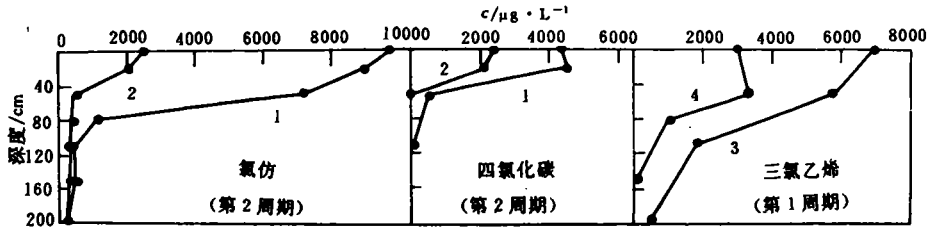


图 2 氯代脂肪烃类试验结果

1. 淹水 14 h 2. 淹水 39 h 3. 淹水 11 h 4. 淹水 35 h

试验结果见图 2.

(1) 氯仿 尽管污水中氯仿的浓度是按照 10 mg/L 配制的,但由于较强的挥发作用,到开始淹水时,其进水浓度变化很大,进入土层后,污水中氯仿浓度持续下降,在 120 cm 深度以上降低最快,在该深度以下仍然缓慢下降.

出水中的氯仿浓度为 100—300 $\mu\text{g}/\text{L}$. 与进水相比,其浓度下降 1—2 个数量级.

(2) 四氯化碳 进水浓度 2300 $\mu\text{g}/\text{L}$ —4400 $\mu\text{g}/\text{L}$,在向下渗滤过程中,浓度迅速下降,在 120 cm 深度以上,其浓度基本降至 100 $\mu\text{g}/\text{L}$ 以下,最终出水浓度很低,通常小于 50 $\mu\text{g}/\text{L}$,与进水相比,浓度下降 1—2 个数量级.

(3) 三氯乙烯 进水浓度 3000 $\mu\text{g}/\text{L}$ —6900 $\mu\text{g}/\text{L}$,随着向下入渗,浓度迅速下降,但下降速度明显小于氯仿及四氯化碳. 最终出水浓度为 50—700 $\mu\text{g}/\text{L}$,与进水相比,浓度下降 1—2 个

数量级.

2.2 芳香烃类

试验结果见图 3.

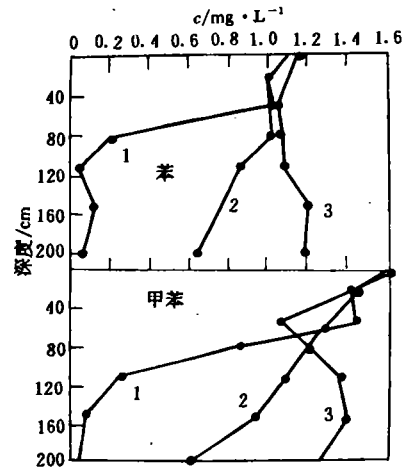


图 3 芳香烃类试验结果(第 3 周期)

1. 淹水 14 h 2. 淹水 38 h 3. 淹水 62 h

苯及甲苯的进水浓度为 1.0—1.7 mg/L.

在开始淹水阶段, 苯及甲苯的浓度随深度迅速下降, 可低至 0.1 mg/L 以下. 随着淹水时间的延续, 浓度随深度下降的速率逐渐减慢, 到淹水期后期, 浓度基本上不随深度而变化, 苯和甲苯的进出水浓度基本相当. 即苯和甲苯在系统中的净化效果与淹水时间有关, 淹水时间愈长, 净化效果愈差, 直至无净化效果. 而 3 种氯代脂肪烃类化合物则没有表现出这种情形.

3 结果讨论

RI 系统由于其干湿交替的运行方式, 从而在系统内形成独特的氧化还原环境特征: 系统开始淹水后, 系统内逐渐由好氧环境转变为厌氧环境; 停止淹水开始落干后, 系统内逐渐恢复为好氧环境.

3.1 氯代脂肪烃类

某些研究表明, 卤代脂肪烃类化合物可在一定的土壤及地下水环境条件下经历生物降解作用, 其中最有意义的为还原性生物脱卤作用. 它是在厌氧环境中, 主要由甲烷氧化细菌参与进行的生物转化过程, 甲烷为电子受体. 在该过程中, 卤代脂肪烃类化合物作为次级基质而被微生物利用. 另外, 在浅层地下环境中这类有机物也可经历好氧降解作用. 一般认为, 脂肪烃卤代程度愈高, 愈容易在厌氧条件下发生还原性脱卤作用, 而卤代程度低的脂肪烃则可在好氧环境中获得降解^[3].

本试验表明, 在淹水期, RI 系统从好氧条件转变为厌氧条件, 而氯代脂肪烃类化合物在淹水期的不同阶段, 其浓度均在向下入渗的过

程中持续降低, 并未受到系统内氧化还原条件变化的影响, 表明氯代脂肪烃类化合物在好氧和厌氧环境中均产生不同程度的生物降解作用.

3.2 芳香烃类

大量的实验室及现场研究结果表明, 苯和甲苯等化合物可在好氧环境中以 O_2 作为电子受体而获得降解, 环境中 O_2 的含量严格地控制着这种生物降解过程. 尽管也有实验室研究表明苯和甲苯等可在厌氧环境中以 NO_3^- 、 SO_4^{2-} 及 Fe^{3+} 等作为电子受体而获得降解, 但到目前为止, 现场研究并不支持这些结论^[4].

本试验结果显示, 苯和甲苯的降解过程受到 RI 系统内氧化还原条件及水中溶解氧含量影响. 在淹水初期, 系统基本处于好氧环境, 水中溶解氧含量很高, 此时苯和甲苯经历好氧降解作用而使浓度迅速下降. 随着淹水进行, 系统逐步转变为厌氧环境, 水中溶解氧量也持续减少, 苯和甲苯浓度下降也愈来愈慢. 当系统完全成为厌氧环境时, 苯和甲苯基本上不发生降解作用.

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the specific activities of ^{45}Ca are 39 532 cpm/g in skin, 38 116 cpm/g in skeleton, 25 495 cpm/g in gill and 1 651 cpm/g in muscle respectively after exposed to pH 7.10 (control) for 96 h. Compared with the control, the specific activities of ^{45}Ca decline about 81.07% in skin, 84.41% in skeleton, 80.11% in gill and 5.88% in muscle after exposed to pH 4.70 without aluminum. Under the condition of pH 4.70 with the addition of aluminum (1.0 mg/L), the specific activities of ^{45}Ca decline about 89.87% in skin, 88.83% in skeleton, 86.17% in gill and 26.47% in muscle respectively. The effects of acid rain on the calcium metabolism in fish were discussed.

Key words: low pH, aluminum, ^{45}Ca , uptake, *Misgurnus anguillicaudatus*.

The Removal of Some Organic Pollutants in Rapid Infiltration Treatment System of Waste Water. Wu Yongfeng et al. (China University of Geosciences, Environmental Science Department, Beijing, 100083): *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 60—62

The removal of some organic pollutants trichloromethane, tetrachloromethane, trichloroethylene, benzene and toluene in rapid infiltration treatment system of waste water have been simulated in large scale soil columns. The three kinds of chlorinated aliphatic hydrocarbons were rapidly removed from influent concentration of 2000—6000 $\mu\text{g/L}$ to effluent concentration of less than 100 $\mu\text{g/L}$. The removal effects of benzene and toluene depended on the flooding time. In the early part of flooding period, benzene and toluene could be removed rapidly from influent concentration of 1000—1700 $\mu\text{g/L}$ to effluent concentration of less than 100 $\mu\text{g/L}$. With the increase of flooding time, the removal effect became lower and lower until the effluent concentration of benzene and toluene almost equal to the influent concentration.

Key words: rapid infiltration, chlorinated aliphatic hydrocarbons, aromatic hydrocarbons simulated test.

Study on the Treatment of Wastewater from the Production Processes of Vitamin B₁₂ and Starch by Using UASB Reactor. Yang Jingliang et al. (Dept. of Environ. Eng., Hebei Institute of Chemical Technology and Light Industry, Shi jiazhuang 050018): *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 63—65

In Order to research the feasibility of treating wastewater from the production processes of vitamin B₁₂ and starch by anaerobic process, the study on treating the wastewater by UASB reactor was made. The results indicated that the volumetric loading of COD was 30 kg/(m³·d), removal rate of COD was 80% and volumetric producing gas rate was 16.80 m³/(m³·d) when influent concentration of COD was 10⁴—1.2×10⁴ mg/L.

Key words: upflow anaerobic sludge blanket reactor, mixed wastewater of vitamin B₁₂ and starch.

Spectrophotometric Method for the Simultaneous Determination of Phenols and Aromatic Amines in Sewage with 4-AAP. Li Meirong and Yuan Cunguang et al. (Dept. of Chemical Engineering, University of

Petroleum, Shandong, 257062): *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 66—68

A modified spectrophotometric method of determination for phenols and aromatic amines of sewage was described. It was found that the peak ranges of phenols were 500—540 nm and that of aromatic amines were 530—480 nm using 4-aminoantipyrine (4-AAP) with potassium hexacyanoferrate and ammonium peroxydisulfate in the medium of pH 5.5 HCl-(CH₂)₆N₄. Phenols of 0.1—30 mg/L and aromatic amines of 0.008—3.0 mg/L were determined simultaneously by spectrophotometry without pre-distillation and extraction. Lower than that 0.3 mg/L of sulphide and co-oil in sewage have no interference with determination of phenols and aromatic amines. The interference of Cu²⁺ and Fe³⁺ could be removed by EDTA masking. The recovery for phenols and aromatic amines were 98%—105% and 95%—105%, respectively. The sensitivities samples of 10 phenols and 13 aromatic amines were studied.

Key words: spectrophotometry, 4-aminoantipyrine, phenols, aromatic amines.

Pretreatment and Detection of Organophosphorus Pesticide Residue in Environmental Sample. Liu Feng et al. (Institute of Environmental Science of Suzhou, 215004): *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 69—70

Detection of methamidophos, dimethoate and parathion-methyl pesticide residue by FPD, NPD and ECD can be accurately determined. Extraction of solid sample into methanol aqueous solution solvent and direct aqueous solution injection not only simplify pretreatment steps but also with enough accuracy. Addition standard recovery rate of soil samples was in range of 93%—98%. The detection limits of dimethoate in water sample were 0.05 mg/L for FPD, 0.001 mg/L for NPD and 0.002 mg/L for ECD, respectively.

Key words: organophosphorus pesticide residue, methanol aqueous solution, direct aqueous solution injection, determination.

Study on the Overall Control Plan of SO₂ Emission from Small and Mid-scale Coal Combustors in Liuzhou City. Xu Kangfu et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, 17(6), 1996, pp. 71—73

Toward the SO₂ emission control technology developed in China for small and mid-scale coal combustors, a research was carried out on the technology perfection and cost-effectiveness analysis, and a practical overall plan for SO₂ emission abatement in Liuzhou city was presented. This plan can ensure the fitness of briquette combustion-vent sulfur and fluidized-bed combustion desulfurization by means of mixing for the high sulfur content low heating value coal and can improve the depth of desulfurization by utilizing the excessive base material and innovating the current wet collection device.

Key words: coal-combustion pollution, SO₂ emission control, desulphurization cost, desulphurization overall control plan.