

废水稳定塘底泥蓄积规律的分析

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摘要 通过对底泥来源及组成的分析,认为底泥由可生物降解和不可生物降解两部分组成,并对每部分的蓄积规律及影响因素进行了分析研究,在此基础上建立了稳定塘底泥蓄积公式。根据该公式可得出:①底泥中不可生物降解部分的蓄积与塘运行时间成正比;②可生物降解部分的蓄积存在一个极限值;③塘底泥的蓄积与进水水质、水量及塘的运行状况密切相关,同时还受温度的影响。

关键词 稳定塘,底泥,厌氧分解。

废水稳定塘是一种经济有效的污水生物处理设施。近年来,不少学者对稳定塘的机理和运行规律进行了研究,但研究的主要方面是塘内的水流形态、塘水体内的生态系统以及塘系统的结构形式等,而对塘底泥蓄积规律及其影响因素、底泥对塘运行规律和效果的影响等方面的研究不够深入。事实上,底泥的蓄积是塘内发生的一个重要过程,其变化过程对塘的运行规律有很大影响。

一、底泥蓄积规律概述

已有的关于稳定塘底泥蓄积规律的研究成果大多是由于工程设计或研究需要,根据研究人员的经验及实际塘的运转情况而得出的,其数学表达形式一般为经验或半经验公式,对稳定塘底泥变化规律的反应缺乏普遍性,不能在理论上对塘底泥的蓄积规律作出科学合理的解释,应用范围十分有限,推广受到限制。

Middlebrooks^[1]用塘龄、BOD 投配负荷以及每个塘中全部污泥样品的总固体和挥发固体的平均百分数等参数来描述塘中平均污泥深度。根据对试验塘污泥蓄积的观测资料,用最小二乘法做曲线拟合得出如下公式:

$$Y = 0.861 + 0.0404X_1 - 0.000175X_2 - 0.00289X_3 + 0.0059X_4 \quad (1)$$

式中, Y : 平均污泥深度(cm); X_1 : 塘龄(月); X_2 : 塘龄乘以平均总固体(%); X_3 : BOD 投

配负荷乘以平均总固体(%); X_4 : 平均总固体乘以平均挥发性固体(%)。式(1)只考虑了 BOD 投配负荷对底泥蓄积的影响,而没有反映出进入悬浮固体(SS)的影响,这显然是不全面的。而且式(1)完全是一个经验式,不能科学地解释底泥的变化规律。底泥总固体及挥发性固体的含量对于正在设计的塘来说是个未知数。因此,式(1)不能用来预测底泥的蓄积情况,也不能用来指导稳定塘的设计和管理。

文献[2]给出的兼性塘底泥蓄积公式反映了塘进水水质(SS、BOD 等)对塘底泥蓄积规律的影响,也考虑了底泥的分解过程,但没有把底泥的分解与底泥的蓄积量联系起来。底泥的分解不应是与底泥量无关的零级反应。底泥量不同,其厌氧分解速率亦不同,对塘运行的影响也不同。

二、稳定塘底泥蓄积公式的建立

本文依据对塘底泥来源、组成及蓄积过程的分析,参照已有实验及生产性数据,建立起了反映塘底泥蓄积规律的数学模型。

(一) 塘底泥的组成与蓄积过程

塘底泥主要有三个来源:①塘进水中的悬浮物;②塘水体中死亡生物体的沉积;③天然或人为的外来物,如风沙,人扔的砖瓦块等。

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塘底泥的组成可分为两部分: ① 可生物降解部分; ② 不可生物降解部分。前者可通过厌氧分解过程转变为 CO_2 、 CH_4 等气体、小分子可溶性有机物(有机酸、醇等)以及生物残渣。生物残渣难以继续降解, 将累积于塘底, 而其余物质最终会通过各种途径离开底泥层, 进入大气或返溶于塘水体, 重新参与塘内的各种变化过程。后者只能在塘底不断积累。

塘底泥的蓄积包括可生物降解部分的蓄积和不可生物降解部分的蓄积。

(二) 底泥蓄积公式的建立

依据常规厌氧过程动力学理论, 假定底泥中可生物降解部分的分解过程符合一级反应。可用下式表达塘底泥的蓄积规律:

$$\frac{dM_t}{dt} = (\alpha + \beta) - (M_t - \beta_t)k_T \quad (2)$$

式中, t 为塘运行时间(d); M_t 为在 t 时塘底泥蓄积量(kg); $\frac{dM_t}{dt}$ 为在 t 时塘底泥量的变化率(kg/d); α 为塘底泥中可生物降解部分的蓄积率(kg/d); β 为塘底泥中不可生物降解部分的蓄积率(kg/d); k_T 为可生物降解部分的厌氧分解速度常数, 在一定温度下为一常量, (1/d)。

对式(2)积分, 得到

$$M_t = \beta t + \frac{\alpha}{k_T} (1 - e^{-k_T t}) \quad (3)$$

式(3)反映了塘底泥的蓄积规律, 右边第一项 βt 反应了不可生物降解部分的蓄积, 第二项 $\frac{\alpha}{k_T} (1 - e^{-k_T t})$ 代表可生物降解部分的蓄积规律。

三、讨 论

1. 塘运行时间对底泥蓄积规律的影响

随塘运行时间的延长, βt 不断增大, 说明底泥中不可生物降解部分随运行时间不断积累。而 $\frac{\alpha}{k_T} (1 - e^{-k_T t})$ 在 $t \rightarrow \infty$ 时存在一极限值。这表明, 尽管可生物降解部分在塘运行

的最初一段时间内也蓄积、增加, 但在运行时间足够长后, 这部分将趋于恒定 (α/k_T) 而不再增加。

从总体上看, 塘中底泥蓄积总量 M_t 随运行时间不断增加, 这和实际情况相符。但运行时间足够长之后, 主要是不可生物降解部分的增加。

2. 塘底泥组成的变化

由于可生物降解与不可生物降解部分的蓄积过程不同, 随运行时间的延长, 两者在底泥中所占比例也在不断变化。可生物降解部分在底泥中的比例将越来越小, 相反, 不可生物降解部分所占比例越来越大。对于稳定运行塘, 运行时间足够长后, 可生物降解部分的累积达到极限, 不可生物降解部分将成为影响底泥蓄积的主要因素。

当然, 塘底泥组成变化还要受到进水水质、塘运行状况及泥层温度等因素的影响, 这些都反映在 α 、 β 及 k_T 等参数中。

3. 关于参数 α 、 β

由式(3)可见, α 、 β 两个参数影响着 M_t 的变化, 反映进水水质、水量、塘的运行状况等对塘底泥蓄积规律的影响。根据前已述及的塘底泥的三个来源, 可由下面两式确定 α 及 β :

$$\begin{aligned} \beta = & Q \cdot f_{ss} \cdot \eta_{ss} \cdot SS + f_A \\ & \cdot k_A \cdot A \cdot V + f_B \cdot k_B \\ & \cdot B \cdot V + W_\beta \end{aligned} \quad (4)$$

$$\begin{aligned} \alpha = & Q \cdot (1 - f_{ss}) \cdot \eta_{ss} \cdot SS \\ & + (1 - f_A) \cdot k_A \cdot A \cdot V \\ & + (1 - f_B) \cdot k_B \cdot B \\ & \cdot V + W_\alpha \end{aligned} \quad (5)$$

式中, Q 为进水水量 (m^3/d); SS 为进水悬浮物 (mg/L); f_{ss} 为进水悬浮物中不可生物降解部分所占比例(%); η_{ss} 为进水悬浮物的去除率(%); A 为塘中藻浓度 (mg/L); k_A 为藻死亡速率常数 (1/d); f_A 为死亡藻体被降解后残渣所占比例(%); B 为塘中菌浓度 (mg/L); k_B 为塘中菌死亡速率常数 (1/d); f_B 为死亡细菌被降解后残渣所占比例(%); V 为塘水体体积 (m^3); W_β 为自然或人为因素造成的不可生物

降解部分的蓄积率 (kg/d); W_a 为自然或人为因素造成的可生物降解部分的蓄积率 (kg/d)。

塘的进水水质、水量、工艺形式一经确定, α 、 β 也就基本确定, 因此 α 、 β 是反映这些因素对底泥蓄积规律影响的特性参数。式(4)、(5)中所涉及的参数可通过试验来确定, 进而求出 α 、 β 。

4. k_T 及温度对底泥蓄积的影响

底泥层的温度、底泥的性质等影响可生物降解部分的变化, 因而也影响其蓄积过程。这些因素的影响主要反映于参数 k_T 之中。

底泥层的温度在塘的运行期间随季节呈周期性变化。底泥厌氧分解的速度常数 k_t (1/d) 的表达式如下:

$$k_t = K_{20} \cdot \theta^{T-20} \quad (6)$$

式中, K_{20} 为 20℃ 时的速度常数 (1/d); θ 为温度常数; T 为底泥层温度 (℃);

式(2)、(3)中的 k_T 即是 k_t 的温度平均值。

$$k_T = \frac{1}{T_2 - T_1} \int_{T_1}^{T_2} k_t \cdot T \cdot dT \quad (7)$$

式中, T_1 为底泥层平均最低温度 (℃); T_2 为底泥层平均最高温度 (℃);

事实上, 当底泥温度很低时, 其中的厌氧分解过程十分缓慢, 甚至停止。因此 T_1 是有下限的, 一般认为 $T_1 \geq 15^\circ\text{C}$ 。

在冬春季节, 塘底泥层温度一般较低 ($< 15^\circ\text{C}$), 尤其是在北方地区。此时 $k_T = 0$, 对式(2)积分得

$$M_t = (\alpha + \beta)t \quad (8)$$

式(8)表明, 底泥层温度很低时, 底泥只积累不分解。底泥层温度低于 15°C 的运行时间越长, 污泥蓄积越快越多, 而且其中可生化降解部分所占比例会有所提高。这样, 在一年中, 由于底泥层温度的变化, 可生物降解部分与不可生物降解部分的比例会产生波动, 底泥的蓄积率 $\left(\frac{dM_t}{dt}\right)$ 也会波动。

所以, 温度对塘底泥蓄积的影响在塘的设计中应予以考虑, 尤其是在北方地区。

四、结 论

在一级反应基础上, 建立了反映稳定塘底泥蓄积规律的公式, 基本上可以反映出进水水质、水量、温度及塘的运行状况等因素对底泥蓄积的影响, 但公式未考虑底泥在塘中的空间分布规律。

α 、 β 及 k_T 是反映塘底泥蓄积规律的几个特性参数。可以通过实验或调查现有塘的运行情况, 求出不同水质条件、不同地区的具有代表性的 α 、 β 及 k_T 值, 为式(2)在设计和预测方面的推广应用创造条件。

参 考 文 献

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- 2 周帆, 龚辉等. 中国给水排水. 1990, 6(2): 30

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对生态与环境如此大范围的预警, 应系统、综合、优化、及时地采取保护和治理的措施。

六、结 语

环境影响预警研究的基础是影响识别、生态与环境质量评价和状态分析。只有这部分工作在理论方法研究和应用实践上深入和提高, 预警研究才能进一步发展和提高。本文的研

究, 一定程度上填补了现阶段环境影响评价理论与预警研究实际需求之间的技术空缺。今后的研究应进一步加强影响作用机理和生态与环境变化规律的研究, 逐步建立和健全预警评价研究的理论体系、技术方法和决策支持系统。

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A Study on the Mechanism of Biological Removal of Phosphorus-Microbial Composition of the Activated Sludge in a Sequencing Batch Reactor.

Zhou Yuexi Qian Yi et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **13**(4), 1992, pp. 2—4

In this paper, the microbial composition of the activated sludge in a sequencing batch reactor, which can effectively remove phosphates from waste water, was investigated. Experimental results demonstrate: (1) The population of bacteria in the mixed liquor of activated sludge during steady operation stage was much larger than that during the start-up stage (about 26 times larger). (2) The predominant genus during the start-up stage was aeromonas and pseudomonas came second (with no acinetobacter found), while the predominant genera during the steady operation stage were pseudomonas and aeromonas (with a limited number of acinetobacter present).

Key words: phosphorus, activated sludge, phosphate removal.

Investigation on the Kinetic Characteristics of Copper Adsorption on Red Earth in Flow Method by Utilizing First-Order Kinetic Differential Equation. Lan Yeqing et al. (Nanjing Agricultural University, Nanjing 210014): *Chin. J. Environ. Sci.*, **13**(4), 1992, pp.5—8

The kinetic characteristics of adsorption of copper on red earth in flow method was investigated by utilizing a first-order kinetic differential equation. Results show that the rate of copper adsorption is affected by diffusion. Specifically, the rate of the process is dominated by external diffusion when the adsorption is at lower levels and by the internal diffusion when the adsorption is at higher levels. At a given temperature and pH value, the theoretical saturated adsorption amount of copper is basically a constant and independent of flow rate and concentration of the solution under study. However, the experimentally determined saturated adsorption amount of copper was found to be significantly affected by the flow rate and concentration of the solution and smaller than the theoretical saturated adsorption amount.

Key words: red earth, adsorption of copper, diffusion.

Influence of Acidic Mining Waste Water on Water Quality of Lean River. Lin Yuhuan, Li Qi (Research Center for Eco-Environmental Sciences, Academia Sinica): *Chin. J. Environ. Sci.*, **13**(4), 1992, pp. 9—14

The lean river, especially in the region of waste water discharging point, was seriously polluted by mining waste water. The pH values of the river water were sometimes observed to be lower than 6.5 during flood season, the concentrations of heavy metals (Cu, Zn, Pb, Cd etc.) in the river water were close to or even obviously higher than the national standards of water quality. Furthermore, simulation calculation indicates that, at pH values lower than 6.5, most of the heavy metals existed in the water in the form of ions,

resulting in even higher toxicity to fishes. The heavy metals were also found to be accumulated in the sediment of the river. Besides, the elements like Al, Fe, Mn etc. also exerted negative influence on the treatment of drinking water and fishery.

Key words: mining waste water, heavy metals, water pollution.

Application of Discrete Multicriteria Optimization Decision Model (DMODM) in EQDSS. Wang Jinnan (Chinese Research Academy of Environmental Sciences 100012): *Chin. J. Environ. Sci.*, **13**(4), 1992, pp.15—19

DMODM is a model that can solve a sort of decisive optimization problems which are formed by discrete values of a number of decisive variables and have multicriteria for assessment of alternatives. This essay briefly describes the principle, solving methods-dominated approximation method and reference point approach of the model, as well as its application and effect in the National Environmental Quality Decision Support System (NEQDSS).

Key words: discrete Multicriteria decision model, optimization decision problem, discrete package.

Study on Warning System of Environmental Impact Assessment. Chen Zhijian, Chen Guojie (Institute of Mountain, Disasters and Environment, Academia Sinica, Chengdu 610015). *Chin. J. Environ. Sci.*, **13**(4), 1992, pp.20—23

This paper discusses the concept and integrative principle, hierarchical principle and practicable principle of the environmental impact warning assessment, defines the warning standard according to the environmental quality index, proposes mathematical models for the poor or worse state warning, deterioration trend warning and deterioration speed warning, and gives a case of the environmental impact warning assessment of the Three Gorges Hydraulic Engineering on the Yangtze River in China.

Key words: environmental impact assessment, environmental impact warning, environmental deterioration.

Study on the Accumulation of Deposits in Waste Water Stabilization Pond. Fan Xiaojun, Qian Yi (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **13**(4), 1992, pp.24—26

Results of the researches on the accumulation of deposits in waste water stabilization pond was summarized. Based on the analysis of the origin and composition of the deposits the authors suggested that the deposits are composed of two fractions: biodegradable and non-biodegradable. A theoretical model describing the accumulation of benthic deposits was hence established. According to the model, the following conclusions could be drawn: (1) the amount of the accumulation of non-biodegradable is directly proportional to the operation time of the pond; (2) the accumulation of biodegradable part of the deposits will not surpass a maximum value; and (3) the accumulation of pond benthic deposits is closely related to the quantity and quality of influents as

well as the operation conditions of the pond.

Key words: waste water, stabilization pond, anaerobic, biodegradation, benthic deposit.

Synthesis of 1-Hydroxypyrene and Its Identification.

Ma Jiang zhao (Beijing Municipal Research Institute of Environmental Protection, Beijing 100037): *Chin. J. Environ. Sci.*, 13(4), 1992, pp.27—30

A procedure for the preparation of 1-hydroxypyrene from pyrene was described. Its mass spectrum, nuclear magnetic resonance, infrared, ultraviolet and fluorescence spectra were determined. The results show that the compound thus prepared is a very pure product.

Key words: 1-hydroxypyrene, pyrene.

Research on Leaching Dynamics of Dimethypo in Soils.

Li Deping, Jin wei (Institute of Soil Science, Academia Sinica, Nanjing 210008) *Chin. J. Environ. Sci.*, 13(4), 1992, pp.31—34

With reference to OECD-Chemicals Testing Guidelines, laboratory experiments were carried out to examine the leaching dynamics of dimethypo in soils. The results suggest that dimethypo possesses a strong tendency of leaching. Thus, most of the pesticide can leach through the soil columns. With the continuous addition of leaching water, all the pesticide in soil columns can leach out. Soil properties did not show great influence on leaching, while flow rate and temperature exerted remarkable effect on leaching dynamics of dimethypo.

Key words: dimethypo, leaching test, dynamics.

Study on the Degradation of Hydrazine Hydrate in River Water.

Sun Hong et al. (Environmental Protection Monitoring Station of Benxi 118000): *Chin. J. Environ. Sci.*, 13(4), 1992, pp. 35—39

Laboratory studies and monitoring practice in a river demonstrate that the degradation of hydrazine hydrate can be described by the first-order reaction dynamics. Its degradation rate was found to be dependent on water temperature, microorganism, concentration of dissolved oxygen, pH and other conditions. The effect of temperature on the degradation rate could be expressed with the formula: $K_T = K_{20} \theta^{(T-20)}$. Calculation with computer shows that when $\text{pH} \approx 6$, then $K_{20} = 0.028 \text{ 1/h}$ and $\theta = 1.045$, when $\text{pH} \approx 8$, then $K_{20} = 0.021 \text{ 1/h}$, $\theta = 1.036$. The degradation coefficient of hydrazine hydrate measured in the experiment carried out in the river was equal to 0.3001/h.

Key words: hydrazine hydrate, degradation, first-order reaction dynamics

Oxidation Dephenolization of Waste Water Catalyzed by Horseradish Peroxidase

Hu Longxing et al. (Shanghai University of Technology 200072): *Chin. J. Environ. Sci.*, 13(4), 1992, pp. 40—44

The results of the study on oxidation dephenolization of waste water catalyzed by horseradish peroxidase show that for the treatment of waste waters containing only one of the three phenols (phenol, o-chlorophenol and o-aminophenol), the highest phenol removal efficiency can be reached at pH values around 7. It was also found that at low (4°C) and high (40°C) temperatures, the removal efficiencies reduced

by about 10%, and in the treatment of waste water containing more than one phenols, there existed synergistic effect among various phenols resulting in phenol removal efficiencies as high as 95%.

Key words: phenols, waste water treatment, horseradish peroxidase.

A Study on Modification of the Surface of Coal Ash.

Lü Yaojiao, Zhang Jishuang (Hunan University 410082): *Chin. J. Environ. Sci.*, 13(4) 1992, pp.45—47

The modification of the surface of coal ash was achieved by treating the ash with six kinds of surfactants including H-NA, H-R through dry or wet processes of activation. Experiment results indicate that the number of hydroxyl group on the ash surface decreased while corresponding groups of activator increased resulting in the improvement of its property of dispersion in organic medium. The properties of processed PVC and rubber samples with the activated coal ash as filler were greatly improved compared with those products with untreated ash as filler. All the technical targets of the new products, except for the decrease of abrasive wear of rubber, which needs to be further improved, reached or surpass the relevant standards. No doubt, this is a new path for making use of the regenerated resource with the advantages of lowering the cost of composite material and protecting the environment.

Key words: coal ash, surface modification, composite material.

Taxonomic System for Environmental Science.

Wang Huijun, Chen Jingsheng (Center of Environmental Science, Peking University, Beijing 100871): *Chin. J. Environ. Sci.*, 13(4), 1992, pp. 48—51

A new and more reasonable taxonomic standard for environmental science is introduced based on the systematic analysis of the synthetic, integrate and inter-disciplinary character of the science and the forms and extent of the synthesis and integration. According to the new standard, environmental science can be regarded as an organic entirety composed of three levels of interrelated discipline groups.

Key words: taxonomic system, environmental science.

Application of Enzyme Immunoassay in Pesticide Analysis

Li Zhixiang, et al. (Institute of Agro-environmental Protection Tian Jing 300191): *Chin. J. Environ. Sci.*, 13(4), 1992, pp. 51—55

This paper introduces briefly the technique of Enzyme Immunoassay and its application in pesticide analysis. The basic types, principles, procedures of development and the prospect of future application and further advancement of Enzyme Immunoassay were discussed.

Key words: pesticides, enzyme immunoassay.

Application of Micronucleus Test in *Vicia Faba* Root Tips in the Rapid Detection of Mutagenic Environmental Pollutants.

Ruan Cuicai, Liang Yu-an, Liu Jinling et al. (Guangxi Cancer Institute, Nanning 530027): *Chin. J. Environ. Sci.*, 13(4), 1992, pp. 56—59

Micronucleus test in *vicia faba* root tips was performed for