东太湖水生植物的促淤效应与磷的沉积

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摘要 东太湖水生植物促进淤积效应显著, 硬度小于5kg/cm^{2}的淤积物平均深度0.96m, 总淤积量149 370 000t, 东南沿岸茭草分布区淤积尤为严重. 生物有机物质只占总淤积量的1.52%, 水生植物并非淤积物的主要来源. 但生物有机物质引起的淤积物疏松效应使得全湖淤积深度增加了0.20m, 占总淤积深度的20.8%. 表层沉积物中生物有机物质含量3.77%, 疏松效应占淤积深度的64%. 淤积物中总磷平均含量0.023%, 总积累量34 912t. 磷在淤积物中的积累主要经非生物沉积途径, 水生植物通过促进湖水中含磷物质的沉降和防止淤积物再悬浮起了促进磷沉积的作用. 该湖水生植物收获利用率已达57%, 对减轻生物沉积十分有效, 但尚有进一步开发利用的潜力.

关键词 东太湖, 水生植物, 淤积, 磷.

东太湖是太湖东南部的一个大湖湾, 面积131.25km^2, 平均水深1m 左右, 水生植被覆盖率达97%. 它是太湖的主要出水通道, 湖水由太湖携带的泥沙和污染物质进入东太湖后迅速沉降, 淤积较为严重. 本文根据"八五"期间对东太湖沉积物和水生植物的研究资料, 主要探讨淤积及磷在沉积物中的积累与水生植物间的关系, 旨在揭示水生植物的各种促淤机制在东太湖淤积中所起作用的大小, 分析磷在淤积物中积累的可能机制和途径. 这对于较为深刻地认识水生植物在湖泊生态系统中的功能, 制定适当的水生植物管理政策, 具有科学指导意义.

1 研究方法

1993年11月, 在东太湖沿8条样线设42个样点(图1), 在每个样点上用截面积12cm^{2}的探测棒以4.9×10^{5}Pa 的压力探测湖底松软沉积物的深度, 再用内径6.0cm 的玻璃管采样器采集柱状沉积物样品, 采集深度随淤泥深度而定. 由表层开始, 每10cm 一层对柱状样品进行分割. 样品经风干后全部粉碎, 通过200目筛, 分析以下项目: 密度(干容重), 用105℃恒重法; TOC, 用重铬酸钾-硫酸消化法; TP, 用氢氟酸-硫酸溶钼锑抗比色法[2]. 有关水生植物的资料均引用1992—1993年调查研究结果*.

关于全湖松软沉积物某些定量参数的计算方法如下:

平均淤积深度= $\sum$ {[样点淤积深度][样点面积权重]}

淤积总量(干重) = 湖泊面积 $\sum$ {样点面积权重 $\sum$ [(样品分层厚度)(样品密度)]}

TOC 积累量 = 湖泊面积 $\sum$ {样点面积权重 $\sum$ [(样品分层厚度)(样品密度)(样品TOC 含量)]}

TP 积累量 = 湖泊面积 $\sum$ {样点面积权重 $\sum$ [(样品分层厚度)(样品密度)(样品TP 含量)]}

表层平均 TOC 含量= $\sum$ {[样点面积权重][表层样品 TOC 含量]}

表层平均 TP 含量= $\sum$ {[样点面积权重][表层样品TP 含量]}

其中, 样点面积权重是指样点所代表的湖面占全湖面积的比例, 样点之间湖面的划分界线选用连接2个相邻样点线段的平分线.

2 结果及讨论

2.1 淤积状况

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东太湖淤积较为严重,实测松软淤积层深度0.35—2.28m,全湖平均深度0.96m,以东南沿岸带淤积较深,中部北侧较浅(图2).实测淤积物密度(干容重)0.08—1.72t/m^3,平均密度1.185t/m^3.表层淤积物密度0.08—1.05t/m^3,平均密度0.57t/m^3,最高密度出现在中部湖心区,由湖心区至沿岸带表层淤积物密度依次减小(图3).淤积物密度的垂直梯度十分明显,底层淤积物密度一般可达1.4t/m^{3}以上.在表层淤积物密度最小的35号样点上,在0—70cm深度范围内,淤积物密度与深度呈近似线性关系(图3左上角坐标图).

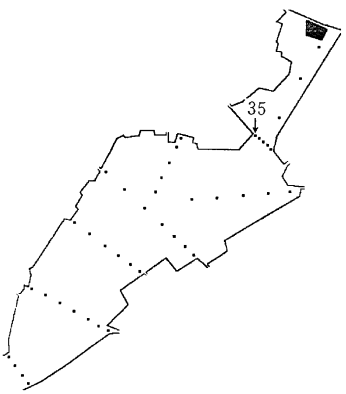

图1 东太湖沉积物采样点分布图

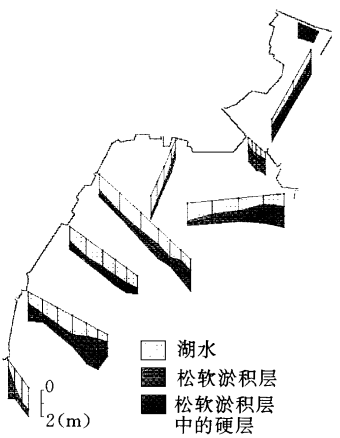

图2 东太湖水深及松软淤积层深度

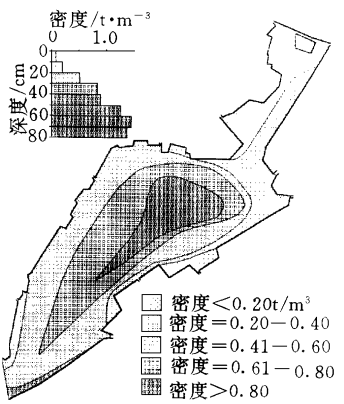

图3 东太湖表层淤积物(0—10cm)及35# 样点上柱状样品的密度(干容重)

2.2 生物淤积与非生物淤积

东太湖总面积131.25km^2,松软淤积层平均深度0.96m,淤积物平均密度1.185t/m^3,全湖松软淤积物总蓄积量约149 370 000t(烘干重).淤积物中TOC平均含量0.88%,总蓄积量1 321 000t,折合有机质2 227 000t,是淤积物总量的1.52%,而非有机成分占了淤积物总量的98.48%.因此,生物沉积物在东太湖淤积物中所占的比重是微不足道的.

对表层淤积物密度和TOC含量进行统计分析(图4),发现二者之间存在密切的负指数关系:

$$\text{密度}(t/m^3) = 0.860e^{-0.155\Gamma OC(\%)}$$

$$R^2 = 0.76$$

这说明,有机物质能使淤积物变得疏松,从而增加淤积层的深度.假如东太湖淤积物中没有有机物,其密度取东太湖TOC含量小于0.1%沉积物的平均密度1.5t/m^3,则现有松软淤积层的期望深度约为0.76m.也就是说,生物沉积物引起的淤积物疏松效应给东太湖增加了大约0.20m的淤积深度,占现有淤积深度的20.8%.加上生物沉积物本身在总淤积物中所占的份额,生物沉积物的总淤积效应对于东太湖的淤积应负22.2%的责任.

东太湖淤积物中的生物沉积物含量呈现出强烈的增长趋势.1960—1993年,表层淤积物中的TOC含量增加了12.9倍[3],这与水生植物现存量的增加幅度基本相近*.TOC含量随着淤积深度的变化也表现出类似的趋.全湖表层淤积物TOC平均含量3.77%,折合有机质含量6.50%;平均密度只有0.57t/m^3,疏松效应占淤积层深度的64%;生物沉积物的淤积效应在总淤积中所占比例高达66.54%.

水生植物是东太湖淤积物中有机物质的主要来源.自1959年**以来,全湖水生植物总现存量增高了9倍,每年大约有521000t的水生植物

* 李文朝、杨清心.东太湖渔业生态环境质量及优化调控对策研究.国家"八五"科技攻关课题"东太湖局部水质恶化原因及防治对策研究"(85-14-01-03-02)研究报告,1995.

** 华东师范大学生物系.东太湖水生生物调查报告.华东师范大学内部资料,1995

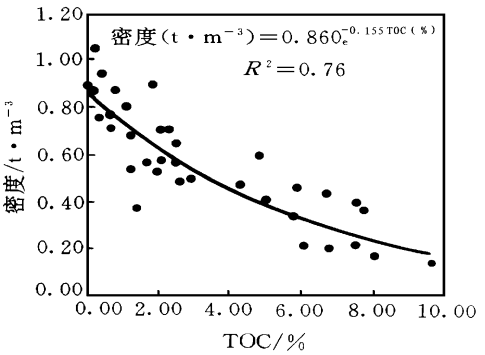

图4　表层淤积物密度与TOC含量的指数关系

(干重)残留在湖内[***],这正是同期内表层淤积物中TOC含量大幅度上升的根本原因.淤积最为严重的东南沿岸带正是茭草(*Zizania latifolia*)分布区,这里的茭草是在60年代人为栽种的.茭草年生长量(干重)高达22200t,仅有10%被收割利用,剩余90%的茭草生长量在湖内自然死亡腐烂,其不易分解的纤维质残骸进入淤积物.

2.3　淤积物中的磷含量

淤积物中总磷(TP)实测含量0.005%—0.061%,平均含量0.023%,总积累量34912t.表层磷含量0.023%—0.061%,平均含量0.029%.磷含量的变化幅度相对较小,在占全湖面积30%左右的西北沿岸带表层淤积物磷含量略有增高(图5).磷含量随淤积深度的变化趋势不很明显(图5左上角坐标图).依据1960[3]、1980[4]和1991[***]年的调查资料,表层淤积物中的磷含量也较为稳定,在30年中仅上升了0.004%.

2.4　水生植物的促淤效应与磷的积累

淤积物中磷含量与TOC含量无明显的相关关系(图6),也与淤积深度和水生植物的分布状况无关.这说明,磷进入淤积物并非依赖于生物沉积途径,而是主要通过沉降、吸附、离子交换等物理过程来实现的.西北沿岸带磷含量较高的主要原因是,东山半岛的生活污水、农田排水及鱼池排水经诸多河流进入东太湖,给沿岸带造成了较高的磷污染负荷.自大缺港进入东太湖的河水来自西太湖,流量比较大,磷含量较

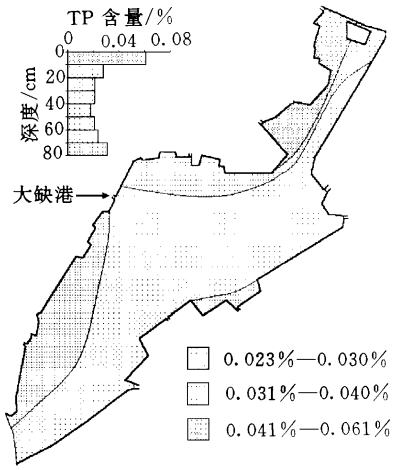

图5　东太湖表层沉积物(0—10cm)及35#样点上柱状样品的TP含量

低,其河口区淤积物中磷含量也比较低.磷沉积的这种地域性特征同样说明,磷是经过非生物沉积途径进入淤积物的.

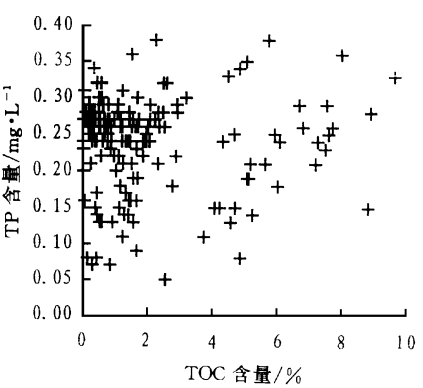

图6　淤积物中TP含量与TOC含量关系

虽然水生植物的生物沉积不是磷沉积的主要通道,但东太湖水生植物仍然能通过其促淤作用促进磷的沉积,因为水生植物的促进淤积效应是显著的,淤积物中具有较为稳定的磷含量.据有关资料[*],每年大约有29亿m^3的湖水经东太湖外泄,随水流携入东太湖的颗粒态固体(直径大于0.45μ)总量8万多t,其中绝大部分沉降在东太湖.茭草的促淤效应尤为显著,东南沿岸带和西北沿岸带的南部均为茭草分布区,其平均淤积深度达1.2m,是沉水植物区淤积深

*** 李文朝等.太湖富营养化调查研究报告(1990—1991).中国科学院南京地理与湖泊研究所内部资料,1992

度的2倍以上. 自60年代以来, 东太湖水生植物现存量增长了约9倍[4—6], 其促淤效应也在随之增强.

适度收获水生植物, 可以减少水生植物在湖泊内的残留量, 有效地减轻生物沉积效应, 但对磷沉积不会产生明显的影响. 东太湖年收获利用水生植物(鲜重)近60万 t, 主要用作围垦区养殖草鱼的饲料, 创造饲料价值上千万元; 同时将57% 的水生植物量移出湖体, 带走磷近300t. 尽管如此, 东太湖水生植物残体引起的湖泊淤浅问题仍然很严重, 在茭草分布区尤为突出. 必须将水生植物的管理列为东太湖水质和生态环境管理的首要任务, 尽早剔除收获利用率较低的茭草, 加强对沉水植物的收获利用, 以减缓湖泊淤积变浅的速度.

3 结语

由于水生植物的促淤效应, 东太湖淤积较为严重, 松软淤积层平均深度0.96m, 总淤积量149 370 000t. 生物有机质只占淤积总量的1.52%, 在表层淤积物中也只有3.77%, 说明东太湖淤积物主要是外源性无机物质, 水生植物自身并非淤积物的主要来源. 但生物有机物质引起的淤积物疏松效应较为显著, 约占到淤积物平均深度的20.8%, 在表层淤积物中已经占64%.

淤积物中磷平均含量0.023%, 总积累量34 912t. 磷含量变幅较小, 而且与 TOC 含量无关. 表层淤积物中的磷含量与水生植物的分布格局无明显关系, 但表现出靠近西北岸磷污染源沉积的特征. 这说明, 磷在淤积物中的积累主要经由非生物沉积途径, 水生植物通过促进湖水含磷物质的沉降和抑制表层沉积物的再悬浮而起到促进磷沉积的作用.

东太湖水生植物总生长量的57% 已被收获利用, 这对于减轻生物沉积极为重要. 继续加强对水生植物的优化改造和利用, 进一步削减生物沉积量和淤积速度, 对于保护东太湖良好的水质和生态环境是至关重要的.

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Study on Inorganic Membrane Bio-Reactor for Domestic Wastewater Treatment. Xing Chuanhong[1], Tardieu Fric and Qian Yi[2] (1) State Key Laboratory of Environmental Simulation and Pollution Control, Dept. of Environ. Eng., Tsinghua University, Beijing, 100084, 2) CIRSEE-Lyonnaise des Eaux, 38, rue du President Wilson, F78230 Le Pecq.): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 1—4

It is proven that Inorganic Membrane Bio-Reactor (IMBR) applied to domestic wastewater treatment is technically feasible and reliable during several months. In this study, under conditions of membrane flux between 75 and 150L/(m^2 • h), hydraulic retention time 5 hours, sludge retention time 5, 15, 30 days and velocity inside the membrane channel 4 m/s, the stable sludge concentrations (MLSS) in the bioreactor reach 3.1, 10.7and 17.3g/L after 10, 16 and 14 days respectively. Average removal rate of COD, NH_3-N, and turbidity of the system are higher than 96%, 95%and 98%, SS and E. coli., 100%. The effluent quality is always better than the quality standard for reuse issued by the Ministry of Construction in China. Moreover, fouling mechanisms of IMBR are also discussed in this paper. The initial permeability of inorganic membrane can be easily recovered over 90% after physical and chemical cleaning operations.

Key words: inorganic membrane, bioreactor, fouling, cleaning.

The Effect of Monocarboxoldehyde on the Structure and Biomass of Crop Population. Huang Yingxiao and Lin Shunhua et al. (Institute of Botany, Chinese Academy of Sciences, Beijing 100093): *Chin. J. Enviro n. Sci.*, **18**(3), 1997, pp. 5_ 8

The effect of a new pesticide mono carboxoldehyde (DMAH, concentration of 25%), on the structure and biomass of crop population was studied. The results showed that the effect of DMAH to biomass population varied following concentration of DMAH and crop species. In the treatment of 1000 times dilution DMAH, both of above-ground and under-ground biomass of cotton and bean were higher than control, while with 10 times dilution treating cotton and with 50 times dilution treating bean were obviously lower than the control. There were significant effect on the yield structure of cotton treated with 1000, 500, and 100 times dilution DMAH, especially in the treating system of 500 times, in which highest biomass of the layer was 2.5 times higher than the control. The amount of non-assimilative system was also obviously higher than the control (1.5 times) for the 1000 times treating system. In the 10 times treatment, both of assimilative system and non-assimilative system of cotton were evidently different, the height, leaf and root biomass were depressed. The structure of bean population changed according to the concentration and acidity of DMAH. The amount of assimilative and non-assimilative system of bean population increased by a factor of 2.2 and 1 respectively for control. The productive structure of bean treated whith 50 times was decreased. There was a linear relationship between the light intensity as well as photosynthesis rate of crop and assimilative system amount in any layer.

Key words: monocarboxoldehyde, crop, population, biomass, structure, cotton, bean.

Silting-up Effect of Aquatic Plants in Lake East Taihu and Accumulation of Phosphorous in The Sludge. Li Wenchao (Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, Nanjing 210008): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 9—12

Remarkable accelerating effect of aquatic plants on silting-up of Lake East Taihu was found. For the whole lake, mean depth of sludge(hardness< 5kg/cm^2) was 0.96m, and the total amount(dry weight) 149 370 000 t. In the zone along Southeastern shore where emerged plant *Zizania latifolia* was growing luxuriantly, the sludge was much more deeper. Organic matter only took 1.52% of the sludge which means that aquatic plants was not the main source of the materials in the sludge. But the organic matter made the sludge very loose (loosening-effect) which added 0.20 m sludge depth, about 20.8% of the total sludge depth. In the surface-layer sludge(0—10 cm), organic matter took 3.77% of the sludge and loosening-effect took as much as 64% of sludge depth. Mean content of phosphorous in the sludge was 0.023%, and the total amount of phosphorous 34 912 t. Phosphorous accumulated in the sludge mainly by non-biological sedimentation means. But aquatic plants accelerated phosphorous sedimentation primarily by promoting settlement of suspended solid in the lake water and protecting the loose sludge from erosion of wind-waves or current. It was very effective for reducing biological sedimentation that about 57% of plant product was harvested from the lake, but there was still large amount of plant matter was left in the lake.

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