东湖生态学研究概况*

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摘要 以长江中下游流域具代表性的武汉东湖为基地对其生态学进行了长期的观测和系统研究. 详细地阐述了氮、磷在水体中分布、转移及积累, 浮游植物的演替, 浮游植物初级生产力及其对鱼产潜力的估算, 浮游动物现存量和生产量, 有机碎屑在生态系统中的功能和鱼类放养对生态系统的下行效应等.

关键词 东湖, 生态学, 结构与功能, 下行效应.

长江中下游浅水湖泊是我国特有的、极其宝贵的淡水资源库, 由于这些水体位于亚热带北缘, 光、热、雨量充沛, 饵料生物丰富, 具有很高的水体生物生产力, 历来是我国重要的淡水渔业基地. 然而, 在利用湖泊的同时, 常对湖泊生态系统的脆弱性估计不足, 由于资源的过度开发以及湖滨人口增长等多种原因, 致使生态平衡受到破坏, 限制了水体综合功能的发挥. 东湖生态学研究依据本学科发展趋势, 紧密结合我国国情并吸收国际联合研究中获得的研究成果, 从个体、种群、群落和生态系统的各个层次进行长期定位观测和系统研究.

东湖生态学研究最早可追溯到 50 年代的水生生物学综合调查, 60 年代的浅水湖泊生物生产力研究, 70 年代的渔业增产试验和生物生产力研究[4], 80 年代的生态系统结构、功能和生物生产力研究等.

1 东湖主要营养元素氮、磷的收支及积累

1979 年– 1980 年, 通过现场观测和实验室分析宏观地估算了东湖氮、磷的输入和输出[5]. 结果表明: 东湖氮的总输入量为 536.3t/a, 单位面积总负荷量为 19.22g/(m^2 · a); 磷的总输入量为 87.8t/a, 单位面积总负荷量为 3.15g/(m^2 · a). 氮、磷输入的主要来源为生活污水和工业废水, 分别占总输入量的 59.2%和 74.7%. 氮、磷的总输出量分别为 323.2t/a 和 67.7t/a, 有 39.7%的氮和 22.9%的磷积累于水体中.

2 浮游植物群落结构的演替规律

50 年代东湖大型水生植物覆盖率达 70%以上, 水质清新, 金藻门如棕鞭藻(*Ochromonas*)、锥囊藻(*Dinobryon*)和单鞭金藻(*Chromulina*); 硅藻门如: 窗纹藻(*Epithemia*)、异极藻(*Gomphonema*)、直链硅藻(*Melosira*)、小环藻(*Cyclotella*)出现率在 47.9%– 85.7%之间(其中直链硅藻为 29.1%), 年平均变幅为 50– 1000 ind · ml^{-1}, 优势种的数量也只有 35 ind · ml^{-1}. 60 年代, 浮游植物优势种发生明显变化, 蓝藻门的微囊藻(*Microcystis*)、鱼腥藻(*Anabaena*)、绿藻门的栅藻(*Scenedesmus*)等数量逐渐上升, 硅藻门的直链硅藻的出现率提高到 52.8%– 83.3%. 藻类的年数量平均变幅由 50 年代的 50 ind · ml^{-1}– 1000 ind · ml^{-1}提高到 200 ind · ml^{-1}– 2000 ind · ml^{-1}, 优势种群的数量达 729 ind · ml^{-1}. 70 年代平裂藻(*Merismopedia*)出现率由 1962– 1963 年的 35.4%提高到 61.1%. 浮游植物数量的年变幅为 500 ind · ml^{-1}– 5000 ind · ml^{-1}.

80 年代中期开始, 浮游植物小型化加速, 群体藻类如微囊藻、鱼腥藻数量显著下降, 大小

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仅为几微米的微型藻如隐藻(*Cryptomonas*)、蓝隐藻(*Chroomonas*)出现率由 20% – 30% 上升至 80% – 90%,数量激增,由 32 ind · ml^{-1}增加到 2889 ind · ml^{-1}. 此外,小环藻(*Cyclotella*)、针杆藻(*Synedra*)等数量亦有增加. 小型颤藻(*Oscillatoria tenuis*)、中华尖头藻(*Raphidiopsis sinensis*)等在 50– 70 年代并未发现. 80 年代起,逐年增加至 1986 年成为优势种. 浮游植物不但体型变小,而且数量大幅度增加,从 1956 – 1957 年的约 1000 ind · ml^{-1}至 1986 年增为 35000 ind · ml^{-1},几乎每年增加 1 倍.

在浮游植物数量大幅度增加的同时,多样性则随之下降. 以代表性较强的湖中心来说,浮游植物多样性指数由 1956 年的 3.41 至 1986 年下降为 2.26[3,7].

3 浮游植物初级生产力及其对鱼产潜力的估算

60 年代初,在我国率先用黑白瓶测氧法测定了东湖浮游植物初级生产力[1],并对 3 种不同类型的湖区:藻型湖区、草型湖区、草–藻过渡型湖区的生产力进行了比较研究,结果表明以藻型湖区浮游植物生产量(干重)最高,达 1306.5 g · m^{-3} · a^{-1};草型湖区最低,仅为 228.6 g · m^{-3} · a^{-1},草–藻过渡型湖区居中,为 527.1 g · m^{-3} · a^{-1}.

藻型湖区(郭郑湖)近 30 年浮游植物全年最高水柱日产量(P_{Ga})的逐年(T_y)变化规律为:

$$P_{Ga} = 4.532 + 0.243\ T_y$$

草型湖区(汤林湖)水草生物量(B_m)与浮游植物全年最高水柱日产量(P_{Ga})之间的关系为:

$$P_{Ga} = 4.277 - 0.012\ B_m$$

同时根据浮游植物初级生产量求得对鲢、鳙的供饵能力,并通过浮游植物对鲢、鳙的转化效率的计算,估算出东湖鲢、鳙的生产潜力,进而求得鲢、鳙的合理投放量. 计算结果东湖浮游植物全年对鲢、鳙供饵能力为 6×10^7 kg 以上,由此估算出东湖鲢鳙的生产潜力为 789kg/hm^2 以上[1,2].

4 浮游动物现存量和生产量

应用直接称重法获得了东湖优势浮游动物不同体长组的体重并用统计方法获得了体长–体重回归方程[8]. 采用室内外相结合的方法测定了东湖优势浮游动物在不同培养温度下的不同发育阶段的发育时间,结合野外种群统计资料测算它们的生产量. 结果表明 80 年代东湖原生动物、轮虫、枝角类和桡足类的生产量(干重)分别为 16.50、9.60、14.51、5.87 g · m^{-3} · a^{-1},浮游动物的总生产量为 46.48 g · m^{-3} · a^{-1}[3,9].

随着环境的变迁,30 年来东湖浮游动物群落结构发生了明显变化. 60 年代至 80 年代中,枝角类中透明♀蚤(*Daphnia hyalina*)和隆线♀蚤一亚种(*D. carinata* ssp.)是绝对优势种群,最高密度可达 169 ind · L^{-1}. 80 年代中期以来,这二种优势枝角类的种群密度日益减少,至 90 年代已趋于绝迹. 在种群密度减少的同时,体型小型化也极明显. 透明♀蚤在 1980 年的平均体长为 1.22mm,至 1988 年缩小为 0.65mm. 以东湖 3 种优势枝角类为例,分析了它们的平均体长(Y, mm)与时间(X)的回归关系:

透明♀蚤: $Y = 142.18 - 0.07117\ X$

隆线♀蚤一亚种: $Y = 122.23 - 0.06107\ X$

短尾秀体♀蚤: $Y = 61.56 - 0.03067\ X$

小型浮游动物数量的增加十分明显. 如原生动物由 60 年代的每升几千个增长为几万个.

高 r_m 种群取代低 r_m 种群是东湖浮游动物演替的显著特点,r_m 是种群的内禀增长力(intrinsic rate of increase),它的大小取决于生殖能力、寿命和发育速度等. 高 r_m 值的种群增殖速度快,以高的出生率弥补高的死亡率,在异源演替强烈的生境中能适应环境的激烈变动. 通过实验室培养获得了在 35℃,短尾秀体♀蚤(*Diaphanosoma brachyurum*)和隆线♀蚤一亚种的 r_m 值分别为 0.94 和 0.65. 自 80 年代以来 r_m 值较低的隆线♀蚤一亚种为高 r_m 的短尾秀体♀蚤逐渐取代,后者已成为目前东湖的夏秋季第一优势枝角类[10].

5 有机碎屑在生态系统中的功能

有机碎屑(Organic detritus)是生态系统中的一类能源物质. 它是死亡后有机体形成的颗粒有机物与微生物紧密结合的一个整体,具有很大的异质性. 根据显微镜观察和显微摄影研究了有机碎屑的形成过程并用沉淀采集器采得沉淀物,用显微镜计数和元素分析仪进行了定量研究. 80年代东湖3个湖区的有机碎屑的现存量分别为72.505、18.125和52.398$\mu g \cdot L^{-1}$. 并用特制的浮式沉降物采样器研究东湖颗粒有机碳的沉淀率及各种成分. 对颗粒有机碎屑在鲢、鳙鱼营养中的作用进行了试验性研究[3, 11].

6 鱼类放养对生态系统的“下行效应”

武汉东湖是全国闻名的面积在万亩以上的渔业高产、稳产湖泊. 该湖1971年的鱼产量为182.5t至1995年上升至1840t,其中鲢、鳙鱼的产量占总产量的95%以上. 这些滤食性鱼类的代谢活动对湖泊生态系统结构、功能有何影响?这在经典的湖沼学中找不到现成的答案. 因此紧紧围绕鱼类放养对生态系统的下行效应(top-down effects)以及养鱼与水体富营养化间的关系进行了深入研究,结果表明,①鲢、鳙鱼摄食过程加速了水体氮、磷释放进程;②鲢、鳙鱼的摄食过程一方面提高了对初级生产量的利用率,而另一方面却通过渔获物从水中移出大量的氮和磷;③在选择效率规律的作用下,鲢、鳙鱼的大量滤食,促进浮游生物小型化. 因此在强化渔业的湖泊中导致湖泊生态系统功能加速,物质循环形成‘短路’,打破了正常的系统演替、平衡规律[3, 6].

7 新技术、新方法的应用

结合我国国情及时地应用新技术、新方法提高湖沼学研究水平. 在浅水湖泊中,首次用鱼探仪估算了东湖鱼群密度和个体大小,建立起一整套测定水细菌现存量和浮游动物对细菌牧食力的实验方法(包括AODC法、扫描电镜等);把多种放射性核素应用于浮游生物群落生态学以研究不同营养层次间的碳流动态;利用电子转移酶系统测定浮游藻类和细菌的呼吸量以及酶学方法在菌、藻生产力中的应用等[12, 13].

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The Mn^{2+} removing activity of the filter sand from 2 Chinese Water Plants was analyzed to determine the role of the bacteria in the Mn^{2+} removing Procession. Enumeration of bacteria on PYCM medium showed that there were 10^5-10^6 bacteria per g wet sand and about 40%-50% of the colonies had the ability to oxidize Mn^{2+}. By the in situ enrichment of the bacteria, sterilization and the $HgCl_2$ inhibition of the mature sand, it was found that bacteria were indispensable to the maintenance of the activity of the sand. When the bacterial activity was inhibited, the activity of the sand was reduced to20% of the original one. The remaining activity might be due to the chemical catalysis. Bacteria were the major source of the Mn^{2+} removing activity of the filters.

Key words: groundwater, Mn^{2+}, bacteria, chemical factors, filter sand.

A Study on the Characteristics of the Activated Sludge for Anaerobic Attached Microbial Film Expanded Bed Process. Zhang Jianli and Li Lijian (Dept. of Food Science, Laiyang Agricultural College, Laiyang 265200), Feng Xiaoshan (Dept. of Environ Science, Zhejiang Agricultural University, Hangzhou 310029): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 42-44

The characteristics of activated sludge in the anaerobic attached microbial film expanded bed (AAFEB) reactor were studied. The results showed that there were three consecutive phases in the course of biofilm formation and development, namely, adsorbtion phase, partly coating phase and fully coating phase. In this process, the predominant microorganisms were changed gradually from coccus to filamentous organisms, which caused anaerobic sludge activity increasing. Under the acidification condition, there were a lot of streptococcus and extracellular polymer on the surface of activated sludge, and the sludge activity was low.

Key words: anaerobic attached microbial film expanded bed reactor, anaerobic activated sludge, biofilm.

Catalytic Properties of Two Kind of Catalysts in Toluene Combustion Reaction. Li Shiyao, Li Shulian et al. (Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 45-47

Toluene organic exhausts were regarded as index reaction in evaluating the catalytic performance of honeycomb ceramic monolith catalysts consisting of noble metals and non-noble metals respectively by means of a continuous system with a fixed bed of catalysts. The effect of toluene concentration and oxygen content in the exhaust, space velocity, linear velocity on toluene reaction, and the thermal stability of catalysts were investigated. It is found that the activity of noble metal catalyst is superior than that of non-noble metal catalyst under different conditions. The light-off temperature of toluene exhaust on non-noble metal catalyst is by 50℃ higher than that on noble metal catalyst after catalysts calcine at 600℃ for 3h. Meanwhile, after catalysts calcine at 900℃ for 3h, the light-off temperature of toluene exhaust on noble metal catalyst increases only by 3℃ as compared with the calcination of 600℃ for 3h. But under same condition, the light-off temperature of toluene exhaust on non-noble metal catalyst increases by 87℃.

Key words: combustion reaction of toluene exhaust, honeycomb ceramic monolith catalyst, thermal stability, light-off temperature.

Photochemical Disinfection of Wastewater. Kong Lingren, Chen Xi et al. (Dept. of Environ. Sci. and Eng., Nanjing University, 210093): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 48-50

A new method of photochemical disinfection for wastewater from Nanjng city was investigated. By aerating and using methylene blue(MB) as photosinsitizer, the wastewater samples were disinfected under sunlight and a medium pressure mercury lamp separately. The results were as follows: (1) The disinfection of wastewater were remarkably affected by the light sources, light intensity, irradiaded time, MB concentration and dissolved oxygen; (2) The bacteria which were disinfected by UV could be partially photoreactivated under sunlight; (3) The disinfection rate could reach 100% and the bacteria photoreactivation were not appeared when 1 liter of the sample containing 3.1×10^6 bacteria and 2 mg MB were irradiaded by a 300W medium pressure mercury lamp for 4 min; (4) The residual MB in the samples could be removed by bentonite clay. The disinfection mechanisms of UV and photosensitization, the bacteria photoreactivetion and the effects for affecting disinfection were discussed.

Key words: photochemistry, photosinsitization, UV irradiation, disinfection.

Summary of Studies on the Ecology of Lake Donghu. Liu Jiankang and Huang Xiangfei (Institute of Hydrobiology, Chinese Academy of sciences, Wuhan 430072): *Chin. J. Enwiron. Sci.*, **18**(1), 1997, pp. 51-53

Taking the Donghu (in Wuhan), a representative lake of the middle and lower basins of Chang Jiang River as a base, the present project has conducted stationary monitoring and systematic researches on the ecology of Lake Donghu for more than 30 years. Achievements of the studies include the estimation of the budgets for the main nutrients nitrogen and phosphorus of the lake, as well as their distribution and accumulation in

the lake; studies on the succession of phytoplankton; assessment of the fishery potential on the basis of phytoplanktonic primary productivity; determination of the standing crop and production of zooplankton; studies on the function of organic detritus in the system and the top-down effects of fish on the system, etc.

Key words: Lake Donghu, ecology, structure and functioning, top-down effects.

Thermal Environment of Urban Area and The Improvement of Its Micro-thermal Environment. Liu Xiaotu and Chen Enshui (Dept. of Architecture, Southeast University, Nanjing 210096), Shao Tieru (The Association for Science and Technology of Zhenjiang City 212001): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 54-58

On the basis of the change of thermal environmental factors in several cities and counties of southern part in Jiangsu province, this article analyzed firstly the changing trend of thermal environmental factors that caused by the urbanization, then introduced the effects for improving micro-thermal environment of habitation by using the measures including the planning of road network in urban area, the control of density of the buildings, the greenery and the waters in the urban area.

Key words: development of the cities, thermal environment, heat island effect, improvement of micro-thermal environment.

The Photolysis Character of Methyl Bromide and Tribromomethane in the Presence of Hydrogen Peroxide. Zhong Jinxian, Zhang Deqiang (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085), Chen Dazhou (Chinese Center for Certified Reference Materials, Beijing, 100013): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 59-61

Under simulated atmospheric condition, photolysis for $CH_3Br + H_2O_2$ and $CHBr_3 + H_2O_2$ systems were studied. H_2O_2 was irradiated by 253.7nm UV and produced OH radicals. The OH radicals can initiate photooxidation of $CHBr_3$ and CH_3Br. The products of photooxidation were determined by a fourier transform infrared spectroscopy with 20m long path cell. The products were CO, CO_2, CH_2O and H_2O for $CH_3Br + H_2O_2$ system, CO_2, CO, H_2O and $COBr_2$ for $CHBr_3 + H_2O_2$ system, based on those results the mechanisms of photooxidation were suggested.

Key words: photolysis, OH radicals, brominated methanes.

The Effect of Parents Smoking on the Urinary Concentration of 1-Hydroxypyrene of Children. Zhao Zhenhua (Beijing Municipal Research Academy of Environmental Protection, Beijing 100037), Tong Jingyi (Shanxi Provincial Children's Hospital, Taiyuan 030013): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 62-64

Using the urinary 1-hydroxypyrene as a biological index, the effect of parents smoking on the content of 1-hydroxypyrene in the pupil's urine was investigated. The 1-hydroxypyrene level in 234 urine specimens of pupils from 4 urban districts was determined, and the ambient air in these districts was synchronously sampled and analyzed for the content of benzo(a)pyrene (BaP). It was found that the content of urinary 1-hydroxypyrene of the pupils is significantly correlated with the ambient concentration of benzo(a)pyrene in the corresponding region where the school is located. For the groups of pupils whose parents smoke the urinary level of 1-hydroxypyrene are always higher than that of the groups with non-smoking parents, but the t-tests indicate that the difference is not statistically significant due to small populations.

Key words: smoking, urinary 1-hydroxypyrene, benzo(a)pyrene.

Primary Study on Sulfur Capture in Coal Briquet Combustion by Fe_2O_3 Promoting. Zhang Liangquan, Chen Siwei et al. (China Chemical Industry Economic and Technical Development Centre, Beijing 100723): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 65-67

According to the ignition point of sulphur in coal, the sulphur capture reaction process was divided into two stages in this paper. It was found that sulphur capture in coal ash mainly happened in stage of below 500℃. Relationship between time of raising temperature and fraction of sulphur capture was obtained that time of raising temperature must be below 30 min. It was found that the more Fe_2O_3 was used, the more $CaSO_3$ changed into $CaSO_4$. The actual process of sulphur captured in coal ash was simulated through the reaction $CaO + SO_2 + 0.5O_2 \rightarrow CaSO_4$. At last some special experiments were designed and proved that Fe_2O_3 mainly promoted the reaction $CaO + SO_2 \rightarrow CaSO_3$.

Key words: coal briquet, sulphur capture, Fe_2O_3.

Study on the Synthetizing Building Materials by Steam Curing Asbestos Tailings. Lu Zhongyuan, Wang Haibin et al. (Southwest Institute of Technolgy, Mianyang 621002): *Chin. J. Environ. Sci.*, **18**(1), 1997, pp. 68-69

A Study on synthetizing the building materials by steam curing from asbestos tailing have been done in the present thesis. The effects of calcined temperature of the raw materials, the additions on the properties of products have been studied in this paper. The results showed that function of the material are the best when optimum temperature of pretreating the asbestos tailing is 950℃ and component in the material is 90% for the asbestos tailing and component in the material is all 5% for MA and NB.

Key words: asbestos tailings, building materials, steam curing.