白洋淀水生食物链 BHC、DDT 生物浓缩分析*

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摘要 为了评价 BHC 和 DDT 在水生食物链的生物累积放大效应, 对白洋淀地区端村水域生态系统水、泥及水生生物体内六六六、DDT 含量进行分析. 结果表明, 白洋淀水域生态系统水生生物对六六六、DDT 的富集沿食物链生物营养等级而递增的规律性较强(当年生鲫鱼例外). 水体、底泥、水生维管束植物、浮游动物、底栖动物、当年生鲫鱼及2龄乌鳢体内六六六残留量分别为: 0.3μg/L、0.7μg/kg、19.0μg/kg、30.0μg/kg、60.9μg/kg、17.2μg/kg、110.7μg/kg、; DDT 残留量分别为: 0.1μg/L、0.7μg/kg、6.3μg/kg、21.0μg/kg、37.9μg/kg、19.4μg/kg、124.4μg/kg. 水生生物对 DDT 的富集系数(63—1244)明显超过六六六(63.3—369). 水生生物体内六六六 4种异构体的含量顺序(α> δ> γ> β 与其在水体及底泥中的含量顺序(α> γ> δ> β 略有不同. 在白洋淀水生生态系统中DDT 主要以代谢物 P, P′-DDE 形式存在, 但少量的DDT 最初化合物 P, P′-DDT 的检出, 说明白洋淀水环境最近受到DDT 的轻度污染.

关键词 白洋淀水域生态系统, 六六六, DDT, 食物链, 营养级, 富集系数, 污染.

DDT 和六六六(BHC) 能够在生物体内积累, 并沿食物链生物积累和放大, 对位于食物链最高营养级的人及高等动物构成潜在的威胁.

1967年 Woodwell 等人对美国长岛水生食物链生物浓缩现象的研究表明, DDT 浓度随营养级的递增而急剧增加[1]. 在此之后, 对于食物链的生物浓缩放大现象又有陆续的报道[2-6].

白洋淀是我国华北地区最大的淡水湖和重要的水产养殖基地. 自60年代以来, 由于气候、水文条件的变化及人为不合理的开发, 致使淀水收缩、污染加重、水产资源持续下降. 70年代中期, 国务院曾组织力量对白洋淀水域生态系统有毒有机污染物进行调查和治理. 本调查的目的是了解 BHC、DDT 在白洋淀水体、底泥及水生生物体内的富集状况和评价水生食物链的生物积累放大效应.

1 材料与方法

1995-06, 在白洋淀区端村水域现场采集水、表层底泥、水生维管束植物苜草 (*Potamogeton crispus*)、茨藻 (*Najas major*)、浮游动物大型蚤 (*Daphniamagna*)、底栖动物日本沼虾 (*Macrobrachium nipponenss*)、铜绿方田螺 (*Bellamya aeruginosa*)、当年生鲫鱼 (*Carassius auratus*) 以及2龄乌鳢 (*Ophiocephalus argus*) 样品.

样品的处理参照文献介绍的方法[7-8]. BHC、DDT 用60% 高氯酸和冰醋酸混合液消化, 正己烷提取, 浓硫酸磺化, 用带电子捕获检测器的岛津-6AM 气相色谱仪测定其 BHC (α-体、β-体、γ-体、δ-体) 及 DDT (P, P′-DDE、O, P′-DDT、P, P′-DDD、P, P′-DDT) 的含量. 其中底泥样品是烘干去除含水量后测定; 浮游动物、底栖动物(螺及虾类取肉) 为全体测定; 鱼类样品只测定肌肉. 所有生物样品均以湿重计算.

2 结果分析

水体 BHC 及 DDT 含量尽管不高, 但各种水生生物体内含量却比较高(表1).

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表1 白洋淀水生生态系统中BHC、DDT的积累/μg·kg⁻¹

测定项目	BHC		BHC	
	X ±SD	BCF[1)]	X ±SD	BCF
水	0.3±0		0.1±0	
底泥	0.7±0.2	2.3	0.7±0	7
水生维管束植物	19.0±3.2	63.3	6.3±4.1	63
浮游动物	30.0±21.6	100	21.0±7.1	210
底栖动物	60.9±2.4	203	37.9±17.5	379
当年生鲫鱼	17.2±55	57.3	19.4±2.2	194
2龄乌鳢	110.7±43.2	369	124.4±56.3	1244

1):BCF 代表富集系数

水体BHC含量为0.3μg/L,DDT含量为0.1μg/L,二者远低于国家规定的渔业水质标准(BHC为20μg/L,DDT为1μg/L).表层底泥BHC、DDT含量均为0.7μg/kg(干)重,去除5%的含水量),均高于水体含量.水生维管束植物体内BHC残留量为19.0g/kg,是水体含量的63.3倍;DDT残留量为6.3μg/kg,是水体含量的63倍.以浮游植物为食的浮游动物体内BHC、DDT残留量分别为30.0μg/kg和21.0μg/kg,是水体含量的100倍和210倍.底栖动物生活于湖底,主要食浮游生物及水草碎屑,还可从底泥中吸收有机物,其体内毒物含量较高,BHC及DDT残留量分别为60.9μg/kg和37.9μg/kg,是水体含量的203和379倍.当年生鲫鱼幼体常以枝角类、桡足类等浮游生物为食,其体内BHC、DDT残留量较低,其中BHC残留量为17.2μg/kg,是水体含量的57.3倍;DDT残留量为19.4μg/kg,是水体含量的194倍.乌鳢是凶猛肉食性鱼类,体内脂肪成分含量较高,加之取食本身含农药量较多的动物性饵料,体内毒物含量最高,其中BHC残留量为110.7μg/kg,是水体含量的369倍;DDT残留量为124.4μg/kg,是水体含量的1244倍.由此可见,白洋淀水生生态系统各营养级生物对BHC、DDT的积累,随营养等级的升高而积累量增加.尽管如此,白洋淀鱼体内BHC、DDT残留量均低于我国鱼肉食用卫生标准(BHC含量不超过2000μg/kg,DDT残留量不超过1000μg/kg).

白洋淀水域生态系统水生生物对BHC及DDT的富集沿食物链生物营养等级而递增的规律性较强(图1),但当年生鲫鱼例外,其体内的BHC、DDT残留量均较浮游动物及底栖动物体内的含量低.据Sijm等人报道,幼鱼对水中有机氯农药的富集作用不明显[9];另外农药在鱼体内主要富集在脂肪组织和肝脏内,在肌肉中分布量较少[10,11],由于上述原因造成当年生鲫鱼肌肉中农药残留含量较低.而位于食物链较高营养级的2龄乌鳢体内BHC及DDT残留量明显高于其他水生生物,这显然与肉食性鱼类的取食特点及体内脂肪含量高有关.故BHC、DDT沿水生食物链生物积累放大的结果,必然对位于食物链最高营养级的人及高等动物构成潜在的威胁.

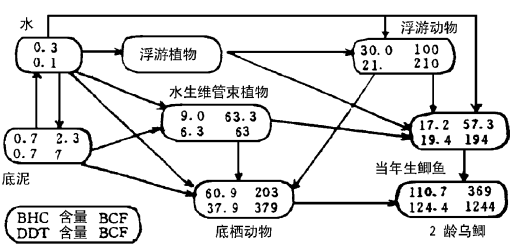

图1 白洋淀水生生物BHC、DDT食物链网积累模式/μg·kg⁻¹

水生生物对DDT的浓缩因子(63—1244)明显高于BHC(63.3—369),说明DDT较BHC更易于在生物体内富集.日本国际工贸部规定化学物质的浓缩因子超过1000则表示对环境具有较大的危害性[5].以此标准,DDT较BHC有更大的环境危害性.

白洋淀水生生物体内BHC 4种异构体的含量顺序为δ>α>γ>β与其在水体及底泥中的顺序(α>γ>δ>β)略有不同,说明BHC各异构体在水生生态系统的迁移转化过程中会发生构象的变化[12,13].白洋淀水生生态系统中,DDT主要以代谢物P,P′-DDE的形式存在,但个别样品中少量P,P′-DDT的存在,说明白洋淀水环境最近受到DDT的轻度污染[14-17].

白洋淀水生食物链各营养级生物对BHC、DDT的积累情况与津巴布韦Mcllwaine湖基

本一致[18],比印度 Jamuna 河测定结果低[4],但高于 Vojvodina 河检测结果[6].

3 结束语

(1) 在白洋淀水域生态系统中,水生生物对 BHC、DDT 均有很强的积累能力,体内积累量沿生物营养等级而递增的规律性较强.

(2) 水生生物对 DDT 的富集系数(63-1244)明显高于 BHC (63.3—369),说明 DDT 较 BHC 更易于在生物体内富集.

(3) 水生生物体内 BHC 4种异构体的含量顺序 (δ> α> γ> β)与其在水体及底泥中的顺序 (α> γ> δ> β)略有不同,说明 BHC 各异构体在水生生态系统的迁移转化过程中会发生构象的变化.

(4) 白洋淀水生生态系统中 DDT 主要以代谢物 P, P′-DDE 的形式存在,但个别样品中少量 P, P′-DDT 的存在,意味者白洋淀水生生态系统最近受到 DDT 的轻度污染.

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troaromatic compounds in the ecosystem, the study on the mixtoxicity of 2, 4-DNT and other 6 kinds of nitroaromatics to the algae (*Scenedesmus obliquus*) was carried out. 48h-EC_{50} of monotoxicity of 7 kinds of compunds and 48h-EC_{50} of mixtoxicity of 2, 4-DNT + 6 kinds of compounds were measured. Results indicated that there are synergisms between, 2, 4-DNT + 4-NAn, 2, 4-DNT + 4-NAnis, and 2, 4-DNT + 1, 4-DNB as well as antagonisms between 2, 4-DNT + 4-NT, 2, 4-DNT + 4-NPh and 2, 4-DNT + 4-NCB. Under the microscope (400 times) 3 kinds of toxic symptoms, the inhibition to the filial spores forming and releasing, the irregular big cells appearing, nucleus and cell organs as well as the protoplast distegrating were observed.

Key words: mixtoxicity, 2, 4-DNT, nitroaromatic compounds, algae, *Scenedesmus obliquus*.

Study on the Volatile Property of Organics in Coke-Plant Wastewater under the Aerated Stripping Condition. He Miao, Zhang Xiaojian etal. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 34—36

A study was conducted to determine the volatile property of organics in the coke-plant wastewater under the condition of aerated stripping. The results show that there are different volatile characteristics among the organics. 11 kinds of compounds such as ethylbenzene and naphthalene are more volatile. The removal rate can get to 20% - 40% after an aeration of 12 hours. Their volatile rate constant K_v have a fairly good linear relation with the Henry constant (H), of which relation equation is $K_v = 2.906 \times 10^3 H + 0.0146$. Volatile effect plays a very important role in the removal process of these organic compounds. 12 compounds like phenol have a medium volatile property. The other compounds like resorcinol have a low volatility.

Key words: volatile property, coke-plant wastewater, aerated stripping, volatile organic compound, volatile rate constant.

Activity, Kinetics and Spatial Variation of Dissolved Alkaline Phosphatase in Lake Donghu. Zhou Yiyong, Li Jianqiu, Chen Xudong et al. (Institute of Hydrobiology, The Chinese Academy of Sciences, Wuhan 430072): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 37—40

The extra cellular enzyme activities in aquatic environments are of monitoring significance. Dissolved alkaline phosphatase activities (APA_{Diss}) at the littoral outfalls, which receive the domestic waste water were significantly higher than those in pelagic zone in Donghu Lake. APA_{Diss} detected at the outfalls and in pelagic zone showed different relationships with soluble reactive phosphorus.

Key words: dissolved phosphatase, kinetics, characteristics, spatial distribution.

A Study on Bioaccumulation and Biomagnification of BHC and DDT in Baiyangdian Lake Foodweb. Dou Wei, Zhao Zhongxian (Institute of Zoology, Chinese Academy of Sciences, Beijing 100080): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 41—43

BHC、DDT and their metabolites were analysed in Duancun area from Baiyangdian Lake ecosystem in June 1995. The content levels of pesticides in water and bottom sediments were relatively lower: in water, the average values of BHC and DDT were 0.3μg/L and 0.1μg/L, respectively; in sediments, the residue level of BHC was same with DDT with a mean concentration of 0.7μg/kg(wet). The organochlorine insecticides content in aquatic organisms was much higher: the average concentration of BHC in hydrophytes, planktons, benthic macroinvertebrates, young-of-the-year *Carassius auratus and* 2-year-old *Ophiocephalus cris-pus* was 19.0, 30.0, 60.9, 17.2 and 110.7 μg/kg, respectively; for DDT, the content sequence was 6.3, 21.0, 37.9, 19.4 and 124.4g/kg, respectively. So the lipophilic nature and low biodegradation rates of BHC and DDT led to the accumulation of these compounds and subsequent magnification of concentration in organisms progressing up the food chain. DDT had a much profound bioaccumulation potential than BHC for the bioconcentration factor of DDT in organisms (63.3- 1244) was well above that of BHC (63- 369). The ratios of BHC isomers monitored in organisms ($\delta > \alpha > \gamma > \beta$) were different from that in water and sediments ($\alpha > \delta > \gamma > \beta$). The predominant DDT derivative was p, p′-DDE. Base upon the observed that the original DDT (P, P′-DDT) was indentified in some specimens, it has been concluded that there was a recent input of DDT to Baiyangdian Lake.

Key words: Baiyangdian Lake ecosystem, BHC, DDT, foodweb, the bioconcentration factor.

Joints Toxicities of Heavy Metals and Pesticides to *Pagrosomus major and Rhabdosargus sarba* Larvae. Dai Jiayin, Zheng Weiyun, Wang Shuhong (Environ. Sci. Res. Centre, Xiamen University, Xiamen 361005): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 44—46

The additive index of coeffects was used to study the toxicities of Cu-Mn, Cu-isofenphos-methyl and methamidphos-isofenphos-methyl