

研究简报

室内空气中总有机污染物浓度探讨

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摘要 随机选择安徽南方城、乡 82 户家庭居室, 以监测空气耗氧量(AOD)做为一项综合指标反映室内总有机污染状况。研究结果, 室内总有机污染物浓度水平, 农村居室 4.87—5.05mg/m³, 城市居室 3.69—4.17mg/m³, 浓度随着空气污染的程度不同而变化。结果揭示人群活动频繁、吸烟、居室人均容积 < 25m³、室温 > 5.0℃、风速 < 0.07m/s、ACH < 1.0 等因素均可使室内总有机污染物浓度增高, 加强居室通风及增加新风量, 是降低室内总有机污染物的一个有效措施, 并可减少对人体的直接危害。

关键词 室内空气污染, 空气耗氧量, 总有机污染物。

室内空气中总有机污染物作为一项综合指标来反映室内污染状况, 在国外已有些报道^[1,2], 但国内报道甚少^[3]。随着人民生活水平的提高, 家庭居室进行装修美化, 采用各种建筑和装饰材料、清洁剂、烹调、取暖、吸烟等因素, 给室内带来了新的污染物, 在室内通风换气不良情况下, 对健康造成不利的影响。据中科院与南铁医报道^[1-3], 其中有机物及其还原性物质可被氧化剂氧化, 监测 AOD 可做为一项综合指标来反映室内总有机污染状况。本研究试图以 AOD 作为指标探讨城、乡居室环境有机污染状况及其有关因素的影响, 为室内总有机物污染状况及评价室内空气污染提供科学依据。为此, 于 1991 年 10 月至 1992 年 4 月, 对安徽南方城、乡砖瓦结构的居室污染状况进行了调查与监测, 并汇总分析。

1 材料与方法

(1) 研究对象 选安徽南方城市与农村砖瓦结构条件相近 82 户家庭居室作为研究对象。

(2) 居室规模 测量居室容积、气窗、大窗和房门面积等。

(3) 指标方法 AOD(重铬酸钾法); HCHO(酚试剂比色法); NH₃(靛酚蓝分光光度法); CO₂(气相色谱法); CO(气相色谱法); SO₂(盐酸副玫瑰苯胺法); TSP(称重法); NO₂(盐酸萘乙二胺比

色法); 细菌总数(沉降法)。

(4) 采样时间 于 1991 年 10 月至 1992 年 4 月冬季时期, 按统一测试时间上午 8:00 及下午 3:00, 在居室中央离地面 1.5m 处采样, 连续监测 5d。通风换气计算式:

$$ACH = 3600 \cdot \mu \cdot v \cdot S / Q$$

式中, ACH 为每小时换气次数; μ 为通风口流量系数; v 为通风口风速 (m/s); S 为通风面积 (m²); Q 为居室容积 (m³)。

2 结果与分析

2.1 城市与农村居室总有机污染物浓度水平

按'90 Indoor Air 欧洲分会报告, 分析居室总有机污染物宜用百分位数 P_{50} , 通过 82 户家庭居室 164 个数据分析显示, 农村居室总有机污染物浓度高于城市居室, P_{50} 的农村居室总有机污染物浓度 (5.05mg/m³) 比城市居室 (3.86mg/m³) 高 ($P < 0.05$), 见表 1。调查还反映了安徽南方一般城、乡居室空气中总有机污染的现状, 平均浓度水平在 3.86—5.05mg/m³, 算术均数在 4.36—5.60mg/m³, 此浓度在参考标准值范围内^[3,4]。在调查中发现, 室内卫生状况较差及通风换气不良情况下, 其浓度可达 25.69mg/m³。

表 1 城市与农村居室总有机污染物浓度水平

测定时间	城市居室				农村居室			
	n	P ₅₀	P ₁₀	P ₉₀	n	P ₅₀	P ₁₀	P ₉₀
上午	32	4.17	0.50	7.20	50	4.87	0.90	8.34
下午	32	3.69	1.28	6.80	50	4.67	1.63	11.17
日平均	64	3.86	2.03	7.30	100	5.05	2.40	9.30

2.2 室内空气污染物及其平均浓度水平

表 2 室内空气污染物及其平均浓度比较

污染物	城市居室 $\bar{x} \pm SD$	农村居室 $\bar{x} \pm SD$
HCHO(mg/m ³)	0.023 ± 0.010	0.037 ± 0.013
NH ₃ (mg/m ³)	0.043 ± 0.017	0.088 ± 0.021
CO ₂ (%)	0.097 ± 0.021	0.057 ± 0.013
CO(%)	0.003 ± 0.001	0.002 ± 0.001
SO ₂ (mg/m ³)	0.278 ± 0.035	0.150 ± 0.021
TSP(mg/m ³)	0.691 ± 0.082	0.826 ± 0.064
NO ₂ (mg/m ³)	0.121 ± 0.074	0.096 ± 0.027
细菌总数(个/皿)	67.30 ± 14.32	39.30 ± 17.50
AOD(mg/m ³)	4.63 ± 1.41	5.60 ± 1.51

城市与农村家庭的燃料基本上是以煤或柴草为主,部分家庭用液化气或煤气,特别是燃煤及柴草家庭居室空气污染物中以 TSP、SO₂ 较高,而用煤气或液化气的家庭居室以 NO₂ 污染较高;对于居室中 NH₃ 的污染则农村高于城市 ($P < 0.05$),说明农村居室存放粪尿桶及燃料等造成 NH₃ 污染比城市严重;CO₂ 的平均浓度不论城市居室或农村居室均偏高,这是因为在冬季时期居室门窗紧闭,以致造成 CO₂ 浓度增高。

从室内空气污染物及其平均浓度水平分析提示,安徽南方一般家庭居室有机污染状况,其污染水平对人体健康的影响不可忽视。当前降低室内污染水平,其主攻方向仍然是燃料对健康影响的问题,这与国外和公共场所情况不同,后者有机污染与装饰品、化妆品、建筑材料释放有机污染物为主。

2.3 室内总有机污染物浓度与有关因素的探讨

2.3.1 居室空气交换次数对室内总有机污染物浓度影响

从 ACH 对室内总有机污染物浓度影响分析,ACH < 1.0 组的室内总有机污染物浓度均高

于 ACH > 1.0 组(均为 $P < 0.05$),说明不论城市或农村,居室换气次数少,则室内总有机污染物浓度较高,对人体健康的影响也相对较大。

表 3 居室 ACH 与室内总有机污染物浓度关系(mg/m³)

ACH	城市居室 ¹⁾		农村居室 ²⁾	
	n	平均浓度	n	平均浓度
<1.0	15	6.64	23	6.29
>1.0	17	5.12	27	5.08

1) $t = 2.121, P < 0.05$ 2) $t = 2.087, P < 0.05$

2.3.2 吸烟对室内总有机污染物浓度影响

表 4 吸烟与室内总有机污染物浓度关系(mg/m³)

区别	城市居室 ¹⁾		农村居室 ²⁾	
	n	平均浓度	n	平均浓度
吸烟	19	6.59	39	6.31
不吸烟	13	4.38	11	4.47

1) $t = 2.196, P < 0.05$ 2) $t = 2.184, P < 0.05$

从吸烟对室内总有机污染物浓度影响分析发现,吸烟组室内总有机污染物浓度高于不吸烟组(均为 $P < 0.05$),说明城市或农村居室内吸烟直接影响室内总有机污染物浓度增加。吸烟对室内空气污染仍是一个不可忽视的因素,这与南京铁道医学院研究认为吸烟所致的室内空气污染物,用 AOD 与 CO 反映污染状况都有同样代表性相一致^[4]。

2.3.3 居室人均容积对室内总有机污染物浓度影响

表 5 居室人均容积与室内总有机污染物浓度关系

居室人均容积(m ³)	n	平均浓度(mg/m ³)
<25	58	6.67
>25	24	5.25

1) $t = 3.231, P < 0.01$

从居室人均容积与室内总有机污染物浓度影响分析,人均容积 < 25m³ 组的室内总有机污染物浓度(6.67mg/m³)高于人均容积 > 25m³ 组(5.25mg/m³) ($P < 0.01$),说明居室人均容积小,室内总有机污染物浓度则较高,认为居室人均容积对室内总有机污染是有影响的。

2.3.4 室温和风速对居室总有机污染物浓度影响

表 6 室温和风速与居室总有机污染物浓度关系

室温 ¹⁾ (℃)	风速 ²⁾ (m/s)	n	平均浓度(mg/m ³)
>5.0		50	5.21
<5.0		32	4.42
	<0.07	65	5.87
	>0.07	17	4.90

1) $t=2.241, P<0.05$ 2) $t=2.387, P<0.05$

从室温和风速对居室总有机污染物浓度影响分析,当室温>5.0℃组及风速<0.07m/s组的居室总有机污染物浓度高于室温<5.0℃组及风速>0.07m/s组(均为 $P<0.05$),说明室温大于5.0℃及风速小于0.07m/s时,室内空气中总有机污染物浓度较高,反映有机污染严重。

2.4 居室总有机污染物与有关因素相关性分析

表 7 居室总有机污染物与有关因素的相关关系

污染物	n	r	P 值
HCHO	164	0.181	<0.05
NH ₃	164	0.174	<0.05
CO ₂	164	0.198	<0.05
室温	164	0.248	<0.05
风速	164	-0.167	<0.05

从相关性分析中看到,居室总有机污染物与HCHO、NH₃、CO₂的相关关系为正相关,虽然其相关程度较低,但可知CO₂浓度增加,表明人群活动增加,也同样增高居室总有机污染物浓度。室温与总有机污染物的相关关系为正相关,表示室温略增高,室内总有机污染物浓度则增加,而风速则相反,它与总有机污染物的相关关系为负相关,提示在冬季时期风速略增大,则室内总有机污染物浓度减少。

3 讨论

3.1 室内总有机污染物浓度水平

居室的装修和美化,使得各种有机化合物随之向室内散发,给室内带来了新的污染物,如HCHO、NH₃、CO₂等浓度增加,对健康可产生不良影响,如病楼综合征等,我国居室一般为自然通风,若居室门窗关闭情况下,各种挥发性有机污染物不易排出,加上人群活动频繁、居室人均容积小、燃料消耗、吸烟等因素更易加重室内空

气污染。通过AOD浓度的监测可以反映居室空气有机污染物的污染状况,这是因为空气中有有机物及其还原物经强氧化剂氧化与室内空气有机污染成分相吻合^[4]。此指标作为室内空气污染的评价具有实用价值。本次调查与监测室内总有机污染物浓度水平,农村居室为4.87—5.05mg/m³,城市居室为3.69—4.17mg/m³,它的浓度水平随着室内空气污染的程度不同而变化。在调查中还发现室内卫生状况较差及居室通风不良情况下,居室的总有机污染物浓度高达25.69mg/m³,远高于平均水平。

3.2 室内总有机污染物浓度与其它因素的关系

调查结果提示,人群活动频繁、吸烟、居室人均容积<25m³、室温>5.0℃、风速<0.07m/s等因素均可使室内总有机污染物浓度增高;农村居室环境比城市居室总有机污染物浓度偏高,这是由于农村住宅内存放粪尿桶、燃料、人群活动频繁以及室内吸烟等因素更易造成居室空气有机污染严重。加上空气交换次数不足,室内污染物更不易排出,导致总有机污染物浓度集聚,故ACH<1.0组比ACH>1.0组的居室总有机污染物浓度高,若适当加大风速(大于0.07m/s),则可大大降低室内总有机污染物浓度;从相关性分析,总有机污染物浓度与风速呈负相关关系,证明了这一点,说明冬季居室经常开启门窗,增加室内空气交换次数,可使室内有机污染物排出,对减少居室空气污染至关重要,因此,加强居室通风及增加新风量,是当前降低室内有机污染物浓度的一个有效措施^[5],并可减少对人体的直接危害。

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Abstracts

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maximum number (MPN) of *Thiobacillus denitrificans*, the maximum denitrification rate, the maximum concentration of oxidizing Na_2S , and sludge loading rate of S^{2-} were $1.1 \times 10^8/\text{g VSS}$, $3.6\text{mg NO}_3^-/\text{g VSS} \cdot \text{h}$, 1750mg/L and $25\text{mg S}^{2-}/\text{gVSS} \cdot \text{d}$, respectively.

Key words: anaerobic- anoxic- aerobic process, municipal wastewater, nitrogen and phosphorus removal, *Thiobacillus denitrificans*.

Study on the Catalytic Oxidation of Na Alkylbenzenesulphonate in Aqueous Solution. Wang Xiaocheng et al. (Department of Environmental Engineering, Taiyuan University of Technology, Taiyuan 030024); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 43—46

A catalytic oxidation and degradation process of Na alkylbenzenesulphonate (NABS) in aqueous solution was experimentally studied by using NaClO as an oxidant, the type "TU" catalyst selected from a set of experiments, and the IR analysis to monitor the process. The factors affecting the removal of NABS from water were also studied. The results show that the type "TU" catalyst has a better ability to catalytically oxidize NABS in water, generally with a removal of about 80%, and almost all of the NABS in water can be degraded by the catalytic oxidation into simple inorganics and less carbonyl compounds.

Key words: Na, alkylbenzene sulphonate, catalytic oxidation, wastewater treatment.

Effect of Benzoylphenyl Ureas on Non- target Organisms and Their Metabolism in the Organisms.

Liu Guoguang et al. (Department of Chemistry, Henan Normal University, Xinxiang 453002); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 47—50

The reported research results concerning the probable effect of benzoylphenyl ureas on non- target organisms and their absorption, and metabolism in organisms have been reviewed in this paper, which include the effect of the insecticides on terrestrial life (including bees, silkworms and birds) and aquatic life (including fishes, crustaceans and arthropods), and their absorption, and metabolism in animal. It was suggested that the insecticides would not cause evident poisoning and pollution to bees, birds, poultry, cattle and fishes, but they are toxicants to silkworms, crustaceans and arthropods, especially to their larvae.

Key words: benzoylphenyl ureas, ecosystem, terrestrial, aquatic, poultry, cattle, toxicity, absorption, metabolism.

Theories, Methods and Applications about Environmental Carrying Capacity of Reservoir-

induced Resettlement. Xun Houping et al. (Centre of Reservoir- Induced Resettlement Research, Nanjing 210024); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 51—54

Environmental carrying Capacity of reservoir-induced resettlement is an important theory in reservoir-induced resettlement. Its basic theories are that living conditions of human being are restricted by the environment, environmental carrying capacity of reservoir-induced resettlement has a variability depending on the quality and quantity of the affecting factors. Its analysis methods are based on combining macroscopic qualitative analysis with microcosmic quantitative analysis as well as dynamic, primary and secondary, reliability analysis etc. Its theories and methods have been applied successfully in resettlement planning, with good results achieved.

Key words: reservoir-induced resettlement, environmental carrying capacity, resettlement planning.

Application of Bacteria to Monitoring of Environmental Contaminant Toxicity.

Cheng Jingquan et al. (Shenzhen Public Health and Anti-Epidemic Station 518020); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 55—59

This paper deals with a sort of monitoring methods in which germs are used as indicators for biochemical toxicity screening, bacteria growth inhibition, respirometric techniques, bioluminescence microtox, microcalorimetric and mutation test etc.

Key words: toxicity assay, biochemical toxicity screening, bacteria growth inhibition, microtox, microcalorimetric.

A Survey on the Levels of Total Organic Compounds

in Indoor air. Chen Guifu et al. (Wannan Medical College, Wuhu 241001); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 60—62

The total organic compounds in air of the living rooms of 82 households in both rural and urban areas were determined by monitoring AOD which serves as a synthetic index to show the level of air pollution by total organic compounds. The results showed that the concentration of air borne total organic compounds was $4.87 - 5.05\text{mg/m}^3$ in the rural living rooms, and $3.69 - 4.71\text{mg/m}^3$ in the urban living rooms, and the level of concentration depends on the degree of air pollution. It is also revealed that the increased human activity, smoking, residential volume $< 25\text{m}^3$, room temperature $> 5.0^\circ\text{C}$, wind velocity $< 0.07\text{m/s}$, and ACH < 1.0 are among the factors which raise the concentration of air borne total organic

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compounds.

Key words: pollution of indoor air, oxygen consumption, total organic compounds.

Development of a Novel Automatic Water Sampler.

Huang Juwen et al. (School of Environmental Engineering, Tongji University, Shanghai); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 63—65

For this development, computer technique was applied to the sampling instrument to realize the mankind-machine interaction, and to achieve the goal of intelligentization. Some reliable, lower cost elements for water sampling, memory and convention were used to realize auto-sampling. The control system of this sampling instrument adopted a monistic microprocess. The 8031 chip was used as a microprocessor, coordinated with peripheral interface circuits and function keyboard, to make it compact and low cost. The sampling and storage system consists of a wriggle pump, electromagnet, machanical transfer devices, water sample storage tank and container. This system has a simple structure with a smooth and steady operation and can be operated continuously or intermittently. Sampling time, sampling period and sampling bottle switching can be adjusted arbitrarily to collect water sample accurately, reliably and conveniently.

Key words: computer's technique, control, water sampling.

Determination of Trace Amounts of Se with Oscillopolarography.

Jiang Zhiliang et al. (Department of Chemistry, Guangxi Normal University, Guilin 541004); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 66—68

In 0.60mol/L acetic acid medium, the complex of Se(IV) and sulfanilic acid exhibits a sensitive and selective oscillopolarographic wave at -0.63 V vs. SCE. This provides a new oscillopolarographic method for the determination of Se in the range of 0.3—80ng/ml. The detection limit is achieved at 0.15ng/ml. Se in real samples was analysed by this method, with satisfactory results.

Key words: Se, sulfanilic acid, oscillopolarography.

Study on the Environmental Impact Caused by the Electromagnetic Radiation of Weihai Broadcasting Station.

Lu Deming et al. (Dept. of Physics, Qingdao University of Oceanography, Qingdao); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 69—72

The attenuation of the electrical field strength E of an electromagnetic source was investigated theoretically and experimentally. For the 10kW medium wave transmitter, the electrical field E is

less than 25V/m for distances $r > 75$ m near the ground (2m above the ground), which is lower than the "Second Class Standard" stipulated in the State Standard GB9175-88. For distances $r > 150$ m, the field strength near the ground is less than 10V/m, which is lower than the "First Class Standard". However, it is discovered from the measurements that at places such as the platforms on top of high buildings within 200m the field strength can be so strong that it exceeds the State Standard value, and that injures to human bodies can be caused by metal structures poorly earthed due to induction charge and secondary radiation.

Key words: environmental impact assessment, electromagnetic radiation, broadcasting station.

Vector-operator: A New Method for Environmental Quality Assessment and Environmental Management.

Wang Haifeng et al. (Institute of Environmental Science, Beijing Normal University, Beijing 100875); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 73—76

This paper deals with a systematical analysis on the common methods for environmental quality assessment and a new method suggested for environmental quality assessment, called Vector-Operator. This method, by mainly considering the most important environment elements while not neglecting other environment elements, uses some special arithmoprocess but maximal operator and cluster analysis. It is able to present better the real conditions of the environment. It is of general purpose and of comparability. It can be extended, repaired, modified and modelled. It not only serves effectively for science research but also provides a convenient means for decision-making, management and evaluation.

Key words: environmental assessment, environmental management, Vector-Operator.

Influence of Cloud on Solar Ultraviolet Radiation.

Bai Jianhui (Institute of the Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029); *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 77—78

Cloud has an important effect on the solar ultraviolet radiation reaching the ground. Based on one year data in Xianghe Synthetical Observation station, an empiric epuation for calculating the solar ultraviolet radiation under cloudy sky conditions is obtained by using correlation analysis, and the results of the calculation are satisfactory. A simple analysis for the decrease in the solar ultraviolet radiation under cloudy sky conditions is given.

Key words: cloud, solar ultraviolet radiation, cloud fraction.