北京市汽车污染分担率的研究

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摘要 本文首先明确了汽车道路污染分担率和汽车区域污染分担率两个不同的概念,介绍了汽车区域污染分担率的计算方法.计算结果表明北京市三环内汽车区域污染分担率冬季 CO 为 14.3%, NO_x 为 32.2%, THC 为46.0%,秋季 CO 为 58.4%, NO_x 为 68.7%, THC 为 86.6%. 北京市汽车道路污染分担率(路中)冬季 CO 为 65.7%, NO_x 为 71.6%, THC 为 37.6%; 秋季 CO 为 58.8%, NO_x 为 75.5%, THC 为 67.5%.

关键词 道路污染分担率,区域污染分担率.

一、汽车污染分担率的概念及其计算方法

过去计算汽车污染分担率常采用下面两种方法:

$$\eta_r = \frac{c_{rs} - c_0}{c_{rs}} \% \tag{1}$$

$$\eta_r = \frac{c_{cal}}{c_{cal} + c_0} \% \tag{2}$$

式中, η_r 为汽车道路污染分担率, c_{rs} 为道路中心或路边污染物浓度, c_0 为远离道路的一般环境污染物浓度. c_{cal} 为模式计算出的污染物浓度,它们可由各种线源模式或统计模式求出.公式(1)可从监测值直接算出,亦称之为监测法;公式(2)可从数学模式算出,亦称之为计算法.利用公式(1)、(2)可以计算出汽车源在某条道路上的污染分担率. 但是这两个公式只能评价某条道路上汽车造成的污染程度,不能给出城市中所有道路汽车对城市区域的污染程度,也就是说计算出的路中或路边道路污染分担率不能与点、面源对城市区域的污染相比较,这是因为前者是局部污染,后者是整体污染. 其次,在公式(1),(2)中,暗含着将一般环境浓度 c_0 中汽车造成的贡献视为零. 在一些文章中,也曾指出汽车对 c_0 的贡献可忽略不计. 但是对于有 50 万辆汽车保有量,年耗汽、柴油 70 多万吨的北京市来说,是值得怀疑的. 再其次,当利用公式(1)计算采暖期道路污染分担率时,由于 c_0 值往往较高,计算出的 η_r 往往为零或小于零,这是煤烟型城市污染的一个特点.

为了弥补上述缺陷,我们提出了汽车区域污染分担率的概念,得出计算汽车区域污染分担率的方法.

汽车区域污染分担率的概念可由下式表述:

$$\eta_{area} = \frac{c_{mob}}{c_p + c_s + c_{mob} + c_{bg}} \% \tag{3}$$

式中 η_{area} 为汽车区域污染分担率, c_{mob} 为汽车源在整个区域内造成的污染物浓度, c_p、c_s 为区域内外点源、面源在区域内造成的污染物浓度. c_{bg} 为环境本底污染物浓度.

下面以北京市三环内区域作为研究对象,探讨该区域内的汽车污染分担率. 计算月份为 1989 年 2 月(冬季), 9 月(秋季).

三环内是北京市交通网络中心区域,面积 158km², 道路密度为 3.0km/km² (1989 年),中心区域道路为横、竖线交叉网络结构,区域外为放射形结构. 北京市区公路主要十字路口约

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有 187 个，三环内拥有 150 个，占 80.2%。三环内 10m 以上宽道路 223 条。

公式(3)中，c_{mob} 由下式计算：

$$c_{mob}=\left(\frac{2}{\pi}\right)^{\frac{1}{2}}\cdot\frac{\left(\frac{L}{2}\right)^{1-d}}{c(1-d)}\cdot\frac{Q_{mob}}{\bar{U}} \quad (4)$$

式中 L 为区域宽度，计算时三环内区域宽度取为 13km，比实际宽度略大，Q_{mob} 为区域内汽车源强，$\bar{U}$ 为平均风速，u，d 为垂直扩散参数，$\sigma_z(x)=uX^d$。

计算 Q_{mob} 是问题的关键：

$$Q_{mob}=\sum_{i=1}^{n}N_i\cdot L_i\cdot E_i/S$$

$$E_i=\sum_{k=1}^{k}e_{ik}\cdot\eta_{ik}$$

式中 N_i 为第 i 条道路上的车流量，L_i 为第 i 条道路上的长度，E_i 为第 i 条道路上各种汽车的平均排放因子，S 为区域面积，e_{ik}、η_{ik} 分别为计算 E_i 时第 k 种车型的排放因子和所占百分比。

只要获得所有道路的车流量、车型、道路长度就可计算出该地区的汽车源强 Q_{mob}。汽车排放因子采用交通部公路科研所 1990 年取得的成果，见表 1。

表 1　各类车型排放因子（mg/m）

车　型	CO	NO_x	THC
小轿车	36.09	0.92	3.17
面包车	28.81	2.15	2.91
吉普车	50.67	2.01	5.52
摩托车	36.09	0.92	3.17
公共客车	37.23	16.83	15.98
绞结大客车	37.23	16.83	15.98
解放卡车	17.34	12.68	6.98
东风卡车	37.23	16.83	15.98
北京 130 轻卡	60.70	4.33	7.77

c_p 采用高斯模式计算：

$$c_p=\sum_i\sum_j\sum_k\left(\frac{2}{\pi}\right)^{\frac{1}{2}}\cdot\frac{Q_p\cdot f_{ijk}}{\bar{U}_k\sigma_{zi}(\pi x/8)}\cdot\exp\left(-\frac{h^2ik}{2\sigma_{zi}^2}\right)$$

式中 f_{ijk} 为 i 类稳定度、j 方向、k 级风速的发生频率，σ_{zi} 为 i 类稳定度、垂直方向的扩散参数，h_{ik} 为 i 类稳定度，k 级风速时的烟气有效抬升高度，Q_p 为某点源源强。

计算 c_a 采用下式计算：

$$c_a=\frac{1}{U}(c_oQ_0+c_1Q_1+\cdots+c_5Q_5)$$

$$c_o=\left(\frac{2}{\pi}\right)^{\frac{1}{2}}\cdot\int_0^{\frac{L}{2}}\frac{1}{\sigma_z(x)}\cdot\exp\left(-\frac{h^2}{2\sigma_z^2(x)}\right)\cdot dx$$

$$c_i=\left(\frac{2}{\pi}\right)^{\frac{1}{2}}\cdot\int_{(i-\frac{L}{2})}^{(i+\frac{L}{2})}\frac{1}{\sigma_z(x)}\cdot\exp\left(-\frac{h^2}{2\sigma_z^2(x)}\right)\cdot dx$$

计算时将三环内、外区域的点、面源对三环内区域的影响均考虑在内。本次计算考虑了 4 种面源，它们包括工业、采暖、公福、火炉面源。面源源块为 $4km^2$，点源为北京市 9 个大点源，包括电厂、热电厂、供热厂。

二、计 算 结 果

根据上述计算方法计算出汽车排放物 CO、NO_x、THC 对该区域的污染分担率，结果见表 2。

表 2　北京市三环内汽车区域污染分担率（%）

	无背景值汽车分担率		有背景值汽车分担率	
	2 月	9 月	2 月	9 月
CO	14.3	58.4	11.4	34.3
NO_x	32.2	68.7	29.8	61.8
THC	46.0	86.6		

利用模式可分别计算自然背景值下的汽车区域污染分担率和无背景值下的汽车区域污染分担率。在不考虑自然背景值的情况下，汽车 3 种主要排放物的分担率对于非采暖期(9 月)均大于 50%，CO 为 58.4，NO_x 为 68.7%，THC 为 86.6%，对于采暖期(2 月)则小于 50%，CO 为 14.3%，NO_x 为 32.2%，THC 为 46.0%。表中未能给出考虑背景值情况下的 THC 分担率，这是因为没有 THC 自然背景值的结果。

三、汽车区域污染分担率与道路污染分担率的比较

利用公式(1)、(2)计算了三环内 23 条主要道路的汽车道路污染分担率，平均结果见表 3。其中 c_{cal} 采用高斯无限线源模式计算：

$$c_{cal} = \sqrt{\frac{2}{\pi}} \cdot \frac{Q_l}{\overline{U} \cdot (\sigma_z(x) + \sigma_0) \cdot \sin\theta} \cdot \exp\left(-\frac{h^2}{2(\sigma_z(x) + \sigma_0)^2}\right)$$

式中 Q_l 为线源源强，h 为线源源高，$\overline{U}$ 为平均风速，θ 为风向与道路夹角，σ_0 为初始扩散参数，$\sigma_z(x)$ 为扩散参数，$\sigma_z(x) = ax^b$。a、b 值采用 1989 年北京环保所在城、郊两条道路进行示踪剂试验取得的成果，见表 4。

表 3　北京市汽车道路(路中)污染分担率(%)

方法	CO		NO_x		THC	
	2 月	9 月	2 月	9 月	2 月	9 月
实测法	46.0	40.2	60.4	67.8	39.0	70.7
模式法	65.7	58.8	71.6	75.5	37.6	67.5

表 4　城市和郊区道路扩散参数

$\sigma_z(x)=a\times b$ ＼ 稳定度	A · B	C
郊区	$0.264X^{0.840}$	$0.200X^{0.682}$
城市	$0.504X^{0.608}$	$0.200X^{0.682}$
	D	E · F
郊区	$0.180X^{0.663}$	$0.123X^{0.701}$
城市	$0.221X^{0.662}$	$0.123X^{0.701}$

两种分担率都如实地反应了汽车对空气的污染程度，但是因其污染的范围不同其值差别很大，以 CO 为例，冬季 2 月份道路污染分担率实测法为 46.0%，而区域分担率为 11.4%(考虑了自然背景值)，秋季 9 月份道路分担率实测法为 40.2%，而区域分担率为 34.3%，这种差别反映了汽车对道路的局部污染和对区域的整体污染的不同性质。

四、汽车区域污染分担率与污染物排放分担率的关系

任何污染源排出的污染物在空气中产生的浓度与其排放量是紧密相关的，研究汽车污染分担率的同时，研究汽车污染物的排放分担率则可从整体上认清汽车源对空气的污染程度。

根据三环内汽车源和点、面源(固定源)的能源消费资料，可以计算出它们排放 3 种污染物的排放分担率，结果见表 5。

表 5　北京市三环内汽车污染物排放分担率(%)

污染源 ＼ 污染物		CO	NO_x	THC
汽车源	采暖季	26.1	38.0	62.7
固定源		73.9	62.0	37.3
汽车源	非采暖季	60.6	54.7	86.8
固定源		39.4	45.3	13.2

结果表明，对于非采暖季汽车源占 CO 排放量 60.6%，NO_x 为 54.7%，THC 为 86.8%，这种比例关系恰好与汽车区域污染分担率的比例关系相一致，对于采暖季也有同样的规律。

五、结　论

利用两种分担率的概念研究汽车对城市空气的污染，能够较完整地掌握汽车源对城市的污染程度。汽车区域污染分担率更能说明汽车源对城市空气的影响大小。通过对北京市区汽车污染分担率的研究，进一步认清了汽车源对北京市空气的影响，为决策部门制定和调整控制汽车污染技术政策提供了科学依据。与此同时，提供了一套计算汽车污染分担率的方法，可供同行借鉴。

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lake in summer was 1.02 $mg/m^2 \cdot d$. The total phosphorus release capacity from the sediments was estimated to be 1.346 t/y which is equivalent to 36.4% of the average annual external phosphorus loading. Sediment release of phosphorus is a major contributory factor for the eutrophication of the lake.

Key words: sediments, phosphorus, eutrophication.

Effect of Proper Ventilation on Improving Indoor Air Quality and Dweller's Health. Qiu Shicong, Chen Guifu (Wannan Medical College, Wuhu, Anhui): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 29—32

An investigation on the natural ventilation in 417 rural dwellinghouses with children living in was carried out in south China from December 1988 to April 1989. Meanwhile, a follow-up observation of respiratory health conditions for the dwelling children was performed. An experimental model was also established to explore the possible improving measures. The results revealed that in 85% of the dwelling-houses, the times of air changes per hour (ACH) ranged from 0.5 to 1.0, and ACH was negatively correlated to the rate of respiratory symptoms (RRS) in the children ($P<0.01$); when ACH was less than 0.5, the children's RRS was 3.52/100pw, which is much higher than that of other groups with larger ACH; when room doors and windows were open, the ACH was 4 times as much as that when they were closed; moreover, closing doors and windows increased the indoor air concentrations of CO_2, HCHO, and ^{222}Rn by 1—3 times; when the indoor air flow velocity was below 0.05 m/s the ventilation efficiency decreased to below 1.0, accordingly, the pollutants gradually accumlated and would finally impair the health of the residents. This study suggested that the proper arrangement of the ventilation in the light of the convection theory may effectively improve the air quality and thereby the health conditions of the residents.

Key words: ventilation in dwelling-house, indoor air quality, health efficiency.

Evaluation of the Pollution in Lake Dianchi with *Zooplankton* as Indicator. Huang haikui, Zhao Jiachong (Kunming Municipal Institute of Environment Science): *Chin, J. Environ. Sci.*, **13**(3), 1992, pp. 33—36

Analysis of the species and mass population of *zooplankton* was carried out by means of Sander's sparse curve and Shannon-Wiener's diversity index on different regions of lake Dianchi. Integrated with the output of the analysis of *zooplankton* indicator distribution. the following results were obtained: (1) the extent of pollution is obviously defferent in the inlake from the outlake i. e. the inlake is in α stage of pollution and the outlake is in β stage. (2) the gravity of pollution in different regions of lake Dianchi are: the exit of river Xinhe > the exit of river Daguang > the center of inlake > Huiwan > Darhewei > the middle of Guanyinshan. (3) the inlake is in the process of swamping.

Key words: lake Dianchi, *zooplankton*, pollution indicator, Sander's Sparse curve, Shannon-Wiener's diversity index.

Catalyst for Removing Carbon Monooxide at Room Temperature. Li Chunhua, Xu Hongbing and An Lidun (Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou,): *Chin. J. Environ. Sci.*, **13**(3), 1992, PP. 37—39

Activated carbon compound carrier supported noble metal catalysts for the catalytical oxidation of CO were investigated in the following aspects: selection and preparation of supports and precursors of active components as well as preparation conditions of the catalysts. Results show that CO-20-2 catalyst made in this work can remove CO completely at room temperature. Both of its activity and stability are better than the catalysts available now.

Key words: palladium and platinum catalysts, carbon monoxide oxidation, activated carbon complex support.

Study on Pollution Contributions from Traffic in Beijing City. Han Zhixiong, Xing Yulan, Quan Baoling (Beijing Municipal Research Institute of Environmental Protection): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 40—42

This paper clearly defines the conceptions for both road and regional pollution contributions and gives a set of methods for the calculation of regional pollution contribution. As an example, the pollution contributions of CO, NO_x, and THC, which are major pollutants from vehicles, were studied for an central area of 158 km^2 of Beijing city. The study shows that the regional pollution contributions for CO, NO_x and THC reached 14.3%, 32.2% and 86.6% in winter and 58.4%, 68.7%, and 86.6% in fall, respectively. While, the road pollution contributions for CO, NO_x and THC reached 65.7%, 71.6%, and 37.6% in winter and 58.8%, 75.5% and 67.5% in fall, respectively.

Key words: air pollution, traffic pollution.

Assessment of the Maximum Removal Rate of Pulp-making Waste Water with Flocculation Treatment by UF Technology. Cheng Yanjun (Environmental Protection Institute, Ministry of Light Industry): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 43—44

Relative molecular weight fractions of COD in the waste water were determined by UF technology, so as to estimate the maximum removal rate of COD with flocculation-treatment. It has been found that most of the COD in the water is associated with the fractions having molecular weight greater than 10000 or smaller than 3000; the maximum removal rate of COD is 71.3%.

Key words: UF, Flocculation, Pulp-making waste water, COD.

A Study on Denitrification of Coke-plant Wastewater through a Biological Process Wen Yibo