浅析河流允许排污量计算的设计流量

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摘要　对淮河淮南段水污染物允许徘放量计算中出现大流量小允许排放量的反常现象进行了讨论,并从河流纳污能力形成机制和排污量计算方程等方面对问题的产生原因作了定量剖析。又以淮南市段为实例,对设计流量应如何判别和确定作了初步探讨。

关键词　水污染物,允许排放量,设计流量。

1　问题

最近在做淮河淮南段污染物允许排放量计算时,发现一个有意思的现象。如表1所示,在河流不同的单元段内,用3个保证率流量计算各个水质指标的允许排污量,在各个流量组中允许排污量的最小值,出现了与通常理解相反的现象,即流量变大后允许排污量反而小了。

表1　淮河淮南段污染物允许排放量(kg/d)

月平均枯水流量		凤台段			李咀孜段			田家庵段		
流　量(m^3/s))	保证率(%)	COD_{Mn}	NH_3-N	酚	COD_{Mn}	NH_3-N	酚	COD_{Mn}	NH_3-N	酚
26.17	90	2748.1	2582.8	10.25	5626.4	2538.0	9.55	8150.9	1114.6	19.13
61.30	75	1637.9	3753.2	15.66	5140.5	2218.0	8.53	14048.5	1030.6	33.83
111.31	50	391.7	5674.9	24.10	4976.5	2106.7	8.18	22633.6	1003.6	55.27

为了搞清这些问题,先回顾允许排放量的计算方法。如图1所示,河流来水流量Q_r(也就是计算允许排放量的设计流量),与来水流量对应

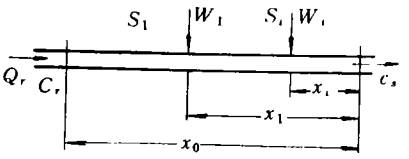

图1　河流排放系统

的水质浓度值c_r(也就是本河段的水质背景浓度值);污水排放点源S_i($i=1\cdots\cdots n$),距下游监测断面x_i;监测断面水质目标值c_s。则本河段污染源S_i的污染物允许排放量W_i可用下示的方程组计算:

$$\sum_{i=1}^{n}W_i\exp(-K_it_i)\leqslant c_s(Q_r+\sum_{i=1}^{n}q_i)-Q_rc_r\exp(-K_0t_0)\qquad(1)$$

式(1)中,K_i为污染物衰减系数,t_i为污染物从源点至监测断面的输运时间,$t_i=x_i/u_i$,u_i为河流平均流速,q_i为各点源的污水排放量。因河段内有n个排口,解式(1)尚须配合另外方程。现匹配以总排放量对各个排污口的分配方程,总量分配方法大致是:一类是以治理费用为根据,使河段的治理总费用最省,这类方法虽科学合理,因目前治理费用难于确定,操作困难;另一类是以净化能力为根据,使污染物总排量最大,这类方法没有考虑费用;再一类是以现状排放量为根据,按比例分配总量,这类方法操作方便。现采用第二类方法匹配方程,得总量分配到各点源i的方程:

$$W_i=\frac{1-\exp(-K_it_i)}{1-\exp(-K_1t_1)}W_1\qquad\forall i\qquad(2)$$

联解式(1)、(2)得各排污口允许排放量W_i,河段的总允许排放量$=\sum_{i=1}^{n}W_i$。从理论和方法角度看,上述的计算是合理的。

2　析因

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众所周知，河流纳污能力的形成主要由于 2 种机制。一是因河水浓度比排放浓度低所形成的稀释能力；另一是因生物化学作用所产生的净化能力。在总纳污能力中扣除河水背景浓度所占部分，余下的是净纳污能力。以净纳污能力为基础计算各排放口允许排放量，这就是式(1)的建立根据。所以用式(1)分析上述问题的原因是恰当的。为了方便，将式(1)简化到仅有一个点源，得

$$W_1 \leqslant c_s(Q_r + q_1)e^{K_1 t_1} - c_r Q_r e^{-K_0 t_0} \cdot e^{K_1 t_1} \quad (3)$$

式(3)是点源 1 的允许排污量，其中所包含的稀释纳污量 W'_1 为：

$$W'_1 = (Q_r + q_1)c_s - Q_r c_r \quad (4)$$

式(4)右边第 2 项是背景浓度部分。式(3)与式(4)之差就是净化纳污量 W_1^*：

$$W_1^* = (Q_r + q_1)c_s(e^{K_1 t_1} - 1) - Q_r c_r(e^{-K_0 t_0} \cdot e^{K_1 t_1} - 1) \quad (5)$$

若 $K_0 = K_1$，则式(5)可写成

$$W_1^* = (Q_r + q_1)c_s(e^{K_1 t_1} - 1) - Q_r c_r(e^{K_1(t_1 - t_0)} - 1) \quad (6)$$

从式(6)可知：只要河水还存在有净化能力，即 $K_1 > 0$，且当 $t_1 > 0$ 时，必定 $\exp(-K_1 t_1) > 1$。表 2 是 Kt 的指数值。可见此项的作用是成倍的，并且总是 $t_0 \geqslant t_1$，$t_1 - t_0 \leqslant 0$。由表 2 又可知，式(6)第二项中的指数值总是小于 1，结果又是加大了 W_1^* 值。所以净化能力最终总是增加允许排放量。

表 2 Kt 指数值

Kt	−3	−2	−1	0	1	2	3
$\exp(Kt)$	0.050	0.135	0.368	1	2.718	7.389	20.086

当 $c_s - c_r \leqslant 0$ 时，从式(4)可知，此时稀释纳污量已近消失。纳污能力只能借靠净化机制，这由式(3)可以得到证明。与输运时间 t 相比较，表征净化强度的衰减系数 K 在一般情况下同一河段内变动不大。因而输运时间 t 无疑成了影响允许排污量的最主要因素。流量小时流速也小，输运时间就大，靠净化机制形成的纳污量就大；反之，流量大时流速大，输运时间就小，纳污量也小。

表 3 是淮南段的实况计算。表中的 $Q_r(c_s - c_r e^{-K_0 t_0})$ 项是式(3)中的决定项，算出此项大致就能确定出流量与排污量的关系。从表中容易看出，随着 c_s 与 c_r 的不同关系，流量与 $Q_r(c_s - c_r e^{-K_0 t_0})$ 项的关系也在变化。

表 3 淮河淮南市凤台段计算实况(mg/L)

组	Q_r(m³/s)	COD				NH_3-N			
		c_s	c_r	$e^{-K_0 t_0}$	$Q_r(c_s - c_r e^{-K_0 t_0})$	c_s	c_r	$e^{-K_0 t_0}$	$Q_r(c_s - c_r e^{-K_0 t_0})$
I	26.17	4.0	3.0	0.540	62.1	1.0	0.54	0.364	21.0
	61.30	4.0	3.0	0.770	10.36	1.0	0.54	0.649	39.8
	111.31	4.0	3.0	0.866	156.1	1.0	0.54	0.788	63.9
II	26.17	4.0	4.267	0.540	44.1	0.3	0.54	0.364	2.70
	61.30	4.0	4.267	0.770	43.8	0.3	0.54	0.649	−3.13
	111.31	4.0	4.267	0.866	33.9	0.3	0.54	0.788	−13.91
III	26.17	4.0	4.1	0.540	46.7	0.5	0.54	0.364	7.93
	61.30	4.0	4.1	0.770	51.7	0.5	0.54	0.649	9.19
	111.31	4.0	4.1	0.866	50.0	0.5	0.54	0.788	8.24

3 讨论

表 3 的计算实况表明，计算污染物允许排放量的设计流量，已不能按通常的仅仅考虑水量因素的工程设计方法来确定。譬如水利工程考虑防洪、防旱、防涝的不利条件，供水工程考虑枯水的不利条件，水运工程考虑航深的不利条件等等。作为环境工程和环境管理则应从环境中物质的迁移转化特有规律出发，考虑水质在环境中降解机制所带来的影响，自然这是有待深入探讨的问题。

从表 3 的实况还可看出：

(1)第Ⅰ组数据是在 $c_r/c_s<1$ 的情形下计算的。此时河流存在稀释能力,形成允许排污量的机制包括稀释和净化2部分。从表3中可以看出,因是稀释为主,所以小流量为不利条件,当流量为 26.17m³/s 时,允许排污量为最小。

(2)第Ⅱ组数据是在 $c_r/c_s>1$ 的情形下计算的。也就是上面所谈的 $c_s-c_r\leqslant 0$ 的情形,组成允许排污量的机制主要是借靠净化功能,所以流量愈大愈不利。表3的计算实况正是流量为 111.31m³/s 时,允许排污量为最小。

(3)第Ⅲ组数据也是在 $c_r/c_s>1$ 的情形下计算的。其计算结果与第Ⅱ组正相反,最小允许排放量是发生在小流量(26.17m³/s)之时。可见在 $c_r/c_s>1$ 的情形下有2种可能。

(4)由上述实例讨论可见,当 $c_r/c_s<1$ 时,无疑小流量为不利,设计流量仍然可用现行办法。当 $c_r/c_s>1$ 时,情况较复杂,必须通过试算决定设计流量。如 $c_r/c_s\gg 1$,可以肯定,大流量是不利条件。

但应指出,用大流量作为设计流量并不意味用洪水流量,因为一旦流量加大背景浓度(c_r)也将随之改变。所以在表2的计算中,流量还是枯水流量,只是保证率不一样,这样其背景浓度还是不利于枯水期。

上面仅是针对淮南段实例展开讨论,是否有一般性还有待深入探索,本文只起抛砖引玉作用。

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(上接第40页)($x^2=7.47$,$P<0.01$)。从表2也可见渔民发汞的均值也是一松显著地高于二松。这是与二松与嫩江汇合以后形成第一松花江,嫩江的汇入不但极大地稀释了松花江的污染物,使有害污染物的浓度下降,而且带来了大量的饵料,为鱼类的生存和繁殖带来了良好的条件,因而鱼产量明显地高于二松,渔民的食鱼也相应地较二松要多,前者渔民年均食鱼量为124.4kg,后者年均食鱼量为89.4kg,而渔民的食鱼量与发汞含量是紧密相关的。从松花江、尤其是第一松花江少数渔民发汞值仍然超过标准这一事实说明,为了预防人体内过量的汞蓄积,食松花江的鱼量仍应作适当限制。

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美国和墨西哥试图建立第一个国际大气污染控制区

美国和墨西哥正在建立第一个国际大气污染控制区,它有权控制边境两边的工业发展。这项努力要想获得成功,它最初就应包括一个环得克萨斯州埃尔帕索和墨西哥华雷斯城的地区。但未来,该项目的支持者想让该控制区拥有这种权力:制定和实施排放标准,以及确定何时、何地和如何建造工厂。该控制区的建立不需要得到国会批准,因为可以将它作为美-墨现有一项涉及环境问题的条约的附属物。虽然它的建立与北美自由贸易区协议(NAFTA)无关,但它可以减少基于环境原因的、对NAFTA的批评。环境保护基金会是该控制区的主要鼓动者。

淮海译自 ES&T,1993,27(11):2260

than 0.5 mg/L, i.e., the national standard for its discharge.

Key words: acidic wastewater, pollution control, arsenic (As), iron salts neutralization.

Study on the Manufacture of Activated Carbon from the Carbon in Coal Ash from a Power Station. Wu Xinhua and Yu Wei (Fujian College of Forestry, Nanping 353001): *Chin. J. Environ. Sci.*, **15**(1), 1994, pp. 47—49

A production process of activated carbon in which the carbon in a coal ash from a power station was used as a starting material has been developed. The optimized conditions for this process to produce a granular activated carbon were using charcoal, white charcoal or coal as an auxiliary raw material, together with which the starting material was undergoing a treatment in a preactivation process, then was washed with acid and water, and finally was activated or even further reactivated if required. The activated carbon product thus produced had an iodine value of 600—700 mg/g. The activated carbon from a pilot industrial production had an iodine value of 630—800 mg/g with a wearability of over 95%. This process provides a new way for coal ash to be utilized comprehensively.

Key words: coal ash, activated carbon, comprehensive utilization.

Comparative Study on the Capacities of Aerobic and Anaerobic Immobilized Microbes to Treat Organics. Wu Xiaolei et al. (Dept. of Environ. Eng., Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 50—52

Activated and anaerobic sludges were respectively immobilized with polyvinyl alcohol (PVA) used as an entrapping agent, and then the immobilized sludges were separately used to degrade the organics in wastewater under the aerobic and anaerobic conditions, respectively. Comparisons in the capacity of treating organics were also made between the immobilized and free sludges and between the immobilized activated sludge and the immobilized anaerobic sludge. The results show that the volumetric loading was 1.3 to 2.1 times that of free sludge, meant by that the immobilized sludges had a higher capacity of treating organics than a free sludge. Under the conditions studied, the volumetric loading ratio of the immobilized anaerobic sludge to the free anaerobic sludge (2.13) was much higher than that of the immobilized activated sludge to the free activated sludge (1.30—1.54). Considering the sludge loading and gas yield per unit of sludge by weight, it was concluded that the capacity of microbe treating organics could be fullier developed in the immobilized anaerobic sludge so that the immobilized microbes entrapped in a gel would be more suitable for the anaerobic treatment of a high strength organic wastewater.

Key words: immobilized microbes, immobilized activated sludge, immobilized anaerobic sludge, treating capacity.

Study on the Indicators for Evaluating the Activity of Immobilized Microorganism in the Degradation of Isocarbophos. Zhang Xiaohe et al. (Institute of Environmental Medicine, Tongji Medical University, Wuhan 430030): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 53—55

The indicators for evaluating the performance of immobilized microorganism before and after the biodegradation of isocarbophos in water samples have been studied. It has been found that the levels and degradation rates of the organophosphorus pesticide in water were in highly positive correlation to COD_{Cr} and COD_{Cr} removal, respectively, so that it would be proper to choose COD_{Cr} removal as a routine indicator for evaluating the activity of immobilized microorganism in the degradation of this pesticide. What was given in this article also included the regression equations established on the basis of experimental data, and the results from their significance tests, wherein the correlative coefficients of Eqs. 1—4, Eqs. 5 and 7, Eqs. 6 and 8, and Eqs. 9—12 were 0.992, 0.940, 0.951 and 0.978, respectively.

Key words: Isocarbophos, immobilized microorganism, biodegradation, indicators for evaluating activity.

Speciation of Selenium in Soils. Lan Yeqing et al. (Dept. of Basic Courses, Nanjing University of Agriculture, Nanjing 210014): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 56—58

The distribution of natural and applied selenium (Se) species in three kinds of soil, i.e., tide-saline soil (C), gray tide-soil (G) and yellow brown soil (Y), in Jiangsu province was studied. The results show that the naturally occurred Se species were mainly distributed as residual species (F_5), and F_5 in each of the three kinds of soil accounted for about 80% of total Se species. After an incubation for 4 months, the applied Se species were relatively homogeneous to be distributed as soluble species (F_1) (except in Y), exchangeable species (F_2), aqueous ammonia extractable species (F_3) and residual species (F_5). With two different treatments, the distribution of Se species was found to be in some relation to soil pH value, glutinous grains and free iron oxide levels. The soil pH value was in such an order as $C \doteq G > Y$; the levels of glutinous grain and free iron oxides: $Y > C > G$; the percentage levels of F_1 and F_2: $C = G > Y$; and the percentage levels of F_3 and F_5: $Y > C > G$.

Key words: selenium (Se), soil, species.

Preliminary Analysis of Design Flow for Allowable Discharge Capacity of Rivers. Zheng Yingming (Institute of Environ. and Water Conservancy, Hehai University, Nanjing 210024): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 59—61

An anomalous phenomenon was discussed, in which it was found from a calculation of the allowable discharge levels of water pollutants in the Huainan reaches of the Huaihe River that there was a large flow of water with a small allowable capacity of pollutant discharge. A quantitative analysis for the causes of this problem was made, based on the mechanism of forming the capacity of the river to receive pollutants and on the equations for calculating the discharge of pollutants. Finally, the reaches of the Huaihe River in Huainan city were taken as an example to preliminarily study how can identify and determine the design flow of a river.

Key words: allowable discharge level, water pollutants, design flow.

Grey Systems Analysis of the Factors Affecting the Efficiency of Wastewater Treatment in Anearobic Reactors. Guo Jingsong, Long Tengrui (Dept. of Urban Construction, Chongqing Institute of Architecture and Engineering, Chongqing 630045): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 62—65

The methods for grey systems analysis have been applied to studying the significance of each of major factors that would affect the efficiency of anearobic reactors in treating wastewater. The data from the experiments in an anearobic fluidized bed reactor were taken as an example to make a calculation analysis, resulting in a conclusion which was consistent with that based on a theoretical analysis. The results show that the use of a grey systems analysis for the factors affecting the efficiency of a biological reactor has the advantage of requiring relatively less data, as compared with other methods.

Key words: grey system, interference analysis, efficiency of wastewater treatment, anaerobic reactor, fluidized bed.

Accelerated Simplex Algorithm to Determine the Longitudinal Dispersion Coefficient in a River by Tracer Test. Zhang Jiangshan (Institute of Environmental Science, Fujian Normal University, Fuzhou 350007): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 66—68

The accelerated simplex algorithm has been used to calculate the longitudinal dispersion coefficient in a river, as an example for which the Ynagkou reaches of the Futunxi River, a mainstream of the Minjiang River in Fujian province, was found to have a longitudinal dispersion coefficient D_2 of 2.62 m^2/s. The results show that the accelerated simplex algorithm was more effective to be used for evaluating the parameters for a nonlinear model than the nonlinear approach algorithm. This was simply because the accelerated simplex algorithm had a process of optimization in which it was not necessary to calculate the partial derivative of the goal function and was not limited by the complexity of a model so that it was easy to be calculated and widely applicable. This algorithm could be widely used to fit environmental and ecological models and to make parameters evaluation.

Key words: river water quality model, parameter estimation, longitudinal dispersion coefficient, accelerated simplex algorithm.

Effects of Fumigation with sulfur Dioxide, Nitrogen Dioxide, Ozone and Mixtures Thereof on Ethylene Emissions from Rice. Yu Fei et al. (Nanjing Institute of Environmental Sciences, NEPA, Nanjing 210042): *Chin. J. Environ. Sci.*, **15**(4), 1993, pp. 69—71

A study was carried out on the effects of fumigation with sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3) and mixtures thereof on the release of ethylene from rice plant being fumigated. It was found that the emission of ethylene as an internal hormone of plant increases when the crop rice is fumigated with SO_2, NO_2, O_3, or mixtures thereof. This can be considered as an indicator for the level of environmental pollution. If the O_3 level is constant, the emission of ethylene from rice is directly proportional to the levels of SO_2 and NO_2 in fumigating gases, where $O_3 + SO_2$ have a greater effect on the emission of ethylene from rice than $O_3 + NO_2$. If the total level of both SO_2 and NO_2 altogether is kept constant, an increased level of SO_2 can lead to a higher emission of ethylene than an increased level of NO_2. A fumigation with NO_2 at a concentration of 4 ppm for 2 hours has caused the leaves of rice to have bleached or yellow spots when ethylene and ethane are released at 7.70 and 2.30 $nl/g \cdot F \cdot W \cdot h$, respectively.

Key words: rice, sulfur dioxide, nitrogen dioxide, ozone, fumigation, ethylene, ethane, release.

Watercolumn Barometer without Mercury Contamination. Zhang Xiong (Dept. of Physics, Yunnan Normal University, Kunming 650092): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 72—74

A miniatured (1.2 m long) watercolumn barometer has been developed to solve the environmental problem of mercury pollution resulted from the production and opreation of a mercury column barometer. The working principles, use methods and measurement errors of the watercolumn barometer were discussed and some aspects of its application were briefly described. This barometer can work well at 0— 3 km above sea level and at an ambient temperature in the range of 6— 40℃. The results from its measurement have a standard error of less than ± 0.9 mmHg and it can detecct a change in atmospheric pressure of ± 0.1 mmHg. This newly developed barometer is applicable to measure the atmospheric pressure in a room where there will be a less change in ambient temperature. A conventional watercolumn barometer is very difficult to be used to measure the atmospheric pressure because the pressure of saturated water vapor varies largely with a change in room temperature. The use of this new barometer can also solve this problem.