蚕豆（*vicia faba*）细胞微核技术监测农业土壤污染的研究*

金 波 陈光荣 李 明 王衍国
（华中师范大学生物系 武汉 430070）

摘要 本文报道了利用蚕豆叶尖和根尖细胞微核技术，监测湖北省洪湖、应城两市近郊农业土壤污染的情况，获得明显效果．经统计学分析，棉麦地、水稻田、菜地各采样点土壤，用盆栽法和浸提法处理的叶尖和根尖细胞微核千分率（MCN‰）均明显高于林地对照组（$F>F_{0.01}$，$P<0.01$），表明洪湖、应城市郊农业土壤均存在不同程度的污染．

关键词 微核试验，蚕豆细胞，土壤污染，盆栽法，浸提法．

微核试验（micronucleus test, MCNT）是根据在细胞质内产生额外核小体的现象来检测某些理化因素诱导染色体损伤作用的一种简便、快速的遗传毒理学方法[1,2]．用蚕豆初生根尖细胞微核技术监测水质污染的测试系统[3,4]，1986年被国家环境保护局编入《生物监测技术规范》（水环境部分）[5]，已在全国推广应用．随后又研究建立了蚕豆叶尖细胞微核技术监测大气污染的测试系统[6,7]．为扩大和完善蚕豆（*vicia faba*）细胞微核技术检测环境（水、气、土）污染的这一新的生物学测试系统，笔者于1988年起又开展了监测农业土壤污染的研究．

一、材料和方法

测试品种：松滋青皮豆[8]．

测试土样：1988年和1989年，分别采集湖北省洪湖市和应城市近郊的水稻田、棉麦地、菜地、林地及河堤土等土样．按“梅花形布点法”[9]，每块地设五个采样点，分耕作层（0—20cm）和犁底层（20—40cm）分别采样，风干、碾碎、弃去石块残根等杂物后，将同一类型、同一层次的土样混合均匀，用四分法留取足够用量的样品，贮存待测．

测试方法：

1．盆栽法

将蚕豆种子按本室建立的常规方法浸种催芽[8]，等初生根长至2—3cm时，将发芽的种子种入盛有不同土样的花缽中，待幼苗长出2—4片真叶时，将整株幼苗从土样中取出，用自来水冲洗干净，以终止染毒．再将幼苗置烧杯中，用自来水没住根部，修复20 h．整株幼苗用Carnoy's液固定．每一处理选5株固定好的幼苗，按本室建立的常规程序分别制作根尖、叶尖细胞压片[5,6]．每片观察计数1000个细胞，统计微核千分率（MCN‰）．

2．浸提法

将各土样分别称取50g，放入500ml三角瓶中，加pH 6—7的蒸馏水250ml，充分振荡，静置浸提24h，取上清液备测．待发芽蚕豆的初生根长至2—3cm时，放进培养皿中，倒入测试的土壤浸提液，让根部浸泡在测试液中处理24h，然后用自来水冲洗干净终止染毒，再换入蒸馏水中修复20h，截取1cm左右的根尖用Carnoy's液固定，按常规方法制片，计数细胞方法同上．此法用蒸馏水处理的蚕豆初生根尖MCN‰作为对照．

叶尖和根尖细胞微核的识别标准同参考文献[3、6]．

二、结果和讨论

1．各土样间污染物诱变效应的差异

* 本研究属国家自然科学基金课题
收稿日期：1991年7月25日

表 1　洪湖市郊不同土壤诱发蚕豆叶尖、根尖细胞 MCN‰

测试方法		盆栽法	
测试部位		叶尖细胞 $\bar{x}\pm SE$	根尖细胞 $\bar{x}\pm SE$
土样来源	棉麦地 上层 (0—20cm)	4.97±0.22	3.88±0.26
	棉麦地 下层 (20—40cm)	2.84±0.32	1.72±0.24
	水稻田 (1) 上层	7.82±0.42	7.53±0.45
	水稻田 (1) 下层	3.94±0.29	3.93±0.18
	水稻田 (2) 上层	6.87±0.34	4.46±0.24
	水稻田 (2) 下层	2.25±0.28	2.40±0.15
	菜地 上层	5.59±0.13	3.86±0.33
	菜地 下层	4.02±0.22	3.82±0.21
	林地 (CK) 上层	1.64±0.36	1.17±0.15
	林地 (CK) 下层	1.19±0.36	0.40±0.14
F 测验		$F>F_{0.01}$　$P<0.01$	$F>F_{0.01}$　$P<0.01$

注：水稻田 (1) 是排污渠道改造而成.

表 2　应城市郊不同土壤诱发蚕豆叶尖、根尖细胞 MCN‰

测试方法		盆栽法	浸提法
测试部位		叶尖细胞 $\bar{x}\pm SE$	初生根尖细胞 $\bar{x}\pm SE$
土样来源	棉麦地 上层 (0—20cm)	7.56±0.67	14.08±0.32
	棉麦地 下层 (20—40cm)	3.19±0.30	9.52±0.53
	水稻田 上层	5.66±0.18	10.68±0.44
	水稻田 下层	3.39±0.32	7.50±0.38
	菜地 上层	4.82±0.45	9.56±0.63
	菜地 下层	3.22±0.30	6.38±0.48
	河堤土 上层	3.35±0.34	5.30±0.28
	河堤土 下层	3.47±0.35	5.48±0.35
	林地 上层	1.45±0.33	4.18±0.45
	蒸馏水		3.04±0.47
F 测验		$F>F_{0.01}$　$P<0.01$	$F>F_{0.01}$　$P<0.01$

将洪湖、应城市郊不同农业土样诱发的蚕豆叶尖和根尖细胞 MCN‰ 分别进行 F 测验，各土样处理间均有极显著差异($P<0.01$)．表明不同农业土壤的污染程度及遗传毒性效应有所不同．结果见表 1、表 2．

为进一步了解不同土样一对对之间的差异显著性，将洪湖、应城市郊各土样诱发的蚕豆叶尖细胞 MCN‰ 平均值作多重比较，进行新复极差测验（即 SSR 测验）[10]．结果见表 3、表 4．

从表 3、表 4 可见，林地诱发 MCN‰ 最低，说明其土壤残毒物较少，因周围厂矿少，废水、废气、废渣等的污染及人为因素干扰少，以其作为对照，其它农业土壤与它相比，诱发微核效应均有显著性差异 ($P<0.05$)．其中以棉麦地、水稻田、菜地耕作层 (0—20cm) 诱发的 MCN‰ 较高，这与人们生产中经常施用农药、化肥及灌溉用水等情况有关．如应城市土样中

表 3 洪湖市郊土样诱发蚕豆叶尖细胞 MCN‰ 平均值的差异显著性（SSR 测验）

土样来源	MCN‰ 平均值	差异显著性 5%	差异显著性 1%
水稻田（1） 上层	7.82	a	A
水稻田（2） 上层	6.87	a	AB
菜 地 上层	5.59	b	BC
棉麦地 上层	4.97	bc	CD
菜 地 下层	4.02	cd	CD
水稻田（1） 下层	3.94	cd	DE
棉麦地 下层	2.84	de	DE
水稻田（2） 下层	2.25	ef	EF
林 地 上层	1.64	f	F
林 地 下层	1.19	f	F

注：凡有一个相同标记字母的即为差异不显著，凡具不同标记字母的即为差异显著.

表 4 应城市郊土样诱发蚕豆叶尖细胞 MCN‰ 平均值的差异显著性（SSR 测验）

土样来源	MCN‰ 平均值	差异显著性 5%	差异显著性 1%
棉麦地 上层	7.56	a	A
水稻田 上层	5.66	b	B
菜 地 上层	4.82	b	BC
河堤土 下层	3.47	c	CD
水稻田 下层	3.39	c	CD
河堤土 上层	3.35	c	CD
菜 地 下层	3.22	c	D
棉麦地 下层	3.19	c	D
林 地 上层	1.45	d	E

注：同表 3

长期栽培棉麦的土壤，因施用农药、化肥较多，其诱发的 MCN‰ 明显高于其它土壤（$P<0.01$）. 又如洪湖市土样中水稻田(1) 耕作层诱发 MCN‰ 也明显高于其它土壤（$P<0.01$）. 据调查，这块水稻田是刚从排污渠道改造而成，长期污水流经，已严重污染了土壤，其含有的污染物较多，因此诱发微核率也较高. 上述结果说明，利用蚕豆叶尖和根尖细胞微核试验，可以监测不同农用土壤污染的遗传毒性效应.

2. 土层间污染物诱变效应的差异

耕作层土壤（0—20cm）一般比犁底层土壤（20—40cm）诱发的微核率高（见表 1、表 2）. 说明诱变污染物由于土壤的吸附作用或表层植物的富集等，大多集中在上层土壤中，随着土层加深，污染程度相对减小. 本试验表明土壤对污染物有一定的净化作用，这与郑玉瑛等证明土壤具有净化污水的作用，使蚕豆微核率降低的结果相吻合[11]. 而河堤土主要是由于泥土搬迁的混合和砂性较重，透水性较强，也无耕作层与犁底层之分，故上、下层差异不大.

3. 农业土壤污染监测的处理方法比较

盆栽法和浸提法均可作为农业土壤污染监测的处理方法.

将应城市郊不同土样浸提法测定的蚕豆初生根尖 MCN‰ 进行 SSR 测验（见表 5）与盆栽法叶尖细胞 MCN‰ SSR 测验（见表 4）的结果相比较，它们监测不同农业土壤污染相对程度的趋势基本一致，故两者均可作为监测土壤污染的方法. 但这两种方法各有特点，盆栽法监测的周期相对较长，浸提法相对较短. 浸提法检测的只是土壤中水溶态诱变物，比较间接地反映土壤诱变物的遗传毒性. 而盆栽法可检测土壤中水溶和非水溶态诱变物，尤其是与根系接触的土粒界面或土壤溶液中的诱变物，可更为直接地反映土壤诱变物的遗传毒性. 因此从反映土壤污染的遗传毒性效应来说，盆栽法比浸提法更为真实. 但浸提法有其更省时、省力的特点，可根据时间、人力等情况，作为监测土壤污染更为快速、简便的方法加以采用.

表 5 应城市郊土样浸提法诱发蚕豆初生根尖细胞 MCN‰ 平均值的差异显著性（SSR 测验）

土样来源	MCN‰ 平均值	差异显著性 5%	差异显著性 1%
棉麦地 上层	14.08	a	A
水稻田 上层	10.68	b	B
菜 地 上层	9.56	b	BC
棉麦地 下层	9.52	b	BC
水稻田 下层	7.50	c	CD
菜 地 下层	6.38	cd	DE
河堤土 下层	5.48	de	DE
河堤土 上层	5.30	de	DE
林 地 上层	4.18	ef	EF
蒸馏水（CK）	3.04	f	F

注：同表 3

4. 蚕豆根尖和叶尖细胞的微核效应间有良好的相关性

将洪湖市郊各土样盆栽试验中，同一土壤内生长的蚕豆幼苗根尖和叶尖细胞出现的MCN‰平均值的资料进行回归和相关分析，结果表明根、叶细胞微核率间呈高度正相关，其直线回归方程为 $\hat{y} = 1.0896 + 0.916x$，相关系数 $r = 0.919$。对相关系数作显著性测验 $P < 0.01$ $(n = 10)$。这说明蚕豆根尖、叶尖细胞对不同农业土壤污染物的综合遗传毒性效应是一致的[12]，二者微核率的高低均可作为监测农业土壤污染程度的相对指标。由于盆栽时根部与土粒粘连较紧，如不小心则易损伤根尖，特别是较难保存初生根尖，而叶尖细胞取材、制片比根尖细胞更为方便，因此，用盆栽法进行土壤监测时，可考虑只检测叶尖细胞的微核率，以节省更多的时间和人力。

综上所述，蚕豆叶尖和根尖细胞微核技术，是监测土壤污染的一种新的遗传毒理学测试系统，它具有快速、简便、经济、可靠等特点，便于推广应用。

致谢　本研究得到湖北省洪湖市、应城市环境保护局和监测站的大力协助，特此致谢。

参 考 文 献

1 Schmid W et al. *Humangenetik*. 1971, **11**: 103
2 Heddle J A. *Mutate Res.*. 1973, **18**: 187
3 陈光荣等. 中国环境科学. 1985,5(4): 2
4 陈光荣等. 中国环境科学. 1986,6(2): 60
5 国家环境保护局. 生物监测技术规范（水环境部分）. 1986: 75—78
6 陈光荣等. 中国环境科学. 1988,8(5): 3
7 金波等. 城市环境与城市生态，1989,(2): 7
8 金波等. 华中师范学报. 1984,(2): 101
9 奚旦立等. 环境监测. 北京：高教出版社,1987: 164
10 南京农学院，田间试验和统计方法. 北京：农业出版社，1979: 91
11 郑玉瑛等. 中国环境科学. 1988,8(3): 53
12 Guangrong C, Jin Bo et al. *China Environmental Science*. 1989, **1**(1): 62

环境样品放射性测量数据的实用统计处理

韩 寿 岭

（辽宁省劳动卫生研究所，沈阳　110005）

摘要　本文就环境样品放射性核素含量测量中存在的数据处理问题进行了综合性讨论与分析。结合数据统计分析新理论提出一些实用的数据统计分析方法，包括测量结果的判断、探测限和测定限、极低水平环境样品放射性测量数据处理和测量结果总不确定度估计等。

关键词　环境样品，放射性测量，数据统计分析。

环境样品放射性含量测量较困难，一因放射性元素衰变事件具有随机性，在测量时间 t 内某个原子可能衰变，也可能不衰变；二因测量仪器和条件的不稳定性；三因环境样品中放射性核素比活度一般都很低。因此，测量数据的正确统计处理就显得格外重要。

数据统计分析是很复杂的。就环境样品放射性核素分析来说有时很难找到现成的简单实用的数据处理方法。本文从简单实用观点出发，综合一些文献资料，试图提出一些关于环境样品放射性测量数据的简单处理方法，以供同行参考。

一、测量结果的判断

一组测量结果获得后，测量者应首先判断测得的数据是否真正反映出客观实际。尤其在低水平环境样品测量中有时放射性水平与本底相近，统计涨落可引起对样品中有无放射性的错误判断。在应用某种方法对测量结果进行可疑数据的取舍判断后[1,2]，还应进行被测样品中

收稿日期：1991 年 5 月 15 日

(Chemicl Planning Institute), Zhang Huiming, Qian Yi (Departtment of Environmental Engineering, Tsinghua University): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 45—50

In this study, a biological process for controlling the concentration of residual nitrogen in coke-plant wastewater was investigated on a bench scale and through pilot plant experiments. It is concluded that the cultivation and acclimation of nitro bacteria is the key step of biodenitrification process, continuous acclimation gave better results than intermittent operations. 98—99% of NH_3-N and more than 75% of the total nitrogen could be removed using A-A/O system when the fluctuation of influent quality is low and the operation parameters are rational. The anaerobic pre-treatment plays an important role in the process.

Key words: coke-plant wastewater, anaerobic pretreatment, nitrification, denitrification.

A Study on the Treatment of Tetracycline Spent Liquor by an Anaerobic-aerobic Process. Wang Lei, Yu Yixin (Department of Environmental Engineering, Tsinghua University): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 51—54

The anaerobic-aerobic process under study may effectively remove. COD and tetracycline from the tetracycline spent liquor. The total retention time for the liquor is 30h (24h for anaerobic stage and 6h for the aerobic), the temperature for anaerobic stage is kept at 35°C and the volumetric loading for COD is 1.51 $kg/m^3 \cdot d$. After removal of oxalic acid, being diluted and its pH value adjusted, the tetracycline spent liquor is used as sample water. The maximum allowable concentration of tetracyline was found to be 300 mg/L for anaerobic digestion.

Key words: anaerobic-aerobic process, tetracycline.

Rapid Mixing Chlorination for Water Disinfection and Its Efficiency. Shen Yaoliang (Department of Environmental Protection, Suzhou Institute of Urban Construction and Environmental Protection), Zhu Qinshi (Department of Environmental Engineering, Tsinghua University): Chin. J. Environ. Sci., **13**(3), 1992, pp. 55—59

Rapid Mixing chlorination process for water disinfection was developed with astatic mixer as the mixing device. Experimental results show that inactivation of *E. Coli*, which was chosen as the indicator of disinfection, by chlorine can be greatly improved by initial rapid strong mixing. 99.99% of *E. Coli* Killing efficiency can be obtained within 5 sec. of contact time. Effects of chlorine dosage and contact time on inactivation efficiency become less important with the increase of mixing strength. Compared with traditional chlorination processes, this method is 100 times more effective. In addition, both chlorine dosage and contact time Can be greatly decreased.

Key Words: chlorination, water disinfection, *E.Colir*

Approaches to the Research of Environmental Impact Related to Water Conservancy Projects. Chen Guojie (Chengdu Institute of Mountain Disaster and Environment, Chinese Academy of Sciences): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 60—65

This paper gives briefly the contemporary trend of the utilization of water resources and the studies on environmental impact related to water conservancy projects. It also summarizes the progress, achievements and weakness of the studies in the area in China. Finally, the paper lists the steps towards strengthening the research of environmental impact related to water conservancy projects: (1) emphasizing the guiding role of idea of value in environmental impact assesment; (2) deepening and widening the studies on environmental carrying capacity for resettlement (3) paying more attention to the research in economic assessment; (4) developing risk analysis of environmental impact in the projects; (5) strengthening the studies of countermeasure system for adjusting environmental impact; (6) making efforts to set up fixed field observatories and stations.

Key words: environmental impact assessment, water conservancy project, environmental carrying capacity for resettlement

Rapid COD Determination by Using $CuSO_4$-KAl $(SO_4)_2$-Na_2MoO_4 as Catalyst. Wang Jun, Fan Shuenli, Liu Xingwang (Henan Normal University, Xinxiang, Henan): *Chin. J.Environ. Sci.*, **13**(3), 1992, pp. 66—69

A new procedure for the rapid determination of COD of waste water in the medium of H_2SO_4 and H_3PO_4 with $CuSO_4$-KAl $(SO_4)_2$-Na_2MoO_4 as catalyst was developed. Orthogonal experiments indicated the optimal conditions of the determination as: $CuSO_4$, 0.4g, $KAl(SO_4)_2$, 1.8g, Na_2MoO_4, 0.5g, H_2SO_4:H_3PO_4 (V/V)=3:1, and the reflux time, 0.5 hour. Experimental results show that the proposed procedure is similar to the standard procedure in accuracy and reproducibility. The reflux time and the cost of reagents, however, were reduced to 0.5 hour and 50 percent of the standard procedure, respectively.

Key words: COD, determination, catalysts.

A Study on the Monitoring of Soil Pollution with the Technique of *Vicia Faba* Micronucleus. Jin Bo, Chen Guangrong, Li Ming, Wang Xingguo (Departtment of Biology, Central China Normal University, Wuhan): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 74—77

This paper reports the application of the technique of micronucleus from leaf and/or root tip cells of *vicia faba* to the detection of agricultural soil pollution in the suburbs of the cities of Honghu and Yingcheng. Through statistical analysis, it was observed that the MCN‰ of leaf and roof cells of *vicia faba* treated with the soils of wheat and cotton field, rice field and vegetable plots by means of pot culture

or maceration was obviously higher than that of the cells treated with control soil ($F>F_{0.01}$, $P<0.01$). The results show the pollution of the land in the suburbs of the two cities.

Key words: micronucleus test, *vicia faba* cell, soil pollution.

Pragmatized Statistics for Data Processing in Radioactivity Measurement of Environmental Samples. Han Shouling (Liaoning Institute of Labour and Hygiene, Shenyang.): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 77—80

Comprehensive discussions and analysis were performed on the processing of data from the determination of the content of radioactive nuclein in environmental samples, including the judgement of experimental results, detection limit, treatment of the data for samples with extremely low levels of radioactivity and the uncertainty of the measurement results. Taking the new theories for data treatment and analysis into consideration, the paper proposed several functional data processing approaches.

Key words: radioactivity determination, statistical analysis.

Environmental Quality Assessment and Countermeasures for Pollution Control, Fluoring Pollution Sources in Shanghai Zhu Wenjiang, Zhang Yongming, Pan Liangyin (Shanghai Agricultural College, Shanghai): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 81—85

Fluorine contents of atmosphere, river water, soil, and plants were surveyed in the surrounding areas of fourteen major fluorine pollution sources in Shanghai. All the data obtained from the survey were treated with statistical method, the reasonable weighted values calculated based on the serial complex method, and the environmental quality was classified according to the index range. By using the figure of comprehensive assessment of environmental quality, the extent of influence of each major pollution source on its surrounding area were evaluated. The results show that the sequence of the extent of pollution of the sources are freon-producing chemical works, iron and steel works and enamelware factory, glass factory, and phosphorus fertilizer works with the last one having mildest environmental impacts. As for the brick and tile factories, some had severe and some had mild influence on their surrounding environment. Therefore, the countermeasures for pollution control for each pollution source should be varied according to its own pollution conditions. These counter measures include moving the factory away, stopping the manufacture of old product, reducing the amount of pollutants, reforming production processes, enforcing environmental management, and improving the distribution of agriculture.

Key words: fluorine Pollution, environmental quality assessment, environmental quality control.

Analysis of Factors Affecting Background Values of Hg in soils of Dalian. Wang Xin (Institute of Applied Ecology, Academia Sinica, Shenyang): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 86—88

The paper mainly discusses different environmental factors, such as soil type, parent rocks, texture, organic matter, land-use types and landform, which affect background values of mercury in soils of Dalian. Through calculation of variable coefficient of each environmental factor, it was found that the background values of Hg in soils are mainly affected by land-use type and parent rock. The natural background values of Hg in soils of Dalian was also obtained. The background values of Hg in soils of Dalian are higher than those in Liaohe River Plain because of different parent rocks and industrial or agricultural activities.

Key words: background values in soil, Hg, Dalian.

A Study on Manufacturing Manure with Fine Coal Ash in Power Station. Cheng Shuiyuan, Bai Tianxiong, Sun Yusheng (Department of Environmental Engineering, Hebei Institute of Chemical Technology and Light Industry, Shijiazhuang), Zhao Ying (Electricity and Trial Institute of Hebei Province): *Chin. J. Environ. Sci.*, **13**(3), 1992, pp. 89—90

A feasibility study on manure manufacturing with fine coal ash was performed. After the apatite fluxing agent and additives were mixed with fine coal ash in appropriate proportion and melted, non-dissoluble components in the mixture were changed into dissoluble elements which could be absorbed by plants. The formulation of materials and technological conditions were screened through hundreds of fusion experiments and the optimal burden parameters and technological conditions were obtained. The content of the fine coal ash in the studied manure could reach to 40%. The manure has the function of compound manure and therefore has good effect on plant growth.

Key words: fine coal ash, manure, fusion, apatite.

(上接第 93 页)

图. 在该图中，关键是有一个得力的执法部门按照总量控制实施流程行使监督和管理权力，并能作到秉公执法. 在我国，这样的行政管理机构就是各级环境保护局.