北京环境辐射水平现状与分布

章文英　吴增新　郑汝宽

（北京市环境保护科学研究所，北京　100037）

摘要　在北京市按网格布点调研了环境辐射水平。北京原野γ辐射及宇宙射线室外剂量率按网点加权均值分别为56.2及32.3nGy·h^{-1}，全市土壤中^{238}U、^{232}Th、^{226}Ra、^{40}K及^{137}Cs含量按面积加权均值分别为19.4、34.1、21.4、622及8.3Bq·kg^{-1}，各类水体水中U、Th及^{226}Ra、^{40}K浓度范围分别是0.12—8.94、0.02—0.66μg·L^{-1}及6.0—98.1、19.2—643 mBq·L^{-1}。北京环境辐射水平地理分布的大致趋势是西北部山区较高，东南部平原区较低。

关键词　环境辐射水平，剂量率，北京。

北京位于北纬39°28′—41°05′和东经115°25′—117°30′，面积16807km^2，辖有18个区县。北京地势西北高、东南低，海拔最高点灵山2303m，最低点通县柴厂屯8m。山地面积约占61%，西部由北东南西走向的褶皱山脉组成，属太行山余脉，北部属燕山山脉，山间夹有盆地，东南部由洪积-冲积扇及洪冲积平原组成。北京主要河流属海河-蓟运河水系[1]。

环境辐射水平随海拔高度、地质、建材等地域条件而变化，核技术应用及伴有辐射的工业活动也会影响环境的辐射水平。

1　调研方法

1.1　点位布设

在北京郊区以纬度5′和经度7.5′、域区以1×1km^2为1个网格点，全市共布网格点177个。考虑人口密度、土壤类型及样本量等因素，增布加密点210个。在每个点位上测量原野、道路、建筑物室内的γ辐射剂量率，并采集土壤样品。在古建筑、地下建筑及核设施周围布特殊点，测量γ剂量率。与环境常规监测布点基本一致，布地表水、地下水及自来水取样点。

1.2　采样及测量分析方法

土壤样品在10×10m^2范围内按梅花采样法取表层土壤，个别山坡地用蛇形采样法。水样分别在枯水期及平水期采集。样品测量分析方法见表1。

2　结果与讨论

2.1　北京环境贯穿辐射水平

北京原野、道路、建筑物室内的γ辐射水平调查统计结果见表2—4。北京全市原野γ辐射剂量率范围是29.2—88.9 nGy·h^{-1}，按点平均及按人口加权均值分别为56.2及50.1 nGy·h^{-1}；按区县统计，最高为延庆县，最低为崇文区。北京道路γ剂量率范围是14.7—105 nGy·h^{-1}，不同路面γ剂量率以土路最高、柏油路最低。建筑物室内γ剂量率与建材、房屋结构等有关，全市变化范围是42.3—152 nGy·h^{-1}，按人口加权均值为77.1 nGy·h^{-1}。经统计检验，农村砖、土、石各类房屋γ剂量率无显著性差异，而城区平房明显高于砖和混凝土材料和楼房。所测33处古建筑物室内γ辐射剂量率均值为58.5 nGy·h^{-1}，比城区室内约低20%。地下建筑物γ辐射水平与全市平均水平无显著性差异。

宇宙射线（电离成分）剂量率与海拔高度及经纬度有关。北京室外宇宙射线剂量率范围是30.5—38.1 nGy·h^{-1}，按网点、人口加权均值分别为32.3、30.8 nGy·h^{-1}；室内宇宙射线剂量率范围是24.4—32.3 nGy·h^{-1}，按网点、人口加权均值分别为29.0、27.5 nGy·h^{-1}。

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表1　测量分析方法

项　　目	方　　法	仪　　器
γ辐射剂量率	就地测量(距地面1m)	FT-620照射量率仪
土壤中 ^{238}U	混合铵盐预处理、激光荧光法	UA-3铀测定仪
土壤中 ^{232}Th、^{226}Ra、^{40}K、^{137}Cs	γ能谱分析	同轴型高纯锗γ谱仪
水中U	液体激光荧光法	UA-3铀测定仪
水中Th	N_{263}-DA201色层分离、分光光度法	7215全差式分光光度仪
水中 ^{226}Ra	$BaSO_4$沉淀、射气法	FD-125氡钍分析仪
水中 ^{40}K	原子吸收法	AAS-1原子吸收分光光度仪

表2　北京原野γ辐射剂量率

区　县	测点数	γ辐射剂量率(nGy·h⁻¹)		
		范　围	点平均值	按人口加权均值
东　城	23	41.7—55.5	48.3	48.3
西　城	25	41.6—54.8	47.4	47.4
宣　武	20	34.8—52.8	45.2	45.2
崇　文	15	36.0—47.9	44.5	44.5
丰　台	19	34.5—60.9	51.4	51.6
海　淀	34	38.7—69.7	52.9	49.2
石景山	11	38.7—55.3	53.4	52.0
朝　阳	18	35.3—56.2	47.3	42.2
门头沟	33	31.7—79.4	53.2	56.5
通　县	17	44.0—65.8	53.6	55.2
大　兴	11	32.9—58.0	48.8	48.0
房　山	28	29.2—76.9	59.0	56.9
昌　平	21	37.7—88.9	57.1	53.9
顺　义	13	39.3—61.6	50.5	47.8
平　谷	16	46.1—76.7	51.9	52.2
密　云	26	33.6—64.3	54.7	53.7
怀　柔	29	40.2—77.7	62.0	60.8
延　庆	28	44.2—80.9	65.1	60.4
全　市	387	29.2—88.9	56.2	50.1

表3　北京道路γ辐射

类　型	测点数	γ辐射剂量率(nGy·h⁻¹)		
		范　围	均值	标准差
柏油路	235	14.7—105	41.7	9.2
水泥路	25	31.8—61.5	46.5	6.4
土路	56	29.3—87.3	57.9	10.5
砂石路	72	15.4—97.1	50.1	11.5
全市总计	388	14.7—105	45.9	9.7
全市网点统计	177网点	29.3—88.9	49.3	13.1

表4　北京建筑物室内γ辐射剂量率

类　型	测点数	γ辐射剂量率(nGy·h⁻¹)		
		范　围	均值	标准差
砖平房	265	43.2—119	79.3	12.0
砖混楼房	27	46.2—110	69.2	12.4
土平房	23	61.3—109	82.2	12.8
石平房	78	48.3—152	84.1	16.2
古建筑	94	10.2—80.8	58.5	15.4
地　铁	36	69.6—101	80.8	8.9
全市总计1)	393	42.3—152	77.1	32.1

1)　全市总计不包括古建筑及地铁,均值为按人口加权均值

γ辐射、宇宙射线和贯穿辐射所致北京居民人均年有效剂量当量分别为0.426、0.249和0.675mSv,贯穿辐射所致北京居民集体年有效剂量当量为6230人·Sv。

2.2　北京土壤中放射性核素含量及地理分布

北京土壤以褐土为主,次为潮土、棕壤。褐土占土壤面积64.9%,分布在山地、丘陵和平原;潮土占24.7,分布在冲积平原;棕壤占9.5%,分布在400—800m的山地和丘陵。北京土壤中天然放射性核素含量按土壤类型统计结果见表5,土壤中 ^{238}U、^{232}Th、^{226}Ra、^{40}K 含量范围分别为8.2—34.5、17—63、10—40、315—895 Bq·kg⁻¹,经统计检验,棕壤和褐土中 ^{238}U、^{232}Th、^{226}Ra 含量均高于潮土,该3类土壤中 ^{40}K 含量无显著差异。人工核素 ^{137}Cs 含量与土壤形成条件无关,全市土壤统计结果:^{137}Cs 含量范围是0.2—23 Bq·kg⁻¹,按点及面积加权均值分别为7.7及8.3 Bq·kg⁻¹。

北京土壤中天然放射性核素含量地理分布见图1至图4,^{238}U、^{232}Th、^{226}Ra 含量均为西部山区较高,南部平原较低。^{137}Cs 含量按区县统计大致趋势为西北部区县高于东南部区县。

2.3　北京水中天然放射性核素浓度

调查了北京5条河系(永定河、北运河、大清

河、蓟运河、潮白河)、6座水库(密云、怀柔、官厅、海子、斋堂、龙庆峡)及自来水、农村地下井水、泉水的水中放射性核素浓度,其结果汇总于表6。各类水中U、Th及^{226}Ra、^{40}K浓度范围分别为0.12—8.94、0.02—0.66μg·L^{-1}及6.0—98.1、19.2—643 mBq·L^{-1}。北京水库与河流相通,两者水中U、Th及^{226}Ra浓度无显著差异。河水中^{40}K较库水高,最高者为北运河,其值为其他河系的4—4倍,这与其部分河段的非放射性污染有关。官厅水库U浓度略高于其他水库,地下水中U浓度高于地面水。^{226}Ra最高者为小汤山泉水。

表5　北京土壤中天然放射性核素含量(Bq·kg^{-1})

土壤类型	样品数	^{238}U		^{232}Th		^{226}Ra		^{40}K	
		范　围	均值	范　围	均值	范　围	均值	范　围	均值
棕　壤	10	8.2—34.5	21.2	17—59	35.7	10—40	25.0	383—883	597
褐　土	92	9.0—34.5	20.4	17—63	36.2	10—37	23.2	315—895	663
潮　土	43	8.2—28.0	18.5	24—45	30.9	12—32	20.6	508—783	636
水稻土	2	13.5—26.3	19.9	33—37	35.0	22—32	27.0	526—659	592
全市土壤	147	8.2—34.5	19.8	17—63	34.6	10—40	22.6	315—895	650
全市按面积加权			19.4		34.1		21.4		662

表6　北京水中放射性核素浓度

类　型	样品数	U (μg·L^{-1})		Th (μg·L^{-1})		^{226}Ra (mBq·L^{-1})		^{40}K (mBq·L^{-1})	
		范　围	均值	范　围	均值	范　围	均值	范　围	均值
河　流	64	0.26—6.26	1.73	0.02—0.66	0.13	6.0—14.6	7.45	43.0—643	163
水　库	11	0.25—5.13	1.90	0.02—0.44	0.09	6.0—8.5	7.02	42.4—143	69.1
湖　泊	6	0.70—3.35	2.03	0.04—0.31	0.13	6.0—8.5	7.12	62.6—124	80.3
地下水	28	0.50—8.94	3.42	0.02—0.40	0.09	6.0—13.3	7.97	19.2—150	60.0
自来水	12	0.56—8.94	4.28	0.02—0.30	0.07	6.0—20.4	8.43	46.2—119	83.3
泉　水	4	0.12—1.28	0.68	0.02—0.02	0.02	6.0—98.1	49.9	72.7—446	262

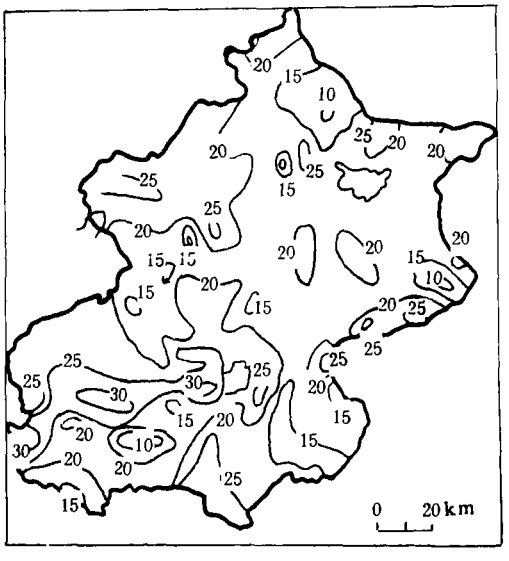

图1　北京土壤^{238}U含量等值分布(Bq·kg^{-1})

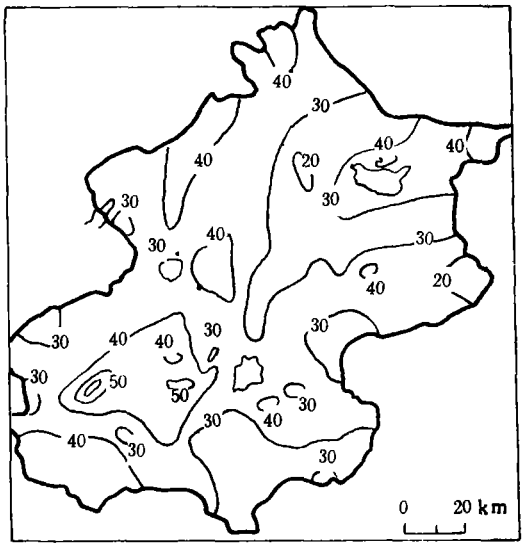

图2　北京土壤^{232}Th含量等值分布(Bq·kg^{-1})

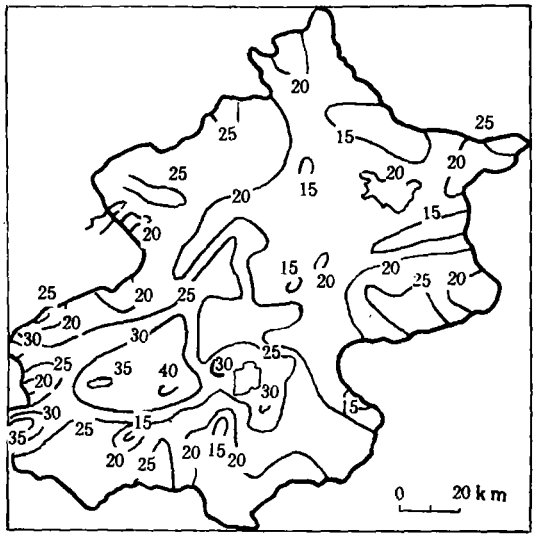

图3　北京土壤^{226}Ra含量等值分布(Bq·kg^{-1})

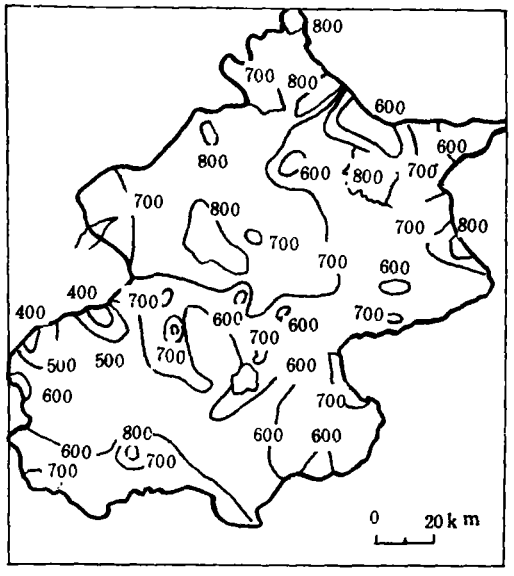

图4　北京土壤^{40}K含量等值分布(Bq·kg^{-1})

2.4　北京核设施周围环境γ辐射水平

利用汽车γ谱仪系统，对北京两个核设施单位内、外环境γ辐射水平进行了高密度巡测，结果见表7。该两单位外围地区环境γ辐射水平均在北京环境正常水平范围内，其中一单位院内局部环境γ辐射水平较高，最高处约为该单位正常水平的8倍。

表7　北京两核设施周围环境γ辐射剂量率(nGy·h^{-1})

地　点	设　施(Ⅰ)			设　施(Ⅱ)		
	测点数	范围	平均值	测点数	范围	平均值
	520	18—65	45.4	82	47—85	53.2
工作区	11	87—105	92.5			
	6	175—594	371			
周围地区	1250	22—69	41.9	1103	30—99	56.7

3　小结

北京原野γ剂量率按人口加权均值为50.1 nGy·h^{-1}，比世界均值55 nGy·h^{-1}约低9%。按网点统计的道路及建筑物室内γ剂量率均值分别为49.3及83.5 nGy·h^{-1}。贯穿辐射所致北京居民人均年有效剂量当量为0.675mSv，居民集体年有效剂量当量为6230人·Sv。

北京土壤中^{238}U、^{232}Th、^{226}Ra、^{40}K及^{137}Cs含量按面积加权均值分别为19.4、34.1、21.4、662及8.3 Bq·kg^{-1}，是我国土壤中^{238}U、^{226}Ra含量较低的地区[2]。各类水中U、Th及^{226}Ra、^{40}K浓度范围分别是0.12—8.94、0.02—0.66μg·L^{-1}及6.0—98.1、19.2—643 Bq·L^{-1}。北京环境辐射水平地理分布的大致趋势是西北部山区较高，东南部平原区较低。

北京古建筑室内γ剂量率明显低于北京城区一般建筑物。核设施周围环境γ剂量率属正常水平。

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Abstracts

Chinese Journal of Environmental Science

Study on Removing Hexavalent Chromium by Sulfate-Reducing Bacteria (SRIV). Wang Pin et al. (Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 1—4

A strain of sulfate- reducing bacteria capable of reducing hexavalent chromium was isolated from electroplating sludge by using Hungate anaerobic technique. The strain was a motile curved rod, possessing singly polar flagella. The cell was 0. 5—0. 8μm in length, non- sporing, non- capsules, Gram-negative. The oxidation was incomplete, leading to acetate production; and glucose, sucrose, pyruvate, $H_2 + CO_2$, alcohol, and formate were fermented in the absence of an external electron acceptor. These characteristics established the isolate as *Desulfovibrio* sp. Reclaiming of hexevalent chromium with the isolate has shown that it was resistant to Cr(VI) concentrations of up to 10×10^{-3}mol/L at the optimum temperature 30℃ and at optimum pH 7. 0. And under such conditions, the optimun Cr(VI) concentration for its growth was 4×10^{-3}mol/L. The removal of Cr(VI) was 99. 8 %. SRIV strain was a engineered strain in removing Cr(VI) from wastewater.

Key words: fulfate-reducing bacteria, chromium, electroplating wastewater.

Inhibition of Nickel to the Anaerobic Digestion. Wang Jusi et al. (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 5—8

The inhibition of nickel ion to anaerobic digestion was described in this paper. Nickel ion was added at different concentrations in three experimental digesters. No inhibition effect on the anaerobic system was observed when daily addition of nickel to the digester was less than 36. 4 mg/L. When the daily addition of nickel was 40—60mg/L, or more than 80mg/ L, however, digestion system was inhibited significantly or seriously, respectively. Toxicity of nickel to anaerobic system was found to be dependent on the concentration of dissolved nickel ions in digester. The systemwas not affected when the concentration of dissolved nickel ion is less than 2. 5mg/ L. At the ratio of concentration of daily nickel addition to activated sludge (dry weight) being less than 0. 08(w/w), the digestion system would be normally running.

Key words: nickel, anaerobic digestion, inhibition effect.

Crops Lead Pollution by Sludge Land Application. Yang Zhuoya, Wang hongkang. (Resource and Environment College. Beijing Agricultural University, Beijing, 100094): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 9—11

Pot experiments and field trails were conducted to study the effect of soil lead levels on phytotoxicity, growth and tissue accumulation in soybean and rice grown on sludge treated calcareous soil. The results indicated that lead didn' t cause significant growth depression symptoms of the two crops. The lead tolerabilities of two crops were equal. As a whole, the higher lead concentration in soil would bring about higher lead concentration in crops tissue. The lead accumulation rate of the two crops was different, soybean absorbed fewer lead than rice. Soil lead concentration 260mg/kg would make rice seed lead concentration to reach 1mg/kg. This value was suggested as critical level in the soil. and 600mg/kg was calculated as maximum permissible concentration in sludge when it is applied on cropland.

Key words: lead, sludge, soybean, rice, control standard.

Nonlinear Description of Industry- Environment Systems. Qi Anshen et al. (Department of Physics, Beijing Normal University): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 12—15

In this note, a nonlinear dynamic modeling describing the time evolutions of industry-environmental systems is established using the theory and method of self- organization. The model characterizes the interactions amongst the output, the investment in environment protection, the improvements in production technique and pollution control, and the environmental capacity. The modeling is simple and easy to use. Additionally, the modeling is employed to study the problems of industry development and environmental pollution in Baiyin region, Gansu Province.

Key words: industry- environment system, the theory of self- organization, nonequilibrium phase transition, coordinative development.

Current Level and Distribution of Environmental Radiation in Beijing. Zhang Wenying et al. (Beijing Municipal Research Institute of Environmental Protection, Beijing 100037): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 16—19

This paper reports the environmental radiation level in Beijing. The monitoring sites were set up by net-grid method. In Beijing the grid point- weighted average values for γ radiation dose and cosmic ray outdoors radiation dose are 56. 2 and 32. 3 nGy/h, respectively. The area- weighted average values of U-238, Th-232, Ra-226, K-40 and Cs-137 in soil are 19. 4、34. 1、21. 4. 662 and 8. 3 Bq/ kg, respectively. The concentration range of U、Th and

Abstracts

Ra-226, K-40 in various waters are 0. 12—8. 94、0. 02—0. 66μg/L and 6. 0—98. 1、19. 2—643 mBq/L, respectively. The geographical distribution of the environmental radiation levels is higher in the west-north mountain area and lower in the east-south plain of Beijing.

Key words: environmental radiation level, dose rate, Beijing.

Study of Treating Acid Cd-Containing Effluent with Expanded Graphite Fluidized Electrode. Zhang Hongbo et al. (Chemistry and Chemical Engineering Department, Hunan University chang sha): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 20—23

Acid Cd- containing effluent was treated with expanded graphite fluidized electrode effectively. It has advantages of fairly high current efficiency (40—50%), rapid removal of Cd^{2+} (40. 7mg/min), fairly low energy consumption (6—10kWh/kg Cd) and so on. The concentration of cadium ion in treated effluent can be decreased to below 10ppm. It does not comply with national effluent dis charge standard, but it is still effective in the recovery of cadium. Suitable conditions of treating acid Cd- containing effluent and methods for Cd-recovering were also investigated.

Key words: expanded graphite, fluidized electrode, Cd-containing effluent.

Pollution by Phosphorus in Farmland Drainage to the Taihu-Lake Water system. Zhang Shuiming et al. (Institute of Soil Science, Chinese Academy of Sciences, Nanjing 210008): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 24—29

By the phosthorus balance method in a closed system, this paper dealt with the discharge of phosphorus from agricultural non-point source in Taihu-Lake region in southern Jiangsu Province, and the measures to reduce this discharge. The results showed that the total discharge of phosphorus from the surface drainage of farmland in Taihu-Lake region was 440. 4 t/a in a raing year as 1987, and 299. 9 t/a in a dry year as 1988.

Key words: farmland drainage, phosphorus discharge.

Study of the Genotoxicity and Concentration of Five Metals in Air-Borne Particles. Lei Xiufen et al. (Department of Epidemiology, Beijing Medical University, Beijing 100083): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 30—33

Samples of variously- sized total suspended particulates (TSP) in the air of one sampling site of Taiyuan are collected in winter. The concentration and the percentage of the particulates are measured, five metals including Pb, Mn, Cr, Ni and Cd in the extracts from the samples are quantitatively analyzed by atomic absorption spectrometer, and the genotoxicity of the extracts are detected by the SOS chromotest and the mouse bone marrow cellular chromosome aberration assay in vivo. The results show that the mean concentration of TSP is 1. 04mg/m^3, much higher than the National Standard. The pollution of the smaller- sized particles is serious, as nearly half of the particles are less than 7. 0μm in diameter. The concentration of Pb, Mn and Ni are high. Besides, the metals can be enriched strongly on the surface of the small particles. Having extracted by simulated lung fluid (SLF), it has been found that metals can dissolve partialy into the SLF. The experiments show that both the extracts of acid and that of SLF of the smaller sized particles can induce SOS response and cause an increase in chromosomal aberrations. This indicates the existence of genotoxicants which may cause DNA damage or have clastogenic effects in the smaller-sized particles.

Key words: air-borne particles, genotoxicity, SOS chromotest, chromosome aberration assay.

Study on the Collection Efficiency of a Granules-moving Bed Dust Filter. Zhang Liping et al. (Department of Chamical Engineering, Tsinghua University, Beijing 100084): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 34—37

Based on analysing the mechanism of filtration through a granule layer and the factors affecting the dust collection efficiency of a granule layer moving bed filter, an orthogonal multi-factor method was used in a laboratory apparatus to preliminarily study the effects of the factors such as the filtration velocity, the size and type of particles, the bed thickness, and the dust load of granule layer, on the dust collection efficiency. Then, a demonstration was made in an industrial pilot plant. The results showed that the suitable filtration velocity was 0. 2m/s, the particle size in the moving bed was preferred in 1—2mm, and the bed thickness should be equal to or slightly more than 150mm.

Key words: dust collection efficiency, granular moving-bed, filter.

Anaerobic-Anoxic-Aerobic Process for Municipal Wastawater Treatment. Yang Xiushan et al. (Capital Normal University, Beijing, 100037): *Chin. J. Environ. Sci.*, 14(6), 1993, pp. 38—42

A pilot reactor of anaerobic-anoxic-aerobic process was operated to treat municipal wastewater. The results indicated that the process was able to remove 90% total COD, 89% TSS, 93% VSS, and the removal rates of nitrogen and phosphorus were 80% and 40%, respectively. In anoxic phase, the