

# 内蒙镶黄旗人群胃癌环境病因的研究\*

## ——关于人体内合成亚硝胺的评估

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**摘要** 测定了内蒙古自治区锡盟镶黄旗 15 个不同地点水样中的  $\text{NO}_2^-$  含量。实验结果显示, 15 个地点水样中  $\text{NO}_2^-$  的含量相差很大, 大致分为 A、B、C 3 组, 其平均值分别为 0.186、0.640、3.850  $\mu\text{g}/\text{ml}$ 。同时, 还测定了霉变奶酪中总胺含量为  $1.34 \times 10^5 \mu\text{g}/\text{kg}$ 。根据每人每天的饮食和饮水量, 从理论上计算不同地点人群体内生物合成亚硝胺的相对产量。

**关键词** 内合成, 亚硝胺, 胃癌病因。

亚硝胺的体内生物合成已被实验所证明, Fine 等曾发现人在进餐之后, 血液中挥发性亚硝胺的含量增高。Ohshima 等人测定了服用硝酸盐和脯氨酸的人的尿液中脯氨酸亚硝胺的含量, 证明人体内能合成脯氨酸亚硝胺。另外, 动物实验也证明了生物体内合成亚硝胺<sup>[1]</sup>。

根据最近流行病学的调查, 内蒙古自治区镶黄旗的胃癌死亡率中调值为 30/10 万左右。笔者测定了内蒙古自治区锡盟镶黄旗 15 个地点水样中  $\text{NO}_2^-$  的含量, 以及该地区霉变奶酪中胺类化合物的含量, 对于人体内合成亚硝胺作了预测性的评估。

## 1 实验

### 1.1 材料与方法

(1) 化学试剂 亚硝酸钠、氨基乙酸、对氨基苯磺酸, N-1 萘乙烯二胺盐酸盐, 茚三酮, 吡啶等均为分析纯。无水酒精为特级纯, 36% 醋酸, 以上药品为北京化学试剂厂产品。

(2) 显色剂 格氏试剂: 1.00 g 对氨基苯磺酸和 0.150 g N-1 萘乙烯二胺盐酸盐分别溶于 100 ml 10% 醋酸溶液中, 置于棕色试剂瓶中于 4℃ 保存, 使用前 1:1(V/V) 混合。茚三酮溶液: 0.600 g 茚三酮溶于 100 ml 含有 2% 吡啶的无水酒精溶液中, 置于棕色瓶中保存。

(3) 仪器 紫外可见分光光度计(UV-

200), 日本岛津。离心机(LXJ-64-01), 北京医疗仪器厂。

### 1.2 水样中 $\text{NO}_2^-$ 的测定

将水样充分静置后, 取其上层清液各 5 ml 分别加入 2 ml 格氏试剂显色 30 min, 用 UV-200 测定每份水样中  $\text{NO}_2^-$  的含量。 $\text{NO}_2^-$  的浓度在 0—2  $\mu\text{g}/\text{ml}$  范围之内, 与格氏试剂反应得到符合 Beer 定律的工作曲线。

### 1.3 霉变奶酪中总胺的测定

将霉变的固体奶酪研磨成均匀粉末, 称取 2.0 g 该样加入 40 ml 去离子水充分搅拌, 浸泡过夜, 离心后取其上层清液 5 ml, 加入 4 ml 茚三酮显色 4 h 后, 用 UV-200  $\lambda=570 \text{ nm}$  下测其吸光度, 由工作曲线可知奶酪中胺的含量。以氨基乙酸作标准物, 在 0—10  $\mu\text{g}/\text{ml}$  的浓度范围内, 与茚三酮显色剂反应呈现特征的紫色, 得到符合 Beer 定律的工作曲线。

## 2 结果与讨论

### 2.1 水样 $\text{NO}_2^-$ 的含量

水样  $\text{NO}_2^-$  的含量, 对所得的结果经统计归纳, 其平均值如表 1。

### 2.2 奶酪中总胺的含量

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根据胺类化合物与茚三酮试剂的显色反应，奶酪中总胺的含量如表 2 所示。

表 1 3 组水样中 NO<sub>2</sub><sup>-</sup> 的平均含量(μg/ml)

分组	$\bar{X} \pm S(n=10)$
A	0.186 ± 0.053
B	0.640 ± 0.036
C	3.840 ± 1.720

表 2 发霉奶酪中总胺的含量(μg/ml)

温度(℃)	$\bar{X} \pm S(n=6)$
15—20	(1.73 ± 0.09) × 10 <sup>5</sup>
30—40	(1.34 ± 0.11) × 10 <sup>5</sup>

2.3 讨论

NO<sub>2</sub><sup>-</sup> 和胺类是合成亚硝胺的前体物，无论是动物或人类，通过饮水或饮食摄取 NO<sub>2</sub><sup>-</sup> 和胺类，在体内，特别是在胃内，NO<sub>2</sub><sup>-</sup> 和胺类相互反应合成亚硝胺。Mirvish 在模拟胃液条件下，研究了胺类经亚硝化合成亚硝胺的反应。在 pH < 5 的酸性水溶液中，NO<sub>2</sub><sup>-</sup> 是对胺类亚硝化的最好试剂。

最终反应产物 R<sub>2</sub>N-NO 可以是亚硝胺或亚硝酰胺。烷基和杂环的二级胺，在 pH 2—5 的 NO<sub>2</sub><sup>-</sup> 缓冲水溶液中发生亚硝化反应生成亚硝胺，此反应速率方程为<sup>[2]</sup>：

$$\text{速度} = K[R_2NH][NO_2^-]^2$$

这说明亚硝胺合成的速率与非离子化胺的浓度和亚硝酸根浓度平方的乘积成正比。以二甲基亚硝胺(NDMA)为例，0.02 ml/L 二甲基胺同 0.1 ml/L 的 NO<sub>2</sub><sup>-</sup> 反应，产率在 pH = 3—4 之间呈现最大值，约为 15%，当 pH 值为 1—2 的酸性时，产率降低到约为 2% 左右<sup>[3]</sup>。根据内蒙古自治区锡盟镶黄旗地区饮水中 NO<sub>2</sub><sup>-</sup> 的含量，以及发霉奶酪中的胺类化合物的含量，可以从理论上计算人体胃内合成亚硝胺的相对产量。若每人每天饮水 2000 ml，进食奶酪 200 g，假设当胃液 pH 为 3—4 左右时，胃内合成亚硝胺(相对于 NDMA)的产率为 3%，胃液 pH 为 1—2 左右时，胃内合成亚硝胺(相对于 NDMA)的产率为 0.4%，理论计算 A、B、C 3 组人群胃内合成亚硝胺(相对于 NDMA)的产量列于表 3 中<sup>[1]</sup>。

测定霉变奶酪的胺类化合物时，发现溶液

表 3 胃内合成亚硝胺的产量估算(相当于 NDMA)

项目	A	B	C
每人每天饮入 NO <sub>2</sub> <sup>-</sup> 的量(μg)	372	1280	7680
每人每天进食总胺的量(μg)	2.68 × 10 <sup>2</sup>	2.60 × 10 <sup>2</sup>	2.68 × 10 <sup>2</sup>
(pH = 3—4)胃内合成 NA 量(μg)	17.96	61.78	370.64
(pH = 1—2)胃内合成 NA 量(μg)	2.40	8.24	49.42

的温度和 pH 值对测定总胺有明显的影响。例如，在室温下(18℃左右)，测得同一样品溶液中总胺的含量高于 40—80℃ 的含量，这可能由于温度升高，部分胺化合物被分解。当溶液的 pH 值为 5—7 时，总胺的含量高于 pH 值 4—5 时的含量，这可能是由于在酸性条件下，有一部分胺和酸作用生成铵盐而使总胺含量降低。已经注意到，一些具有二级胺和三级胺化学结构的胺类和肽类，在模拟胃液条件下，同亚硝化试剂作用，都可能生成亚硝胺或亚硝酰胺<sup>[4]</sup>。

总之，人体通过进食摄取胺类和肽类等物

质，如果当饮水中含有较高浓度的 NO<sub>2</sub><sup>-</sup> 时，在胃液条件下，有可能合成亚硝胺或亚硝酰胺，因此，胃内合成亚硝胺是探讨胃癌病因的一个重要部分<sup>[5]</sup>。

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autumn. In addition, the concentration of nitrate and sulfate were often of high values in one or two days before raining and in 3 or 4 days after raining. This indicates that rainfall had a significant effect of scavenging particulates. The level of nitrate in particulates was found to have a much better correlation with ozone concentration than the level of sulfate in particulates.

**Key words:** particulate, nitrate, sulfate, ozone, ion chromatography.

**Study on the Photocatalytic Degradation of Organo-Phosphorus Pesticides.** Chen shifu et al. (Dept. of Chemical Eng., Zhengzhou Institute of Technology, Zhengzhou 450002); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 61–63

The feasibility of photocatalytic degradation of three different structures' organophosphorus pesticides using  $\text{TiO}_2$  powders as a photocatalyst was studied. The results show that different structures of organophosphorus pesticides had different photodegradation efficiencies, and four organophosphorus pesticides of  $1.0 \times 10^{-4}$  mol/L were completely photocatalytically degraded into inorganic phosphate after 40 min illumination with a medium pressure mercury lamp of 375 W. Some intermediate products of photocatalytic degradation of monocrotophos were detected and the effects of the parameter, such as amount of  $\text{TiO}_2$ , flow rate of air and  $\text{Fe}^{3+}$  concentration, on the photocatalytic degradation were also investigated. The mechanism were discussed preliminarily.

**Key words:** organophosphorus pesticides, photocatalytic degradation,  $\text{TiO}_2$  powders.

**Preliminary study on the relationship between seasonal dynamics of microfauna in the root system of water hyacinth and their effects on the purification of waterbody.** Li Baolin (Beijing Municipal Research Academy of Environmental Protection, Beijing 100037); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 64–66

Seasonal variation characteristics of microfauna in the root system of water hyacinth has been primarily studied when it was used to treat sewage water from the Beijing Zoo. 70 species of microfauna was found in the water-root system in 1992, with the largest number of 60 species in 49 genera in August. Biomass (by relative quantity and average wet weight) of microfauna was heavier in July and August, and the weight percentage of protozoa in the same two months were 76.9% and 64.1%. The dominant species (po-

pulation) examined in each month (June to October) was reported. The main physical and chemical indexes such as TN, TP and BOD varied seasonally. The removal of TSS was up to 82.9% and those of BOD and TP were 66.6% and 91.6%. This study demonstrates that the purifying efficiency of water-hyacinth system was in a relationship with the seasonal characteristics of the microfauna built up in its rootsystem.

**Key words:** water hyacinth, root system, microfauna, purification.

**Study on the Decolourization Activity of Activated Sludge with Immobilized Decolourization Bacteria.** Zhang Lin et al. (Dept. of Environ. Eng., Taiyuan Univ. of Technology, Taiyuan 030024), Ma Minghuan (Shanxi Textile Industry Designing Institute, Taiyuan 030002); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 67–69

The highly efficient decolourization bacteria were selected and immobilized on an activated sludge by using an aggregated/cross-linked immobilization method to form a microstructure of cross-linked floccule-granule. The activity of decolourization enzyme increased by about 70% as compared with a non immobilized activated sludge. The results of textile dyeing wastewater treatment under anaerobic condition show that there was an average colour removal 77.3% with an average  $\text{COD}_{\text{Cr}}$  removal of 65.1%.

**Key words:** aggregated/cross-linked immobilization, the activated sludge with immobilized decolourization bacteria, activity of decolourization enzyme, dyeing wastewater.

**Study on Environmental Etiology Among a Population at a High Risk of Gastric Cancer in Xianghuangqi County of Inner Mongolia: An Appraisalment on the Endogenous Synthesis of Nitrosamines in Human Body.** Song Xiuxian et al. (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085), Liu Kezhong (Inner Mongolia Autonomous Region's Hospital, Huhhot 010017); *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 70–71

The contents of nitrites in water from 15 rural areas in Xianghuangqi, Xilinguole Meng, Inner Mongolia Autonomous Region, were measured. The results show that the contents of nitrites in water widely varied and could be classified broadly into three groups with an average nitrite level of 0.186, 0.640 and 3.840  $\mu\text{g}/\text{ml}$  respectively. The contents of amines in mildewed cheese were

also measured, and the total levels of amines in the cheese were also measured, and the total levels of amines in the cheese were about  $1.34 \times 10^5 \mu\text{g/kg}$ . Based on the daily diet and drinking a person, the theoretical calculation was made for the relative yield of endogenously synthesized nitrosamines in human body in different areas.

**Key words:** endogenous synthesis, nitrosamine, gastric cancer etiology.

**Temporal and Spatial Patterns of Environmental Risk Events in the Past 30 Years in Shenyang City.** Bi Jun (Institute of Geography, Chinese Academy of Sciences, Beijing 100101), Wang Huadong (Institute of Environ. Sciences, Beijing Normal Univ., Beijing 100875): *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 72–75

The index of "risk frequency" and other relative indices are used to analyze the temporal and spatial patterns of environmental risk events in the past 30 years in Shenyang city. The results show that there existed an extremely significant variation in the risk frequency during the periods of 1966–1977 and 1978–1979 ( $t = -7.353$ ,  $t_{0.01} = 2.807$ ). During the past 30 years, there was no significant variation in the spatial patterns of the environmental risk, while the distribution of environmental risk among the districts was extremely different. In Shenyang city, there existed a series of high-risk enterprises, and the chemical industry was of the highest risk.

**Key words:** Shenyang, environmental risk, temporal and spatial patterns, risk frequency.

**Assessment on the Comprehensive Urban Environmental Quality Based on a Matter Element Analysis.** Li Zuoyong (Dept. of Atmospheric Electronics Eng., Chengdu Institute of Meteorology, Chengdu 610041): *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 76–78

In order to study the possibility of the use of a matter element analysis in the assessment on comprehensive urban environmental quality, an assessment model for the comprehensive urban environmental quality was developed by calculating the comprehensive cognate degree between the environment and each assessment class. The results from exemplified application to 16 cities in Sichuan show that it was rational and practicable to assess the comprehensive urban environment quality by using a matter element analysis.

**Key words:** matter element analysis, cognate function, environmental quality assessment.

**Membrane Bio-reactor Technology for the Treatment of Water and Wastewater.** Fan Yaopo and Wang Jusi (Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085): *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 79–81

A review was made on the concept, categories and characteristics of membrane bioreactors and the advances in their R & D for use in the treatment of water and wastewater. The bioreactors, including the immersed hollow fiber membrane bioreactors, the crossflow filtration membrane bioreactors and the extractive membrane bioreactors, were described by giving eight examples of membrane bioreactors for the treatment of water and wastewater, and their respective technical parameters and treatment efficiencies. All of these membrane bioreactors used an activated sludge process in their bioreactors and were equipped with an ultrafiltration membrane, a microfiltration membrane or an extractive membrane in their membrane units. They have been developed for the purposes of nitrogen removal, organic pollutants removal, or degradation of priority toxic substances. The membrane bioreactors had higher removal efficiencies, for example, a COD removal of up to 80%–90% and a  $\text{NH}_3\text{-N}$  removal of over 98%. There was a lower turbidity in their effluents which are thus suitable for reuse. It was pointed out that more and more attention has been paid in many countries to the membrane bioreactor as technology for recycling or reusing wastewater as a secondary resource.

**Key words:** bioreactor, membrane technology, water treatment, wastewater treatment.

**Study on Metals Behavior in Marine Salt Marsh Environments.** Fan Zhijie et al. (Institute of Marine Environ. Protection, SOA, Dalian 116023): *Chin. J. Environ. Sci.*, **16**(5), 1995, pp. 82–86

The behaviors of metals and their affecting chemical/physical factors, including salt marsh area classifications, metal mobility, and the relationship between salt marsh plants and metals in the marine salt marsh environments, have been discussed in some details. The study has also shown that some salt plants in an early growth stage may be damaged by higher concentration of metals. Those plants can therefore be used as biomonitor for the environmental condition.

**Key words:** marine salt marsh, salt marsh plant, metal contamination, bioindicator.