APPLICATION OF NUCLEAR ANALYSIS TECHNIQUES IN STUDY OF ENVIRONMENTAL POLLUTION IN THE VICINITY OF SHANGHAI

Li Minqian (李民乾), Zhang Yongping (张勇平), Tong Yongpeng (童永彭), Xu Yaoliang (徐耀良), Sheng Kanglong (盛康龙) and Rui Jingyi (芮静宜)

(Institute of Nuclear Research, Academia Sinica, Shanghai 201800, China)

(Received June 1992)

ABSTRACT

Aerosol samples were collected from three typical areas during three years: 1) north suburb of Shanghai city (NSSC); 2) north part of Shanghai city; 3) a lead-zinc smeltery and its surrounding areas. The hair samples were collected from lead-exposed workers and control people. Aerosol samples have been analyzed by PIXE, and hair samples by EDXRF (energy-dispersive X-ray fluorescence) method. S, Cl, K, Ca, Mn, Fe, Cu, Zn, Pb *etc* were detected in most of the aerosol and hair samples. According to the analytical results, the compositions of NSSC aerosol samples were quite similar to those from north part of Shanghai city, both the lead concentrations of these samples were less than the limit of the National Standard (70 $\mu g/m^3$); There was serious air pollution in smeltery and its surrounding areas. Especially, the lead concentration in the aerosol exceeded 200 $\mu g/m^3$; The average lead concentration of hair samples for half-year exposed group was about 3-fold higher than that of unexposed group.

Keywords: PIXE Trace metals Aerosol Hair

1 INTRODUCTION

Environmental protection has become a problem of major concern in most parts of the world today. Like what has happened to many industrialized countries, a great challenge of protecting the air, the lands and the waters from industrial pollutants is now faced to China, as she is speeding up her economic developments. The situation is even more serious in some of China's industrial centres, such as Shanghai and the neighbouring cities, i.e. the Shanghai Economic Zone.

Elevated level of the body results in inhibition of porphobilinogen synthase, which causes neurologic damage in Pb exposed individuals and contributes to the anemia associated with Pb poisoning. As most industrial cities and some lead smeltery areas have high levels of Pb, which, once introduced into the biosphere, is a permanent nonbiodegradable toxin[1]. This paper is based on our previous work of PIXE analysis[2-5].

2 EXPERIMENTAL

The area chosen for working and environmental monitoring is a hilly area named Guichi, 400 km northwest to Shanghai. The typical contaminated area is the Guichi Lead-Zinc Smeltery. The sites chosen for comparing are the south surrounding area of the factory and Qinfeng town (500 m southwest to Guichi smeltery). The north section of Shanghai is quite typical in terms of urban atmospheric contamination. Our Institute located in Jiading county was chosen as a typical suburb area of Shanghai.

In order to search for the possible biological indicator of environmental pollution, we collect the hair from exposed workers of the lead-zinc smeltery and the control people, who were unexposed, living in same place and with same ages (20–35 years old). These exposed workers were undergone a half-year working period.

Eighty five aerosol samples were collected in aeras at different seasons of the whole year. Stacked filter samplers (BSD-0.5, made in China) were used. The aerosol sampler is configured with two nucleopore filters in series, the first is 30 mm in diameter and 5 microns of pore size, the second is correspondingly 10 mm and 0.45 microns. The samplers were deployed at a height of about 10 m above the ground level, except collections inside the workshops, in which the samplers were placed at about 1.5 m above the floor. An integrated volume meter was connected to the sampler. The collecting rate and time varied from 1 to 10 l/min and 1 to 10 h, respectively, depending on the cleanness of the air at the sampling sites. The samples were kept in lucite capsules before PIXE analysis. Only the fine particulates (on the second filter) were analyzed using an improved PIXE analysis system on a 4 MeV Van de Graaff Accelerator. A 3.1 MeV proton beam was collimated to a spot of 6 mm diameter with a current of 10–20 nA. The target chamber was maintained in low vacuums (0.001 to 0.0001 torr) to avoid charge accumulation effect. PIXE spectra were obtained in a nuclear data system (ND-76) and treated in a micro VAX-II computer. Elemental compositions of the samples were determined by comparing the spectra with those derived from a set of standard samples (micro matter films) bombarding with the same conditions. S, Cl, K, Ca, Mn, Fe, Cu, Zn and Pb were determined in most of these aerosol samples, but Br can only be detected in aerosol samples of Shanghai city.

The scalp hair was prepared by following proccess. The hair was soaked in "White Cat" detergent solution for 20 min, washed by distilled water, and then washed three times with acetone. The hair was dried at room temperature for 24 h. The weight of each was about 300 mg. All samples were burnt to ashes in air oven at 300 °C for 2 h and at 600 °C for 4 h. The hair ash was dissolved by 100 μl 6 mol/l HNO_3-$Y(NO_3)_3$ (2 mgY/ml). The solution was piped onto a target for EDXRF analysis. The standard was NIES No.5 Hair Standard Reference Material.

3 RESULTS AND DISCUSSION

Average concentrations of the aerosol contents are listed in table 1. We have mentioned above that the atmospheric environment of suburb area (SINR) should be a representative of a non-contaminated area[5], but now it can be seen that the compositions of SINR's samples are quite similar to those of north part of Shanghai city. The reasons might be: a. The environmental condition has been getting improved in Shanghai since 1989; b. Meanwhile, two small metal-material factories had been built within near area (1 km from SINR) that made the atmosphere getting worse in the past two years. Anywhere, the lead contents of these aerosol samples are still less than the limitation (0.7 $\mu g/m^3$ from national standard). Results in table 1 show that there is serious air pollution in smeltery and its surrounding areas. Especially, the lead concentration here is much higher than the limitation. The worst one is at the workshops in which the average Pb contents exceed 200 $\mu g/m^3$, and Zn became close to 32 $\mu g/m^3$. At the near area (Qinfeng village) of the smeltery, the atmosphere heavy metal pollution is getting improved because of short of pro-material for smelting.

Table 1

Average concentrations (ng / m^3) of elements in aerosol samples in the year of 1989, 1990 and 1991

	S	Cl	K	Ca	Mn	Fe	Cu	Zn	Pb
(1)	6.6×10^5	2.6×10^4	1.5×10^3	1.0×10^4	4.1×10^1	2.0×10^3	2.6×10^2	3.2×10^4	2.1×10^5
(2)	1.2×10^4	1.3×10^3	4.2×10^3	4.1×10^3	6.8×10^1	3.7×10^3	2.5×10^1	8.2×10^2	8.4×10^2
(3) (89)	1.7×10^4	8.0×10^2	6.0×10^3	1.4×10^4	4.2×10^1	2.8×10^3	3.0×10^1	9.8×10^2	1.1×10^3
(90)	5.4×10^3	3.1×10^3	1.3×10^3	1.3×10^3	1.0×10^1	3.2×10^2	1.5×10^1	2.0×10^2	4.9×10^2
(91)	5.0×10^3	2.0×10^3	2.3×10^2	2.5×10^2	6.0×10^0	9.6×10^1	5.0×10^0	1.1×10^2	3.0×10^2
(4) (90)	5.5×10^3	2.4×10^3	3.6×10^3	1.4×10^3	6.2×10^1	6.5×10^2	2.1×10^1	3.3×10^2	1.7×10^2
(91)	1.1×10^4	3.2×10^3	4.7×10^2	3.0×10^2	3.9×10^1	5.0×10^2	1.4×10^1	2.9×10^2	1.4×10^2
(5) (89)	2.0×10^3	2.4×10^2	1.3×10^3	7.0×10^2	1.3×10^1	6.0×10^2	1.4×10^1	1.1×10^2	1.3×10^2
(90)	4.6×10^3	2.0×10^3	2.7×10^3	9.2×10^2	6.0×10^1	4.7×10^2	2.0×10^1	3.5×10^2	1.4×10^2
(91)	8.0×10^3	3.3×10^3	4.4×10^2	5.2×10^2	2.8×10^1	3.8×10^2	1.1×10^1	1.9×10^2	7.9×10^1

(1)— Average values of the two workshops of Guichi Smeltery; (2)— Open places of the factory; (3)— Qinfeng Village; (4)— Shanghai city; (5)— Shanghai suburb; (89), (90), (91)— Average values of the whole year in 1989, 1990 and 1991 respectively.

The hair samples from exposed workers ($n=65$) and control people ($n=55$) have been analyzed by EDXRF method[6]. Comparing with the Chinese hair standard[7], the elemental concentrations of the scalp hair samples were listed in Table 2. The lead concentrations of exposed and unexposed worker groups are shown in table 3 and table 4. As expected, the average Pb concentration of hair samples for half-year exposed group was about 3-fold higher than that of unexposed one. There is a

significant difference between them. Meanwhile, there is also a significant difference between Qinfeng people, who live near the factory, and Shanghai citizens. The Pb concentration of hair might be a biological response of lead environmental pollution.

Table 2

Elemental concentrations of hair sampls in ppm (dry weight) ± S.D. of the average value

Group		Pb	Zn	Fe	Ca
Exposed workers	Average	331.2	139.6	22.3	953.8
(n = 65)	S.D.	42.0	3.4	1.2	72.5
Control people	Average	96.8	136.9	30.1	707.4
(n = 55)	S.D.	14.0	3.9	2.1	37.7
Chinese hair reference	Average	7.2	189	71.2	1090
material[7]	S.D.	0.7	8	6.6	72

Table 3

Lead concentration of hair in exposed and un-exposed workers (μg / g dry weight)

	Group 1	Group 2	Group 3	Group 4
Number	17	21	9	17
Range of concen.	64—677	76—840	8—176	3—42
Mean ± S.D.	229 ± 42	279 ± 37	58 ± 18	16 ± 3

Table 4

Test significant differences

P value	Group 1	Group 2	Group 3
Group 2	>0.05	—	<0.01
Group 3	<0.01	<0.01	—
Group 4	<0.001	<0.001	<0.05

P values calculated using student's *t*-test

Group 1: Exposed, more than 2 year; Group 2: Exposed, less than 1 year; Group 3: In the factory area (un-exposed Qinfeng people); Group 4: In the town (Shanghai citizens)

REFERENCES

1 Jaffe E K, Bagla S, Michini P A. Biol Trace Element Res, 1991; 28:223

2 Li Minqian, Sheng Kanglong, Chin Pokang. Nucl Instr Meth Phys Res, 1981; 181:37

3 Tong Yongpeng, Li Minqian, Zhang Yongping *et al.* Biol Trace Element Res, 1991; 29:31

4 Li Minqian, Zhu Jingde, Zhu Jieqing *et al.* Nucl Instr Meth Phys Res, 1991; B54:156

5 Li Minqian, Tong Yongpeng, Zhang Yongping *et al.* "The first progress report of the second research co-ordination IAEA meeting in Jakarta", No.RB/58 20-24, Nov. 1989, Jakarta, Indonesia

6 Qin Junfa, Wang Yongxian, Xu Yiaoliang *et al.* Environmental Sciences of China, 1990; 7(2):15

7 Cheng Yuandi, Wang Xuepeng, Qian Yinge *et al.* Nucl Sci Techniq, 1993, 4(1):56.