

## Activity level of gross $\alpha$ and gross $\beta$ in airborne aerosol samples around the Qinshan NPP

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**Abstract** The monitoring results of gross  $\alpha$  and gross  $\beta$  activity from 2001 to 2005 for environmental airborne aerosol samples around the Qinshan NPP base are presented in this paper. A total of 170 aerosol samples were collected from monitoring sites of Caichenmen village, Qinlian village, Xiajiawan village and Yangliucun village around the Qinshan NPP base. The measured specific activity of gross  $\alpha$  and gross  $\beta$  are in the range of 0.02~0.38 mBq/m<sup>3</sup> and 0.10~1.81 mBq/m<sup>3</sup>, respectively, with an average of 0.11 mBq/m<sup>3</sup> and 0.45mBq/m<sup>3</sup>, respectively. They are lower than the average of 0.15 mBq/m<sup>3</sup> and 0.52mBq/m<sup>3</sup>, of reference site at Hangzhou City. It is indicated that the specific activity of gross  $\alpha$  and gross  $\beta$  for environmental aerosol samples around the Qinshan NPP base had not been increased in normal operating conditions of the NPP.

**Key words** Environmental radioactivity, Aerosol, Gross  $\alpha$ , Gross  $\beta$ , Qinshan NPP

**CLC numbers** TM623.8, X831

### 1 Introduction

According to relevant environmental protection law in China and regulations of the State Environmental Protection Administration and Environmental Protection Bureau of Zhejiang Province, radiations in the environment around the Qinshan Nuclear Power Plant (NPP) have been monitored by Zhejiang Province Environmental Radiation Monitoring Center (ZERMC).

Through the environmental monitoring, a large collection of data about activity of radionuclides and ambient radiation level around the Qinshan NPP has accumulated. By combining the data with the results of effluent discharge monitored routinely by the NPP, we are able to validate and evaluate the operation safety and waste discharge management level of the Qinshan NPP and the impact of its accidental discharge on the environment.

In the normal operation of the NPP, specific activities of gross  $\beta$  and gross  $\alpha$  are in a stable range. In case of an accident, however, some nuclear fission

products from the reactor may emit into the atmosphere. A sharp increase of the radioactivity in aerosol samples around the NPP gives an accurate judgement of the accident.

Specific activities of gross  $\beta$  and gross  $\alpha$  in environmental aerosol samples around the Qinshan NPP have been monitored by ZERMC since April 2001. The monitoring results from 2001 to 2005 are evaluated in this paper.

### 2 Monitoring method

#### 2.1 Distribution of sampling sites

The Qinshan NPP is located about 8 km in the southeast of Wuyuan town, Haiyan County, Zhejiang Province, on the north coast of the Hangzhou Bay (Fig.1). The aerosol monitoring sites are at Caichenmen, Xiajiawan and Yangliucun, which are villages in the north or west to the NPP within a 5-km radius. Meanwhile, a reference site was established in the Hangzhou City, about 90 km from Qinshan. The

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Caichenmen site was replaced by Qinlian in 2003 according to monitoring requirement.

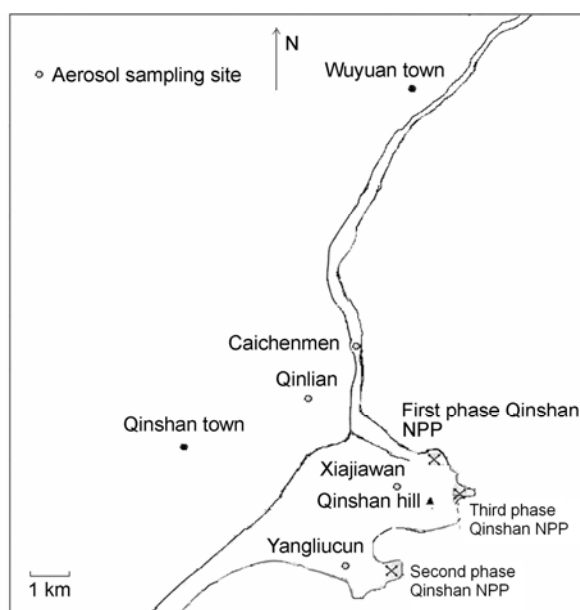


Fig.1 Distribution of aerosol sampling spots.

## 2.2 Measuring instrument and sampling

The aerosol samples are collected with a large flux aerosol sampler manufactured by Wuhan Tianhong Intellectual Meter Corp. A monthly aerosol sample of about 11000 m<sup>3</sup> in air volume can be collected in 7~8 days at a sampling rate of 1 m<sup>3</sup>/min.

According to Ref.[1], the aerosol samples were incinerated at 350°C in a muffle furnace, and gross  $\beta$  and gross  $\alpha$  activities of the weighed ashes, in a  $\Phi 20$ mm stainless steel sample tray, [2,3] were measured by a low background  $\alpha$  &  $\beta$  counter (LB4100 or MPC9604).

## 3 Measuring result and analysis

Specific activities of gross  $\beta$  and gross  $\alpha$  for aerosol samples collected in 2001~2005 from the four monitoring sites around the Qinshan NPP and the reference site in Hangzhou are listed in Table 1 and Table 2 respectively.

### 3.1 Gross $\alpha$

As shown in Table 1, the specific activities of gross  $\alpha$  of aerosol samples collected at the monitoring sites in 2001~2005 are in the range of 0.02~0.38 mBq/m<sup>3</sup>. The average specific activity of gross  $\alpha$  of the aerosol samples of Caichenmen, Qinlian, Xiajiawan and Yangliucun is 0.10, 0.10, 0.13 and 0.11 mBq/m<sup>3</sup>, respectively, with a total average of 0.11 mBq/m<sup>3</sup>, which is lower than that of the reference site (0.15 mBq/m<sup>3</sup>).

Table 1 Specific activity (in mBq/m<sup>3</sup>) of gross  $\alpha$  in aerosol samples around Qinshan NPP and the reference site in 2001~2005<sup>1</sup>

The sites <sup>2</sup>	Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
CCM	2001	—	—	—	0.02	0.10	0.12	0.14	0.17	0.17	0.09	0.09	0.11	0.11
	2002	0.19	0.21	0.10	0.10	0.05	0.12	0.04	0.07	0.06	0.04	0.06	0.07	0.09
	Average	0.19	0.21	0.10	0.06	0.08	0.12	0.09	0.12	0.12	0.06	0.08	0.09	0.10
QL	2003	0.13	0.03	0.08	0.09	0.05	0.05	0.05	0.04	0.09	0.14	0.06	0.11	0.08
	2004	0.13	0.21	0.18	0.07	0.06	0.09	0.09	0.07	0.03	0.09	0.13	0.11	0.11
	2005	0.09	0.03	0.09	0.16	0.06	0.03	0.29	0.09	0.17	0.10	0.08	0.27	0.12
	Average	0.12	0.09	0.12	0.11	0.06	0.06	0.14	0.07	0.10	0.11	0.09	0.16	0.10
XJW	2001	—	—	—	0.10	—	0.05	0.09	0.22	0.25	0.15	0.23	0.21	0.16
	2002	0.22	0.20	0.18	0.16	0.06	0.06	0.11	0.12	0.11	0.08	0.11	0.09	0.13
	2003	0.15	0.07	0.03	0.07	0.03	0.08	0.05	0.03	0.10	0.20	0.15	0.10	0.09
	2004	0.34	0.38	0.27	0.09	0.08	0.10	0.17	0.10	0.04	0.17	0.11	0.11	0.16
	2005	0.13	0.04	0.13	0.14	0.03	0.04	0.15	0.16	0.11	0.11	0.17	0.20	0.12
	Average	0.21	0.17	0.15	0.11	0.05	0.07	0.11	0.13	0.12	0.14	0.15	0.14	0.13

1. To be continued in next page

2. CCM: Caichenmen, QL: Qinlian, XJW: Xiajiawan

Table 1 (continued)

The sites <sup>1</sup>	Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
YLC	2001	—	—	—	0.08	0.15	0.06	0.08	0.12	0.19	0.21	0.25	0.15	0.14
	2002	0.13	0.20	0.30	0.18	0.09	0.06	0.08	0.05	0.07	0.04	0.08	0.05	0.11
	2003	0.11	0.07	0.03	0.08	0.05	0.06	0.06	0.03	0.08	0.12	0.13	0.11	0.08
	2004	0.21	0.21	0.20	0.09	0.05	0.07	0.14	0.09	0.07	0.13	0.09	0.09	0.12
	2005	0.09	0.03	0.11	0.15	0.09	0.15	0.13	0.13	0.26	0.08	0.06	0.21	0.12
	Average	0.14	0.13	0.16	0.12	0.09	0.08	0.10	0.08	0.13	0.12	0.12	0.12	0.11
RS	2001	—	—	—	0.20	0.17	0.08	0.19	0.28	0.19	0.31	0.04	0.10	0.17
	2002	0.11	0.30	0.17	0.16	0.07	0.08	0.10	0.10	0.24	0.08	0.11	0.05	0.13
	2003	0.16	0.21	0.06	0.17	0.19	0.12	0.08	0.07	0.09	0.13	0.14	0.11	0.13
	2004	0.24	0.24	0.24	0.12	—	0.11	0.12	0.16	0.13	0.18	0.11	0.15	0.16
	2005	0.10	0.08	0.11	0.17	0.08	0.05	0.16	0.13	0.31	0.24	0.32	0.24	0.17
	Average	0.15	0.21	0.14	0.16	0.13	0.09	0.13	0.15	0.19	0.19	0.14	0.13	0.15

1. YLC: Yangliucun, RS: the reference site

**Table 2** Specific activity (mBq/m<sup>3</sup>) of gross  $\beta$  in aerosol samples around the Qinshan NPP and the reference site in 2001~2005

The sites <sup>1</sup>	Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
CCM	2001	—	—	—	0.11	0.54	0.44	0.68	0.50	0.62	0.49	0.56	0.59	0.50
	2002	1.06	0.99	0.84	0.37	0.30	0.20	0.18	0.26	0.40	0.34	0.56	0.57	0.51
	Average	1.06	0.99	0.84	0.24	0.42	0.32	0.43	0.38	0.51	0.42	0.56	0.58	0.50
QL	2003	0.84	0.17	0.45	0.36	0.20	0.25	0.12	0.18	0.39	0.54	0.30	0.74	0.38
	2004	0.46	0.46	0.43	0.26	0.30	0.54	0.28	0.18	0.19	0.38	0.32	0.28	0.34
	2005	0.29	0.14	0.17	0.36	0.14	0.14	0.53	0.14	0.65	0.34	0.28	0.50	0.31
	Average	0.53	0.26	0.35	0.33	0.21	0.31	0.31	0.17	0.41	0.42	0.30	0.51	0.34
XJW	2001	—	—	—	0.54	—	0.14	0.24	0.83	0.78	0.78	0.87	1.02	0.65
	2002	1.81	1.00	0.90	0.30	0.37	0.22	0.22	0.54	0.39	0.38	0.74	0.73	0.63
	2003	1.19	0.49	0.28	0.28	0.17	0.45	0.14	0.18	0.32	0.88	0.54	0.61	0.46
	2004	0.90	0.88	0.65	0.57	0.37	0.62	0.38	0.40	0.12	0.56	0.36	0.32	0.51
	2005	0.33	0.17	0.32	0.33	0.15	0.11	0.23	0.20	0.57	0.36	0.66	0.55	0.33
	Average	1.1	0.64	0.54	0.40	0.26	0.31	0.24	0.43	0.44	0.59	0.63	0.65	0.52
YLC	2001	—	—	—	0.49	0.89	0.44	0.20	0.42	0.25	0.52	0.84	0.76	0.53
	2002	1.18	1.00	0.78	0.46	0.27	0.15	0.36	0.23	0.50	0.41	0.58	0.33	0.52
	2003	0.72	0.32	0.22	0.32	0.18	0.27	0.21	0.22	0.48	0.83	0.78	0.68	0.44
	2004	1.17	0.56	0.42	0.39	0.34	0.32	0.30	0.22	0.28	0.37	0.20	0.28	0.40
	2005	0.23	0.10	0.20	0.38	0.17	0.31	0.20	0.33	0.55	0.34	0.28	0.52	0.30
	Average	0.83	0.50	0.40	0.41	0.37	0.30	0.25	0.28	0.41	0.49	0.54	0.51	0.44
RS	2001	—	—	—	0.83	1.39	0.44	0.67	0.92	0.54	0.74	0.23	0.50	0.70
	2002	0.53	1.68	1.12	0.44	0.21	0.39	0.54	0.27	0.77	0.48	0.63	0.48	0.63
	2003	0.65	0.49	0.25	0.61	0.50	0.52	0.22	0.28	0.27	0.79	0.79	0.62	0.50
	2004	0.42	0.49	0.49	0.50	—	0.61	0.17	0.29	0.22	0.41	0.29	0.40	0.39
	2005	0.23	0.34	0.22	0.37	0.17	0.22	0.22	0.21	0.52	0.48	0.73	0.57	0.36
	Average	0.46	0.75	0.52	0.55	0.57	0.44	0.36	0.39	0.46	0.58	0.53	0.51	0.52

1. CCM: Caichenmen, QL: Qinlian, XJW: Xiajiawan, YLC: Yangliucun, RS: the reference site

### 3.2 Gross $\beta$

As shown in Table 2, the specific activities of gross  $\beta$  of aerosol samples collected at the monitoring sites in 2001~2005 are in the range of 0.10-1.81 mBq/m<sup>3</sup>. The average specific activity of gross  $\beta$  of the aerosol samples of Caichenmen, Qinlian, Xiajiawan and Yangliucun are 0.50, 0.34, 0.52 and 0.44 mBq/m<sup>3</sup>, respectively, with a total average of 0.45 mBq/m<sup>3</sup>, which is lower than that of the reference site (0.52 mBq/m<sup>3</sup>).

### 3.3 Yearly specific activity

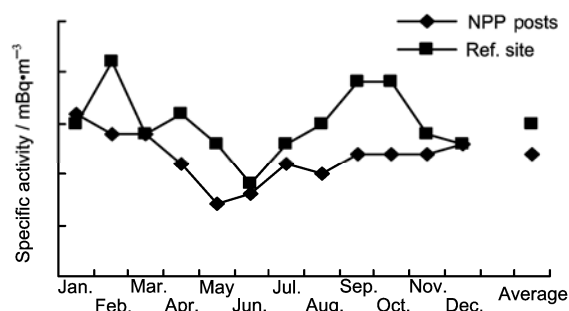
As shown in Table 3, the annual average of specific activities of gross  $\alpha$  in aerosol samples collected from the four monitoring sites around the NPP are 0.14, 0.11, 0.08, 0.13 and 0.12 mBq/m<sup>3</sup> in 2001~2005, respectively. And the annual averages of gross  $\beta$  are 0.56, 0.55, 0.43, 0.42 and 0.31 mBq/m<sup>3</sup> in 2001~2005, respectively. These show a descending trend year by year. Variation trend of gross  $\alpha$  and gross  $\beta$  in aerosol samples from the reference site is similar to the monitoring sites around the NPP.

**Table 3** Annual average specific activity (in mBq/m<sup>3</sup>) of gross  $\alpha$  and gross  $\beta$  in aerosol samples collected around the Qinshan NPP and the reference site in 2001~2005

The sites	Gross $\alpha$					Gross $\beta$				
	2001	2002	2003	2004	2005	2001	2002	2003	2004	2005
CCM & QL	0.11	0.09	0.08	0.11	0.12	0.50	0.51	0.38	0.34	0.31
XJW	0.16	0.13	0.09	0.16	0.12	0.65	0.63	0.46	0.51	0.33
YLC	0.14	0.11	0.08	0.12	0.12	0.53	0.52	0.44	0.40	0.30
Average	0.14	0.11	0.08	0.13	0.12	0.56	0.55	0.43	0.42	0.31
RS	0.17	0.13	0.13	0.16	0.17	0.70	0.63	0.50	0.39	0.36

### 3.4 Monthly and seasonal change

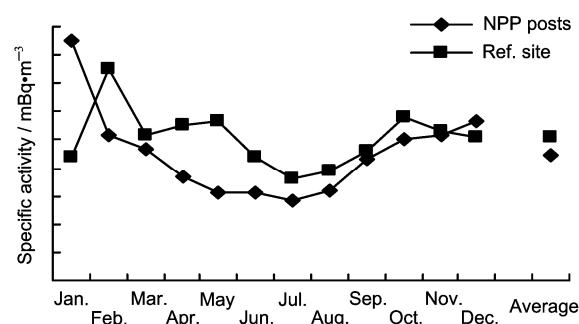
The monthly average specific activity change trend of gross  $\alpha$  and gross  $\beta$  for aerosol samples from the four monitoring sites around the Qinshan NPP and the reference site are shown in Fig.2 and Fig.3.



**Fig.2** Monthly change of gross  $\alpha$  for aerosol samples from Qinshan NPP and the reference site in 2001-2005.

As is shown in Fig.2 and Fig.3, monthly change trend of the monitoring sites around the Qinshan NPP and the reference site in Hangzhou are similar.

From the data above, the seasonal average of the gross  $\alpha$  specific activity in the aerosol samples of spring, summer, autumn and winter are 0.15, 0.09,

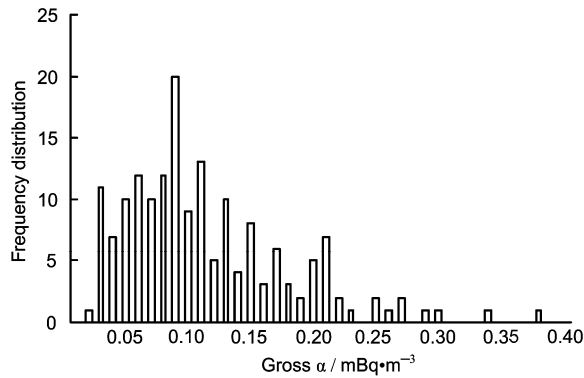


**Fig.3** Monthly change of gross  $\beta$  for aerosol samples from Qinshan NPP and the reference site in 2001-2005.

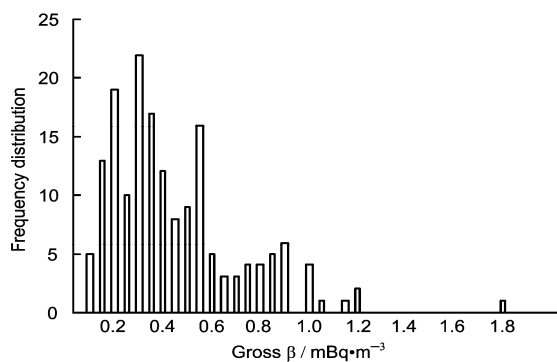
0.11 and 0.12 mBq/m<sup>3</sup>, respectively, while the gross  $\beta$  are 0.61, 0.33, 0.34 and 0.53 mBq/m<sup>3</sup>, respectively. The highest radioactivities were observed in spring, which are 67% and 85% higher than those in summer, respectively.

### 3.5 Frequency distribution

Frequency distribution of specific activities of gross  $\alpha$  and gross  $\beta$  in the 170 aerosol samples collected around the Qinshan NPP and in Hangzhou are shown as a Poisson distribution of Fig.4 and Fig.5.



**Fig.4** Frequency distribution of specific activity of aerosol gross  $\alpha$ .



**Fig.5** Frequency distribution of specific activity of aerosol gross  $\beta$ .

## 4 Conclusion

In 2001~2005, the average specific activities of gross  $\alpha$  and gross  $\beta$  from 170 aerosol samples collected from the four monitoring sites within 5 km radius of the Qinshan NPP are 0.11 mBq/m<sup>3</sup> and 0.45 mBq/m<sup>3</sup>, respectively, which are lower than those of the reference site. It indicates that the specific activity of gross  $\alpha$  and gross  $\beta$  for aerosol samples had not been increased in the external environment of the Qinshan NPP.

## Acknowledgement

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