

Gamma radiation levels in the ambient environment of the QNPP Base

WENG Jianqing HE Jun XIANG Yuanyi* WANG Kan LI Xia HAN Zhengdong

(Zhejiang Province Environmental Radiation Monitoring Center, Hangzhou 310012, China)

Abstract Monitoring results of gamma dose rate level in 1992~2004 in the ambient environment of the Qinshan Nuclear Power Plants (QNPP) Base, the northeast of Zhejiang Province, are reported in this paper. It is shown that the gamma dose rate of five monitoring sites of 2.5 km to QNPP Base is 84~113 nGy/h, with an average of 96 nGy/h in the 13 years. The average value is close to the background level of 93 nGy/h prior to operation of the QNPP Base, and is lower than the monitoring result of 101 nGy/h at the reference site in Hangzhou City. Within 50 km from the QNPP Base, the cumulative dose rate of the thermoluminescent dosimeter (TLD) is 90 nGy/h, which is lower than the background level of 111 nGy/h.

Key words Gamma dose rate, Environmental radiation monitoring, Qinshan NPP, HPIC, TLD

CLC numbers X837, TM623.8

1 Introduction

With development of the nuclear power industry in China, the State Environmental Protection Administration of China (SEPA) has established a nationwide network on environmental radiation monitoring. The centers or institutes for environmental radiation monitoring of each province undertake the mission of regional supervising and monitoring pollution sources of ionizing radiation and electromagnetic radiation, especially base of nuclear power plants (NPP), which is a major concern of the government and the public. Since 1992, Zhejiang Province Environmental Radiation Monitoring Center (ZERMC) has been supervising and monitoring ambient environment of the Qinshan Nuclear Power Plants (QNPP) Base. Monitoring the radiation level and radionuclide contents in ambient environment of QNPP provides a better understanding of environmental radiation level and accumulation of man-made radionuclides. According to discharge data and monitoring results about radioactive effluents of QNPP under normal operation, the control of pollutant emission and the situation of safety operation can be verified and assessed, and influence on the ambient

environment due to accidental emission of QNPP can be evaluated. Therefore, useful regulatory references can be provided for administration bodies of environmental protection.

Referring to “Annual Report of Environmental Radiation Quality of Ambient Environment around the QNPP Base” released by ZERMC and the present monitoring data, analysis results and trends of the gamma dose rate and contents of special radionuclides in aerosol, fallout, water, soil and organic samples are presented in this paper. The γ -ray radiation levels in ambient environment around the QNPP in 1992~2004 are presented.

2 Monitoring methods

2.1 Geographical location

The QNPP Base is located near the Qinshan Hill on the north coast of Hangzhou Bay. Eight km in its southeast is the Wuyuan Town, Haiyan County, Zhejiang Province. The base is in 90, 30 and 80 km from the cities of Shanghai, Jiaxing and Hangzhou, respectively. The Phase I, II and III NPPs are located at the north, south and east of the Qinshan Hill, re-

* E-mail: xyy@rmte.org.cn

Received date: 2007-03-07

spectively.

2.2 Distribution of monitoring sites

Since 1992, automatic real-time monitoring systems of high pressure ionization chamber (HPIC) have been measuring gamma dose rate at five sites within 2.5 km to QNPP, i.e. top of Qinshan Hill, Qianyanzhan Station, Primary School of Qinshan Town, Qinlian Village and Caichenmen Village. In 2003, when the Phase II and III NPPs were built, the monitoring sites at Wuyuan Town, Yangliucun East Village, Yangliucun Village, Geshan, Xiajiawan Village, Datacenter of Qinshan Town (abbreviated as the Qinshan Town) and the Dock of Phase II NPP (abbreviated as the Dock) (Fig.1) were established. Therefore, the environmental monitoring span has been extended to 10 km to QNPP since then. Meanwhile, a reference site was chosen in Hangzhou City. In this paper, monitoring results from 1992 to 2004 at the five sites of the hill top of Qinshan, Qianyanzhan Station, Primary School of Qinshan Town, Qinlian Village and Caichenmen Village are discussed.

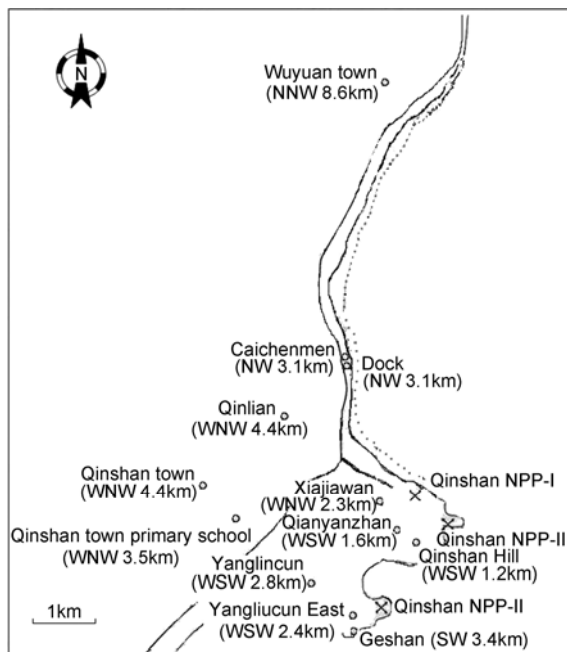


Fig.1 Monitoring sites of gamma radiation level in the external environment around QNPP Base (both direction and distance marked are relative to Qinshan NPP-III).

In addition, in an area of 50 km to QNPP, there were up to about 80 monitoring sites for measuring the cumulative gamma radiation dose with thermoluminescent dosimeter (TLD). In 2005, the site number

was reduced to 25 in optimizing the site distribution. And TLDs have been read every 90 days since then.

2.3 Measurement instruments

The automatic real-time monitoring system mainly consists of a RSS-131HPIC detector (General Electric), a data acquisition system and a data transmission system. The HPIC detector in $\Phi 250\text{mm} \times 3\text{mm}$ is pressurized with highly purified argon gas of 2.53×10^6 Pa (25 atm). They are installed in top floor of the barrack at each monitoring site, about 3 meters above the ground.

The instruments to read the thermoluminescent dosimeters are TLD 4000 (Harshaw Corp.). The TLDs are made of $\text{LiF}(\text{Mg, Cu, P})$ in $\Phi 4.5\text{mm} \times 0.8\text{mm}$ (Chinese Research Institute of Chemical Defense).

3 Monitoring results and analysis

3.1 Gamma radiation dose rate

3.1.1 Average level of monitoring sites

The gamma radiation dose rates (including response value of cosmic rays) from the five monitoring sites and the reference site at Hangzhou City in 1992~2004 are shown in Table 1~Table 6.

As what is shown in the tables, the annual average gamma dose rate at the hill top of Qinshan, Qianyanzhan Station (including Xiajiawan), Primary School of Qinshan Town (including Datacenter of Qinshan Town), Qinlian Village and Caichenmen Village (including Dock of Phase II NPP), is in a range of 84~113 nGy/h, with a mean value of 96 nGy/h, less than the mean value of 101 nGy/h from the reference site, but close to the average background value of 93 nGy/h from the five sites before QNPP operation. It indicates that the environmental gamma dose rate in the ambient environment around the QNPP Base has no distinctive increase and remains the background level after 13-year operation.

3.1.2 Annual average level

Table 7 shows the annual average values of the gamma dose rate at the five sites outside QNPP. It can be seen that the mean value of the gamma dose rate among the five sites in the 13 years is 96 nGy/h, close to the average background value of 93 nGy/h before QNPP operation. The maximum values of the top of

Qinshan Hill and the Qianyanzhan Station, which are at the center of the Phase I, II and III NPPs area, are 113 and 105 nGy/h, respectively. The minimum value of the Caichenmen Village located at the north windward is 82 nGy/h. It indicates that the changes of the annual mean value at the five monitoring sites are in the normal fluctuation range.

3.1.3 Monthly and quarterly average level

The mean values of month and quarter gamma dose rates at 5 monitoring sites are shown in Table 8

and Table 9.

As shown in Tables 8 and 9, dose rate changes in each month and quarter at the five monitoring sites in 13 years are not remarkably noticed. It is not like that the relation between gross β specific activity and the amount of fallouts collected in each season, *e.g.*, the average value of gross β specific activity of fallouts collected in the first half year is higher than that in the second half year in 1992~2002^[1].

Table 1 The gamma dose rate of the Qinshan Hill top from 1992 to 2004 (nGy/h)¹⁾

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1992	111	111	114	114	114	-	-	-	-	118	118	119	115
1993	118	118	116	118	111	120	120	119	119	117	117	116	117
1994	117	117	116	117	119	121	121	120	119	118	118	119	118
1995	118	117	119	118	119	120	123	122	117	118	118	118	119
1996	118	116	118	117	117	120	117	120	---	111	111	111	116
1997	110	109	110	112	114	116	116	115	112	113	113	111	113
1998	111	110	110	111	113	116	117	119	110	110	113	111	113
1999	110	110	112	112	115	119	118	118	119	115	120	115	115
2000	118	115	114	116	118	113	112	112	113	114	112	114	114
2001	113	114	116	117	117	117	118	117	116	117	116	114	116
2002	109	106	108	109	104	104	103	106	105	105	106	106	106
2003	102	102	102	101	101	102	102	102	102	102	102	102	102
2004	102	102	101	102	103	102	102	102	100	101	102	102	102
Average	112	111	112	113	113	114	114	114	112	112	113	112	113
Background ²⁾ -	-	-	-	-	113	113	114	118	118	114	114	113	115

1) The data in the table were calculated by the averages of everyday, and including response value of cosmic rays; 2) Measured in 1991, prior to operation of QNPP Base.

Table 2 The gamma dose rate of the Qianyanzhan Station from 1992 to 2004 (nGy/h)¹⁾

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1992	110	109	111	109	108	108	110	112	104	109	109	111	109
1993	112	114	115	114	106	115	110	111	112	113	113	120	113
1994	111	107	104	102	100	102	99	97	96	94	-	-	101
1995	-	-	-	97	95	96	90	88	91	96	99	102	95
1996	103	100	101	98	93	93	91	91	93	108	108	109	99
1997	109	107	106	102	100	98	103	96	104	109	114	116	105
1998	116	112	112	108	107	108	105	105	104	106	110	112	109
1999	114	112	113	112	113	117	114	114	115	114	112	113	114
2000	115	113	113	112	114	113	118	118	117	110	108	109	113
2001	106	108	115	116	115	115	112	113	94	97	100	102	108
2002	99	98	98	96	93	95	96	94	96	99	99	98	97
2003	98	99	98	99	99	99	99	99	98	98	98	98	99
2004	99	99	98	100	100	99	99	99	98	98	99	98	99
Average	108	107	107	105	103	104	104	103	102	104	106	107	105
Background -	-	-	-	-	111	108	110	110	111	108	110	111	110

1) The monitoring site of the Qianyanzhan Station was replaced by the Xiajiawan Village since 2005.

Table 3 The gamma dose rate of the Qinshan Town Primary School from 1992 to 2004 (nGy/h)¹⁾

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1992	75	75	77	78	79	76	78	73	74	71	73	74	75
1993	71	72	72	73	72	72	72	70	-	-	-	-	72
1995	-	-	-	-	82	80	77	82	83	87	94	96	85
1996	103	96	98	91	91	88	83	-	-	76	70	70	87
1997	86	84	82	81	82	78	74	79	80	82	87	87	82
1998	88	85	85	82	82	81	76	76	78	76	72	79	80
1999	75	73	75	77	70	72	78	82	78	81	78	79	77
2000	78	77	77	75	76	77	78	77	78	81	84	83	78
2001	76	84	83	82	81	78	72	73	78	82	86	89	80
2002	84	82	82	85	83	79	80	81	83	85	87	85	83
2003	102	103	102	102	103	104	105	106	108	108	104	101	104
2004	102	102	101	102	104	102	104	103	101	104	103	105	103
Average	85	85	85	84	84	82	81	82	84	85	85	86	84
Background	-	-	-	-	87	77	77	71	72	72	71	70	75

1) The monitoring site of the Qinshan Town Primary School was replaced by the Qinshan Town since 2005.

Table 4 The gamma dose rate of the Qinlian Village from 1992 to 2004 (nGy/h)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1992	100	98	102	97	96	96	-	-	93	97	101	102	98
1993	105	101	101	100	98	99	-	-	-	-	-	-	100
1996	-	-	-	-	-	-	113	-	-	-	102	103	106
1997	91	89	90	86	86	87	83	84	87	90	92	93	88
1998	93	89	93	90	97	92	94	92	94	93	94	91	93
1999	85	87	90	84	83	85	84	85	85	86	88	85	86
2000	86	85	85	86	85	84	86	85	87	85	88	91	86
2001	91	91	91	91	90	89	85	88	92	92	95	97	91
2002	99	100	100	99	88	93	92	92	89	95	94	96	95
2003	104	104	104	104	103	104	103	103	102	103	104	104	103
2004	105	105	104	105	106	104	102	103	102	102	104	105	104
Average	96	95	96	94	93	93	94	92	92	94	96	97	94
Background	-	-	-	-	-	93	94	-	91	96	97	-	94

Table 5 The gamma dose rate of the Caichenmen Village from 1997 to 2004 (nGy/h)¹⁾

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1997	95	94	94	81	79	79	78	78	78	80	83	83	84
1998	86	84	84	81	81	88	85	82	78	85	85	84	84
1999	81	82	85	84	81	83	85	84	83	81	80	81	83
2000	83	83	84	84	82	83	82	81	82	80	80	79	82
2001	80	82	83	83	83	76	76	76	84	85	83	90	82
2002	89	79	83	84	84	83	81	82	89	82	83	82	83
2003	90	91	91	91	91	91	91	90	89	90	89	89	90
2004	90	90	90	91	92	91	90	90	92	92	93	92	91

Average	87	86	87	85	84	84	84	83	84	84	85	85	85
Background	-	-	-	-	-	70	71	70	70	68	68	67	69

1) The Dock site has replaced the monitoring site of Caichenmen Village since 2003.

Table 6 The gamma dose rate at the reference site of Hangzhou City from 2002 to 2004 (nGy/h)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
2002	100	100	100	103	102	103	---	---	---	---	---	---	101
2003	103	105	103	101	98	98	97	95	98	99	101	100	100
2004	99	101	101	99	102	100	102	102	101	101	100	102	101
Average	101	102	101	101	101	100	100	99	100	100	101	101	101

Table 7 The annual averages of gamma dose rate of 5 sites outside the QNPP Base from 1992 to 2004 (nGy/h)¹⁾

Sites ¹⁾	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average	BKG
Hill top	115	117	118	119	116	113	113	115	114	116	106	102	102	113	115
Qianyanzhan	109	113	101	95	99	105	109	114	113	108	97	98	99	105	110
School	75	72	-	85	87	82	80	77	78	80	83	104	103	84	75
Qinlian	98	100	-	-	106	88	93	86	86	91	95	103	104	95	94
Caichenmen	-	-	-	-	-	84	84	83	82	82	83	90	91	85	69
Average	99	101	110	100	102	94	96	95	95	95	93	99	100	96	93

1) Hill top: Qinshan Hill top, Qianyanzhan: Qianyanzhan Station, School: Qinshan Town Primary School, Qinlian: Qinlian Village, BKG: background.

Table 8 The monthly averages of gamma dose rate of 5 sites outside the QNPP Base from 1992 to 2004 (nGy/h)

Sites	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Hill top	112	111	112	113	113	114	114	114	112	112	113	112	113
Qianyanzhan	108	107	107	105	103	104	104	103	102	104	106	107	105
School	85	85	85	84	84	82	81	82	84	85	85	86	84
Qinlian	96	95	96	94	93	93	94	92	92	94	96	97	94
Caichenmen	87	86	87	85	84	84	84	83	84	84	85	85	85
Average	98	97	97	96	95	95	95	95	95	96	97	97	96

Table 9 The quarterly averages of gamma dose rate of 5 sites outside the QNPP Base from 1992 to 2004 (nGy/h)

Sites	Results of 5 sites				
	The first quarter	The second quarter	The third quarter	The fourth quarter	Average
Hill top	112	113	114	112	113
Qianyanzhan	107	104	103	106	105
School	85	83	82	85	84
Qinlian	96	93	93	96	95
Caichenmen	87	84	84	85	85
Average	97	95	95	97	96

3.2 Gamma cumulative dose rate

In 1992~2004, the results of the gamma cumulative dose rate (including contribution of cosmic rays) within the area of 50 km outside QNPP are listed in Table 10.

As shown in Table 10, the average value of the

gamma cumulative dose rate within 50 km to QNPP is 90 nGy/h. This is slightly less than the background value (111 nGy/h) before the operation of QNPP, within the range of normal data fluctuation^[2]. Compared to the background survey on the QNPP Base, it

is interpreted that there were many factors for the reduced background radiation, such as the number and the location of the monitoring sites were adjusted, the measuring equipment was renewed, the surveyors

were changed and a new calibration method was invented in the 13 years, etc.

Table 10 The cumulative dose rate monitored by TLD within 50 km outside the QNPP Base in 1992~2004 (nGy/h)¹⁾

Year	Number of samples	Range	Average	Standard deviation
1992	50	75~126	95	11
1993	56	78~107	90	7
1994	56	75~140	94	12
1995	70	59~150	97	11
1996	70	74~110	89	6
1997	70	76~111	90	7
1998	70	71~116	91	6
1999	70	76~118	91	8
2000	70	75~115	88	8
2001	80	68~115	91	9
2002	80	62~128	89	9
2003	25	69~107	82	7
2004	25	67~119	87	8
Total	---	59~150	90	4
Background	33	59~150	111	11

1) The measuring values in the Table include contribution of cosmic rays.

4 Conclusion

The average value of environmental gamma dose rate in the environment around the QNPP Base in 1992~2004 measured by HPIC real-time monitoring system within 2.5 km from QNPP is 96 nGy/h. The averages gamma cumulative dose rate within 50 km to the Base in 1992~2004 given by TLD dosimeter is 90 nGy/h. According to these monitoring results in 1992~2004, the gamma dose rate is at the same level as the data of background survey before QNPP's operation and the results of the reference site in Hangzhou. Consequently, the gamma dose rate in the environment around the QNPP Base is in the normal level under the conditions of normal operation of the reactors, and

remarkable increase is not observed.

Acknowledgement

We would like to express gratitude to co-workers for their hard work of the data monitoring, data analysis and processing, data arrangement of environmental gamma dose rate.

References

- 1 YE Jida, ZENG Guangjian, CHEN Bin, *et al.* Radiation Protection Bulletin (in Chinese), 2005, **25**(1): 36
- 2 XIANG Yuanyi, WANG Kan, ZHANG Yu, *et al.* Nuclear Science and Techniques, 2007, **18**(5):319