Guangdong-Hong Kong-Macao
Pearl River Delta
Regional Air Quality Monitoring Network

A Report of Monitoring Results in 2014

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Approved by	**:**	**Quality Management Committee of Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network**
Security Classification	**:**	**Unrestricted**

Purpose of the Report

This report provides the 2014 monitoring results from the Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network and their statistical analysis.

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1. Foreword

Since the Pearl River Delta (PRD) Regional Air Quality Monitoring Network came into operation on 30 November 2005, a half-yearly and an annual air quality monitoring reports were published every year since 2006.

In view of the needs of air pollution control and economic development of the region, the environmental protection departments of Guangdong and Hong Kong have worked in collaboration with the environmental protection cum meteorological authority of Macao to enhance the network by extending the coverage of monitoring area to the 3 places, i.e. Guangdong, Hong Kong and Macao, in September 2014. The enhancement include the increase of number of monitoring station from 16 to 23 to further improve the spatial distribution; and the addition of two more monitoring parameters, i.e. carbon monoxide (CO) and fine suspended particulates ($PM_{2.5}$), to enrich the air quality monitoring information. The network was accordingly renamed "Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Monitoring Network" (the "Network").

In conjunction with the enhancement of the Network, the update of national ambient air quality standards and the increase of reporting frequency of monitoring results, starting from 2014, we report real time monitoring data of the Network on hourly basis through a new internet platform and publish a quarterly air quality monitoring report to replace the previous half-yearly report and continue the publishing of annual air quality monitoring report. The quarterly report is mainly a brief statistical summary of the monitoring results of the regional air quality in a quarter while the annual report, in addition to the reporting of the relevant data, will provide a more detailed analysis and comparison of the condition of air quality in the year.

2. Introduction to Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network

The PRD Regional Air Quality Monitoring Network was jointly established by the Guangdong Provincial Environmental Monitoring Centre (GDEMC) and the Environmental Protection Department of the Hong Kong Special Administrative Region (HKEPD) from 2003 to 2005. The network came into operation on 30 November 2005 and its data have been used for reporting Regional Air Quality Index (RAQI) to the public. At that time, the network comprises 16 automatic air quality monitoring stations (see Figure 1) across the PRD region. Ten of these stations were operated by the Environmental Monitoring Centres of the individual cities in Guangdong while the three stations located in Hong Kong were managed by the HKEPD. The remaining three regional stations were operated by the GDEMC. All stations were installed with equipment to measure the ambient concentrations of respirable suspended particulates (PM_{10} or RSP), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3).

The network was enhanced in September 2014 and renamed "Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Monitoring Network". The number of monitoring station was increased from 16 to 23 that the Guangdong, on its original 13 stations, added 5 stations, including Modiesha and Zhudong in Guangzhou, Duanfen and Huaguoshan in Jiangmen, and Xijiao in Huizhou. Hong Kong added Yuen Long monitoring station on the basis of its original 3 stations and Macao joined in with the monitoring station at Taipa Grande. As regards the monitoring parameters, the Network continues to monitoring the original 4 air pollutants with the addition of two new monitoring parameters, i.e. carbon monoxide (CO) and fine suspended particulates ($PM_{2.5}$). Figure 2 shows the spatial distribution of the monitoring stations including the newly added stations.

The Network employs the existing "Standard Operating Procedures on Quality Assurance and Quality Control of the PRD Air Quality Monitoring System for Hong Kong and Guangdong" (QA/QC Operating Procedures) jointly developed by Guangdong and Hong Kong to ensure that the air quality monitoring results attain a high degree of accuracy and reliability. The design and operation of the Network comply with the requirements set out in the QA/QC Operating Procedures. In light of the development of the Network, the QA/QC Operating Procedures will be appropriately revised..

Figure 1：Spatial distribution of monitoring stations (Nov 2005 to Sep 2014)

Figure 2：Spatial distribution of monitoring stations in the Network

To cope with the enhancement of the Network and the update of national ambient air quality standards, the internet platform has increased the data reporting frequency from the previous daily RAQI to hourly dissemination of real time air quality monitoring information of each monitoring station.

The objectives of the Network are to :

- provide accurate air quality data that can help the Guangdong Provincial, Hong Kong and Macao SAR governments to appraise the air quality situation and pollution problems in the PRD region for formulating appropriate control measures;
- evaluate the effectiveness of the air pollution control measures through long-term monitoring;
- provide the public with information on the air quality of various places in the region.

This is an annual report of monitoring results in 2014. As the new stations and new monitoring parameters were added in September 2014, there were not sufficient data for a full year analysis and evaluation. The corresponding results are thus not included in this report[1]. Nevertheless, full coverage of the monitoring results of all 23 monitoring stations and 6 monitoring parameters from the 2015 annual monitoring reports of the Network.

Annexes A and B set out, respectively, the site information of the monitoring stations and the methods used for measuring air pollutant concentrations.

[1] The relevant monitoring results are reported in the Statistical Summary of the Fourth Quarter 2014.

3. Operation of the Network

The operation of the Network (excluding Wanqingsha monitoring station) was generally smooth in 2014, the average hourly data capture rates of all monitoring stations in the Network was 95% (overall average of 15 monitoring stations and 4 pollutants).

The extensive renovation work at the Wanqingsha monitoring station in Guangzhou Nansha has been completed, the station has resumed normal operation starting from September 2014.

Furthermore, since there were only 3 months data from the new stations and new parameters added in September 2014 that they cannot be used for a full year analysis and evaluation, this report therefore will not include these new stations and parameters in the analysis.

3.1 Quality Control (QC) and Quality Assurance (QA) Activities

The governments of Guangdong and Hong Kong have fully implemented the agreed QA/QC programme, which include zero/span checks, precision checks, dynamic calibration, etc., in accordance with the QA/QC Operating Procedures so as to ensure that the air quality data from the monitoring stations are highly accurate and reliable. To ensure the operation of the Network in compliance with the QA/QC requirements, the GDEMC, HKEPD, Environmental Protection Bureau of Macau SARG and Meteorological and Geophysical Bureau of Macao SARG jointly established the "Quality Management Committee of Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network" (Quality Management Committee, the "QMC") to review, on a quarterly basis, the set-up of the Network, its performance in QA/QC and the operation of its data transmission system. The QMC also conducts system audit once a year to evaluate the effectiveness of the quality management system. The QMC prepares a report summarizing the findings of the system audit including the deficiencies found, and take appropriate corrective measures.

3.2 Accuracy and Precision

The accuracy of the Network is assessed by means of performance audits. The control limits set for the gaseous pollutants and respirable suspended particulates (PM_{10}) are ±15% and ± 10% respectively, these limits are similar to those of the United States Environmental Protection Agency and other international standards. In 2014, we have carried out 370 audit checks on the analyzers and samplers at the monitoring stations of the Network. The results showed that, based on the 95% probability limits, the accuracy of the Network varied between -9.9% and 10.5% and was within the specified control limits (see Figure 3).

Precision is a measure of repeatability and is calculated in accordance with the QA/QC Operating Procedures. The control limits adopted for the gaseous pollutants and respirable suspended particulates (PM_{10}) are ±20% and ±10% respectively. In 2014, we have carried out 2310 precision checks on the analyzers and samplers at the monitoring stations of the Network. The results showed that, based on the 95% probability limits, the precision of the Network varied between -12.4% and 12.0% and was within the specified control limits (see Figure 4). Overall, the QA/QC performance of the monitoring network was good in 2014, and met all the requirements specified in the QA/QC Operating Procedures.

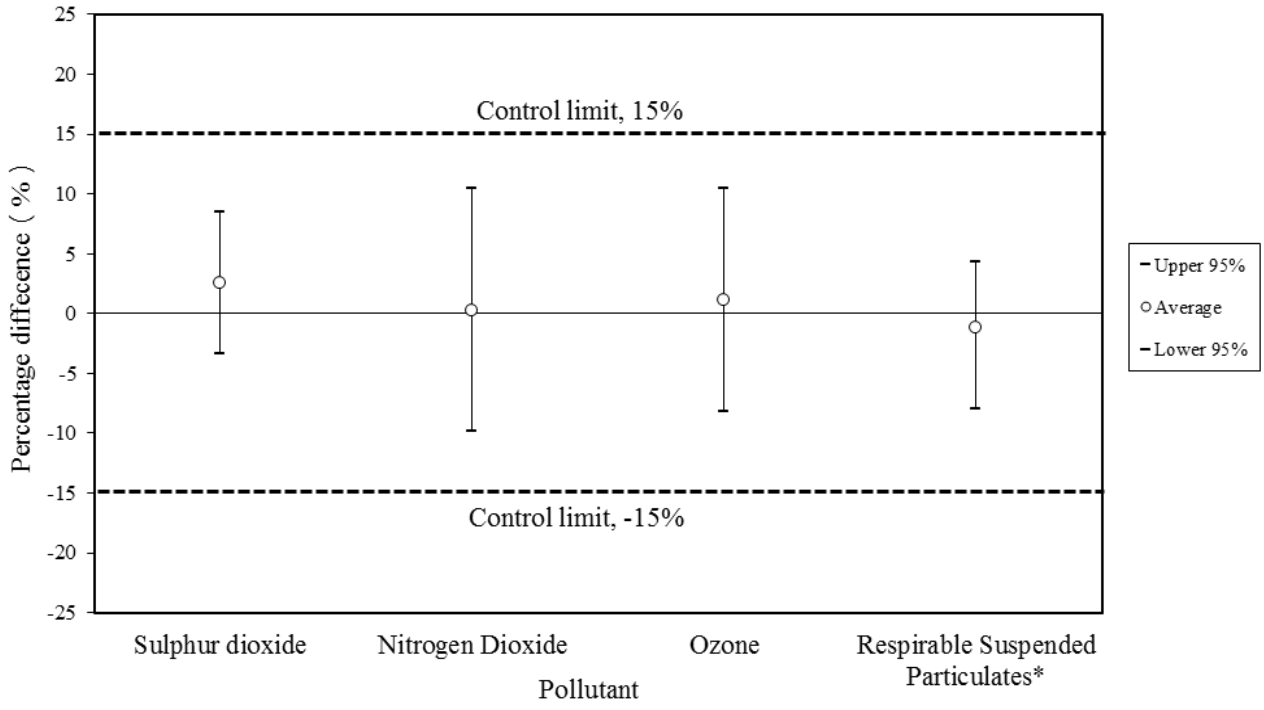

Figure 3：Accuracy of the monitoring network in 2014

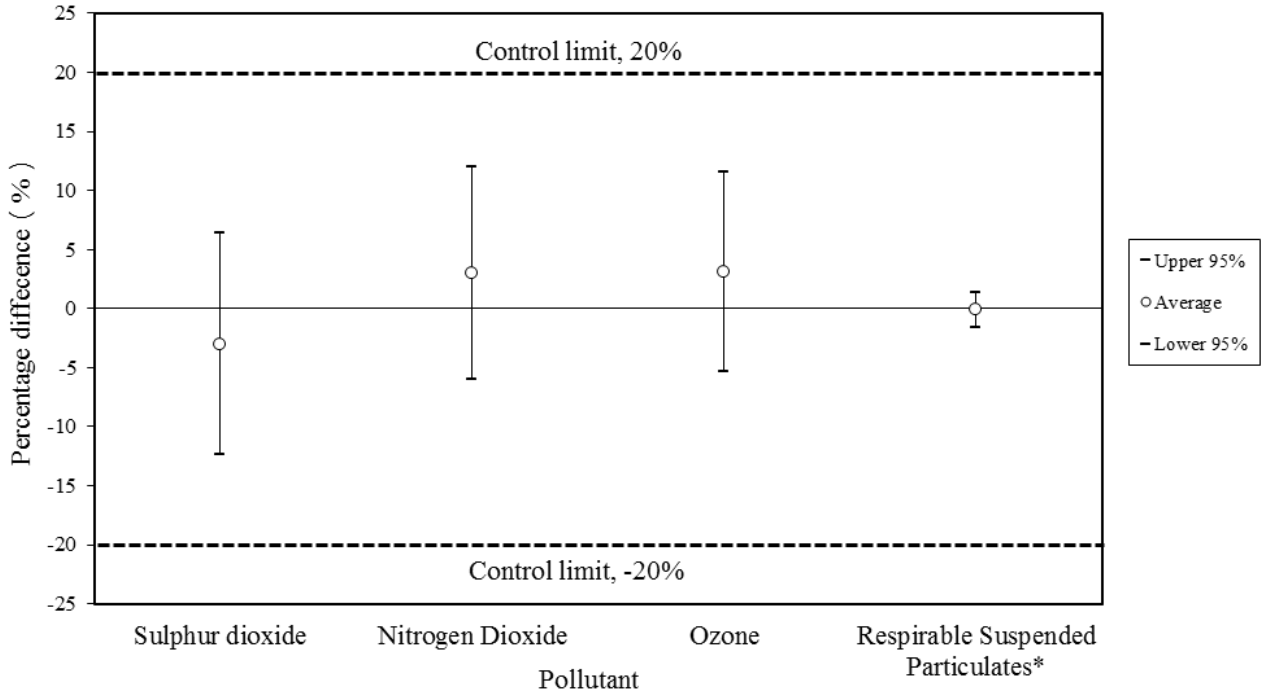

Figure 4：Precision of the monitoring network in 2014

* Both the accuracy and precision of respirable suspended particulates (PM_{10}) adopt a control limit of ±10%.

4. Statistical Analysis of Pollutant Concentrations

Starting from 2014 annual report, the air quality assessment is conducted in reference to the class II limits of the national "Ambient Air Quality Standards" (NAAQS) (GB3095-2012).

4.1 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) comes mainly from the combustion of sulphur-containing fossil fuel. Its major sources of emissions include power plants, fuel combustion plants, vehicles and vessels. Apart from its impact on the human respiratory system, SO_2 can also be oxidized in the air to form sulphate, which has significant impact on the levels of particulate matters, acid rain and visibility in the region.

The annual averages of SO_2 at various monitoring stations in the Network ranged from 7 μg/m^3 to 27 μg/m^3 in 2014; all were in compliance with the national annual air quality limit (60 μg/m^3). As shown in Figure 5, the average levels of SO_2 along the eastern coastal areas of PRD were in general lower than those of other areas. Summary of the monthly and annual averages of SO_2 at various stations are in Table 4.1c.

During the year, all monitoring stations in the Network were in compliance with the national hourly limit (500 μg/m^3) and 24-hour average daily air quality limit (150 μg/m^3) of SO_2. Details are shown in Table 4.1a and Table 4.1b.

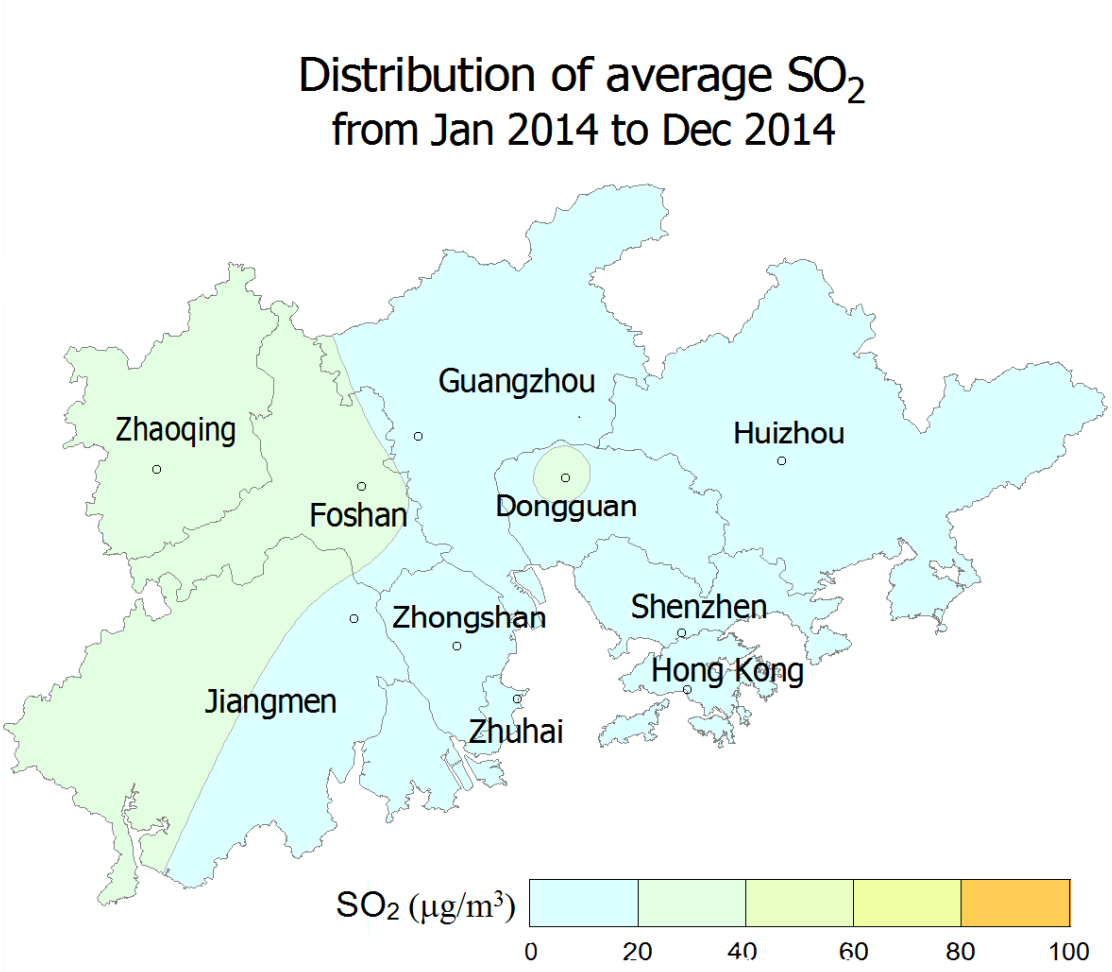

Figure 5：Spatial distribution of average concentrations of Sulphur Dioxide (SO_2)

Table 4.1a： Hourly averages of Sulphur Dioxide (the monthly maxima and percentage of annual compliance) [Class II limit: 500 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceedance Hours	Compl-iance
Luhu (Guangzhou)	79	53	52	51	56	38	58	68	81	57	45	61	0	100%
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	72	107	111	0	--
Tianhu (Guangzhou)	87	40	72	53	21	41	55	48	37	80	37	60	0	100%
Liyuan (Shenzhen)	55	38	63	59	24	39	59	51	38	32	29	42	0	100%
Tangjia (Zhuhai)	67	39	39	53	36	53	45	38	54	54	40	36	0	100%
Jinjuzui (Foshan)	116	84	84	83	58	91	46	84	66	61	76	100	0	100%
Huijingcheng (Foshan)	197	127	123	98	112	104	227	181	160	142	124	158	0	100%
Donghu (Jiangmen)	129	91	127	115	72	95	52	69	119	78	114	157	0	100%
Chengzhong (Zhaoqing)	431	176	269	326	171	156	195	261	154	76	110	106	0	100%
Xiapu (Huizhou)	60	33	42	37	50	37	49	90	54	28	35	113	0	100%
Jinguowan (Huizhou)	68	27	77	45	28	29	40	23	34	23	33	46	0	100%
Nanchengyuanling (Dongguan)	90	122	95	157	86	70	134	106	93	86	83	97	0	100%
Zimaling (Zhongshan)	97	72	51	61	29	63	57	35	68	64	56	105	0	100%
Tsuen Wan (Hong Kong)	109	76	139	90	139	58	81	69	67	50	84	83	0	100%
Tap Mun (Hong Kong)	42	37	41	40	23	28	44	28	29	20	19	39	0	100%
Tung Chung (Hong Kong)	88	60	62	58	48	45	61	33	65	46	75	58	0	100%

Table 4.1b： Daily averages of Sulphur Dioxide (the monthly maxima and percentage of annual compliance; the 98th percentile and its multiple of exceedance) [Class II limit: 150 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceed-ance Days	Compl-iance	98th percen-tile	Multiple of exceedance
Luhu (Guangzhou)	38	24	28	28	23	18	32	21	24	25	29	33	0	100%	30	Complied
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	37	46	68	0	100%	--	--
Tianhu (Guangzhou)	54	17	30	28	14	27	18	24	20	25	26	47	0	100%	35	Complied
Liyuan (Shenzhen)	31	11	16	15	9	10	19	10	12	10	13	30	0	100%	22	Complied
Tangjia (Zhuhai)	37	25	19	22	15	18	13	14	25	28	21	24	0	100%	26	Complied
Jinjuzui (Foshan)	58	41	43	35	23	28	19	32	34	33	37	47	0	100%	44	Complied
Huijingcheng (Foshan)	88	67	82	52	58	39	62	49	55	52	57	68	0	100%	64	Complied
Donghu (Jiangmen)	70	36	66	33	31	29	22	21	27	35	52	61	0	100%	52	Complied
Chengzhong (Zhaoqing)	112	58	86	65	46	42	62	57	64	43	52	49	0	100%	64	Complied
Xiapu (Huizhou)	46	20	23	20	16	15	25	25	23	17	22	32	0	100%	29	Complied
Jinguowan (Huizhou)	31	18	45	23	14	13	13	12	14	14	19	30	0	100%	35	Complied
Nanchengyuanling (Dongguan)	54	67	41	53	41	29	57	37	44	48	41	40	0	100%	46	Complied
Zimaling (Zhongshan)	29	32	25	28	15	19	25	18	31	37	35	37	0	100%	34	Complied
Tsuen Wan (Hong Kong)	40	32	43	43	32	27	28	27	30	20	29	28	0	100%	32	Complied
Tap Mun (Hong Kong)	32	18	16	18	13	15	19	15	18	12	14	27	0	100%	20	Complied
Tung Chung (Hong Kong)	44	25	25	27	14	18	20	12	25	19	23	33	0	100%	34	Complied

Table 4.1b：The monthly and annual averages of Sulphur Dioxide [Class II limit: 60 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	18	10	14	15	11	10	13	12	12	16	14	16	14
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	24	28	38	--
Tianhu (Guangzhou)	20	9	11	12	7	11	10	13	12	16	13	24	14
Liyuan (Shenzhen)	15	6	7	7	5	4	5	5	5	7	6	16	7
Tangjia (Zhuhai)	19	12	12	13	10	12	7	7	16	21	11	15	13
Jinjuzui (Foshan)	29	15	21	16	11	12	11	15	17	19	20	24	18
Huijingcheng (Foshan)	41	26	30	27	25	20	21	18	18	28	30	35	27
Donghu (Jiangmen)	30	16	29	13	10	8	9	11	13	19	22	20	17
Chengzhong (Zhaoqing)	34	24	44	35	23	23	28	28	21	20	23	23	27
Xiapu (Huizhou)	23	15	13	9	6	7	9	10	9	13	13	18	12
Jinguowan (Huizhou)	16	13	21	13	6	6	6	7	7	10	10	15	11
Nanchengyuanling (Dongguan)	29	20	23	21	17	18	22	21	22	22	22	26	22
Zimaling (Zhongshan)	17	10	11	11	8	10	14	14	18	21	26	27	16
Tsuen Wan (HKSAR)	22	15	18	15	16	16	17	15	16	13	13	17	16
Tap Mun (HKSAR)	15	9	10	11	10	10	11	12	8	7	7	12	10
Tung Chung (HKSAR)	28	17	16	14	10	8	9	8	11	13	15	19	14

Remark : All concentration units are in micrograms per cubic metre (μg/m^3).

4.2 Nitrogen Dioxide (NO_2)

Nitrogen Dioxide (NO_2) is mainly formed from oxidization of nitric oxide (NO) emitted in the process of combustion. Its major emission sources include power plants, fuel combustion plants, vehicles and vessels. Apart from its impact on human respiratory system, NO_2 can also be oxidized in the air to form nitrate, which has significant impact on the levels of particulate matters, acid rain and visibility in the region.

The annual averages of NO_2 at various monitoring stations in the Network ranged from 11 $\mu g/m^3$ to 62 $\mu g/m^3$ in 2014, and 6 monitoring stations have exceeded the national annual air quality limit (40 $\mu g/m^3$). During the year, 11 monitoring stations in the Network have recorded exceedance of the national hourly limit (200 $\mu g/m^3$) where the hourly average annual compliance rates ranged from 99.18% to 100%. As regards the national 24-hour average daily air quality limit (80 $\mu g/m^3$), 12 monitoring stations have recorded exceedance in the year and the annual compliance rates ranged from 77.1% to 100%. For the 98th percentile of the daily averages, 9 monitoring stations exceeded the limit and their multiple of exceedance ranged from 0.08 to 0.74. Details are shown on Tables 4.2a to 4.2c.

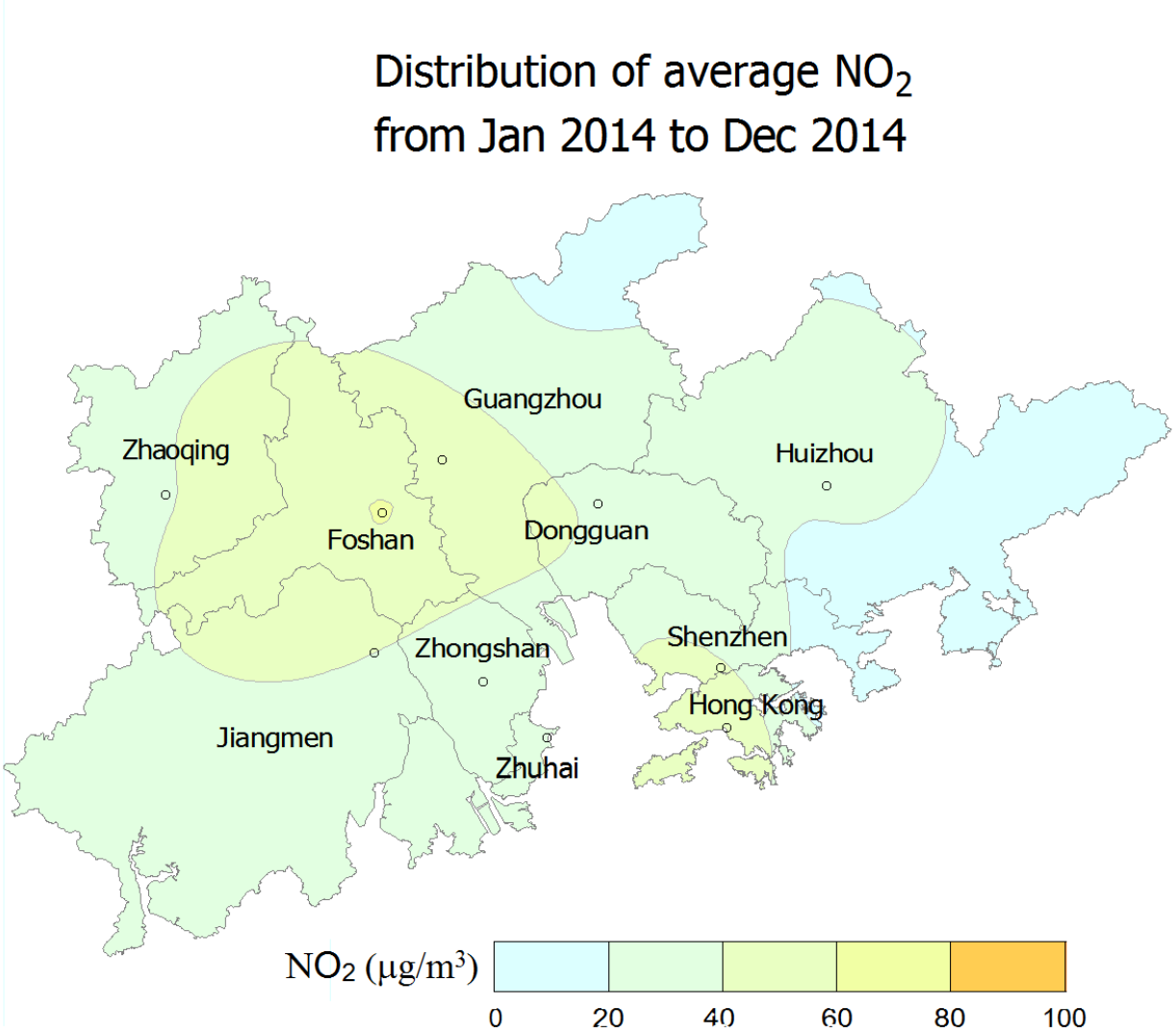

Figure 6：Spatial distribution of average concentrations of Nitrogen Dioxide (NO_2)

Table 4.2c： Hourly averages of Nitrogen Dioxide (the monthly maxima and percentage of annual compliance) [Class II limit: 200 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceedance Hours	Compl-iance
Luhu (Guangzhou)	215	164	162	147	106	156	172	139	169	192	173	167	2	99.98%
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	124	158	219	1	--
Tianhu (Guangzhou)	71	70	100	85	41	62	55	55	56	89	66	48	0	100%
Liyuan (Shenzhen)	268	178	223	113	95	112	136	83	128	151	159	177	11	99.87%
Tangjia (Zhuhai)	144	76	69	66	99	105	77	51	48	94	100	134	0	100%
Jinjuzui (Foshan)	199	190	168	126	134	154	120	81	112	150	157	274	4	99.95%
Huijingcheng (Foshan)	265	183	226	173	196	202	131	114	138	242	247	258	68	99.18%
Donghu (Jiangmen)	164	156	167	170	128	98	87	68	116	162	186	261	4	99.95%
Chengzhong (Zhaoqing)	221	137	184	190	166	167	104	108	88	89	88	96	2	99.98%
Xiapu (Huizhou)	202	83	89	139	74	79	77	74	120	97	116	141	1	99.99%
Jinguowan (Huizhou)	36	67	82	74	59	65	66	59	75	34	55	73	0	100%
Nanchengyuanling (Dongguan)	208	243	181	123	111	162	129	73	119	147	154	166	7	99.92%
Zimaling (Zhongshan)	137	135	87	88	66	83	64	50	101	99	90	194	0	100%
Tsuen Wan (Hong Kong)	302	179	207	158	123	171	176	128	243	167	207	224	22	99.74%
Tap Mun (Hong Kong)	100	101	59	52	41	64	78	41	77	51	87	90	0	100%
Tung Chung (Hong Kong)	295	181	162	179	102	186	141	88	134	162	181	281	27	99.68%

Table 4.2b： Daily averages of Nitrogen Dioxide (the monthly maxima and percentage of annual compliance; the 98th percentile and its multiple of exceedance) [Class II limit: 80 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceed-ance Days	Compl-iance	98th percen-tile	Multiple of exceedance
Luhu (Guangzhou)	131	88	82	71	68	89	89	77	87	100	91	105	26	92.8%	100	0.25
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	50	76	130	4	--	--	--
Tianhu (Guangzhou)	42	44	56	36	22	26	25	28	24	31	27	25	0	100%	37	Complied
Liyuan (Shenzhen)	167	77	92	75	58	71	80	49	72	75	91	117	16	95.6%	100	0.25
Tangjia (Zhuhai)	70	65	32	30	33	48	34	31	41	36	56	77	0	100%	61	Complied
Jinjuzui (Foshan)	136	119	107	74	81	77	64	43	59	80	87	141	22	93.8%	100	0.25
Huijingcheng (Foshan)	157	106	129	114	107	106	74	65	68	140	151	152	80	77.1%	139	0.74
Donghu (Jiangmen)	102	90	107	78	81	53	44	36	59	97	91	142	27	92.3%	105	0.31
Chengzhong (Zhaoqing)	139	88	115	80	93	56	47	50	52	51	44	68	22	93.8%	99	0.24
Xiapu (Huizhou)	108	57	50	51	40	37	44	41	37	38	52	75	3	99.2%	60	Complied
Jinguowan (Huizhou)	15	21	36	36	31	23	21	27	27	20	26	40	0	100%	29	Complied
Nanchengyuanling (Dongguan)	119	142	93	73	64	67	55	34	46	59	77	86	11	96.9%	86	0.08
Zimaling (Zhongshan)	80	79	57	51	44	44	36	21	38	60	57	91	1	99.7%	66	Complied
Tsuen Wan (Hong Kong)	173	86	121	89	86	91	96	73	127	80	92	121	56	84.5%	112	0.40
Tap Mun (Hong Kong)	35	26	25	31	19	22	39	21	40	16	22	27	0	100%	27	Complied
Tung Chung (Hong Kong)	151	101	104	96	54	80	77	54	84	89	89	137	41	88.7%	120	0.50

Table 4.2d：The monthly and annual averages of Nitrogen Dioxide [Class II limit: 40 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	73	43	51	48	46	47	46	44	49	59	48	54	51
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	31	51	62	--
Tianhu (Guangzhou)	21	19	21	16	10	10	11	15	6	13	11	15	14
Liyuan (Shenzhen)	65	41	43	36	35	33	36	33	37	33	44	63	42
Tangjia (Zhuhai)	43	32	19	19	22	26	16	16	22	22	30	43	26
Jinjuzui (Foshan)	71	46	61	53	42	40	34	26	33	47	52	61	47
Huijingcheng (Foshan)	93	56	69	71	63	53	45	30	36	68	72	84	62
Donghu (Jiangmen)	58	36	53	40	27	23	24	21	31	40	50	74	40
Chengzhong (Zhaoqing)	76	46	57	51	49	29	27	29	28	25	25	26	39
Xiapu (Huizhou)	47	31	34	33	29	21	21	26	21	25	25	33	29
Jinguowan (Huizhou)	10	11	19	19	15	12	9	16	13	16	17	21	15
Nanchengyuanling (Dongguan)	61	39	52	45	36	31	26	22	29	30	46	48	39
Zimaling (Zhongshan)	49	32	28	23	13	12	11	9	21	34	31	42	25
Tsuen Wan (HKSAR)	89	59	67	63	50	52	53	49	60	64	62	68	61
Tap Mun (HKSAR)	14	8	13	11	10	9	9	10	9	10	11	16	11
Tung Chung (HKSAR)	89	56	55	53	27	28	29	24	41	50	58	70	48

Remark : All concentration units are in micrograms per cubic metre (μg/m^3).

4.3 Ozone (O_3)

Ozone (O_3) is not directly emitted from emission sources. It is formed by the photochemical reaction of oxygen, nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the air under sunlight, and is one of the main components of photochemical smog. Ozone can cause irritation to the eyes, nose and throat. At elevated levels, it can increase a person's susceptibility to respiratory diseases and aggravate pre-existing respiratory diseases such as asthma.

The precursors of O_3 (NOx and VOCs) mainly originate from pollution sources in urban areas. However, as it usually takes several hours for O_3 to be formed and rise to its peak level, O_3 and its precursors can be transported to other areas downwind of their sources during this period. The concentrations of O_3 in downwind rural areas are therefore often higher than those in the urban areas.

In 2014, the annual averages of O_3 recorded by the Network ranged from 41 $\mu g/m^3$ to 91 $\mu g/m^3$ with higher average values being recorded in rural areas such as Tianhu of Guangzhou, Tap Mun of Hong Kong and Jinguowan of Huizhou, similar to the situation in previous years. During the year, all monitoring stations in the Network have recorded exceedance of the national hourly limit (200 $\mu g/m^3$) where the hourly average annual compliance rates ranged from 95.82% to 99.95%. As regards the national daily maximum 8-hour average limit (160 $\mu g/m^3$), all monitoring stations have recorded exceedance in the year and the annual compliance rates ranged from 74.7% to 99.4%. For the 90th percentile of the daily maximum 8-hour averages, 9 monitoring stations exceeded the limit and their multiple of exceedance ranged from 0.04 to 0.26. Details are shown on Tables 4.3a to 4.3c.

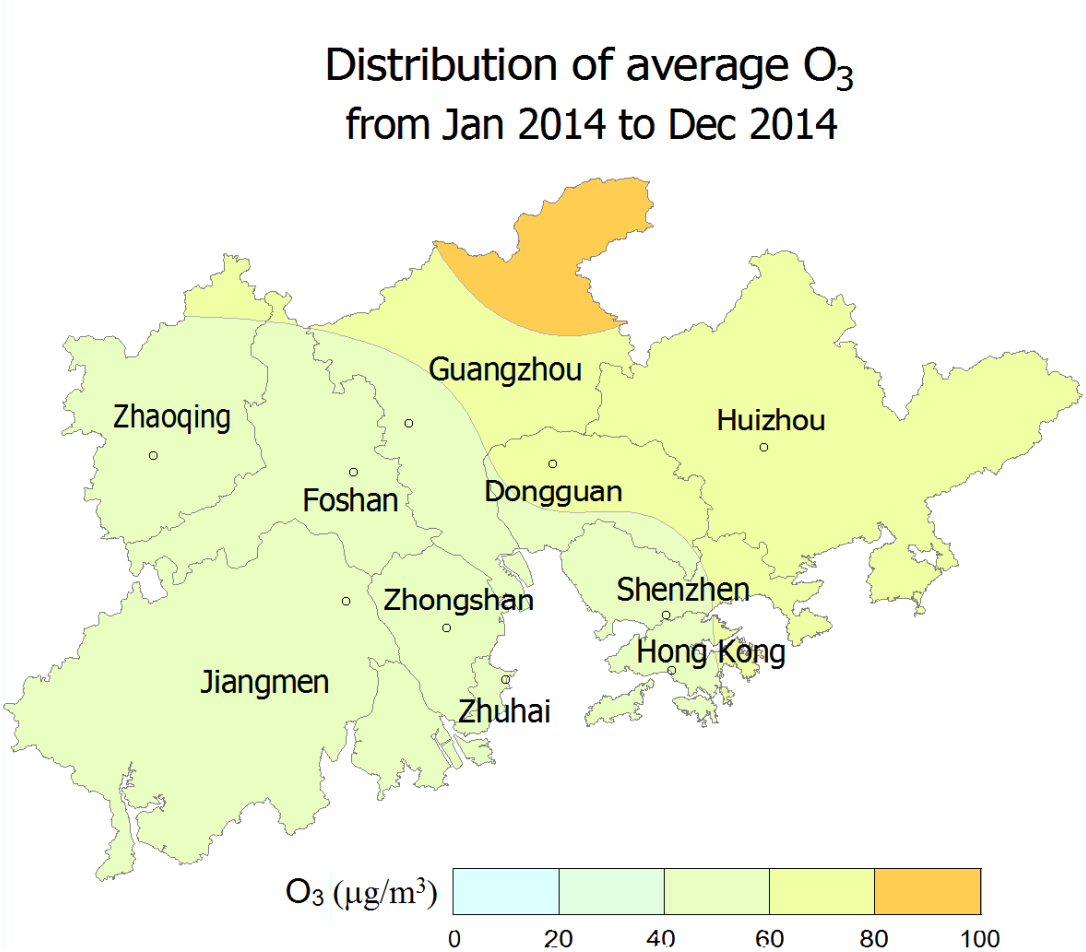

Figure 7：Spatial distribution of average concentrations of Ozone (O_3)

Table 4.3e： Hourly averages of Ozone (the monthly maxima and percentage of annual compliance)

[Class II limit: 200 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceedance Hours	Compl-iance
Luhu (Guangzhou)	235	231	286	221	255	247	394	312	302	263	238	147	187	97.81%
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	358	349	205	169	--
Tianhu (Guangzhou)	208	191	258	238	235	298	309	263	238	284	280	143	178	97.74%
Liyuan (Shenzhen)	139	104	104	125	117	179	251	185	210	187	129	147	4	99.95%
Tangjia (Zhuhai)	170	134	175	206	137	190	194	136	333	271	161	123	123	98.57%
Jinjuzui (Foshan)	195	187	262	295	215	317	319	358	322	313	269	138	254	96.92%
Huijingcheng (Foshan)	198	129	259	233	249	237	275	283	240	266	284	125	133	98.38%
Donghu (Jiangmen)	182	121	203	287	202	332	282	270	338	264	233	176	179	97.83%
Chengzhong (Zhaoqing)	178	155	204	264	209	268	261	363	238	293	217	116	129	98.45%
Xiapu (Huizhou)	471	150	242	219	347	285	336	298	273	218	221	130	92	98.91%
Jinguowan (Huizhou)	203	150	230	222	295	233	375	312	283	305	251	168	112	98.62%
Nanchengyuanling (Dongguan)	226	204	277	269	371	266	387	403	384	269	335	162	352	95.82%
Zimaling (Zhongshan)	157	99	129	189	142	282	298	244	278	276	196	158	103	98.73%
Tsuen Wan (Hong Kong)	172	120	117	207	126	376	256	152	282	181	161	113	20	99.77%
Tap Mun (Hong Kong)	220	158	178	219	175	230	318	218	371	219	180	201	78	99.08%
Tung Chung (Hong Kong)	186	132	128	270	138	381	295	180	363	247	156	135	70	99.18%

Table 4.3b： Daily maximum 8-hour averages of Ozone (the monthly maxima and percentage of annual compliance; the 90th percentile and its multiple of exceedance) [Class II limit: 160 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceed-ance Days	Compl-iance	90th percen-tile	Multiple of exceedance
Luhu (Guangzhou)	184	164	178	184	187	193	266	253	200	198	168	105	51	85.5%	171	0.07
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	318	226	144	28	--	--	--
Tianhu (Guangzhou)	193	157	222	205	211	264	255	218	223	227	267	132	68	78.6%	189	0.18
Liyuan (Shenzhen)	124	84	96	99	91	145	184	118	167	149	111	120	2	99.4%	100	Complied
Tangjia (Zhuhai)	138	114	139	171	89	167	158	103	276	238	123	107	25	92.9%	139	Complied
Jinjuzui (Foshan)	168	121	198	220	178	253	252	215	265	256	199	111	63	81.6%	192	0.20
Huijingcheng (Foshan)	174	116	193	180	194	193	225	235	205	237	209	88	49	85.8%	167	0.04
Donghu (Jiangmen)	144	109	144	232	123	279	213	191	280	239	189	134	41	88.1%	171	0.07
Chengzhong (Zhaoqing)	144	111	158	209	156	216	211	283	202	253	193	113	48	85.8%	169	0.06
Xiapu (Huizhou)	150	118	167	182	249	168	230	244	202	190	172	118	32	90.9%	153	Complied
Jinguowan (Huizhou)	183	140	166	191	232	199	326	254	238	238	202	152	45	86.4%	167	0.04
Nanchengyuanling (Dongguan)	182	152	224	204	282	201	328	329	294	233	272	135	91	74.7%	202	0.26
Zimaling (Zhongshan)	124	85	90	161	121	248	216	179	212	228	147	120	34	89.9%	160	Complied
Tsuen Wan (Hong Kong)	152	101	99	152	113	299	166	84	190	143	104	92	4	98.8%	105	Complied
Tap Mun (Hong Kong)	215	147	157	194	164	182	211	148	305	211	164	166	42	87.5%	166	0.04
Tung Chung (Hong Kong)	179	117	122	182	131	298	206	134	280	188	113	105	22	93.5%	140	Complied

Table 4.3f：The monthly and annual averages of Ozone

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	66	50	47	34	24	44	54	49	49	77	35	33	47
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	140	62	48	--
Tianhu (Guangzhou)	114	67	72	92	61	84	88	96	91	136	94	89	91
Liyuan (Shenzhen)	54	38	40	46	33	34	28	26	40	73	41	34	41
Tangjia (Zhuhai)	75	44	47	40	29	40	35	32	84	100	46	76	54
Jinjuzui (Foshan)	56	37	30	48	37	57	64	56	77	100	45	34	54
Huijingcheng (Foshan)	49	35	28	38	28	44	60	54	54	89	41	29	46
Donghu (Jiangmen)	41	32	33	59	37	54	50	47	59	86	44	36	48
Chengzhong (Zhaoqing)	50	40	26	37	26	50	63	56	73	109	67	53	54
Xiapu (Huizhou)	73	45	42	67	45	58	64	54	65	108	63	52	62
Jinguowan (Huizhou)	96	62	63	61	57	64	67	62	70	120	78	78	72
Nanchengyuanling (Dongguan)	71	48	39	65	50	62	80	74	84	112	67	58	68
Zimaling (Zhongshan)	42	29	26	39	33	55	53	44	66	91	32	26	45
Tsuen Wan (HKSAR)	55	38	40	51	25	32	23	20	38	80	50	44	41
Tap Mun (HKSAR)	104	73	79	95	58	60	54	41	73	118	94	84	78
Tung Chung (HKSAR)	55	41	48	55	45	50	39	31	51	94	50	39	50

Remark : All concentration units are in micrograms per cubic metre ($\mu g/m^3$).

4.3 Respirable Suspended Particulates (PM_{10})

Respirable suspended particulates (PM_{10} or RSP) in the atmosphere come from a great variety of emission sources, such as power plants, vehicles, vessels, cement and pottery manufacturing, fugitive dust, etc. while some are products of oxidization of gaseous pollutants in the air (e.g. sulphate formed from oxidation of SO_2) or formed from photochemical reactions. PM_{10} can penetrate deeply into human lungs and cause impact on human respiratory system. Furthermore, finer particles in PM_{10} have significant effect on visibility.

In 2014, the annual averages of PM_{10} at various monitoring stations in the Network ranged from 42 $\mu g/m^3$ to 74 $\mu g/m^3$, and 1 monitoring station has exceeded the national annual air quality limit (70 $\mu g/m^3$). During the year, 11 monitoring stations in the Network have recorded exceedance of the national 24-hour average daily air quality limit (150 $\mu g/m^3$) where the daily average annual compliance rates ranged from 93.6% to 100%. For the 95th percentile of the daily averages, 2 monitoring stations exceeded the limit and their multiple of exceedance ranged from 0.01 to 0.11 . Details are shown on Tables 4.4a to 4.4b.

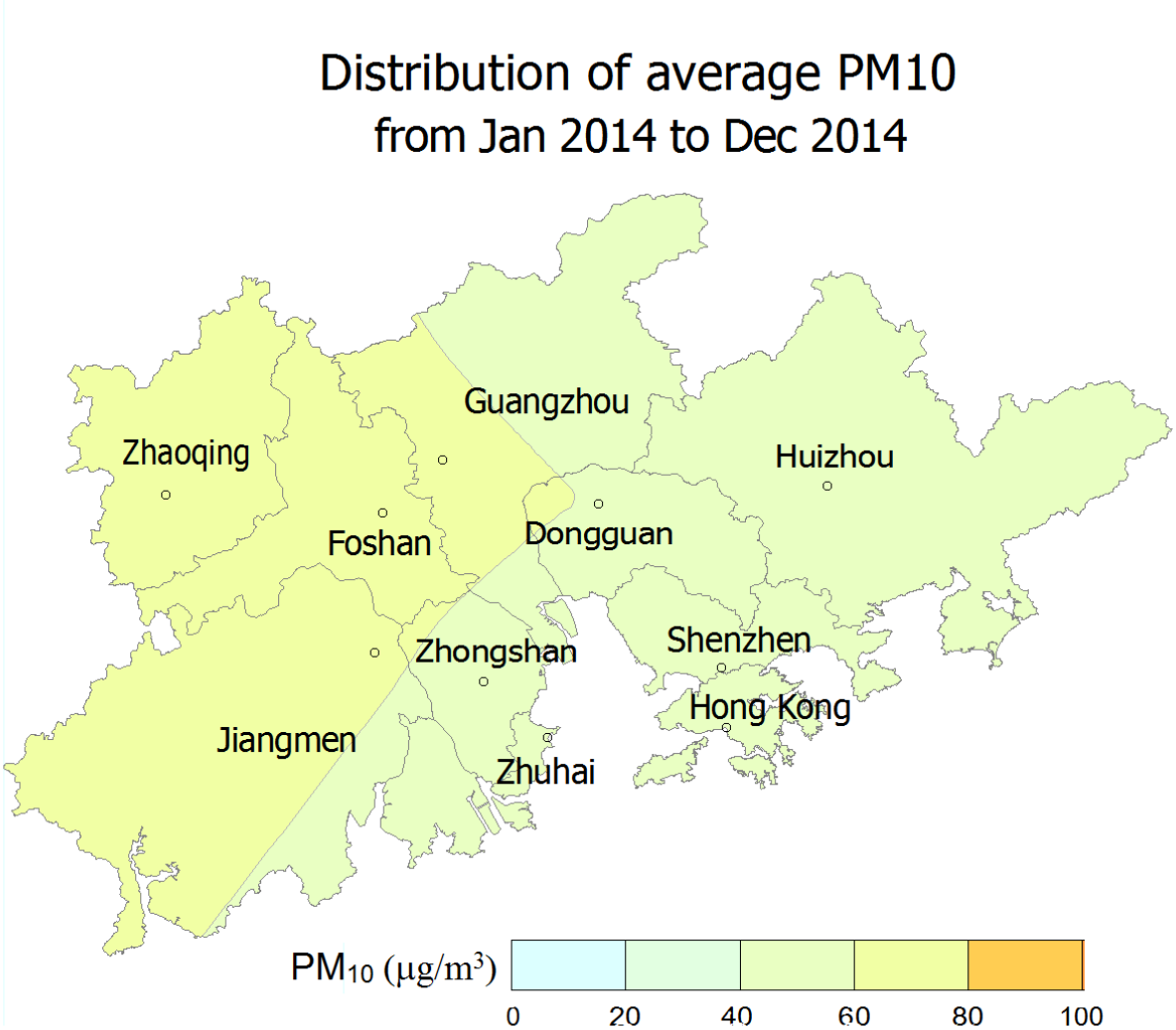

Figure 8：Spatial distribution of average concentrations of PM_{10}

Table 4.4a： Daily averages of PM_{10} (the monthly maxima and percentage of annual compliance; the 95th percentile and its multiple of exceedance) [Class II limit: 150 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exceed-ance Days	Compl-iance	95th percen-tile	Multiple of exceedance
Luhu (Guangzhou)	217	186	211	112	98	115	97	79	97	125	99	114	9	97.4%	124	Complied
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	124	110	157	1		--	--
Tianhu (Guangzhou)	136	75	102	88	44	115	97	97	80	129	109	110	0	100%	97	Complied
Liyuan (Shenzhen)	184	71	102	84	48	80	91	57	92	128	103	162	2	99.4%	113	Complied
Tangjia (Zhuhai)	173	87	120	72	38	84	85	41	105	141	116	148	4	98.8%	109	Complied
Jinjuzui (Foshan)	193	210	179	95	84	131	107	62	102	117	122	174	11	96.9%	126	Complied
Huijingcheng (Foshan)	211	179	195	79	90	128	101	79	97	156	169	209	22	93.6%	167	0.11
Donghu (Jiangmen)	202	261	161	120	118	127	69	65	106	153	134	172	12	96.5%	134	Complied
Chengzhong (Zhaoqing)	247	230	312	200	140	127	99	97	97	179	172	106	18	94.9%	151	0.01
Xiapu (Huizhou)	173	88	110	88	63	82	107	68	88	136	105	131	4	98.9%	107	Complied
Jinguowan (Huizhou)	143	62	87	72	100	82	110	68	77	119	100	123	0	100%	99	Complied
Nanchengyuanling (Dongguan)	197	204	146	93	90	89	109	76	84	113	106	135	5	98.6%	118	Complied
Zimaling (Zhongshan)	140	124	141	72	66	97	80	44	100	138	108	142	0	100%	108	Complied
Tsuen Wan (Hong Kong)	126	86	102	61	48	94	67	49	87	99	84	98	0	100%	87	Complied
Tap Mun (Hong Kong)	159	73	112	78	62	67	54	27	74	111	93	123	3	99.1%	99	Complied
Tung Chung (Hong Kong)	136	68	91	77	40	86	61	32	70	97	98	126	0	100%	98	Complied

Table 4.4b：The monthly and annual averages of PM_{10} [Class II limit: 70 μg/m^3]

Monitoring Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	120	61	80	69	44	54	52	47	52	73	62	64	65
Wanqingsha (Guangzhou)	--	--	--	--	--	--	--	--	--	79	67	84	--
Tianhu (Guangzhou)	82	39	45	51	24	41	38	40	36	70	58	60	49
Liyuan (Shenzhen)	91	41	52	46	31	38	36	29	47	74	59	83	52
Tangjia (Zhuhai)	94	39	45	43	22	27	29	25	44	79	68	83	49
Jinjuzui (Foshan)	110	62	75	60	40	48	44	36	46	76	70	88	63
Huijingcheng (Foshan)	128	68	64	49	45	53	48	44	51	93	92	108	70
Donghu (Jiangmen)	111	67	73	63	47	46	38	32	45	78	77	93	64
Chengzhong (Zhaoqing)	126	72	95	87	68	61	56	47	53	91	78	63	74
Xiapu (Huizhou)	102	55	61	54	33	41	42	40	47	87	73	74	59
Jinguowan (Huizhou)	84	42	55	51	30	37	40	33	42	77	64	68	51
Nanchengyuanling (Dongguan)	105	54	65	55	37	41	45	37	47	78	69	79	60
Zimaling (Zhongshan)	82	46	59	44	24	34	32	22	41	75	67	85	51
Tsuen Wan (HKSAR)	75	40	54	44	28	35	29	24	37	64	51	58	45
Tap Mun (HKSAR)	91	50	59	47	25	28	20	16	33	66	55	72	48
Tung Chung (HKSAR)	83	41	49	38	17	24	21	15	29	61	57	74	42

Remark : All concentration units are in micrograms per cubic metre (μg/m^3).

4.5 Monthly Variations of Pollutant Concentrations

Figure 9 shows the monthly variations of the major pollutants (SO_2, NO_2, O_3, and PM_{10}) recorded by the Network in 2014. The overall concentrations of SO_2, NO_2 and PM_{10} were generally higher during the winter season (first and fourth quarters of the year) and relatively lower in the summer months. The lower pollutants levels in summer were mainly due to the relatively clean maritime air stream prevailed in the PRD region under the influence of southern monsoon together with heavier rainfall and higher mixing layer that favoured the dispersion of pollutants. As for ozone, higher monthly averages occurred in October because of more days with meteorological conditions that favoured photochemical reactions (such as strong solar radiation, less amount of clouds, low wind speed etc.) causing more ozone formation in the period.

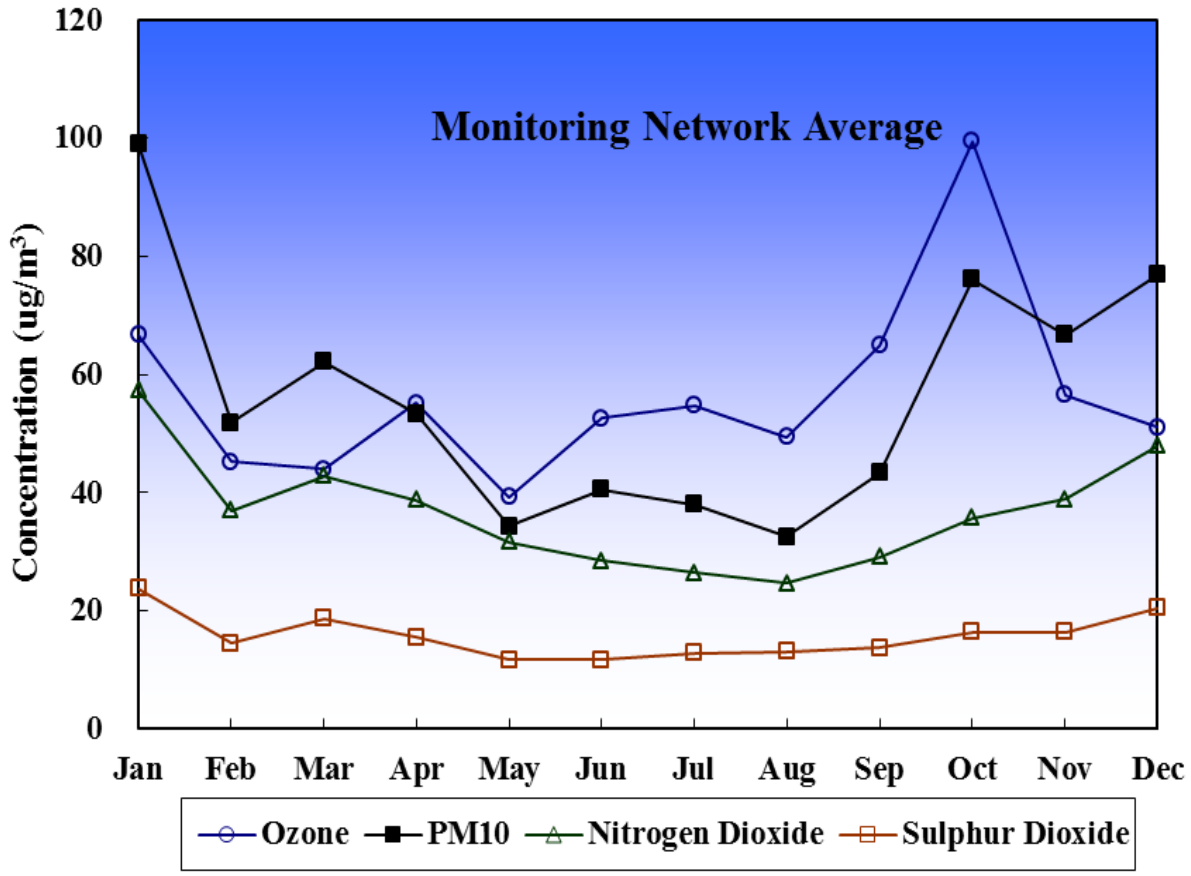

Figure 9： Monitoring network monthly variations of average pollutant concentrations

4.6 Annual Variations of Pollutant Concentrations (2006-2014)

Table 4.6 shows the annual average concentrations of the major pollutants (SO_2, NO_2, O_3, and PM_{10}) recorded by the Network from 2006 to 2014, while Figure 10 shows the tendency trend of the annual pollutant concentrations by percentage changes.

From 2006 to 2014, the annual averages recorded by the Network for SO_2, NO_2, and PM_{10} decreased by 66%, 20% and 24% respectively, which exhibited an obvious downward trend in an annual descending rate of about 3.9, 1.1 and 2.3 $\mu g/m^3$ respectively. These reductions indicate that the measures implemented in recent years by Guangdong and Hong Kong, including the retrofitting of power plants with flue-gas desulphurization facilities, tightening the vehicle emission standards and fuel specifications, phasing out the more polluting industrial facilities in the PRD, etc., have brought improvements in the overall air quality in the PRD region. However, the Network had recorded an increase of 19% in the annual average of ozone in the same period, which displayed a gradual upward trend in an annual ascending rate of about 1.1 $\mu g/m^3$. The increase of ozone reflects that the situation of photochemical smog pollution in the region has yet to be improved. The Guangdong and Hong Kong governments will continue to implement emission reduction measures to further improve the air quality in the region and tackle the photochemical pollution problem.

Table 4.6：Annual averages of the pollutants from the monitoring network ($\mu g/m^3$)

	Sulphur Dioxide	Nitrogen Dioxide	Ozone	PM_{10}
2006	47	46	48	74
2007	48	45	51	79
2008	39	45	51	70
2009	29	42	56	69
2010	25	43	53	64
2011	24	40	58	64
2012	18	38	54	56
2013	18	40	54	63
2014	16	37	57	56

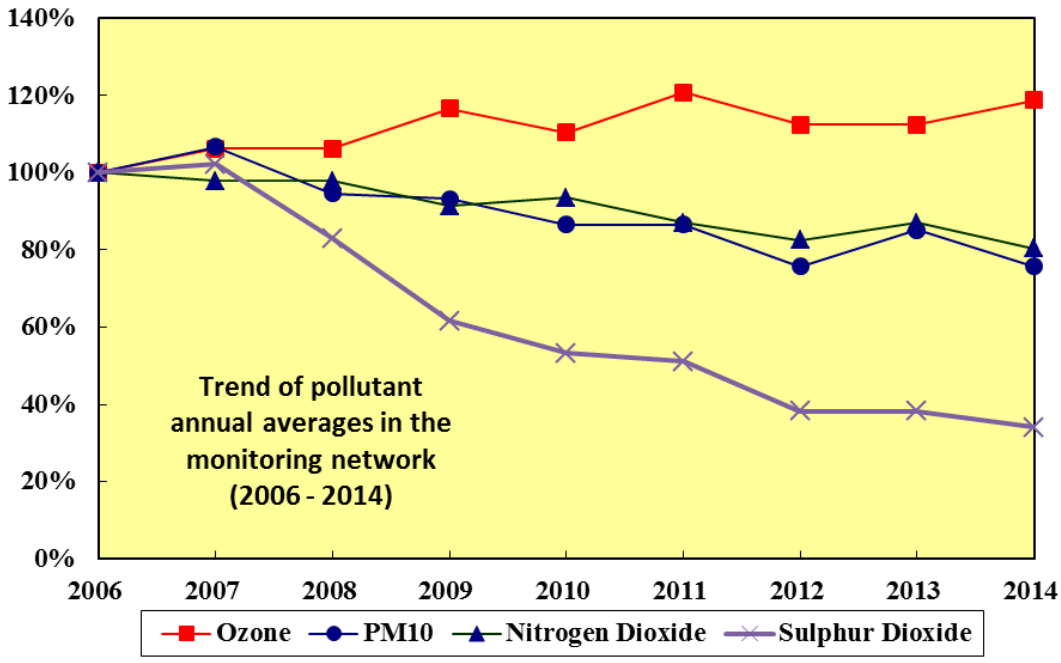

Figure 10：Trend of pollutant annual averages in the Network

Annex A：Site Information of Monitoring Stations

Monitoring Stations	Address	Area Type	Sampling Height (Above P.D.)	Above Ground	Date Commenced Operation
Luhu (Guangzhou)	Jufong Garden of Luhu Park (Big yard, No. 11 Luhu Park)	City	30m	9m	1993
Wanqingsha (Guangzhou)	HKUST Fok Ying Tung Research Institite, Nansha	Mixed educational/ commercial and residential/industrial	13m	12m	Oct 2004
Tianhu (Guangzhou)	Tianhu Park, Conghua	Background : rural	251m	13m	Oct 2004
Liyuan (Shenzhen)	Shennan Zhong Road, Futian District	City	38m	12m	Sep 1997
Tangjia (Zhuhai)	Qiao Island Mangrove Monitoring Station, Tangjia Town	Mixed educational/ commercial and residential/industrial	13m	13m	Jan 2010
Jinjuzui (Foshan)	Foshan City Communist Party School, Jinjuzui, Shunde District	Tourist and cultural /educational	27m	17m	Oct 1999
Huijingcheng (Foshan)	No. 127, Fenjiang Nan Road, Chancheng District	Urban: mixed residential/commercial/ industrial	24m	14m	Feb 2000
Donghu (Jiangmen)	Donghu Park, Jiangmen	City	17.5m	5m	Nov 2001
Chengzhong (Zhaoqing)	No. 17, Qintian Road, Zhaoqing	Urban: mixed residential/commercial	21m	16m	Jun 2001
Xiapu (Huizhou)	No. 4 Xiabuhengjiang Road No. 3, Huicheng District	Urban: commercial	49m	20m	Dec 1999
Jinguowan (Huizhou)	Jinguowan Ecological Farm, Huizhou	Residential	77m	8m	Oct 2004
Nancheng-yuanling (Dongguan)	Nanchengyuanling Community, Dongguan	Mixed residential/ commercial/industrial	33 m	18m	Sep 2010
Zimaling (Zhongshan)	Zimaling Park, Zhongshan	Mixed residential/ commercial	45 m	7m	Aug 2002
Tsuen Wan (Hong Kong)	60 Tai Ho Road, Tsuen Wan	Urban: mixed residential/commercial/ industrial	21m	17m	Aug 1988
Tap Mun (Hong Kong)	Tap Mun Police Station	Background: rural	26m	11m	Apr 1998
Tung Chung (Hong Kong)	6 Fu Tung Street, Tung Chung	New Town: residential	34.5m	27.5m	Apr 1999

Annex B：Measurement Methods of Air Pollutant Concentration

Pollutants	**Measuring Principles**
Sulphur Dioxide	UV fluorescence / Differential Optical Absorption Spectroscopy
Nitrogen Dioxide	Chemiluminescence / Differential Optical Absorption Spectroscopy
Ozone	UV absorption / Differential Optical Absorption Spectroscopy
Respirable Suspended Particulates (PM_{10})	Oscillating microbalance (TEOM) Beta particulate monitor