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

A Report of Monitoring Results in 2016

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Report Prepared by	**:**	**Guangdong Provincial Environmental Monitoring Centre** **Environmental Protection Department, Hong Kong SARG** **Environmental Protection Bureau, Macao SARG** **Meteorological and Geophysical Bureau, Macao SARG**
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Purpose of the Report

This report provides the 2016 monitoring results from the Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network and their statistical analysis.

Contents

Page

1. Foreword 6

2. Introduction to Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network **6**

3. Operation of the Network **9**

3.1 Quality Control (QC) and Quality Assurance (QA) Activities **9**

3.2 Accuracy and Precision **9**

4. Statistical Analysis of Pollutant Concentrations **11**

4.1 Sulphur Dioxide (SO_2) **11**

4.2 Nitrogen Dioxide (NO_2) **15**

4.3 Ozone (O_3) **19**

4.4 Respirable Suspended Particulates (PM_{10}) **23**

4.5 Fine Suspended Particulates ($PM_{2.5}$) **26**

4.6 Carbon Monoxide (CO) **29**

4.7 Monthly Variations of Pollutant Concentrations **33**

4.8 Annual Variations of Pollutant Concentrations (2006-2016) **34**

Annex A：Site Information of Monitoring Stations **36**

Annex B：Measurement Methods of Air Pollutant Concentration **38**

List of Tables

Page

Table 4.1a：Hourly averages of Sulphur Dioxide (the monthly maxima) 12

Table 4.1b：Daily averages of Sulphur Dioxide (the monthly maxima and the 98th percentile) 13

Table 4.1c：The monthly and annual averages of Sulphur Dioxide 14

Table 4.2a：Hourly averages of Nitrogen Dioxide (the monthly maxima) 16

Table 4.2b：Daily averages of Nitrogen Dioxide (the monthly maxima and the 98th percentile) 17

Table 4.2c：The monthly and annual averages of Nitrogen Dioxide 18

Table 4.3a：Hourly averages of Ozone (the monthly maxima) 20

Table 4.3b：Daily maximum 8-hour averages of Ozone (the monthly maxima and the 90th percentile) 21

Table 4.3c：The monthly and annual averages of Ozone 22

Table 4.4a：Daily averages of PM_{10} (the monthly maxima and the 95th percentile) 24

Table 4.4b：The monthly and annual averages of PM_{10} 25

Table 4.5a：Daily averages of $PM_{2.5}$ (the monthly maxima and the 95th percentile) 27

Table 4.5b：The monthly and annual averages of $PM_{2.5}$ 28

Table 4.6a：Hourly averages of CO (the monthly maxima) 30

Table 4.6b：Daily averages of CO (the monthly maxima and the 95th percentile) 31

Table 4.6c：The monthly and annual averages of CO 32

Table 4.8 : Annual averages of the pollutants from the monitoring network 34

List of Figures

Page

Figure 1：Spatial distribution of monitoring stations (Nov 2005 to Sep 2014) 7

Figure 2：Spatial distribution of monitoring stations in the Network 8

Figure 3：Accuracy of the monitoring network in 2016 10

Figure 4：Precision of the monitoring network in 2016 10

Figure 5：Spatial distribution of annaul average concentrations of Sulphur Dioxide (SO_2) 11

Figure 6：Spatial distribution of annual average concentrations of Nitrogen Dioxide (NO_2) 15

Figure 7：Spatial distribution of annual average concentrations of Ozone (O_3) 19

Figure 8：Spatial distribution of annual average concentrations of Respirable Suspended Particulates (PM_{10}) 23

Figure 9：Spatial distribution of annual average concentrations of Fine Suspended Particulates ($PM_{2.5}$) 26

Figure 10：Spatial distribution of annual average concentrations of Carbon Monoxide (CO) 29

Figure 11：Monitoring network monthly variations of average pollutant concentrations 33

Figure 12：Trend of rates of changes of pollutant's annual averages in the monitoring network 35

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 growing 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 stations 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 Quality 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 an hourly basis through a new internet platform and publish a quarterly air quality monitoring report to replace the previous half-yearly report and continue publishing the 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 Quality Monitoring Network". The number of monitoring stations was increased from 16 to 23. 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. Eight of Guangdong stations were operated by the operation-cum-maintenance agencies commissioned by the State since November 2016.

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)

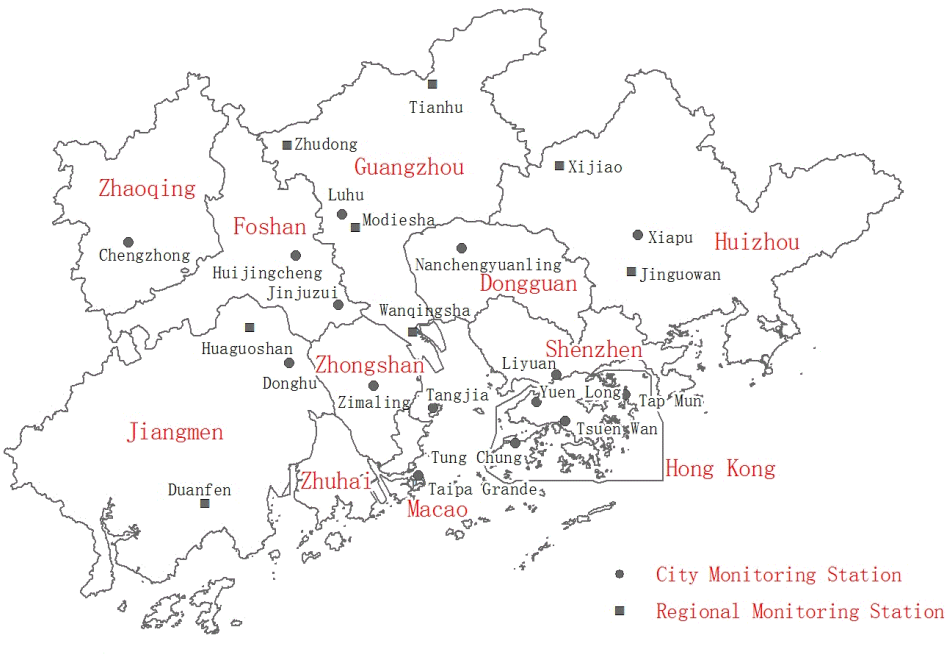

Figure 2：Spatial distribution of monitoring stations in the Network

Remark: For the boundary of the administrative division of the Macao Special Administrative Region, according the Decree n.º665 of the State Council of the People's Republic of China, "the map of the administrative division of the Macao Special Administrative Region" was approved at the 116th Executive Meeting of the State Council on 16 December 2015.

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 2016, which covers fully the monitoring results of 6 monitoring parameters recorded at 23 monitoring stations 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.

3. Operation of the Network

Owing to the extensive renovation work at the Tap Mun monitoring station in Hong Kong, the station was temporarily suspended from 30 November 2015 to 26 February 2016.

The operation of the Network was generally smooth in 2016, the average hourly data capture rates of all monitoring stations in the Network was 95.8% (Excluding the data recorded at Tap Mun monitoring station from January to February).

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

The governments of Guangdong, Hong Kong, and Macao 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 and evaluate, on a quarterly basis, the setup of the network and performance of equipment, QA/QC works, data transmission system and the operation of monitoring stations. 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 performance goals set for the gaseous pollutants and suspended particulates (PM_{10} and $PM_{2.5}$) are ±20% and ±15% respectively, these limits are similar to those of the United States Environmental Protection Agency and other international standards. In 2016, we have carried out 415 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 -9.4% and 12.8% and was within the specified performance goals (see Figure 3).

Precision is a measure of repeatability and is calculated in accordance with the QA/QC Operating Procedures. The performance goals adopted for the gaseous pollutants and suspended particulates (PM_{10} and $PM_{2.5}$) are ±15%. In 2016, we have carried out 3474 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 -14.2% and 14.2% and was within the specified performance goals (see Figure 4). Overall, the QA/QC performance of the monitoring network was good in 2016, and met all the requirements specified in the QA/QC Operating Procedures.

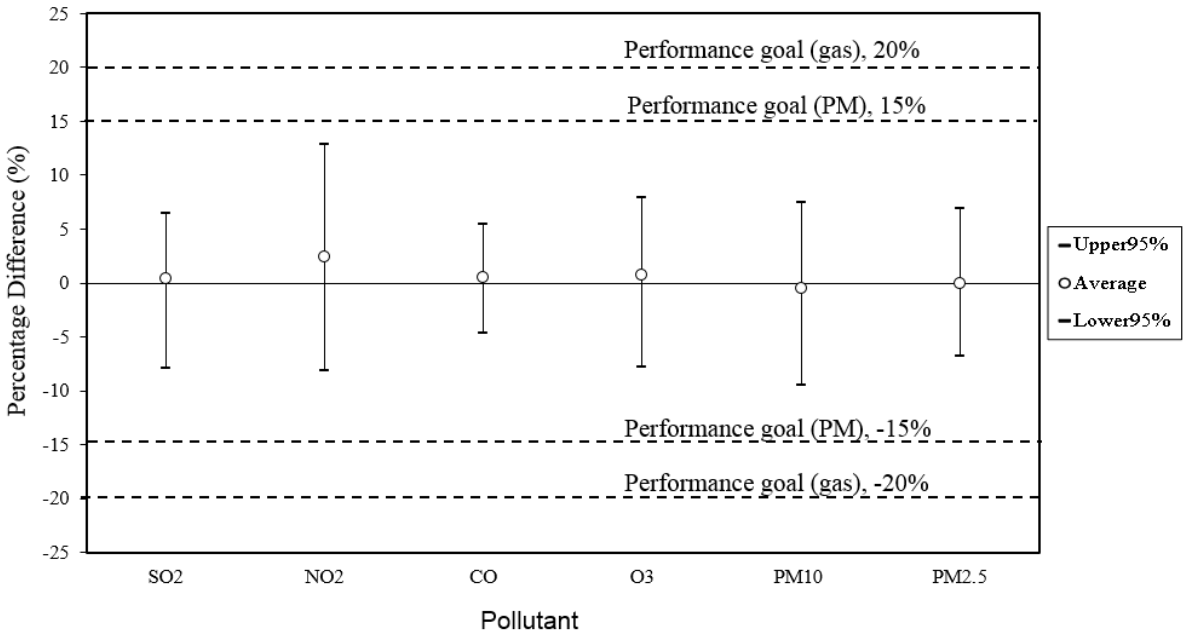

Figure 3：Accuracy of the monitoring network in 2016

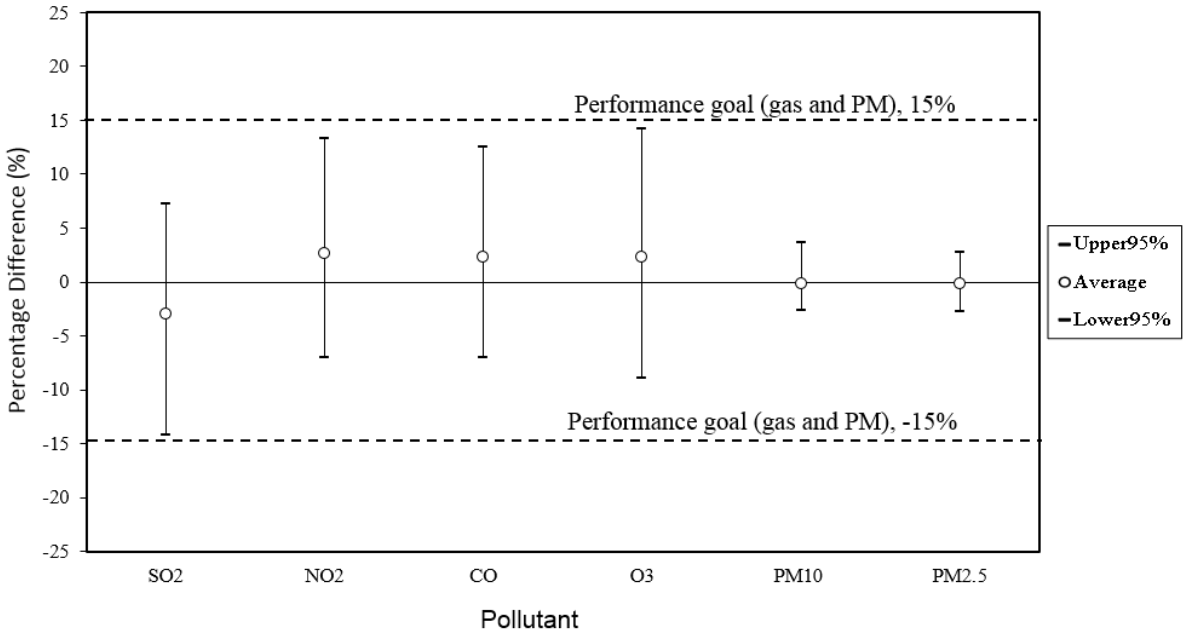

Figure 4：Precision of the monitoring network in 2016

4. Statistical Analysis of Pollutant Concentrations

Starting from 2014 annual report, the air quality assessment is conducted based on the class II limits of the national "Ambient Air Quality Standards" (NAAQS) (GB3095-2012). The Tap Mun monitoring station in Hong Kong was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation and statistical analysis owing to its low data capture rate in 2016 but for reference only.

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 5 μg/m^3 to 22 μg/m^3 in 2016; all were in compliance with the national annual air quality concentration limit (60 μg/m^3). As shown in Figure 5, the annual average concentrations of SO_2 in PRD were in general quite low.

During the year, all monitoring stations in the Network were in compliance with the national 24-hour average air quality concentration limit (150 μg/m^3) and 1-hour concentration limit （500 μg/m^3） of SO_2. Summary of the monthly maximum hourly and daily averages of SO_2 with the 98th percentile at various stations are in Table 4.1a and Table 4.1b, respectively. Summary of the monthly and annual averages of SO_2 at various stations are in Table 4.1c.

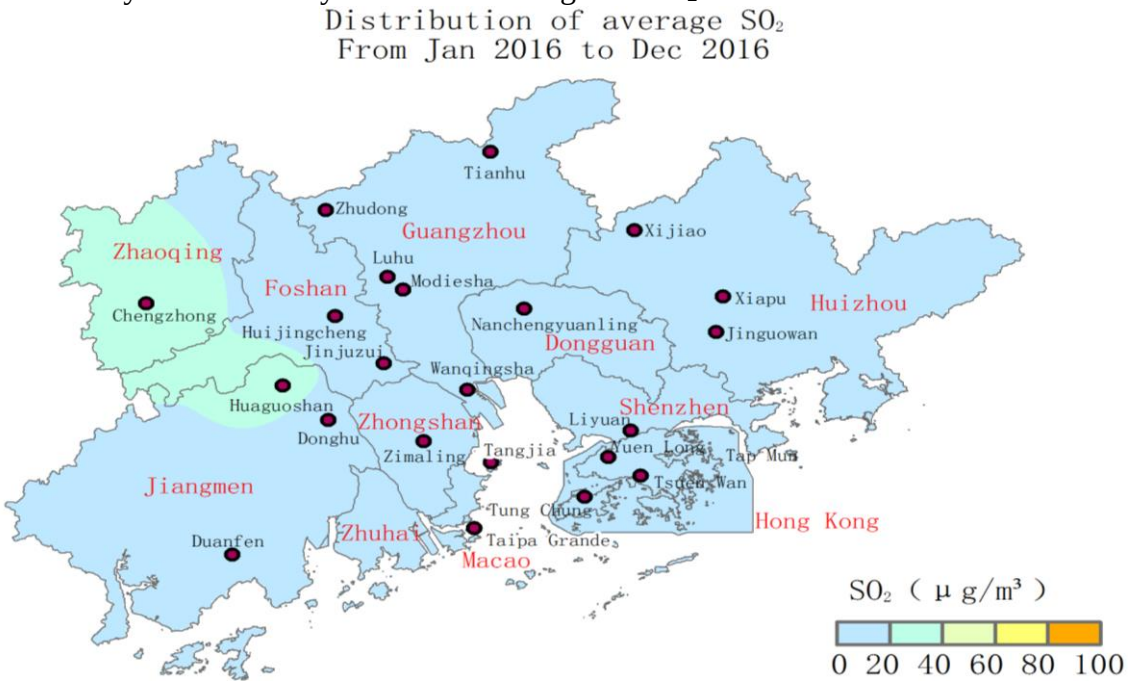

Figure 5：Spatial distribution of annual average concentrations of Sulphur Dioxide (SO_2)

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.1a：Hourly averages of Sulphur Dioxide (the monthly maxima)

[Class II limit: 500 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	32	37	65	38	34	119	37	284	38	32	40	28
Modiesha (Guangzhou)	40	73	81	50	42	27	49	44	41	35	50	39
Wanqingsha (Guangzhou)	54	47	80	98	67	68	49	60	43	68	90	95
Tianhu (Guangzhou)	21	28	41	43	28	36	34	21	26	23	34	29
Zhudong (Guangzhou)	56	42	55	51	61	46	66	61	68	64	67	89
Liyuan (Shenzhen)	14	16	34	28	20	24	29	26	22	18	12	16
Jinjuzui (Foshan)	48	48	59	73	64	52	37	81	75	35	75	42
Huijingcheng (Foshan)	56	75	65	48	70	40	83	45	51	89	66	80
Tangjia (Zhuhai)	34	28	45	37	23	23	15	21	49	42	44	63
Donghu (Jiangmen)	30	48	70	49	50	33	34	36	35	50	79	80
Duanfen (Jiangmen)	35	25	33	28	24	18	28	21	26	34	31	44
Huaguoshan (Jiangmen)	94	82	95	134	83	64	89	58	63	68	98	136
Chengzhong (Zhaoqing)	153	144	398	246	334	424	224	165	224	351	166	104
Xiapu (Huizhou)	21	76	31	26	26	39	65	68	36	31	24	28
Xijiao (Huizhou)	39	34	23	25	26	35	36	28	44	51	50	56
Jinguowan (Huizhou)	25	40	31	19	18	40	39	35	53	24	17	32
Zimaling (Zhongshan)	43	165	49	36	43	17	41	29	47	41	47	53
Nanchengyuanling (Dongguan)	45	28	38	36	61	33	64	53	66	43	46	42
Tap Mun (Hong Kong) #	--	--	37	42	20	26	43	29	25	17	19	21
Tsuen Wan (Hong Kong)	54	70	94	85	57	43	49	62	43	37	30	57
Yuen Long (Hong Kong)	32	24	26	38	29	51	34	34	39	27	21	35
Tung Chung (Hong Kong)	54	32	46	44	32	32	37	45	55	39	30	67
Taipa Grande (Macao)	29	23	99	46	37	82	123	49	36	30	43	40

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.1b: Daily averages of Sulphur Dioxide (the monthly maxima and the 98th percentile)

[Class II limit: 150 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	98th percentile
Luhu (Guangzhou)	14	25	24	23	18	14	17	25	21	16	23	16	100%	23
Modiesha (Guangzhou)	25	19	40	30	16	12	23	22	18	17	26	21	100%	25
Wanqingsha (Guangzhou)	36	26	42	37	25	22	23	27	25	26	37	51	100%	39
Tianhu (Guangzhou)	14	16	24	24	17	18	17	12	15	15	21	20	100%	18
Zhudong (Guangzhou)	22	19	28	28	25	19	29	27	27	26	35	33	100%	28
Liyuan (Shenzhen)	9	12	14	14	12	11	16	13	13	13	10	14	100%	13
Jinjuzui (Foshan)	31	23	34	29	19	21	15	51	23	19	29	25	100%	35
Huijingcheng (Foshan)	42	34	38	31	32	17	25	19	26	31	32	42	100%	32
Tangjia (Zhuhai)	20	13	16	12	11	8	8	9	17	19	22	23	100%	19
Donghu (Jiangmen)	19	22	37	24	28	17	18	15	22	23	25	37	100%	26
Duanfen (Jiangmen)	19	11	15	13	12	6	8	14	13	17	22	23	100%	21
Huaguoshan (Jiangmen)	50	39	48	44	42	28	28	30	31	30	45	49	100%	43
Chengzhong (Zhaoqing)	44	27	106	66	69	40	64	43	32	43	49	26	100%	63
Xiapu (Huizhou)	9	22	14	11	10	13	24	23	10	9	15	19	100%	19
Xijiao (Huizhou)	19	13	12	14	9	16	29	18	20	20	19	23	100%	19
Jinguowan (Huizhou)	14	15	13	12	10	12	20	15	20	8	12	15	100%	15
Zimaling (Zhongshan)	26	30	28	22	19	9	21	14	23	26	26	28	100%	25
Nanchengyuanling (Dongguan)	23	13	17	16	22	14	24	20	35	20	23	24	100%	23
Tap Mun (Hong Kong) #	--	--	13	19	12	11	16	12	16	11	14	16	--	--
Tsuen Wan (Hong Kong)	23	17	34	39	25	20	24	26	18	17	15	22	100%	24
Yuen Long (Hong Kong)	18	17	15	19	18	16	18	15	16	14	14	19	100%	16
Tung Chung (Hong Kong)	21	16	22	14	16	15	20	19	27	22	12	20	100%	20
Taipa Grande (Macao)	17	13	17	15	8	9	20	10	10	10	16	19	100%	17

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.1c：The monthly and annual averages of Sulphur Dioxide

[Class II limit for annual average: 60 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	7	12	14	17	8	10	9	16	12	11	14	11	12
Modiesha (Guangzhou)	10	8	15	16	8	5	10	11	11	9	13	13	11
Wanqingsha (Guangzhou)	20	17	23	24	16	13	12	14	17	19	21	28	19
Tianhu (Guangzhou)	6	7*	11	10	10	12	11	8	9	9	10	12	10
Zhudong (Guangzhou)	13	10	14	18	15	12	17	13	17	19	19	21	16
Liyuan (Shenzhen)	5	7	8	7	7	7	8	8	8	7	7	8	7
Jinjuzui (Foshan)	17	12	17	16	13	11	9	19	13	11	14	14	14
Huijingcheng (Foshan)	17*	14	20	20	18	8	10	10	11	12	15	19	14
Tangjia (Zhuhai)	10	8	7	6	6	5	4	6	13	11	14	13	9
Donghu (Jiangmen)	14	15	18	15	16	10	5	7	9	13	13	17	13
Duanfen (Jiangmen)	9	5	7	4	6	4	4	6	8	10	11	16	7
Huaguoshan (Jiangmen)	16	15	28	29	26	18	19	19	21	22	25	29	22
Chengzhong (Zhaoqing)	13	11	35	40	26	22	24	20	15	17	19	16	22
Xiapu (Huizhou)	5	6	6	6	6	6	11	10	6	6	9	13	7
Xijiao (Huizhou)	12	8	9	8	7	8	15	5	5	9	7	10	9
Jinguowan (Huizhou)	8	8	9	9	8	8	9	6	8	6	7	9	8
Zimaling (Zhongshan)	16	14	16	12	9	7	9	8	13	16	15	18	13
Nanchengyuanling (Dongguan)	12	7	10	8	8	9	10	12	15	13	12	15	11
Tap Mun (Hong Kong) #	--	--	9	9	9	8	9	9	10	9	10	13	--
Tsuen Wan (Hong Kong)	10	10	12	14	12	13	14	14	12	10	10	14	12
Yuen Long (Hong Kong)	12	13	10	9	9	11	11	10	11	10	10	12	11
Tung Chung (Hong Kong)	11	11	11	10	11	11	13	13	9	9	8	11	11
Taipa Grande (Macao)	5	5	6	4	3	2	2	2	3	6	8	11	5

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

* The hourly data capture rate of the pollutant is below 85%.

The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

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 10 μg/m^3 to 61 μg/m^3 in 2016, and 17 monitoring stations met the national annual air quality concentration limit (40 μg/m^3).

During the year, 6 monitoring stations in the Network recorded no exceedance of the national 24-hour average air quality concentration limit (80 μg/m^3) while the corresponding compliance rates in the Network ranged from 87.8% to 100%. 14 monitoring stations recorded no exceedance of national 1-hour NO_2 concentration limit (200 μg/m^3). Summary of the monthly maximum hourly and daily averages with the 98th percentile, the monthly and annual averages of NO_2 at various stations are in Tables 4.2a to 4.2c, respectively.

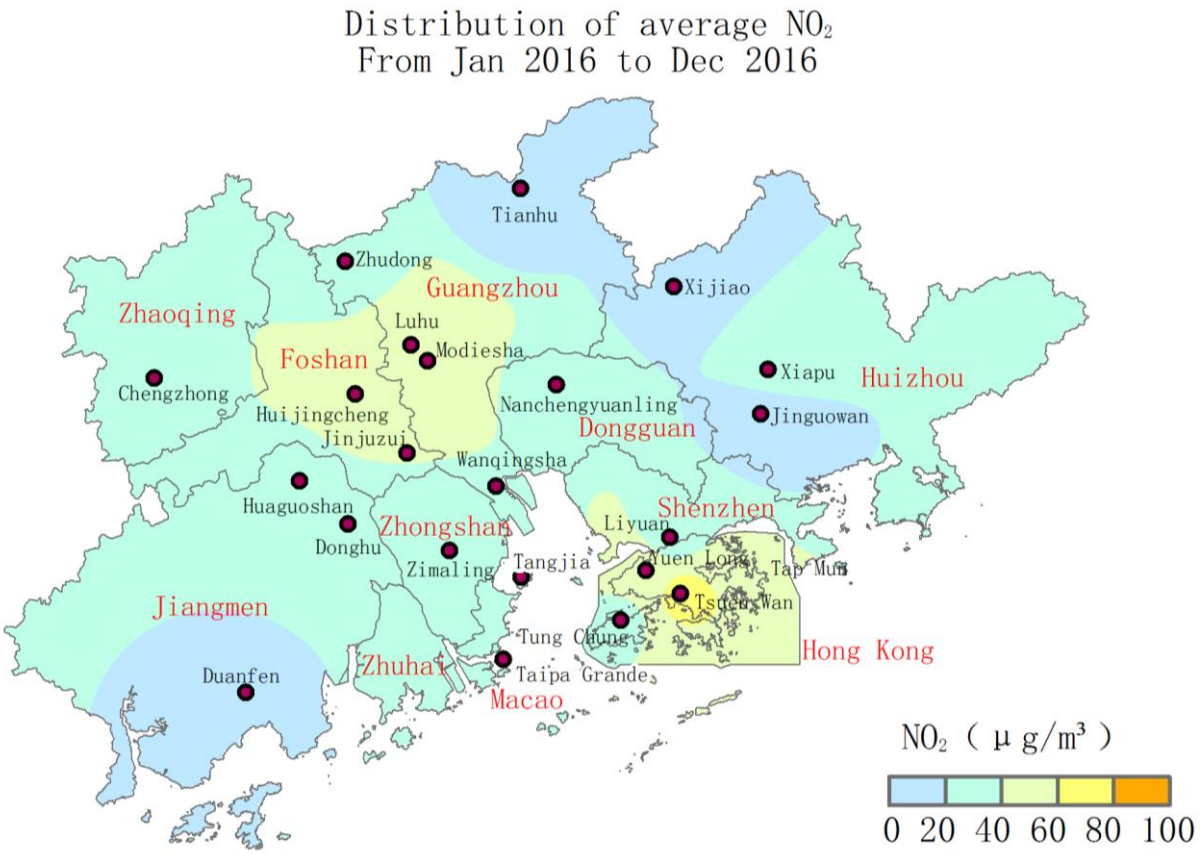

Figure 6: Spatial distribution of annual average concentrations of Nitrogen Dioxide (NO_2)

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.2a：Hourly averages of Nitrogen Dioxide (the monthly maxima)

[Class II limit: 200 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	145	121	219	163	202	132	126	155	197	159	232	221
Modiesha (Guangzhou)	187	160	179	152	112	135	145	156	140	118	270	269
Wanqingsha (Guangzhou)	123	135	165	127	118	98	83	117	120	105	161	196
Tianhu (Guangzhou)	43	21	55	58	32	42	50	42	32	54	47	39
Zhudong (Guangzhou)	155	103	122	120	81	83	77	105	94	80	123	92
Liyuan (Shenzhen)	120	146	208	108	80	84	115	114	133	87	198	125
Jinjuzui (Foshan)	125	122	147	106	92	86	76	115	97	148	195	164
Huijingcheng (Foshan)	169	155	200	158	146	112	137	152	156	161	263	237
Tangjia (Zhuhai)	105	103	133	100	87	77	59	63	68	76	131	149
Donghu (Jiangmen)	137	77	110	81	67	84	88	52	72	83	210	194
Duanfen (Jiangmen)	94	70	80	59	46	24	25	29	48	55	79	97
Huaguoshan (Jiangmen)	101	77	194	106	95	62	68	69	157	101	123	163
Chengzhong (Zhaoqing)	124	116	150	120	94	86	62	94	107	101	149	150
Xiapu (Huizhou)	95	100	154	83	57	64	72	76	59	70	140	148
Xijiao (Huizhou)	44	30	54	51	54	52	71	34	37	29	52	48
Jinguowan (Huizhou)	45	34	60	49	32	44	56	49	66	56	32	49
Zimaling (Zhongshan)	101	126	114	82	76	62	87	53	102	85	161	148
Nanchengyuanling (Dongguan)	130	114	139	107	98	91	99	104	124	144	172	176
Tap Mun (Hong Kong) #	--	--	90	63	50	55	59	62	103	90	34	71
Tsuen Wan (Hong Kong)	157	157	183	210	192	113	222	209	151	183	176	241
Yuen Long (Hong Kong)	137	149	176	130	98	87	150	131	128	120	164	217
Tung Chung (Hong Kong)	172	122	189	153	101	87	116	128	169	143	209	211
Taipa Grande (Macao)	107	128	146	109	98	84	115	85	92	88	165	184

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.2 a： Daily averages of Nitrogen Dioxide (the monthly maxima and the 98th percentile）

[Class II limit: 80 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	98th percentile
Luhu (Guangzhou)	105	68	154	108	70	55	65	73	87	68	119	141	91.0%	108
Modiesha (Guangzhou)	103	81	138	94	70	78	80	107	70	72	129	167	89.6%	116
Wanqingsha (Guangzhou)	75	65	111	70	64	49	41	50	57	56	88	137	95.5%	92
Tianhu (Guangzhou)	14	12	28	37	16	18	20	19	17	26	23	24	100.0%	26
Zhudong (Guangzhou)	82	61	81	89	55	42	40	58	55	41	71	54	99.2%	68
Liyuan (Shenzhen)	75	63	101	69	47	52	55	63	75	46	77	70	99.7%	67
Jinjuzui (Foshan)	79	71	107	64	54	50	42	59	52	61	92	85	97.6%	83
Huijingcheng (Foshan)	109	101	131	93	72	64	70	73	66	78	149	137	87.8%	124
Tangjia (Zhuhai)	59	43	69	53	39	31	28	39	46	41	60	80	100.0%	65
Donghu (Jiangmen)	78	46	58	45	37	30	40	31	37	50	119	112	97.2%	89
Duanfen (Jiangmen)	71	46	67	29	27	12	10	15	30	31	57	57	100.0%	57
Huaguoshan (Jiangmen)	69	52	109	67	54	34	39	38	45	46	63	98	98.8%	70
Chengzhong (Zhaoqing)	90	61	102	96	51	40	36	48	63	47	95	102	97.2%	85
Xiapu (Huizhou)	46	31	61	55	34	36	43	41	34	27	63	73	100.0%	55
Xijiao (Huizhou)	19	16	25	30	16	23	24	22	21	14	21	20	100.0%	22
Jinguowan (Huizhou)	20	17	35	30	17	24	24	24	32	21	20	28	100.0%	27
Zimaling (Zhongshan)	67	66	77	42	29	32	32	31	44	42	75	93	99.2%	74
Nanchengyuanling (Dongguan)	63	56	83	64	45	58	46	63	64	70	73	95	98.9%	74
Tap Mun (Hong Kong) #	--	--	31	30	18	16	37	24	48	19	18	28	--	--
Tsuen Wan (Hong Kong)	115	93	141	118	95	70	98	96	95	76	91	115	88.3%	105
Yuen Long (Hong Kong)	91	76	98	76	55	59	79	74	81	61	86	102	96.4%	91
Tung Chung (Hong Kong)	96	62	118	70	53	48	64	61	102	69	71	112	98.0%	80
Taipa Grande (Macao)	67	74	80	54	44	52	43	45	60	57	76	114	98.0%	80

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.2b：The monthly and annual averages of Nitrogen Dioxide

[Class II limit for annual average: 40 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	53	43	67	58	46	35	34	45	50	38	65	72	51
Modiesha (Guangzhou)	56	41	68	64	47	47	37	52	48	42	68	75	54
Wanqingsha (Guangzhou)	48	32	63	47	35	25	20	29	35	34	44	69	40
Tianhu (Guangzhou)	9	6	13	12	9	10	9	9	10	9	12	11	10
Zhudong (Guangzhou)	30	21	46	44	33	28	29	26	29	27	34	36	32
Liyuan (Shenzhen)	44	36	43	35	24	30	29	35	35	30	40	48	36
Jinjuzui (Foshan)	48	42	52	41	29	25	24	33	36	36	51	62	40
Huijingcheng (Foshan)	66*	46	70	59	46	37	35	46	47	43	68	79	54
Tangjia (Zhuhai)	38	25	36	30	22	18	15	22	21	22	35	49	28
Donghu (Jiangmen)	40	22	33	23	22	16	15	19	23	34	51	69	31
Duanfen (Jiangmen)	43	23	28	12	9	4	4	7	11	17	24	39	18
Huaguoshan (Jiangmen)	44	25	47	28	23	20	19	24	28	33	42	58	32
Chengzhong (Zhaoqing)	43	27	50	35	26	25	22	32	23	22	44	55	34
Xiapu (Huizhou)	25	17	33	30	22	25	25	24	20	17	27	37	25
Xijiao (Huizhou)	13	9	14	14	10	14	16	11	13	10	14	16	13
Jinguowan (Huizhou)	12	10	19	16	10	13*	14	12	15	12	15	20	14
Zimaling (Zhongshan)	44	28	40	23	15	13	13	19	23	25	33	58	28
Nanchengyuanling (Dongguan)	33	24	47	37	24	34	27	32	34	36	43	56	36
Tap Mun (Hong Kong) #	--	--	12	12	8	7	11	11	13	10	11	16	--
Tsuen Wan (Hong Kong)	63	62	70	73	57	52	53	63	58	49	55	72	61
Yuen Long (Hong Kong)	53	49	60	47	35	34	38	49	52	45	56	67	49
Tung Chung (Hong Kong)	47	41	48	34	27	23	24	39	44	34	43	58	39
Taipa Grande (Macao)	39	37	52	35	23	18	17	27	28	34	44	61	35

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

* The hourly data capture rate of the pollutant is below 85%.

The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only

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 2016, the annual averages of O_3 recorded by the Network ranged from 35 μg/m^3 to 76 μg/m^3 with higher average values being recorded in rural areas such as Tianhu of Guangzhou, Duanfen of Jiangmen 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 daily maximum 8-hour average concentration limit (160 μg/m^3) while the corresponding compliance rates in the Network ranged from 85.9% to 99.4%. For the 90th percentile of the daily maximum 8-hour averages, 6 monitoring stations exceeded the limit. As regards the national 1-hour O_3 concentration limit (200 μg/m^3), all monitoring stations have recorded exceedance in the year. Summary of the monthly maximum 1-hour, daily maximum 8-hour with the 90th percentile, the monthly and annual averages of O_3 at various stations are in Tables 4.3a to 4.3c, respectively.

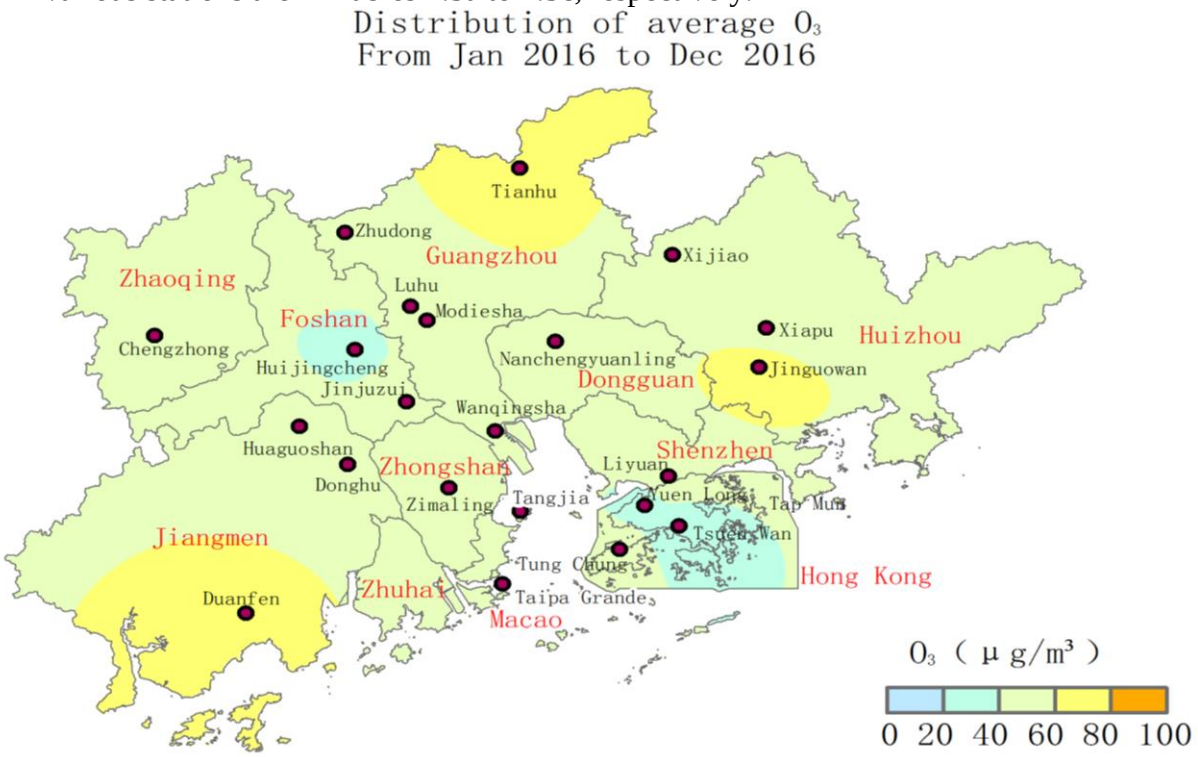

Figure 7：Spatial distribution of annual average concentrations of Ozone (O_3)

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.3a: Hourly averages of Ozone (the monthly maxima) [Class II limit: 200 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	103	131	220	132	170	241	393	351	453	186	329	228
Modiesha (Guangzhou)	108	138	227	208	252	265	385	311	308	197	297	200
Wanqingsha (Guangzhou)	161	167	263	184	374	232	339	352	327	269	442	316
Tianhu (Guangzhou)	142	137	205	204	235	256	262	262	269	195	235	142
Zhudong (Guangzhou)	128	141	231	218	292	286	322	330	323	248	401	183
Liyuan (Shenzhen)	164	139	200	252	235	108	280	289	261	194	234	193
Jinjuzui (Foshan)	101	149	268	203	320	246	314	344	299	234	361	263
Huijingcheng (Foshan)	132	140	202	93	263	263	330	318	257	185	332	212
Tangjia (Zhuhai)	147	136	159	144	147	84	125	163	212	182	159	230
Donghu (Jiangmen)	129	158	244	222	284	211	369	269	258	235	372	233
Duanfen (Jiangmen)	162	173	228	249	268	170	242	275	260	282	252	260
Huaguoshan (Jiangmen)	119	167	260	107	152	174	352	210	186	229	319	204
Chengzhong (Zhaoqing)	99	158	212	160	281	235	301	306	262	192	308	157
Xiapu (Huizhou)	173	383	202	182	191	221	266	321	196	137	179	151
Xijiao (Huizhou)	95	124	166	195	112	121	119	306	186	170	209	167
Jinguowan (Huizhou)	124	138	222	165	256	206	318	330	226	131	188	155
Zimaling (Zhongshan)	151	157	271	239	281	152	283	305	288	233	281	233
Nanchengyuanling (Dongguan)	139	110	171	171	289	212	317	317	371	200	286	171
Tap Mun (Hong Kong) #	--	--	188	190	213	127	381	235	235	182	204	208
Tsuen Wan (Hong Kong)	104	110	152	163	217	102	263	195	220	183	116	119
Yuen Long (Hong Kong)	133	109	149	252	249	87	351	273	290	214	199	193
Tung Chung (Hong Kong)	134	128	195	211	217	74	304	215	263	295	195	197
Taipa Grande (Macao)	183	140	182	191	297	142	186	251	307	266	299	230

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table4.3b：Daily maximum 8-hour averages of Ozone (the monthly maxima and the 90th percentile) [Class II limit: 160 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	90th percentile
Luhu (Guangzhou)	80	122	155	82	135	175	297	237	258	128	240	148	92.4%	151
Modiesha (Guangzhou)	87	134	193	152	215	202	301	252	249	147	252	152	90.8%	158
Wanqingsha (Guangzhou)	112	152	207	156	294	159	273	274	277	228	344	210	85.9%	178
Tianhu (Guangzhou)	108	126	192	154	206	213	238	197	234	168	220	134	91.2%	156
Zhudong (Guangzhou)	103	130	177	118	243	246	278	309	259	205	325	147	88.8%	171
Liyuan (Shenzhen)	122	129	155	154	168	90	253	207	190	131	149	152	96.6%	131
Jinjuzui (Foshan)	83	129	204	162	264	197	250	272	238	151	284	198	86.5%	172
Huijingcheng (Foshan)	92	112	164	80	224	195	287	261	197	148	247	155	93.3%	144
Tangjia (Zhuhai)	108	113	150	111	114	59	92	141	182	137	130	167	99.4%	110
Donghu (Jiangmen)	85	137	192	179	243	160	330	214	228	164	274	147	92.9%	147
Duanfen (Jiangmen)	119	150	185	210	221	122	219	228	219	222	215	187	87.8%	168
Huaguoshan (Jiangmen)	101	133	221	86	129	145	305	177	145	173	275	150	96.7%	131
Chengzhong (Zhaoqing)	89	139	180	121	224	172	258	262	238	160	229	107	90.2%	160
Xiapu (Huizhou)	125	289	154	134	167	169	210	239	184	116	148	134	95.8%	134
Xijiao (Huizhou)	84	119	137	137	97	88	103	243	168	134	160	135	98.2%	119
Jinguowan (Huizhou)	102	133	197	135	154	153	212	280	194	110	151	131	95.4%	140
Zimaling (Zhongshan)	113	118	231	188	225	101	214	234	235	185	234	166	88.7%	165
Nanchengyuanling (Dongguan)	105	91	130	141	270	170	238	246	335	157	210	138	89.7%	166
Tap Mun (Hong Kong) #	--	--	182	186	198	93	310	189	183	148	173	181	--	--
Tsuen Wan (Hong Kong)	84	93	137	144	144	50	198	134	172	124	97	95	99.1%	92
Yuen Long (Hong Kong)	87	100	133	134	158	69	289	199	187	133	125	131	98.3%	116
Tung Chung (Hong Kong)	93	102	152	150	158	65	247	168	193	180	140	96	98.3%	113
Taipa Grande (Macao)	133	116	149	144	227	57	174	194	222	195	201	173	96.6%	139

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table4.3c：The monthly and annual averages of Ozone

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	22	47	27	16	30	40	57	61	54	41	37	43	40
Modiesha (Guangzhou)	27	48	39	30	50	40	55	62	54	45	47	48	45
Wanqingsha (Guangzhou)	33	51	42	40	63	48	59	82	79	54	59	68	57
Tianhu (Guangzhou)	54	73	77	69	83	80	80	82	86	75	76	84	76
Zhudong (Guangzhou)	31	49	40	36	63	62	65	75	75	63	48	56	55
Liyuan (Shenzhen)	46	55	60	52	64	45	51	67	67	43	48	60	55
Jinjuzui (Foshan)	21	41	40	40	66	45	51	67	70	54	51	46	49
Huijingcheng (Foshan)	18	34	29	15	52	42	45	59	55	41	38	41	39
Tangjia (Zhuhai)	35	52	69	54	54	39	41	50	72	51	49	59	52
Donghu (Jiangmen)	19	35	38	32	57	42	46	61	55	49	42	45	43
Duanfen (Jiangmen)	35	57	60	65	76	45	47	71	82	74	67	74	63
Huaguoshan (Jiangmen)	23	46	41	26	36	31	52	56	52	51	45	51	43
Chengzhong (Zhaoqing)	27	44	37	41	65	52	54	72	81	58	47	40	51
Xiapu (Huizhou)	40	47	52	54	68	47	59	63	65	48	49	62	55
Xijiao (Huizhou)	38	49	63	47	34	29	41	61	60	52	49	64	49
Jinguowan (Huizhou)	46	64	68	62	73	63	59	72	67	51	58	70	62
Zimaling (Zhongshan)	25	38	44	50	64	44	55	77	75	54	47	51	52
Nanchengyuanling (Dongguan)	30	34	29	38	70	48	57	75	74	50	43	46	49
Tap Mun (Hong Kong) #	--	--	79	69	81	47	52	69	79	66	77	89	--
Tsuen Wan (Hong Kong)	34	32	39	26	40	18	23	30	47	37	43	49	35
Yuen Long (Hong Kong)	26	30	32	33	47	29	34	46	53	40	37	52	38
Tung Chung (Hong Kong)	29	34	47	51	65	35	44	45	51	37	36	40	43
Taipa Grande (Macao)	28	39	41	39	56	29	40	56	70	60	58	65	49

Remark : All concentration units are in micrograms per cubic metre ($\mu g/m^3$).
The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

4.4 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 2016, the annual averages of PM_{10} at various monitoring stations in the Network ranged from 32 μg/m^3 to 61 μg/m^3, and all monitoring stations met the national annual air quality concentration limit (70 μg/m^3).

During the year, 10 monitoring stations in the Network recorded no exceedance of the national 24-hour average air quality concentration limit (150 μg/m^3) while the corresponding compliance rates in the Network ranged from 96.6% to 100%. Summary of the monthly maximum daily averages of PM_{10} with the 95th percentile, the monthly and annual averages of PM_{10} at various stations are in Table 4.4a and Table 4.4b, respectively.

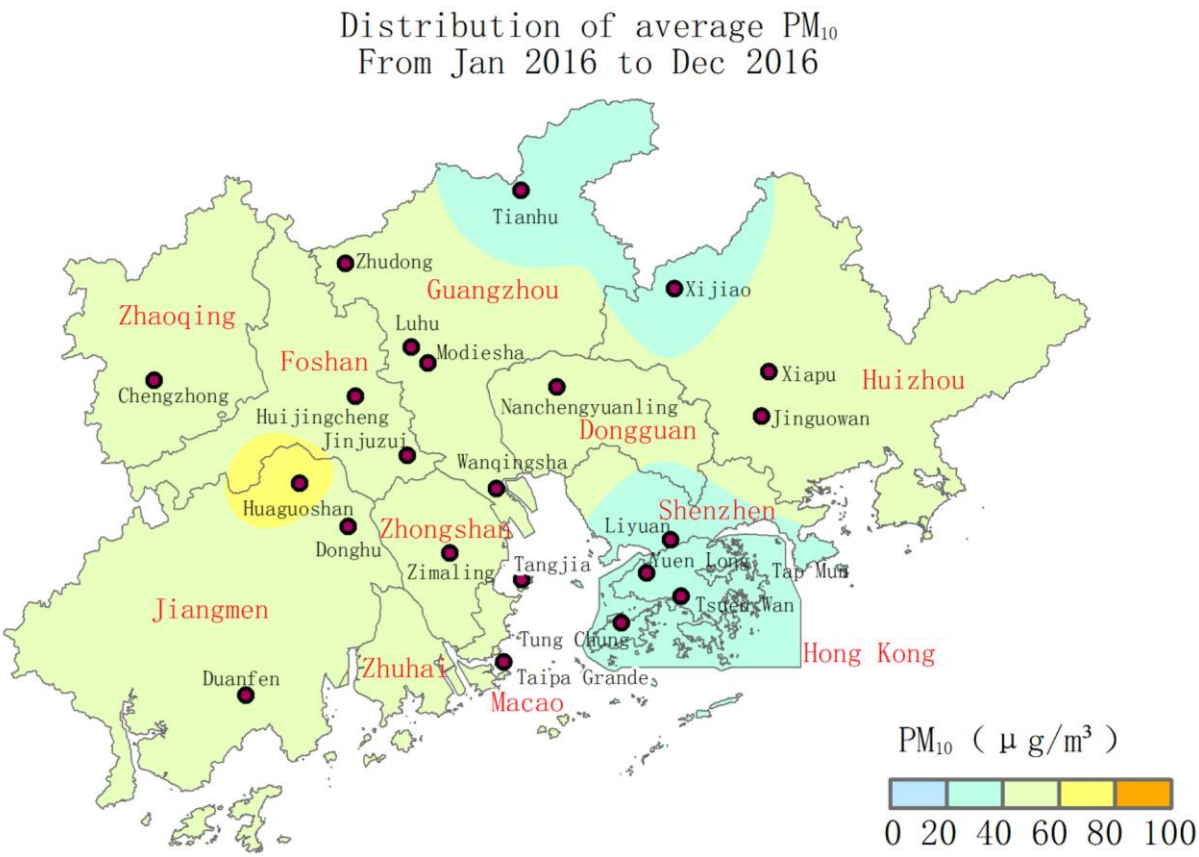

Figure 8: Spatial distribution of annual average concentrations of Respirable Suspended Particulates (PM_{10})

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.4a: Daily averages of PM_{10} (the monthly maxima and the 95th percentile)

[Class II limit: 150 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	95th percentile
Luhu (Guangzhou)	128	96	172	120	87	52	75	97	110	61	134	112	99.7%	96
Modiesha (Guangzhou)	141	107	219	116	100	57	99	136	121	74	158	195	99.1%	115
Wanqingsha (Guangzhou)	105	98	165	99	85	45	85	76	111	64	106	128	99.7%	99
Tianhu (Guangzhou)	75	108	134	129	73	52	57	102	85	58	79	73	100.0%	72
Zhudong (Guangzhou)	152	91	129	149	86	66	74	109	120	105	124	102	99.7%	102
Liyuan (Shenzhen)	92	110	107	67	58	33	78	66	84	56	83	117	100.0%	84
Jinjuzui (Foshan)	110	96	198	96	92	50	79	73	108	61	133	136	99.7%	101
Huijingcheng (Foshan)	136	103	175	96	91	62	73	83	102	83	165	142	99.0%	107
Tangjia (Zhuhai)	92	98	102	70	53	32	69	71	99	67	86	118	100.0%	86
Donghu (Jiangmen)	161	97	124	94	108	64	107	91	107	73	215	196	98.9%	111
Duanfen (Jiangmen)	87	95	96	69	61	29	59	67	87	79	89	124	100.0%	87
Huaguoshan (Jiangmen)	117	93	160	88	104	55	101	90	113	131	268	187	96.6%	137
Chengzhong (Zhaoqing)	167	99	146	143	109	86	70	116	146	85	175	150	98.6%	115
Xiapu (Huizhou)	78	109	153	93	61	49	68	80	89	65	102	110	99.7%	89
Xijiao (Huizhou)	61	84	93	126	57	45	70	94	71	54	64	73	100.0%	62
Jinguowan (Huizhou)	65	79	159	104	94	67	73	83	119	59	77	91	99.7%	77
Zimaling (Zhongshan)	97	89	138	72	74	33	74	61	93	64	94	121	100.0%	90
Nanchengyuanling (Dongguan)	97	94	178	90	102	57	85	83	125	66	115	124	99.7%	99
Tap Mun (Hong Kong) #	--	--	112	62	47	27	76	50	82	46	68	89	--	--
Tsuen Wan (Hong Kong)	103	117	104	63	54	29	34	53	87	43	58	87	100.0%	66
Yuen Long (Hong Kong)	90	140	112	67	45	27	70	62	84	57	79	105	100.0%	78
Tung Chung (Hong Kong)	120	97	94	56	49	24	52	46	101	59	82	124	100.0%	74
Taipa Grande (Macao)	112	116	109	91	73	29	66	73	113	93	104	130	100.0%	95

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.4b：The monthly and annual averages of PM_{10}

[Class II limit for annual average: 70 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	46	48	69	52	49	37	41	54	54	43	58	69	52
Modiesha (Guangzhou)	49	49	72	58	54	41	53	64	63	46	72	89	59
Wanqingsha (Guangzhou)	49	46	61	47	45*	28	35	45	54	47	54	86	50
Tianhu (Guangzhou)	30	38	47	39	39*	25	32	39	35	32	36	48	37
Zhudong (Guangzhou)	39	43	63	54	48	38	40	48	56	49	60	68	51
Liyuan (Shenzhen)	41	46	44	33	33	21*	28	37	39*	35	46	69	39
Jinjuzui (Foshan)	46	48	65	48	46	33	38	48	52	45	62	81	51
Huijingcheng (Foshan)	56*	53	72	53	47	35	36	42*	50	45	58	79	54
Tangjia (Zhuhai)	42	44	47	32	31	18	24	32	41	41	45	78	40
Donghu (Jiangmen)	58	40	53	51	45	36	41	56	60	54	73	94	55
Duanfen (Jiangmen)	47	48	47	34	34	19	25	33	44	49	53	86	43
Huaguoshan (Jiangmen)	49	46	61	46	45	28*	37	50	59	77	111	114	61
Chengzhong (Zhaoqing)	51	43	72	63	57	42	41	56	55	49	72	83	57
Xiapu (Huizhou)	36	51	54	42	40	32	40	38	40	40	54	73	45
Xijiao (Huizhou)	28	35	44	42	36	30	36	40	40	33	37	48	38
Jinguowan (Huizhou)	31	34	43	45	53	37*	39	49*	45	36	40	56	43
Zimaling (Zhongshan)	48	47	53	37	35	20	26	35	42	41	48	76	42
Nanchengyuanling (Dongguan)	47	45	67	49	47	35	39	51	53	45	57	76	51
Tap Mun (Hong Kong) #	--	--	37	27	25	17	22	27	35	31	35	51	--
Tsuen Wan (Hong Kong)	38	44	42	32	27	18	18	26	32	24	33	48	32
Yuen Long (Hong Kong)	41	51	50	32	28	18	21	29	39	36	44	66	38
Tung Chung (Hong Kong)	43	45	39	25	23	13	16	22	31	26	43	68	33
Taipa Grande (Macao)	50	51	52	38	40	19	28	36	46	49	55	86	46

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

* The hourly data capture rate of the pollutant is below 85%.

The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

4.5 Fine Suspended Particulates ($PM_{2.5}$)

Fine suspended particulates ($PM_{2.5}$) in the atmosphere come from a great variety of combustion sources, such as the emissions from power plants and diesel vehicles exhaust 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. $PM_{2.5}$ have significant effect on visibility.

In 2016, the annual averages of $PM_{2.5}$ at various monitoring stations in the Network ranged from 21 μg/m^3 to 39 μg/m^3, and 19 monitoring stations met the national annual air quality concentration limit (35 μg/m^3).

During the year, 1 monitoring station in the Network recorded no exceedance of the national 24-hour average air quality concentration limit (75μg/m^3) while the corresponding compliance rates in the Network ranged from 92.1% to 100%. Summary of the monthly maximum daily averages of $PM_{2.5}$ with the 95th percentile, the monthly and annual averages of $PM_{2.5}$ at various stations are in Table 4.5a and Table 4.5b, respectively.

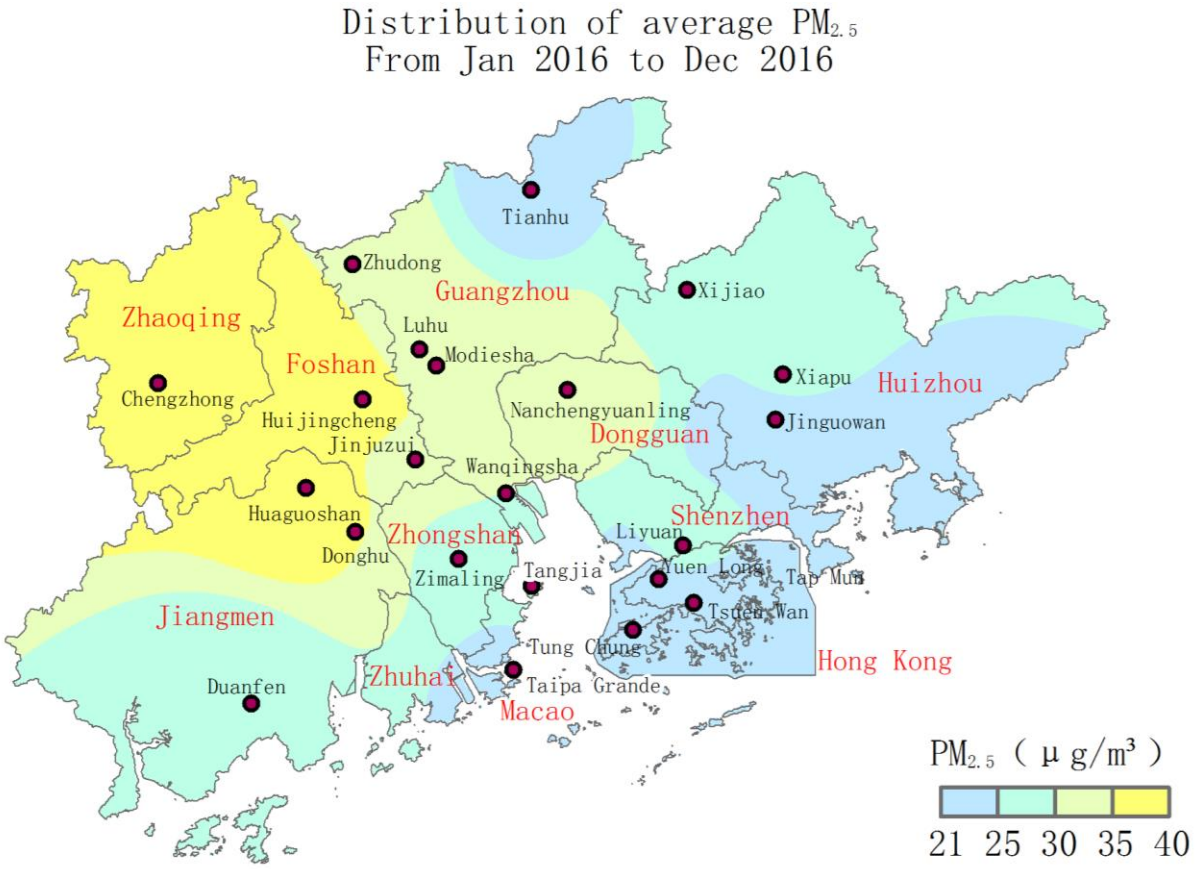

Figure 9: Spatial distribution of annual average concentrations of Fine Suspended Particulates ($PM_{2.5}$)

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.5a: Daily averages of $PM_{2.5}$ (the monthly maxima and the 95th percentile)

[Class II limit: 75 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	95th percentile
Luhu (Guangzhou)	114	68	132	112	57	50	55	78	76	45	71	61	97.5%	63
Modiesha (Guangzhou)	88	75	119	46	48	39	54	62	76	38	83	86	98.5%	62
Wanqingsha (Guangzhou)	80	55	99	55	54	27	53	48	70	45	67	77	98.8%	61
Tianhu (Guangzhou)	60	64	87	83	54	40	37	72	60	42	54	54	99.1%	52
Zhudong (Guangzhou)	108	74	84	94	60	50	53	85	88	78	95	70	95.4%	74
Liyuan (Shenzhen)	69	64	82	48	41	18	59	45	60	36	46	73	99.7%	52
Jinjuzui (Foshan)	77	75	136	67	62	39	49	52	74	39	84	84	98.0%	66
Huijingcheng (Foshan)	54	63	118	69	51	40	70	74	81	65	160	103	95.0%	74
Tangjia (Zhuhai)	69	55	67	47	39	17	55	51	62	49	57	75	100.0%	55
Donghu (Jiangmen)	124	54	92	69	68	55	75	64	73	57	147	128	95.2%	75
Duanfen (Jiangmen)	54	50	49	41	40	18	38	44	53	47	52	116	97.5%	52
Huaguoshan (Jiangmen)	83	56	112	57	67	42	67	58	69	71	157	131	92.1%	89
Chengzhong (Zhaoqing)	86	51	87	101	73	61	46	84	102	67	134	99	93.0%	79
Xiapu (Huizhou)	71	98	116	75	34	21	36	53	53	40	61	68	99.4%	53
Xijiao (Huizhou)	54	70	70	92	45	30	57	72	55	40	48	54	99.7%	49
Jinguowan (Huizhou)	51	60	76	61	40	21	40	50	66	38	48	63	99.7%	47
Zimaling (Zhongshan)	68	60	106	62	63	20	53	43	64	42	56	83	99.2%	60
Nanchengyuanling (Dongguan)	87	68	134	65	70	36	56	55	78	47	80	73	97.5%	67
Tap Mun (Hong Kong) #	--	--	68	44	34	14	49	35	50	28	39	55	--	--
Tsuen Wan (Hong Kong)	79	58	63	45	40	16	27	40	66	28	44	60	99.7%	48
Yuen Long (Hong Kong)	76	70	74	45	29	13	46	39	56	34	44	76	99.4%	51
Tung Chung (Hong Kong)	84	44	70	38	39	15	41	35	75	41	52	79	99.4%	46
Taipa Grande (Macao)	74	51	76	56	52	11	38	41	67	43	52	78	98.6%	52

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.5b：The monthly and annual averages of $PM_{2.5}$

[Class II limit for annual average: 35 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	35	35	48	41	32	24	26	35	31	26	34	38	34
Modiesha (Guangzhou)	28	31*	41	29*	27	20	24	33	37	24	35	45	31
Wanqingsha (Guangzhou)	31	30	37	27	26	15	19	28	33	30	36	51	30
Tianhu (Guangzhou)	21	26	31	26	24	15	19	21	23	23	25	33	24
Zhudong (Guangzhou)	29	32	43	36	32	26	26	35	39	36	42	47	35
Liyuan (Shenzhen)	29	33	32	23	20	12	16	23	25	23	29	42	26
Jinjuzui (Foshan)	32	34	46	33	28	20	22	31	34	28	39	49	33
Huijingcheng (Foshan)	32*	36	46	36	29	21	30	44	43	36	54	58	39
Tangjia (Zhuhai)	32	29	31	22	20	10	15	22	24	26	30	47	26
Donghu (Jiangmen)	35	22	31	35	29	18	20	34	39	36	50	63	35
Duanfen (Jiangmen)	28	27	27	19	18	7	10	18	25	26	29	61	25
Huaguoshan (Jiangmen)	36	32	44	31	28	18	20	31	36	42	64	73	38
Chengzhong (Zhaoqing)	37	24	50	43	34	28	27	40	39	35	53	58	39
Xiapu (Huizhou)	25	30	34	26	22	14	19	22	24	22	31	43	26
Xijiao (Huizhou)	23	29	34	30	26	19	25	27	29	25	27	37	28
Jinguowan (Huizhou)	22	23	24	22	22	14	17	22	25	21	22	36	22
Zimaling (Zhongshan)	37	28	36	29	24	11	15	24	28	28	31	51	29
Nanchengyuanling (Dongguan)	36	34	47	34	30	22	24	34	36	31	39	51	35
Tap Mun (Hong Kong) #	--	--	27	19	16	8	13	16	20	19	21	32	--
Tsuen Wan (Hong Kong)	26	28	29	23	17	11	12	18	22	17	22	33	22
Yuen Long (Hong Kong)	31	38	35	20	15	6	14	20	24	22	25	39	24
Tung Chung (Hong Kong)	27	26	26	16	16	8	10	15	21	19	29	43	21
Taipa Grande (Macao)	30	31	32	22	25	6	11	15	20	24	28	48	24

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

* The hourly data capture rate of the pollutant is below 85%.

The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

4.6 Carbon Monoxide (CO)

Carbon Monoxide (CO) is formed when the fuel is not completely burned. Except for methane conversion, plant emissions, forest fires and other natural sources, deforestation, grassland and waste incineration, and the use of fossil fuels and civilian fuel are the main anthropogenic sources of CO. In most urban areas, the major emission source is automobiles.

The annual averages of CO at various monitoring stations in the Network ranged from 0.6 mg/m^3 to 1.0 mg/m^3 in 2016. During the year, all monitoring stations in the Network were in compliance with the national 1-hour and 24-hour daily concentration limits (10 mg/m^3 and 4 mg/m^3). Summary of the monthly maximum hourly and daily averages with the 95th percentile, the monthly and annual averages of CO at various stations are in Tables 4.6a to 4.6c respectively.

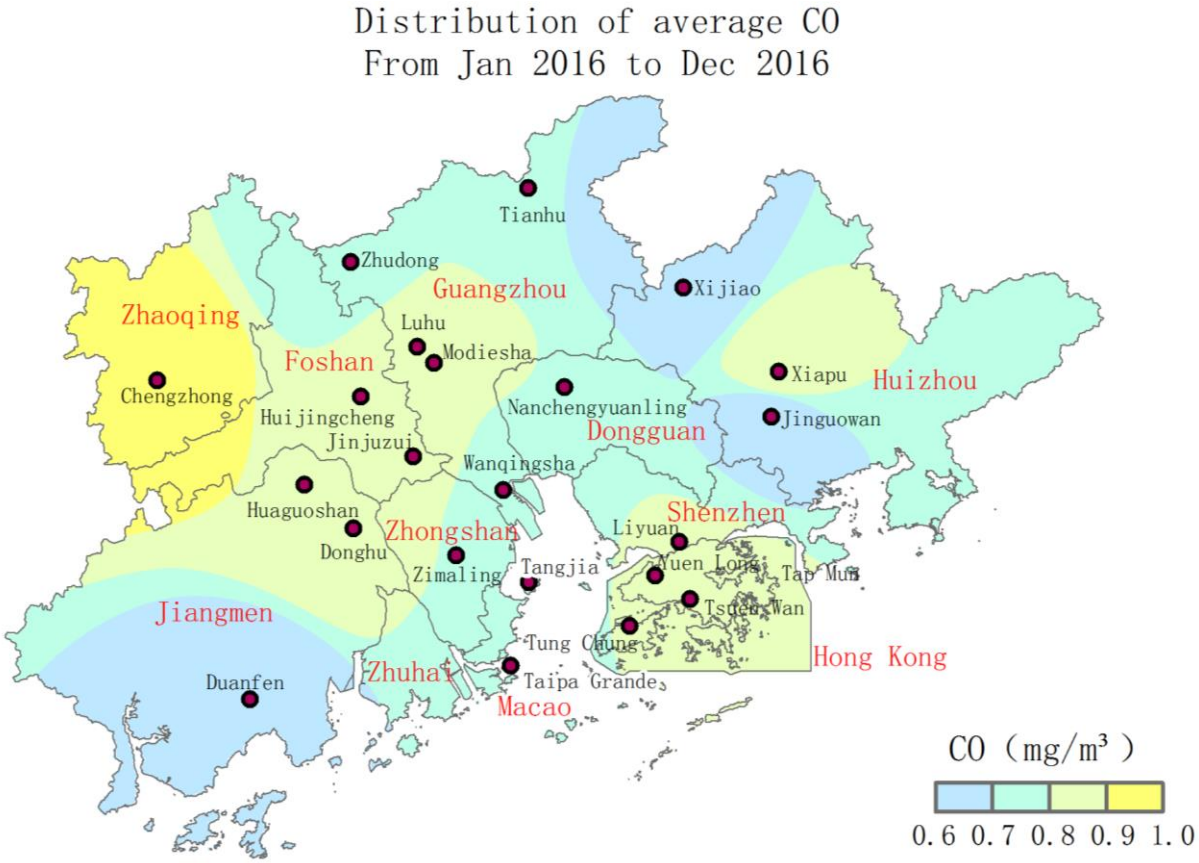

Figure 10: Spatial distribution of annual average concentrations of Carbon Monoxide (CO)

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the figure.

Table 4.6a: Hourly averages of CO (the monthly maxima) [Class II limit: 10 mg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	2.9	2.8	3.5	1.9	1.6	1.7	1.9	1.6	1.9	2.1	2.8	2.0
Modiesha (Guangzhou)	2.7	2.4	2.0	1.5	1.1	1.6	1.4	1.5	1.8	1.4	3.2	2.7
Wanqingsha (Guangzhou)	1.5	1.7	2.2	2.0	1.3	1.3	1.3	1.1	1.3	1.2	1.5	1.9
Tianhu (Guangzhou)	1.5	1.4	1.2	1.4	1.2	1.3	1.2	1.3	1.1	1.2	1.4	1.3
Zhudong (Guangzhou)	2.3	1.5	1.7	1.6	1.2	1.4	1.3	1.3	1.3	1.1	1.9	1.3
Liyuan (Shenzhen)	1.9	2.0	1.8	1.5	1.3	1.1	1.4	1.3	1.6	1.7	2.1	1.8
Jinjuzui (Foshan)	3.0	2.1	3.7	1.5	1.6	1.6	1.8	1.6	1.6	1.3	2.9	2.6
Huijingcheng (Foshan)	2.6	2.5	3.1	2.1	1.7	1.6	1.7	1.4	1.5	1.7	3.3	3.1
Tangjia (Zhuhai)	2.0	1.7	1.6	1.9	1.2	0.8	1.0	1.0	1.2	1.4	1.2	1.7
Donghu (Jiangmen)	3.7	2.8	3.3	2.2	2.8	1.9	1.9	1.6	1.7	2.0	6.5	4.0
Duanfen (Jiangmen)	1.6	1.6	2.5	1.4	1.2	1.2	1.0	1.0	1.2	1.4	1.3	1.5
Huaguoshan (Jiangmen)	2.2	1.8	3.7	1.9	1.5	1.3	1.4	1.4	1.6	1.5	2.4	1.9
Chengzhong (Zhaoqing)	3.4	2.7	3.3	2.5	2.0	1.8	1.4	1.5	1.6	1.5	2.4	2.8
Xiapu (Huizhou)	3.2	2.2	2.8	1.5	2.3	2.0	1.3	1.8	1.7	1.9	3.0	2.8
Xijiao (Huizhou)	1.6	1.4	1.3	1.4	1.7	0.9	1.1	1.3	1.1	1.4	1.0	1.8
Jinguowan (Huizhou)	1.4	1.2	1.8	1.8	1.1	1.4	1.1	1.4	1.5	1.5	1.2	1.0
Zimaling (Zhongshan)	2.3	1.9	2.3	2.1	1.4	3.3	1.6	1.5	1.4	1.5	2.3	2.1
Nanchengyuanling (Dongguan)	1.9	2.0	3.1	1.7	1.0	1.9	1.5	1.4	1.6	1.7	2.3	2.5
Tap Mun (Hong Kong) #	--	--	1.2	1.0	1.1	1.0	0.9	1.1	1.6	1.6	1.1	1.6
Tsuen Wan (Hong Kong)	1.7	1.6	3.0	2.0	1.4	1.3	1.0	1.4	1.5	1.5	1.5	1.6
Yuen Long (Hong Kong)	1.7	2.1	1.7	1.4	1.2	1.0	1.2	1.6	1.4	1.5	1.7	2.2
Tung Chung (Hong Kong)	1.7	2.4	2.0	1.6	2.3	1.5	1.1	1.4	1.4	1.5	1.6	1.9
Taipa Grande (Macao)	1.7	1.4	1.3	1.1	1.0	0.8	1.4	1.5	1.4	1.6	1.4	1.7

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table4.6b：Daily averages of CO（the monthly maxima and the 95th percentile）

[Class II limit: 4 mg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	95th percentile
Luhu (Guangzhou)	2	1.4	1.8	1.4	1.2	1.4	1.4	1	1.1	1.2	1.8	1.4	100.0%	1.4
Modiesha (Guangzhou)	1.6	1.3	1.3	1.2	0.8	1.3	0.9	1.1	1.3	1.2	1.9	1.7	100.0%	1.4
Wanqingsha (Guangzhou)	1.3	1.3	1.6	1.9	1.1	1.1	1.1	0.8	0.9	1.1	1.1	1.3	100.0%	1.2
Tianhu (Guangzhou)	1.3	1.3	1	1	0.7	0.8	1.1	1.1	1	1	1	1.1	100.0%	1.1
Zhudong (Guangzhou)	1.9	1.3	1.5	1.3	1	0.8	0.8	0.8	0.9	0.9	1.1	1.2	100.0%	1.1
Liyuan (Shenzhen)	1.5	1.2	1.4	1.1	1.1	0.9	0.9	1	1.3	1.2	1.2	1.6	100.0%	1.3
Jinjuzui (Foshan)	1.9	1.3	2.1	1.2	1.1	1.1	1.2	1.3	1.3	1.2	1.5	1.6	100.0%	1.5
Huijingcheng (Foshan)	1.5	1.5	2.2	1.4	1.1	0.7	1	1.2	1.2	1.1	2.1	1.8	100.0%	1.4
Tangjia (Zhuhai)	1.5	1	1.3	0.9	0.9	0.6	0.7	0.7	1	1.1	1	1.2	100.0%	1.0
Donghu (Jiangmen)	1.8	1.3	2	1.3	1.4	1.3	1.2	1	1.2	1.3	2.7	1.8	100.0%	1.3
Duanfen (Jiangmen)	1.3	0.9	1.2	0.8	0.9	0.6	0.8	0.7	0.9	0.9	1.1	1.2	100.0%	1.0
Huaguoshan (Jiangmen)	1.6	1.6	2.8	1.4	1.2	1	1.1	1.1	1.4	1.1	1.4	1.5	100.0%	1.4
Chengzhong (Zhaoqing)	2.5	1.4	2.3	2	1.4	1.3	0.9	1	1.1	1	1.6	1.7	100.0%	1.4
Xiapu (Huizhou)	1.4	1.1	1.6	1.1	1.1	1	1	1.2	1.1	1.3	1.5	1.4	100.0%	1.2
Xijiao (Huizhou)	1.1	1.1	0.8	1	1.1	0.5	0.9	0.8	0.8	0.9	0.7	1.1	100.0%	1.0
Jinguowan (Huizhou)	1.1	0.9	0.9	0.8	0.9	1.2	0.9	1	1	1.2	0.7	0.9	100.0%	1.0
Zimaling (Zhongshan)	1.8	1.3	1.9	1.3	1.2	0.9	1	1.2	1	1.4	1.3	1.4	100.0%	1.2
Nanchengyuanling (Dongguan)	1.4	1.2	1.6	1.4	0.8	1.1	1	1.1	1.4	1.3	1.4	1.4	100.0%	1.3
Tap Mun (Hong Kong) #	--	--	0.8	0.9	1	0.9	0.7	1	1.3	1.1	1.1	1.4	--	--
Tsuen Wan (Hong Kong)	1.5	1.2	1.7	1.5	1.2	0.9	0.9	0.8	1.2	1	1.2	1.4	100.0%	1.3
Yuen Long (Hong Kong)	1.2	1.2	1.2	1	1	0.8	1.1	1.1	1.1	1	1.1	1.3	100.0%	1.1
Tung Chung (Hong Kong)	1.4	1.4	1.2	1.3	1	0.8	0.9	1	1.2	1.2	1.2	1.5	100.0%	1.2
Taipa Grande (Macao)	1.2	1	0.9	0.9	0.8	0.6	0.7	0.7	1.2	1.2	1.2	1.3	100.0%	1.0

Remark: # The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

Table 4.6c：The monthly and annual averages of CO

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	1.1	0.8	1.1	0.9	0.8	0.7	0.9	0.7	0.7	0.9	1.0	1.0	0.9
Modiesha (Guangzhou)	1.2	0.8	0.5	0.6	0.4	1.1	0.5	0.8	1.0	0.9	1.0	1.2	0.8
Wanqingsha (Guangzhou)	1.0	0.7	0.9	0.7	0.7	0.6	0.6	0.5	0.6	0.8	0.7	0.9	0.7
Tianhu (Guangzhou)	0.7	0.7	0.7	0.6	0.4	0.6	0.8	0.8	0.7	0.8	0.7	0.7	0.7
Zhudong (Guangzhou)	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.7
Liyuan (Shenzhen)	1.1	0.9	0.9	0.6	0.8	0.5	0.5	0.8	0.8	0.9	0.9	1.0	0.8
Jinjuzui (Foshan)	1.2	0.9	1.3	0.7	0.9	0.8	0.9	1.0	0.9	0.7	0.9	1.1	0.9
Huijingcheng (Foshan)	1.1*	0.8	1.0	0.9	0.6	0.3	0.6	0.8	0.9	0.8	1.1	1.1	0.8
Tangjia (Zhuhai)	0.9	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.7	0.7	0.6	0.9	0.7
Donghu (Jiangmen)	1.2	1.0	1.0	0.8	0.9	0.8	0.7	0.8	0.8	0.9	1.0	1.1	0.9
Duanfen (Jiangmen)	0.9	0.7	0.7	0.5	0.5	0.5	0.4	0.5	0.6	0.7	0.7	0.8	0.6
Huaguoshan (Jiangmen)	1.2	1.2	1.2	0.9	0.8	0.8	0.7	0.7	0.8	0.9	0.9	1.0	0.9
Chengzhong (Zhaoqing)	1.3	1.1	1.2	1.0	0.9	0.8	0.7	0.8	0.8	0.8	1.1	1.2	1.0
Xiapu (Huizhou)	1.1	0.9	1.0	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	0.9
Xijiao (Huizhou)	0.9	0.7	0.6	0.5	0.8	0.5	0.5	0.5	0.5	0.7	0.4	0.7	0.6
Jinguowan (Huizhou)	0.8	0.6	0.7	0.6	0.5	0.8	0.6	0.7	0.7	0.6	0.5	0.5	0.6
Zimaling (Zhongshan)	1.1	0.9	0.9	0.8	0.8	0.6	0.7	0.8	0.8	0.8	0.8	1.0	0.8
Nanchengyuanling (Dongguan)	1.1	0.8	0.7	0.7	0.5	0.7	0.7	0.8	0.9	0.9	1.0	1.2	0.8
Tap Mun (Hong Kong) #	--	--	0.5	0.6	0.7	0.6	0.5	0.7	0.9	0.8	0.8	0.9	--
Tsuen Wan (Hong Kong)	1.1	1.0	1.1	1.1	1.0	0.8	0.5	0.6	0.7	0.8	0.9	0.9	0.9
Yuen Long (Hong Kong)	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.7	0.8	0.8	0.8	0.9	0.8
Tung Chung (Hong Kong)	0.9	1.0	0.8	0.9	0.6	0.5	0.6	0.7	0.7	0.9	0.9	0.9	0.8
Taipa Grande (Macao)	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.7	0.8	0.8	0.9	0.7

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

* The hourly data capture rate of the pollutant is below 85%.

The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016, its data were not used for annual evaluation owing to its low data capture rate in 2016 but for reference only.

4.7 Monthly Variations of Pollutant Concentrations

Figure 11 shows the monthly variations of the major pollutants (Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3), Respirable Suspended Particulates (PM_{10}), Fine Suspended Particulates ($PM_{2.5}$), and Carbon Monoxide (CO)) recorded by the Network in 2016. The overall concentrations of SO_2, NO_2, PM_{10}, $PM_{2.5}$, and CO were generally higher during the winter season (first and fourth quarters of the year) and relatively lower in the summer months. The lower pollutant 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 September 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.

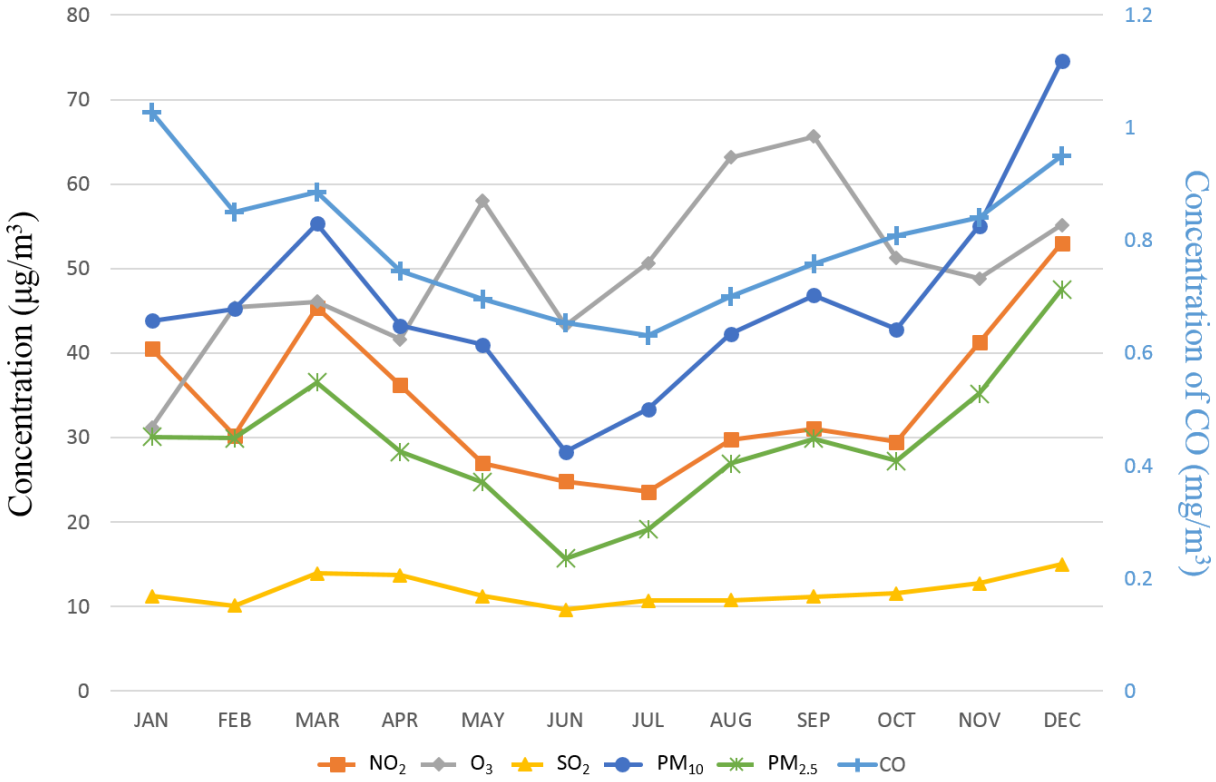

Figure 11：Monitoring network monthly variations of air pollutant concentrations

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the calculation of the monthly variation of pollutant concentrations.

4.8 Annual Variations of Pollutant Concentrations (2006-2016)

Table 4.8 shows the annual average concentrations of air pollutants recorded by the Network from 2006 to 2016, while Figure 12 shows the trend of the annual pollutant concentrations by percentage changes. The trend of annual average concentrations of CO and $PM_{2.5}$ were not included here, as they were not regularly monitored before the enhancement of the network in September 2014.

From 2006 to 2016, the annual averages recorded by the Network for SO_2, NO_2, and PM_{10} decreased by 74%, 24% and 38% respectively, which exhibited an obvious downward trend with an annual descending rate of about 3.5, 1.1 and 2.8 $\mu g/m^3$ respectively. These reductions indicate that the measures implemented in recent years by joint or individual effort of Guangdong, Hong Kong and Macao, including the retrofitting of power plants with flue-gas desulphurization facilities, tightening the vehicle emission standards, prohibiting import of heavy polluting vehicles, tightening the fuel specifications, and phasing out the more polluting industrial facilities in the PRD, etc., have brought improvements in the overall air quality in the PRD region. Moreover, the annual average of O_3 in 2016 decreased by 6% as compared with that in 2015, reflecting that the photochemical smog pollution in the region has improved. The Guangdong, Hong Kong and Macao governments will continue to implement emission reduction measures to further improve the air quality in the region and tackle the photochemical pollution problem.

Table 4.8: Annual averages of the pollutants in the monitoring network

Year	SO_2 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	O_3 ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (mg/m^3)
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	-	-
2015	13	33	53	49	32	0.791
2016	12	35	50	46	29	0.786

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the calculation of annual averages of the pollutants in 2016.

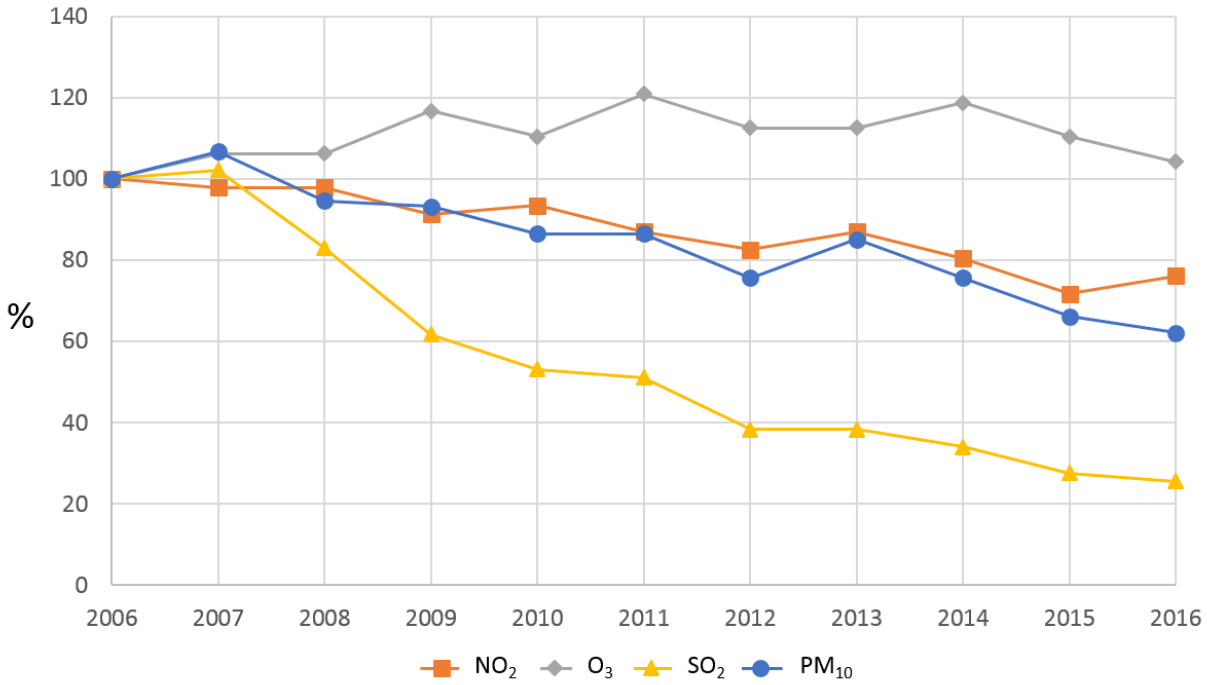

Figure 12：Trend of rates of changes of pollutant's annual averages in the monitoring network

Remark: The Tap Mun monitoring station was temporarily suspended from 30 November 2015 to 26 February 2016 and hence its data were not used for annual evaluation owing to its low data capture rate in 2016 and not included in the calculation of the rates of changes of pollutant's annual averages in 2016.

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	Jan 1993
Modiesha (Guangzhou)	Modiesha Street, Haizhu District	City	95m	45m	Dec 2011
Wanqingsha (Guangzhou)	HKUST Fok Ying Tung Research Institute, Nansha	Mixed educational/ commercial and residential/industrial	54m	28m	Oct 2004
Tianhu (Guangzhou)	Tianhu Park, Conghua	Background : rural	251m	13m	Oct 2004
Zhudong (Guangzhou)	Zhudong Village Committee, Chini Town, Huadu District	Rural	19m	10m	Dec 2011
Liyuan (Shenzhen)	Shennan Zhong Road, Futian District	City	38m	12m	Sep 1997
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
Tangjia (Zhuhai)	Qiao Island Mangrove Monitoring Station, Tangjia Town	Mixed educational/ commercial and residential/industrial	13m	13m	Jan 2010
Donghu (Jiangmen)	Donghu Park, Jiangmen	City	17.5m	5m	Nov 2001
Duanfen (Jiangmen)	Duanfen Middle School, Taishan	Rural	15m	12m	Dec 2011
Huaguoshan (Jiangmen)	Huaguoshan, Taoyuan, Heshan	Rural	25m	15m	Feb 2012
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
Xijiao (Huizhou)	Xijiao Village Committee, Boluo County	Rural	39m	12m	Dec 2011
Jinguowan (Huizhou)	Jinguowan Ecological Farm, Huizhou	Residential	77m	8m	Oct 2004

Monitoring Stations	Address	Area Type	Sampling Height (Above P.D.)	Above Ground	Date Commenced Operation
Zimaling (Zhongshan)	Zimaling Park, Zhongshan	Mixed residential/ commercial	45 m	7m	Aug 2002
Nancheng-yuanling (Dongguan)	Nanchengyuanling Community, Dongguan	Mixed residential/ commercial/industrial	33 m	18m	Sep 2010
Tap Mun (Hong Kong)	Tap Mun Police Station	Background: rural	26m	11m	Apr 1998
Tsuen Wan (Hong Kong)	60 Tai Ho Road, Tsuen Wan	Urban: mixed residential/commercial/ industrial	21m	17m	Aug 1988
Yuen Long (Hong Kong)	Yuen Long District Office, 269 Castle Peak Road, Yuen Long	New Town: residential	31m	25m	Jul 1995
Tung Chung (Hong Kong)	6 Fu Tung Street, Tung Chung	New Town: residential	34.5m	27.5m	Apr 1999
Taipa Grande (Macao)	Rampa do Observatorio, Taipa Grande	Rural	120m	10m	Mar 1999

Annex B: Measurement Methods of Air Pollutant Concentration

Pollutants	**Measuring Principles**
Sulphur dioxide (SO_2)	UV fluorescence / Differential Optical Absorption Spectroscopy
Nitrogen dioxide (NO_2)	Chemiluminescence / Differential Optical Absorption Spectroscopy
Ozone (O_3)	UV absorption / Differential Optical Absorption Spectroscopy
Respirable suspended particulates (PM_{10})	Oscillating microbalance (TEOM) Beta particulate monitor
Fine suspended particulates ($PM_{2.5}$)	Oscillating microbalance (TEOM) Beta particulate monitor Hybrid nephelometric/radiometric particulate mass monitor
Carbon monoxide (CO)	Gas filter correlation infrared absorption method Non-dispersive infrared absorption method