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

A Report of Monitoring Results in 2019

Report Number	**:**	**PRDAIR-2019-5**
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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 2019 monitoring results from the Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network and their statistical analysis.

Contents

List of Tables

Page

List of Figures

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.

With the growing concerns of air pollution control and economic development of the region, the environmental protection departments of Guangdong and Hong Kong had worked in collaboration with the environmental protection cum meteorological authorities of Macao to enhance the network by extending the coverage of monitoring area to Guangdong, Hong Kong and Macao in September 2014. The enhancements included the addition of monitoring stations from 16 to 23 to further improve the spatial distribution and the inclusion of two new monitoring parameters, i.e. carbon monoxide (CO) and fine suspended particulates ($PM_{2.5}$), to enrich the air quality monitoring information. At the same time, the network was renamed to "Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network" (the "Network").

With the enhancement of the network, the update of the national ambient air quality standards as well as the need for improving the reporting frequency of monitoring results, starting from 2014, the real-time hourly monitoring data was reported on a new internet platform to replace the daily Regional Air Quality Index (RAQI), the half-yearly report was also replaced by a quarterly report while the annual air quality monitoring report was maintained. The quarterly report is a brief statistical summary of the regional air quality monitoring results in a quarter. The annual report, in addition to the reporting of the monitoring data, provides a more detailed analysis and comparison of the 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 had been used for reporting Regional Air Quality Index (RAQI) to the public. At that time, the network comprised 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 continued to monitor the original 4 air pollutants with the addition of two new monitoring parameters, i.e. carbon monoxide (CO) and fine suspended particulates ($PM_{2.5}$ or FSP). Figure 2 shows the spatial

distribution of the monitoring stations after the enhancement of the network. Eight city monitoring stations of Guangdong have been operated by the operation-cum-maintenance agencies commissioned by the State since November 2016.

Based on the previous "Standard Operating Procedures on Quality Assurance and Quality Control of the PRD Air Quality Monitoring System for Guangdong and Hong Kong", the Network employs a revised "Standard Operating Procedures on Quality Assurance and Quality Control of the PRD Air Quality Monitoring System for Guangdong, Hong Kong and Macau" (QA/QC Operating Procedures) jointly developed by Guangdong, Hong Kong and Macau to ensure that the air quality monitoring results attain a high degree of accuracy and reliability, and meet the respective quality management policies of the three places. 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 revised as and when necessary.

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

Figure 2：Spatial distribution of monitoring stations in the Network (from Sept 2014)

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 by replacing the previous RAQI that was published once a day 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 to assist the governments of Guangdong, Hong Kong and Macao in understanding 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 different areas in the region.

This is an annual report on the monitoring results for 2019. From 2015 onwards, the annual report covers the monitoring results of 6 monitoring parameters recorded at 23 monitoring stations of the Network.

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

3. Operation of the Network

The overall operation of the Network was smooth in 2019. The average hourly data capture rate for the six air pollutants measured at all monitoring stations was 97.4%.

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

The governments of Guangdong, Hong Kong, and Macao have fully implemented the agreed QC works, which include zero/span checks, precision checks, dynamic calibration, etc. The QA/QC works are carried out 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 is 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, "QMC") to review and evaluate, on a quarterly basis, the performance of equipment, QA/QC works, data transmission system and operation of the Network. The QMC also conducts a system audit every year to evaluate the effectiveness of the quality management system. Based on the audit results, a report will be prepared to summarize any corrective measures and recommendations and the QMC will take appropriate follow-up actions.

3.2 Accuracy and Precision

The accuracy of the Network is evaluated by means of performance audits. The performance goals set for the gaseous pollutants and particulates (PM_{10} and $PM_{2.5}$) are ±20% and ±15% respectively. In 2019, we had carried out 463 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 ranged from -9.6% to 9.2%, which were within the required 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 particulates (PM_{10} and $PM_{2.5}$) are ±15%. In 2019, we had carried out 3660 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 ranged from -12.7% and 14.9%, which were within the required performance goals (see Figure 4). In 2019, the overall QA/QC performance of the Network was satisfactory and met all the requirements specified in the QA/QC Operating Procedures.

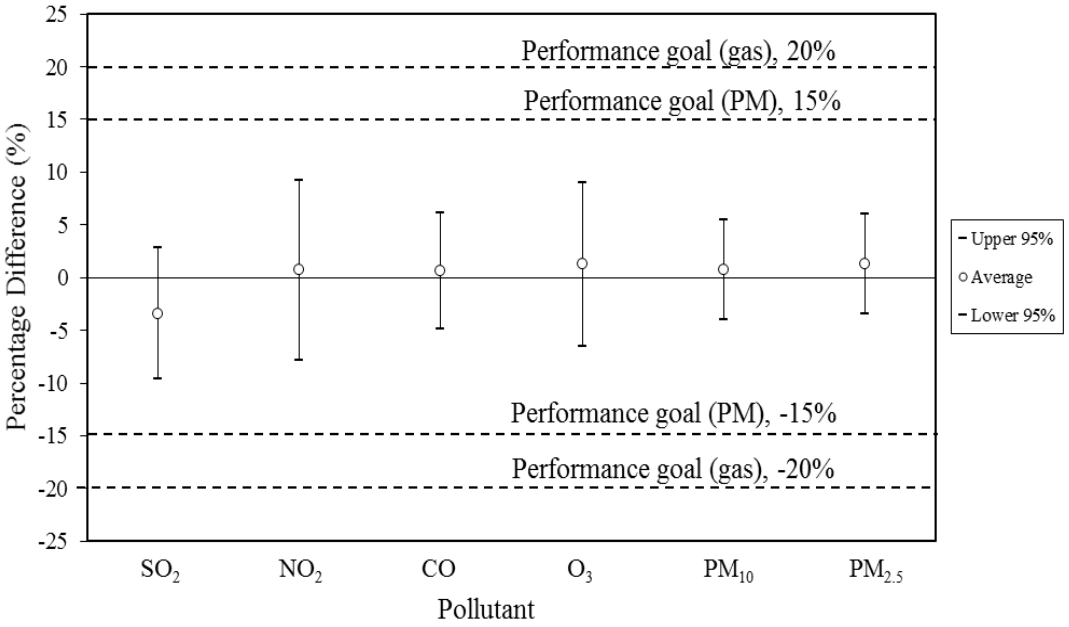

Figure 3：Accuracy of the monitoring network in 2019

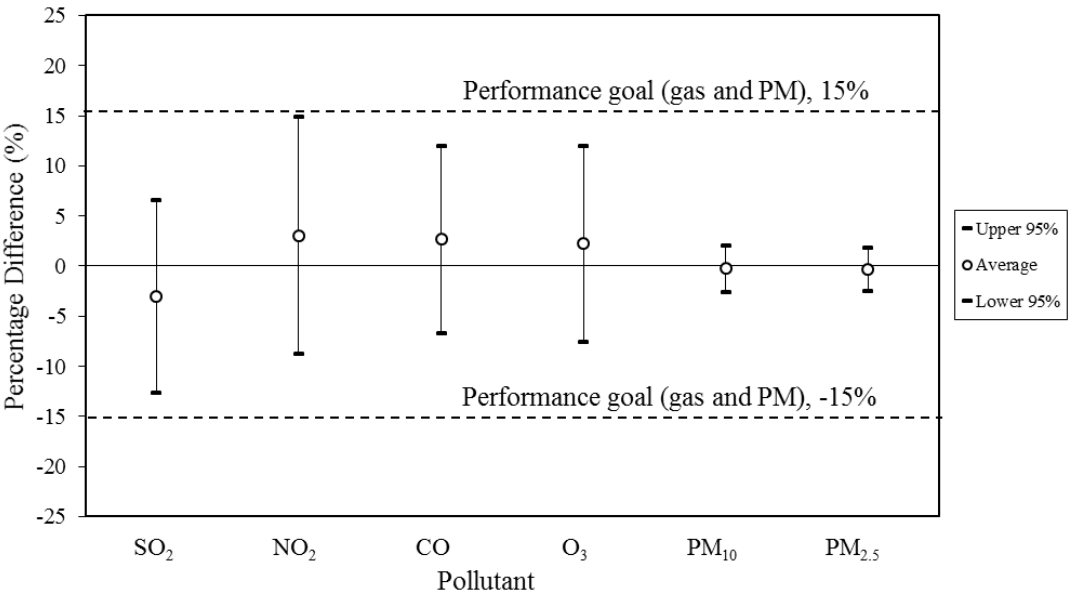

Figure 4：Precision of the monitoring network in 2019

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). Per the amended version of the Standards, starting from 2019, the concentrations of gaseous pollutants are calculated at a reference temperature of 298.15K and a pressure of 101.325 kPa, while the concentrations of PM_{10} and $PM_{2.5}$ are measured at real-time temperature and atmospheric pressure during monitoring.

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.

In 2019, the annual average of SO_2 recorded at each monitoring station in the Network ranged from 3 to 12 μg/m^3, and all stations were in compliance with the national annual average concentration limit (60 μg/m^3). As shown in Figure 5, the annual average concentrations of SO_2 recorded at all the monitoring stations were generally at a low level. During the year, all monitoring stations in the Network could comply with the national 24-hour average concentration limit (150 μg/m^3) and 1-hour average concentration limit (500 μg/m^3) of SO_2.

Tables 4.1a to 4.6c list the monthly maxima of hourly averages, the monthly maxima of daily averages with the 98th percentile of the year, the monthly and annual averages of SO_2 at each station respectively.

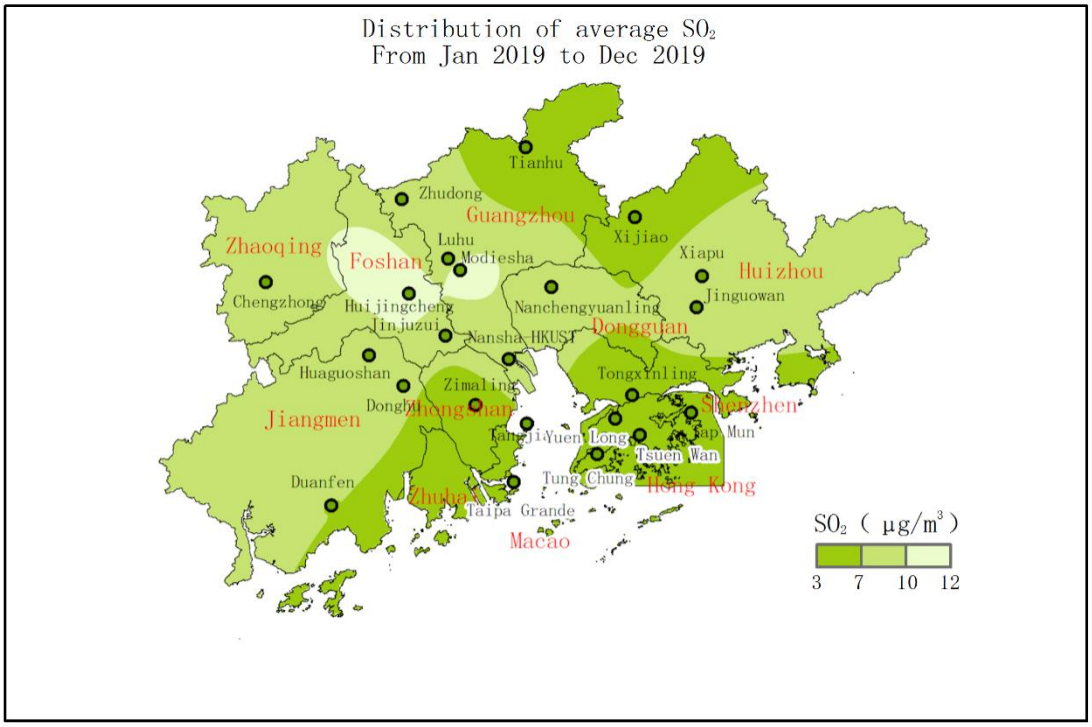

Figure 5：Spatial distribution of annual average concentrations of Sulphur Dioxide (SO_2)

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)	16	11	15	12	15	12	18	23	19	24	17	24
Modiesha (Guangzhou)	23	17	31	29	24	20	34	28	33	20	26	27
Nansha-HKUST (Guangzhou)	67	15	78	24	28	16	22	22	81	41	72	31
Tianhu (Guangzhou)	89	11	17	9	11	11	10	13	23	18	23	25
Zhudong (Guangzhou)	32	65	41	62	22	24	32	22	42	42	36	35
Tongxinling (Shenzhen)	10	10	7	16	6	8	8	7	16	13	12	16
Jinjuzui (Foshan)	33	21	21	36	23	26	24	22	39	28	27	23
Huijingcheng (Foshan)	24	20	48	43	21	35	50	40	53	83	58	55
Tangjia (Zhuhai)	32	18	30	12	13	10	16	19	30	18	24	24
Donghu (Jiangmen)	26	22	45	30	19	22	26	20	40	35	51	49
Duanfen (Jiangmen)	29	14	21	17	16	20	19	16	18	23	32	47
Huaguoshan (Jiangmen)	48	23	30	86	57	70	134	97	110	159	108	95
Chengzhong (Zhaoqing)	78	33	72	52	52	69	45	78	81	134	37	57
Xiapu (Huizhou)	37	22	18	24	18	18	25	23	37	34	38	48
Xijiao (Huizhou)	18	59	12	16	13	12	9	18	37	28	43	40
Jinguowan (Huizhou)	12	10	13	16	11	9	23	19	27	21	22	27
Zimaling (Zhongshan)	26	14	120	17	16	7	20	28	35	23	26	25
Nanchengyuanling (Dongguan)	26	16	30	24	21	18	26	35	25	33	38	36
Tap Mun (Hong Kong)	8	13	8	10	9	10	8	8	12	19	16	18
Tsuen Wan (Hong Kong)	26	14	16	21	15	13	19	21	16	22	11	40
Yuen Long (Hong Kong)	18	9	8	36	10	16	41	28	14	16	15	23
Tung Chung (Hong Kong)	36	20	14	18	14	13	26	17	23	35	16	30
Taipa Grande (Macao)	16	15	13	16	10	7	3	3	9	10	15	18

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

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

[Class II limit: 150 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	98th percentile
Luhu (Guangzhou)	11	7	8	7	8	7	11	10	12	13	12	14	100.0%	11
Modiesha (Guangzhou)	14	12	17	16	15	12	14	15	14	13	16	18	100.0%	16
Nansha-HKUST (Guangzhou)	21	11	13	12	11	9	11	12	14	18	19	20	100.0%	19
Tianhu (Guangzhou)	20	4	9	4	7	5	6	6	12	11	14	15	100.0%	12
Zhudong (Guangzhou)	16	11	25	13	13	9	14	8	17	19	18	21	100.0%	19
Tongxinling (Shenzhen)	9	6	6	7	6	6	6	6	10	9	10	10	100.0%	9
Jinjuzui (Foshan)	14	7	10	9	10	9	9	10	18	13	14	16	100.0%	13
Huijingcheng (Foshan)	19	14	39	21	13	15	20	21	27	34	25	31	100.0%	25
Tangjia (Zhuhai)	17	9	11	7	7	6	8	11	11	11	10	13	100.0%	13
Donghu (Jiangmen)	13	10	11	11	12	8	10	11	18	14	18	26	100.0%	17
Duanfen (Jiangmen)	16	8	10	7	7	6	8	7	11	13	16	17	100.0%	14
Huaguoshan (Jiangmen)	14	11	14	18	14	13	34	20	23	25	20	29	100.0%	23
Chengzhong (Zhaoqing)	17	18	25	17	17	16	18	19	19	25	20	24	100.0%	21
Xiapu (Huizhou)	17	10	9	13	7	7	10	11	15	14	17	19	100.0%	16
Xijiao (Huizhou)	7	5	4	6	5	4	4	5	8	12	11	10	100.0%	9
Jinguowan (Huizhou)	9	7	8	8	8	8	11	13	14	12	15	16	100.0%	14
Zimaling (Zhongshan)	12	6	9	10	7	4	10	11	11	15	13	11	100.0%	11
Nanchengyuanling (Dongguan)	16	11	13	15	14	11	11	11	13	16	19	22	100.0%	17
Tap Mun (Hong Kong)	5	11	7	6	7	7	3	5	9	11	10	13	100.0%	11
Tsuen Wan (Hong Kong)	18	8	8	9	9	9	11	11	12	14	6	9	100.0%	11
Yuen Long (Hong Kong)	12	5	5	7	5	6	10	10	9	9	9	12	100.0%	10
Tung Chung (Hong Kong)	21	13	10	6	10	9	14	9	9	8	7	10	100.0%	13
Taipa Grande (Macao)	10	7	8	6	3	3	1	2	4	6	8	9	100.0%	8

Remark： All concentration units are in micrograms per cubic metre (μg/m³).

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)	8	5	5	6	6	6	7	7	8	9	9	10	7
Modiesha (Guangzhou)	10	9	12	13	11	11	12	12	8	11*	13	14	11
Nansha-HKUST (Guangzhou)	16	8	8	8	7	6	7	8	10	11	12	13	9
Tianhu (Guangzhou)	6	3	3	2	3	4	3	3	6	6	9	7	5
Zhudong (Guangzhou)	11	8	10	9	8	7	6	4	10	13	13	14	10
Tongxinling (Shenzhen)	7	5	5	6	5	5	6	5	6	6	7	7	6
Jinjuzui (Foshan)	7	4	6	6	5	5	5	6	7	7	9	10	7
Huijingcheng (Foshan)	10	9	14*	9	7	11	10	13	13	13	15	16	12
Tangjia (Zhuhai)	11	7	6	6	5	5	6	7	5	6	7	9	7
Donghu (Jiangmen)	9	5	7	6	6	5	5	5	9	9	12	12	7
Duanfen (Jiangmen)	9	6	7	5	5	4	5	6	8	8	10	11	7
Huaguoshan (Jiangmen)	8	4	7	6	3	4	9	8	11	12	15	16	8
Chengzhong (Zhaoqing)	9	8	12	9	8	10	9	10	11	14	12	12	10
Xiapu (Huizhou)	11	8	7	7	5	5	6	8	10	8	12	12	8
Xijiao (Huizhou)	4	2	2	3	2	3	3	3	4	5	6*	5	4
Jinguowan (Huizhou)	7	6	7	6	7	7	8	8	9	9	11	11	8
Zimaling (Zhongshan)	6	4	5	5	4	3	5	6	7	7	9	7	6
Nanchengyuanling (Dongguan)	9	8	9	11	10	7	7	7	9	9	12	14	9
Tap Mun (Hong Kong)	3	7	5	5	6	5	2	3	5	6	7	8	5
Tsuen Wan (Hong Kong)	9	6	7	7	7	7	7	8	8	8	3	3	7
Yuen Long (Hong Kong)	7	3	3	3	3	4	5	7	5	5	6	7	5
Tung Chung (Hong Kong)	12	10	3	3	5	7	8	4	4	4	5	6	6
Taipa Grande (Macao)	7	5	5	3	3	3	0	1	1	3	4	4	3

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

* The capture rate of validated daily data per month is below 85%.

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.

In 2019, the annual average of NO_2 recorded at each monitoring station in the Network ranged from 10 to 47 μg/m^3 and 18 monitoring stations met the national annual average concentration limit (40 μg/m^3). During the year, 7 monitoring stations in the Network recorded no exceedance of the national 24-hour average concentration limit (80 μg/m^3) while the corresponding compliance rates in the Network ranged from 92.3% to 100.0%; 18 monitoring stations recorded no exceedance of national 1-hour average concentration limit of NO_2 (200 μg/m^3).

Tables 4.2a to 4.2c list the monthly maxima of hourly averages, the monthly maxima of daily averages with the 98th percentile of the year, the monthly and annual averages of NO_2 at each station respectively.

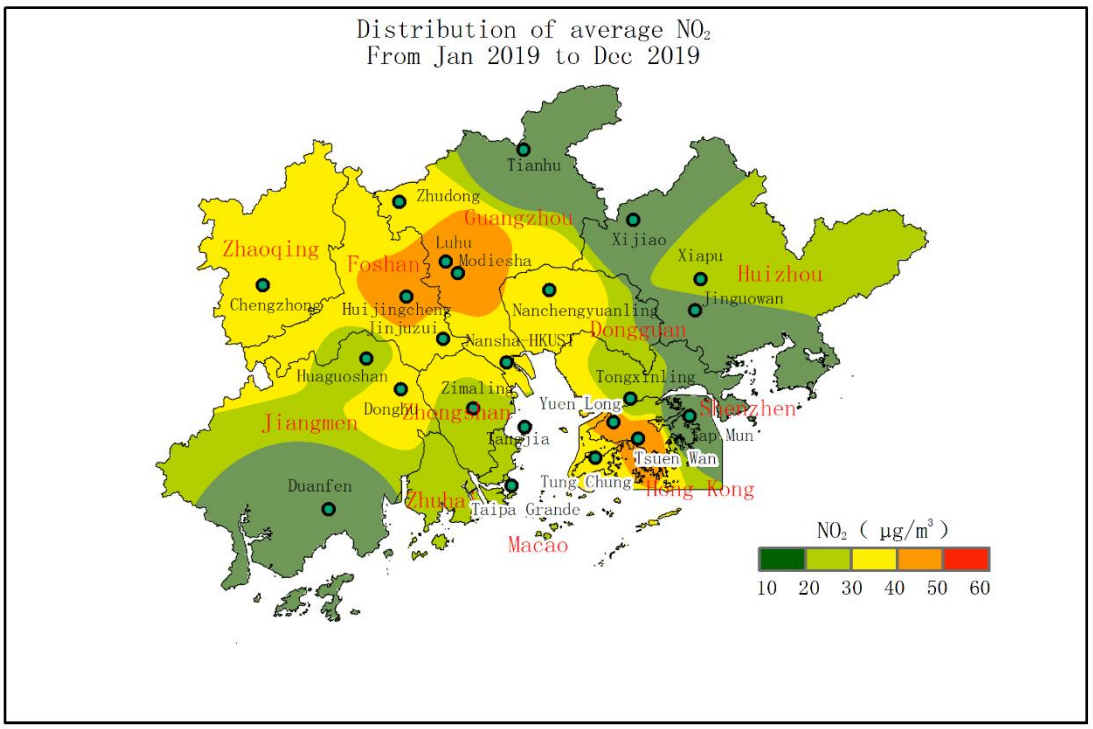

Figure 6：Spatial distribution of annual average concentrations of Nitrogen Dioxide (NO_2)

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

[Class II limit: 200 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	186	138	130	123	111	85	95	119	148	144	211	187
Modiesha (Guangzhou)	162	157	207	143	120	94	90	106	164	178	214	203
Nansha-HKUST (Guangzhou)	176	103	123	128	84	89	113	99	147	108	136	174
Tianhu (Guangzhou)	37	40	57	35	51	34	35	48	22	31	51	108
Zhudong (Guangzhou)	92	64	96	88	87	63	63	52	95	103	141	127
Tongxinling (Shenzhen)	150	69	100	67	66	60	63	48	79	86	121	148
Jinjuzui (Foshan)	180	111	183	87	78	75	71	100	137	127	156	196
Huijingcheng (Foshan)	114	117	140	100	92	91	81	163	169	173	266	399
Tangjia (Zhuhai)	164	85	119	92	86	64	60	70	86	80	107	197
Donghu (Jiangmen)	180	105	137	97	80	71	63	57	116	105	149	168
Duanfen (Jiangmen)	87	53	80	54	67	26	32	24	50	51	78	112
Huaguoshan (Jiangmen)	118	120	120	96	67	43	46	47	91	110	123	176
Chengzhong (Zhaoqing)	144	103	139	104	99	66	76	127	136	130	171	201
Xiapu (Huizhou)	157	97	111	79	63	60	68	88	126	80	126	134
Xijiao (Huizhou)	35	40	39	42	48	31	36	28	34	27	31	32
Jinguowan (Huizhou)	63	33	48	41	30	40	64	57	50	59	57	61
Zimaling (Zhongshan)	176	143	108	78	82	52	51	55	101	102	123	188
Nanchengyuanling (Dongguan)	192	127	118	83	84	74	125	93	139	109	137	161
Tap Mun (Hong Kong)	130	36	46	59	57	39	37	41	33	51	55	48
Tsuen Wan (Hong Kong)	203	131	157	148	140	100	143	160	130	123	144	189
Yuen Long (Hong Kong)	189	119	135	120	121	86	99	103	143	116	161	180
Tung Chung (Hong Kong)	163	105	132	114	94	95	74	94	160	92	121	175
Taipa Grande (Macao)	161	75	127	80	67	65	50	62	73	73	120	138

Remark： All concentration units are in micrograms per cubic metre (μg/m³).

Table 4.2b：Daily averages of Nitrogen Dioxide (the monthly maxima and the 98th percentile of the year) **[Class II limit: 80 μg/m³]**

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	98th percentile
Luhu (Guangzhou)	107	76	80	66	72	53	49	52	81	76	122	129	94.7%	96
Modiesha (Guangzhou)	100	93	124	82	83	59	52	58	68	60	121	126	92.3%	106
Nansha-HKUST (Guangzhou)	114	63	78	61	46	40	43	39	61	45	75	109	98.3%	78
Tianhu (Guangzhou)	25	20	32	21	23	19	18	17	13	19	23	47	100.0%	25
Zhudong (Guangzhou)	58	39	60	50	42	36	36	28	43	54	70	78	100.0%	61
Tongxinling (Shenzhen)	113	39	49	34	31	40	41	30	32	34	56	71	99.7%	55
Jinjuzui (Foshan)	103	78	88	59	48	41	42	50	80	60	98	126	94.4%	101
Huijingcheng (Foshan)	70	76	77	52	45	56	58	63	87	82	135	204	92.8%	128
Tangjia (Zhuhai)	81	40	65	40	42	26	31	37	27	40	58	83	99.2%	69
Donghu (Jiangmen)	89	64	59	59	46	29	31	31	58	65	84	121	97.0%	84
Duanfen (Jiangmen)	55	30	49	24	38	15	16	16	21	36	47	52	100.0%	46
Huaguoshan (Jiangmen)	73	52	53	63	43	21	23	28	51	65	67	87	99.2%	69
Chengzhong (Zhaoqing)	90	76	86	82	58	41	39	48	62	72	87	118	96.1%	85
Xiapu (Huizhou)	72	47	47	42	32	32	33	31	44	40	55	67	100.0%	56
Xijiao (Huizhou)	20	21	22	26	21	15	18	16	12	13	15	19	100.0%	21
Jinguowan (Huizhou)	39	15	23	21	17	17	29	27	21	21	24	35	100.0%	29
Zimaling (Zhongshan)	114	68	50	38	45	25	24	26	53	64	75	98	98.1%	79
Nanchengyuanling (Dongguan)	92	80	58	50	57	48	65	54	54	52	70	92	98.6%	76
Tap Mun (Hong Kong)	53	20	21	22	17	17	21	22	14	24	19	22	100.0%	22
Tsuen Wan (Hong Kong)	133	74	71	74	78	56	67	72	63	58	83	114	96.6%	94
Yuen Long (Hong Kong)	129	54	62	64	60	52	66	71	85	60	73	107	96.6%	86
Tung Chung (Hong Kong)	110	61	57	54	57	56	43	49	69	54	62	108	98.0%	80
Taipa Grande (Macao)	93	44	63	41	32	34	23	27	41	43	72	96	98.6%	73

Remark： All concentration units are in micrograms per cubic metre (μg/m³).

Table 4.2c：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	33	50	46	39	33	30	35	43	44	59	66	44
Modiesha (Guangzhou)	51	33	64	55	42	36	33	37	38	43*	58	67	47
Nansha-HKUST (Guangzhou)	52	25	48	40	32	24	23	27	30	28	40	59	36
Tianhu (Guangzhou)	14	9	12	12	9	10	11	9	7	9	12	18	11
Zhudong (Guangzhou)	32	22	38	30	27	24	21	19	28	34	42	42	30
Tongxinling (Shenzhen)	41	15	22	17	16	18	17	17	20	18	27	37	22
Jinjuzui (Foshan)	59	26	43	34	27	20	23	28	34	36	57	72	38
Huijingcheng (Foshan)	35	26	39*	31	26	30	33	39	46	46	71	88*	42
Tangjia (Zhuhai)	41	19	35	22	20	12	17	19	17	16	29	45	25
Donghu (Jiangmen)	49	25	36	27	23	15	17	20	28	32	50	59	32
Duanfen (Jiangmen)	27	10	17	9	12	8	9	11	15	18	29	31	16
Huaguoshan (Jiangmen)	39	20	30	25	21	12	14	15	28	34	50	54	29
Chengzhong (Zhaoqing)	46	28	44	39	31	25	23	28	32	36	53	57	37
Xiapu (Huizhou)	38	22	30	29	20	21	21	21	21	23	33	39	27
Xijiao (Huizhou)	15	10	14	14	12	12	10	7	8	10	10*	11	11
Jinguowan (Huizhou)	22	9	12	11	9	11	12	11	10	14	18	20	13
Zimaling (Zhongshan)	53	21	29	17	18	8	10	12	23	30	44	58	27
Nanchengyuanling (Dongguan)	47	27	38	35	30	29	30	34	33	33	44	54	36
Tap Mun (Hong Kong)	18	10	12	12	9	9	6	9	6	8	11	14	10
Tsuen Wan (Hong Kong)	70	50	51	43	40	35	32	36	34	36	57	63	46
Yuen Long (Hong Kong)	66	40	44	39	33	28	27	37	46	45	53	62	43
Tung Chung (Hong Kong)	63	32	31	23	25	20	16	22	32	33	41	51	32
Taipa Grande (Macao)	47	26	37	21	14	15	11	14	19	21	35	48	26

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

* The capture rate of validated daily data per month is below 85%.

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 2019, the annual average of O_3 recorded at each monitoring station in the Network ranged from 48 to 82 $\mu g/m^3$ with higher average values being recorded in rural areas such as Tianhu of Guangzhou and Tap Mun of Hong Kong, the situation was similar to the one in previous years. During the year, the compliance rates of the daily maximum 8-hour averages of O_3 in the Network ranged from 73.0% to 96.7%. All monitoring stations recorded exceedance of the national 1-hour average concentration limit (200 $\mu g/m^3$) and the daily maximum 8-hour average concentration limit (160 $\mu g/m^3$) of O_3.

Tables 4.3a to 4.3c list the monthly maxima of hourly averages, the monthly maxima of daily maximum 8-hour averages with the 90th percentile of the year, the monthly and annual averages of O_3 at each station respectively.

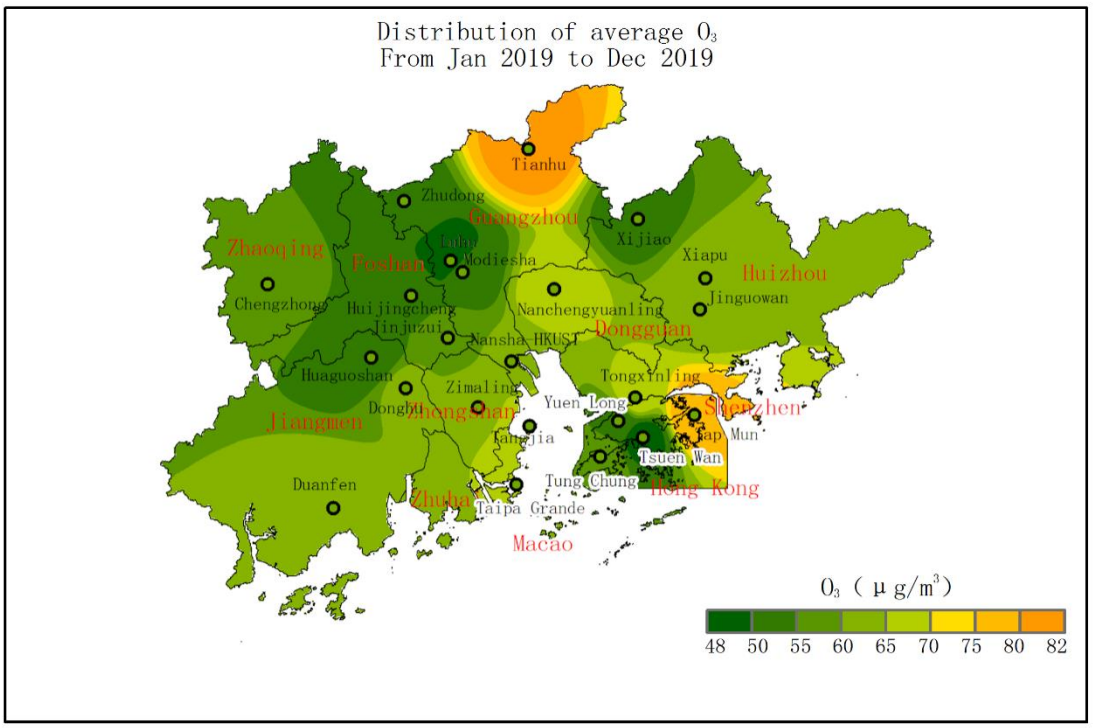

Figure 7：Spatial distribution of annual average concentrations of Ozone (O_3)

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)	175	118	221	169	260	241	245	269	296	266	267	192
Modiesha (Guangzhou)	171	114	216	182	254	231	284	302	260	262	237	185
Nansha-HKUST (Guangzhou)	216	152	252	197	229	281	305	345	365	319	334	332
Tianhu (Guangzhou)	223	128	192	196	295	238	199	238	195	220	212	176
Zhudong (Guangzhou)	204	113	200	216	326	220	241	237	239	256	264	218
Tongxinling (Shenzhen)	152	123	143	203	154	206	359	371	283	298	227	195
Jinjuzui (Foshan)	193	143	217	286	279	250	260	300	296	249	270	289
Huijingcheng (Foshan)	183	129	216	236	276	257	217	312	351	289	302	218
Tangjia (Zhuhai)	246	172	210	217	196	197	234	248	338	244	289	200
Donghu (Jiangmen)	216	158	232	285	271	244	218	246	382	288	343	226
Duanfen (Jiangmen)	174	94	133	115	142	110	110	150	249	193	294	222
Huaguoshan (Jiangmen)	144	93	182	229	202	197	199	247	306	248	298	195
Chengzhong (Zhaoqing)	168	123	237	142	214	244	224	256	243	265	268	226
Xiapu (Huizhou)	174	119	176	232	203	202	192	263	197	218	205	164
Xijiao (Huizhou)	163	123	216	200	258	260	193	211	176	206	183	142
Jinguowan (Huizhou)	220	134	154	191	173	136	240	224	210	254	206	171
Zimaling (Zhongshan)	212	136	161	194	203	253	265	337	349	270	286	178
Nanchengyuanling (Dongguan)	187	120	219	270	273	259	313	399	306	335	272	243
Tap Mun (Hong Kong)	177	119	174	178	181	193	232	314	270	307	198	177
Tsuen Wan (Hong Kong)	116	85	133	145	146	197	210	336	407	239	152	177
Yuen Long (Hong Kong)	139	129	139	194	134	262	298	408	330	257	210	164
Tung Chung (Hong Kong)	161	103	145	189	143	224	295	353	405	248	280	168
Taipa Grande (Macao)	186	130	175	159	163	225	254	313	419	280	254	174

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

Table 4.3b：Daily maximum 8-hour averages of Ozone (the monthly maxima and the 90th percentile of the year) **[Class II limit: 160 μg/m³]**

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	90th percentile
Luhu (Guangzhou)	124	91	145	135	218	192	188	202	236	212	207	147	88.1%	166
Modiesha (Guangzhou)	134	94	156	137	221	199	231	266	228	232	190	160	85.6%	174
Nansha-HKUST (Guangzhou)	181	141	163	155	155	190	253	266	282	282	259	254	77.2%	202
Tianhu (Guangzhou)	204	120	151	174	267	181	175	197	178	202	202	163	89.0%	163
Zhudong (Guangzhou)	157	94	174	157	266	193	168	216	202	216	217	164	85.7%	170
Tongxinling (Shenzhen)	135	100	135	180	146	179	301	291	252	257	176	126	87.9%	166
Jinjuzui (Foshan)	144	122	163	237	235	208	223	239	248	222	231	201	81.8%	179
Huijingcheng (Foshan)	143	108	150	179	232	225	184	283	295	230	221	148	81.9%	191
Tangjia (Zhuhai)	185	118	158	183	169	183	189	209	277	211	228	166	85.4%	175
Donghu (Jiangmen)	181	136	178	199	207	211	188	213	325	247	288	170	78.5%	203
Duanfen (Jiangmen)	137	88	115	101	131	102	100	120	192	177	228	161	93.2%	141
Huaguoshan (Jiangmen)	115	85	141	179	178	169	156	230	255	213	266	149	89.8%	158
Chengzhong (Zhaoqing)	147	108	186	121	192	212	206	215	220	236	243	181	84.3%	176
Xiapu (Huizhou)	133	91	142	183	165	162	163	207	180	199	160	130	94.9%	146
Xijiao (Huizhou)	138	92	151	152	211	191	150	172	162	176	158	127	96.7%	138
Jinguowan (Huizhou)	203	100	129	161	146	124	197	173	189	218	165	149	93.4%	149
Zimaling (Zhongshan)	179	125	129	166	157	221	226	283	302	232	239	141	80.6%	199
Nanchengyuanling (Dongguan)	138	92	169	190	220	202	247	338	252	292	230	198	73.0%	207
Tap Mun (Hong Kong)	158	109	160	168	169	165	214	251	249	256	178	152	87.7%	165
Tsuen Wan (Hong Kong)	101	74	124	125	114	171	155	284	291	189	125	103	95.6%	117
Yuen Long (Hong Kong)	118	81	125	171	118	189	244	305	258	201	163	117	92.3%	137
Tung Chung (Hong Kong)	108	89	142	154	130	187	252	292	320	180	189	116	92.8%	147
Taipa Grande (Macao)	140	99	122	132	140	204	172	262	323	257	209	152	87.4%	167

Remark： All concentration units are in micrograms per cubic metre (μg/m³).

Table 4.3c：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)	31	28	30	30	46	46	43	56	74	77	73	43	48
Modiesha (Guangzhou)	31	28	29	28	52	46	53	75	91	82*	73	46	52
Nansha-HKUST (Guangzhou)	46	42	33	38	47	40	40	69	110	105	101	66	61
Tianhu (Guangzhou)	67	50	69	67	79	77	72	81	109	108	118	85	82
Zhudong (Guangzhou)	34	28	36	35	54	58	52	68	71	74	71	46	52
Tongxinling (Shenzhen)	52	55	60	65	72	45	48	68	98	105	93	56	68
Jinjuzui (Foshan)	35	37	38	43	58	53	49	70	96	88	78	47	58
Huijingcheng (Foshan)	28	26	27*	29	48	51	47	69	96	89	79	42	53
Tangjia (Zhuhai)	71	62	57	61	63	50	43	65	103	105	100	65	70
Donghu (Jiangmen)	38	37	41	42	52	49	48	72	112	100	94	50	61
Duanfen (Jiangmen)	47	47	49	54	60	62	67	46	72	86	96	66	63
Huaguoshan (Jiangmen)	28	27	33	37	46	48	45	68	65	76	82	46	50
Chengzhong (Zhaoqing)	35	36	39	34	52	51	49	72	92	86	84	52	57
Xiapu (Huizhou)	48	46	55	55	64	53	48	62	85	92	83	54	62
Xijiao (Huizhou)	44	41	55	52	60	58	48	53	61	64	62*	43	53
Jinguowan (Huizhou)	88	51	55	52	56	40	42	57	80	85	82	64	63
Zimaling (Zhongshan)	39	43	45	55	58	57	54	73	107	98	94	47	64
Nanchengyuanling (Dongguan)	37	36	42	54	61	59	63	89	106	114	91	58	68
Tap Mun (Hong Kong)	71	64	73	70	83	51	49	66	103	117	111	83	79
Tsuen Wan (Hong Kong)	39	37	46	44	49	27	28	42	75	83	64	41	48
Yuen Long (Hong Kong)	37	40	48	52	55	37	39	52	75	81	72	44	52
Tung Chung (Hong Kong)	35	41	55	60	61	45	45	59	80	92	81	48	59
Taipa Grande (Macao)	42	44	45	52	57	50	44	59	107	112	105	64	65

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

* The capture rate of validated daily data per month is below 85%.

4.4 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 of CO is automobiles.

In 2019, the annual average of CO recorded at each monitoring station in the Network ranged from 0.5 to 0.9 mg/m^3. During the year, all monitoring stations in the Network were in compliance with the national 1-hour and 24-hour average concentration limits (10 mg/m^3 and 4 mg/m^3).

Tables 4.6a to 4.6c list the monthly maxima of hourly and daily averages, the maxima of daily averages with the 95th percentile of the year, the monthly and annual averages of CO at each station respectively.

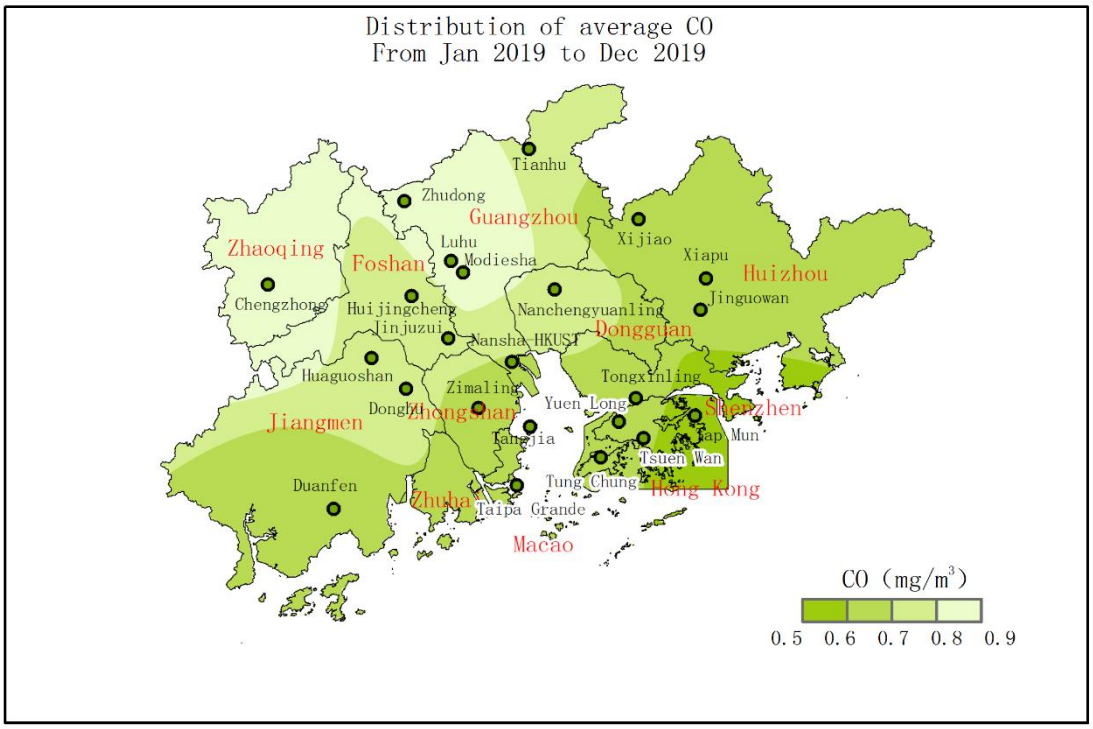

Figure 8：Spatial distribution of annual average concentrations of Carbon Monoxide (CO)

Table 4.4a：Hourly averages of Carbon Monoxide (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)	2.3	3.0	1.9	1.3	1.5	2.0	1.5	1.5	1.7	2.0	2.1	1.8
Modiesha (Guangzhou)	2.1	3.0	2.2	1.7	1.1	1.1	1.2	1.2	1.5	1.6	1.8	1.9
Nansha-HKUST (Guangzhou)	2.0	1.8	2.0	1.5	1.3	0.8	0.8	0.9	1.2	1.3	1.6	1.3
Tianhu (Guangzhou)	1.7	1.4	1.4	1.4	1.2	1.0	1.0	0.9	1.1	1.2	1.2	1.4
Zhudong (Guangzhou)	2.3	1.7	1.6	1.8	0.8	0.9	1.0	1.0	1.1	1.4	1.8	1.5
Tongxinling (Shenzhen)	1.7	1.4	1.5	1.2	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.5
Jinjuzui (Foshan)	2.3	2.4	2.1	1.3	1.3	2.3	4.1	1.2	1.3	1.2	1.6	2.1
Huijingcheng (Foshan)	2.4	2.7	2.5	1.5	1.1	1.0	1.0	1.7	1.4	1.3	2.1	3.1
Tangjia (Zhuhai)	2.1	1.4	1.5	0.9	1.0	1.0	0.9	0.8	1.3	1.1	1.0	1.6
Donghu (Jiangmen)	2.7	2.5	3.1	1.8	1.7	1.6	1.6	1.5	1.6	1.5	2.7	3.5
Duanfen (Jiangmen)	1.6	1.5	3.7	1.3	1.2	0.7	0.6	0.8	1.0	1.1	1.3	1.2
Huaguoshan (Jiangmen)	1.8	2.1	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.4	1.6	1.8
Chengzhong (Zhaoqing)	1.9	3.1	2.2	1.9	1.5	1.6	1.1	1.2	1.4	1.5	1.5	2.5
Xiapu (Huizhou)	2.2	2.3	1.9	1.5	0.9	0.8	0.8	1.0	1.2	1.1	1.4	1.9
Xijiao (Huizhou)	1.3	1.3	1.1	1.0	1.1	1.1	1.0	1.0	1.4	1.1	1.1	1.6
Jinguowan (Huizhou)	1.8	1.0	1.0	1.3	1.2	0.9	0.9	1.2	0.9	1.1	1.8	1.1
Zimaling (Zhongshan)	2.3	2.0	1.6	1.1	1.2	1.2	1.5	1.0	1.2	1.2	1.2	1.9
Nanchengyuanling (Dongguan)	2.5	1.5	1.8	1.3	1.1	1.2	1.2	1.2	1.3	1.2	1.6	1.6
Tap Mun (Hong Kong)	1.3	1.1	1.0	0.9	0.8	0.5	0.6	0.8	1.0	1.1	1.1	1.3
Tsuen Wan (Hong Kong)	1.9	1.4	1.3	1.4	1.1	1.0	0.9	1.0	1.0	1.2	1.2	1.4
Yuen Long (Hong Kong)	2.1	1.3	1.2	1.0	0.9	1.0	1.1	1.1	1.3	1.2	1.2	1.7
Tung Chung (Hong Kong)	2.2	1.0	1.2	1.0	1.0	0.9	1.0	1.0	1.3	1.2	1.1	1.4
Taipa Grande (Macao)	1.7	1.2	1.2	1.2	1.0	1.3	1.8	1.6	1.3	1.3	1.2	1.7

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

Table 4.4b：Daily averages of Carbon Monoxide (the monthly maxima and the 95th percentile of the year) **[Class II limit: 4 mg/m³]**

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	95th percentile
Luhu (Guangzhou)	1.8	1.8	1.4	1.1	1.1	1.0	0.9	0.9	1.0	1.1	1.1	1.3	100.0%	1.3
Modiesha (Guangzhou)	1.5	2.0	1.6	1.3	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.2	100.0%	1.2
Nansha-HKUST (Guangzhou)	1.4	1.3	1.5	1.2	1.2	0.7	0.6	0.6	0.7	1.0	1.0	1.2	100.0%	1.2
Tianhu (Guangzhou)	1.4	1.3	1.3	1.2	1.0	0.9	0.9	0.9	0.9	1.1	1.0	1.2	100.0%	1.1
Zhudong (Guangzhou)	1.4	1.3	1.4	1.2	0.6	0.6	0.7	0.8	0.9	1.2	1.2	1.3	100.0%	1.2
Tongxinling (Shenzhen)	1.3	1.2	1.0	0.8	0.8	0.7	0.8	0.8	0.9	0.9	1.0	1.2	100.0%	1.0
Jinjuzui (Foshan)	1.8	1.6	1.3	1.0	0.8	0.7	0.9	0.9	0.9	0.9	0.9	1.4	100.0%	1.2
Huijingcheng (Foshan)	1.7	1.6	1.3	1.0	0.8	0.6	0.7	0.9	0.8	0.8	1.0	1.3	100.0%	1.2
Tangjia (Zhuhai)	1.7	1.2	1.3	0.8	0.9	0.7	0.7	0.6	1.0	1.0	0.8	1.2	100.0%	1.1
Donghu (Jiangmen)	1.6	1.4	1.3	1.2	1.0	0.9	1.0	1.0	1.1	1.0	1.1	1.4	100.0%	1.2
Duanfen (Jiangmen)	1.4	1.2	1.2	1.0	1.0	0.6	0.5	0.8	0.6	0.7	0.7	1.1	100.0%	1.1
Huaguoshan (Jiangmen)	1.3	1.3	1.0	1.3	1.1	0.7	0.8	1.1	1.1	1.2	0.9	1.3	100.0%	1.1
Chengzhong (Zhaoqing)	1.5	1.9	1.5	1.4	1.1	0.9	0.9	0.9	1.1	1.2	1.1	1.7	100.0%	1.3
Xiapu (Huizhou)	1.4	1.2	0.9	1.0	0.9	0.6	0.6	0.8	0.8	1.0	0.8	1.2	100.0%	1.1
Xijiao (Huizhou)	1.1	0.9	0.7	0.7	0.9	0.9	0.7	0.8	0.7	0.9	0.6	0.9	100.0%	0.8
Jinguowan (Huizhou)	1.2	0.9	0.9	1.1	1.1	0.7	0.7	0.9	0.7	1.0	0.9	0.8	100.0%	0.9
Zimaling (Zhongshan)	1.7	1.2	0.9	0.8	0.8	0.9	1.0	0.8	0.9	0.9	0.8	1.2	100.0%	1.1
Nanchengyuanling (Dongguan)	1.7	1.2	1.2	1.0	0.9	1.1	0.8	1.0	1.0	1.0	1.0	1.1	100.0%	1.1
Tap Mun (Hong Kong)	1.0	1.0	0.8	0.7	0.7	0.4	0.5	0.6	0.9	0.9	0.8	1.2	100.0%	0.8
Tsuen Wan (Hong Kong)	1.6	1.2	1.0	0.9	0.9	0.6	0.7	0.7	0.8	0.8	0.9	1.2	100.0%	1.1
Yuen Long (Hong Kong)	1.6	1.2	0.9	0.7	0.8	0.8	1.0	0.9	1.0	0.9	0.8	1.2	100.0%	1.1
Tung Chung (Hong Kong)	1.6	0.9	1.0	0.7	0.9	0.7	0.6	0.7	0.9	1.0	0.9	1.2	100.0%	1.0
Taipa Grande (Macao)	1.3	1.0	0.9	0.8	0.8	0.6	0.6	1.0	1.1	1.2	0.9	1.5	100.0%	1.0

Remark： All concentration units are in milligrams per cubic metre (mg/m³).

Table 4.4c：The monthly and annual averages of Carbon Monoxide

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	1.2	1.1	0.9	0.8	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.9	0.9
Modiesha (Guangzhou)	1.0	0.9	1.1	0.8	0.6	0.7	0.7	0.7	0.8	0.8*	0.8	0.8	0.8
Nansha-HKUST (Guangzhou)	1.0	0.9	1.0	0.9	0.6	0.5	0.3	0.3	0.4	0.7	0.7	0.7	0.7
Tianhu (Guangzhou)	0.9	0.9	0.9	0.9	0.7	0.7	0.8	0.7	0.7	0.9	0.8	0.8	0.8
Zhudong (Guangzhou)	1.0	1.0	1.0	0.7	0.4	0.3	0.6	0.7	0.7	0.9	0.9	1.0	0.8
Tongxinling (Shenzhen)	0.9	0.8	0.8	0.6	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.7
Jinjuzui (Foshan)	1.2	0.9	0.8	0.7	0.6	0.5	0.6	0.7	0.7	0.7	0.7	1.0	0.8
Huijingcheng (Foshan)	1.1	0.9	0.8	0.6	0.6	0.4	0.5	0.6	0.7	0.6	0.7	0.9	0.7
Tangjia (Zhuhai)	1.0	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.7	0.6	0.7	0.6
Donghu (Jiangmen)	1.1	0.9	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	0.9	0.8
Duanfen (Jiangmen)	0.9	0.6	0.9	0.7	0.5	0.4	0.4	0.5	0.4	0.4	0.5	0.6	0.6
Huaguoshan (Jiangmen)	1.0	0.8	0.8	0.8	0.8	0.5	0.6	0.8	0.8	0.9	0.7	0.9	0.8
Chengzhong (Zhaoqing)	1.1	1.0	1.0	0.9	0.8	0.7	0.6	0.7	0.9	1.0	0.9	1.1	0.9
Xiapu (Huizhou)	1.0	0.8	0.7	0.7	0.5	0.5	0.4	0.6	0.6	0.7	0.7	0.8	0.7
Xijiao (Huizhou)	0.7	0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.5	0.7	0.5*	0.6	0.6
Jinguowan (Huizhou)	0.8	0.6	0.7	0.8	0.7	0.6	0.5	0.7	0.5	0.6	0.6	0.6	0.6
Zimaling (Zhongshan)	1.0	0.7	0.6	0.5	0.5	0.5	0.6	0.4	0.6	0.6	0.6	0.8	0.6
Nanchengyuanling (Dongguan)	1.1	0.8	0.8	0.7	0.7	0.8	0.6	0.7	0.7	0.7	0.8	0.8	0.8
Tap Mun (Hong Kong)	0.7	0.6	0.6	0.4	0.4	0.2	0.3	0.4	0.5	0.6	0.6	0.7	0.5
Tsuen Wan (Hong Kong)	1.0	0.9	0.8	0.7	0.6	0.4	0.4	0.4	0.4	0.5	0.7	0.8	0.6
Yuen Long (Hong Kong)	1.0	0.7	0.6	0.4	0.4	0.5	0.6	0.5	0.5	0.7	0.7	0.8	0.6
Tung Chung (Hong Kong)	1.0	0.5	0.5	0.5	0.5	0.5	0.3	0.4	0.5	0.7	0.7	0.6	0.6
Taipa Grande (Macao)	0.9	0.6	0.6	0.6	0.5	0.4	0.4	0.7	0.7	0.7	0.6	0.7	0.6

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

* The capture rate of validated daily data per month is below 85%.

4.5 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 2019, the annual average of PM_{10} recorded at each monitoring station in the Network ranged from 30 to 56 μg/m^3, and all monitoring stations met the national annual average concentration limit (70 μg/m^3). During the year, 18 monitoring stations in the Network recorded no exceedance of the national 24-hour average concentration limit (150 μg/m^3) while the corresponding compliance rates in the Network ranged from 98.9% to 100.0%.

Table 4.5a and Table 4.5b list the monthly maxima of daily averages with the 95th percentile of the year, the monthly and annual averages of PM_{10} at each station respectively.

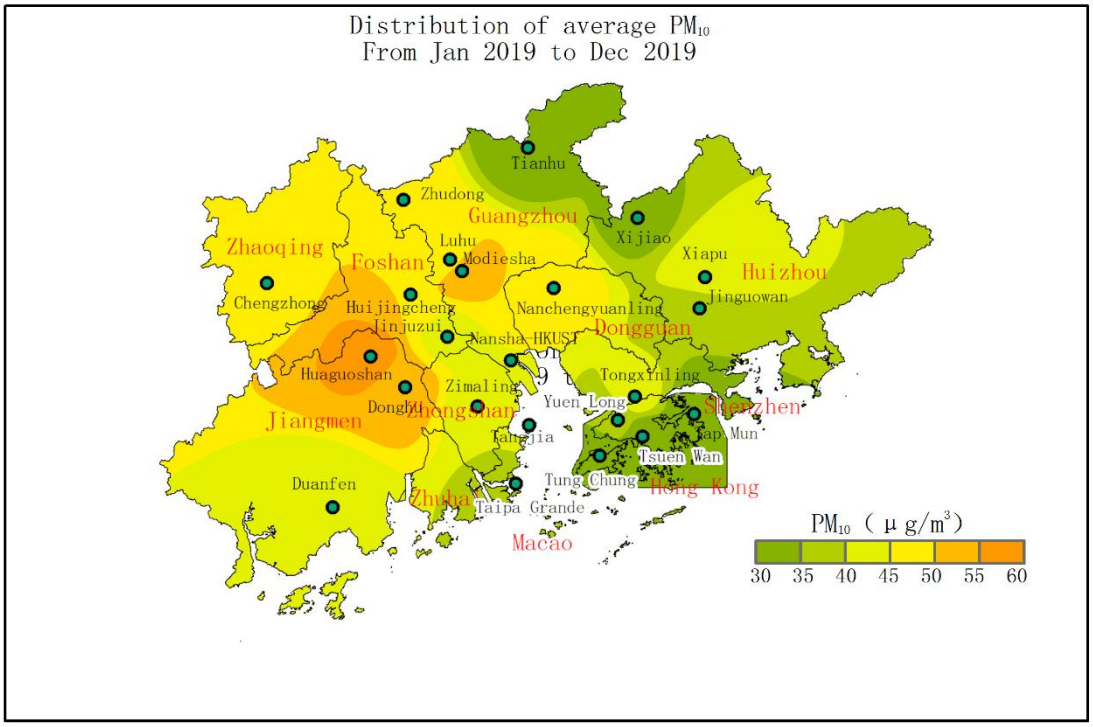

Figure 9：Spatial distribution of annual average concentrations of Respirable Suspended Particulates (PM_{10})

Table 4.5a：Daily averages of PM_{10} (the monthly maxima and the 95th percentile of the year)

[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)	123	120	129	67	77	42	64	68	83	97	113	147	100.0%	97
Modiesha (Guangzhou)	124	105	103	69	77	45	63	76	99	96	136	159	99.7%	103
Nansha-HKUST (Guangzhou)	151	64	67	65	48	42	78	76	89	87	99	116	99.7%	86
Tianhu (Guangzhou)	74	49	74	49	69	51	39	49	53	82	88	59	100.0%	61
Zhudong (Guangzhou)	109	85	82	79	98	116	65	74	73	95	131	133	100.0%	92
Tongxinling (Shenzhen)	130	55	56	62	46	29	67	61	90	98	98	131	100.0%	88
Jinjuzui (Foshan)	144	111	84	54	54	33	52	62	80	80	105	107	100.0%	89
Huijingcheng (Foshan)	119	147	116	84	66	44	61	68	94	93	117	146	100.0%	103
Tangjia (Zhuhai)	165	84	72	87	43	36	62	67	83	100	92	127	99.4%	92
Donghu (Jiangmen)	140	136	106	87	71	47	56	72	113	105	125	174	99.4%	110
Duanfen (Jiangmen)	82	49	49	42	60	40	46	73	88	116	120	150	100.0%	97
Huaguoshan (Jiangmen)	151	154	137	97	89	51	63	67	117	115	142	203	98.9%	115
Chengzhong (Zhaoqing)	108	108	131	125	75	47	57	68	74	95	109	149	100.0%	98
Xiapu (Huizhou)	89	60	65	75	62	36	59	65	99	99	99	119	100.0%	87
Xijiao (Huizhou)	62	50	62	55	63	44	51	45	55	66	59	61	100.0%	56
Jinguowan (Huizhou)	77	53	52	51	47	29	65	77	74	80	71	71	100.0%	64
Zimaling (Zhongshan)	143	84	60	59	49	33	54	70	96	103	98	109	100.0%	87
Nanchengyuanling (Dongguan)	125	79	77	69	64	41	78	72	97	100	106	131	100.0%	94
Tap Mun (Hong Kong)	64	54	52	52	52	34	50	55	74	74	68	57	100.0%	56
Tsuen Wan (Hong Kong)	123	45	48	53	39	28	71	75	85	64	69	78	100.0%	60
Yuen Long (Hong Kong)	125	55	55	59	44	30	73	70	94	88	92	89	100.0%	74
Tung Chung (Hong Kong)	123	47	53	59	35	28	68	71	80	58	67	83	100.0%	66
Taipa Grande (Macao)	125	64	56	54	41	32	47	63	87	79	98	106	100.0%	78

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

Table 4.5b：The monthly and annual averages of PM_{10}

[Class II limit for annual average: 70 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	62	39	47	38	34	27	32	37	48	60	74	76	48
Modiesha (Guangzhou)	60	37	48	42	36	29	37	45	54	68*	85	85	52
Nansha-HKUST (Guangzhou)	70	31	41	31	31	21	33	39	46	57	70	66	45
Tianhu (Guangzhou)	36	25	31	26	27	22	26	26	34	46	49	40	32
Zhudong (Guangzhou)	57	36	45	40	40	45	35	40	49	60	71	70	49
Tongxinling (Shenzhen)	60	30	35	30	28	18	25	28	43	54	74	74	42
Jinjuzui (Foshan)	71	36	43	33	31	22	27	32	42	50	67	63	44
Huijingcheng (Foshan)	66	43	48	41	36	29	33	39	50	59	77	73	50
Tangjia (Zhuhai)	88	37	43	28	28	17	25	26	39	50	66	67	43
Donghu (Jiangmen)	77	41	52	42	39	29	32	36	53	63	85	83	53
Duanfen (Jiangmen)	53	26	29	22	29	19	25	26	39	50	85	86	41
Huaguoshan (Jiangmen)	80	50	56	47	41	28	32	37	55	68	89	92	56
Chengzhong (Zhaoqing)	59	40	49	45	35	30	33	39	47	59	72	73	49
Xiapu (Huizhou)	54	30	39	38	33	27	32	35	45	60	73	72	45
Xijiao (Huizhou)	40	28	32	30	29	24	28	27	36	45	47*	45	34
Jinguowan (Huizhou)	44	23	28	27	23	21	32	34	40	48	53	48	35
Zimaling (Zhongshan)	70	32	36	29	29	19	25	28	46	55	72	65	43
Nanchengyuanling (Dongguan)	62	33	41	39	36	27	34	40	49	64	77	78	48
Tap Mun (Hong Kong)	38	26	27	25	26	17	24	26	34	44	49	40	31
Tsuen Wan (Hong Kong)	47	25	26	23	22	15	21	23	31	38	45	38	30
Yuen Long (Hong Kong)	52	28	34	25	26	15	23	26	39	53	65	58	37
Tung Chung (Hong Kong)	61	27	29	24	21	13	21	24	28	33	41	42	31
Taipa Grande (Macao)	63	31	33	25	25	13*	19	21	34	43	61	59	36

Remark : All concentration units are in micrograms per cubic metre (μg/m³).

* The capture rate of validated daily data per month/year is below 85%.

4.6 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 2019, the annual average of $PM_{2.5}$ recorded at each monitoring station in the Network ranged from 17 to 34 $\mu g/m^3$, and all monitoring stations met the national annual average concentration limit (35 $\mu g/m^3$). During the year, 7 monitoring stations in the Network recorded no exceedance of the national 24-hour average concentration limit (75$\mu g/m^3$) while the corresponding compliance rates in the Network ranged from 95.9% to 100.0%.

Tables 4.6a and 4.6b list the monthly maxima of daily averages with the 95th percentile of the year, the monthly and annual averages of $PM_{2.5}$ at each station respectively.

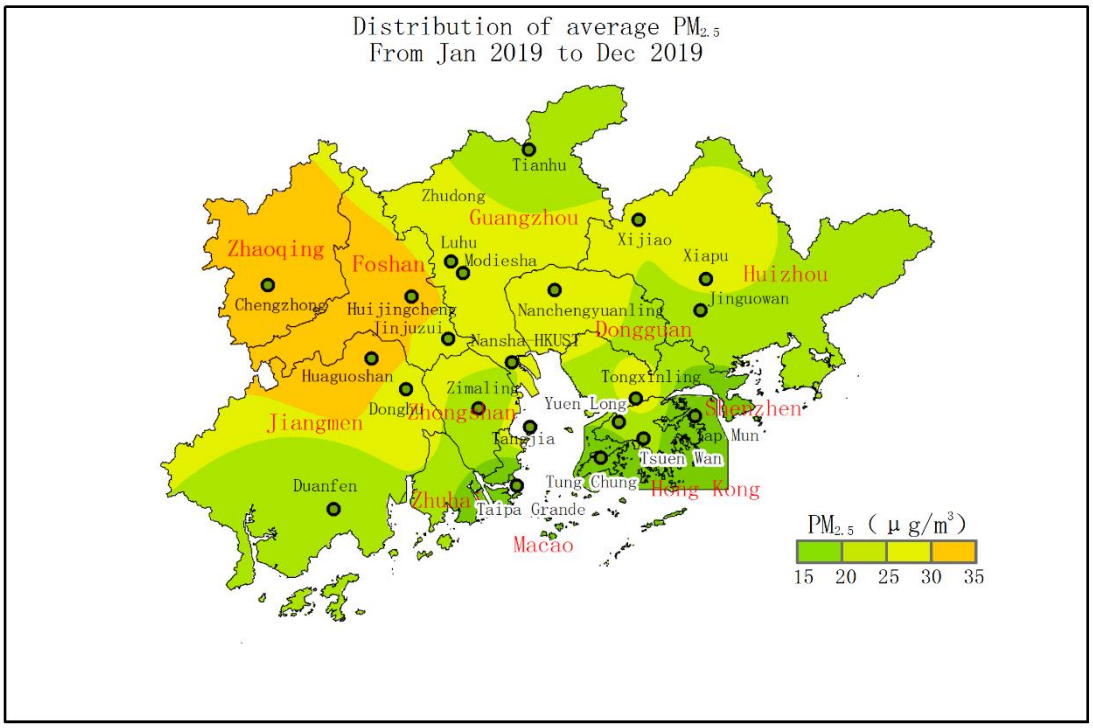

Figure 10：Spatial distribution of annual average concentrations of Fine Suspended Particulates ($PM_{2.5}$)

Remark: Zhudong's data are excluded in the spatial distribution map owing to its low daily data capture rate in 2019.

Table 4.6a：Daily averages of $PM_{2.5}$ (the monthly maxima and the 95th percentile of the year)

[Class II limit: 75 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Compliance	95th percentile
Luhu (Guangzhou)	95	58	61	43	44	29	40	47	52	63	66	76	99.2%	57
Modiesha (Guangzhou)	68	53	50	38	42	23	37	40	53	46	59	67	100.0%	48
Nansha-HKUST (Guangzhou)	88	38	43	37	27	22	44	41	56	58	58	71	99.7%	51
Tianhu (Guangzhou)	49	40	55	34	48	28	28	36	42	50	51	40	100.0%	41
Zhudong ^ (Guangzhou)	66	46	51	41	62	59	48	57	58	61	84	82	--	--
Tongxinling (Shenzhen)	92	34	39	46	29	23	50	44	70	68	52	73	99.4%	51
Jinjuzui (Foshan)	94	62	54	34	34	21	35	42	54	49	61	68	99.7%	54
Huijingcheng (Foshan)	81	88	73	64	50	29	40	51	60	62	77	92	97.7%	65
Tangjia (Zhuhai)	79	42	43	45	26	22	42	50	66	56	55	85	98.9%	56
Donghu (Jiangmen)	73	58	62	46	33	26	34	49	62	52	66	92	99.7%	60
Duanfen (Jiangmen)	51	32	31	25	24	18	23	57	43	46	88	112	97.4%	59
Huaguoshan (Jiangmen)	96	91	76	66	56	26	38	52	69	59	108	121	95.9%	73
Chengzhong (Zhaoqing)	93	102	110	87	47	26	33	43	40	55	62	84	96.2%	70
Xiapu (Huizhou)	66	44	41	52	29	18	33	39	57	59	53	72	100.0%	52
Xijiao (Huizhou)	51	36	37	42	45	42	32	37	44	52	44	47	100.0%	41
Jinguowan (Huizhou)	51	40	34	38	26	18	38	41	52	55	42	48	100.0%	40
Zimaling (Zhongshan)	80	47	35	39	27	22	37	48	62	52	54	73	99.7%	52
Nanchengyuanling (Dongguan)	115	58	61	47	40	25	38	38	54	56	76	70	98.0%	56
Tap Mun (Hong Kong)	44	32	27	30	27	20	34	38	53	51	36	34	100.0%	32
Tsuen Wan (Hong Kong)	86	32	28	40	23	19	50	56	63	47	40	57	99.7%	40
Yuen Long (Hong Kong)	81	25	29	29	22	18	47	46	59	51	40	38	99.7%	38
Tung Chung (Hong Kong)	82	25	35	44	20	19	46	48	63	41	40	59	99.7%	43
Taipa Grande (Macao)	70	31	33	31	21	16	33	46	55	47	41	64	100.0%	42

Remark : All concentration units are in micrograms per cubic metre (μg/m³).

^ Data are for reference only owing to its low daily data capture rate in 2019.

Table 4.6b：The monthly and annual averages of $PM_{2.5}$

[Class II limit for annual average: 35 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	48	24	26	22	20	16	18	23	28	38	41	39	29
Modiesha (Guangzhou)	33	20	24	21	18	14	18	20	25	33*	36	34	25
Nansha-HKUST (Guangzhou)	41	19	25	20	18	10	14*	20	27	34	38	37	25
Tianhu (Guangzhou)	26	17	21	18	20	18	18	19	24	32	31	27	23
Zhudong ^ (Guangzhou)	42	25	29	26*	31*	32*	25	31	34	40	42	43	34*
Tongxinling (Shenzhen)	38	19	23	22	18	11	15	18	28	36	38	41	26
Jinjuzui (Foshan)	44	23	26	21	19	14	16	21	27	33	38	36	27
Huijingcheng (Foshan)	47	29	31	28	24	19	21	27	33	40	46	45	33
Tangjia (Zhuhai)	47	21	25	18	16	9	14	17	27	32	39	41	26
Donghu (Jiangmen)	43	24	27	22	20	13	16	20	30	35	44	40	28
Duanfen (Jiangmen)	32	16	18	13	13	8*	9	15*	17	21	50	53	22
Huaguoshan (Jiangmen)	52	31	35	29	24	15	17	23	35	40	56	55	34
Chengzhong (Zhaoqing)	50	37	38	30	21	15	17	23	27	35	40	41	31
Xiapu (Huizhou)	38	22	25	23	17	12	15	19	24	35	40	41	26
Xijiao (Huizhou)	31	20	24	22	20	17	18	20	27	34	33*	31	25
Jinguowan (Huizhou)	29	18	19	18	16	11	15	17	23	32	32	29	22
Zimaling (Zhongshan)	44	19	22	18	16	9*	13	17	27	33	38	34	24
Nanchengyuanling (Dongguan)	52	26	30	26	19	14	15	21	26	35	39	41	29
Tap Mun (Hong Kong)	22	15	16	16	14	9	12	15	18	25	24	22	17
Tsuen Wan (Hong Kong)	34	18	18	16	14	9	12	15	20	25	27	26	20
Yuen Long (Hong Kong)	31	13	17	16	15	10	14	16	23	28	28	25	20
Tung Chung (Hong Kong)	39	16	19	16	12	8	12	15	21	23	25	27	19
Taipa Grande (Macao) #	34	14	16	12	11	5	9	11	19	23	27	28	18

Remark : All concentration units are in micrograms per cubic metre (μg/m³).

* The capture rate of validated daily data per month/year is below 85%.

^ Data are for reference only owing to its low daily data capture rate in 2019.

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 2019. In general, the monthly average concentrations of SO_2, NO_2, PM_{10}, $PM_{2.5}$, and CO were 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 cleaner 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. The ozone concentration was higher in October, mainly due to the fact that there were more days with meteorological conditions that favoured photochemical reactions (such as strong solar radiation and less amount of clouds) and resulted in more ozone formation during the period.

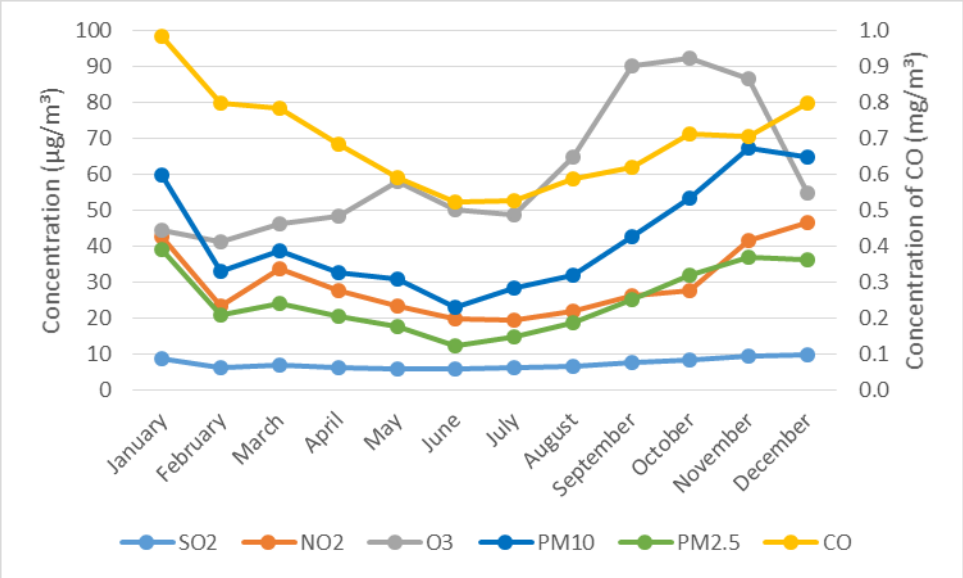

Figure 11：Monitoring network monthly variations of air pollutant concentrations

Remark: Zhudong's $PM_{2.5}$ data is excluded from the calculation of the annual averages of pollutants in 2019 owing to its low daily data capture rate during the year.

4.8 Annual Variations of Pollutant Concentrations (2006-2019)

Table 4.8 shows the annual average concentrations of air pollutants recorded by the Network from 2006 to 2019, while Figure 12 shows the trend of rate of changes in the annual pollutant concentrations.

From 2006 to 2019, the annual averages recorded by the Network for SO_2, NO_2, and PM_{10} decreased by 84%, 29% and 37% respectively, which exhibited a discernible downward trend with a descending rate of about 2.8, 0.9 and 1.9$\mu g/m^3$ per year respectively. As for CO and $PM_{2.5}$, these two parameters had been added to the Network in September 2014 and their annual averages decreased by 4% and 14% respectively between 2015 and 2019. These reductions indicate that the measures implemented in recent years by concerted or individual effort of Guangdong, Hong Kong and Macao, including 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 improved the overall air quality in the PRD region. Compared with 2006, the annual average of O_3 in 2019 increased by 36%, reflecting the photochemical smog problem in the region has not yet been resolved. 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	43	42	44	67	-	-
2007	44	41	46	72	-	-
2008	36	40	46	65	-	-
2009	26	38	51	64	-	-
2010	23	39	49	59	-	-
2011	21	37	53	59	-	-
2012	17	35	49	52	-	-
2013	17	37	49	59	-	-
2014	14	34	52	50	-	-
2015	12	30	47	44	29	0.730
2016	11	32	44	41	26	0.728
2017	10	31	52	45	28	0.665
2018	9	29	53	42	25	0.611
2019	7	30	60	42	25	0.700

Remark:
(1) All Tap Mun's pollutants data are excluded from the calculation of the annual averages of pollutants in 2016 owing to its low hourly data capture rate in 2016.
(2) Taipa Grande's PM_{10} and $PM_{2.5}$, Tap Mun's PM_{10} and Xijiao's $PM_{2.5}$ data are excluded from the calculation of the annual averages of pollutants in 2017 owing to its low daily data capture rate in 2017.
(3) All Tap Mun's pollutants and Jinguowan's O_3 data are excluded from the calculation of the annual averages of pollutants in 2018 owing to its low daily data capture rate in 2018.
(4) Zhudong's $PM_{2.5}$ data is excluded from the calculation of the annual averages of pollutants in 2019 owing to its low daily data capture rate in 2019.

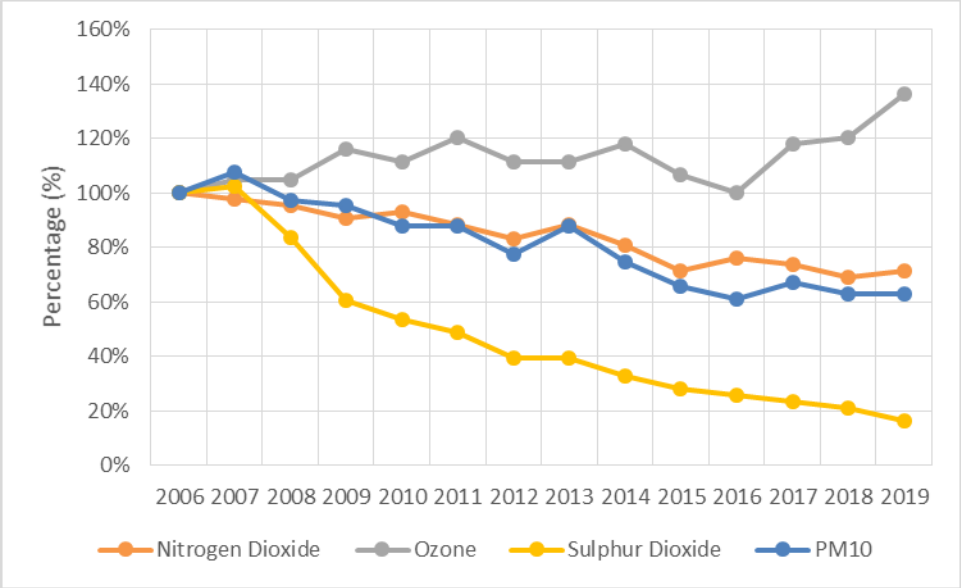

Figure 12：Trend of rates of changes in pollutant's annual averages in the monitoring network

Remark:
(1) All Tap Mun's pollutants data are excluded from the calculation of the annual averages of pollutants in 2016 owing to its low hourly data capture rate in 2016.
(2) Taipa Grande's PM_{10} and Tap Mun's PM_{10} data are excluded from the calculation of the annual averages of pollutants in 2017 owing to its low daily data capture rate in 2017.
(3) All Tap Mun's pollutants and Jinguowan's O_3 data are excluded from the calculation of the annual averages of pollutants in 2018 owing to its low daily data capture rate in 2018.

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
Nansha-HKUST (1) (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
Tongxinling (2) (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. 63, Zhengdong Road, Duanzhou District	Urban: mixed residential/commercial	38m	16m	Jun 2001
Xiapu (Huizhou)	No. 4 Xiabuhengjiang Road No. 3, Huicheng District	Urban: commercial	49m	20m	Dec 1999
Xijiao (3) (Huizhou)	Zhangbei Yaowei She Nationality Primary School, Henghe Town	Rural	44m	10m	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

Remarks:

(1) Wanqingsha station was renamed Nansha HKUST Station in the 1st quarter of 2019.

(2) Liyuan station was renamed Tongxinling Station in the 1st quarter of 2019.

(3) Xijiao Station was relocated to Zhangbei Yaowei She Nationality Primary School, Henghe Town, Boluo County, in the fourth quarter of 2019. The distance of the old and new sites is about 200 metres.

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