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

A Report of Monitoring Results in 2023

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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 2023 monitoring results from the Guangdong-Hong Kong-Macao Pearl River Delta Regional Air Quality Monitoring Network and their statistical analysis.

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1. Foreword

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

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 Ecological and Environmental Monitoring Centre of Guangdong[1] 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 in Guangdong and Hong Kong. Thirteen monitoring stations are located within the territory of Guangdong Province, three stations located in Hong Kong. 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 five stations, including Nanshadawen[2] and Zhudong in Guangzhou, Duanfen and

[1] When the Monitoring Network was established in 2003, the unit was named Guangdong Provincial Environmental Protection Monitoring Centre, which was renamed as Guangdong Provincial Environmental Monitoring Centre in 2008, and was renamed again as Ecological and Environmental Monitoring Centre of Guangdong in December 2020.

[2] Owing to insufficient space after the extensive renovation work at Modiesha monitoring station in Guangzhou, this station closed permanently in 2021, whereas a new Nanshadawen monitoring station in Guangzhou joined the network.

Huaguoshan in Jiangmen, and Xijiao[3] in Huizhou. Hong Kong added Yuen Long monitoring station on the basis of its original three stations and Macao joined in with the monitoring station at Taipa Grande. As regards the monitoring parameters, the Network continued to monitor the original four 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 latest spatial distribution of the monitoring stations after the enhancement of the network.

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.

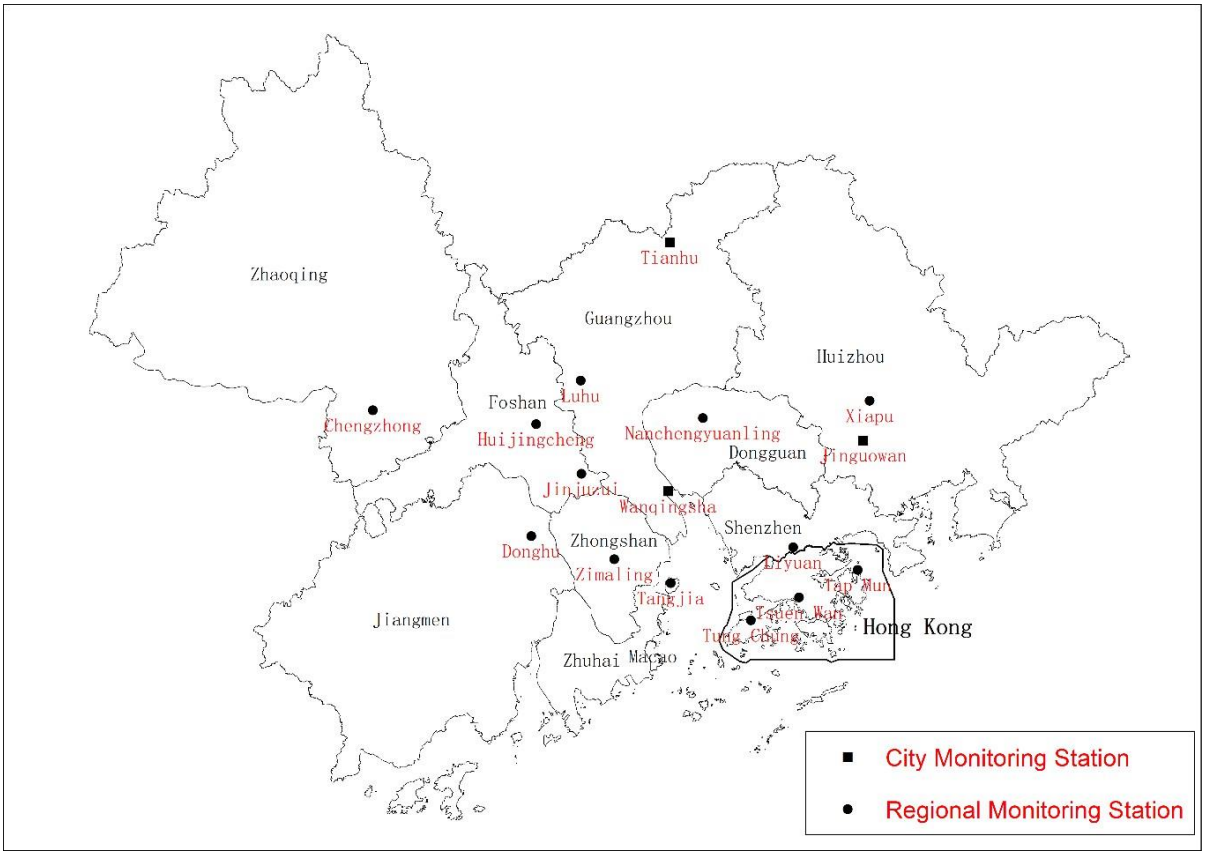

Figure 1：Spatial distribution of monitoring stations (Nov 2005 to Aug 2014)[4]

[3] Xijiao station was relocated to Zhangbei Yaowei She Nationality Primary School, Henghe Town, Boluo County, in the 4th quarter of 2019. Due to potential safety hazards of site load-bearing issue, the station is out of service from 00:00 on August 23, 2022. The new station completed reconstruction and resumed operation on the evening of April 18, 2023, which relocated to Shixia town, Boluo County, and renamed as "Boluo Shixia".

[4] The Figure 1 & 2 were drawn with reference to the China National Standard Map "Map of the Pearl River Delta Region" (approval number: 粵 S (2021) No. 169), and was re-submitted and approved for release. The approval number is GS 粵 (2022) No. 378.

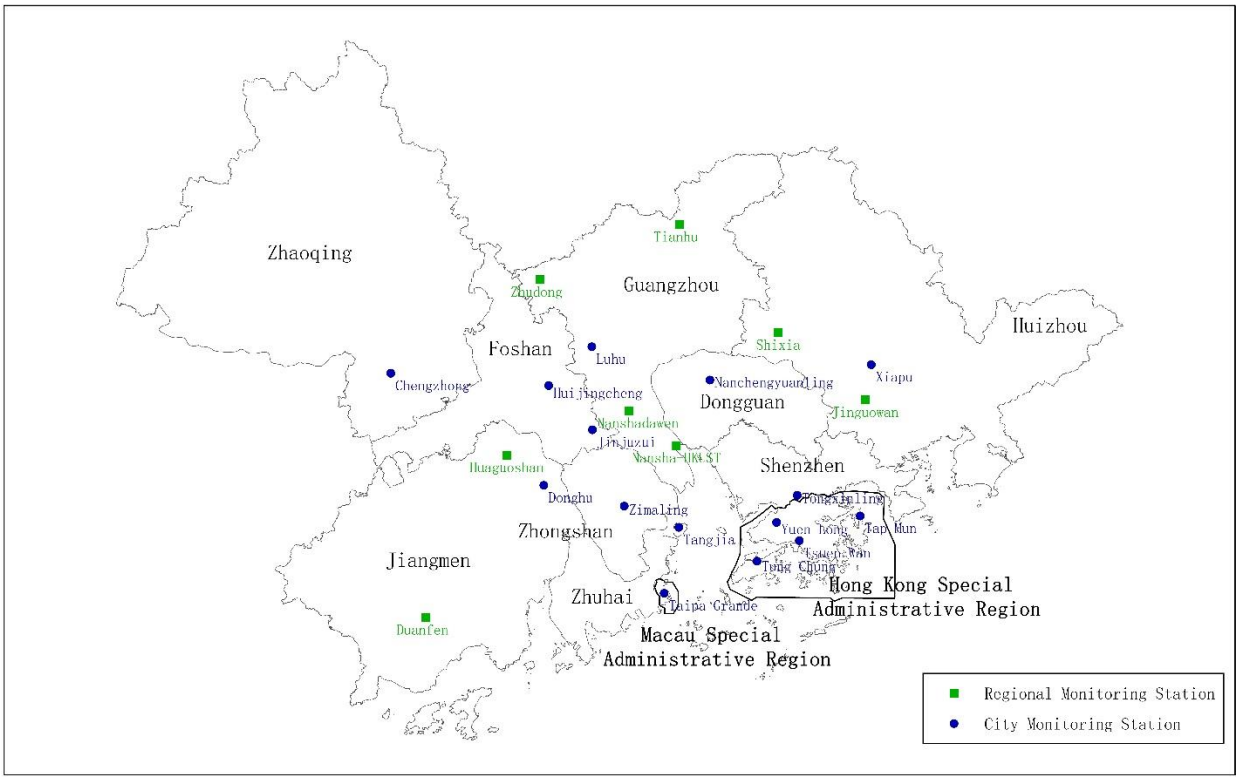

Figure 2：Spatial Distribution of Monitoring Stations in the Network (from Sept 2014)

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 2023. From 2015 onwards, the annual report covers the monitoring results of six 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 2023. The average hourly data capture rate for the six air pollutants measured at all monitoring stations was 96.9%.

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 GDEEMC, 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 2023, we had carried out 442 audit checks on the analyzers and particulate 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 -12.5% to 9.5%, 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 2023, we had carried out 3928 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 -9.5% and 13.1%, which were within the required performance goals (see Figure 4). In 2023, the overall QA/QC performance of the Network was satisfactory and met all the requirements specified in the QA/QC Operating Procedures.

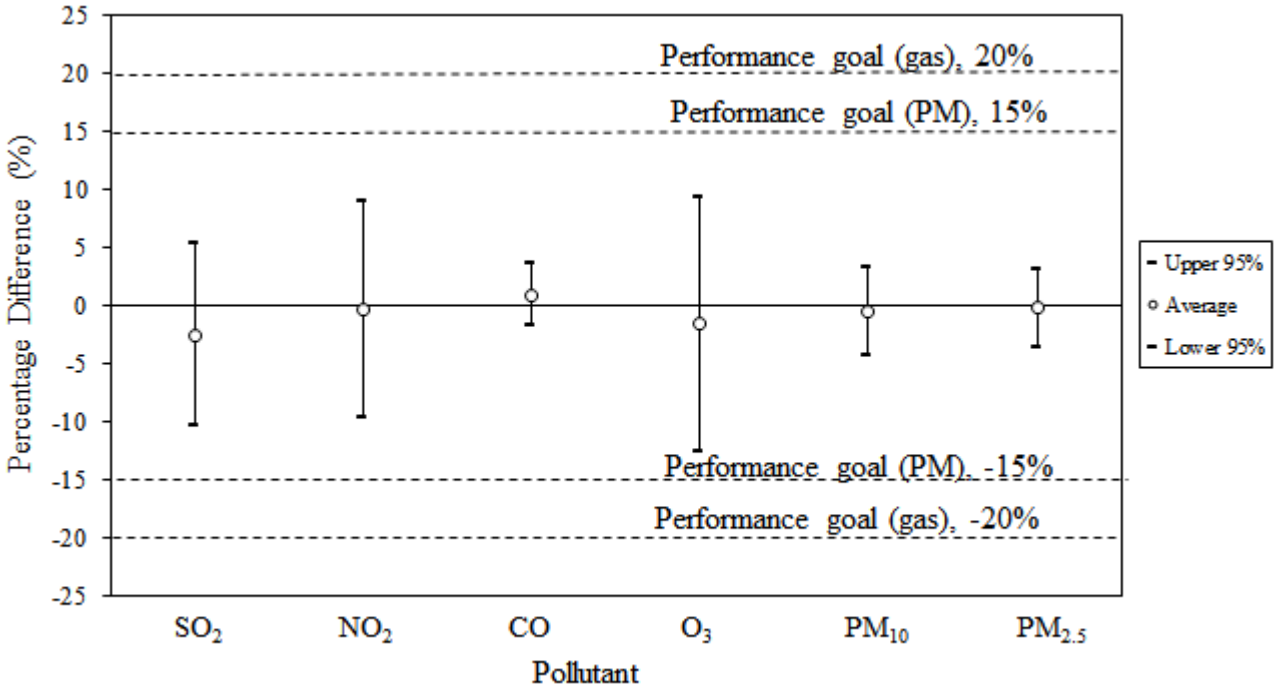

Figure 3：Accuracy of the monitoring network in 2023

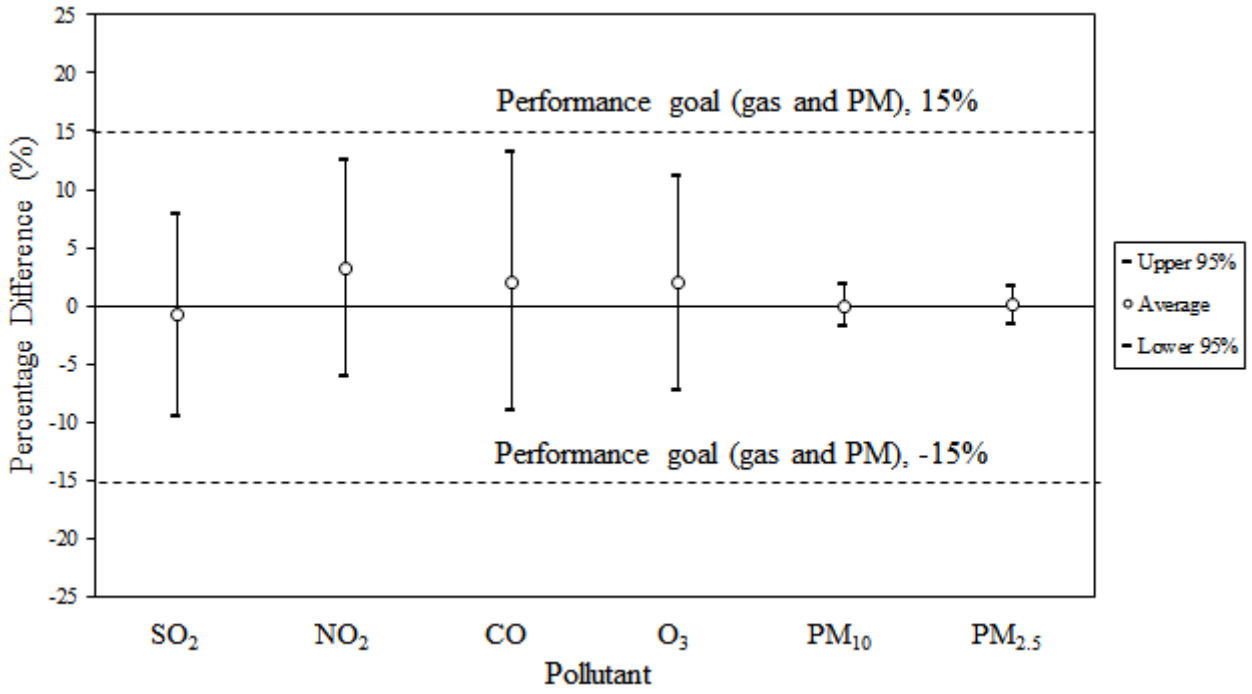

Figure 4：Precision of the monitoring network in 2023

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.

Owing to the low daily data capture rate in 2023 for the six monitoring parameters at Shixia station, these data were not used for statistical analysis 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.

In 2023, the annual average of SO_2 recorded at each monitoring station in the Network ranged from 4 to 11 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 4.1c 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.

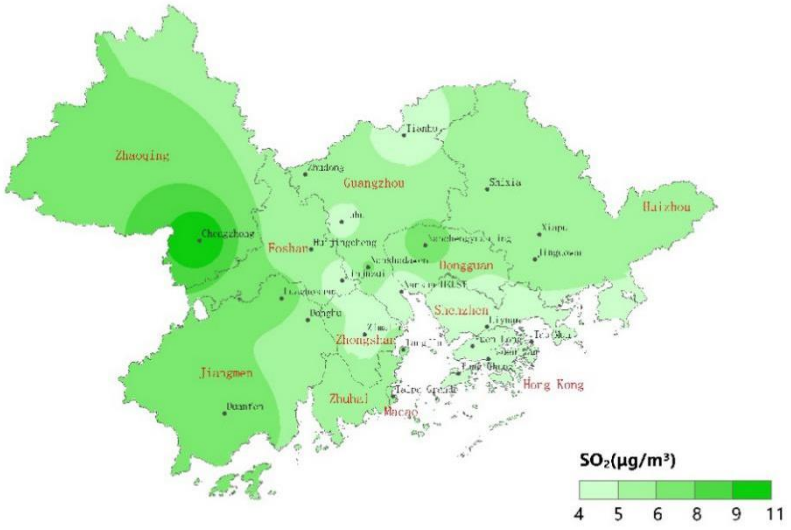

Figure 5：Spatial distribution of annual average concentrations of Sulphur Dioxide (SO_2)[5]

[5] Data at Shixia station in Huizho are excluded from the concentration spatial distribution figure and the calculation of the monthly variation of pollutant concentrations in 2022 owing to its low data capture rate during the year. The same applies to following.

Table 4.1a：Hourly averages concentration of Sulphur Dioxide (monthly maxima)[6]

[Class II limit[7]: 500 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Luhu (Guangzhou)	8	20	16	16	15	9	16	15	18	10	11	14
Nanshadawen (Guangzhou)	35	17	20	14	18	18	10	8	17	20	23	28
Nansha-HKUST (Guangzhou)	54	19	25	13	11	8	12	8	8	10	16	25
Tianhu (Guangzhou)	13	14	21	9	11	7	14	9	8	9	14	13
Zhudong (Guangzhou)	48	17	22	13	10	11	21	22	26	22	32	32
Tongxinling (Shenzhen)	8	6	8	5	9	13	8	8	12	5	11	8
Jinjuzui (Foshan)	9	14	14	8	18	8	8	9	10	10	13	11
Huijingcheng (Foshan)	13	29	22	16	34	18	18	11	10	23	33	39
Tangjia (Zhuhai)	12	11	12	14	12	9	13	8	9	9	10	13
Donghu (Jiangmen)	12	18	18	16	12	7	14	12	16	15	23	46
Duanfen (Jiangmen)	19	19	15	18	17	14	16	15	21	21	21	36
Huaguoshan (Jiangmen)	22	19	21	28	33	22	30	22	26	27	26	29
Chengzhong (Zhaoqing)	16	51	75	39	113	94	102	119	42	56	67	139
Xiapu (Huizhou)	12	13	24	14	16	9	17	14	13	22	20	20
Shixia (Huizhou)	--	--	--	13	17	20	14	14	14	14	18	22
Jinguowan (Huizhou)	29	11	10	13	31	10	18	16	16	7	52	12
Zimaling (Zhongshan)	21	14	15	13	33	16	11	8	14	9	14	17
Nanchengyuanling (Dongguan)	14	18	25	26	17	13	15	14	16	14	11	22
Tap Mun (Hong Kong)	25	11	13	10	11	9	12	10	8	7	6	8
Tsuen Wan (Hong Kong)	18	24	15	11	26	10	41	11	13	10	12	17
Yuen Long (Hong Kong)	16	10	12	9	13	8	20	12	10	10	13	14
Tung Chung (Hong Kong)	16	18	14	12	7	7	12	10	16	12	12	18
Taipa Grande (Macao)	9	11	25	10	15	9	11	9	10	12	12	17

[6] All pollutants, except for carbon monoxide, are measured in micrograms per cubic meter (μg/m3). The unit for carbon monoxide concentration is milligrams per cubic meter (mg/m3). "*" The capture rate of validated daily data per month is below 85%. "—" No monitoring for the corresponding period. This also applies to all the pollutant monitoring mentioned below.

[7] "Class II limit" is the abbreviation of the Class II limit values of the Ambient Air Quality Standard (GB3095-2012). This also applies to all the pollutant monitoring mentioned below.

Table 4.1b：Daily averages concentration of Sulphur Dioxide (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)	7	9	9	7	7	6	8	7	9	8	6	9	100.0%	8
Nanshadawen (Guangzhou)	15	14	9	7	9	9	8	5	8	11	14	15	100.0%	14
Nansha-HKUST (Guangzhou)	11	11	11	8	6	3	5	3	4	4	11	11	100.0%	11
Tianhu (Guangzhou)	7	10	10	6	6	6	9	7	6	7	10	11	100.0%	10
Zhudong (Guangzhou)	8	10	11	8	4	5	9	10	11	13	20	16	100.0%	13
Tongxinling (Shenzhen)	4	5	6	4	5	4	5	5	6	4	7	6	100.0%	6
Jinjuzui (Foshan)	6	7	7	5	5	4	5	4	6	7	6	8	100.0%	6
Huijingcheng (Foshan)	8	13	9	7	14	9	9	8	6	10	16	20	100.0%	15
Tangjia (Zhuhai)	10	8	6	6	7	7	9	6	6	7	6	8	100.0%	9
Donghu (Jiangmen)	8	9	10	10	8	5	9	8	10	9	10	15	100.0%	10
Duanfen (Jiangmen)	7	7	8	11	10	9	12	11	11	11	14	12	100.0%	11
Huaguoshan (Jiangmen)	8	8	10	12	16	13	14	15	11	12	10	13	100.0%	13
Chengzhong (Zhaoqing)	11	20	20	17	24	30	27	26	16	16	24	22	100.0%	23
Xiapu (Huizhou)	9	8	11	8	7	5	6	9	7	11	12	13	100.0%	11
Shixia (Huizhou)	--	--	--	10	12	10	11	10	10	10	11	9	--	10
Jinguowan (Huizhou)	8	8	8	7	11	7	9	7	8	5	10	8	100.0%	8
Zimaling (Zhongshan)	10	9	9	10	8	5	8	5	7	7	7	9	100.0%	9
Nanchengyuanling (Dongguan)	11	12	11	12	11	9	9	9	10	10	8	12	100.0%	11
Tap Mun (Hong Kong)	8	7	7	7	6	7	6	7	6	4	4	5	100.0%	7
Tsuen Wan (Hong Kong)	11	14	10	5	8	5	7	6	8	6	6	9	100.0%	10
Yuen Long (Hong Kong)	7	5	8	6	9	6	7	6	7	8	9	10	100.0%	9
Tung Chung (Hong Kong)	9	13	5	4	3	4	7	6	8	8	8	11	100.0%	10
Taipa Grande (Macao)	7	8	7	7	7	6	8	6	7	8	9	12	100.0%	10

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

[Class II limit: 60 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	4	5	5	5	5	6	6	6	6	6	5	6	5
Nanshadawen (Guangzhou)	9	6	4	3	7	8	4	4	6	8	11	10	7
Nansha-HKUST (Guangzhou)	7	7	4	2	2	2	2	1	2	2	6	8	4
Tianhu (Guangzhou)	5	5	6	4	4	4	6	6	5*	6	8	7	5
Zhudong (Guangzhou)	5	6	6	4	2	3	6	8	9	10	12	7	6
Tongxinling (Shenzhen)	3	4	4	4	3	3	4	4	3	3	5	4	4
Jinjuzui (Foshan)	4	5	4	3	4	3	4	3	4	4	3	3	4
Huijingcheng (Foshan)	5	7	4	4	5	5	6	6	6	7	9	12	6
Tangjia (Zhuhai)	8	6	4	4	5	6	6	5	5	5	5	6	6
Donghu (Jiangmen)	7	7	6	7	6	4	6	7	7	6	7	8	6
Duanfen (Jiangmen)	4	5	5	8	8	7	9	9	9	9	8	8	8
Huaguoshan (Jiangmen)	4	5	5	9	11	9	11	10	7	8	8	8	8
Chengzhong (Zhaoqing)	8	9	13	11	13	14	13	11	9	8	13	12	11
Xiapu (Huizhou)	5	5	6	5	5	4	5	5	6	8	10	10	6
Shixia (Huizhou)	--	--	--	8*	7	7	8	7	7	8	8	7	7*
Jinguowan (Huizhou)	5	6	6	6	6	6	6	6	6	4	5	6	6
Zimaling (Zhongshan)	4	6	6	6	5	4	6	4	5	4	5	6	5
Nanchengyuanling (Dongguan)	9	9	9	9	9	8	7	7	8	8	5	8	8
Tap Mun (Hong Kong)	5	5	5	5	5	5	6	6	3	2	2	3	4
Tsuen Wan (Hong Kong)	9	8	6	3	3	4	5	5	5	5	5	6	5
Yuen Long (Hong Kong)	4	4	5	5	5	4	5	6	6	6	7	8	5
Tung Chung (Hong Kong)	7	4	2	2	3	3	4	5	6	6	7	8	5
Taipa Grande (Macao)	5	6	5	5	5	5	5	6	5	7	8	9	6

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 2023, the annual average of NO_2 recorded at each monitoring station in the Network ranged from 8 to 39 μg/m^3, among them, the monitoring station having the highest annual average value of NO_2 was located in the urban area. During the year, 9 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 95.9% 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.

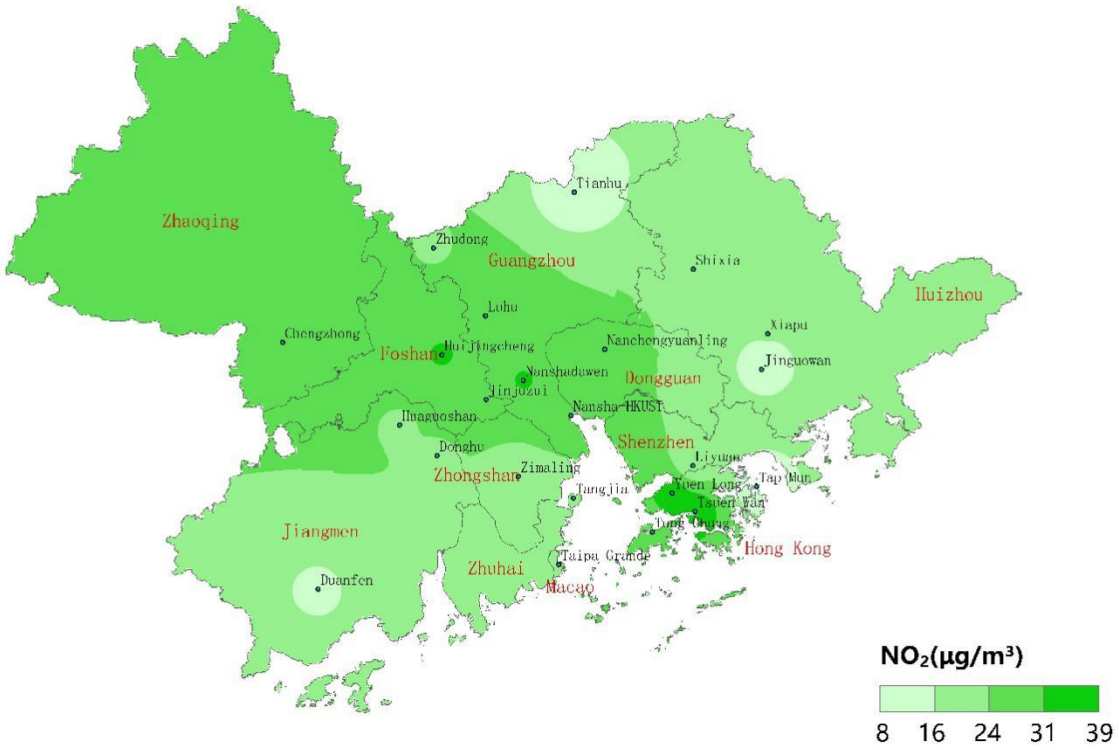

Figure 6：Spatial distribution of annual average concentrations of Nitrogen Dioxide (NO_2)

Table 4.2a：Hourly averages concentration of Nitrogen Dioxide (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)	95	171	153	90	107	70	86	72	64	103	117	127
Nanshadawen (Guangzhou)	125	170	188	104	100	77	69	65	105	115	181	164
Nansha-HKUST (Guangzhou)	102	130	130	88	84	67	73	71	92	92	139	201
Tianhu (Guangzhou)	20	37	45	40	27	23	38	29	34	31	26	41
Zhudong (Guangzhou)	58	99	101	66	71	50	58	59	50	57	90	100
Tongxinling (Shenzhen)	79	69	112	64	68	52	43	48	44	58	91	89
Jinjuzui (Foshan)	89	120	121	84	67	65	44	92	71	67	138	156
Huijingcheng (Foshan)	104	159	168	106	79	65	54	46	59	124	181	179
Tangjia (Zhuhai)	77	82	66	65	42	40	35	40	42	57	82	134
Donghu (Jiangmen)	66	109	118	75	65	44	41	40	43	85	146	159
Duanfen (Jiangmen)	60	45	54	41	40	20	26	24	24	39	57	82
Huaguoshan (Jiangmen)	80	95	108	80	75	42	41	33	45	84	112	147
Chengzhong (Zhaoqing)	105	141	129	105	90	85	92	64	110	113	181	127
Xiapu (Huizhou)	78	88	100	58	38	32	35	40	41	48	92	97
Shixia (Huizhou)	--	--	--	38	36	49	45	54	29	74	42	70
Jinguowan (Huizhou)	35	32	40	50	49	33	34	38	31	28	63	66
Zimaling (Zhongshan)	92	90	70	61	64	30	28	32	43	63	97	156
Nanchengyuanling (Dongguan)	107	162	211	113	70	68	93	67	61	98	136	135
Tap Mun (Hong Kong)	45	43	43	43	41	22	40	46	43	24	49	56
Tsuen Wan (Hong Kong)	128	169	137	172	153	120	177	116	156	98	117	225
Yuen Long (Hong Kong)	145	126	137	90	105	103	93	77	115	106	128	230
Tung Chung (Hong Kong)	78	117	121	111	94	64	84	67	64	73	93	175
Taipa Grande (Macao)	93	78	68	61	52	34	34	58	42	61	117	141

Table 4.2b：Daily averages concentration of Nitrogen Dioxide (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)	55	78	84	48	46	36	36	42	37	63	71	76	99.7%	71
Nanshadawen (Guangzhou)	67	67	78	56	42	27	31	35	45	56	88	102	99.2%	74
Nansha-HKUST (Guangzhou)	52	68	59	65	45	28	31	34	37	44	62	115	99.2%	68
Tianhu (Guangzhou)	11	23	25	30	15	13	18	15	18	16	16	23	100.0%	22
Zhudong (Guangzhou)	36	52	52	54	31	26	25	31	26	35	50	78	100.0%	50
Tongxinling (Shenzhen)	39	28	53	29	29	23	22	31	30	24	44	55	100.0%	40
Jinjuzui (Foshan)	55	60	44	51	40	28	22	46	29	44	75	112	98.9%	66
Huijingcheng (Foshan)	58	96	87	59	56	34	29	25	38	70	118	125	95.9%	94
Tangjia (Zhuhai)	46	38	45	34	23	17	17	21	25	31	49	79	100.0%	47
Donghu (Jiangmen)	46	66	51	48	36	25	17	18	29	44	76	114	99.2%	67
Duanfen (Jiangmen)	39	25	39	29	28	10	15	17	14	27	31	47	100.0%	39
Huaguoshan (Jiangmen)	49	59	60	49	36	21	16	16	31	39	64	84	99.4%	63
Chengzhong (Zhaoqing)	48	65	71	68	47	44	34	32	47	54	84	81	99.2%	73
Xiapu (Huizhou)	30	34	38	28	24	14	17	21	23	23	46	56	100.0%	39
Shixia (Huizhou)	--	--	--	23	22	17	20	19	16	17	18	32	--	20
Jinguowan (Huizhou)	27	17	23	21	25	19	21	19	21	18	23	34	100.0%	25
Zimaling (Zhongshan)	58	36	43	38	36	16	17	24	25	38	54	96	99.7%	57
Nanchengyuanling (Dongguan)	47	69	78	60	43	29	31	34	34	40	69	78	100.0%	62
Tap Mun (Hong Kong)	20	14	19	16	14	10	13	18	15	10	14	24	100.0%	16
Tsuen Wan (Hong Kong)	59	66	70	77	69	65	58	57	76	46	64	105	98.9%	71
Yuen Long (Hong Kong)	61	72	86	49	60	56	46	45	54	49	73	96	99.2%	70
Tung chung (Hong Kong)	44	60	67	61	45	37	40	38	42	39	47	90	99.7%	60
Taipa Grande (Macao)	55	51	56	36	32	20	22	23	26	34	60	103	99.4%	56

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

[Class II limit: 40 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	24	41	41	31	28	24	19	23	25	27	46	43	31
Nanshadawen (Guangzhou)	31	41	45	35	24	19	17	20	25	31	49	48	32
Nansha-HKUST (Guangzhou)	25	36	30	32	26	16	15	17	23	24	38	49	28
Tianhu (Guangzhou)	7	13	16	11	9	7	10	9	7*	6	11	13	10
Zhudong (Guangzhou)	15	28	34	28	21	18	15	18	17	18	32	31	23
Tongxinling (Shenzhen)	17	15	19	14	12	11	12	16	19	17	22	27	17
Jinjuzui (Foshan)	24	31	28	27	18	15	12	19	19	25	40	49	25
Huijingcheng (Foshan)	29	45	39	32	28	23	17	16	24	29	47	57	32
Tangjia (Zhuhai)	22	24	23	19	13	8	7	9	14	19	24	36	18
Donghu (Jiangmen)	23	31	27	21	17	13	11	12	16	24	38	48	23
Duanfen (Jiangmen)	19	19	18	13	9	6	8	8	10	19	20	28	15
Huaguoshan (Jiangmen)	24	36	32	24	16	13	9	10	15	26	38	40	23
Chengzhong (Zhaoqing)	21	37	32	32	25	24	18	20	28	26	49	42	29
Xiapu (Huizhou)	17	20	21	15	12	11	11	14	11	13	23	25	16
Shixia (Huizhou)	--	--	--	15*	13	10	12	12	9	8	11	14	11*
Jinguowan (Huizhou)	11	12	16	13	14*	12	13	14	12	12	16	19	14
Zimaling (Zhongshan)	21	22	21	17	13	5	7	9	13	22	32	45	19
Nanchengyuanling (Dongguan)	20	35	35	30	23	18	15	18	20	17	34	35	25
Tap Mun (Hong Kong)	10	9	10	8	8	4	6	8	7	6	8	12	8
Tsuen Wan (Hong Kong)	41	43	43	42	40	36	33	39	33	32	39	50	39
Yuen Long (Hong Kong)	37	36	44	34	32	30	29	33	29	33	44	52	36
Tung Chung (Hong Kong)	29	34	29	24	20	17	16	20	20	26	28	44	26
Taipa Grande (Macao)	28	27	24	20	14	9	9	11	15	22	30	46	21

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.

In 2023, the annual average of O_3 recorded at each monitoring station in the Network ranged from 46 to 80 μg/m^3 with higher average values being recorded in rural areas such as Tianhu in Guangzhou, Taipa Grande in Macao and Tap Mun in 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 79.4% to 99.7%. All monitoring stations recorded exceedance of the national 1-hour average concentration limit (200 μg/m^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.

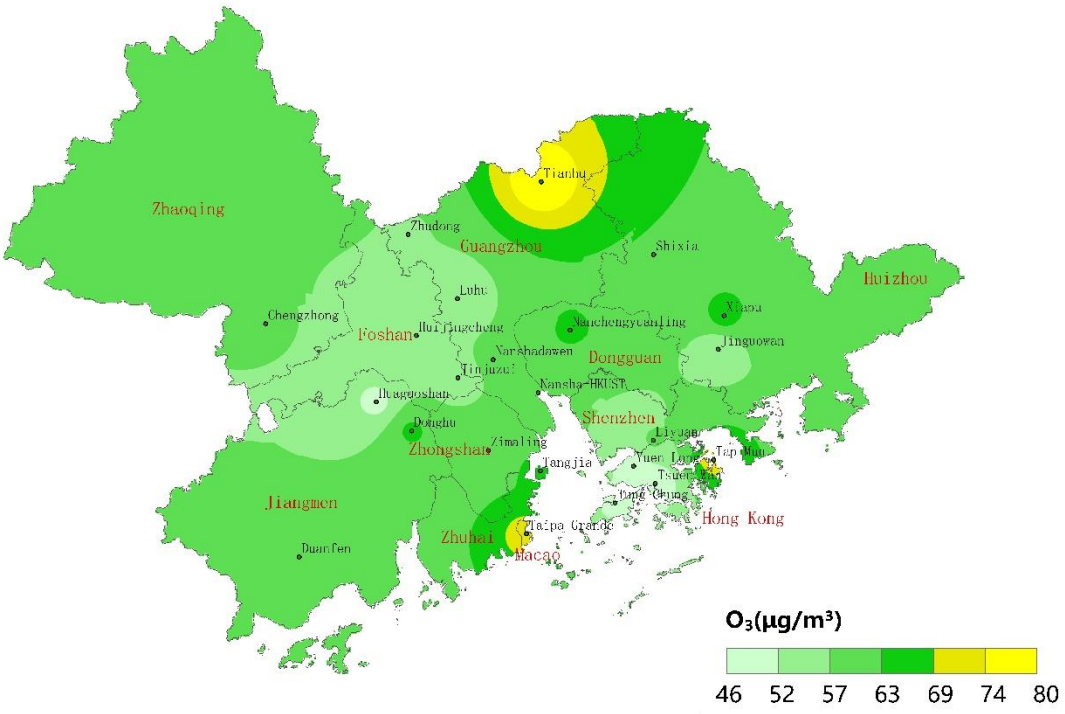

Figure 7：Spatial distribution of annual average concentrations of Ozone (O_3)

Table 4.3a：Hourly averages concentration of Ozone (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)	163	216	278	270	263	263	235	250	222	240	248	166
Nanshadawen (Guangzhou)	155	249	268	253	256	272	296	312	301	351	300	267
Nansha-HKUST (Guangzhou)	179	280	244	289	281	236	280	223	214	230	317	260
Tianhu (Guangzhou)	146	211	244	236	221	174	219	167	195	218	218	193
Zhudong (Guangzhou)	145	249	278	246	248	262	256	343	217	257	297	218
Tongxinling (Shenzhen)	123	174	271	176	332	191	216	150	174	186	268	219
Jinjuzui (Foshan)	115	181	244	246	209	210	251	214	218	233	229	201
Huijingcheng (Foshan)	146	203	248	254	245	278	216	247	216	286	236	226
Tangjia (Zhuhai)	180	247	294	202	261	192	256	195	220	241	327	237
Donghu (Jiangmen)	153	282	356	312	246	225	254	229	255	244	370	302
Duanfen (Jiangmen)	128	197	169	261	199	175	173	159	165	184	196	267
Huaguoshan (Jiangmen)	134	221	236	275	197	205	176	213	200	257	379	241
Chengzhong (Zhaoqing)	163	218	250	204	175	196	143	242	258	220	250	189
Xiapu (Huizhou)	113	165	223	189	220	187	209	196	205	159	175	183
Shixia (Huizhou)	--	--	--	189	201	232	247	225	208	212	206	246
Jinguowan (Huizhou) ^	119	170	196	170	248	196	199	175	190	160	145	166
Zimaling (Zhongshan)	153	237	265	227	265	226	262	204	195	216	297	214
Nanchengyuanling (Dongguan)	162	223	276	287	269	266	240	276	227	247	258	240
Tap Mun (Hong Kong)	137	174	205	184	234	189	310	137	183	173	191	177
Tsuen Wan (Hong Kong)	93	215	129	171	193	138	274	113	181	207	145	153
Yuen Long (Hong Kong)	130	211	235	186	358	204	289	179	218	186	207	216
Tung Chung (Hong Kong)	133	252	287	191	291	146	280	155	212	226	229	217
Taipa Grande (Macao)	182	268	248	226	227	191	302	134	205	216	288	192

Table 4.3b：Daily maximum 8-hour averages concentration of Ozone (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)	132	175	229	229	224	239	199	216	169	201	191	135	89.3%	159
Nanshadawen (Guangzhou)	126	196	213	211	214	219	254	245	249	288	238	204	79.4%	187
Nansha-HKUST (Guangzhou)	139	202	229	236	254	198	227	167	180	182	258	174	87.5%	164
Tianhu (Guangzhou)	125	202	225	205	183	156	196	142	174	211	201	166	92.1%	154
Zhudong (Guangzhou)	138	212	219	184	196	201	208	276	176	209	212	157	84.9%	172
Tongxinling (Shenzhen)	98	137	210	148	270	158	182	98	146	159	218	135	98.6%	126
Jinjuzui (Foshan)	95	160	202	189	183	194	215	158	188	188	197	158	92.5%	148
Huijingcheng (Foshan)	123	166	194	209	205	221	181	207	193	236	192	147	90.5%	153
Tangjia (Zhuhai)	135	183	240	183	241	165	224	127	178	200	255	189	89.3%	160
Donghu (Jiangmen)	129	227	290	236	218	203	219	173	176	206	287	188	83.0%	175
Duanfen (Jiangmen)	112	176	154	213	183	137	144	130	139	164	167	205	97.8%	141
Huaguoshan (Jiangmen)	106	192	195	240	154	187	164	160	175	226	300	178	93.2%	153
Chengzhong (Zhaoqing)	150	192	237	184	153	190	129	205	219	190	209	146	90.9%	154
Xiapu (Huizhou)	101	148	176	165	185	175	161	182	160	145	142	130	95.5%	142
Shixia (Huizhou)	--	--	--	157	186	212	213	170	186	178	179	180	--	157
Jinguowan (Huizhou) ^	103	146	175	140	205	173	164	161	150	141	126	123	97.8%	124
Zimaling (Zhongshan)	116	195	229	200	231	190	221	130	163	188	225	159	88.7%	160
Nanchengyuanling (Dongguan)	141	198	223	221	237	240	189	223	196	231	199	185	86.7%	168
Tap Mun (Hong Kong)	125	157	190	171	172	158	254	100	140	162	171	166	95.6%	147
Tsuen Wan (Hong Kong)	80	148	121	125	153	104	177	90	139	136	129	99	99.7%	103
Yuen Long (Hong Kong)	100	154	186	166	289	156	202	104	169	151	169	151	98.1%	127
Tung Chung (Hong Kong)	91	169	191	125	234	90	231	104	160	166	153	122	98.4%	115
Taipa Grande (Macao)	146	177	208	205	200	159	253	115	175	177	238	151	92.5%	154

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

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	47	52	61	55	63	58	57	55	48	58	51	37	53
Nanshadawen (Guangzhou)	50	55	56	54	61	60	64	64	65	73	66	40	59
Nansha-HKUST (Guangzhou)	51	64	68	65	79	52	45	46	48	66	71	44	58
Tianhu (Guangzhou)	70	79	92	81	80	71	80	72	69*	83	102	77	80
Zhudong (Guangzhou)	48	52	63	54	64	63	68	69	51	56	58	40	57
Tongxinling (Shenzhen)	51	68	73	66	67	46	41	39	49	74	74	52	58
Jinjuzui (Foshan)	43	55	66	54	61	53	50	50	50	61	61	39	54
Huijingcheng (Foshan)	45	49	59	57	67	64	60	56	51	62	57	36	55
Tangjia (Zhuhai)	56	75	78	75	73	59	52	50	56	81	77	51	65
Donghu (Jiangmen)	53	71	78	68	71	59	56	61	60	77	74	46	64
Duanfen (Jiangmen)	52	68	68	78*	67	52	43	42	48	68	67	50	58
Huaguoshan (Jiangmen)	45	51	62	60	53	47	43	44	40	58	60	35	50
Chengzhong (Zhaoqing)	54	58	69	53	63	57	51	55	60	70	65	46	58
Xiapu (Huizhou)	56	71	83	76	75	57	55	61	56	67	70	52	65
Shixia (Huizhou)	--	--	--	69*	66	52	57	54	52	75	77	60	62*
Jinguowan (Huizhou)	53	66	64	60	58	39	42	43	50	57	61	49	53
Zimaling (Zhongshan)	48	69	72	70	72	58	54	49	54	72	69	44	61
Nanchengyuanling (Dongguan)	59	70	72	71	75	61	57	56	50	73	69	49	64
Tap Mun (Hong Kong)	64	83	96	88	79	51	45	42	59	88	95	72	72
Tsuen Wan (Hong Kong)	37	53	62	54	49	28	27	25	39	69	67	45	46
Yuen Long (Hong Kong)	45	39	65	61	61	37	34	33	34	70	64	46	49
Tung Chung (Hong Kong)	40	60	70	58	59	37	38	36	42	62	61	39	50
Taipa Grande (Macao)	57	81	90	86	80	63	61	55	62	87	92	56	72

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 2023, the annual average of CO recorded at each monitoring station in the Network ranged from 0.4 to 0.7 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 4.4a to 4.4c 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.

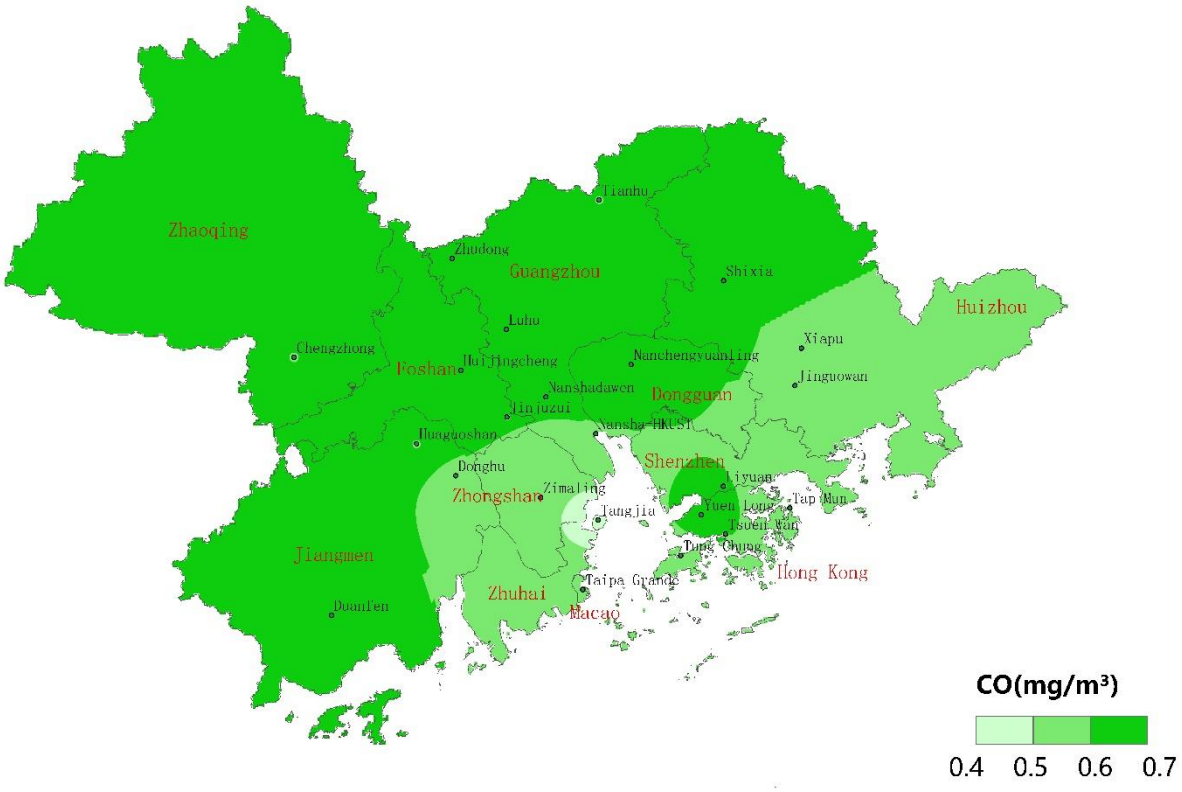

Figure 8：Spatial distribution of annual average concentrations of Carbon Monoxide (CO)

Table 4.4a：Hourly averages concentration of Carbon Monoxide (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)	1.1	1.4	1.1	1.2	1.1	2.0	1.1	1.3	1.1	1.3	1.1	1.6
Nanshadawen (Guangzhou)	1.1	1.7	1.2	1.7	1.0	0.7	0.9	1.4	1.4	1.6	1.5	1.9
Nansha-HKUST (Guangzhou)	0.8	1.1	2.3	1.1	1.0	1.1	0.9	0.9	1.3	1.0	1.1	1.4
Tianhu (Guangzhou)	1.0	1.5	1.6	1.0	0.7	1.0	0.8	1.0	1.7	0.8	1.2	1.1
Zhudong (Guangzhou)	1.4	1.2	1.2	0.9	1.1	0.8	0.9	1.1	1.1	1.0	1.6	1.3
Tongxinling (Shenzhen)	1.2	1.0	1.2	1.0	1.0	1.1	1.0	1.1	0.9	1.1	1.4	1.5
Jinjuzui (Foshan)	1.1	1.5	1.2	1.2	1.1	1.2	0.9	0.9	0.9	1.2	1.3	2.1
Huijingcheng (Foshan)	1.6	1.9	1.9	1.3	1.1	1.0	0.9	1.0	1.4	1.7	2.2	2.8
Tangjia (Zhuhai)	0.9	0.7	0.9	0.8	0.7	0.7	0.6	0.8	0.6	0.8	0.8	1.0
Donghu (Jiangmen)	1.7	1.6	1.8	1.2	1.5	1.1	0.9	1.0	1.1	1.5	2.7	2.4
Duanfen (Jiangmen)	1.0	1.1	1.1	0.9	1.0	1.0	1.0	1.2	1.1	1.0	1.1	1.1
Huaguoshan (Jiangmen)	1.4	1.5	1.4	1.0	1.1	1.0	1.0	1.0	0.8	1.1	1.5	1.4
Chengzhong (Zhaoqing)	1.4	1.4	1.2	1.3	0.9	0.9	0.9	1.0	0.9	1.1	1.2	1.6
Xiapu (Huizhou)	1.4	1.4	1.1	0.8	1.0	1.2	0.9	0.9	0.7	0.9	1.3	2.0
Shixia (Huizhou)	--	--	--	0.9	0.9	1.1	0.8	0.9	0.9	1.1	1.1	1.7
Jinguowan (Huizhou)	1.0	1.2	0.8	0.9	0.8	0.9	0.8	0.8	0.7	0.9	1.0	1.0
Zimaling (Zhongshan)	1.0	1.1	1.2	1.0	0.9	0.8	0.7	0.7	0.7	0.8	1.0	1.2
Nanchengyuanling (Dongguan)	1.6	1.2	1.6	1.3	1.2	1.0	1.0	1.1	1.0	1.1	1.4	1.8
Tap Mun (Hong Kong)	0.9	0.7	0.6	0.7	0.8	0.7	0.8	0.7	0.8	0.9	1.0	0.8
Tsuen Wan (Hong Kong)	1.5	1.0	1.1	1.0	1.0	0.9	0.6	0.8	0.9	1.0	1.2	1.5
Yuen Long (Hong Kong)	1.3	1.3	1.2	0.9	1.0	1.0	0.9	0.9	1.1	1.2	1.1	1.6
Tung Chung (Hong Kong)	1.1	0.8	0.8	1.2	0.8	0.7	0.6	0.6	0.7	0.8	0.7	1.3
Taipa Grande (Macao)	1.2	1.0	1.1	0.9	0.9	0.8	0.9	0.9	1.2	1.1	1.1	1.1

Table 4.4b：Daily averages concentration of Carbon Monoxide (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)	0.9	1.1	1.0	1.0	0.9	1.0	0.9	1.0	0.9	0.9	0.8	0.9	100.0%	0.9
Nanshadawen (Guangzhou)	0.9	1.2	1.1	1.1	0.8	0.5	0.7	1.0	0.9	1.1	1.1	1.2	100.0%	1.0
Nansha-HKUST (Guangzhou)	0.7	0.8	0.9	1.1	0.8	0.9	0.7	0.8	0.9	0.9	0.9	1.1	100.0%	0.9
Tianhu (Guangzhou)	0.6	1.2	1.2	0.9	0.6	0.9	0.7	0.9	0.7	0.8	1.0	0.9	100.0%	0.9
Zhudong (Guangzhou)	1.0	1.0	1.0	0.7	0.7	0.7	0.7	0.9	0.9	0.9	1.0	1.1	100.0%	0.9
Tongxinling (Shenzhen)	0.8	0.9	0.8	0.9	0.9	0.9	0.9	1.0	0.7	0.9	0.8	0.9	100.0%	0.9
Jinjuzui (Foshan)	0.8	1.0	1.0	0.8	0.8	0.7	0.7	0.7	0.6	0.7	0.9	1.0	100.0%	0.8
Huijingcheng (Foshan)	1.0	1.3	1.1	1.0	1.0	0.8	0.8	0.9	1.0	1.2	1.5	1.7	100.0%	1.1
Tangjia (Zhuhai)	0.7	0.6	0.7	0.7	0.5	0.5	0.4	0.5	0.6	0.7	0.6	0.9	100.0%	0.6
Donghu (Jiangmen)	0.9	1.1	1.0	1.0	1.0	0.7	0.6	0.7	0.7	0.9	1.1	1.3	100.0%	0.9
Duanfen (Jiangmen)	0.8	0.9	1.0	0.8	0.9	0.9	0.8	0.8	0.7	0.9	0.9	1.0	100.0%	0.9
Huaguoshan (Jiangmen)	0.8	1.1	1.0	0.9	0.8	0.8	0.7	0.8	0.7	0.9	0.9	1.0	100.0%	0.9
Chengzhong (Zhaoqing)	0.8	1.0	1.0	1.0	0.7	0.7	0.6	0.7	0.7	0.8	0.9	1.0	100.0%	0.9
Xiapu (Huizhou)	0.9	1.0	0.7	0.7	0.8	1.1	0.8	0.8	0.6	0.8	0.8	0.9	100.0%	0.8
Shixia (Huizhou)	--	--	--	0.8	0.7	0.8	0.7	0.7	0.8	0.9	0.9	1.0	--	0.8
Jinguowan (Huizhou)	0.7	1.0	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.9	1.0	0.8	100.0%	0.8
Zimaling (Zhongshan)	0.8	0.8	1.0	0.7	0.7	0.7	0.4	0.5	0.5	0.7	0.8	0.9	100.0%	0.7
Nanchengyuanling (Dongguan)	0.9	0.8	1.0	0.9	0.9	0.8	0.8	1.0	0.7	0.9	1.0	1.3	100.0%	0.9
Tap Mun (Hong Kong)	0.6	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.7	100.0%	0.7
Tsuen Wan (Hong Kong)	0.9	0.8	0.9	0.8	0.9	0.8	0.5	0.7	0.8	0.9	0.9	0.9	100.0%	0.9
Yuen Long (Hong Kong)	0.8	1.1	0.9	0.8	0.8	0.8	0.7	0.8	0.9	1.0	0.8	1.0	100.0%	0.9
Tung Chung (Hong Kong)	0.7	0.6	0.7	1.0	0.8	0.6	0.4	0.6	0.5	0.6	0.6	0.9	100.0%	0.7
Taipa Grande (Macao)	0.9	0.9	1.0	0.8	0.7	0.7	0.6	0.6	0.9	0.9	0.9	1.0	100.0%	0.8

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

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

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 2023, the annual average of PM_{10} recorded at each monitoring station in the Network ranged from 22 to 46 μg/m^3, and all monitoring stations met the national annual average concentration limit (70 μg/m^3). During the year, all monitoring stations in the Network were in compliance with the national 24-hour average concentration limit (150 μg/m^3).

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.

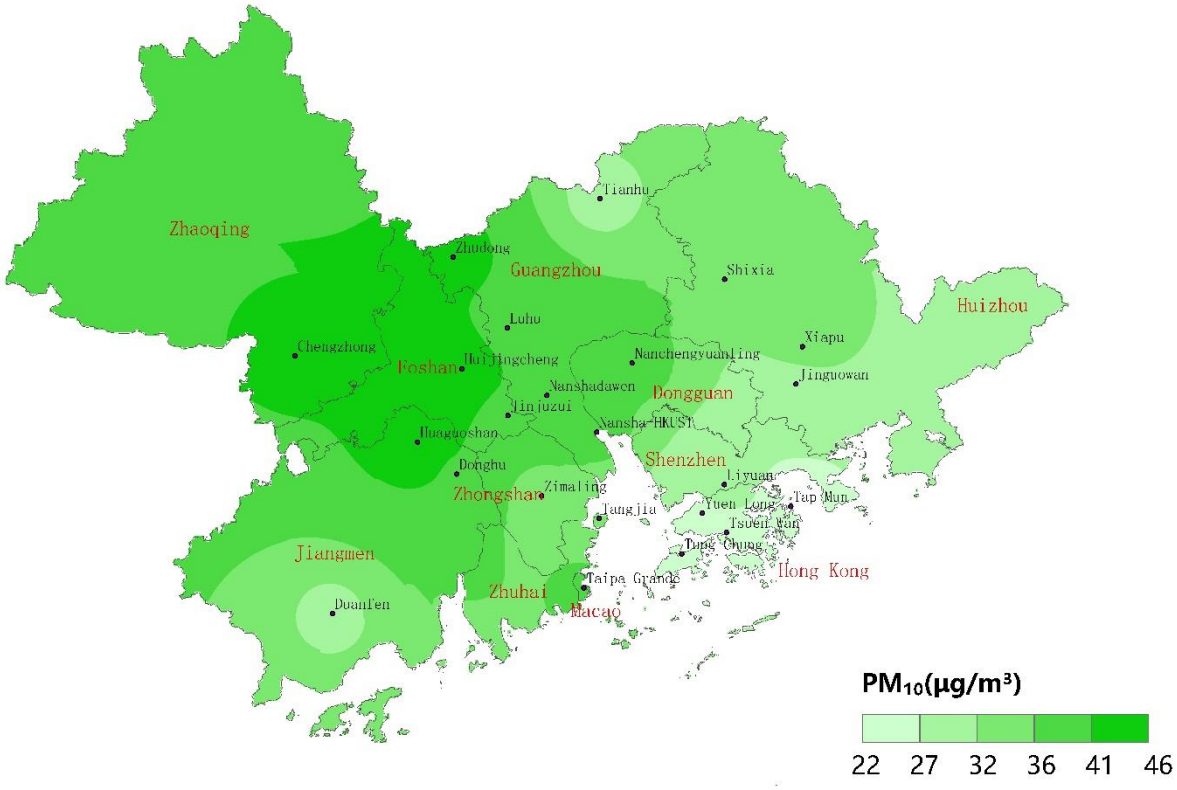

Figure 9：Spatial distribution of annual average concentrations of Respirable Suspended Particulates (PM_{10})

Table 4.5a：Daily averages concentration of PM_{10} (monthly maxima and the 95th 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	95th percentile
Luhu (Guangzhou)	80	97	118	71	64	47	52	48	45	68	99	86	100.0%	76
Nanshadawen (Guangzhou)	72	74	125	75	68	49	63	42	53	78	116	125	100.0%	80
Nansha-HKUST (Guangzhou)	62	65	106	67	44	49	49	67	72	66	111	135	100.0%	74
Tianhu (Guangzhou)	74	69	132	73	79	42	33	35	34	55	63	54	100.0%	64
Zhudong (Guangzhou)	99	95	126	112	78	49	46	51	47	91	88	106	100.0%	86
Tongxinling (Shenzhen)	66	60	102	64	56	33	38	31	37	51	74	76	100.0%	64
Jinjuzui (Foshan)	77	81	120	78	55	40	52	43	42	55	112	137	100.0%	91
Huijingcheng (Foshan)	85	134	135	83	62	47	53	51	55	105	150	144	100.0%	105
Tangjia (Zhuhai)	71	70	87	66	60	33	41	29	34	52	81	109	100.0%	66
Donghu (Jiangmen)	80	88	124	85	60	37	46	49	41	63	133	140	100.0%	87
Duanfen (Jiangmen)	71	58	104	82	45	28	30	26	34	55	71	99	100.0%	59
Huaguoshan (Jiangmen)	83	96	118	93	53	38	47	51	49	69	120	128	100.0%	90
Chengzhong (Zhaoqing)	91	97	131	134	72	55	40	52	57	74	115	135	100.0%	88
Xiapu (Huizhou)	72	71	108	73	66	43	49	43	43	56	86	87	100.0%	72
Shixia (Huizhou)	--	--	--	41	48	50	36	40	45	63	71	84	--	55
Jinguowan (Huizhou)	65	49	97	61	54	40	35	28	29	40	69	58	100.0%	53
Zimaling (Zhongshan)	71	71	110	70	61	33	45	34	37	56	74	97	100.0%	69
Nanchengyuanling (Dongguan)	81	92	117	78	56	43	49	50	48	68	105	108	100.0%	82
Tap Mun (Hong Kong)	60	67	75	51	49	23	35	19	26	40	52	46	100.0%	46
Tsuen Wan (Hong Kong)	51	61	76	50	53	29	32	27	31	42	45	68	100.0%	46
Yuen Long (Hong Kong)	58	70	85	47	54	29	37	24	34	45	59	71	100.0%	54
Tung Chung (Hong Kong)	59	65	74	62	54	28	37	21	33	44	59	68	100.0%	46
Taipa Grande (Macao)	86	76	115	93	75	33	57	35	45	56	104	100	100.0%	78

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

[Class II limit: 70 μg/m^3]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	42	51	55	40	38	26	22	27	26	33	56	50	39
Nanshadawen (Guangzhou)	41	46	51	37	41	28	25	29	29	41	64	60	41
Nansha-HKUST (Guangzhou)	36	38	42	35	29	23	22	35	42	41	63	62	39
Tianhu (Guangzhou)	34	33	45	33	30	19	22	22	20*	23	38	30	29
Zhudong (Guangzhou)	41	53	67	51	43	29	28	32	29	37	58	48	43
Tongxinling (Shenzhen)	38	34	41	34	30	16	16	19	18	30	45	47	31
Jinjuzui (Foshan)	45	49	53	40	35	23	23	25	24	36	60	70	40
Huijingcheng (Foshan)	50	63	63	48	41	27	23	28	28	43	71	73	46
Tangjia (Zhuhai)	43	39	43	36	32	16	17	18	18	33	48	51	33
Donghu (Jiangmen)	45	54	55	44	38	24	21	24	25	41	62	63	41
Duanfen (Jiangmen)	36	36	41	39	26	17	14	17	17	32	45	46	30
Huaguoshan (Jiangmen)	46	56	61	44	37	27	23	29	28	44	66	65	44
Chengzhong (Zhaoqing)	43	56	58	50	40	27	22	28	28	36	61	53	42
Xiapu (Huizhou)	42	42	50	39	34	21	21	26	25	34	55	48	36
Shixia (Huizhou)	--	--	--	31*	34*	24	24	27	24	28	46	40	31*
Jinguowan (Huizhou)	34	30	39	30	30	18	17	21	18	25	38	33	27
Zimaling (Zhongshan)	42	41	43	35	33	18	18	19	19	34	47	49	33
Nanchengyuanling (Dongguan)	41	51	57	41	36	23	21	26	27	34	58	54	39
Tap Mun (Hong Kong)	31	28	30	27	24	10	12	12	13	22	30	28	22
Tsuen Wan (Hong Kong)	32	29	31	27	25	13	13	16	13	22	30	34	24
Yuen Long (Hong Kong)	34	22	34	25	25	12	13	15	14	26	36	40	25
Tung Chung (Hong Kong)	29	30	26	26	24	12	12	13	13	25	31	26	22
Taipa Grande (Macao)	50	45	49	46	38	19	21	23	22	38	56	62	39

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 2023, the annual average of $PM_{2.5}$ recorded at each monitoring station in the Network ranged from 12 to 26 μg/m^3, and all monitoring stations met the national annual average concentration limit (35 μg/m^3). During the year, 17 monitoring stations in the Network recorded no exceedance of the national 24-hour average concentration limit (75 μg/m^3) while the corresponding compliance rates in the Network ranged from 98.9% 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.

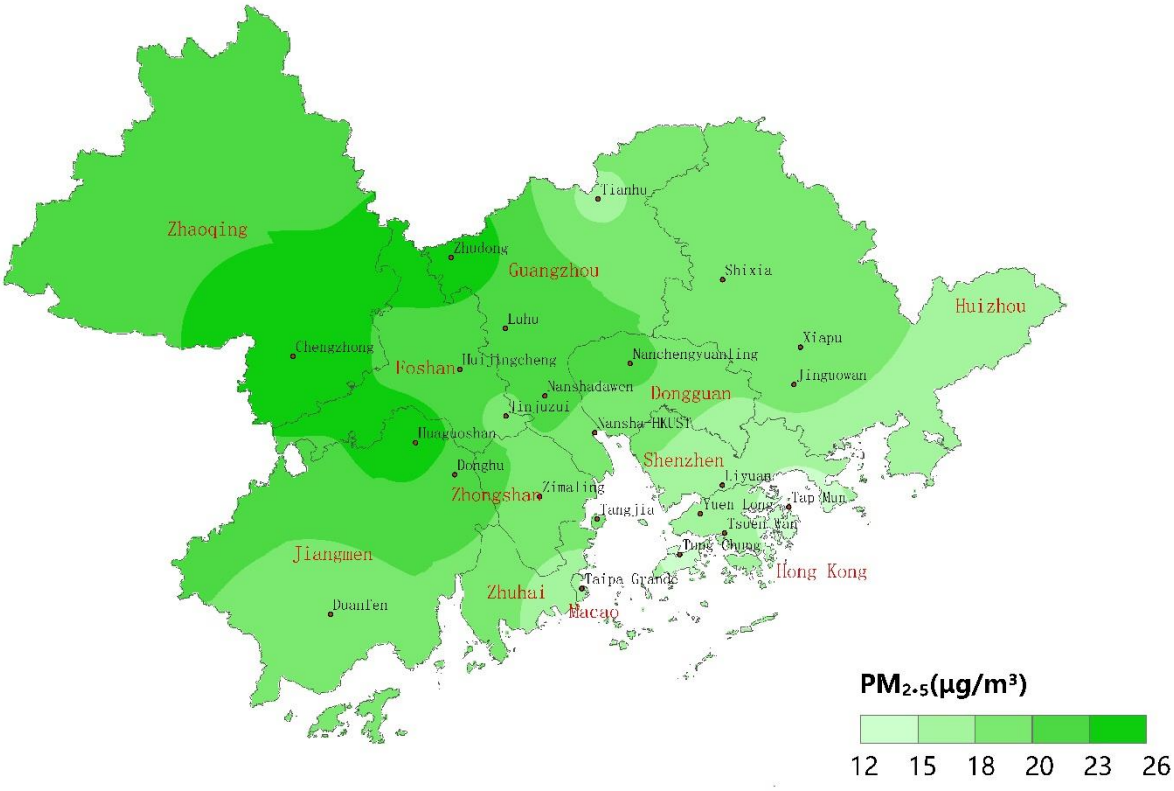

Figure 10：Spatial distribution of annual average concentrations of Fine Suspended Particulates ($PM_{2.5}$)

Table 4.6a：Daily averages concentration of $PM_{2.5}$ (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)	64	59	54	37	37	30	32	29	29	43	51	54	100.0%	45
Nanshadawen (Guangzhou)	55	38	48	33	42	31	35	29	33	46	65	71	100.0%	45
Nansha-HKUST (Guangzhou)	43	41	40	37	41	29	27	21	21	36	47	62	100.0%	39
Tianhu (Guangzhou)	56	50	48	32	25	28	19	21	19	38	36	52	100.0%	34
Zhudong (Guangzhou)	84	64	76	69	44	35	31	35	31	61	58	60	99.4%	54
Tongxinling (Shenzhen)	40	41	47	36	36	20	23	18	21	32	41	46	100.0%	34
Jinjuzui (Foshan)	53	47	50	34	29	22	27	22	22	35	48	65	100.0%	41
Huijingcheng (Foshan)	59	86	62	44	33	28	28	31	29	32	65	55	99.4%	52
Tangjia (Zhuhai)	48	43	45	37	36	21	28	18	22	36	50	91	99.7%	39
Donghu (Jiangmen)	46	53	61	45	35	24	23	26	24	38	76	91	98.9%	46
Duanfen (Jiangmen)	45	43	40	42	25	16	18	16	22	38	50	61	100.0%	38
Huaguoshan (Jiangmen)	53	69	68	43	40	26	30	32	27	44	71	72	100.0%	56
Chengzhong (Zhaoqing)	75	59	64	74	43	36	24	26	37	52	69	79	99.4%	54
Xiapu (Huizhou)	57	44	47	35	29	23	25	21	25	35	43	47	100.0%	38
Shixia (Huizhou) ^	--	--	--	23	31	34	22	25	32	47	50	64	--	37
Jinguowan (Huizhou)	58	31	43	33	37	31	25	19	23	31	35	33	100.0%	32
Zimaling (Zhongshan)	61	44	55	37	42	25	29	26	25	41	55	61	100.0%	42
Nanchengyuanling (Dongguan)	66	45	49	38	43	27	27	34	25	41	52	62	100.0%	42
Tap Mun (Hong Kong)	36	37	32	25	24	15	22	10	19	26	28	28	100.0%	26
Tsuen Wan (Hong Kong)	33	35	42	30	38	22	22	17	22	29	29	56	100.0%	29
Yuen Long (Hong Kong)	39	58	49	29	37	22	23	17	23	29	36	57	100.0%	34
Tung Chung (Hong Kong)	38	40	35	35	38	22	25	16	24	30	40	48	100.0%	28
Taipa Grande (Macao)	45	38	40	32	34	14	23	12	21	29	47	57	100.0%	33

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

[Class II limit: 35 μg/m³]

Monitoring Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Luhu (Guangzhou)	28	30	29	22	21	14	12	15	15	22	29	30	22
Nanshadawen (Guangzhou)	23	22	25	17	23	16	13	16	17	26	34	35	22
Nansha-HKUST (Guangzhou)	24	23	23	20	18	12	11	12	12	20	26	29	19
Tianhu (Guangzhou)	20	23	23	17	16	10	11	10	10*	16	23	22	17
Zhudong (Guangzhou)	28	34	37	32	26	17	15	18	18	25	35	30	26
Tongxinling (Shenzhen)	24	19	22	18	17	8	8	10	10	17	23	26	17
Jinjuzui (Foshan)	27	26	25	19	17	11	10	12	12	19	26	29	19
Huijingcheng (Foshan)	29	36	31	23	15	14	10	14	13	18	29	29	22
Tangjia (Zhuhai)	27	24	24	20	18	9	9	9	9	19	25	32	19
Donghu (Jiangmen)	27	28	26	21	19	12	11	12	13	22	31	36	22
Duanfen (Jiangmen)	27	24	23	20*	13	8	7	9	9	19	25	28	18
Huaguoshan (Jiangmen)	33	37	34	26	23	18	15	16	16	28	36	36	26
Chengzhong (Zhaoqing)	28	35	32	28	23	17	13	16	17	25	37	32	25
Xiapu (Huizhou)	27	25	25	18	16	9	9	13	14	22	28	27	19
Shixia (Huizhou) ^	--	--	--	18*	20*	12	13	14	15	22	30	28	19*
Jinguowan (Huizhou)	25	19	23	18	18	11	11	13	13	19	22	21	18
Zimaling (Zhongshan)	29	24	25	20	20	10	10	12	11	23	27	32	20
Nanchengyuanling (Dongguan)	26	27	27	21	19	13	11	14	15	21	28	30	21
Tap Mun (Hong Kong)	19	16	16	14	12	5	6	6	7	13	16	17	12
Tsuen Wan (Hong Kong)	21	18	19	17	16	9	9	10	9	15	17	23	15
Yuen Long (Hong Kong)	24	16	22	16	16	8	8	10	9	18	20	26	16
Tung Chung (Hong Kong)	18	18	15	16	15	8	8	9	10	17	17	14	14
Taipa Grande (Macao)	24	19	19	17	14	5	6	6	7	16	20	27	15

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 2023. 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 from March to May, and October to November, it was mainly due to the fact that there were increased in light intensity, temperature, decreased in humidity, reduced of cloud coverage, wind field convergence, etc. The poor aerosol dispersion, and unfavorable meteorological conditions caused the rapid formation of ozone. However, from June to September, the relatively low ozone formation was related to the increase in precipitation within the region, the prevailing summer monsoon, the enhanced atmospheric dispersion and the relatively good moisture removal conditions.

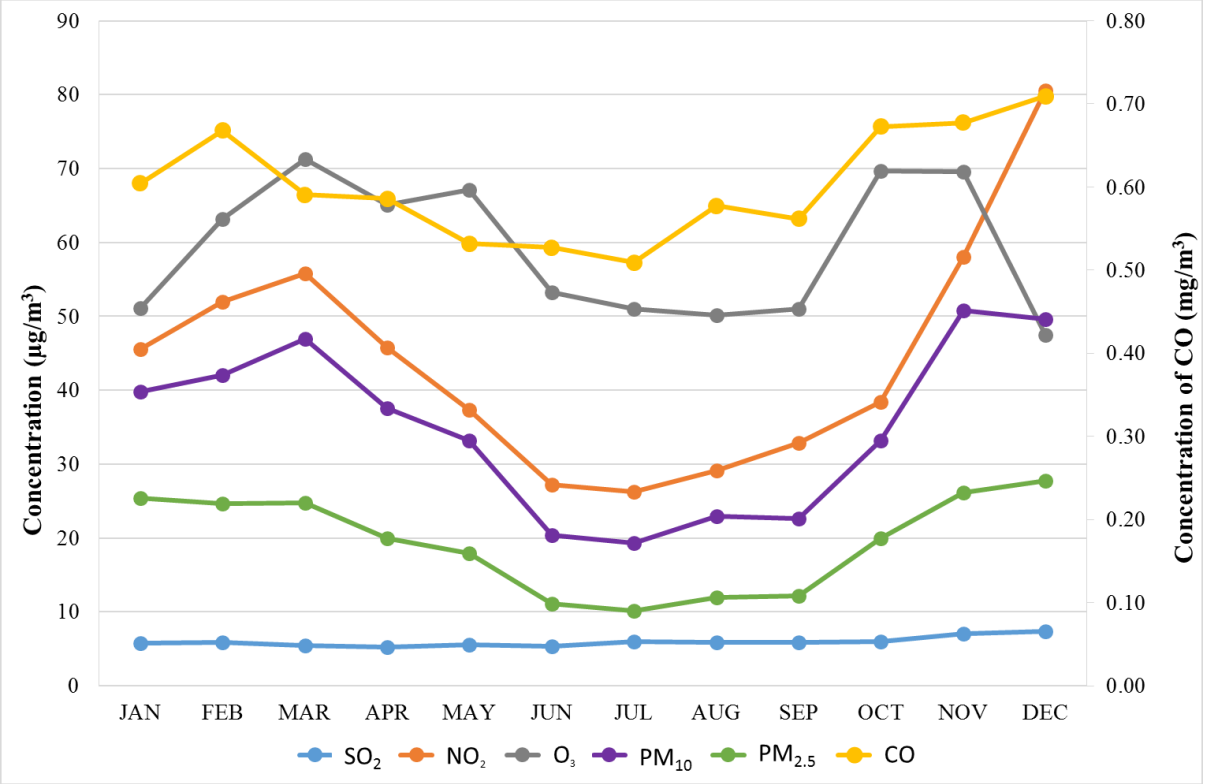

Figure 11：Monitoring network monthly variations of air pollutant concentrations

4.8 Annual Variations of Pollutant Concentrations (2006-2023)

Table 4.8 shows the annual average concentrations of air pollutants recorded by the Network from 2006 to 2023, while Figure 12 shows the trend of rate of changes in the annual pollutant concentrations.

From 2006 to 2023, the annual averages recorded by the Network for SO_2, NO_2, and PM_{10} decreased by 86%, 45% and 48% respectively, which exhibited a discernible downward trend with a descending rate of about 2.2, 1.1 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 17% and 34% respectively between 2015 and 2023. These reductions indicate that the measures implemented in recent years by concerted or individual effort of Guangdong, Hong Kong and Macao, including requiring power plants to implement ultra-low emission upgrades, continuously raising atmospheric pollutant emission standards for key industries, conducting volatile organic compound treatment, phasing out coal-fired boilers and highly polluting vehicles, improving motor vehicle emission standards, improving fuel quality, and regulating non-road mobile machinery , etc., have improved the overall air quality in the PRD region. Compared with 2006, the annual average of O_3 in 2023 increased by 34%, 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 [8]

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	-	-

[8] 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.
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.
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.
All Modiesha, Zhudong, Duanfenm Xijiao and Nanchengyuanling's pollutants data are excluded from the calculation of the annual averages of pollutants in 2020 owing to its low daily data capture rate in 2020.
Ozone data at Xijiao station in Huizhou, and $PM_{2.5}$ data at Xijiao station in Huizhou are excluded from the calculation of the annual averages of pollutants in 2021 owing to its low daily data capture rate in 2021
Data at Xijiao station in Huizhou are excluded from the calculation of the annual averages of pollutants in 2022 owing to its low data capture rate in 2022.

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)
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
2020	6	24	56	34	20	0.611
2021	7	25	59	37	21	0.600
2022	6	23	61	32	18	0.614
2023	6	23	59	35	19	0.605

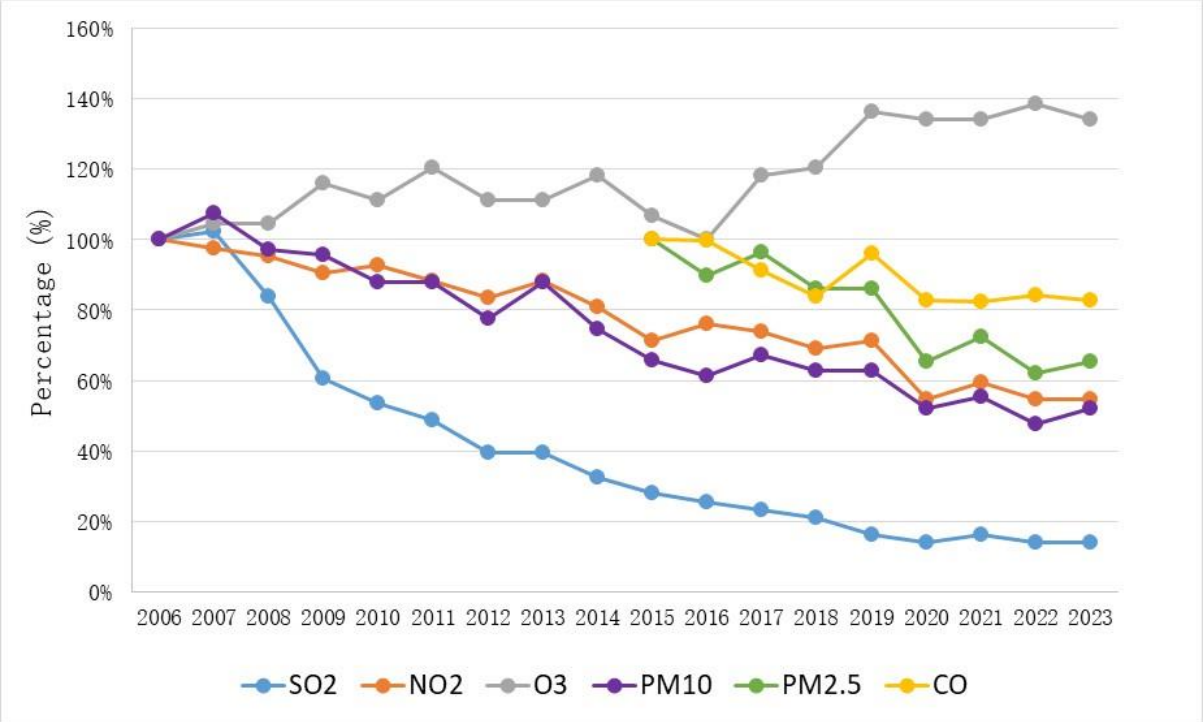

Figure 12：Trend of rates of changes in pollutant's annual averages in the monitoring network[9]

[9] 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.
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.
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.
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.
All Modiesha, Zhudong, Xijiao and Nanchengyuanling's pollutants data and Duanfen's SO_2, NO_2, O_3 and PM_{10} data are excluded from the calculation of the annual averages of pollutants in 2020 owing to its low daily data capture rate in 2020.
Ozone data at Xijiao station in Huizhou, and $PM_{2.5}$ data at Xijiao station in Huizhou are excluded from the calculation of the annual averages of pollutants in 2021 owing to its low daily data capture rate in 2021.
Data at Xijiao station in Huizhou are excluded from the calculation of the annual averages of pollutants in 2022 owing to its low data capture rate in 2022.

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
Nanshadawen[10] (Guangzhou)	Shinan Road, Dongchong Town, Nansha	City	23m	10m	Jan 2021
Nansha-HKUST[11] (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[12] (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

[10] Modiesha station closed permanently owing to insufficient space after the extensive renovation work at station, whereas Nanshadawen station joined the network in the 1st quarter of 2021.
[11] Wanqingsha station was renamed as Nansha-HKUST station in the 1st quarter of 2019.
[12] Liyuan station was renamed as Tongxinling station in the 1st quarter of 2019.

Xijiao (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
Zimaling (Zhongshan)	Zimaling Park, Zhongshan	Mixed residential/ commercial	45m	7m	Aug 2002
Nancheng-yuanling[13] (Dongguan)	Dongguan administration center	Mixed residential/ commercial/industrial	40m	19m	May 2021
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[14] (Macao)	Rampa do Observatorio, Taipa Grande	Rural	120m	10m	Mar 1999

[13] Nancheng-yuanling station was relocated to Dongguan administration center in May 2021. The distance between the old and new sites is about 600 metres.
[14] Taipa Grande station was relocated to SMG observing station in September 2022. The distance between the old and new sites is about 100 meters.

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