2022

World Air Quality Report

Region & City PM2.5 Ranking

IQAir

Contents

About this report

The 2022 World Air Quality Report reviews the status of air quality around the world for the year 2022. This report presents PM2.5 air quality data from 7,323 cities across 131 countries, regions, and territories. The data used in this report was aggregated from over 30,000 regulatory air quality monitoring stations and low-cost air quality sensors. These monitoring stations and sensors are operated by governmental bodies, research institutions, non-profit non-governmental organizations, universities and educational facilities, private companies, and citizen scientists across the globe.

The PM2.5 data in this report is measured in units of micrograms per cubic meter ($\mu g/m^3$) and incorporates the 2021 World Health Organization (WHO) air quality guidelines and interim targets as a basis for data visualization and risk communication.

The air quality data utilized in the 2022 World Air Quality Report was sourced from IQAir's real-time online air quality monitoring platform which validates, calibrates, and harmonizes air quality data from monitoring stations located around the world.

Further historic air quality data sorted by city, country, and region can be found on the IQAir website, including an interactive map featuring annual city concentrations and global rankings of annual air quality for the 7,323 global cities included in this report.

IQAir aims to engage, inform, and inspire governments, educators, researchers, non-profit organizations, companies, and citizens to build collaborative efforts to increase air quality awareness. IQAir seeks to facilitate an informed dialogue and inspires action that improves air quality and the health of global communities and cities.

Executive summary

Air pollution continues to be the world's largest environmental health threat. Worldwide, poor air quality accounts for 93 billion days lived with illness and over six million deaths each year. The total economic cost equates to over $8 trillion dollars, surpassing 6.1 percent of the global annual GDP.[1] Exposure to air pollution causes and aggravates several health conditions which include, but are not limited to, asthma, cancer, lung illnesses, heart disease, and premature mortality.[2]

Air pollution most severely impacts already vulnerable populations. More than 90% of pollution related deaths occur in low-income and middle-income countries.[3] Children under 18 years old, pregnant women, and older adults all have increased risk of developing or worsening health conditions from air pollution exposure.[4]

Data for the World Air Quality Report was aggregated from measurements taken from over 30,000 global air quality monitoring stations. Hourly averaged data from both government-operated regulatory instrumentation and non-government operated, ground-based air quality monitors was collected and aggregated over the course of a year and used as the basis for the content of the report.

In 2021, this report included data from 6,475 locations in 117 countries, territories, and regions. In 2022, these numbers have expanded to now include 7,323 locations in 131 countries, territories, and regions. The coverage for the continent of Africa expanded significantly, with the inclusion of seven additional countries in 2022. Despite the expansion, density of coverage remains extremely scarce. While this report contains data from over 30,000 air quality monitoring stations, only 156 stations produced all the included data for the continent of Africa, home to this year's most polluted country in the world, Chad. With the only real-time, publicly available source of air quality data for the entire country of Chad being provided by a single air quality monitor in the city of N'Djamena, this year the spotlight on global air quality data coverage disparities shines bright on the continent of Africa.

In 2022, 13 out of the 131 countries and regions included in this report have succeeded in achieving PM2.5 concentrations at or below the WHO guideline for annual PM2.5 concentrations of 5 µg/m^3. Much work has been done to combat air pollution; however, as evidenced by this report, there is still a long road ahead to ensure environmental equality. Citizens in only ten percent of the global countries, regions and territories are breathing air that does not pose a risk to their health as indicated by the WHO.

Where does the data come from?

While many other air quality reports and apps utilize modelled, satellite data, the data analyzed for this report comes exclusively from empirically measured PM2.5 data collected from ground-level air monitoring stations. The PM2.5 measurement data in this report is aggregated from both regulatory air quality monitoring instrumentation and low-cost air quality sensors. These devices are operated by government agencies, educational institutions, non-profit organizations, and individual citizens who contribute to the monitoring of their local air quality. Most of the data used in the World Air Quality Report is collected in real-time, with additional supplementary air quality measurements sourced from historical year-end data sets. The combination of PM2.5 measurements collected in real-time and historically sourced data results in the most comprehensive global data set for analysis.

Data from individual air quality monitoring stations and sensors have been grouped into "settlements" that represent cities, towns, villages, counties, and municipalities based on local population distributions and administrative divisions. "Settlements" will be referred to as cities throughout the remainder of this report. Country and region annual PM2.5 concentrations, and their subsequent rankings, are calculated as population weighted, averaged city-level concentrations.

Why PM2.5?

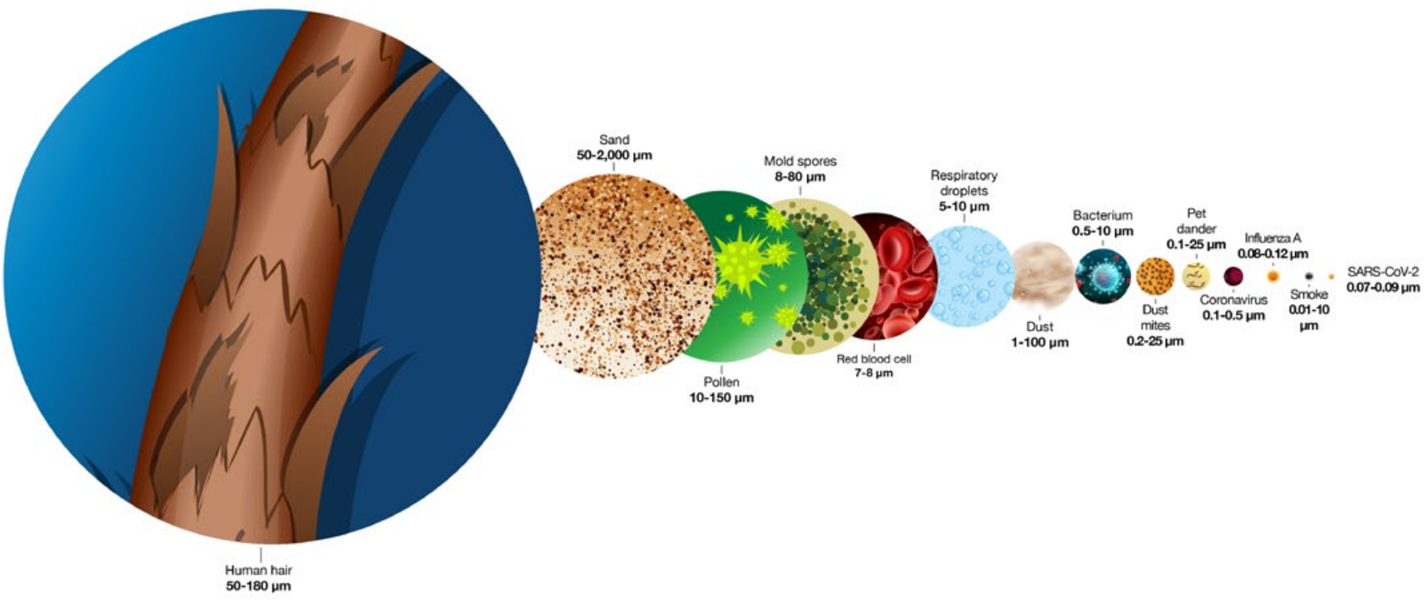
PM2.5 concentration describes the amount of fine particulate aerosol particles up to 2.5 microns in diameter and is used as the standard air quality indicator for the World Air Quality Report. Measured in micrograms per cubic meter (µg/m^3), PM2.5 is one of six major air pollutants commonly used in the classification of air quality. PM2.5 is largely accepted as the most harmful of these pollutants based on its prevalence in the environment and the wide range of negative human health effects associated with its exposure.

PM2.5 can be produced by a variety of sources which can result in different chemical compositions and physical characteristics. Sulfates, nitrates, black carbon, and ammonium are some of the most common particles that make up PM2.5. The anthropogenic generation of PM2.5 can largely be attributed to combustion engines, power generation, industrial processes, agricultural processes, wood and coal burning, and construction. The most prevalent natural sources of PM2.5 include dust storms, wildfires, and sandstorms.

Particulate Size Matters: **Comparing sizes**

Small particles pose the greatest risk to human health. While the nose can filter most coarse particles, fine and ultrafine particles are inhaled deeper into the lungs where they can be deposited or even pass into the bloodstream.

Measurement indicate microns in diameter (µm).



Interpreting health risks with air quality guidelines and standards

In 2021, the World Health Organization (WHO) updated their air quality guidelines to reflect the abundance of scientific evidence from the past 15 years showing the effects of PM2.5 on air quality and health.[5] The 2021 World Air Quality Report contained a detailed discussion outlining how the WHO determined their annual PM2.5 guideline level of 5 µg/m^3 and the daily PM2.5 guideline level of 15 µg/m^3.

The need for two different standards, an annual exposure threshold and a daily exposure threshold, is not immediately intuitive. The reasoning arises due to differing health risks posed by short term versus long term PM2.5 exposure. Both threshold values consider the concentration that a person is exposed to and the amount of time they are exposed to it. Daily threshold values aim to protect people from short-term events that can cause immediate health problems, such as wildfires and dust storms or heavy traffic and agricultural burning with periodic emissions that occur on timescales of minutes to hours. The WHO daily average PM2.5 guideline was designed to express the concentration at which a 24 hour exposure could incur a similar severity of health risks associated with chronic exposure to levels at the annual average PM2.5 guideline level. Risks posed to human health quantitatively increases when periods of acute exposure to PM2.5 concentrations above the daily average guideline occur more than three to four days in a given year for individuals in environments that otherwise sustain the annual PM2.5 guideline level.[5] Exposure to acute events of poor air quality can affect sensitive groups such as the elderly, children, and people with pre-existing health conditions like asthma or diabetes more severely than healthy adults.[6]

The annual average guideline aims to quantify risks for long-term, chronic exposure. Sustained exposure to PM2.5 concentrations above the annual average guideline level result in a chronic impact on individuals' respiratory and circulatory systems leading to long-term complications such as heart disease and decreased lung function.[7] Apart from the explicit health effects from chronic exposure, long-lasting poor air quality conditions can have detrimental consequences related to mental health of affected populations.[8] While concentrations can vary seasonally in some areas, chronic exposure to air pollution is mostly determined by residential geographical location rather than short-term pollution events such as wildfires or meteorological conditions such as temperature inversions.

For the purposes of this report, it is more beneficial to focus on long-term, annual average PM2.5 concentrations that reflect the state of air quality chronically experienced in distinct geographic locations rather than to analyze daily acute events. Health risks associated with the day to day living conditions experienced by local residents in cities and countries are better described in terms of long-term exposures, and therefore annual guidelines are more applicable as a metric for evaluating the risk posed at quantified PM2.5 concentrations.

Data presentation

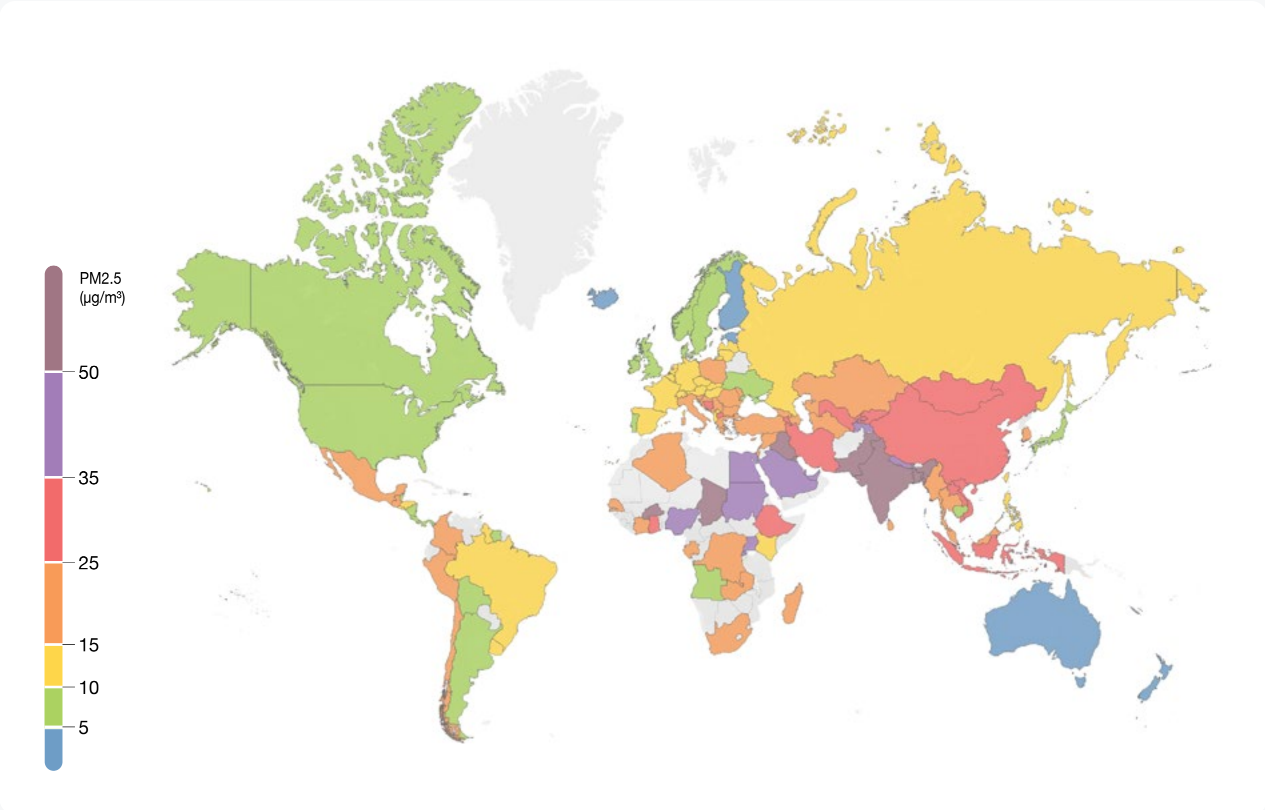
The data in this report is visualized using the World Health Organization (WHO) annual air quality guideline levels and interim targets for PM2.5. This method of visualizing data allows for easy identification of the cities and regions that are experiencing the greatest health risks related to PM2.5.

The table below outlines the framework for the color coding used throughout the report. Seven different colors are utilized, each color representing a range of PM2.5 concentrations that bracket WHO designated guideline or target values. The colors span from blue, representing the lowest PM2.5 concentrations and designate locations that have achieved the WHO annual PM2.5 guideline level to maroon, representing the highest PM2.5 concentrations and designate locations that exceed the WHO annual PM2.5 guideline by more than ten times.

2022 World Air Quality Report visualization framework

Annual PM2.5 breakpoints based on WHO guideline and interim targets	PM2.5	Color code	WHO levels
Meets WHO PM2.5 guideline	0-5 (μg/m³)	Blue	Air quality guideline
Exceeds WHO PM2.5 guideline by 1 to 2 times	5.1-10 (μg/m³)	Green	Interim target 4
Exceeds WHO PM2.5 guideline by 2 to 3 times	10.1-15 (μg/m³)	Yellow	Interim target 3
Exceeds WHO PM2.5 guideline by 3 to 5 times	15.1-25 (μg/m³)	Orange	Interim target 2
Exceeds WHO PM2.5 guideline by 5 to 7 times	25.1-35 (μg/m³)	Red	Interim target 1
Exceeds WHO PM2.5 guideline by 7 to 10 times	35.1-50 (μg/m³)	Purple	Exceeds target levels
Exceeds WHO PM2.5 guideline by over 10 times	>50 (μg/m³)	Maroon	Exceeds target levels

2022 Global PM2.5 Map



2022 global map color coded by annual average PM2.5 concentration

In 2022, the countries, regions, and territories in Africa and Central and South Asia suffered from the highest annual average PM2.5 concentrations weighted by population. While the availability of air quality data in Africa continues to slowly grow, only 19 out of 54 countries in Africa had sufficient data available to be included in this year's report, leaving 35 countries unaccounted for. Afghanistan has consistently ranked in the top 15 most polluted countries since 2018, however it, along with the country of Oman (ranked as the 6th most polluted country in 2021), is notably absent due to a lack of data availability. 20 new countries are now represented that were not present in last year's report, including Burkina Faso, ranking at 6th, and Rwanda, ranking at 13th in this year's Most Polluted Countries List. 13 countries, territories, and regions achieved the WHO guidelines in 2022, many of which were located in the region of Oceania.

Highlighted Contributor:

Kyiv City

Official Kyiv city air quality monitoring station.

Community efforts in Kyiv, Ukraine, are driven by a commitment to improve the health of its citizens through better air quality. To achieve this goal, a comprehensive air quality network is being constructed. These efforts are supported by contributions from public servants in city government, Kyiv's scientific community, and local businesses and citizens invested in providing real-time air quality information in a country that has historically had some of the worst air quality in Europe.

Kyiv's Department of Ecology and Natural Resources operates a network of five reference monitoring stations around the city. Air quality data from these stations is shared publicly in collaboration with the non-governmental air quality monitoring network LUN Misto AIR, which operates forty additional monitoring stations in Kyiv. Scientists from the Main Astronomical Observatory in Kyiv, the Taras Shevchenko National University of Kyiv, and the V.E. Lashkaryov Institue of Semiconductor Physics NAS have further expanded air quality monitoring by hosting sensors at their institutions around the city.

The collection and dissemination of air quality data empowers residents of Kyiv to make changes that positively impact their communities. In spite of the ongoing conflict, collaborators provide essential information to citizens of Kyiv for the betterment of their health. The community efforts involved in maintaining the city's monitoring infrastructure demonstrates Kyiv's dedication to the well-being and autonomy of its citizens and its investment in the health of current and future generations.

Mayor of Kyiv visiting one of the official Kyiv City air quality monitoring stations in 2022

Highlighted Contributor:

Aires Nuevos

Community member installing an air quality sensor near a playground

Aires Nuevos is Latin America's largest citizen operated air quality network. It was created by Fundación Horizonte Ciudadano in partnership with the Centro de Acción Climática PUCV of Chile in 2020 with support from CIFF and Bernard van Leer Foundation, with the goal of closing the air quality monitoring gaps in the region. The Aires Nuevos program is a collaborative multi-stakeholder effort based on the ideal of community air quality governance. It includes members from local governments, communities, and universities who share their knowledge and expertise to utilize air quality data to drive action that results in reduced exposure to air pollution.

The Aires Nuevos monitoring network consists of 115 AirVisual air quality sensors spanning 42 municipalities in eight Latin American countries. Currently eight cities in the network are actively working to implement local air pollution reduction measures based on network collected data. Lima, Peru is one of these cities that serves as an example of comprehensive program-related effort. Six urban interventions in children's spaces have been made over the last two years, to reduce their exposure to air pollution and improve the environment in which they spend most of their days.

Community air quality monitoring in Chile

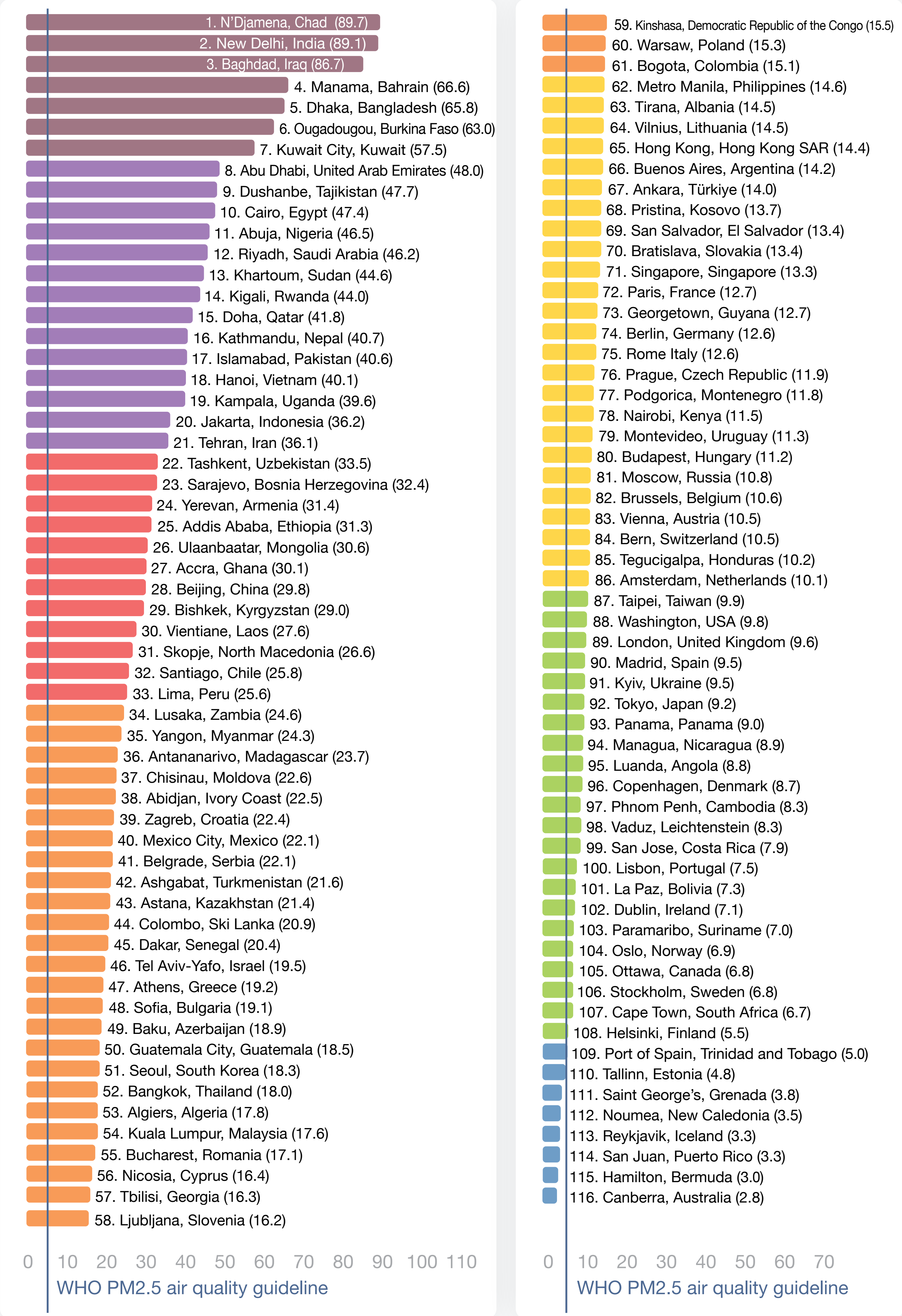
2022 Country/region ranking

Population weighted, 2022 average PM2.5 concentration (μg/m³) for countries, regions, and territories in descending order

1	Chad	89.7
2	Iraq	80.1
3	Pakistan	70.9
4	Bahrain	66.6
5	Bangladesh	65.8
6	Burkina Faso	63.0
7	Kuwait	55.8
8	India	53.3
9	Egypt	46.5
10	Tajikistan	46.0
11	United Arab Emirates	45.9
12	Sudan	44.6
13	Rwanda	44.0
14	Qatar	42.5
15	Saudi Arabia	41.5
16	Nepal	40.1
17	Uganda	39.6
18	Nigeria	36.9
19	Bosnia Herzegovina	33.6
20	Uzbekistan	33.5
21	Iran	32.5
22	Armenia	31.4
23	Ethiopia	31.3
24	Kyrgyzstan	31.1
25	China	30.6
26	Indonesia	30.4
27	Ghana	30.2
28	Mongolia	29.5
29	Laos	27.6
30	Vietnam	27.2
31	North Macedonia	25.6
32	Gabon	25.0
33	Serbia	24.7
34	Zambia	24.6
35	Myanmar	24.3
36	Madagascar	23.7
37	Croatia	23.5
38	Peru	23.5
39	South Africa	23.4
40	Kazakhstan	23.0
41	Moldova	22.6
42	Ivory Coast	22.5
43	Chile	22.2
44	Turkmenistan	21.6
45	Türkiye	21.1
46	Sri Lanka	20.7
47	Senegal	20.4
48	Syria	20.0
49	Mexico	19.5
50	Greece	19.0
51	Azerbaijan	18.9
52	Italy	18.9
53	Israel	18.8
54	Guatemala	18.6
55	Bulgaria	18.3
56	South Korea	18.3
57	Thailand	18.1
58	Algeria	17.8
59	Malaysia	17.7
60	Romania	17.2
61	Georgia	17.0
62	Poland	16.3
63	Colombia	15.7
64	Montenegro	15.7
65	Cyprus	15.6
66	Democratic Republic of the Congo	15.5
67	Macao SAR	15.4
68	Slovenia	15.1
69	Philippines	14.9
70	Kosovo	14.7
71	Slovakia	14.5
72	Hong Kong SAR	14.5
73	Albania	14.5
74	El Salvador	14.2
75	Czech Republic	13.4
76	Taiwan	13.4
77	Singapore	13.3
78	Lithuania	13.2
79	Guyana	12.6
80	Hungary	12.6
81	Brazil	12.2
82	Malta	11.7
83	Kenya	11.5
84	France	11.5
85	Uruguay	11.3
86	Russia	11.2
87	Netherlands	11.0
88	Germany	11.0
89	Spain	10.9
90	Maldives	10.9
91	Belgium	10.8
92	Austria	10.6
93	Honduras	10.2
94	Latvia	10.1
95	Switzerland	10.0
96	Ukraine	9.7
97	Japan	9.1
98	Panama	9.0
99	United States	8.9
100	Nicaragua	8.9
101	United Kingdom	8.9
102	Angola	8.8
103	Denmark	8.6
104	Cambodia	8.3
105	Liechtenstein	8.3
106	Portugal	8.1
107	Costa Rica	7.9
108	Argentina	7.7
109	Ireland	7.5
110	Luxembourg	7.4
111	Canada	7.4
112	Bolivia	7.3
113	Suriname	7.0
114	Norway	7.0
115	Sweden	6.2
116	Belize	5.6
117	Andorra	5.4
118	Trinidad and Tobago	5.1
119	Finland	5.0
120	Estonia	4.9
121	New Zealand	4.8
122	Puerto Rico	4.3
123	Australia	4.2
124	Grenada	3.8
125	New Caledonia	3.5
126	Iceland	3.4
127	Bonaire, Sint Eusatius and Saba	3.3
128	Bermuda	3.0
129	U.S. Virgin Islands	2.9
130	French Polynesia	2.5
131	Guam	1.3

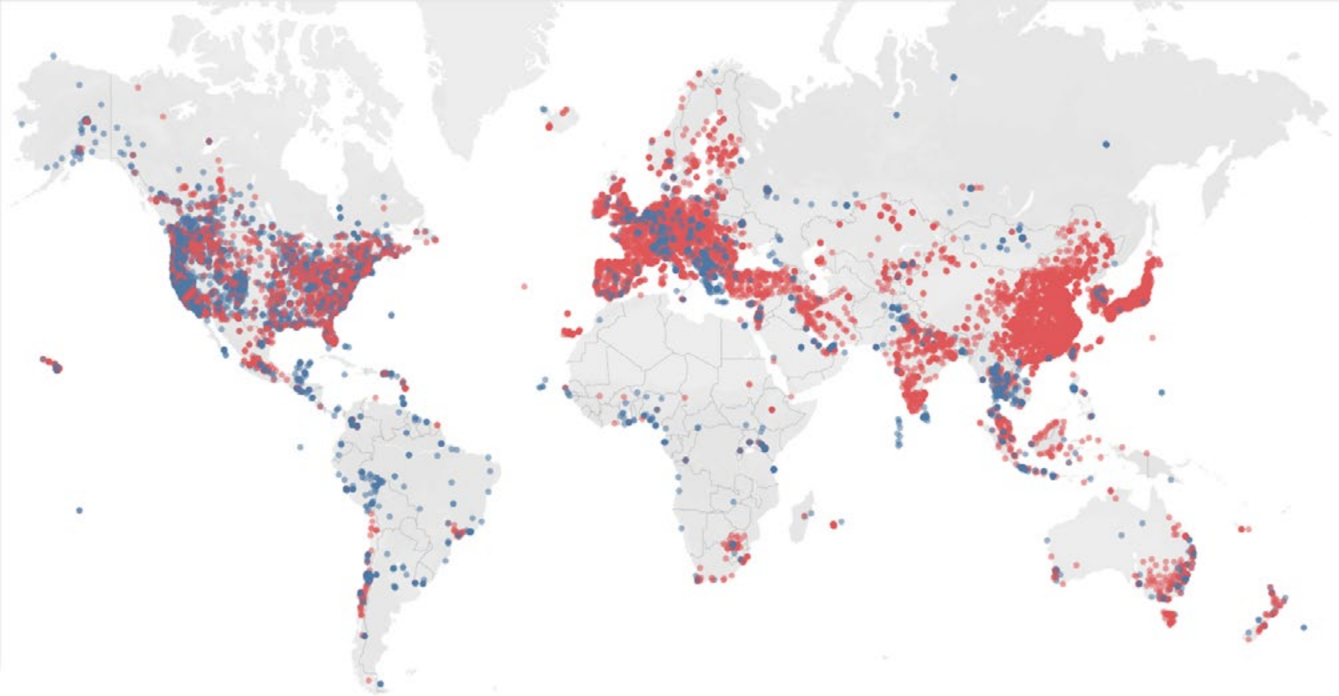
2022 Regional capital city ranking

Population weighted, 2022 average PM2.5 concentration (μg/m³) for countries, regions, and territories in descending order



Overview of public monitoring status

Global distribution of PM2.5 monitoring stations



Global Distribution of PM2.5 air quality monitoring stations providing data included in this report. Independently operated monitoring stations are represented by blue markers. Government stations are represented by red markers

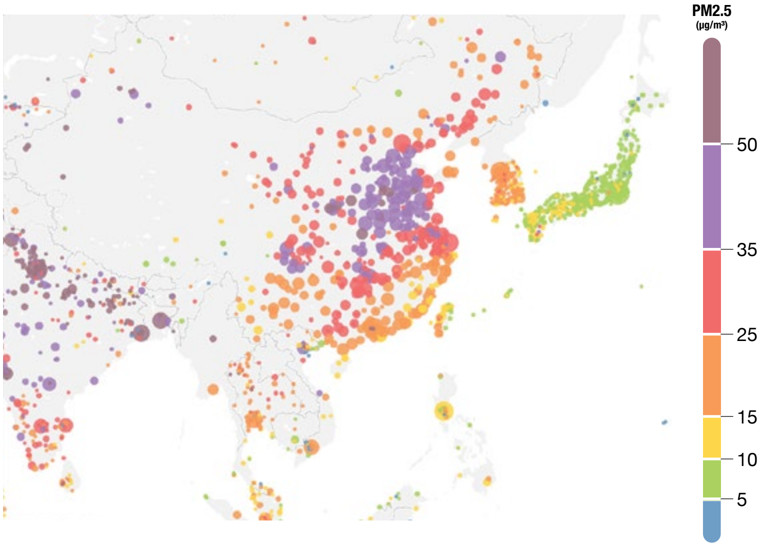
A map visualising the distribution of global air quality monitoring reveals obvious gaps in Latin America, Africa, and Central Asia despite the high population of these regions and recent studies demonstrating high risk factors of PM2.5 exposure in these areas.[9] In contrast, North America, Europe, and some places in Southeast Asia have much more dense air quality monitoring networks. Nonetheless, recent efforts on filling air quality monitoring gaps have increased the number of air quality monitoring stations in Latin America, Africa, and Central Asia. Independently operated air quality monitoring stations have shown huge potential to resolve the disproportional air quality monitoring coverage around the globe.

Ongoing advancements in low-cost monitors have made them a viable public alternative for those countries, regions, and territories that lack government-operated air quality monitoring stations. These advancements enable ease of deployment and allow for operation in remote areas. Affordable pricing reduces some of the economic barriers of creating a dense network of stations due to very minimal maintenance costs. In 2022, independently operated low-cost air quality monitoring provided the only real-time air quality data for Afghanistan*, Albania, Angola, the Bahamas, Belize, Bermuda, Bolivia, Bonaire, Cambodia, Cameroon*, Cape Verde, Central African Republic, Ecuador, French Polynesia, Gambia*, Grenada, Guam, Guyana, Honduras, Jamaica*, Jersey*, Latvia, Lebanon, the Maldives, Moldova, Mauritius, Morocco*, Mozambique, Namibia, Nicaragua, Niger*, Panama, Saint Eustatius and Saba, Sierra Leone, Oman, Papua New Guinea, South Sudan*, Suriname, Tanzania, Timor Leste*, Togo*, Trinidad and Tobago, U.S. Virgin Islands, Uruguay, Venezuela*, Zambia, Zimbabwe*.

**Cities in these countries did not meet the required limit of 60% annual data availability and were therefore excluded from the report.*

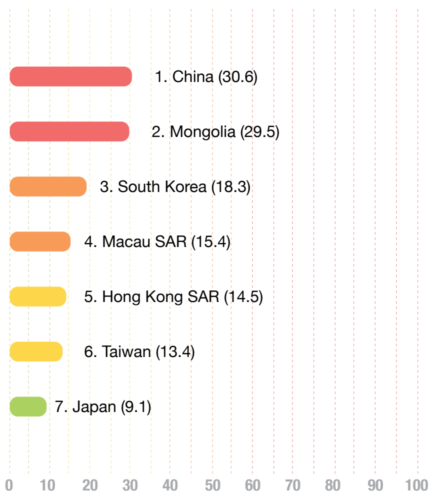
EAST ASIA

China Mainland | Hong Kong SAR | Japan | Macau SAR | Mongolia | South Korea | Taiwan



City markers indicating 2022 PM2.5 levels, size adjusted for population

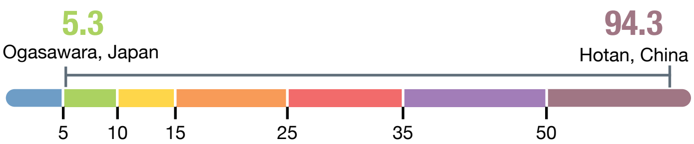
Country/Region Ranking



2022 PM2.5 average (µg/m³)

0%

Regional cities that met the WHO PM2.5 guideline in 2022



Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	Hotan, China	94.3
2	Kashgar, China	73.4
3	Shihezi, China	57.3
4	Yigou, China	56.4
5	Aksu, China	55.5
6	Puyang, China	54.3
7	Wujiaqu, China	53.3
8	Kizilsu, China	52.8
9	Hebi, China	52.2
10	Changji, China	51.5
11	Luohe, China	51.2
12	Anyang, China	51.0
13	Weinan, China	51.0
14	Xianyang, China	50.8
15	Kaifeng, China	50.2

Least Polluted Regional Cities

Rank	City	2022
1	Ogasawara, Japan	5.3
2	Kushiro, Japan	5.4
3	Ngari, China	5.6
4	Okinawa, Japan	5.6
5	Nyingchi, China	5.7
6	Obihiro, Japan	5.8
7	Naha, Japan	5.8
8	Taitung, Taiwan	5.8
9	Minamiaizu, Japan	6.0
10	Shingu, Japan	6.0
11	Gero, Japan	6.1
12	Shinshiro, Japan	6.2
13	Oyabe, Japan	6.2
14	Aizuwakamatsu, Japan	6.3
15	Kuji, Japan	6.3

SUMMARY

The region of East Asia included data from 1,283 cities from seven different countries and territories. China, Macau SAR, Hong Kong SAR, Mongolia, Taiwan, and South Korea all had decreases in their annual average PM2.5 concentrations while Japan remained level. Taiwan showed the largest percentage reduction of 17.3 percent going from 16.2 µg/m³ in 2021 to 13.4 µg/m³ in 2022. Despite being home to the world's coldest capital of Ulaanbaatar, where city residents often use coal fires to warm their homes, the country of Mongolia showed an 11 percent drop in PM2.5 concentrations. This is promising news for a country where, according to data based on the 2020 WHO Global Health Estimates, three out of the top four leading causes of death in the country – heart disease, stroke, and respiratory infections – are known to have increased risk factors from chronic exposure to air pollution.[10]

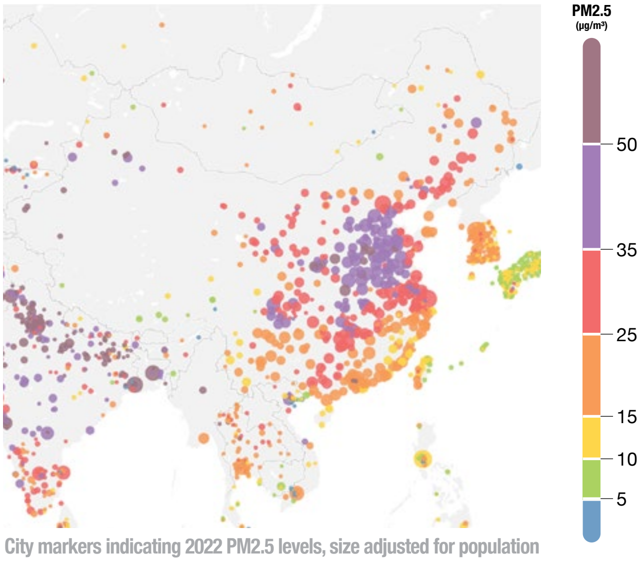
The reductions in concentrations in 2022 in Hong Kong SAR and Taiwan were sufficient to achieve WHO interim target 3 levels, with annual PM2.5 concentrations below 15 µg/m³. Of the 1,283 cities in the region, 558 had increased annual average PM2.5 concentrations, 53 cities stayed the same, and 638 decreased from last year. In 2022, no cities in this region achieved the WHO annual guideline PM2.5 concentration 5 µg/m³.

Hotan remains the most polluted city in the region with an annual average of 94.3 µg/m³ despite a concentration reduction of 7.1 percent. Hotan, however, has dipped below the 100 µg/m³ mark for the first time since 2017. This is one of the 18 cities above or equal to 10 times the WHO guidelines, all of which are in China. The least polluted city in the region is Ogasawara, Japan which maintained last year's concentration of 5.3 µg/m³.

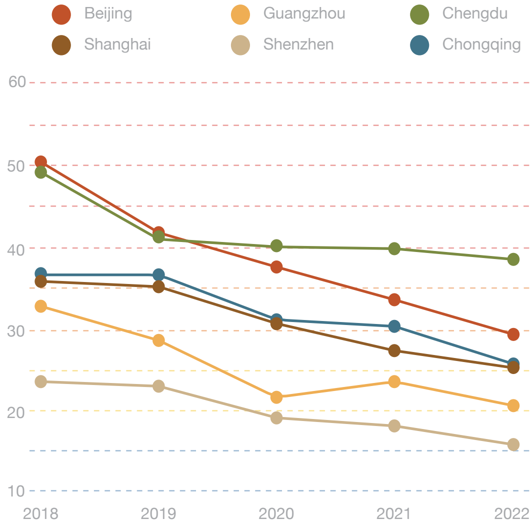
MONITORING STATUS

Government operated monitoring stations in this region continue to provide some of the best monitoring coverage in the world. China, Japan, and South Korea have a robust amount of government stations. In this region, China provides the most coverage of landmass and monitors the air quality for the highest number of people in the world. Japan's combination of government-operated stations and non-government-operated sensors provides the highest monitoring resolution. China is home to the greatest number of new cities and sensors in this region, adding 24 new cities and 114 new stations in 2022. Government-operated monitors accounted for over 97 percent of the stations in the region whose air quality data was used in this report.

CHINA MAINLAND



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual mean (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Beijing	29.8	45.4	22.5	40.4	35.8	21.0	22.5	17.0	18.4	29.4	39.6	44.3	21.2	34.4
Chengdu	38.3	66.5	42.7	47.4	31.3	29.4	28.3	24.3	22.9	23.4	38.5	47.0	57.6	40.3
Chongqing	26.0	42.5	30.9	27.4	19.3	15.2	15.1	12.4	11.1	25.6	26.9	34.7	51.0	31.0
Guangzhou	21.3	32.0	16.0	23.3	20.6	17.8	11.5	16.1	13.3	30.7	24.9	23.0	25.9	24.4
Shanghai	25.4	43.0	30.6	30.0	22.7	21.6	20.8	23.1	20.1	17.1	15.7	26.2	33.9	27.7
Shenzhen	15.7	24.9	13.2	16.2	16.0	11.2	6.5	10.9	8.9	26	18.3	15.1	21.4	17.9

PROGRESS

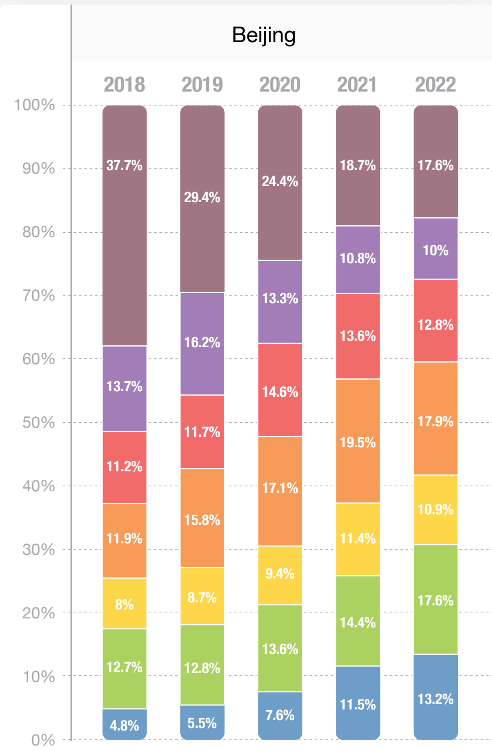
China's air quality continues to show year by year improvement. Of the 524 cities included in the data for this report, nearly 64 percent of cities demonstrated reductions in their annual PM2.5 concentrations. This resulted in a slight decrease of China's annual PM2.5 concentrations from 32.6 µg/m³ in 2021 to 30.6 µg/m³ in 2022. While all the most populated Chinese cities featured in this report have seen improving PM2.5 levels with reductions ranging from a five percent (Chengdu) to 16 percent (Chongqing), none of the cities in the country have met the WHO annual guideline of 5 µg/m³.

CHALLENGES

China's coal usage continues to be a point of concern. China is responsible for a large portion of the world's coal production and usage.[11] Coal combustion is a significant contributor to the country's PM2.5 emissions profile along with other sources such as industry, biomass burning, road dust, and road vehicles.[12] In order to combat these issues, China announced a new emissions reporting framework in 2022 to hold companies and industries accountable for the pollution they release.[13]

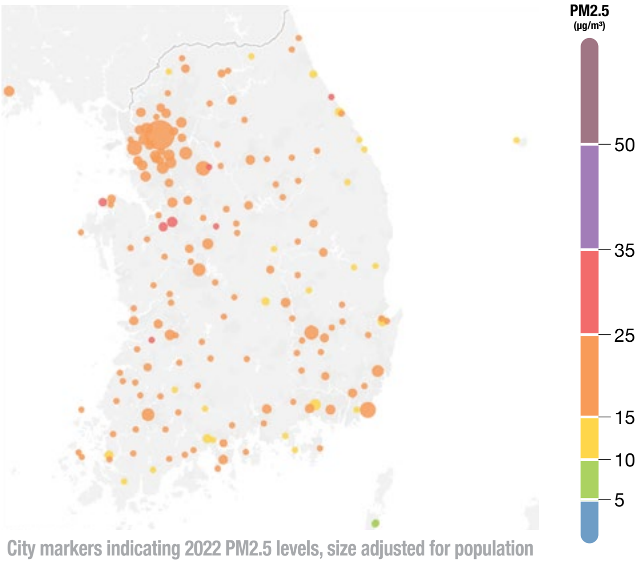
HIGHLIGHT: BEIJING WINTER OPLYMPICS

The Olympic Games in Beijing coincided with a large decrease in PM2.5 concentrations during February. The monthly concentration dropped from 62.7 µg/m³ in 2021 to 22.5 µg/m³ in 2022. All the venues for the games were powered with only renewable resources, and there was a focus on utilizing vehicles that used sustainable energy sources.[14] These new measures contributed to Beijing's trend of continual reductions in PM2.5 levels, which have dropped by 20 percent over the last two years with large improvements being made in the winter months. The data demonstrates the significant results achievable by such an intervention strategy, which makes it a promising framework to reduce air pollution.

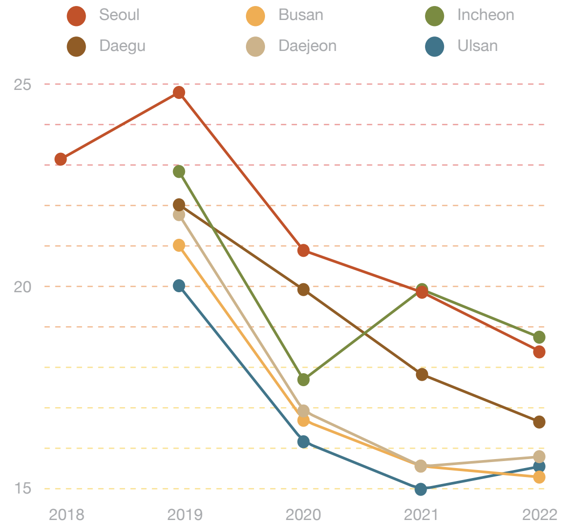


Annual hours spent at different PM2.5 pollution levels

SOUTH KOREA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Seoul	18.3	28.5	25.2	21.1	21.9	16.9	12.3	16.1	11.2	11.5	14.0	22.6	18.9	19.7
Busan	15.3	20.9	19.4	20.5	15.6	17.5	10.5	12.1	10.2	9.7	10.8	19.1	17.3	15.6
Daegu	16.7	24.2	21.5	22.1	16.8	16.7	12.1	12.2	9.2	8.9	12.3	23.8	20.5	17.8
Daejeon	15.8	25.0	24.3	22.7	16.6	12.6	8.6	10.1	5.7	9.9	12.6	22.5	19.7	15.6
Incheon	18.7	28.3	24.5	22.1	21.4	16.5	11.9	17.5	11.3	13.7	16.4	24.1	No Data	19.9
Ulsan	15.5	18.1	17.2	19.8	16.0	18.0	11.6	12.0	13.0	11.3	11.8	20.0	17.9	14.9

PROGRESS

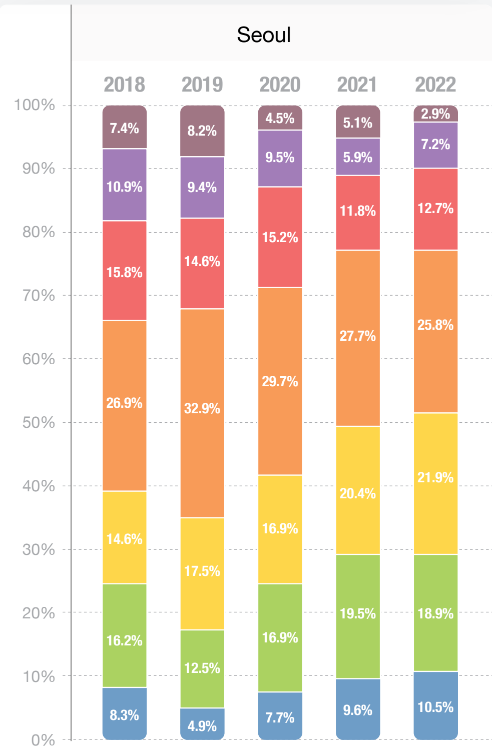
South Korea continues the trend of PM2.5 concentration reductions with an annual concentration of 18.3 µg/m³ in 2022 down from 19.1 µg/m³ in 2021. This includes reductions in the key cities of Seoul, Busan, and Daegu. The capital city Seoul, which is the most populous in the country, saw a reduction in PM2.5 concentrations of 7.1 percent from last year and 27.3 percent since 2017. Incheon, Ulsan, and Daejeon however, suffered small increases in their annual average concentrations. Although no city in South Korea met the WHO annual concentration guideline of 5 µg/m³ or less, the monthly concentrations in some cities fell below 5.0 µg/m³ in July. The country as a whole saw PM2.5 concentrations reduced in 55 of the 98 total cities included in the report.

CHALLENGES

South Korea faces pollution from areas of manufacturing, industrial sites, sand and dust storms from the Gobi Desert, and high traffic pollution from big cities. The geography of the nation, the proximity to deserts, and increased frequency of dust storms due to climate change come together to bring fine dust to many parts of the country.[15] These combined threats to air quality require careful consideration and specialized plans to reduce the health impact for people in South Korea.

HIGHLIGHT: FINANCE AND FRAMEWORKS FOR BETTER AIR

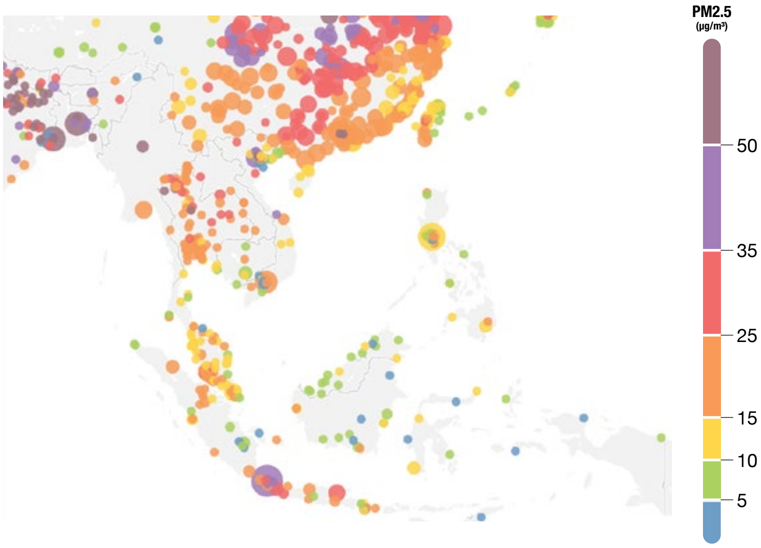
In 2022, South Korea battled air pollution by implementing financially focused frameworks and promoting multinational partnerships on clean air. They hosted the fourth Asia Pacific Clean Air Partnership Joint Forum to address multinational concerns.[16] South Korea also used their platform at COP 27 to announce a multimillion-dollar donation to the Climate Change Adaptation Fund to address issues outside of Asia.[17] Domestically, they introduced frameworks such as the K-Taxonomy and joined the international Task Force on Climate-Related Financial Disclosures to help define emissions goals and how financial contributions towards environmental causes must be standardized and promulgated.[18,19]



Annual hours spent at different PM2.5 pollution levels

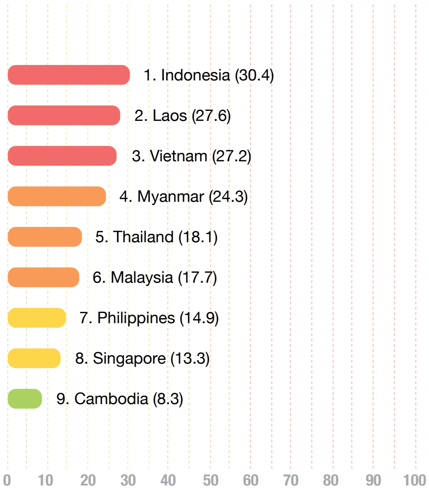
SOUTHEAST ASIA

Cambodia | Indonesia | Laos | Malaysia | Myanmar | Philippines | Singapore | Thailand | Vietnam



City markers indicating 2022 PM2.5 levels, size adjusted for population

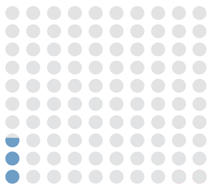
Country/Region Ranking



2022 PM2.5 average (µg/m³)

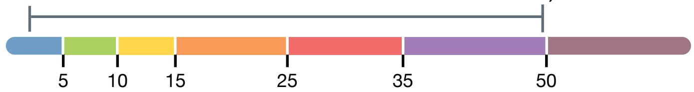
2.7%

Regional cities that met the WHO PM2.5 guideline in 2022



2.0
Nam Sach, Vietnam

49.6
Pasarkemis, Indonesia



Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	Pasarkemis, Indonesia	49.6
2	Hanoi, Vietnam	40.1
3	Cileungsir, Indonesia	36.6
4	Jakarta, Indonesia	36.2
5	Chaloem Phra Kiat, Thailand	36.2
6	Bekasi, Indonesia	35.4
7	Surabaya, Indonesia	34.4
8	Nan, Thailand	30.4
9	Pak Nam, Thailand	30.4
10	Thanh Hoa, Vietnam	29.9
11	Khlong Takhot, Thailand	29.0
12	Tha Wasukri, Thailand	28.8
13	Don Han, Thailand	28.2
14	Vientiane, Laos	27.6
15	Yang Sai, Thailand	27.3

Least Polluted Regional Cities

Rank	City	2022
1	Nam Sach, Vietnam	2.0
2	Kupang, Indonesia	2.3
3	Pangkalpinang, Indonesia	3.3
4	Kinh Mon, Vietnam	3.8
5	Cam Pha, Vietnam	3.9
6	Mamuju, Indonesia	4.0
7	Bongawan, Malaysia	4.7
8	Mong Cai, Vietnam	5.3
9	Tra Vinh, Vietnam	5.5
10	Samarinda, Indonesia	5.7
11	Phu Thai, Vietnam	6.1
12	Quang Yen, Vietnam	6.6
13	Palangkaraya, Indonesia	6.7
14	Limbang, Malaysia	6.8
15	Pangkalan Bun, Indonesia	6.9

SUMMARY

Countries in the Southeast Asia region have continued their efforts to decrease PM2.5 concentrations to safe levels recommended by the WHO guidelines. Industry, power generation, vehicle emissions, and open burning remain top contributors of PM2.5 in the area. The highlighted countries of Indonesia, Malaysia, Thailand, and Vietnam are using governmental bodies and regulatory action to address these sources of ambient air pollution.

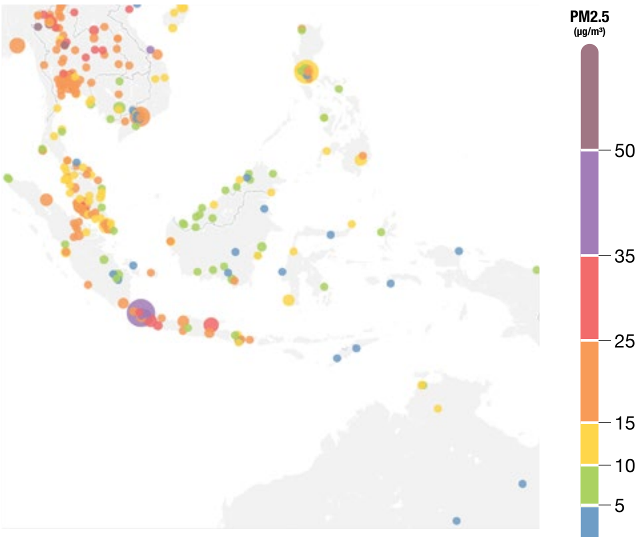
PM2.5 concentrations decreased for seven of nine countries in the Southeast Asia region; only Laos and Vietnam recording higher annual averages compared to 2021. Indonesia ended the year with the highest PM2.5 concentration of all countries in the region with an annual average of 30.4 µg/m³. Indonesia was worst in the region in PM2.5 concentration in 2021 as well. Cambodia improved its air pollution levels in 2022 with a 58 percent decrease in its annual average PM2.5 concentration down to 8.3 µg/m³, the lowest in the region. Cambodia was the 6th most polluted Southeast Asia country in 2021, so it is encouraging to note its improvement in 2022.

Of the 296 regional cities included in this report, just 8 satisfied the WHO PM2.5 guideline limit of 5 µg/m³, leaving a total of 288 cities that exceeded WHO-recommended PM2.5 concentrations. Thailand and Indonesia are the most represented in the list of the 15 most polluted cities, with 7 and 5 respectively. Indonesia is also well represented in the list of the 15 least polluted cities with 6. While Vietnam has 7 cities in the 15 least polluted cities list, its capital city Hanoi was the second most polluted city in the region with an annual average PM2.5 concentration of 40.1 µg/m³.

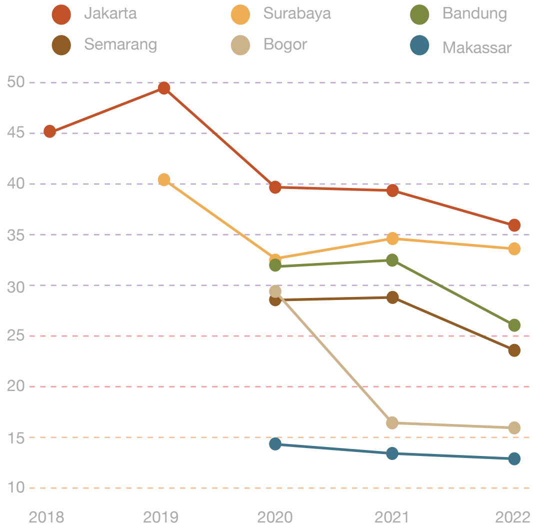
MONITORING STATUS

The Southeast Asia region is represented by 296 cities across 9 countries, a net increase of 69 cities compared to the 227 represented in 2021. The eight cities that met the WHO PM2.5 guidelines set at 5 µg/m³ were in three countries: Indonesia (four cities), Vietnam (three), and Malaysia (one). As air quality data collection continues to increase, historical trends can be uncovered and we can better our understanding of the impacts of air pollution on human health.

INDONESIA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Jakarta	36.2	27.8	27.9	28.2	33.2	36.2	50.7	48.6	48.1	46.5	32.1	27.2	27.7	39.2
Surabaya	34.4	41.5	35.2	33.4	42.2	24.9	42.4	28.6	28.6	38.1	35.0	36.7	29.9	34.8
Bandung	26.1	26.0	27.4	14.5	16.5	12.6	20.9	35.1	32.7	38.9	31.3	29.3	28.5	33.4
Semarang	24.3	34.8	28.7	19.9	22.3	15.7	22.5	25.4	22.2	31.6	26.0	20.9	22.7	28.6
Bogor	15.9	21.8	18.1	15.8	18.1	18.8	20.7	24.6	20.5	14.0	6.5	5.2	3.8	16.1
Makassar	13.2	10.2	8.3	7.9	12.4	11.4	14.1	17.6	17.6	20.2	12.9	11.8	10.1	13.5

PROGRESS

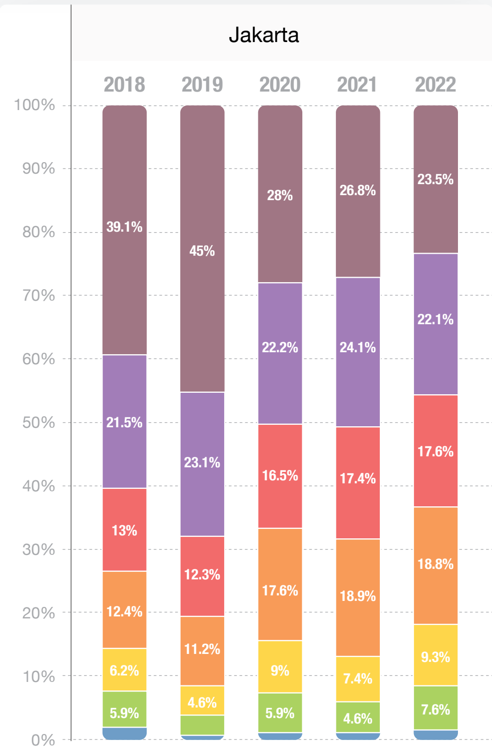
Indonesia's air quality improved in 2022, with an annual average PM2.5 concentration of 30.4 µg/m³ marking an 11 percent decrease from 2021. Jakarta improved its PM2.5 concentration for the third year in a row, with a 7.7 percent decrease since 2021 and a 27 percent decrease since 2019. The city's annual average PM2.5 concentration was 36.2 µg/m³ in 2022. Citizens in Jakarta and other major cities are especially vulnerable to air pollution from vehicle emissions and high-congestion traffic areas. Four cities in Indonesia satisfied the WHO PM2.5 concentration recommendations, accounting for ten percent of cities that provided adequate air quality information for the year. The two new cities represented in this year's report are also the two most polluted: Pasarkemis and Cileungsir recorded average PM2.5 concentrations of 49.6 µg/m³ and 36.6 µg/m³, respectively.

CHALLENGES

Air pollution in Indonesia is driven by coal-fired power plants, forest fires, and peatland degradation, while major cities are especially impacted by vehicle emissions.[20] Indonesia is still developing sustainable infrastructure to mitigate airborne pollutants from these sources. Recent regulatory actions include setting stricter standards on vehicle emissions, programs to improve residential stoves, and making landowners and corporations responsible for fires that occur on their land.[21,22,23]

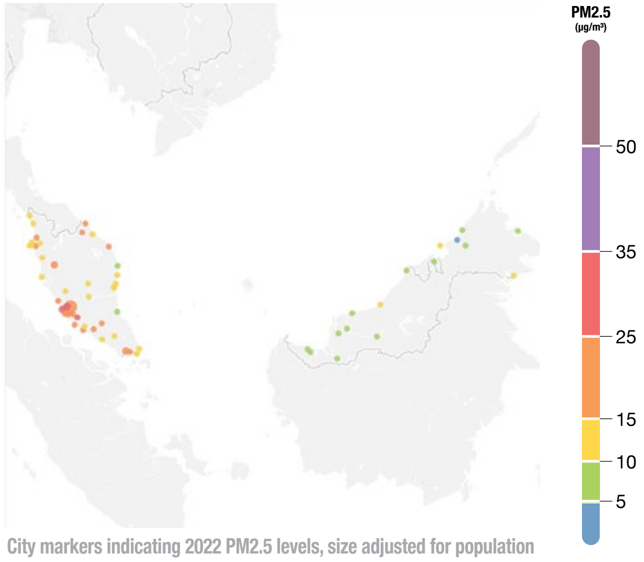
HIGHLIGHT: RETIRING COAL-FIRED POWER PLANTS

Indonesia's Energy Transition Mechanism announced in November that they would be retiring their first power plant through a partnership with the Asian Development Bank that seeks to retire or repurpose coal-fired power plants.[24] This action aligns with the goals of Perusahaan Listrik Negara (PLN), Indonesia's state-run utilities firm, to achieve carbon neutrality by 2060.[25] The agreement states that the Cirebon 1 power plant will be refinanced and retired in 2037,[26] 15 years before the end of its estimated useful life. The early closure of the 660 MW plant could reduce greenhouse gas emissions by as much as 30 million metric tonnes across the 15-year span and significantly reduced PM2.5 throughout the region.[24]

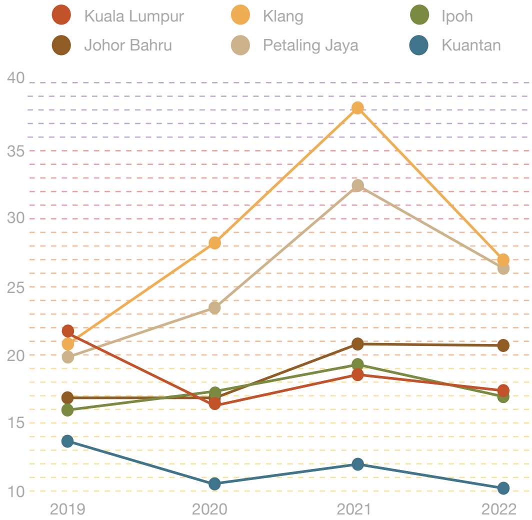


Annual hours spent at different PM2.5 pollution levels

MALAYSIA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (μg/m³) over 4 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Kuala Lumpur	17.6	22.0	16.3	19.0	19.9	17.4	12.7	19.4	19.3	21.9	14.5	15.2	14.0	18.6
Klang	27.1	39.0	29.0	25.9	28.0	26.1	17.1	24.6	25.6	26.8	22.9	25.6	34.3	38.2
Ipoh	16.9	24.3	17.3	19.9	18.0	17.5	13.9	19.3	17.3	13.4	11.9	15.4	15.1	19.3
Johor Bahru	20.6	14.0	15.2	17.3	22.7	22.9	27.3	25.6	27.3	26.2	17.8	15.9	15.0	20.7
Petaling Jaya	26.5	32.9	24.8	28.6	28.5	22.3	19.1	27.8	21.3	30.9	30.0	29.0	22.9	32.5
Kuantan	10.3	12.0	6.6	9.8	9.0	12.9	12.6	14.5	9.9	12.8	7.8	7.6	7.7	11.8

PROGRESS

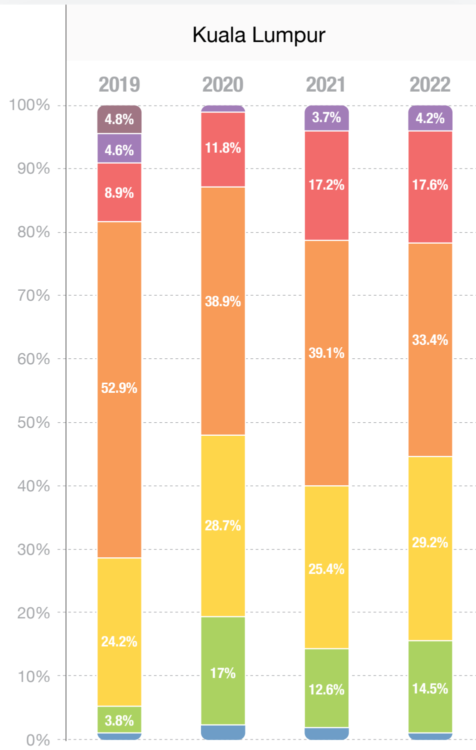
Malaysia experienced an overall drop in PM2.5 levels, with an annual average concentration of 17.7 μg/m³, marking a 9.6 percent improvement from 2021. Klang, the country's most polluted city in 2021, saw a 29.1 percent decline in PM2.5 levels down to 27.1 μg/m³. Malaysia's capital city, Kuala Lumpur, also experienced cleaner air, as PM2.5 concentrations dropped 5.4 percent to 17.6 μg/m³. Malaysia's only city to meet WHO PM2.5 guidelines was Bongawan, which averaged 4.7 μg/m³ in 2022. The largest increase in PM2.5 occurred in Seremban where concentrations rose 68 percent to 25.7 μg/m³. The general improvement in air quality was observed alongside more comprehensive air quality monitoring. 62 cities publicly reported PM2.5 data in 2022, up from 49 in 2021. The availability of more air quality data provides a better representation of air quality across Malaysia and a more accurate picture of the air breathed by its citizens.

CHALLENGES

Air pollution in Malaysia is driven by growing industrialization, vehicle emissions, and open burning[27]; the country is simultaneously affected by transboundary haze from biomass burning and forest fires in neighboring countries.[28] This combination of sources makes Malaysia's air pollution difficult to address in a single action. A collaborative study by the Centre for Research on Energy and Clean Air and Greenpeace Malaysia revealed that poor air quality is an attributable cause of roughly 32,000 avoidable deaths across the country each year.[29]

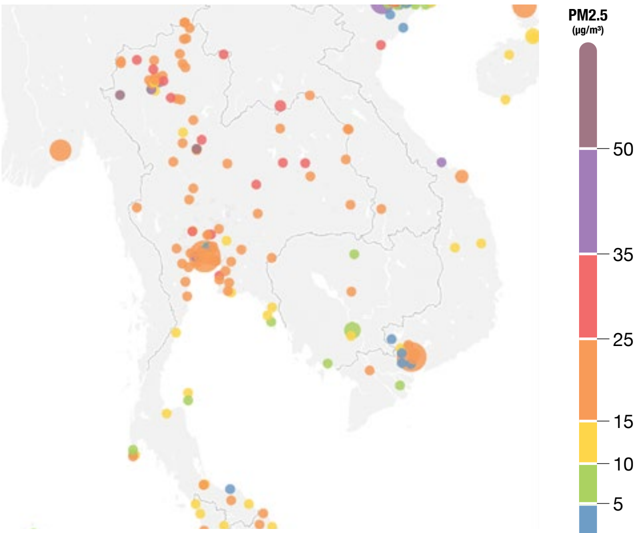
HIGHLIGHT: PUNISHING POLLUTERS

In October 2022, the Department of Environment published a revision of the Environmental Quality Act that increased penalties for environmental polluters. The amendment includes a clause that clarifies the regulations regarding open burning,[30] but the document mainly targets the penalties for noncompliance rather than making the existing pollution and emission requirements stricter. The Department of Environment is working on another amendment to the Environmental Quality Act, expected in 2025.[31]

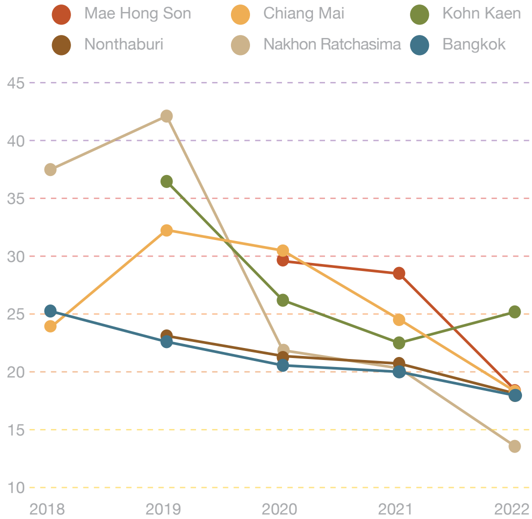


Annual hours spent at different PM2.5 pollution levels

THAILAND



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Bangkok	18.0	25.4	27.1	20.1	27.9	12.2	8.4	7.7	8.6	11.0	21.2	22.5	24.6	20.0
Chiang Mai	18.4	19.5	24.8	39.9	38.8	13.2	7.2	6.0	5.7	7.9	14.8	17.8	26.3	24.9
Khon Kaen	25.1	41.8	37.7	40.2	40.6	18.3	13.9	12.8	11.8	15.4	2.8	No Data		22.6
Mae Hong Son	18.8	No Data		73.2	55.6	17.5	10.4	5.0	5.4	9.4	15.3	16.1	26.3	28.5
Nakhon Ratchasima	13.9	21.9	24.2	27.5	21.3	6.8	5.7	8.3	7.0	8.0	12.3	10.1	13.7	20.3
Nonthaburi	18.0	25.7	29.6	20.9	31.2	11.6	6.5	6.3	7.3	9.7	21.4	22.9	23.9	20.8

PROGRESS

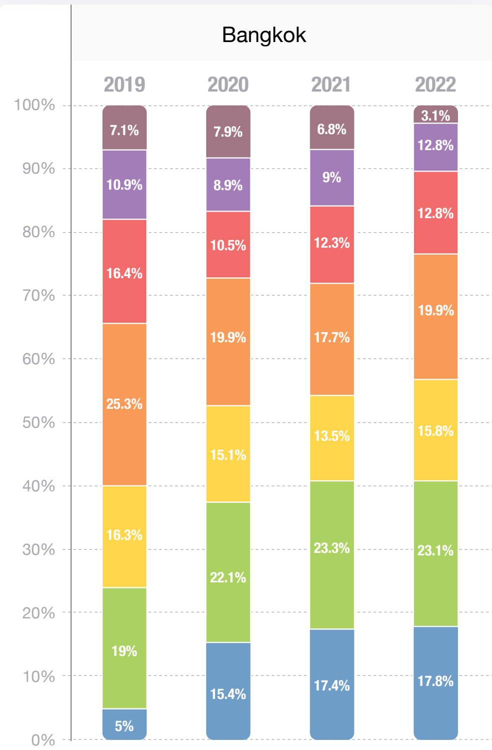
Thailand had cleaner air in 2022, decreasing its annual average PM2.5 concentration to 18.1 µg/m³, a 10.4 percent decrease from 2021 levels. Some of these improvements can be be attributed to more rain due El Niño. Bangkok, Thailand's capital and most populous city, improved its air quality for another year, decreasing its annual average PM2.5 by 10 percent down to 18.0 µg/m³. Air pollution in Thailand follows seasonal trends, with higher PM2.5 concentrations during the dry season from November through February. This period is followed by the summer season beginning in March that is often accompanied by agriculture burning from farmers clearing their land.[32] 157 cities provided enough PM2.5 data for inclusion in the 2022 World Air Quality Report, zero of which met the WHO guidelines of 5 µg/m³.

CHALLENGES

People in northern Thailand are especially vulnerable to negative health impacts from air pollution, as forest fires in March and April caused spikes in PM2.5 concentrations 400 percent higher than WHO recommended levels.[33] Transboundary haze, illegal crop burning, and teak wood smuggling operations contribute to much of this pollution. The Geo-Informatics and Space Technology Development Agency identified 1,060 air pollution hotspots across Thailand's 76 provinces, with a combined 202 hotspots in the northern provinces of Chiang Mai, Lampang and the Mekong region.[34]

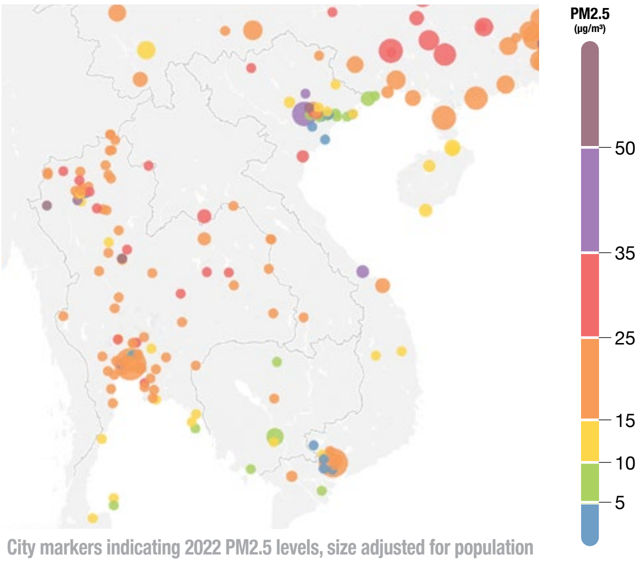
HIGHLIGHT: AIR QUALITY IN THE CAPITAL

Bangkok's new governor, Chadchart Sittipunt,[35] has identified air pollution control as a priority in his goal to make Bangkok a welcoming and liveable city for everyone. Chadchart hopes to improve the quality of life for Bangkok residents and visitors through policy objectives to increase air pollution monitoring, PM2.5 forecasting, and black smoke detection.[36,37,38] It remains to be seen if these actions, in addition to efforts to cut emissions, can lead to significantly improvements in ambient air quality and inspire future country-wide action.

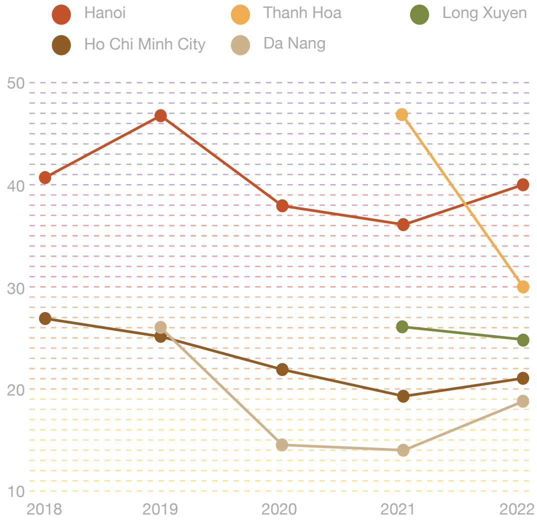


Annual hours spent at different PM2.5 pollution levels

VIETNAM



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Hanoi	40.1	50.9	38.2	42.3	43.6	32.5	29.0	24.6	26.1	39.5	45.0	47.9	61.6	36.2
Da Nang	18.8	26.1	11.3	20.9	23.6	17.6	15.6	13.6	14.0	16.3	21.1	20.1	24.3	14.1
Thanh Hoa	29.9	38.2	34.9	28.7	33.1	26.2	19.4	14.2	15.5	28.7	37.3	32.2	50.7	46.9
Ho Chi Minh City	21.2	29.7	17.9	21.5	23.6	14.3	17.1	16.2	16.9	12.3	23.4	26.8	33.9	19.4
Long Xuyen	24.8	36.5	27.0	28.9	29.6	16.9	16.7	17.2	15.0	14.5	31.4	32.6	31.9	26.0

PROGRESS

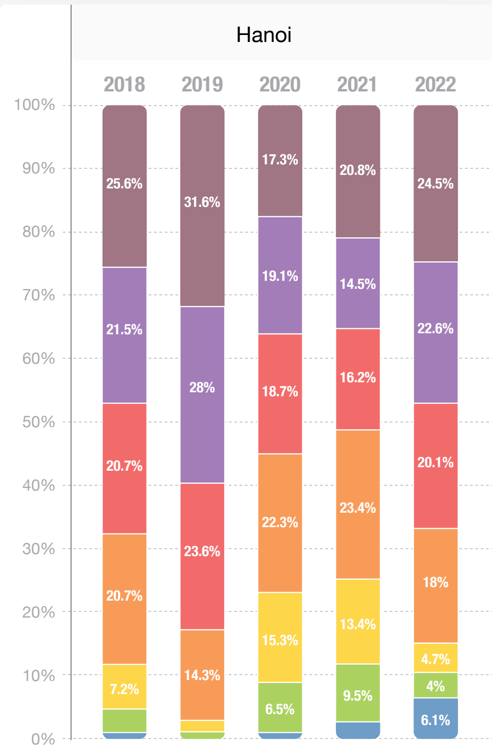
Vietnam's annual average PM2.5 concentration increased to 27.2 $\mu g/m^3$ in 2022 after falling in 2021. The country's two most populous cities, Ho Chi Minh City and Hanoi, experienced 9.3 percent and 10.8 percent higher PM2.5 concentrations, respectively. Air quality monitoring increased to cover 20 cities in 2022, five more than the previous year. Cam Pha, Kinh Mon, and Nam Sach each met the WHO PM2.5 guidelines of 5 $\mu g/m^3$, with their annual averages even falling below 4 $\mu g/m^3$. Vietnam's PM2.5 concentrations follow seasonal trends, with greater PM2.5 exposure during the dry season from November through April. Air pollution from open burning and wildfires can be exacerbated by a dry climate, contributing to higher PM2.5 levels during these months.

CHALLENGES

Power generation from fossil fuels, motor vehicles emissions, and industrial factories are still significant contributors of air pollution in Vietnam.[39] The National Strategy for Environmental Protection to 2030 with a vision until 2050 was approved in response to growing environmental concerns related to these pollutant sources. The Strategy emphasizes the use of eco-friendly transportation and the phase-out of fossil fuels while also targeting industry through environmental zoning, permitting, impact assessments, as well as increased monitoring.[40,41]

HIGHLIGHT: REDUCING POLLUTION

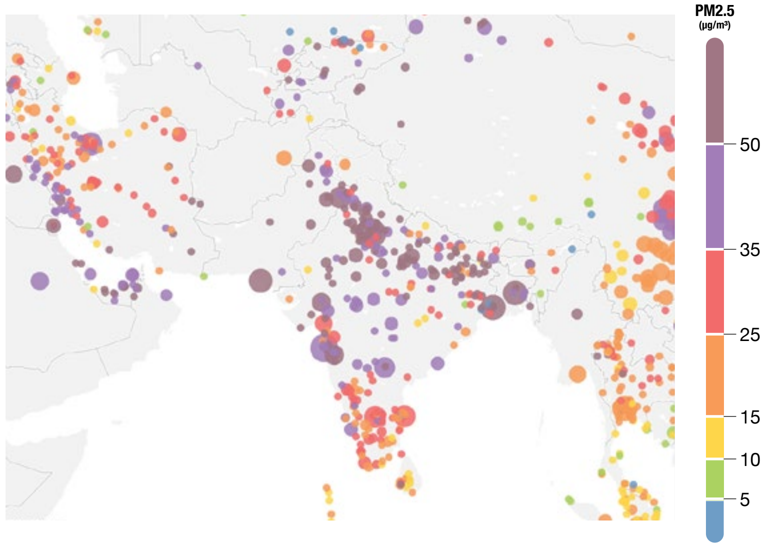
Vietnam's Ministry of Natural Resources and Environment partnered with the United States Agency for International Development to launch the "Reducing Pollution" initiative. The project will invest $11.3 million USD over a five-year period to target environmental pollution with a focus on air pollution.[42] Initiatives include reducing air pollution from road transportation and open burning, as well as the development of an environmental data disclosure platform and improved waste management.[43]



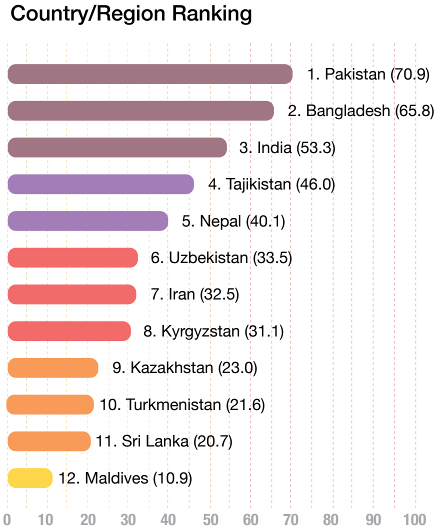
Annual hours spent at different PM2.5 pollution levels

CENTRAL & SOUTH ASIA

Bangladesh | India | Iran | Kazakhstan | Kyrgyzstan | Maldives | Nepal | Pakistan | Sri Lanka | Tajikistan | Turkmenistan | Uzbekistan



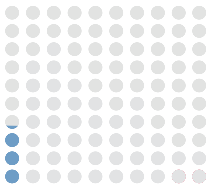
City markers indicating 2022 PM2.5 levels, size adjusted for population

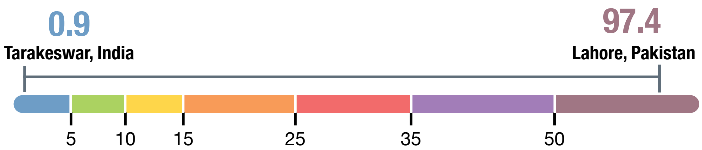


2022 PM2.5 average (µg/m³)

3.2%

Regional cities that met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	Lahore, Pakistan	97.4
2	Bhiwadi, India	92.7
3	Delhi, India	92.6
4	Peshawar, Pakistan	91.8
5	Darbhanga, India	90.3
6	Asopur, India	90.2
7	Patna, India	88.9
8	Ghaziabad, India	88.6
9	Dharuhera, India	87.8
10	Chapra, India	85.9
11	Muzaffarnagar, India	85.5
12	Faisalabad, Pakistan	84.5
13	Greater Noida, India	83.2
14	Bahadurgarh, India	82.2
15	Faridabad, India	79.7

Least Polluted Regional Cities

Rank	City	2022
1	Tarakeswar, India	0.9
2	Digboi, India	1.4
3	Chu, Kazakhstan	1.5
4	Petropavl, Kazakhstan	2.4
5	Shchuchinsk, Kazakhstan	2.6
6	Aladu, India	2.7
7	Kattupalli, India	2.8
8	Zhezqazghan, Kazakhstan	3.0
9	Aqtobe, Kazakhstan	4.2
10	Beyneu, Kazakhstan	5.7
11	Kyzyl-Orda, Kazakhstan	7.8
12	Polampalle, India	8.3
13	Aktau, Kazakhstan	9.7
14	Kharsawan, India	9.8
15	Muttayyapuram, India	10.6

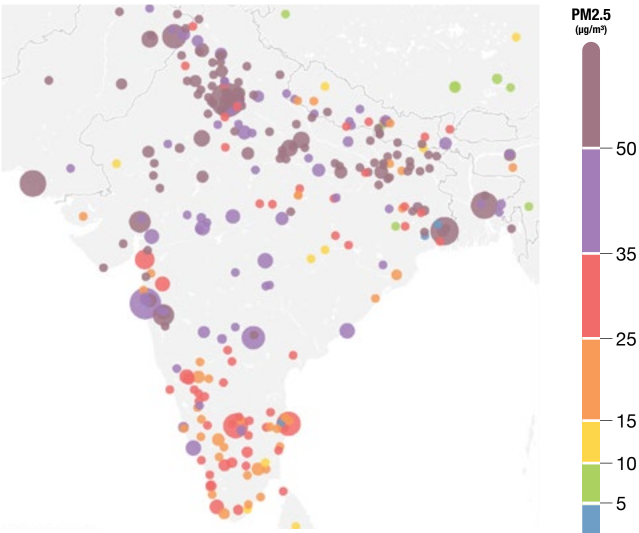
SUMMARY

In 2022, Central and South Asia was home to eight of the world's ten cities with the worst air pollution. According to the World Bank's report on Air Pollution in South Asia 2022, air pollution causes an estimated two million premature deaths across the region each year and incurs significant economic costs.[44] India and Pakistan generally experience the worst air quality in this region. Only nine cities in the region achieved annual PM2.5 concentrations in 2022 that met WHO Guidelines. Nearly 60 percent of the population lives in areas where concentrations of PM2.5 are seven times higher than the WHO guideline. In addition to the dominant primary sources of air pollution around the globe, other sources make substantial contributions in this region, including combustion of solid fuels for cooking and heating, emissions from small industries such as brick kilns, burning of municipal and agricultural waste, and cremation. Air pollution travels long distances—crossing municipal, state, and national boundaries—and gets trapped in large "airsheds" that are shaped by climatology and geography. The World Bank report identifies six major airsheds in South Asia where spatial interdependence in air quality is high.[44] It is estimated that less than half the air pollution in South Asia's major cities is produced within cities themselves, highlighting the importance for widespread emissions reductions, not only those centered in urban areas.

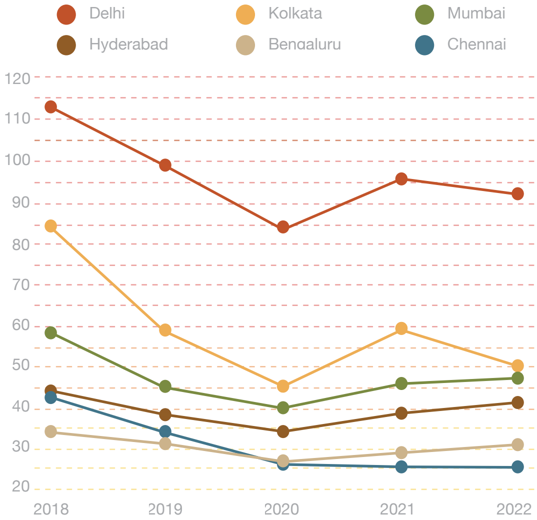
MONITORING STATUS

In 2022, nearly all Central and South Asia countries have expanded their air quality network by increasing the number of stations publicly reporting PM2.5 concentration data. While most of the countries in the region are highly dependent on government-operated monitoring stations to provide most public air quality data, the number of non-government stations in the region has increased by 30 percent from 2021. In some of the capital cities in the region (Dhaka, Bangladesh; Bishkek, Kyrgyzstan; Islamabad, Pakistan; Colombo, Sri Lanka) the percentage of low-cost sensor stations is more than 80 percent. The Maldives is included for the first time in this year's report, with six cities providing publicly accessible data for their citizens through low-cost sensors.

INDIA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Delhi	92.6	141	100.9	91.0	98.0	73.2	56.2	34.3	31.1	38.3	99.7	176.8	171.9	96.4
Kolkata	59.0	98.3	77.4	62.1	23.6	27.6	23.4	12.6	16.5	19.6	33.6	88.7	120.6	59
Mumbai	46.7	74.8	65.9	67.5	41.7	41.5	17.8	17.1	15.3	18.7	37.9	74.8	88.1	46.4
Hyderabad	42.4	61.0	55.8	56.4	43.4	39.5	23.1	18.0	17.8	23.0	38.6	72.0	61.3	39.4
Bengaluru	31.5	37.9	42.5	45.1	39.9	29.5	15.0	15.0	14.2	18.1	36.9	45.8	38.8	29.0
Chennai	25.3	20.1	24.9	29.5	14.5	26.0	21.1	17.2	17.5	21.9	32.4	36.6	41.5	25.2

PROGRESS

India's annual average PM2.5 level in 2022 was 53.3 µg/m³, only slightly lower than the 2021 average of 58.1. In 2021, 12 of the 15 most polluted cities in the Central and South Asia were in India. That number stayed the same in 2022. Two of the top 15 most polluted cities in the region, Darbhanga and Asopur, deployed government stations in 2022. Bhiwadi, the most polluted city in the country, saw annual PM2.5 levels of 92.7 µg/m³, and roughly 60 percent of cities in India included in this report experienced annual PM2.5 levels of at least seven times higher than the WHO guideline.

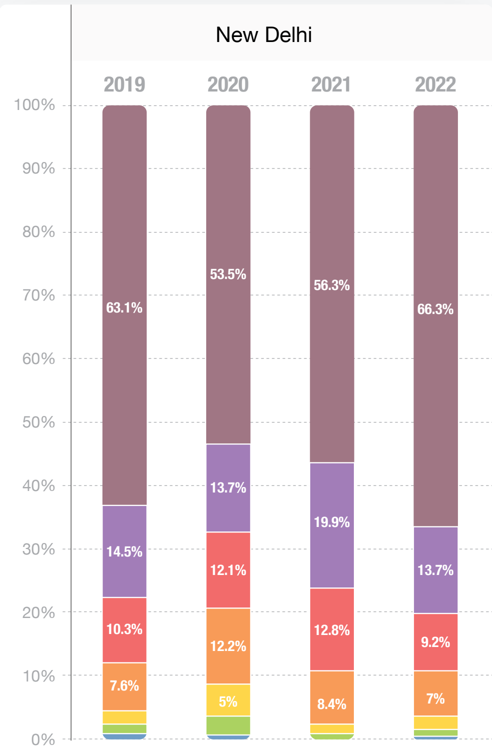
CHALLENGES

Air pollution is the second biggest risk factor for disease based on the 2019 Global Burden of Disease report, and the economic cost of air pollution is estimated to exceed $150 billion dollars annually. The transportation sector's contribution to PM2.5 varies from 20-35 percent across Indian cities.[45] The National Clean Air Program (NCAP), launched by the Indian government in 2019, was updated in 2022 with a new target of 40 percent reduction in PM concentration by 2026. The plan seeks to reduce PM concentrations by 20-30 percent by 2024 in all identified non-attainment cities, increase air quality monitoring, and conduct source apportionment studies.

Stubble (crop) burning is also an important challenge in the region but is an episodic phenomenon confined to few areas, including Delhi and North India. In 2022, India relaxed environmental compliance rules for coal mines which allowed for increased production in response to power outages exacerbated by extreme heatwaves.[46] In November, steam coal/thermal coal imports hit a ten month low and total coal production increased 11.7 percent to 75.9 million tons.[47,48]

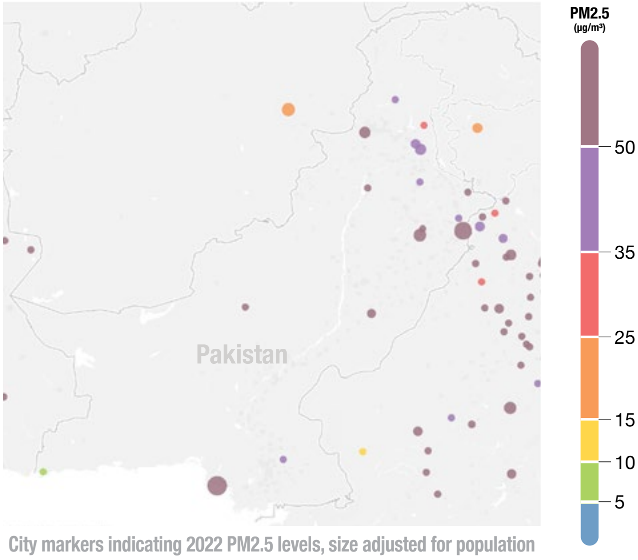
HIGHLIGHT: LACK OF A NATIONAL EMISSION INVENTORY

Air quality monitoring has increased over the past years in India, but the country still lacks the ability to track the progress of reduction strategies through an effective and reliable emissions inventory.[49] A 2021 study shows that global and regional estimates agree on the leading sources of air pollution in India, but they vary significantly from in terms of uncertainty associated with these estimations. The highest variations in the estimated emissions are related to power plants, transportation, and agricultural residue burning.[49] A comprehensive national emission database is critical in determining sectoral emission reductions needed to meet the targeted 40 percent reduction in particulate concentrations by 2026 outlined in the NCAP. The ability to attribute emissions to their respective sources is necessary to monitor the progress of emissions-lowering initiatives.

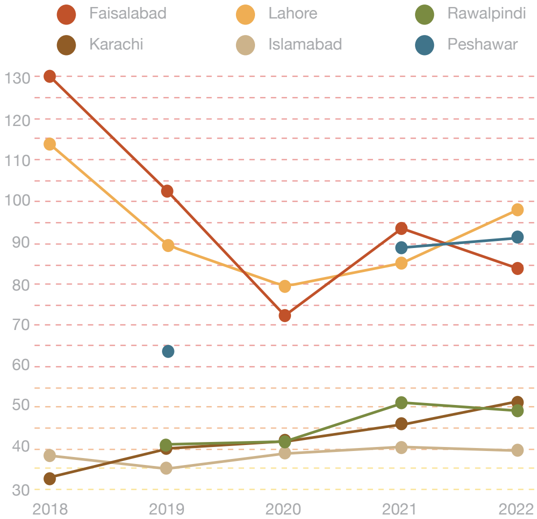


Annual hours spent at different PM2.5 pollution levels

PAKISTAN



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Islamabad	40.6	56.0	42.6	35.2	25.9	24.6	33.8	27.0	25.9	34.2	39.4	56.0	86.0	41.1
Faisalabad	84.5	154.9	81.6	97.4	77.4	65.6	52.8	51.5	41.3	57.0	84.9	144.5	189.0	94.2
Karachi	50.6	66.2	58.5	48.4	39.4	43.2	21.6	21.6	27.9	30.4	47.2	78.9	117.0	45.9
Lahore	97.4	133.0	102.5	85.6	69.3	60.9	52.1	47.8	46.2	64.2	123.2	190.5	192.9	86.5
Peshawar	91.8	110.2	103.5	78.3	68.5	53.5	56.3	51.8	57.8	79.0	100.0	132.0	212.1	89.6
Rawalpindi	48.5	72.0	51.3	37.9	27.7	31.3	33.3	28.9	26.4	33.2	36.8	78.5	114.8	51.4

PROGRESS

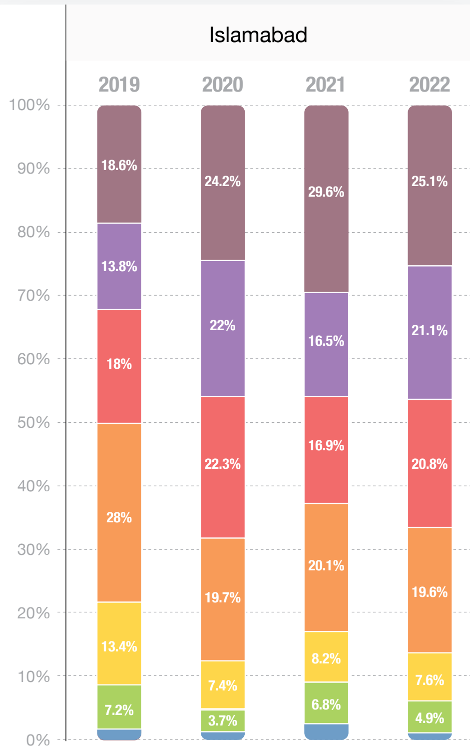
In 2022, Pakistan ranked as the third most polluted global country. Ranking number one in this year's list of most polluted global cities, Lahore has continued the trend of increasing PM2.5 levels. PM2.5 concentrations in Lahore dropped from a high of 133.2 µg/m³ in 2017 to a low of 79.2 µg/m³ in 2020. Since then however, concentrations have continued to climb, now reaching 97.4 µg/m³ in 2022. Every Pakistani city included here reported annual average PM2.5 concentrations at least eight times higher than the recommended WHO guideline. The city of Peshawar, with a population of nearly two million, is listed as fourth in the region's most polluted cities rankings with an annual concentration of 91.8 µg/m³. The average life expectancy in Pakistan would increase by 2.6 years if the country reached the WHO interim target 4 value of 10 µg/m³.[50]

CHALLENGES

House and forest fires contributed to Pakistan's poor air quality in 2022. The Dadu village fire in April, the Haripur and Sherani District wildfires in May, and the Shangla District and Karachi fires in June each contributed to Pakistan's 12 percent increase in annual PM2.5 concentrations. Crop burning and winter weather patterns resulting in temperature inversions that promote air stagnation keep air pollution trapped close to the ground are other main contributors to this country's poor air quality.

HIGHLIGHT: AIR QUALITY MONITORING AND POLLUTION REDUCTION EFFORTS

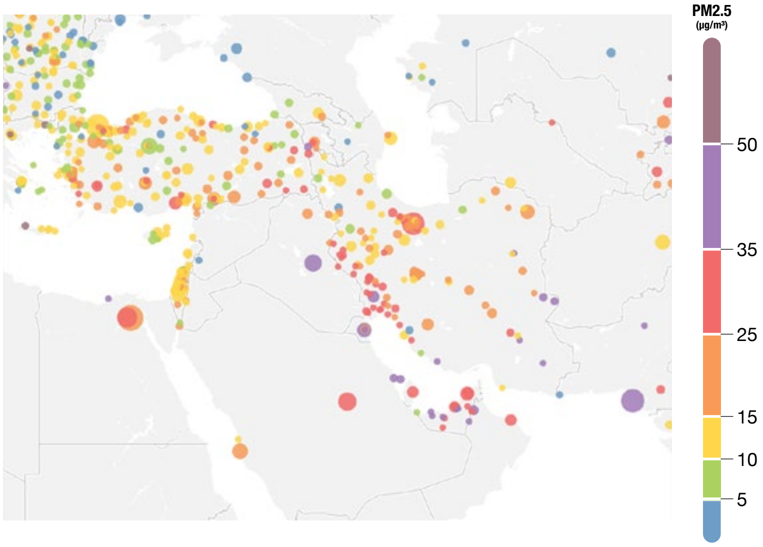
In June of 2021, Pakistan announced a revised Pakistan Clean Air Plan (PCAP) to perform national and local air pollution assessments. Implementation of this plan continued in 2022 via the development of a National Clean Air Plan,[51] a joint effort with contributions from the Pakistan Ministry of the Environment and support from the Climate and Clean Air Coalition (CCAC), the Stockholm Environment Institute (SEI), and Clean Air Asia. This plan sets targets for air pollution concentrations, identifies air pollution mitigation strategies, and outlines a plan for coordinating action on air quality management. Development of the plan has also resulted in the country's first national air pollutant inventory, which includes the first-ever quantification of black carbon and other air pollutants at both the national and the provincial scale.



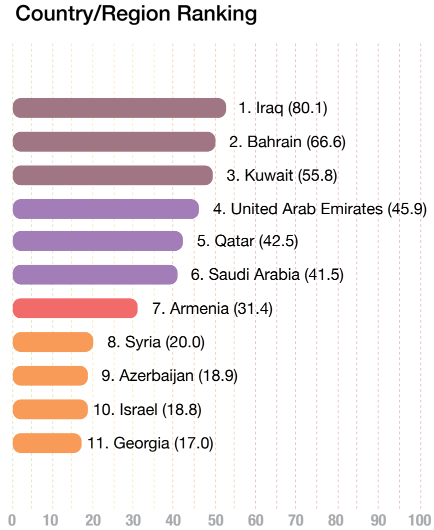
Annual hours spent at different PM2.5 pollution levels

WEST ASIA

Armenia | Azerbaijan | Bahrain | Georgia | Iraq | Israel | Kuwait | Qatar | Saudi Arabia | Syria | United Arab Emirates



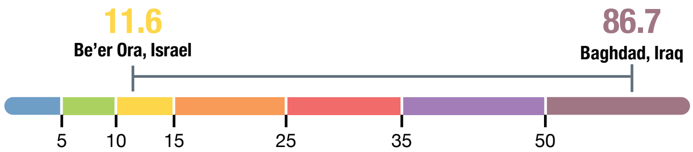
City markers indicating 2022 PM2.5 levels, size adjusted for population



2022 PM2.5 average (µg/m³)

0%

Regional cities that met the WHO PM2.5 guideline in 2022



Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	Baghdad, Iraq	86.7
2	Manama, Bahrain	66.6
3	Dhahran, Saudi Arabia	62.8
4	Kuwait City, Kuwait	57.5
5	Ras Al Khaimah, UAE	55.2
6	Ash Shihaniyah, Qatar	48.8
7	Abu Dhabi, UAE	48.0
8	Riyadh, Saudi Arabia	46.2
9	Dubai, UAE	43.7
10	Doha, Qatar	41.8
11	Erbil, Iraq	35.0
12	As Salimiyah, Kuwait	32.5
13	Jeddah, Saudi Arabia	32.5
14	Yerevan, Armenia	31.4
15	Yeghegnavan, Armenia	28.4

Least Polluted Regional Cities

Rank	City	2022
1	Be'er Ora, Israel	11.6
2	Batumi, Georgia	14.1
3	Nesher, Israel	15.7
4	Kfar Menahem, Israel	15.7
5	Sde Yoav, Israel	15.7
6	Gan Yavne, Israel	15.9
7	Erez, Israel	16.0
8	Mavki'im, Israel	16.0
9	Qiryat Shemona, Israel	16.1
10	Tbilisi, Georgia	16.3
11	Ashdod, Israel	16.3
12	Karmia, Israel	16.3
13	Ein Tamar, Israel	16.4
14	Yad Binyamin, Israel	16.5
15	Haifa, Israel	16.5

SUMMARY

Three out of four of the region's most polluted cities were the capital cities of Baghdad (Iraq), Manama (Bahrain), and Kuwait City (Kuwait). Baghdad, the region's most polluted city, showed a nearly 75 percent increase in 2022, going from 49.7 µg/m³ to 86.7 µg/m³. This sharp increase comes from higher PM2.5 concentrations in the summer months from intense dust storms in the area. The capital city of Georgia, Tbilisi, demonstrated the highest PM2.5 reduction of any capital city in the region, 20 percent, after going from 20.4 µg/m³ in 2021 to 16.3 µg/m³ in 2022. Of the 74 cities included in this region for the report, 38 cities had increased annual PM2.5 concentrations from last year, 32 cities had decreased concentrations, and four new cities have been included. No cities had annual averages below the WHO guidelines.

Of the 11 countries in this region, nine had their annual average increase and two had their annual average decrease from 2021. PM2.5 concentrations in the region range from 17.0 µg/m³ in Georgia to 80.1 µg/m³ in Iraq. Thus, the least polluted country in the region is still higher than three times the WHO guidelines.

While the anthropogenic sources of air pollution in the region such as fossil fuel-based energy production, emissions from industrial processes, waste burning, construction, and vehicles continue to contribute to the PM2.5 concentrations, dust storms have been a major source of natural pollution in the area.[52] There was a series of dust storms in May 2022 that caused massive amounts of particulate matter to pollute countries in the region which instigated environmental, social, and health impacts.[52,53]

MONITORING STATUS

West Asia continues to have relatively scarce air quality monitoring in comparison to other regions of the world. Dubai in the United Arab Emirates holds by far the most monitoring stations in the region, housing almost one fifth of the region's monitors in this single city. Israel has the most cities accounted for in the region with 52, giving the highest spatial resolution of air quality data. There has been an increase in low-cost sensor data in the region with an increase of 65 percent from last year. The resulting distribution of government monitors to non-government monitors is 60 percent government to 40 percent non-government.

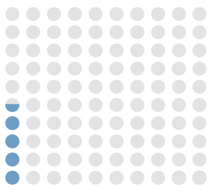
EUROPE

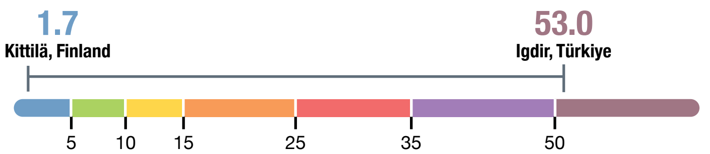
Albania | Andorra | Austria | Belgium | Bosnia and Herzegovina | Bulgaria | Croatia | Cyprus | Czech Republic | Denmark | Estonia | Finland | France | Germany | Greece | Hungary | Iceland | Ireland | Italy | Kosovo | Latvia | Liechtenstein | Lithuania | Luxembourg | Malta | Moldova | Montenegro | Netherlands | North Macedonia | Norway | Poland | Portugal | Romania | Russia | Serbia | Slovakia | Slovenia | Spain | Sweden | Switzerland | Türkiye | Ukraine | United Kingdom

City markers indicating 2022 PM2.5 levels, size adjusted for population

4.6%

Regional cities which met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (μg/m³) across regional cities

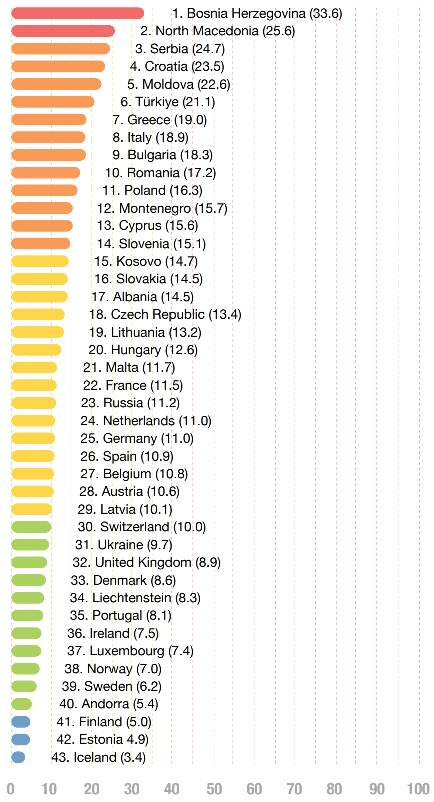
Most Polluted Regional Cities

Rank	City	2022
1	Igdir, Türkiye	53.0
2	Krasnoyarsk, Russia	51.7
3	Tuzla, Bosnia Herzegovina	49.4
4	Zenica, Bosnia Herzegovina	48.6
5	Ilidza, Bosnia Herzegovina	43.1
6	Novi Pazar, Serbia	41.7
7	Gaziantep, Türkiye	40.2
8	Uzice, Serbia	40.0
9	Bijelo Polje, Montenegro	39.6
10	Banja Luka, Bosnia Herzegovina	37.1
11	Duzce, Türkiye	36.8
12	Cacak, Serbia	35.7
13	Mersin, Türkiye	35.3
14	Pljevlja, Montenegro	34.5
15	Konya, Türkiye	34.5

Least Polluted Regional Cities

Rank	City	2022
1	Kittilä, Finland	1.7
2	Blaarthem, Netherlands	1.8
3	Corfu, Greece	2.3
4	Ulsteinvik, Norway	2.5
5	Vaasa, Finland	2.7
6	Korsholm, Finland	2.7
7	Husavik, Iceland	3.0
8	Albalat dels Tarongers, Spain	3.1
9	Reykjavik, Iceland	3.3
10	Alcoutim, Portugal	3.3
11	Bodo, Norway	3.5
12	Voore, Estonia	3.6
13	Chatou, France	3.6
14	Saint-Joseph, France	3.6
15	Vladivostok, Russia	3.6

Country/Region Ranking



2022 PM2.5 annual average (μg/m³)

SUMMARY

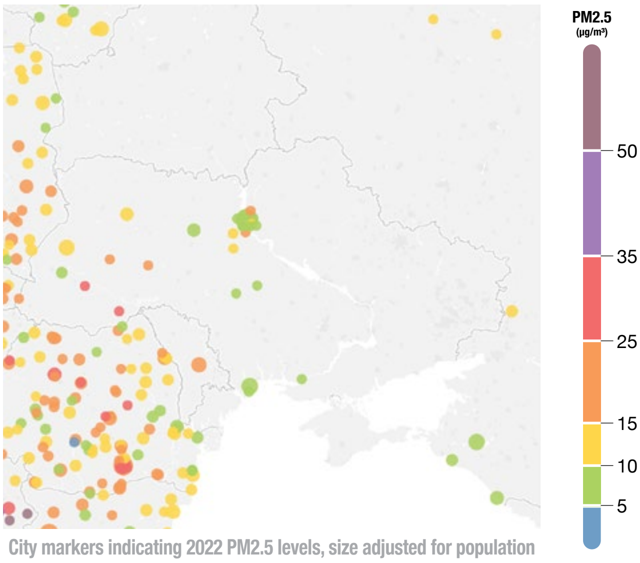
The region of Europe is represented in this year's report by 1,713 cities in 43 countries. The annual average PM2.5 concentrations in 2022 range from from 3.4 μg/m³ in Iceland to 33.6 μg/m³ in Bosnia Herzegovina. Europe is home to three countries that meet the WHO annual PM2.5 guideline: Iceland, Finland, and Estonia. Of the 41 countries reporting data in 2021, 15 countries reported increased annual PM2.5 concentrations, three remained the same, and 23 have reduced averages compared to 2021. There are two new countries added to this region from last year: Moldova and Latvia. Bosnia Herzegovina had the largest absolute PM2.5 concentration increase in the region going from 27.8 μg/m³ in 2021 to 33.6 μg/m³ in 2022. The largest decrease of annual concentration was in Montenegro, dropping from 35.2 μg/m³ in 2021 to 15.7 μg/m³ in 2022 for a decrease of 19.5 μg/m³. This year, five additional cities are included for the country of Montenegro providing more data and enabling a more comprehensive assessment of air quality for the country.

Of the 1,713 cities in Europe included in this year's report, 4.6 percent had annual averages below the WHO annual PM2.5 guideline of 5 μg/m³. Finland had the most cities in the region that achieved the guideline value with a total of 20 cities, followed by the UK with 13, and Spain with eight. Europe's air quality benefited in 2022 from having a mild winter which decreased the demand for pollution generating energy consumption.

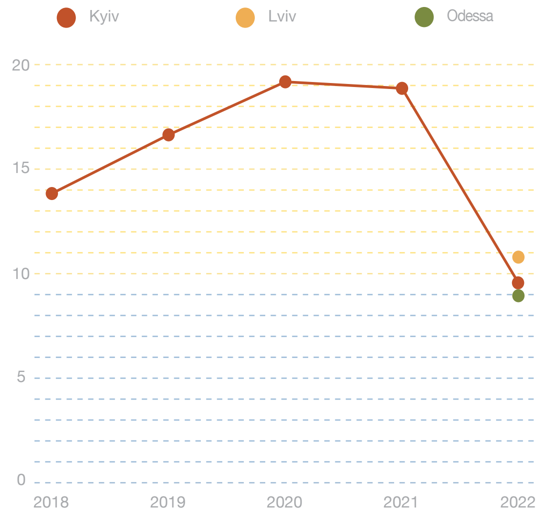
MONITORING STATUS

Europe continues to have a robust network of monitors which enable high spatial resolution air quality information for this region. Countries in Western Europe, as well as Poland and Türkiye, continue to have a strong network of government sensors. Low-cost sensors in, for example, Greece and Romania, help provide granularity to government data. The distribution of government and low-cost sensors is 73 percent government operated to 27 percent non-government operated monitoring stations.

UKRAINE



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Kyiv	9.5	9.6	11.2	15.4	7.2	6.0	6.6	5.0	7.2	7.3	7.6	13.1	18.3	18.8
Lviv	10.8	12	11.7	19.7	10.3	6.7	7.6	6.9	8.0	6.8	9.1	15.2	14.8	No Data
Odessa	9.0	13.2	14.4	13.1	7.3	5.7	6.8	6.6	9.2	5.4	7.3	9.0	11.0	No Data

PROGRESS

Russia's invasion of the Ukraine on February 24, 2022 upended industries and destroyed businesses.[54] Infrastructure such as grids and powerplants has been heavily targeted by Russia. An estimated 2.4 million Ukrainians are out of work.[55] Furthermore, 8 million refugees fled the country in 2022.[56] This devasting war has led to a reduction of human-generated air pollution. Ukraine's annual average PM2.5 concentration decreased from 18.5 $\mu g/m^3$ in 2021 to 9.7 $\mu g/m^3$ in 2022, a finding which can be largely attributed to concentration reductions in large cities early in the year. PM2.5 concentrations in Ukraine's capital, Kyiv, decreased nearly 50%, dropping from 18.8 $\mu g/m^3$ to 9.5 $\mu g/m^3$. Kyiv and many other Ukranian cities experienced lower concentrations in January and February and did not return to high levels for the rest of the year. The city-level concentrations range from 6.7 $\mu g/m^3$ in Uman to 15.8 $\mu g/m^3$ in Velyki Dmytrovychi.

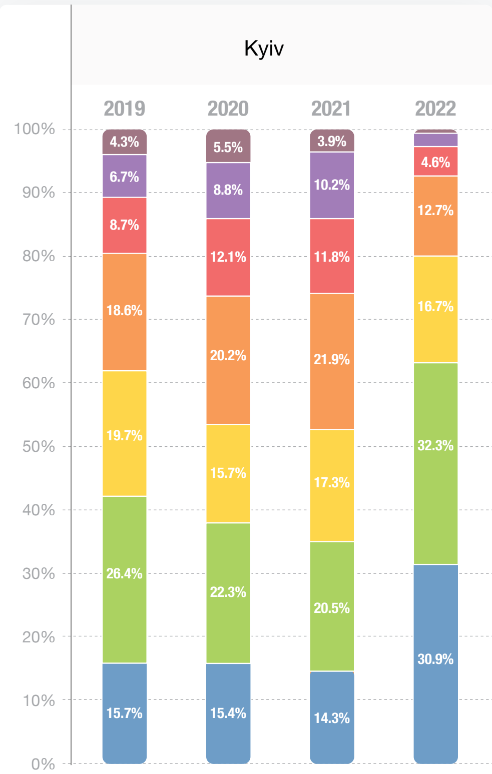
CHALLENGES

It would be impossible to ignore the effect that armed conflict has on a country's air quality. The operation of heavy military vehicles and aircrafts release air pollution from oil combustion, and the destruction of buildings and other infrastructure pose health issues to those exposed.[57.58]

The main sources of peacetime air pollution in Ukraine are industries involving ferrous metallurgy, thermal energy, coal, oil, gas, and cement production. Many of these emissions come from energy generation.

HIGHLIGHT: RESILIENT AND EXPANDING MONITORING NETWORKS

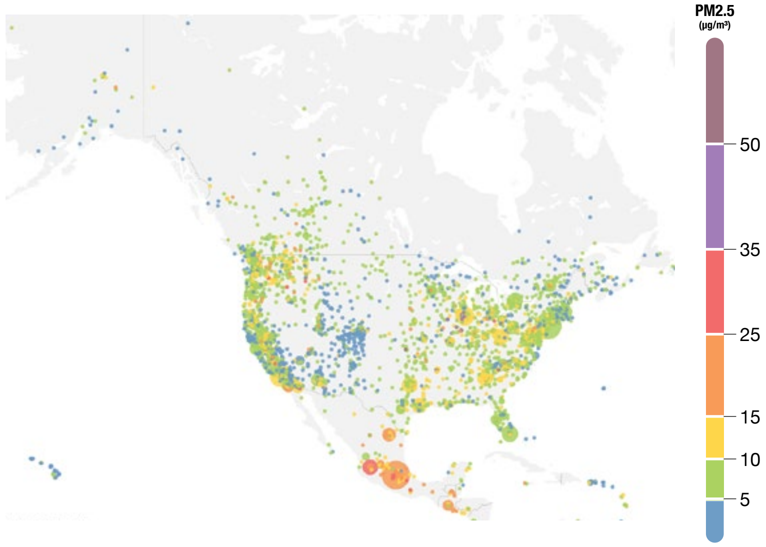
Despite the outbreak of war, Ukraine expanded air monitoring networks to cover more people and a greater geographic area. Collected data represents almost triple the number of cities in 2022 than in 2021 thanks to the combined efforts of government groups and non-governmental organizations. The Department of Ecology and Natural Resources in Kyiv ensured air quality monitoring stations were operational to provide year-round data. Supplemental data was provided by educational organizations like the Main Astronomical Observatory of the National Academy of Sciences of Ukraine. LUN City Air, a private sector project, helped install sensors in other cities to provide more spatial coverage for the monitoring network. This cross-sectional cooperation gives people a clear picture of the air they breathe.



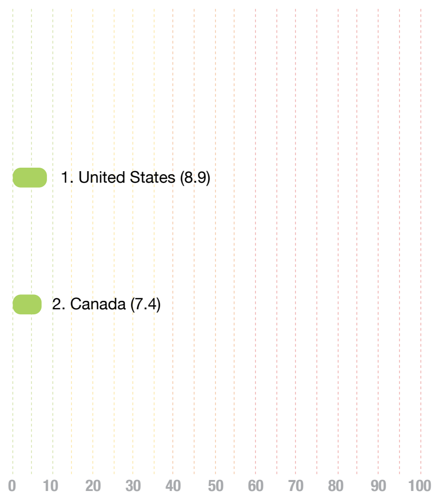
Annual hours spent at different PM2.5 pollution levels

NORTHERN AMERICA

United States | Canada



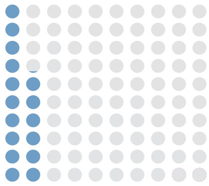
City markers indicating 2022 PM2.5 levels, size adjusted for population

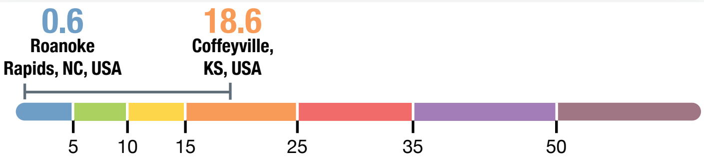


2022 PM2.5 average (µg/m³)

16.1%

Regional cities that met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities*

Rank	City	2022
1	Coffeyville, KS, USA	18.6
2	Baldwin Park, CA, USA	17.8
3	Hughson, CA, USA	17.0
4	Tulare, CA, USA	16.9
5	Claymont, DE, USA	16.4
6	Paramount, CA, USA	16.3
7	Visalia, CA, USA	16.2
8	Forest Park, GA, USA	15.5
9	Lewiston, ME, USA	15.5
10	Cutler, CA, USA	15.3
11	Ontario, CA, USA	15.1
12	Enterprise, OR, USA	15.0
13	Exeter, CA, USA	14.8
14	Hanford, CA, USA	14.8
15	Parlier, CA, USA	14.7

*For the region of Northern America, only cities with populations >5,000 are ranked here

Least Polluted Regional Cities

Rank	City	2022
1	Roanoke Rapids, NC, USA	0.6
2	Castroville, CA, USA	0.8
3	Utqiagvik, AK, USA	1.0
4	Jeffersontown, KY, USA	1.0
5	Shorewood, MN, USA	1.0
6	Terryville, NY, USA	1.0
7	Rio Del Mar, CA, USA	1.1
8	Ossining, NY, USA	1.1
9	Williams, CA, USA	1.2
10	Ayer, MA, USA	1.3
11	Sierra Vista, AZ, USA	1.5
12	Wailea, HI, USA	1.5
13	Parker, CO, USA	1.6
14	Sedona, AZ, USA	1.7
15	Durango, CO, USA	1.7

SUMMARY

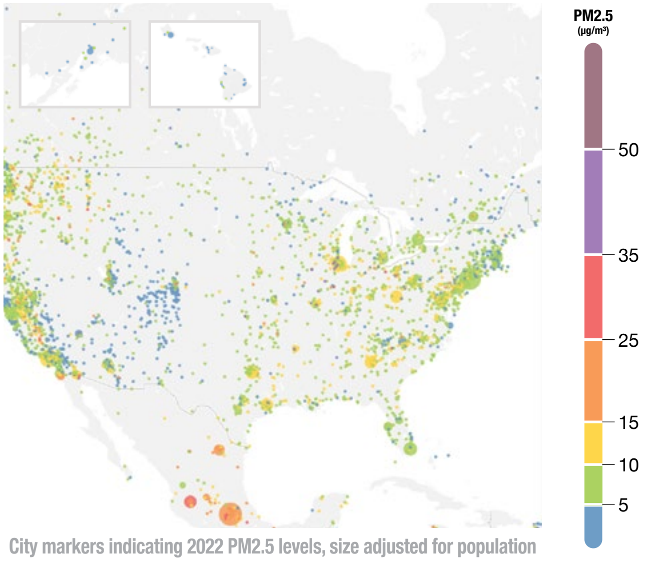
The Northern America region is populated by two countries: the United States and Canada. Both countries showed reduction in their overall annual average PM2.5 concentration this year, each improving by 13-14 percent. The United States lowered its annual average PM2.5 concentration to 8.9 µg/m³, while Canada dropped its annual average to 7.4 µg/m³. These improvements in PM2.5 concentration coincide with the Paris Agreement emissions reduction goals as well as individual actions from each country. Neither of the two countries improved enough to satisfy the WHO annual PM2.5 guideline, but continued investment in renewable energy, sustainable development, and responsible practices can reduce PM2.5 emissions in the future.

16.1 percent of cities in the Northern America region met the WHO PM2.5 concentrations guidelines in 2022, despite a record-breaking number of wildfires. The United States, along with Canadian provinces like British Columbia and Alberta, experienced numerous wildfires in 2022.[59] In spite of recent emissions reduction plan updates for both countries, year-round wildfire occurrence increases PM2.5 concentrations. Annual premature deaths blamed on anthropogenic PM2.5 particulates are estimated at 200,000 in the United States and nearly 15,000 in Canada.

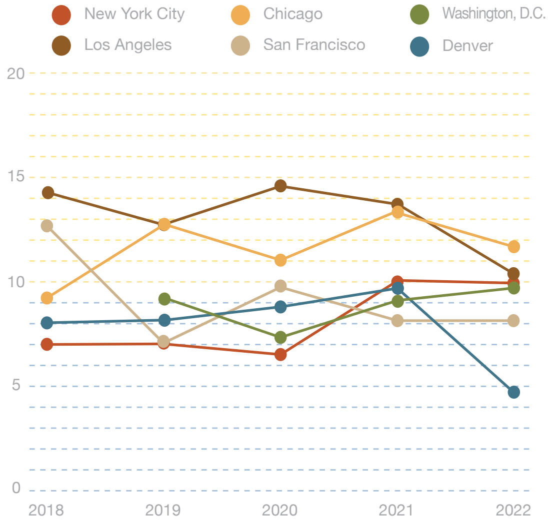
MONITORING STATUS

In Northern America, there is a structured monitoring network comprised of government monitors and non-government operated sensors. In 2022, 3,198 cities in the region provided adequate air quality information for inclusion in this report. 2,143 of these cities reported data from only non-government operated monitors, and 477 reported data from only government stations that provide publicly available air quality information. Roughly 400 more cities in the Northern America region are represented in this year's report compared to 2021.

UNITED STATES



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (μg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Washington, D.C.	9.8	10.0	9.1	7.8	5.5	8.5	11.0	14.2	10.6	8.6	9.3	10.5	12.9	9.1
New York City	9.9	12.4	10.2	10.4	5.7	10.2	9.5	13.6	11.0	7.4	8.5	9.5	10.8	10.0
Los Angeles	10.5	11.5	6.0	7.4	8.6	12.3	14.7	12.2	10.6	10.0	15.1	8.0	9.3	13.7
Chicago	11.8	13.5	14.9	11.5	9.5	11.3	9.5	12.6	10.8	9.1	10.7	13.7	14.7	13.4
San Francisco	8.1	15.1	10.3	4.3	5.3	5.2	5.4	3.7	6.7	9.3	9.2	9.2	13.9	8.2
Denver	4.9	7.3	5.9	4.0	2.8	3.6	3.8	4.4	4.2	6.7	5.9	4.8	5.4	9.8

PROGRESS

In 2022, air quality in the United States improved significantly relative to 2021. A major contributing factor to this year's improvements was a relatively mild wildfire season. 15.7 percent of the cities included in this year's report achieved annual average PM2.5 concentrations meeting the WHO annual PM2.5 guideline. In 2022, nine out of ten most populous cities in the United States showed improvements in annual PM2.5 concentrations compared to 2021. Miami, FL observed a 14 percent increase in PM2.5 concentrations. Monthly average PM2.5 concentrations for multiple cities in Arizona, Colorado, California, Idaho, Oregon, New Mexico, Texas, and Washington peaked with the wildfire occurrence throughout the year.

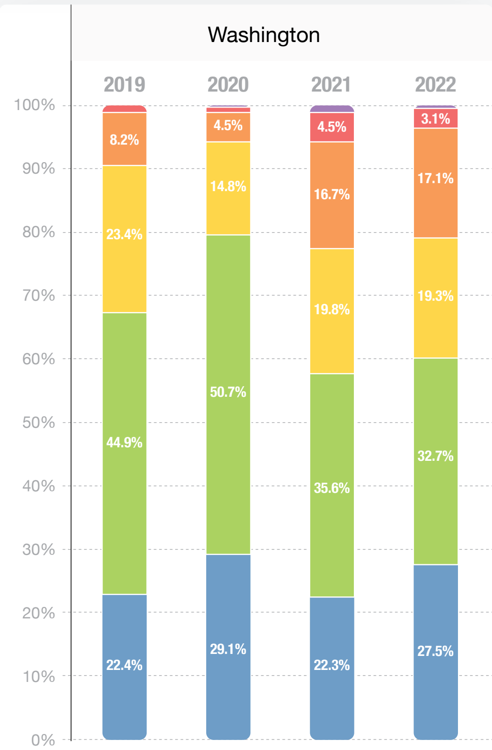
CHALLENGES

Wildfires in the United States are becoming a year-round challenge. Increasing emissions from wildfires in recent years are quickly erasing air quality improvements gained over the past decade.[60] Research studies[61] observe improvements in particulate matter air quality in the United States over the past decade except in wild-fire prone areas like the Pacific Northwest region.

In 2022, the most polluted city in U.S. was Coffeyville, KS with an annual PM2.5 concentrations ranging between 18-20 μg/m³. Environmental justice, especially for clean air, has been a historical challenge in United States. In 2022, the U.S. EPA announced multiple clean energy infrastructure and air quality monitoring investments would be funded by the Inflation Reduction Act and American Rescue Plan aimed at reducing the harmful environmental impacts on communities in close proximity of industry and transportation corridors.

HIGHLIGHT: RECONSIDERATION OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER (PM)

The U.S. EPA announced[62] its proposed decision to lower the primary (health-based) annual PM2.5 standard from its current level of 12.0 μg/m³ and is considering a revised level ranging between 9 to 10 μg/m³. By 2032 EPA projects that 18 counties will not meet the current standard. A reduction of the standard to 9 μg/m³ is projected to result in this number nearly tripling to 51 counties unable to reach attainment. While there is an ongoing debate on the adequacy of the proposed standard[63], and a potential change as low as 8.0 μg/m³, more emission reductions will be needed in many areas of the country to meet the new proposed standard.



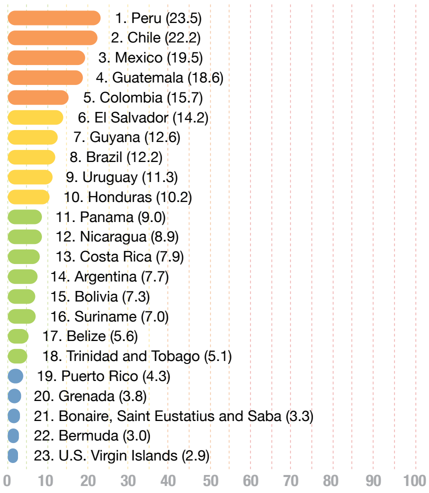
Annual hours spent at different PM2.5 pollution levels

LATIN AMERICA & CARIBBEAN

Argentina | Belize | Bermuda | Bolivia | Bonaire, Saint Eustatius, and Saba | Brazil | Chile | Colombia | Costa Rica | El Salvador | Grenada | Guatemala | Guyana | Honduras | México | Nicaragua | Panama | Perú | Puerto Rico | Suriname | Trinidad and Tobago | U.S. Virgin Islands | Uruguay

City markers indicating 2022 PM2.5 levels, size adjusted for population

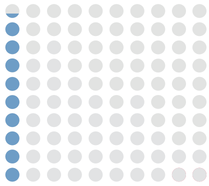
Country/Region Ranking

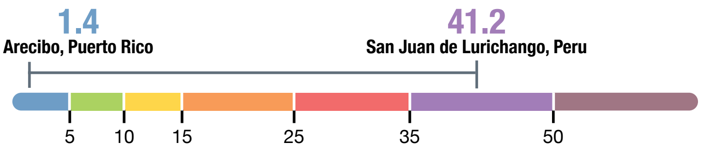


2022 PM2.5 average (µg/m³)

9.3%

Regional cities that met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (µg/m³) across regional cities

SUMMARY

Vehicle emissions, power generation, wildfires, landfills, and industrial operations continue to be major air pollution sources in the Latin America & Caribbean region. Commitments to cleaner air and the environment can reduce pollutants and protect the region's citizens. Countries are already shifting towards a healthier future by investing in renewable energy, engaging in environmental protection regulations, and supporting citizen knowledge and safety.

Of the 15 countries that passed data inclusion criteria in both 2021 and 2022, average annual PM2.5 concentrations improved in 12 µg/m³. Peru, the region's most polluted country, experienced the largest net improvement by decreasing its annual average PM2.5 concentration by 6.1 µg/m³, a 21% decrease, down to 23.5 µg/m³. By percentage, the Caribbean Netherlands (Bonaire, Saint Eustatius, and Saba) had the greatest positive change, with a 35% decrease in PM2.5 concentration bringing the annual average to 3.3 µg/m³. Conversely, PM2.5 concentrations in Colombia rose 10% reaching an annual average of 15.5 µg/m³. The U.S. Virgin Islands remains the region's least polluted country.

In 2022, four countries achieved the WHO PM2.5 annual guideline, compared to just two in 2021. 9.7% of qualified cities in the region achieved the WHO guideline of 5 µg/m³, up from 6.9% in the previous year. This improvement in air quality has positive implications for the lives of millions, with decreased concentrations of airborne particulate matter reducing health risks related to ambient air pollution.

MONITORING STATUS

Air quality monitoring in the Latin America & Caribbean region grew significantly from 2021 to 2022, with a net gain of 53 cities contributing to a total of 227 cities across 24 countries. This expansion of air quality monitoring provides insight into underrepresented areas whose air quality can now be observed on a global scale. Countries represented for the first time in the World Air Quality Report include Belize, Bermuda, Bolivia, El Salvador, Guyana, Nicaragua, Panama, and Suriname.

The support from contributors like the Aires Nuevos project has strengthened air quality information in Latin America and the Caribbean, emphasizing the importance of community engagement. The Aires Nuevos network of monitors contributed data from 8 countries, with coverage of 42 local governments and 14 universities using 115 low-cost air quality monitors from IQAir.

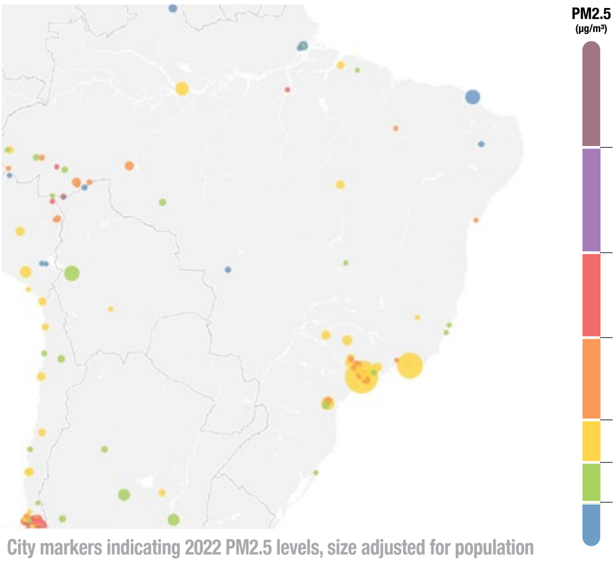
Most Polluted Regional Cities

Rank	City	2022
1	San Juan de Lurigancho, Peru	41.2
2	Vitarte, Peru	40.0
3	Quilpue, Chile	39.1
4	Santa Anita, Peru	38.8
5	Coyhaique, Chile	37.7
6	Carabayllo, Peru	37.6
7	Metepec, Mexico	36.1
8	Villa Maria del Triunfo, Peru	35.0
9	Padre las Casas, Chile	33.8
10	Villa Alemana, Chile	33.0
11	Traiguen, Chile	30.1
12	Llaillay, Chile	29.0
13	Xonacatlan, Mexico	28.5
14	El Bosque, Chile	28.3
15	Providencia, Chile	28.2

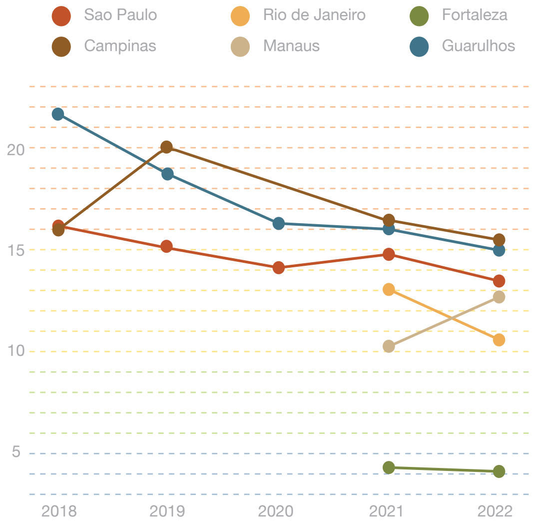
Least Polluted Regional Cities

Rank	City	2022
1	Arecibo, Puerto Rico	1.4
2	Caguas, Puerto Rico	2.4
3	San Jose del Cabo, Mexico	2.5
4	Cruz Bay, U.S. Virgin Islands	2.7
5	San German, Puerto Rico	2.8
6	Camuy, Puerto Rico	2.9
7	Hamilton, Bermuda	3.0
8	Charlotte Amalie, U.S. Virgin islands	3.0
9	The Bottom, Bonaire, Saint Eustatius and Saba	3.3
10	Guayanilla, Puerto Rico	3.3
11	San Juan, Puerto Rico	3.3
12	Saint George's, Grenada	3.8
13	Pianco, Brazil	4.0
14	Punta Arenas, Chile	4.0
15	Fortelaza, Brazil	4.1

BRAZIL



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Sao Paulo du Campo	13.5	10.7	12.1	11.8	12.3	14.7	17.0	21.8	15.7	13.8	13.1	8.9	9.7	15.2
Rio de Janeiro	10.6	8.4	7.6	11.3	9.1	11.1	15.6	17.4	11.4	11.4	10.8	6.6	6.5	13.0
Fortaleza	4.1	5.9	6.8	3.0	2.3	2.5	2.8	2.6	4.5	6.1	6.6	2.4	4.2	4.3
Campinas	15.5	11.8	12.7	No Data	17.3	17.2	19.4	22.8	19.6	16.5	14.4	10.8	9.6	16.4
Manaus	12.7	6.6	4.6	3.6	5.0	6.5	6.8	11.3	24.5	30.2	23.1	15.3	7.8	10.3
Guarulhos	15.0	10.7	12.6	12.2	14.3	17.1	19.5	25.3	16.8	15.5	14.1	11.1	10.3	16.1

PROGRESS

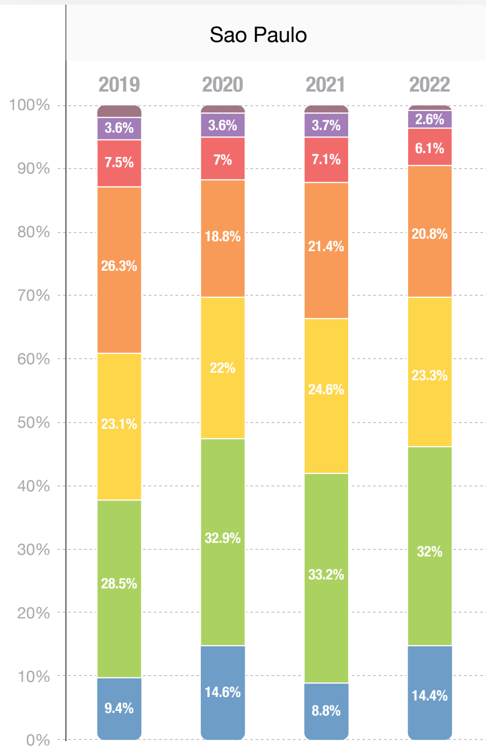
Brazil continued its trend in reducing annual average PM2.5 concentrations, dropping to 12.2 $\mu g/m^3$ in 2022 from 13.6 $\mu g/m^3$ in 2021 and 14.2 $\mu g/m^3$ in 2020. Rio de Janeiro, Brazil's most populous city, experienced an 18.5 percent decrease in average PM2.5 concentration to 10.6 $\mu g/m^3$. Amazon wildfires in September caused a massive spike in PM2.5, with six cities in the states of Rondonia and Acre recording PM2.5 concentrations exceeding 60 $\mu g/m^3$.[64] Four cities maintained annual average PM2.5 concentrations below the WHO guidelines limits in 2022, up from just two in 2021.

CHALLENGES

Illegal deforestation and burning are still issues for Brazil as the country remains a global leader in wood charcoal production.[65,66] Brazil's charcoal is largely produced from native Amazonian wood and non-native eucalyptus harvested for its fast growth. Wood is heated in a low oxygen environment, producing carbon-rich charcoal, ash, and airborne pollutants like methane and carbon dioxide. Workers in the wood charcoal industry experience health risks related to their extreme exposure to PM2.5 and CO2.[67]

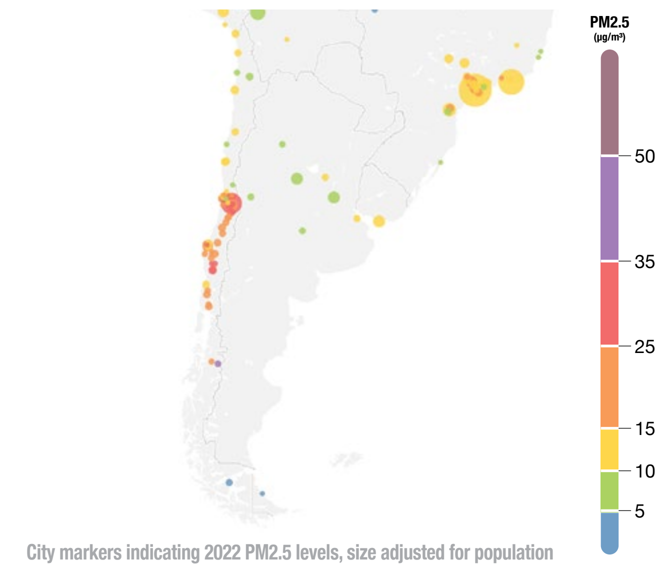
HIGHLIGHT: DEFORESTATION

Luiz Inácio "Lula" da Silva became the 39th President of Brazil in January 2023 after winning the general election in October.[68] At COP 27, Lula reinforced his commitment to the environment and climate security, announcing goals to stop deforestation of the Amazon rainforest, halt illegal gold mining, and restore climate-critical ecosystems.[69] This commitment follows sharp increases in Amazon rainforest deforestation during the previous administration.[70] Preservation of the Amazon can lead to human health benefits through increased carbon sequestration from the forest and reduced carbon emissions from logging and burning.

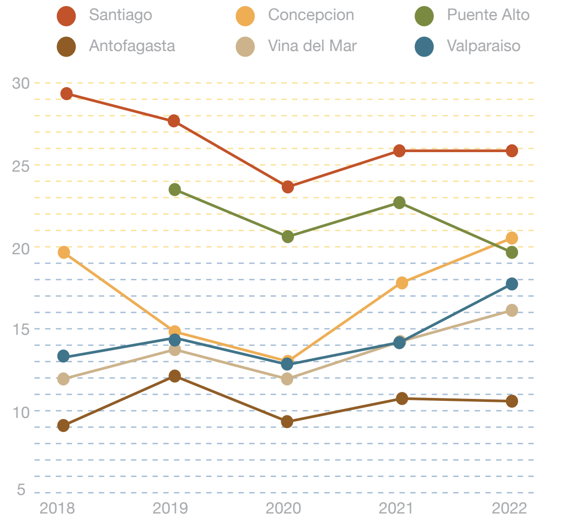


Annual hours spent at different PM2.5 pollution levels

CHILE



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Santiago	25.8	9.1	13.0	16.1	23.3	56.4	50.8	37.3	41.6	25.2	12.7	11.4	12.4	25.8
Concepcion	20.6	5.8	11.7	10.4	19.4	46.4	37.0	32.0	34.8	23.1	9.5	8.0	8.0	17.7
Puente Alto	19.7	8.8	13.0	12.6	18.4	39.4	35.9	27.7	30.4	18.5	10.3	10.6	11.0	22.7
Antofagasta	10.6	6.2	8.0	9.5	11.3	14.3	13.0	14.1	14.5	12.3	9.2	7.2	7.7	10.7
Vina del Mar	16.2	9.0	11.7	14.8	19.1	33.6	23.6	14.4	19.6	15.1	9.5	10.9	11.4	14.3
Valparaiso	17.7	7.1	11.5	15.4	15.6	41.6	30.8	19.9	26.0	16.1	9.3	8.4	9.7	14.2

PROGRESS

Chile's air pollution worsened slightly in 2022, increasing annual PM2.5 concentration just 2 percent to 22.2 µg/m³. The country is home to eight of the top 15 most polluted cities in the region. City-based PM2.5 concentrations are exacerbated by the dry season from May through November, with one city exceeding the PM2.5 concentration of 100 µg/m³ in June. Air pollutant concentrations in this range are dangerous for all citizens and outdoor areas should be avoided to reduce exposure. Punta Arenas was the only city whose annual average PM2.5 concentration fell below WHO PM2.5 guidelines.

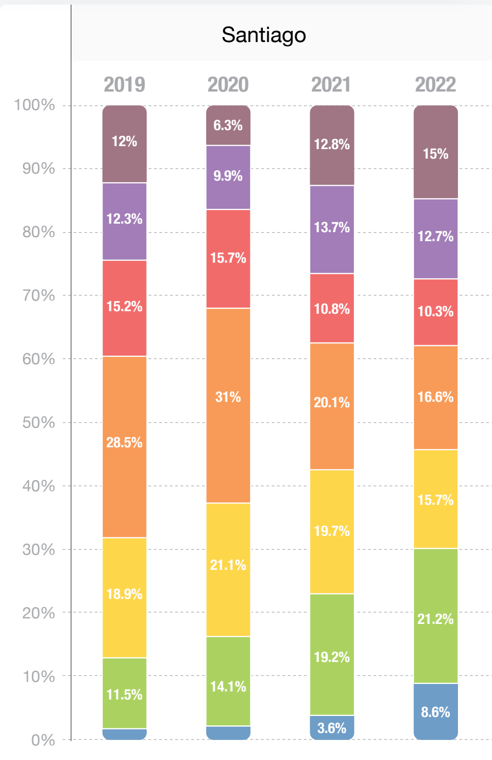
CHALLENGES

Chileans near Valparaiso experience increased health-related risks from the high concentrations of airborne pollutants emitted by mining, gas, oil, cement, and chemical companies that operate in the region. Codelco, Chile's state-owned mining firm, agreed to close their copper smelter and refinery in the Valparaiso province following the hospitalizations of over 100 residents, including children. Codelco had already spent over $150 million in efforts to reduce emissions, but outdated technology at the smelter led to difficulties that eventually resulted in the closure.

Chile's topography also contributes to increased air pollution risks, as the Andes Mountains and the smaller Chilean Coast Range can create bowl-like conditions in the country's valleys.[71] The Andes Mountains are the longest continental mountain range in the world and the highest outside of Asia. The effects of Chile's geography are exacerbated in the winter months when cool, dense coastal fog traps air near the earth's surface. Much of Chile experienced its highest average PM2.5 concentrations in May and June, with 29 percent of cities included in the report reaching PM2.5 concentrations above 50 µg/m³ during these months. With little atmospheric circulation during this time, air pollution and its associated health risks are magnified.

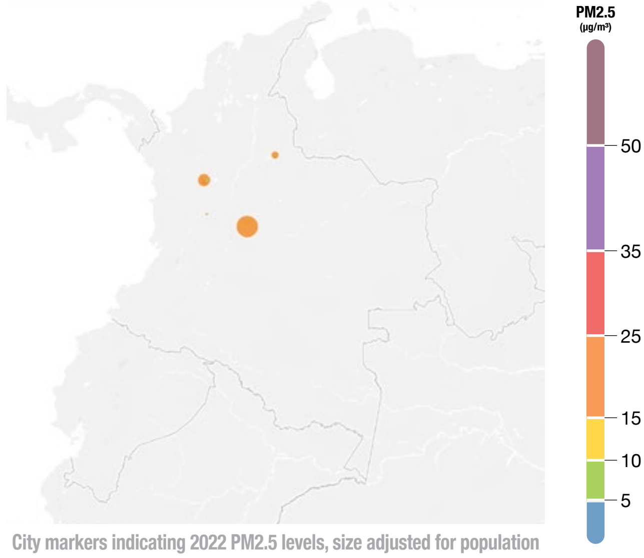
HIGHLIGHT: AIR QUALITY SCIENCE EDUCATION IN CHILE'S NATIONAL CURRICULUM

In addition to providing air quality sensor data, Aires Nuevos empowers citizen scientists in the Chilean community. Aires Nuevos uses low-cost sensors to host technical workshops, teach data analysis, and spread environmental knowledge. These efforts have contributed to new material in a citizen science book for Chile's national curriculum, exposing students to air quality information and scientific analysis for the first time.

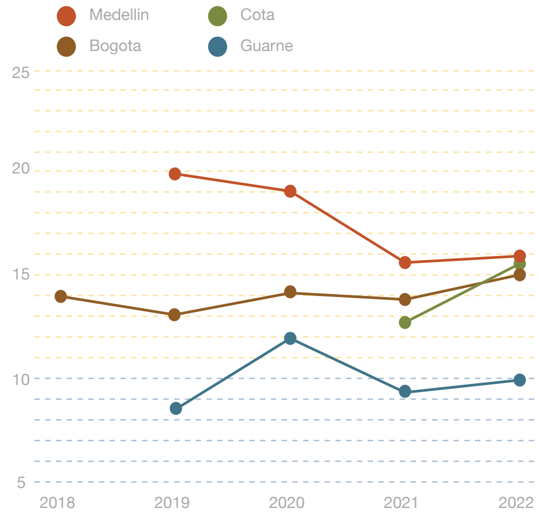


Annual hours spent at different PM2.5 pollution levels

COLOMBIA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 5 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Bogota	15.1	16.9	21.1	18.2	14.9	10.5	12.4	8.2	11.6	16.6	14.9	16.9	19.1	13.7
Cota	15.5	16.5	20.0	18.3	15.4	10.6	12.3	10.6	13.0	17.5	15.6	15.6	17.8	12.8
Guarne	9.8	10.9	14.1	13.6	9.3	6.8	7.0	6.6	9.2	9.2	No Data			9.4
Medellin	15.9	17.8	22.8	20.4	14.7	13.7	14.3	12.1	14.9	16.8	14.0	13.2	17.2	15.6

PROGRESS

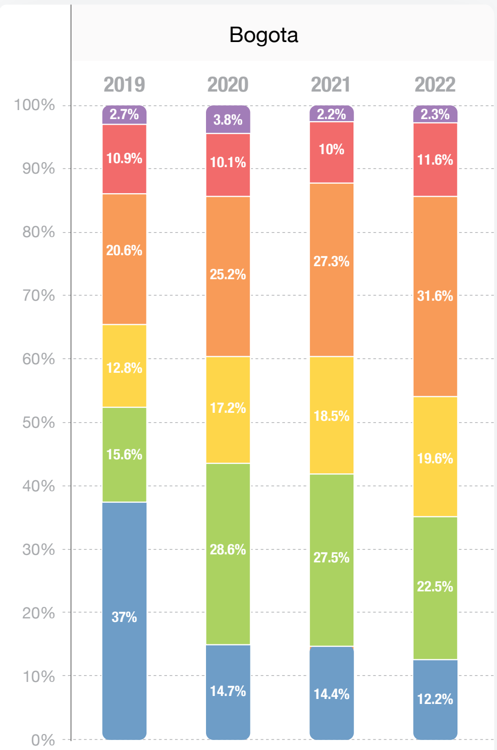
The national annual average in Colombia rose this year to 15.5 µg/m³, up from 14.1 µg/m³ in 2021. This increase was in part due to the significant increase in forest fires in the Colombian Amazon during the dry season of 2022. The PM2.5 suspended in the air from the fires can travel long distances and pollute the air of major cities such as Bogotá or Medellín. In January 2022, nearly 30 times more wildfires were reported compared to the same month in 2021.[72] While data from the rainy season months of 2022 recorded lower PM2.5 concentrations relative to 2021, the poor air quality experienced during the dry season offset all gains incurred during the rainy season resulting in increased overall annual averages in 2022.

CHALLENGES

Air pollution threats in rural and urban areas come from different sources. Pollution in large cities results mostly from mobile emission sources such as road transportation and private vehicles. Rural pollution in Colombia often comes from solid fuel use for cooking and heat.[73] This is amplified by the geographical conditions in mountainous regions that are subject to atmospheric temperature inversions.[74] Forest fires were particularly bad in Columbia during 2022. In February, fires near Bogota triggered an environmental warning from the mayor due to the high concentration of fire-generated smog and particulate matter that wafted into the city.[75]

HIGHLIGHT: POWER GRID COMPOSITION

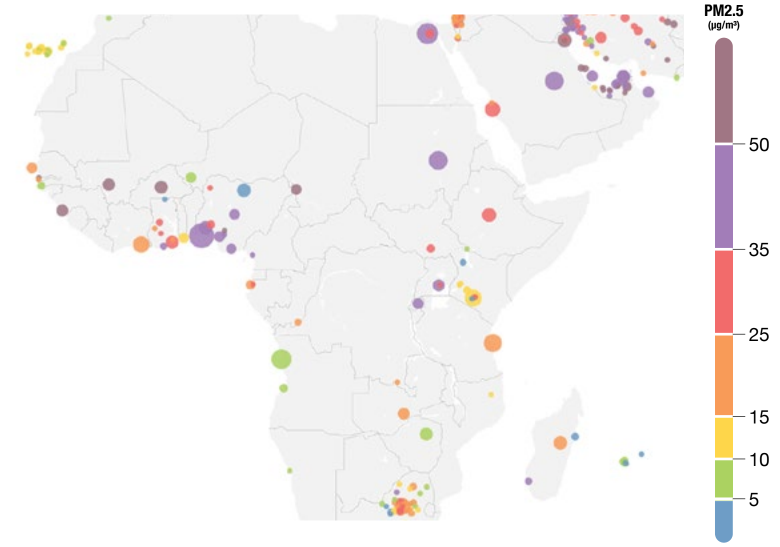
Colombia continues to create policy shifting away from fossil fuels and investing more in wind and solar. Although there is a strong policy for the energy transition, clear and viable projects must be planned for this transition to become a reality. They have historically used hydro-electric power to supply their energy demands but want to bolster the grid's stability by awarding contracts for new wind farms off their coast.[76] Combining this with the country's announcement at COP 27 to reduce methane extraction can help slow the energy demands for fossil fuel production and combustion, as well as combat climate change which is known to exacerbate wildfire-prone conditions during the dry season.[77]



Annual hours spent at different PM2.5 pollution levels

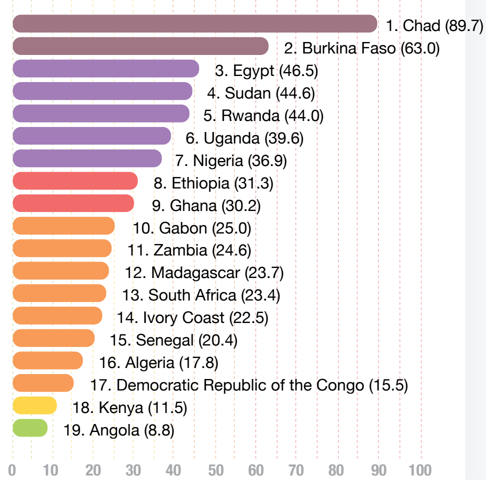
AFRICA

Algeria | Angola | Burkina Faso | Chad | Democratic Republic of the Congo | Egypt | Ethiopia | Gabon | Ghana | Ivory Coast | Kenya | Madagascar | Nigeria | Rwanda | Senegal | South Africa | Sudan | Uganda | Zambia



City markers indicating 2022 PM2.5 levels, size adjusted for population

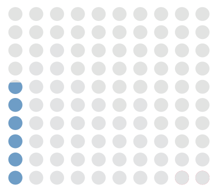
Country/Region Ranking

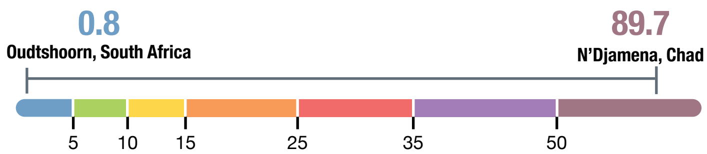


2022 PM2.5 average (µg/m³)

5.8%

Regional cities that met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	N'Djamena, Chad	89.7
2	Oagadougou, Burkina Faso	63.0
3	Cairo, Egypt	47.4
4	Abuja, Nigeria	46.5
5	Khartoum, Sudan	44.6
6	Kigali, Rwanda	44.0
7	Thabazimbi, South Africa	42.2
8	Kampala, Uganda	39.6
9	Benin City, Nigeria	38.1
10	Lagos, Nigeria	36.1
11	Kintampo, Ghana	32.9
12	Osogbo, Nigeria	32.8
13	Ekurhuleni, South Africa	32.0
14	Addis Ababa, Ethiopia	31.3
15	Accra, Ghana	30.1

Least Polluted Regional Cities

Rank	City	2022
1	Oudtshoorn, South Africa	0.8
2	Grabouw, South Africa	2.6
3	Nieuwoudtville, South Africa	3.4
4	Knysna, South Africa	5.2
5	Cape Town, South Africa	6.7
6	Luanda, Angola	8.8
7	Port Elizabeth, South Africa	9.3
8	Hendrina, South Africa	9.7
9	Pumwani, Kenya	10.9
10	Mokopane, South Africa	11.1
11	Nairobi, Kenya	11.5
12	KwaMbonambi, South Africa	12.2
13	Bethlehem, South Africa	13.7
14	Secunda, South Africa	14.4
15	Howick, South Africa	15.4

SUMMARY

Limited availability of air quality data in Africa is still the most important issue in tackling air pollution.[9] Based on NASA satellite data, 70 percent of the world's wildfires take place in Africa. Most of these fires burn through grasslands and generate a large amount of ambient PM2.5.

Six new cities have been added in Africa this year, bringing the regional city total to 52 cities. Two of the new cities are Ouagadougou, Burkina Faso and Cairo, Egypt that recorded annual PM2.5 concentrations of 63.0 and 47.4 µg/m³, respectively. N'Djamena, the capital of Chad, ranked number one as the most polluted regional city with an annual average PM2.5 concentration of 89.7 µg/m³, a 12 percent increase from 2021. The 10 most populous cities in Africa each experienced PM2.5 levels exceeding the WHO guideline level of 5 µg/m³. Excluding N'Djamena and Ouagadougou, the annual average PM2.5 concentration in capital cities of Africa ranged from 6 to 46 µg/m³. Such huge variation in the concentration levels requires more attention and investment on monitoring and source/area-specific reduction plan development.

MONITORING STATUS

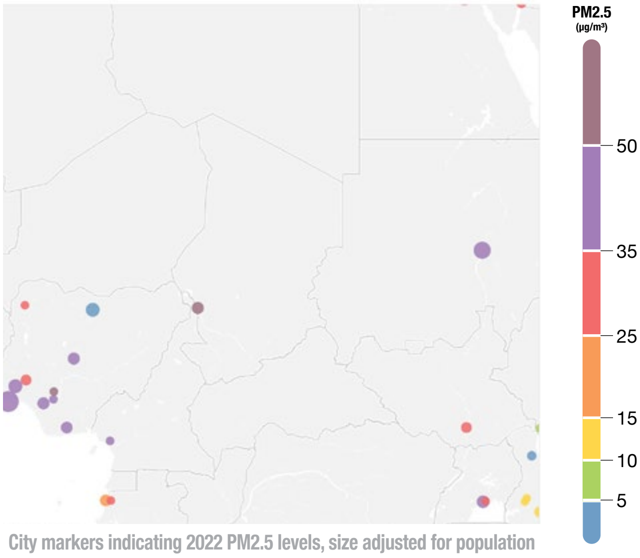
Reliable and accessible air quality data in Africa remains sparse. Most African countries lack air quality monitoring data, leaving most people on the continent without the information necessary to make important health decisions.

This report includes PM2.5 data from 52 cities and 156 stations in the region, where roughly 70 percent of the population is living. Seven new countries are included in Africa that provide public data via both government and non-government networks. These new monitoring stations are deployed in cities where roughly 93 million people reside.[9]

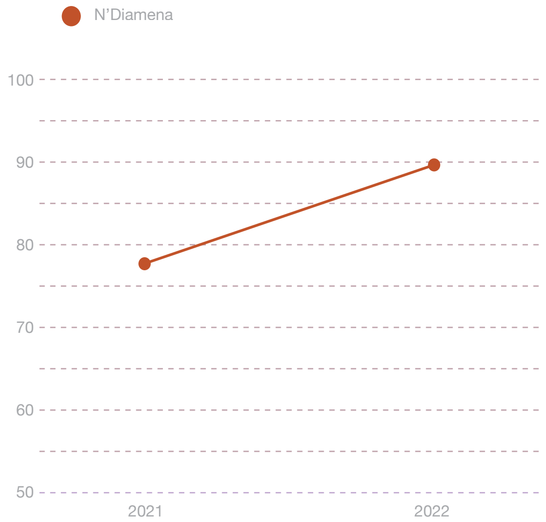
Several governments are already investing in resources to expand air quality monitoring and beginning to implement air quality management plans. Furthermore, independently funded initiatives, including Africa Qualité de L'air (AfriqAir), AirQo, and Clean Air Monitoring and Solutions Network (CAMS-Net), are also attempting to fill the data gap using both reference-grade and low-cost air quality sensors. There are also project-driven monitoring stations in some African countries (e.g., PM2.5 monitors in Ethiopia, Kenya, Rwanda, and Uganda as part of the Eastern Africa GEOHealth Hub).

Most African countries in this report relied on monitoring stations operated by the U.S. State Department, individuals, and non-governmental organizations. Almost half of the stations in this region are non-government-operated monitors. There is huge potential to provide more non-government air quality stations in this sparsely monitored region of the world.

CHAD



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (μg/m³) over 2 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
N'Djamena	89.7	162.3	163.7	245.6	103.7	74.2	36.6	21.2	21.8	22.1	49.7	59.9	132.4	77.6

PROGRESS

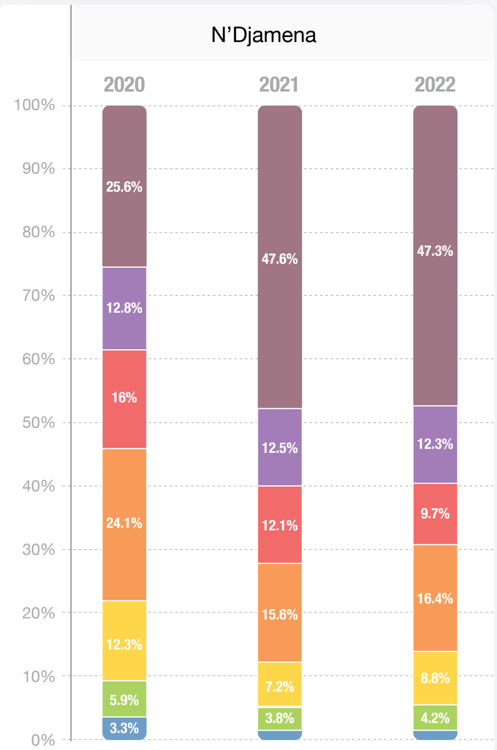
Air quality in Chad worsened in 2022 as PM2.5 concentrations increased to 89.7 μg/m³, an 18 percent increase from 75.9 μg/m³ in 2021. While the monthly average PM2.5 concentrations from June to December are relatively similar to the previous year, the country experienced increases during January and March. PM2.5 concentrations increased 75 percent in January, going from 93 μg/m³ to 162.3 μg/m³, and increased 53 percent in March, increasing from 160 μg/m³ to 245.6 μg/m³. These dramatic increases can be partially attributed to massive dust storms from the Sahara Desert during these months.[78]

CHALLENGES

Chad is often buffeted by dust storms which contribute to higher PM2.5 concentrations in the country. A key contributor to the dust storms in the country is the largest source of dust emissions in the world: the Bodélé Depression.[79] Exposure to these increased levels of dust can pose many threats to human health, including decreased lung function and pregnancy complications.[80] Exposure to particulate matter has been linked to 400,000 preventable infant deaths per year in Sub-Saharah Africa; this accounts for up to 40 percent of the total number of infants deaths in the region.[81] An additional factor of Chad's air quality is the use of biomass fuels and traditional stoves for cooking.[82] Combustion of these fuels can cause immediately harmful levels of indoor air pollution that can spread outside into surrounding communities.[83]

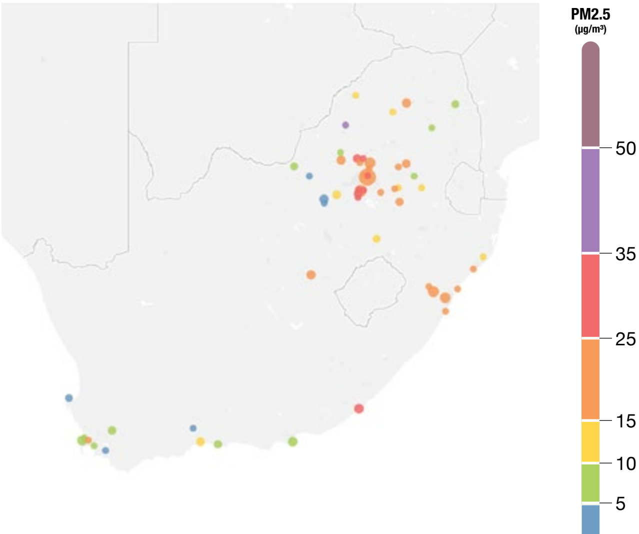
HIGHLIGHT: DATA GAPS IN AFRICA

Real-time publicly accessible data in Chad is provided by a single government operated, air monitoring station in the N'Djamena. Chad's status as one of the most polluted countries in the world underlines the lack of comprehensive air quality monitoring in Africa. A sustainable and informative network is integral to report air quality data and its implications for citizens living in underrepresented areas. Air quality issues in the region have been known to pose human health risks for years, with governments and citizen-led organizations needed as leaders in organizing and maintaining a more robust collection of sensors. Real-time monitoring stations can inform citizens of incoming dust storms and other air quality phenomena so people can better prepare and protect themselves. Increased monitoring could also allow people to see the air quality in the places where they work or where their children play. Chad, along with other countries in the region, may be the next frontier for global air quality equity. The full extent of air quality issues in this region may remain unclear until larger networks of air monitoring stations are developed.

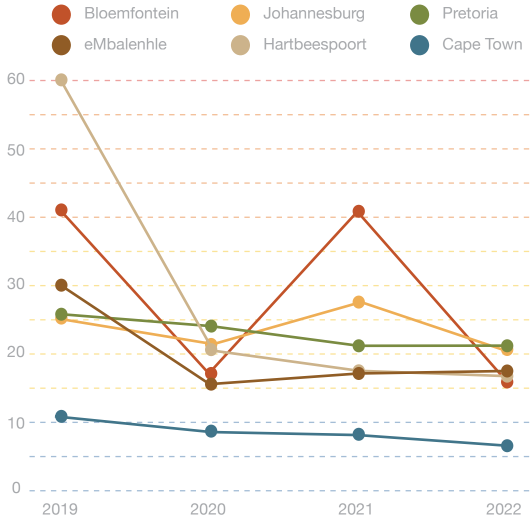


Annual hours spent at different PM2.5 pollution levels

SOUTH AFRICA



City markers indicating 2022 PM2.5 levels, size adjusted for population



PM2.5 annual average (µg/m³) over 4 years

City	2022	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2021
Cape Town	6.7	6.9	7.9	6.4	5.8	9.1	12.5	8.6	7.3	6.3	4.0	2.9	2.8	7.6
Bloemfontein	16.2	8.8	11.2	10.3	11.6	21.0	22.3	23.2	18.8	24.4	24.0	10.4	9.3	42.2
eMbalenhle	17.4	10.4	8.7	15.1	12.2	20.6	24.7	29.2	22.2	22.4	22.4	9.8	10.1	17.1
Hartbeespoort	16.3	8.1	10.4	8.7	8.6	19.4	27.7	25.1	23.0	24.5	20.0	10.3	9.4	17.0
Johannesburg	21.7	12.4	16.4	17.2	14.4	25.5	27.5	31.8	26.7	31.7	28.1	15.9	13.4	27.3
Pretoria	21.7	10.1	14.8	16.5	13.1	27.4	24.5	32.1	30.1	31.9	29.0	15.5	12.0	21.6

PROGRESS

South Africa's constitution guarantees a clean environment free of pollution: a right enshrined within the country's Bill of Rights. But poor air quality in many cities means that right remains unrealized for far too many South Africans.

Air quality in most of South African cities showed continued improvement in 2022, building on previous improvements in air quality measured in 2021. The country's overall PM2.5 concentrations showed a slight increase from 22.7 µg/m³ in 2020 to 23.4 µg/m³ in 2022.

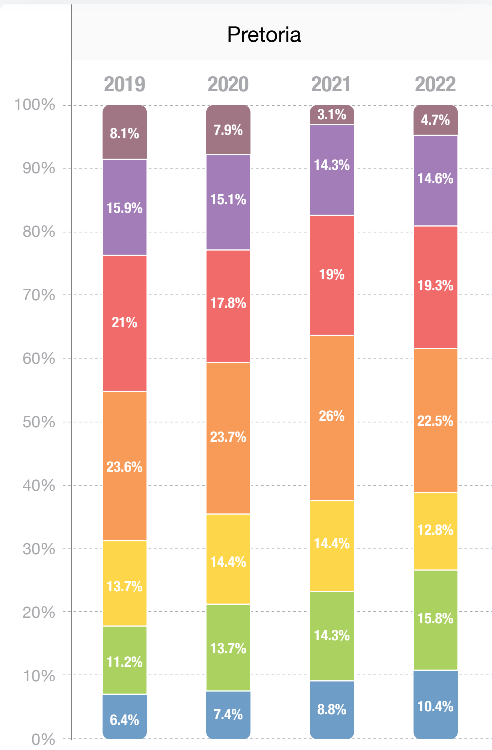
This year, Nieuwoudtville in the Northern Cape province recorded an average PM2.5 concentration that met the WHO recommended air quality guidelines. In Cape Town, the annual PM2.5 concentration dropped to 6.7 µg/m³ with a 12% decrease in comparison to 2021 and closer to achieving the 5 µg/m³ guideline level. Thabazimbi, which experienced several fire breakouts and a shortage of operational firefighting in 2022[84] observed annual PM2.5 levels around 42.2 µg/m³, a 50% increase in comparison to 2021. All the other cities included in the report from South Africa are meeting the interim WHO guideline target of 35 µg/m³ in 2022.

CHALLENGES

Air pollution in South Africa is driven by a variety of factors that compound as the country develops and the population increases. Transportation, energy generation and consumption, and industrial growth each feed into the country's outdoor air quality, while the burning of waste and the use of solid cooking fuels contributes to indoor air pollution.[85] South Africans living especially close to the country's coal-fired power plants are exposed to higher levels of SO2, CO2, NOx, and particulate matter, and are more susceptible to experiencing negative health impacts related to air pollution. Air pollution monitoring and efforts to reduce pollutants at the source will continue to be important in risk reduction.

HIGHLIGHT: CONSTITUTIONAL CLEAN AIR

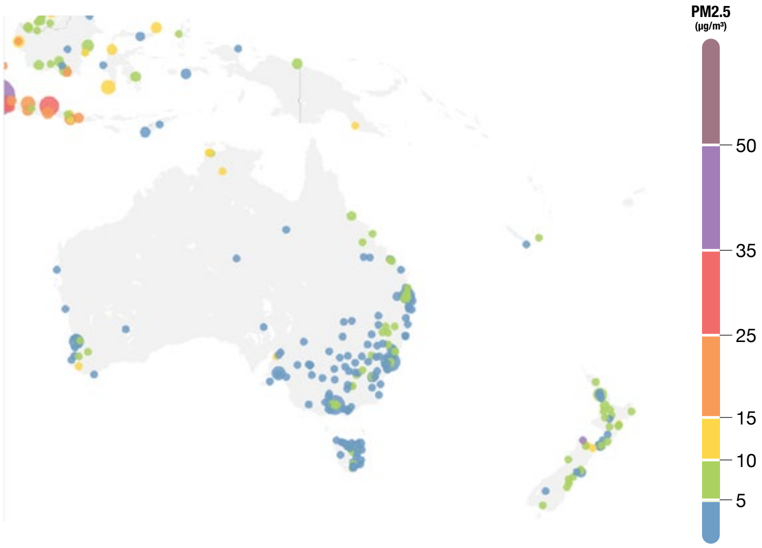
In March 2022, South Africa's Pretoria High Court ruled on a case brought against the government by two environmental justice groups regarding poor ambient air quality in the Highveld Priority Area.[86] The province of Mpumalanga accounts for more than 80% of the country's coal production, a significant contributor to regional air pollution. The Mpumalanga Highveld was recognized as a priority area in 2007 under the Air Quality Act. The environmental justice group advocating for the community argued that the air quality in the area violated the constitutional right to "an environment not harmful to their health or wellbeing", an argument which was upheld in the official court ruling. The South African government has been given one year to implement and enforce the previously established Highveld Plan under the Air Quality Act.[87]



Annual hours spent at different PM2.5 pollution levels

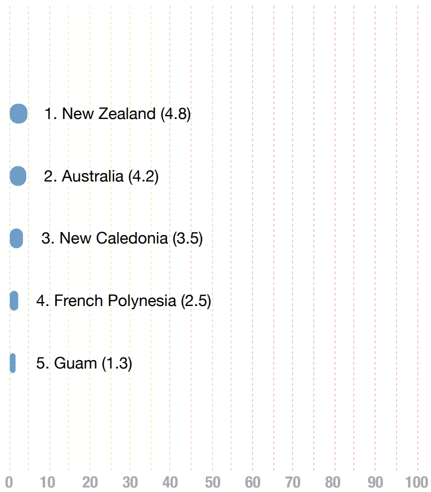
OCEANIA

Australia | French Polynesia | Guam | New Caledonia | New Zealand



City markers indicating 2022 PM2.5 levels, size adjusted for population

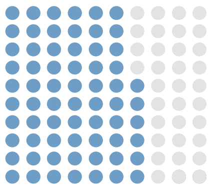
Country/Region Ranking

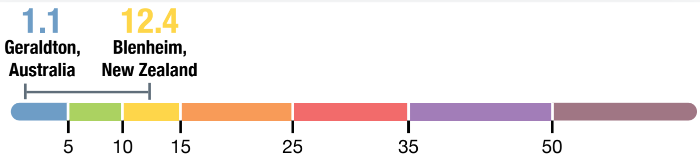


2022 PM2.5 average (µg/m³)

66%

Regional cities that met the WHO PM2.5 guideline in 2022





Range of 2022 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2022
1	Blenheim, New Zealand	12.4
2	Ludmilla, Australia	12.3
3	Nelson South, New Zealand	10.5
4	Richmond, New Zealand	10.0
5	Tokoroa, New Zealand	10.0
6	Collie, Australia	9.9
7	Greymouth, New Zealand	9.3
8	Taupo, New Zealand	9.1
9	Kaiapoi, New Zealand	9.0
10	Timaru, New Zealand	8.8
11	Otorohanga, New Zealand	8.7
12	Hastings, New Zealand	8.3
13	Masterton, New Zealand	8.3
14	New Norfolk, Australia	8.0
15	Manilla, Australia	7.8

Least Polluted Regional Cities

Rank	City	2022
1	Geraldton, Australia	1.1
2	Turangi, New Zealand	1.2
3	Tamuning, Guam	1.3
4	Broken Hill, Australia	1.5
5	Roxby Downs, Australia	1.5
6	Seville Grove, Australia	1.5
7	Carnarvon, Australia	1.6
8	Tailem Bend, Australia	1.7
9	Emu River, Australia	1.7
10	Mandurah, Australia	1.7
11	Brewarrina, Australia	1.8
12	Hillston, Australia	1.8
13	Renmark, Australia	1.8
14	St Helens, Australia	1.8
15	Griffith, Australia	1.9

SUMMARY

Oceania continues to have the cleanest overall air quality in the world. The capital cities of Canberra, Australia and Noumea, New Caledonia both decreased their pollution levels from last year and had annual average concentrations under the WHO guidelines at 2.8 µg/m³ and 3.5 µg/m³, respectively. Of the 202 cities included in this year's report, this region had both the highest number of cities below the WHO guidelines (133) and the highest percentage of cities below the guidelines with 65 percent. This is coupled with 155 cities reducing their annual average PM2.5 concentrations. The improvement to regional air quality is due to most cities having year-round, consistently low levels of pollution and the cities with higher PM2.5 concentrations showing spikes during the summer bushfire season. Bushfires are the primary threat to air quality in this area which are exacerbated by droughts and atmospheric conditions such as inversion layers.[88]

There is still progress to be made in the region. There are still 69 cities that show annual concentrations above the WHO guidelines. This represents millions of people who may be affected by adverse air quality conditions.

MONITORING STATUS

Oceania continues to have an air quality monitoring network that is heavily bolstered by non-government sources. Australia has more non-government operated than government-operated monitoring stations. This has allowed smaller cities and municipalities in the five countries and territories in this region to be represented in the report. Two new locations in this region added to the report in 2022 are Guam and French Polynesia. This brings the total number of represented countries and territories up to five, and all of them have annual average PM2.5 concentrations at or below 4.8 µg/m³.

Next Steps

What can governments do?

Decrease air pollution emissions

- Incorporate WHO air quality guidelines into future air quality standards
- Invest in renewable energy projects
- Expand the use of clean and renewable energy in public transportation
- Establish incentive programs to promote clean air vehicles for personal and commercial use
- Utilize trade-in programs and other financial incentive programs to support divestment from internal combustion engines
- Subsidize battery-powered and human-powered transportation methods
- Support infrastructure projects that support pedestrian traffic
- Fortify air pollutant emission limits for vehicles and industrial activities
- Engage in responsible forest management practices to prevent wildfires
- Ban agricultural and biomass burning
- Encourage innovative and critical thinking for addressing local air quality issues and improving air quality

Expand the air quality monitoring framework

- Increase the coverage and accessibility of government-run air quality monitoring stations
- Offer financial incentives to community-based organizations, university groups, and individuals who install their own air quality monitoring stations

What can I do?

- Advocate for local and national air quality projects, including initiatives, propositions, and measures that target air pollution
- Support organizations, community leaders, and politicians who value air quality improvement
- Voice air quality concerns to local representatives

Limit your exposure to air pollution

- Download the free IQAir AirVisual app to stay informed on real-time air quality conditions
- Limit outdoor activities when air quality is at unhealthy levels
- Wear a high-quality face mask outdoors when air quality is at unhealthy levels
- Monitor outdoor air quality using real-time reports and forecasted air pollution levels
- Use environmentally conscious alternatives to wood-burning stoves for heating and cooking.
- Use air filtration devices and air purification systems to improve indoor air quality
- When outdoor air quality is at unhealthy levels, set A/C systems to recirculation mode and close doors and windows to prevent polluted air from entering buildings
- When outdoor air quality is at healthy levels, set A/C systems to fresh air intake and open doors and windows to ventilate indoor areas

Lower your personal air pollution footprint

- Walk, bike, or ride public transportation when possible
- Save money and lessen energy demand by reducing energy consumption
- Moderate personal waste by purchasing less and recycling, upcycling, and reusing existing goods

Become an air quality data contributor

Increasing global awareness of air pollution issues, knowledge of the related consequences on human health, and the availability of air quality data are crucial advancements in confronting the shared challenge of poor air quality. Access to air quality information on a local level can empower citizens to advocate for clean air initiatives in their communities.

Although the quantity of air quality monitoring stations and number of represented communities continues to increase, many areas around the world still lack real-time air quality data. Local efforts to bolster air quality monitoring are essential in this regard, whether they are spearheaded by governments, community organizations, educational institutions, or concerned citizens.

Low-cost sensor technology advancements have enhanced the world's ability to collect accurate air quality information using devices that can be installed without specific training or experience. As more stations are deployed, more data becomes available for researchers, legislators, corporations, and community members to understand the status of global air quality, prompt thoughtful discussion, and inform decision-making that can lead to cleaner air and healthier communities.

To learn more about becoming an individual contributor or larger community contributor, visit our website.

Methodology

Data sources

The PM2.5 data used in the 2022 World Air Quality Report was collected exclusively by ground-level air quality monitoring stations. Of these monitoring stations, 39 percent were operated by governmental agencies, with the remaining 61 percent operated by non-profit community organizations, educational institutions, and individual citizens using low-cost sensors.

Most of the air quality data used in the report was collected in real-time, with supplementary air quality information obtained from year-end data sets. The integration of historically sourced data with real-time PM2.5 measurements contributes to the most complete global data set for analysis.

Data validation

Regulatory-grade air quality monitors and low-cost sensors alike may experience data anomalies caused by defects or short-term disturbances in the immediate environment. To counter these irregularities, IQAir's cloud-based data platform performs quality control measures on reported air quality measurements. Abnormal measurements from individual sensors are flagged and quarantined before the data is integrated into the IQAir platform. These measurements are cross-referenced using other data collected by the sensor in addition to the reported pollutant concentrations from nearby sensors. Data points that fail to satisfy quality control criteria are excluded from the IQAir platform and from this report.

Data calibration

Low-cost air quality sensor data included in this report measure airborne PM2.5 concentrations using laser scattering technology. Correction factors calibrate data from low-cost sensors to account for environmental factors that can bias the concentration data.

Data calculation

The annual average PM2.5 concentrations presented in this report are a function of the data accumulated by individual air quality monitoring stations within the geographic boundaries of a given area. Stations periodically record and time stamp PM2.5 concentration measurements of ambient air. The data from each station is consolidated hourly using the average value of all validated data points from the past 60 minutes. This value is the hourly average PM2.5 concentration of the immediate area around each specific station. When collected over the course of a year, the resulting series of hourly average PM2.5 concentrations can be used to calculate annual average PM2.5 concentrations for cities. This data is then weighted by population statistics to create the annual averages for countries, territories, and regions.

City level data

City level data in this report is listed using annual and monthly average PM2.5 concentrations. Monthly average PM2.5 concentrations are calculated using the average of all hourly average PM2.5 concentrations collected within the city's boundaries during a given month. This method assures consistent weighting of data from different monitoring stations at different hours. Annual average PM2.5 concentrations are calculated in a similar manner, using the average of all hourly average PM2.5 concentrations collected within the city's boundaries for that year.

Country/region data

Annual average PM2.5 concentrations for countries, territories, and regions are determined based on the city-level annual average PM2.5 concentration and the total population of all represented cities within a country, territory, or region. Cities with insufficient PM2.5 data do not have their populations represented in these population aggregations. Throughout the remainder of this section, "area" will be used in place of "country, territory and region."

IQAir aims to present an overview of the global state of air quality in a way that is conducive for meaningful comparisons of ambient air quality conditions in different locations with an emphasis on airborne pollutant exposure and the effects on human health. Consequently, a simple average calculation of all city-level PM2.5 concentrations within an area would fail to offer meaningful insight into the relative air quality experienced by individuals across the area.

As such, population data for cities reporting PM2.5 concentrations is utilized to provide a more accurate representation of the human experience of air quality in an area. Population weighting as a normalization factor can more appropriately convey air quality conditions, such that densely populated cities are proportionately represented in an area's reported annual average. This method allows the air quality information collected in cities with larger populations to have a greater influence on the annual average PM2.5 concentration of an area. This more accurately reflects individual human experiences in the local area and provides context to air quality information, facilitating global comparisons.

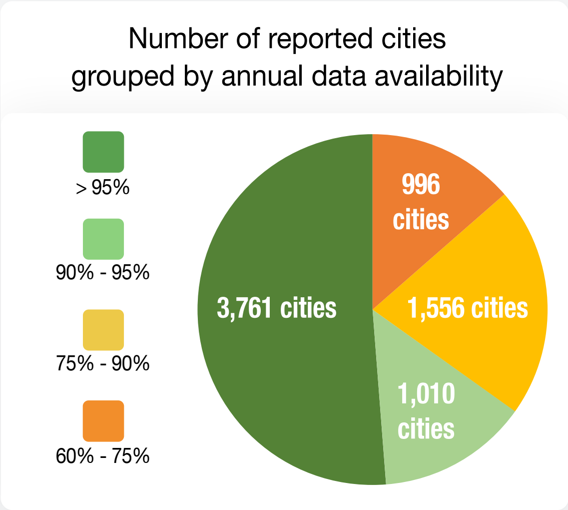
The calculation below is used to determine the annual average PM2.5 concentration in an area based on the city-level PM2.5 data and weighed using city populations to add global context.

$$\frac{\Sigma \text{ city mean PM2.5 } (\mu g/m^3) \times \text{ city population}}{\text{Total regional population covered by available city data}}$$

Data availability

Annual data availability was the primary metric used to determine whether a city's reported average annual PM2.5 concentration was representative of the city's actual air quality conditions. The threshold for inclusion in the 2022 World Air Quality Report was 60 percent, meaning that cities must have hourly average PM2.5 data for at least 60 percent of the year (at minimum 5,256 hours out of a possible 8,760 hours) for their data to be included in the report.

The 2022 data availability for PM2.5 data used in this report is summarized below.



The pie chart shows the distribution of the total number of reported cities (7,323) by annual data availability.

Disclaimer

The PM2.5 data presented in this report is derived from ground-level air quality monitoring stations that include both regulatory-grade monitors and low-cost sensors. All data was collected in the 2022 calendar year.

IQAir is a politically independent organization. Maps, graphs, and other content included in this report are intended to provide insight into the global data set and are not indicative of any political stance. Regional maps were created with a data visualization tool.

FAQ

Why are some locations (city/country/region) not included in this ranking?

Locations without sufficient PM2.5 data availability, those not meeting the 60% inclusion criteria, are excluded from the 2022 World Air Quality Report. The report seeks to accurately represent the status of air quality around the world using data collected by ground-based PM2.5 monitoring stations, and therefore does not include air quality data derived from satellites.

Why does the data provided within this report differ from the data provided by my government?

City-based averages for PM2.5 can be calculated on an hourly, daily, monthly, or annual basis. IQAir uses station hourly averages to generate a comprehensive city average, a method which helps prevent outliers in the data from affecting the accuracy of city averaging calculations.

The PM2.5 data included in this report is aggregated from a broad range of sources, including both government and privately operated air quality monitors. Data collected by independent citizens using low-cost monitors is often excluded from government data sets and reports. The inclusion of this data can yield a more comprehensive and accurate representation of the status of air quality on a local and global level.

Why is the report missing some locations that are available on the IQAir website?

Data inclusion criteria require annual data availability of at least 60% of the total number of hours in a year. The report only includes data from cities that meet this availability criteria to ensure a representative presentation of air quality.

The IQAir AirVisual platform includes satellite data for locations without real-time ground-level PM2.5 monitoring, denoting the PM2.5 values in these locations with an asterisk (*). The modeled and satellite data on the AirVisual platform contribute to a more extensive look at real-time PM2.5 concentrations, but this data is not included in the 2022 World Air Quality Report.

Where can I find the complete city ranking of all locations included in the report?

Compete global rankings of the most polluted cities are published on the IQAir website. The interactive set of rankings also includes monthly PM2.5 concentration averages and historical annual PM2.5 concentration averages.

What is adequate data availability?

With many developing nations and regions still expanding and improving their air quality monitoring capabilities, a data availability threshold of 60 percent is required for inclusion in the 2022 World Air Quality Report. Cities represented in the report must possess at minimum, hourly PM2.5 data from 60 percent of the total number of hours in 2022. The 60 percent data availability inclusion criterion ensures a sufficient level of scientific rigor while also providing enough lenience to include PM2.5 data from developing regions and budding air quality networks.

References

1. The World Bank. The global health cost of PM2.5 air pollution: A case for action beyond 2021. Washington, DC: World Bank License: Creative Commons Attribution CC BY 3.0 IGO; 2022.
2. Zehnder C, Manoylov K, Mutiti S, et al. Introduction to environmental science: 2nd edition. Biological Sciences Open Textbooks. Published 2018. https://oer.galileo.usg.edu/biology-textbooks/4
3. Fuller R, Landrigan PJ, Balakrishnan K. Pollution and health: A progress update. The Lancet Planetary Health. 2022: 6, (6), E535-E547. doi: 10.1016/S2542-5196(22)00090-0
4. United States Environmental Protection Agency. Which populations experience greater risks of adverse health effects resulting from wildfire smoke exposure? Environmental Protection Agency. Published October 20, 2022. https://www.epa.gov/wildfire-smoke-course/which-populations-experience-greater-risks-adverse-health-effects-resulting
5. World Health Organization. WHO global air quality guidelines. World Health Organization. Published September 22, 2021. https://www.who.int/news-room/questions-and-answers/item/who-global-air-quality-guidelines
6. California Air Resources Board. Inhalable particulate matter and health (PM2.5 and PM10). California Air Resources Board. Published 2023. https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health
7. United States Environmental Protection Agency. Health and environmental effects of particulate matter (PM). Environmental Protection Agency. Published August 30, 2022. https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
8. Eisenman, DP, Kyaw, May MT, Eclarino, K. Review of the mental health effects of wildfire smoke, Solastalgia, and non-traditional firefighters. UCLA Center for Healthy Climate Solutions, David Geffen School of Medicine at UCLA, & Climate Resolve. Los Angeles, CA. Published March 2021. https://healthyclimatesolutions.org/wp-content/uploads/2021/07/REVIEW-OF-THE-MENTAL-HEALTH-EFFECTS-OF-WILDFIRE-SMOKE-SOLASTALGIA-AND-NON-TRADITIONAL-FIREFIGHTERS.pdf
9. Health Effects Institute. State of global air 2020. Special Report. Health Effects Institute; 2020.
10. World Health Organization. Cause-specific mortality, 2000–2019. World Health Organization. Published 2023. https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death
11. Pui D YH, Chen S-C, Zuo Z. PM2.5 in China: Measurements, sources, visibility and health effects, and mitigation. Particuology. 2014: 1-26. https://doi.org/10.1016/j.partic.2013.11.001 science/article/abs/pii/S1674200113002228
12. Zheng M, Yan C, Wang S, et al. (2017). Understanding PM2.5 sources in China: Challenges and perspectives. National Science Review. 2017: 4(6):801-803. https://doi.org/10.1093/nsr/nwx129
13. Ministry of Ecology and Environment of the People's Republic of China. Ministerial decree no. 24: measures for the administration of lawful disclosure of enterprise environmental information. Ministry of Ecology and Environment. Published 2021. https://www.mee.gov.cn/xxgk2018/xxgk/xxgk02/202112/t20211221_964837.html
14. International Olympic Committee. Beijing 2022 facts and figures. Olympics. Published 2021. https://olympics.com/ioc/beijing-2022-facts-and-figures
15. UNEP, WMO, UNCCD. Global assessment of sand and dust storms. Nairobi: United Nations Environment Programme; 2016.
16. United Nations Environment Programme. Fourth Asia pacific clean air partnership (APCAP) joint forum (Hybrid Event, September 5-7, 2022). Suwon, Republic of Korea.
17. Sada Elbalad English. S. Korea to provide $2.72 mln for adaptation fund at COP27. See News. Published November 16, 2022. https://see.news/s-korea-to-provide-272-mln-for-adaptation-fund-at-cop27
18. Ministry of Environment. The ministry of environment successfully conducted a pilot project for k-taxonomy. Ministry of Environment. Published December 15, 2022. https://eng.me.go.kr/eng/web/board/read.do?menuId=461&boardMasterId=522&boardId=1568510
19. Financial Services Commission. Financial authorities and relevant institutions declare support for TCFD and its recommendations. Financial Services Commission. Published May 24, 2021. https://www.fsc.go.kr/eng/pr010101/75957
20. Yudha SW. Air pollution in Indonesia. NBR. Published April 11, 2016. https://www.nbr.org/publication/air-pollution-in-indonesia/
21. TransportPolicy.net. Regions: Indonesia. Transport Policy. Published 2018. https://www.transportpolicy.net/region/asia/indonesia/#:~:text=The%20Indonesian%20Ministry%20of%20Environment%20and%20Forestry%20requires,replacing%20the%20current%20Euro%202%2FII%20emission%20standard%20requirements.
22. The World Bank. Cleaner cook stoves for a healthier Indonesia. World Bank. Published November 3, 2014. https://www.worldbank.org/en/news/feature/2014/11/03/cleaner-cook-stoves-for-a-healthier-indonesia
23. Greenpeace Southeast Asia. Indonesian forest fires crisis: Palm oil and pulp companies with largest burned land areas are going unpunished. Greenpeace. Published September 24, 2019. https://www.greenpeace.org/southeastasia/publication/3106/3106/

24. Lawder D. Indonesia, ADB launch first coal power plant retirement deal. Reuters. Published November 14, 2022. https://www.reuters.com/business/cop/exclusive-indonesia-adb-launch-first-coal-power-plant-retirement-deal-2022-11-14/

25. Shofa JN. PLN to gradually retire coal-fired power plants. Jakarta Globe. Published July 14, 2021. https://jakartaglobe.id/business/pln-to-gradually-retire-coal-fired-power-plants

26. Global Energy Monitor Wiki. Cirebon power station. Global Energy Monitor. Published January 31, 2023. https://www.gem.wiki/Cirebon_power_station

27. Velcro Envirotech Sdn Bhd. Air pollution in Malaysia: What are the causes? VETSB. Published October 20, 2021. https://vetsb.com.my/2021/10/20/air-pollution-in-malaysia/

28. Centre for Research on Energy and Clean Air and Greenpeace Malaysia. The state of air quality in Malaysia. Greenpeace. Published June 8, 2022. https://www.greenpeace.org/malaysia/press/49795/the-state-of-air-quality-in-malaysia/

29. Centre for Research on Energy and Clean Air (CREA). The health & economic impacts of ambient air quality in Malaysia. Energy and Clean Air. Published June 8, 2022. https://energyandcleanair.org/publication/hia-ambient-aq-malaysia/

30. CLJ Malaysia Sdn. Bhd. A bill intituled: An act to amend the Environmental Quality Act 1974. CLJ Law. Published 2023. https://www.cljlaw.com/files/bills/pdf/2022/MY_FS_BIL_2022_38.pdf

31. Malaysian-German Chamber of Commerce and Industry. Environmental Quality (Amendment) Bill 2022 ups penalties. Malaysian-German Chamber of Commerce and Industry. Published October 31, 2022. https://www.malaysia.ahk.de/en/infocentre/news/detail/environmental-quality-amendment-bill-2022-ups-penalties#:~:text=On%205%20th%20October%202022%2C%20Malaysian%20Parliament%20passed,-to%20strengthen%20regulations%20on%20different%20forms%20of%20pollution

32. Royal Coast Review Thailand Editor. Thailand's northern region's burning season continues to pollute. Royal Coast Review. Published February 4, 2022. https://royalcoastreview.com/2022/02/thailands-northern-regions-burning-season-contues-to-pollute/

33. Kummetha TA. The cost of clean air in Thailand. World Health Organization Thailand. Published June 8, 2022. https://www.who.int/thailand/news/detail/08-06-2022-the-cost-of-clean-air-in-thailand#:~:text=Forest%20fires%20are%20common%20in%20the%20dry%20season,than%20the%20WHO%20annual%20air%20quality%20guideline%20value.

34. Bangkok Post Reporters. Air pollution hotspots rise in north with forest fires. Bangkok Post. Published March 3, 2022. https://www.bangkokpost.com/thailand/general/2272871/air-pollution-hotspots-rise-in-north-with-forest-fires

35. Vejpongsa T. Popular independent wins Bangkok governor's election. AP News. Published May 23, 2022. https://apnews.com/article/2022-midterm-elections-bangkok-government-and-politics-general-b6a249a2e334c64d0b2290d3bae99bc6

36. Chatchachart Sittiphan. Expanded dust tracking and alert system to 1,000 district levels. Chad Chart. Published March 12, 2022. https://www.chadchart.com/policy/6214c687204d4c4f8ab8c836/

37. Chatchachart Sittiphan. Forecast, warning, and prevention of PM2.5. Chad Chart. n.d. https://www.chadchart.com/policy/6215ef934e43cd8b4760bc17/

38. Chatchachart Sittiphan. Detecting black smoke from the root cause. Chad Chart. Published March 12, 2022. https://www.chadchart.com/policy/62151f1b204d4c4f8ab8c841/

39. Le H. Eliminating air pollution in Vietnam. Borgen Project. Published March 6, 2020. https://borgenproject.org/air-pollution-in-vietnam/#:~:text=Generally%2C%20exhaust%20from%20cars%20and%20motorbikes%2C%20factory%20emissions,is%20the%20cause%20of%20Vietnam%E2%80%99s%20polluted%20air%20quality.

40. Tuan V. Vietnam builds master plan to cut air pollution. VN Express. Published April 14, 2022. https://e.vnexpress.net/news/news/vietnam-builds-master-plan-to-cut-air-pollution-4451237.html

41. Vietnam News Agency. National strategy on environmental protection to 2030 approved. VNA Published May 3, 2022. https://en.vietnamplus.vn/national-strategy-on-environmental-protection-to-2030-approved/227786.vnp

42. United States Agency for International Development. USAID reducing pollution. USAID. Published 2022. https://www.usaid.gov/vietnam/fact-sheets/usaid-reducing-pollution

43. Vietnam News Agency. Vietnam, US launch new five-year project to reduce environmental pollution. VNA. Published November 16, 2022. Retrieved from https://en.vietnamplus.vn/vietnam-us-launch-new-five-year-project-to-reduce-environmental-pollution/243978.vnp

44. World Bank. Striving for clean air: Air pollution and public health in South Asia. Washington, DC.: License: Creative Commons Attribution CC BY 3.0 IGO; 2022.

45. Sharma S. Air pollution costs India rs 7 lakh crore a year: Report. Science the Wire. Published April 28, 2021. https://science.thewire.in/health/air-pollution-costs-india-rs-7-lakh-crore-a-year-report/

46. Science X Network. India relaxes environment rules for coal mines, citing heatwave. Phys.org. Published May 11, 2022. https://phys.org/news/2022-05-india-environment-coal-citing-heatwave.html#:~:text=May%2011%2C%202022%20India%20relaxes%20environment%20rules%20for,exacerbate%20a%20sweltering%20heatwave%2C%20a%20government%20notice%20showed.

47. Varadhan S. India November thermal coal imports at nine-month low as local output soars. Reuters. Published December 10, 2022. https://www.reuters.com/markets/commodities/india-nov-thermal-coal-imports-10-month-low-local-output-soars-2022-12-09/

48. Big News Network. India's coal production surges 11.66 pc to 76 mt in Nov. Big News Network. Published December 20, 2022. https://www.bignewsnetwork.com/news/273166180/india-coal-production-surges-1166-pc-to-76-mt-in-nov

49. Ganguly T, Ganesan K, Khan A. What is polluting India's air? The need for an official air pollution emissions database. Council on Energy, Environment and Water. Published October 2021. New Delhi: Council on Energy, Environment and Water: https://www.ceew.in/publications/sources-of-air-pollution-in-india-and-need-for-official-air-pollution-emissions-inventory

50. Ali, Manzoor. (2022, April 21). Air pollution brings down life expectancy in Peshawar: Study. Retrieved from Air pollution brings down life expectancy in Peshawar: study - Pakistan - DAWN.COM

51. Climate and Clean Air Coalition Secretariat. Pakistan develops a national clean air plan using the country's first air pollutant inventory. Climate and Clean Air Coalition. Published December 30, 2022. https://www.ccacoalition.org/en/news/pakistan-develops-national-clean-air-plan-using-country%E2%80%99s-first-air-pollutant-inventory

52. United Nations Environment. Global environment outlook - GEO-6: Healthy Planet, healthy People. Nairobi; 2019.

53. Francis D, Fonseca R, Nelli N, et al. On the Middle East's severe dust storms in spring 2022: Triggers and impacts. Atmospheric Environment, 2023: 119539. https://doi.org/10.1016/j.atmosenv.2022.119539

54. United Nations. The UN and the war in Ukraine: Key information. Published September 3, 2022. https://unric.org/en/the-un-and-the-war-in-ukraine-key-information/#top

55. Rott N, Harbage C, Malofieieva K. Millions of Ukrainians have escaped the war. Many still can't find enough work. Published November 2, 2022. https://www.npr.org/2022/11/01/1132167234/russia-ukraine-war-unemployment-displaced-economy#:~:text=A%20new%20report%20from%20the,the%20country%27s%20social%20welfare%20system.

56. UNHCR. Situation Ukraine refugee situation. Published 2023. https://data.unhcr.org/en/situations/ukraine

57. Watson Institute for International and Public Affairs. Environmental Costs | Costs of War. Brown.edu. Published 2015. https://watson.brown.edu/costsofwar/costs/social/environment

58. Miller A. The surprising effects of construction on the environment. The Environmental Blog.org. Published June 26, 2020. https://www.theenvironmentalblog.org/2020/06/surprising-effects-of-construction-environment/

59. The Center for Disaster Philanthropy. 2022 North American wildfires. Disaster Philanthropy. Published January 19, 2023. https://disasterphilanthropy.org/disasters/2022-north-american-wildfires/

60. O'Dell K, Ford B, Fischer EV, et al. Contribution of wildland-fire smoke to US PM2.5 and its influence on recent trends. Environmental Science & Technology. 2019:53(4):1797-1804. https://europepmc.org/article/MED/30681842

61. McClure CD, Jaffe DA. US particulate matter air quality improves except in wildfire-prone areas. Earth, Atmospheric, And Planetary Sciences. 2018:115 (31) 7901-7906. https://www.pnas.org/doi/pdf/10.1073/pnas.1804353115

62. United States Environmental Protection Agency. Proposed decision for the reconsideration of the national ambient air quality standards for particulate matter (PM). Environmental Protection Agency. Published February 3, 2023. https://www.epa.gov/pm-pollution/proposed-decision-reconsideration-national-ambient-air-quality-standards-particulate#:~:text=On%20January%206%2C%202023%2C%20after%20carefully%20reviewing%20the,within%20the%20range%20of%209.0%20to%2010.0%20%C2%B5g%2Fm3.

63. Hailstone J. Are the proposed EPA air quality standards strong enough to tackle pollution? Forbes. Published January 13, 2023. https://www.forbes.com/sites/jamiehailstone/2023/01/13/are-the-proposed-epa-air-quality-standards-strong-enough-to-tackle-pollution/?sh=137f89e760bf

64. Araujo G. Fires in Brazil's Amazon surge in September, worst month since 2010. Reuters. Published September 26, 2022. https://www.reuters.com/business/environment/fires-brazils-amazon-surge-september-worst-month-since-2010-2022-09-26/

65. Nabukalu C, Gieré R. Global charcoal consumption and the question of energy security. University of Pennsylvania. Published November 11, 2020. https://kleinmanenergy.upenn.edu/news-insights/global-charcoal-consumption-and-the-question-of-energy-security/

66. Food and Agriculture Organization of the United Nations. Global forest products facts and figures. Food and Agriculture Organization. Published 2019. https://www.fao.org/3/ca7415en/ca7415en.pdf

67. Teixeira F. In Brazil, charcoal industry fuels illegal deforestation and slavery. Reuters. Published January 5, 2022. https://www.reuters.com/article/us-brazil-environment-forests-slavery-idUSKBN2JF0PL

68. Rocha C. Lula da Silva will return to Brazil's presidency in stunning comeback. CNN. Published October 31, 2022. https://www.cnn.com/2022/10/30/americas/brazil-election-lula-da-silva-wins-intl/index.html

69. Greenfield P, Harvey F. Lula vows to undo environmental degradation and halt deforestation. Reed B, ed. The Guardian. Published November 16, 2022. https://www.theguardian.com/environment/2022/nov/16/lula-vows-to-undo-brazils-environmental-degradation-and-halt-deforestation

70. Rannard G. COP27: Brazil is back on the world stage, Lula tells climate summit. BBC. Published November 16, 2022. https://www.bbc.com/news/science-environment-63625698
71. Diaz-Robles LA, Schiappacasse LN, Cereceda-Balic F, et al. The air quality in Chile: Twenty years of challenge. Research Gate. Published August 2011. https://www.researchgate.net/publication/225089100_The_air_quality_in_Chile_Twenty_years_of_challenge
72. Rueda M. Environmental groups alarmed over fires in Colombian Amazon. AP News. Published February 9, 2022. https://apnews.com/article/climate-business-bogota-environment-environment-and-nature-102dbcf365cba1cab5320ba5cd1783df
73. Copenhagen Consensus Center. Colombia Perspective: Air Pollution. Copenhagen Consensus. n.d. https://www.copenhagenconsensus.com/publication/colombia-perspective-air-pollution
74. United Nations Environment Programme. Working with nature, Colombia fights air pollution. United Nations Environment Programme. Published September 7, 2021. https://www.unep.org/news-and-stories/story/working-nature-colombia-fights-air-pollution
75. TeleSUR. Colombia: Environmental pollution alert issued in Bogota. teleSUR English. Published February 6, 2022. https://www.telesurenglish.net/news/Colombia-Environmental-Pollution-Alert-Issued-In-Bogota-20220206-0008.html
76. International Trade Administration U.S. Department of Commerce. Electric power and renewable energy systems. Published November 24, 2022. https://www.trade.gov/knowledge-product/colombia-electric-power-and-renewable-energy-systems
77. Climate and Clean Air Coalition Secretariat. What the CCAC did at #COP27. Climate and Clean Air Coalition. Published November 8, 2022. https://www.ccacoalition.org/en/news/what-ccac-did-cop27#:~:text=Colombia%20became%20the%20first%20South%20American%20country%20to,shut%20down%20all%20flares%20located%20near%20human%20settlements
78. Pratt SE. An atmospheric river of dust. Earth Observatory. Published March 15, 2022. https://earthobservatory.nasa.gov/images/149588/an-atmospheric-river-of-dust
79. Jordan R. Stanford researchers reveal air pollution's connection to infant mortality. Stanford News. Published June 29, 2020. https://news.stanford.edu/2020/06/29/air-pollutions-connection-infant-mortality/
80. Aghababaeian H, Ostadtaghizadeh A, Ardalan A, et al. (2021). Global Health Impacts of Dust Storms: A Systematic Review. Environmental Health Insights. 2021;15. doi: 10.1177/11786302211018390
81. Horton M. Air pollution a major cause of infant deaths in sub-Saharan Africa. Stanford Earth Matters magazine. Published June 27, 2018. https://earth.stanford.edu/news/air-pollution-major-cause-infant-deaths-sub-saharan-africa
82. Ritchie H, Roser M. Chad: Energy country profile. Our World in Data. Published 2022. https://ourworldindata.org/energy/country/chad
83. Whiting K. Cooking with polluting fuels is a silent killer - here's what can be done. WeForum. Published October 27, 2021. https://www.weforum.org/agenda/2021/10/polluting-cooking-fuels-deaths-women-climate/
84. Kgothlang H. Shortage of operational firefighting vehicles places Thamazimbi residents at risk. Published June 27, 2022. https://limpopo.da.org.za/2022/06/shortage-of-operational-firefighting-vehicles-places-thamazimbi-residents-at-risk
85. Olutola B, Wichmann J. Air pollution, temperature and respiratory disease: A South African study. The Conversation. Published July 13, 2020. https://theconversation.com/air-pollution-temperature-and-respiratory-disease-a-south-african-study-141080
86. Garland R. South African court rules that clean air is a constitutional right: What needs to change. The Conversation. Published March 23, 2022. https://theconversation.com/south-african-court-rules-that-clean-air-is-a-constitutional-right-what-needs-to-change-179706
87. Trustees Judgement, 39724/2019 (High Court of South Africa March 18, 2022). https://cer.org.za/wp-content/uploads/2022/03/TRUSTEES-JUDGMENT-DATED-18-MARCH-2022-1.pdf
88. Commonwealth of Australia, Bureau of Meteorology. Bushfire weather. Bureau of Meteorology. Published 2023. http://www.bom.gov.au/weather-services/fire-weather-centre/bushfire-weather/index.shtml

Acknowledgments

IQAir would like to acknowledge the government agencies, researchers, educational institutions, non-governmental organizations, and citizen scientists that operate and host air quality monitoring stations around the globe. Their passion for air quality monitoring provides the data basis for this report.

IQAir would like to thank the United Nations Environment Programme (UNEP) and the United Nations Human Settlements Programme (UN-HABITAT) for their collaboration, and continued support to governments around the world to monitor air quality and engage with communities in a collaborative spirit.

A special thanks to Greenpeace Colombia, India, Indonesia, Malaysia, Thailand, Türkiye, South Korea, South Africa, and the U.S. for providing valuable insight and serving as a high-level collaborator of this report every year.

GREENPEACE

UN environment programme

UN-HABITAT FOR A BETTER URBAN FUTURE

About IQAir

IQAir is a Swiss-based air quality technology company that seeks to empower individuals, organizations and communities to breathe cleaner air through information, collaboration and technology solutions.

IQAir's AirVisual global air quality information platform aggregates, validates and calibrates air quality data from a wide variety of sources, including governments, private citizens and organizations. The AirVisual platform supports the free integration of air quality data from a wide variety of data sources and monitoring devices.

IQAir®