2023

World Air Quality Report

Region & City PM2.5 Ranking

IQAir®

Contents

About this report

The 2023 World Air Quality Report provides a global review of air quality data for the year 2023. The report summarizes PM2.5 air quality data from 7,812 cities spanning 134 countries, regions, and territories. The data utilized to create this report was aggregated from more than 30,000 air quality monitoring stations operated by research institutions, governmental bodies, universities and educational facilities, non-profit organizations, private companies, and citizen scientists.

PM2.5 data is reported in units of micrograms per cubic meter ($\mu g/m^3$) and incorporates the latest World Health Organization (WHO) annual PM2.5 guideline and interim targets for data visualization and risk communication (released in 2021).

The 2023 World Air Quality Report was created from real-time air quality data sourced from IQAir's global air quality monitoring platform that vets incoming data with validation and calibration protocols to harmonize air quality data from monitoring stations around the world.

Historic air quality data utilized in the creation of this report can be found on the IQAir website, including **an interactive map featuring annual city concentrations**, global city-level rankings and links to the more than 7,000 dedicated city pages providing local real-time air quality data and information.

IQAir strives to actively involve, educate, and motivate governments, educators, researchers, non-profit organizations, corporations, and individuals to foster collaborative endeavors aimed at enhancing public awareness of air quality. IQAir seeks to facilitate well-informed discussions and inspire initiatives that advance air quality and promote the well-being of communities and cities worldwide.

Executive summary

Causing an estimated one in every nine deaths worldwide, air pollution is the greatest environmental threat to human health. According to the World Health Organization (WHO), air pollution is responsible for an estimated seven million premature deaths worldwide every year.[1]

Exposure to PM2.5 air pollution leads to and exacerbates numerous health conditions, including but not limited to asthma, cancer, stroke, and lung disease.[2] Additionally, exposure to elevated levels of fine particles can impair cognitive development in children, lead to mental health issues, and complicate existing illnesses including diabetes.

The data utilized to create this report was aggregated from the global distribution of more than 30,000 regulatory air quality monitoring stations and low-cost air quality sensors operated by research institutions, governmental bodies, universities and educational facilities, non-profit non-governmental organizations, private companies, and citizen scientists.

The 2022 World Air Quality Report included data from 7,323 locations in 131 countries, regions, and territories. In 2023, those numbers have grown to include 7,812 locations in 134 countries, regions, and territories. Coverage in Africa has expanded significantly in 2023 with seven new countries being added to the region. Coverage has also expanded across Latin America with four additional countries included in 2023. The African nations of Chad and Sudan, as well as the West Asian country of Iran, are notably absent in 2023 due to a lack of publicly available monitoring data.

In 2023, 10 out of the reporting 134 countries and regions succeeded in achieving the WHO annual PM2.5 guideline value of 5 µg/m^3. With only 9% of globally reporting cities achieving the WHO annual PM2.5 guideline, much more work remains to be done to combat air pollution. While PM2.5 poses direct health risks, its implications extend beyond human health to complex environmental processes impacted by the Earth's climate. Climate change, primarily driven by greenhouse gas emissions, plays a pivotal role in influencing concentrations of PM2.5 air pollutants, and fossil fuel emissions are simultaneously responsible for the majority of PM2.5 related deaths.[3] Simultaneously addressing air pollution and climate change goals is feasible, offering opportunities for comprehensive environmental improvements.

Where does the data come from?

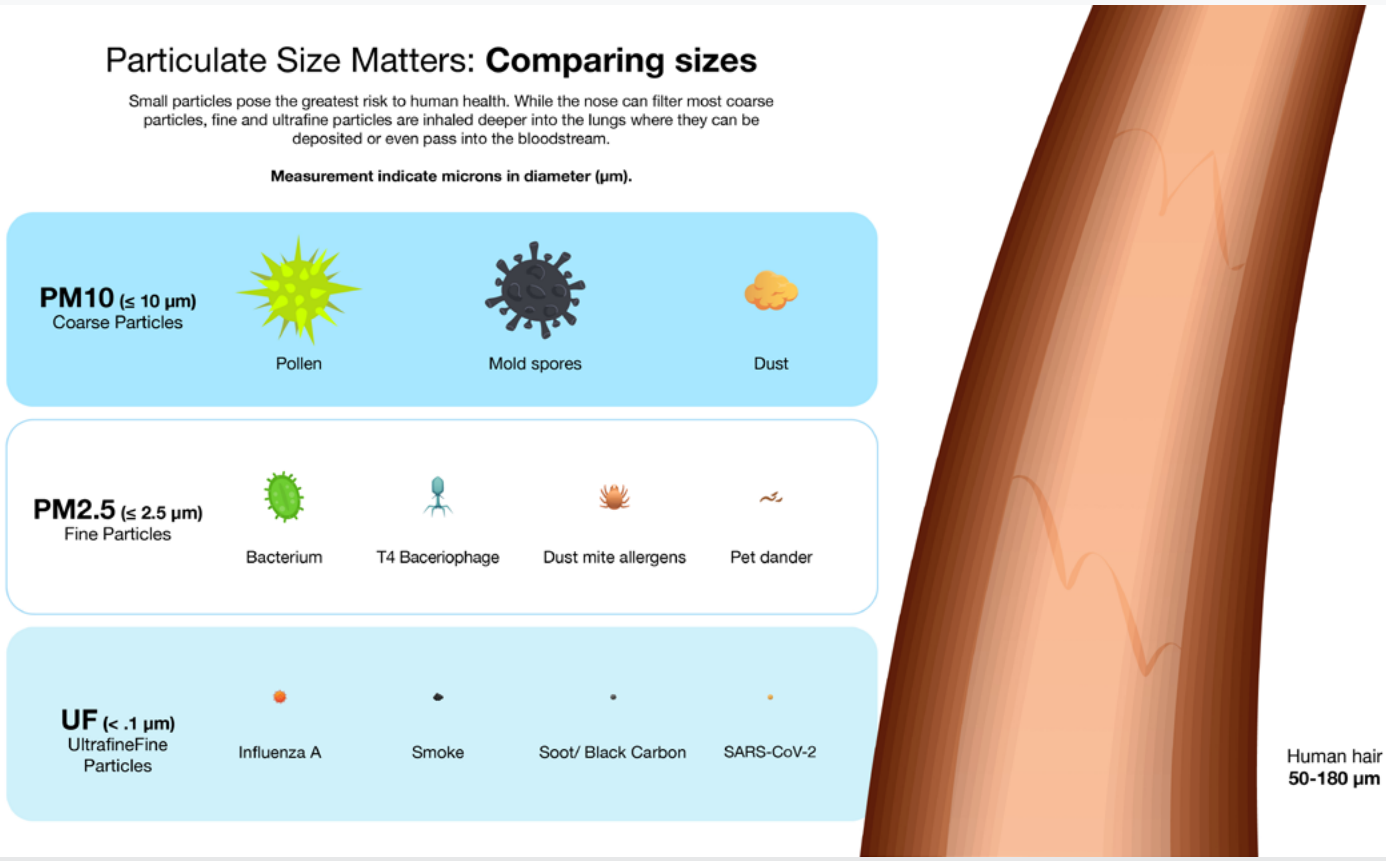
Unlike many other air quality reports and applications that rely on modeled satellite data, our report exclusively utilizes empirically measured PM2.5 data obtained from ground-level air monitoring stations. PM2.5 measurement data in this report is aggregated from a combination of regulatory air quality monitoring equipment and low-cost air quality sensors. These instruments are maintained and operated by a diverse range of entities, including government agencies, educational institutions, non-profit organizations, and individual citizens committed to monitoring their local air quality. Most of the data integrated into the World Air Quality Report is collected in real-time, bolstered by supplementary air quality measurements sourced from historical year-end datasets. This comprehensive approach, blending real-time and historical data, generates our global dataset for in-depth analysis.

Individual air quality monitoring stations and sensors are grouped into "settlements," representing cities, towns, villages, counties, and municipalities, based on local population distributions and administrative divisions. We refer to these "settlements" as cities throughout this report. Our calculations of annual PM2.5 concentrations for countries and regions are population-weighted averages of city-level concentrations.

Why PM2.5?

PM2.5 concentration, fine particulate aerosol particles measuring up to 2.5 microns in diameter, is the primary air quality indicator for the World Air Quality Report. Measured in micrograms per cubic meter (μg/m³), PM2.5 is one of six common pollutants monitored and regulated by environmental agencies worldwide due to the significant impacts to human health and the environment.

PM2.5 can originate from a variety of sources, each potentially resulting in distinct chemical compositions and physical characteristics. Common components of PM2.5 include sulfates, black carbon, nitrates, and ammonium. Anthropogenic sources of PM2.5 are predominantly linked to combustion engines, industrial processes, power generation, coal and wood burning, agricultural activities, and construction. Natural sources include dust storms, wildfires, and sandstorms.



Climate change and air pollution

PM2.5, or particulate matter with a diameter of 2.5 micrometers or smaller, is a key component of air pollution. Exposure to these particles has been directly linked to health problems including cardiovascular disease, neurological disease, and increased risk of death. While PM2.5 poses direct health risks, its implications extend beyond human health to complex environmental processes that are impacted by the Earth's climate. Climate change, primarily driven by greenhouse gas emissions, plays a pivotal role in influencing concentrations of PM2.5 air pollutants through various pathways, including the impact of wildfire smoke and pollen-based aeroallergens. Fossil fuel emissions account for 65% of global CO_2 emissions and are also the primary cause of the majority of PM2.5-related deaths, highlighting the interconnected relationship between air quality and climate change.[4,5,6] Simultaneously addressing air pollution and climate change goals is feasible, offering opportunities for comprehensive environmental improvements.

Climate change can alter weather patterns, leading to changes in wind and precipitation. This, in turn, can affect the dispersion and removal of PM2.5 from the atmosphere. Projections indicate that climate change will exacerbate air quality issues, with extreme heat events becoming more severe and frequent. In many regions, intense pollution events coincide with extreme heat, exacerbated by air stagnation events where weak winds hinder ground-level ventilation, allowing pollutants to accumulate. As climate change progresses, the frequency of such events is anticipated to increase.

Extended periods of dry, hot conditions have led to the increased frequency and severity of wildfires in many regions. Wildfires emit gases and fine particles that pose threats to human health, leading to premature mortality, asthma, and various health issues. Wildfire smoke can travel for hundreds of miles, negatively impacting populations at significant geographic distances from the original fire.

Pollen seasons have become longer and more intense with increased levels of grass and tree pollen emissions due to changing climate patterns. Allergic airway disease, such as allergic rhinitis and asthma, occur through exposure to allergenic pollens and molds.[7,8] The health impact of allergic airway disease is exacerbated by concurrent exposure to allergens and air pollutants like PM2.5.[9,10]

Data presentation

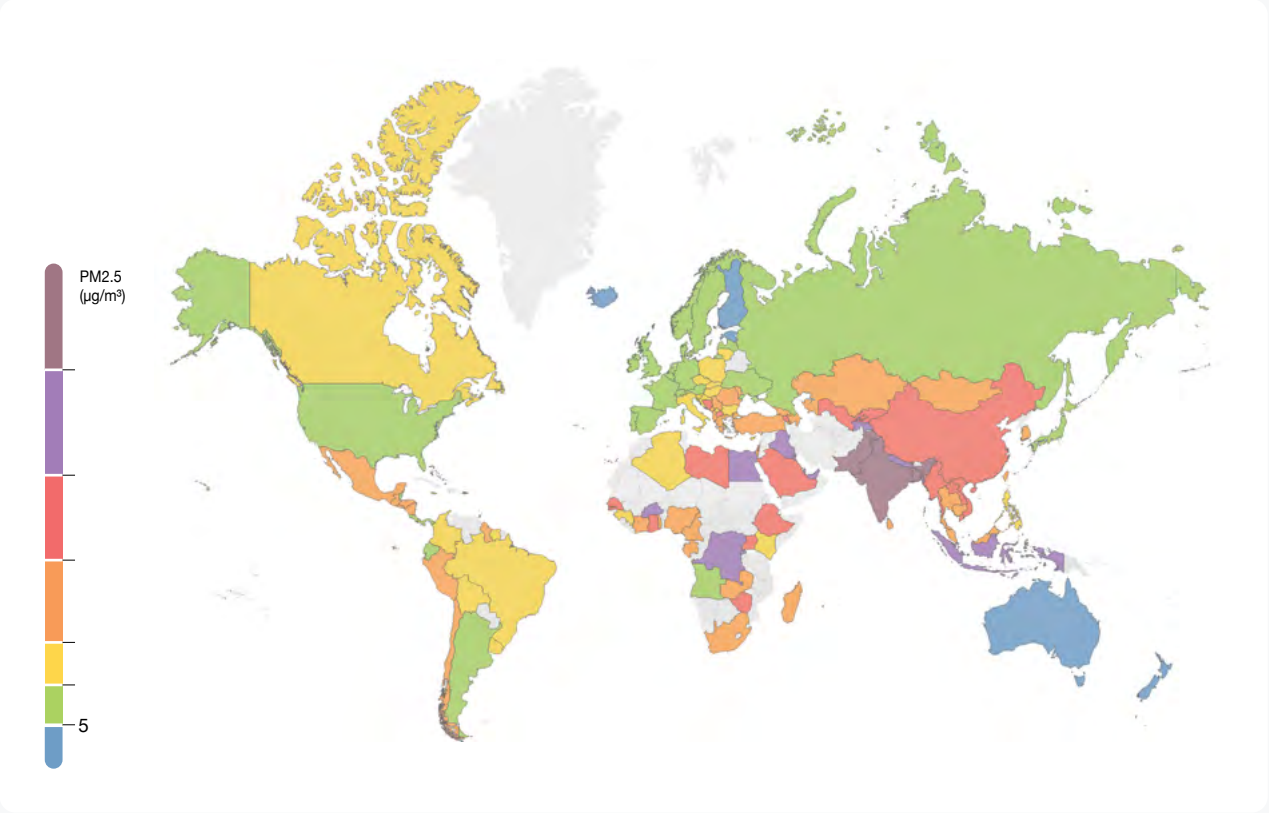
This report employs the World Health Organization's (WHO) annual PM2.5 guideline levels and interim targets for PM2.5 to visualize data. This approach makes it easier to identify cities and regions facing significant health risks due to PM2.5.

The table below shows the framework for the color-coding used in this report. The framework employs seven distinct colors. Each color represents a PM2.5 concentration range corresponding to WHO annual PM2.5 guideline or target values. The colors range from blue, denoting the lowest PM2.5 levels and locations meeting the WHO annual PM2.5 guideline level, to maroon, indicating the highest PM2.5 concentrations exceeding the guideline by tenfold.

2023 World Air Quality Report visualization framework

Annual PM2.5 breakpoints based on WHO annual PM2.5 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

2023 Global PM2.5 Map



2023 global map color coded by annual average PM2.5 concentration

In 2023, 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 24 out of 54 countries in Africa had sufficient data available to be included in 2023's report, leaving 30 countries unaccounted for. Afghanistan had consistently ranked in the top 15 most polluted countries since 2019, however it, along with the country of Oman (ranked as the 6th most polluted country in 2022), is notably absent due to a lack of data availability. In 2023, 20 new countries were represented including Burkina Faso, 2023's 5th most polluted country, and Rwanda, 2023's 15th most polluted country. In 2023, 10 countries, territories, and regions achieved the WHO annual PM2.5 guideline, many of which were located in the region of Oceania.

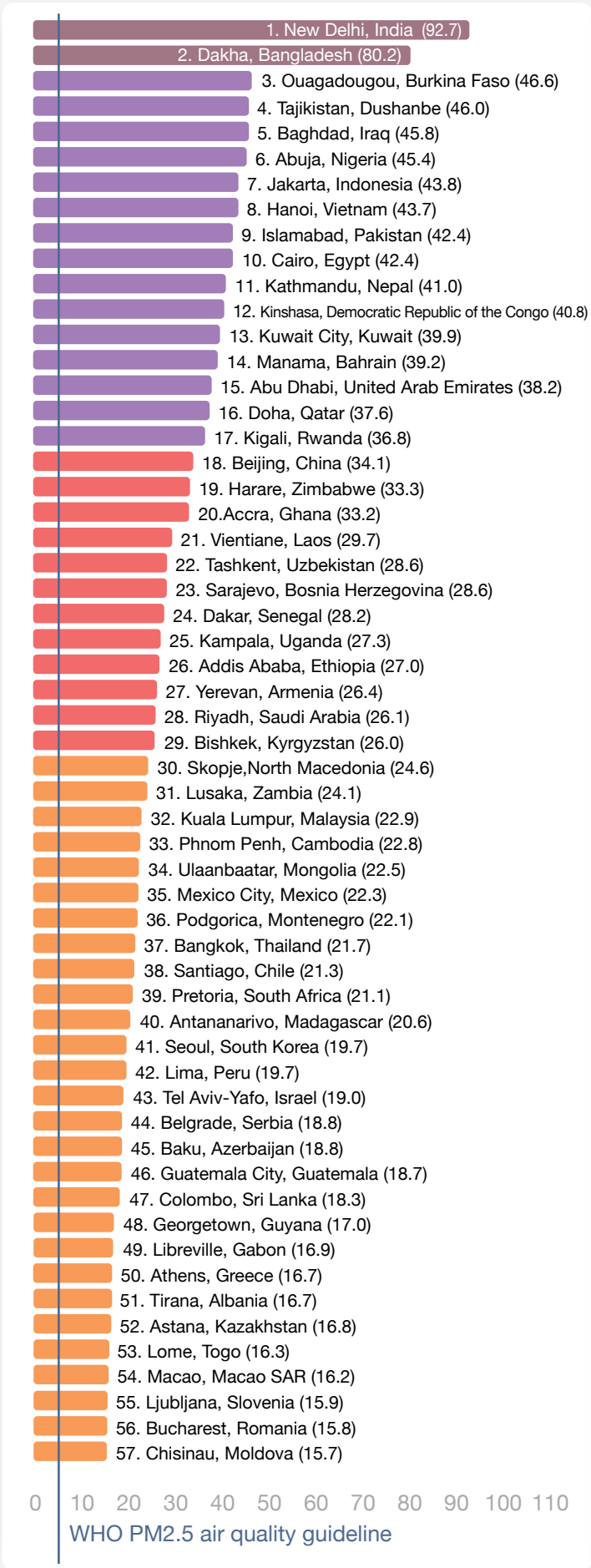
2023 Country/region ranking

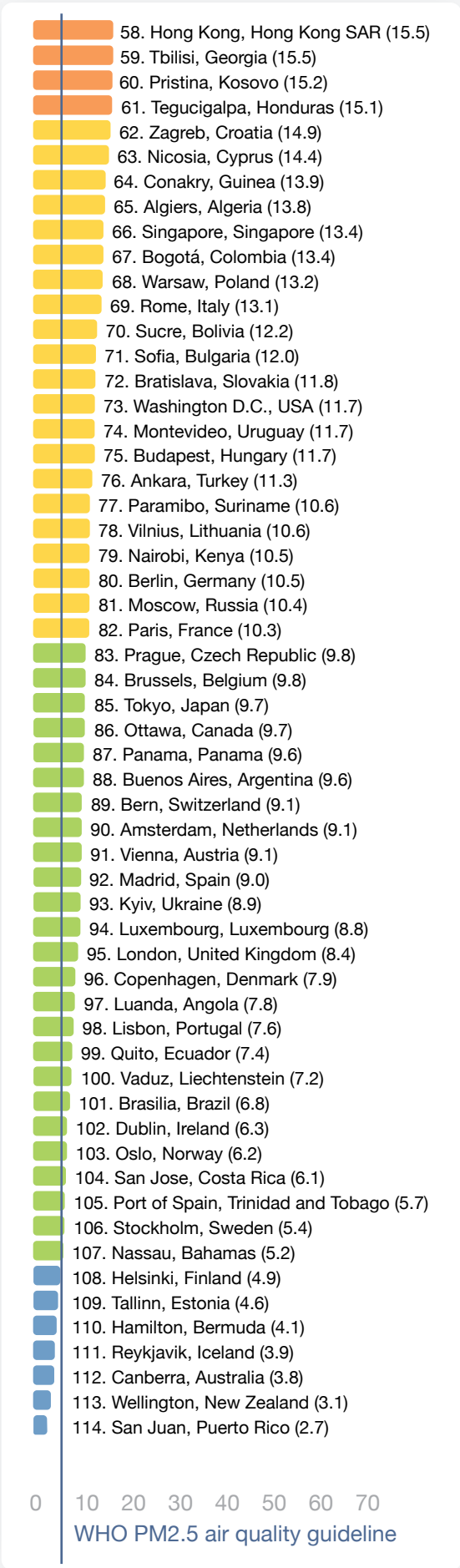
Population weighted, 2023 average PM2.5 concentration (μg/m³) for countries, regions, and territories in descending order.

1	Bangladesh	79.9	46	Mexico	20.1	91	Suriname	10.6
2	Pakistan	73.7	47	South Africa	19.9	92	Lithuania	10.4
3	India	54.4	48	El Salvador	19.5	93	Canada	10.3
4	Tajikistan	49.0	49	Sri Lanka	19.3	94	Russia	10.0
5	Burkina Faso	46.6	50	South Korea	19.2	95	Spain	9.9
6	Iraq	43.8	51	Peru	18.8	96	Japan	9.6
7	United Arab Emirates	43.0	52	Azerbaijan	18.8	97	Panama	9.6
8	Nepal	42.4	53	Chile	18.8	98	Austria	9.6
9	Egypt	42.4	54	Guatemala	18.7	99	France	9.5
10	Dem. Rep. of the Congo	40.8	55	State of Palestine	18.6	100	Belgium	9.4
11	Kuwait	39.9	56	Israel	17.8	101	Argentina	9.2
12	Bahrain	39.2	57	Greece	17.4	102	USA	9.1
13	Qatar	37.6	58	Guyana	17.1	103	Germany	9.0
14	Indonesia	37.1	59	Gabon	16.9	104	Switzerland	8.9
15	Rwanda	36.8	60	Albania	16.7	105	Luxembourg	8.9
16	Zimbabwe	33.3	61	Ivory Coast	16.6	106	Netherlands	8.7
17	Ghana	33.2	62	Georgia	16.4	107	Ukraine	8.6
18	Kyrgyzstan	33.1	63	Togo	16.3	108	Belize	8.3
19	China	32.5	64	Macao SAR	16.2	109	Latvia	8.0
20	Libya	30.4	65	Moldova	15.7	110	Andorra	7.9
21	Laos	29.6	66	Nicaragua	15.7	111	Angola	7.8
22	Vietnam	29.6	67	Romania	15.7	112	United Kingdom	7.7
23	Uzbekistan	28.6	68	Hong Kong SAR	15.6	113	Denmark	7.7
24	Gambia	28.5	69	Maldives	15.3	114	Anguilla	7.4
25	Myanmar	28.2	70	Honduras	15.1	115	Ecuador	7.4
26	Senegal	28.2	71	Italy	15.0	116	Liechtenstein	7.2
27	Bosnia Herzegovina	27.5	72	Slovenia	14.9	117	Jamaica	7.1
28	Uganda	27.3	73	Cyprus	14.3	118	Portugal	6.8
29	Ethiopia	27.0	74	Poland	14.1	119	Ireland	6.3
30	Saudi Arabia	26.5	75	Colombia	14.1	120	Norway	6.3
31	Armenia	26.4	76	Guinea	13.9	121	Costa Rica	6.1
32	North Macedonia	25.2	77	Croatia	13.8	122	Trinidad and Tobago	5.8
33	Zambia	24.1	78	Algeria	13.8	123	Bahamas	5.2
34	Cameroon	24.0	79	Philippines	13.5	124	Sweden	5.1
35	Nigeria	23.9	80	Singapore	13.4	125	Finland	4.9
36	Thailand	23.3	81	Bulgaria	13.2	126	Estonia	4.7
37	Cambodia	22.8	82	Slovakia	13.1	127	Puerto Rico	4.5
38	Malaysia	22.5	83	Brazil	12.6	128	Australia	4.5
39	Mongolia	22.5	84	Bolivia	12.6	129	New Zealand	4.3
40	Kazakhstan	22.2	85	Kosovo	12.1	130	Bermuda	4.1
41	Montenegro	21.3	86	Malta	12.0	131	Grenada	4.1
42	Madagascar	20.6	87	Hungary	12.0	132	Iceland	4.0
43	Serbia	20.5	88	Uruguay	11.7	133	Mauritius	3.5
44	Turkey	20.3	89	Czech Republic	11.5	134	French Polynesia	3.2
45	Taiwan	20.2	90	Kenya	10.6			

2023 Regional capital city ranking

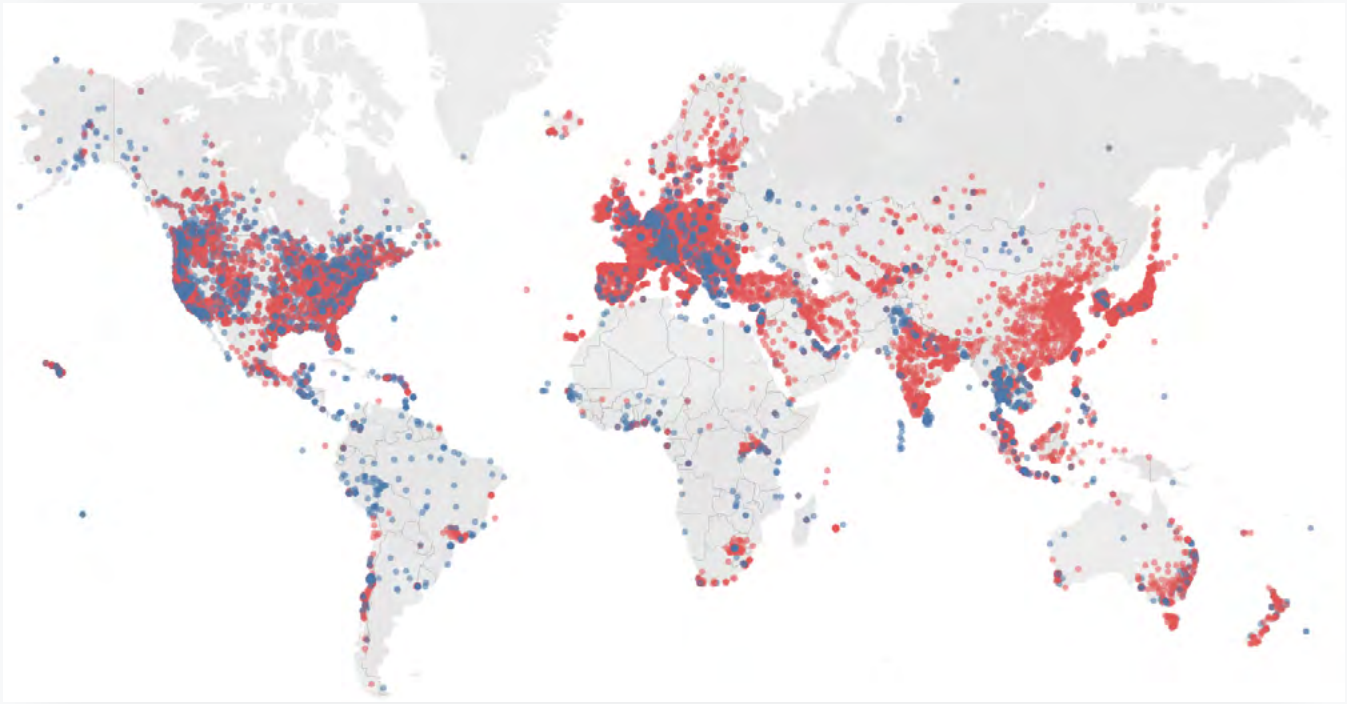
Population weighted, 2023 average PM2.5 concentration (μg/m³) for countries, regions, and territories in descending order





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. Blue markers denote independently operated monitoring stations, while red markers indicate government-operated stations.

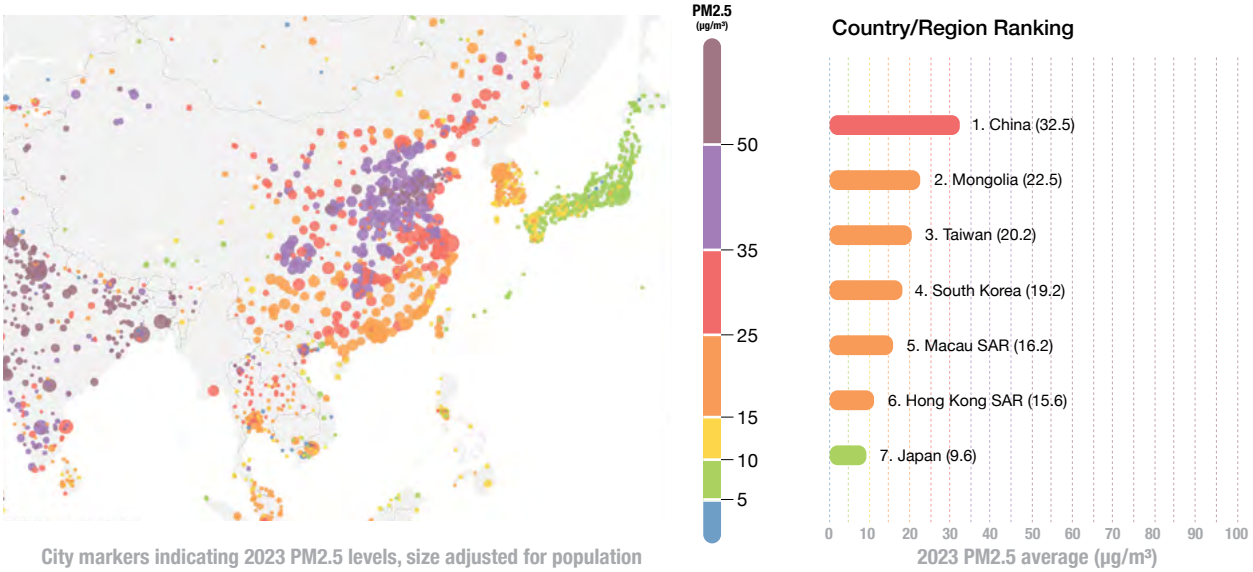
A map illustrating the global distribution of air quality monitoring stations reveals significant disparities in real-time air quality data accessibility for the public. In regions heavily affected by pollution, where effective air quality monitoring is crucial, the availability of data is at times uncertain. Notable countries not included in the 2023 report due to a lack of publicly available monitoring data include the African nations of Chad (2022 rank: 1) and Sudan (2022 rank: 12) and the West Asian country of Iran (2022 rank: 21).

Continuous progress in the development of cost-effective monitors has established them as a practical public alternative in countries, regions, and territories where government-operated air quality monitoring stations are absent. These technological advancements facilitate easy deployment and operation even in remote areas. The affordability of these monitors mitigates economic barriers, as their minimal maintenance costs make it feasible to establish a dense network of stations. In 2023, independently operated low-cost air quality monitoring provided the only real-time air quality data for Afghanistan*, Albania, Angola, the Bahamas, Barbados*, Bermuda, Bolivia, Cambodia, Cape Verde*, Cayman Islands, Djibouti*, Dominican Republic*, Ecuador, French Polynesia, Gabon, Gambia, Greenland*, Grenada, Guyana, Honduras, Jamaica, Jersey*, Lebanon*, Libya, Maldives, Mauritius, Montserrat*, Morocco*, Mozambique*, Namibia*, Nicaragua, Niger, Oman*, Panama, Papua New Guinea*, Suriname, Tanzania*, Timor Leste*, Tonga*, Trinidad and Tobago, U.S. Virgin Islands*, Uruguay, Venezuela, Zambia, and 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

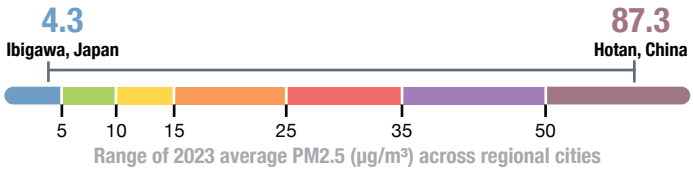
China Mainland | Hong Kong SAR | Japan | Macau SAR | Mongolia | South Korea | Taiwan



City markers indicating 2023 PM2.5 levels, size adjusted for population

0.2%

Regional cities that met the WHO annual PM2.5 guideline in 2023



Range of 2023 average PM2.5 (μg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Hotan, China	87.3
2	Kashgar, China	72.3
3	Aksu, China	58.8
4	Kizilsu, China	54.2
5	Linfen, China	51.7
6	Puyang, China	51.6
7	Shihezi, China	51.3
8	Xianyang, China	51.1
9	Anyang, China	50.6
10	Hebi, China	50.2
11	Yigou, China	50.2
12	Shahecheng, China	49.5
13	Xinxiang, China	49
14	Changji, China	48.7
15	Yanliang, China	48.6

Least Polluted Regional Cities

Rank	City	2023
1	Ibigawa, Japan	4.3
2	Godo, Japan	4.4
3	Ngari, China	5.5
4	Nyingchi, China	5.5
5	Ogasawara, Japan	5.8
6	Shingu, Japan	5.8
7	Suzu, Japan	5.9
8	Hengchun Township, Taiwan	5.9
9	Guanshan, Taiwan	6.1
10	Wajima, Japan	6.2
11	Gero, Japan	6.3
12	Minami Ward, Japan	6.2
13	Tsubata, Japan	6.4
14	Kamaishi, Japan	6.4
15	Uchinada, Japan	6.5

SUMMARY

In 2023, the region of East Asia included data from 1,285 cities from seven different countries and territories. China, Macau SAR, Hong Kong SAR, Taiwan, Japan, and South Korea all had increases in their annual average PM2.5 concentrations, while Mongolia showed a decrease in their annual average PM2.5 concentration. Taiwan experienced the largest change in annual PM2.5 concentration with a 50% increase from 13.4 μg/m³ in 2022 to 20.2 μg/m³ in 2023. Mongolia recorded a nearly 25% decrease to continue a downward trend in their annual PM2.5 concentration from 2022.

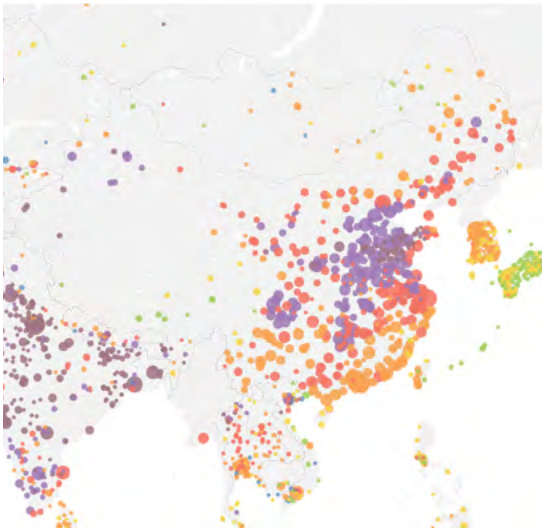
The increases in concentrations in 2023 in Taiwan and Hong Kong SAR mark their return to the WHO interim target 2 level, with annual PM2.5 concentrations rising above 15 μg/m³. Mongolia's decrease in annual average PM2.5 concentration below 25 μg/m³ were sufficient to achieve the WHO interim target 2 level. Of the 1,285 cities in the region, the annual average PM2.5 concentrations for 870 cities had increased, remained constant for 28 cities, and decreased for 276 compared to 2022. In 2023, two regional cities, Ibigawa, Japan and Godo, Japan, achieved the WHO annual PM2.5 guideline concentration of 5 μg/m³.

Despite a three-year downward trend in annual average PM2.5 concentrations, Hotan continues to remain the most polluted city in the region, in 2023 with an annual average of 87.3 μg/m³. Hotan is one of 11 regional cities whose annual average exceeds the WHO annual PM2.5 guideline by 10 times or more, all of which are in China. The least polluted city in the region is Ibigawa, Japan which posted an annual average concentration of 4.3 μg/m³.

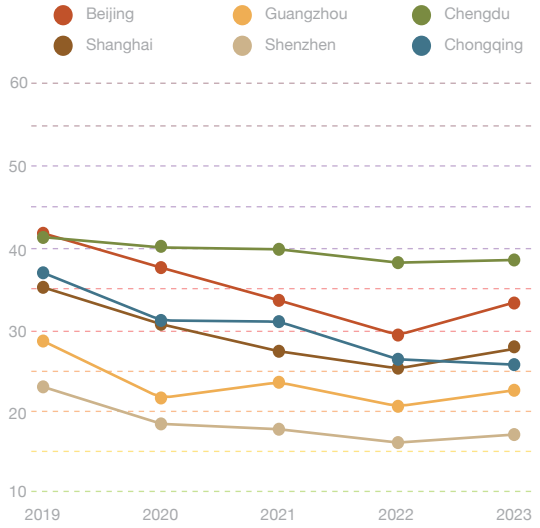
MONITORING STATUS

Government-operated monitoring stations in East Asia continue to provide some of the best monitoring coverage of any region in the world. China, Japan, and South Korea maintain expansive networks of government-operated stations producing 100%, 99%, and 81% of the country's publicly reported air quality data, respectively. Japan continues to provide the highest spatial monitoring resolution in the region. Japan is home to the greatest number of new cities added in 2023 with 51. Government-operated monitors accounted for over 97% of air quality data generated for this specific region in this report.

CHINA MAINLAND



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Beijing	34.1	32.0	53.9	58.6	41.4	30.0	19.4	18.2	21.0	27.0	35.9	30.1	43.2	29.8
Chengdu	39.0	74.0	60.6	38.3	32.6	30.4	23.1	20.9	17.0	24.0	28.9	44.5	72.1	38.3
Chongqing	25.4	54.1	38.7	24.5	22.8	18.9	13.1	10.7	13.4	14.4	17.8	30.0	47.2	26.0
Guangzhou	23.5	29.0	32.7	31.1	23.6	22.1	15.3	12.6	15.7	16.2	23.3	30.6	30.2	21.3
Shanghai	28.7	36.5	28.0	31.3	32.5	28.3	26.8	17.8	16.1	19.3	23.9	33.4	48.5	25.4
Shenzhen	17.1	24.2	20.2	22.6	18.3	17.6	8.4	8.0	10.4	10.2	17.4	22.4	24.9	15.7

PROGRESS

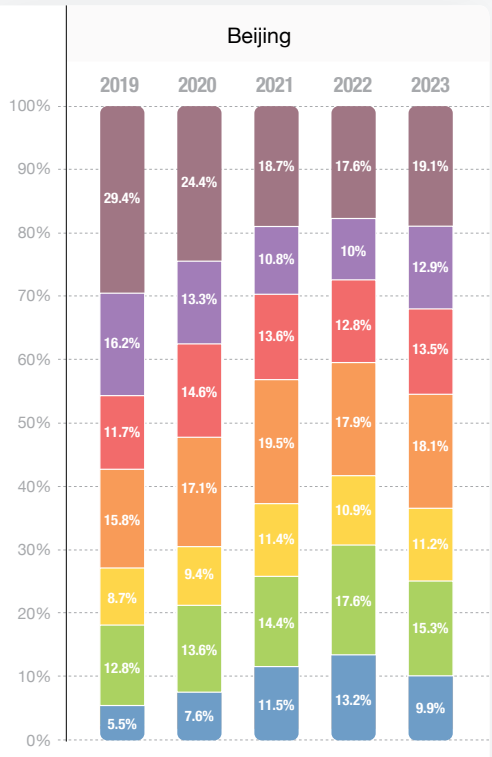
China's five-year historic trend of declining PM2.5 concentrations ended in 2023 following a 6.3% increase in PM2.5 levels with an annual average concentration of 32.5 μg/m^3. This long-term trend reversal was evident in the capital city of Beijing, where citizens there experienced a 14% increase in the annual average PM2.5 concentration. Air quality in China varies across different regions due to a combination of factors, including diverse geographical features, industrial activities, and sources of pollution. Provinces such as Hebei and Henan show higher pockets of pollution with nearly 75% of provinces' cities reporting annual average PM2.5 concentrations seven to ten times the recommended WHO annual PM2.5 guideline value. Air quality conditions in the province of Tibet remain consistent with those reported 2022 with 90% of cities reporting annual averages between 5 and 10 μg/m^3.

CHALLENGES

China has transformed its air quality for the better over the past decade thanks to a government campaign to curb air pollution.[11] However, thick smog returned to Beijing, major cities like Tianjin, and numerous provinces for several days in the spring and fall of 2023.[12] Following these incidents, China's state council released an action plan in December to reduce coal consumption in northern China.[13] 70% of China's emissions can be attributed to coal power.[14] China's air quality was also impacted by dust storms, coal production, industry, household solid biomass fuel burning, and transportation.[15,16]

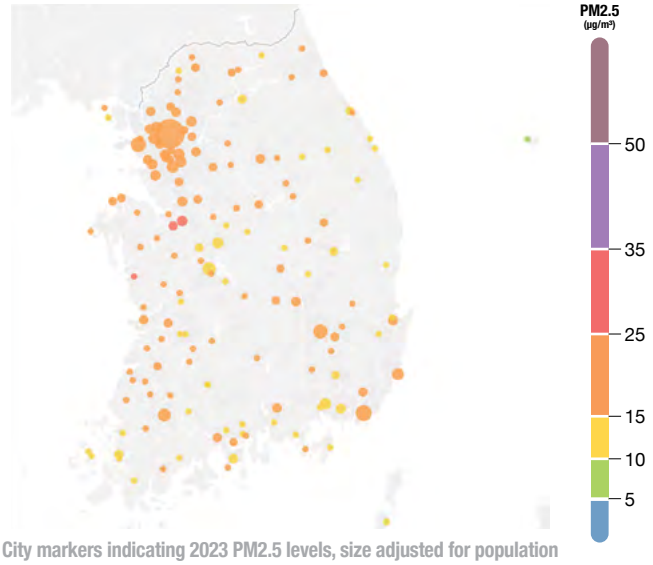
HIGHLIGHT: COAL-FIRED POWER PLANT PERMITS

China is the world's largest emitter of greenhouse gases, emitting 12.7 billion metric tons of carbon dioxide annually.[17] The country has committed to reach peak carbon dioxide emissions by 2030, to becoming carbon-neutral by 2060, and increasing non-fossil fuel energy sources. However, China increased approvals for coal-powered power plants, with 243 gigawatts of coal-fired capacity permitted or under construction in 2023.[18,19] This recently accelerated permitting jeopardizes country's ability to meet its goals and commitments.

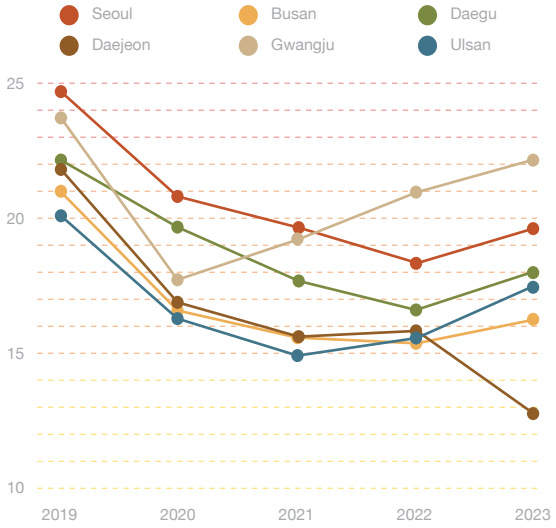


Annual hours spent at different PM2.5 pollution levels

SOUTH KOREA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Seoul	19.7	25.3	29.9	30.2	21.5	18.3	17.0	16.4	12.9	11.2	15.0	17.0	21.8	18.3
Busan	16.2	21.2	21.6	22.8	19.3	16.6	13.7	12.1	9.5	9.0	13.1	15.8	20.0	15.3
Daegu	18.0	24.1	27.4	25.4	19.8	16.7	14.1	14.1	10.3	9.3	14.3	17.9	22.7	16.7
Daejeon	12.8	16.9	22.0	17.9	15.3	9.9	8.9	9.1	7.9	6.9	9.8	10.9	18.9	15.8
Gwangju	22.2	26.3	37.6	30.9	22.3	18.4	18.6	15.5	17.4	15.5	18.1	19.8	26.4	21.0
Ulsan	17.3	21.5	22.4	23.3	19.8	18.2	17.1	17.2	12.5	10.5	14.1	14.4	17.4	15.5

PROGRESS

In 2023, South Korea reversed recent trends of declining annual average PM2.5 concentration, seeing a 5% increase in 2023 (19.2 μg/m³) compared to 2022 (18.3 μg/m³). There were increases in the key cities of Seoul, Busan, Daegu, Incheon, and Ulsan. Seoul, the capital and most populous city, posted an increase of over 7% to return to the 2021 annual average PM2.5 concentration of 19.7 μg/m³. Daejeon was the only key city to reduce their concentration in 2023, dropping from 15.8 μg/m³ in 2022 to 12.8 μg/m³ in 2023. No cities in South Korea achieved the WHO PM2.5 guideline level of 5 μg/m³ in annual or monthly average concentrations. The country saw concentrations increase in 44 cities out of 76 total cities included in the report.

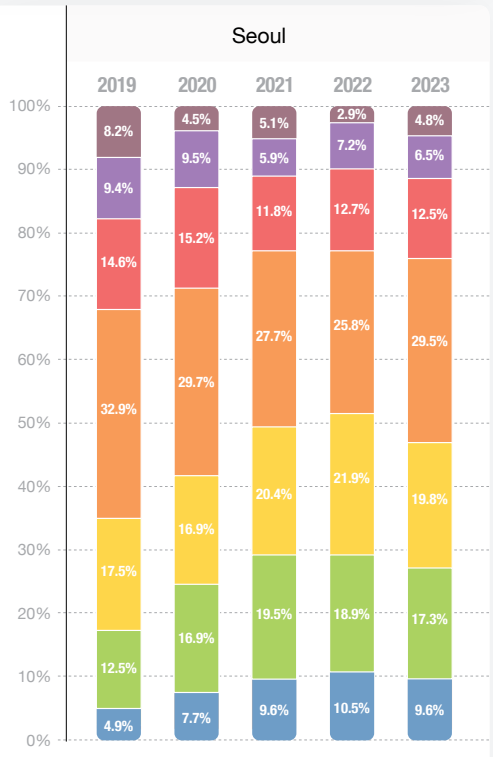
CHALLENGES

South Korea's air pollution stems largely from manufacturing and industrial pollution, city vehicle emissions, and dust and sand from the Gobi Desert. While yellow, desert sand-filled skies are a natural springtime phenomenon, the number of dust storms has risen since the 1960's.[20] Climate change is expanding the Gobi and is impacting health across East Asia.

South Korea's 57 coal-fired plants are a major source of air pollution.[21] To combat this health threat, the country is implementing new air pollution controls, is shifting 24 of the plants to natural gas, and will shutter an additional 30 plants by 2034.

HIGHLIGHT: TRANSBOUNDARY INDUSTRIAL POLLUTANTS

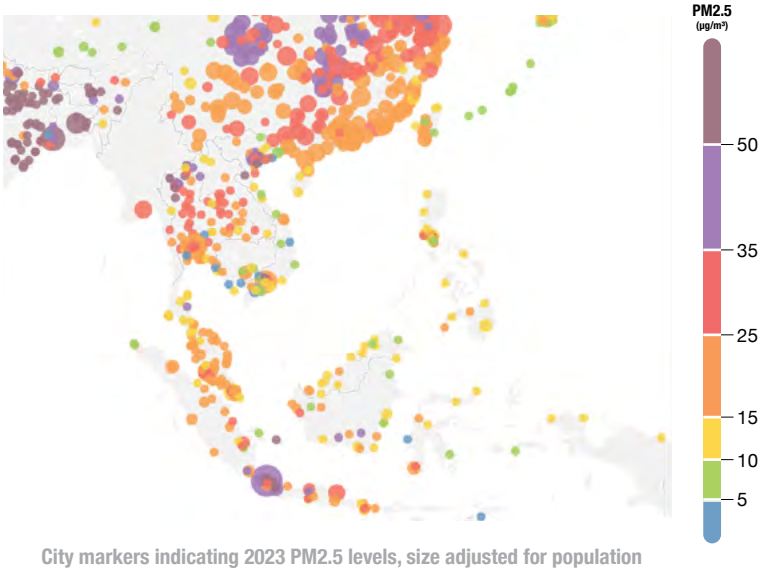
While South Korea faces air pollution from its own industrial and energy production activity, pollution from its neighbors can also play a considerable role. In the fall and winter, prevailing winds blow west across East Asia. Those winds can carry PM2.5 sourced from coal-burning power plants in northern China into South Korea.[22] The country's more immediate neighbor, North Korea, likely plays an even greater role in impacting South Korean air quality. Research and estimations of North Korea's emissions hypothesize that the country has produced roughly similar or less amounts of PM2.5 emissions in comparison to South Korea, while carbon monoxide and sulfur oxide emissions are estimated to be 2.7 times greater.[23]



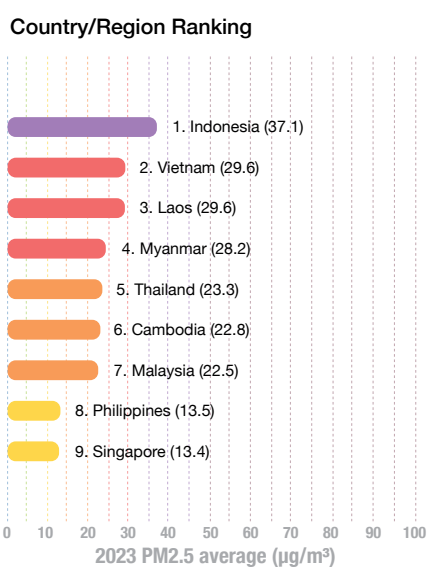
Annual hours spent at different PM2.5 pollution levels

SOUTHEAST ASIA

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



City markers indicating 2023 PM2.5 levels, size adjusted for population

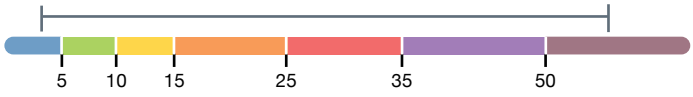


0.9%

Regional cities that met the WHO annual PM2.5 guideline in 2023

3.7
Mamuju, Indonesia

71.7
South Tangerang, Indonesia



Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	South Tangerang, Indonesia	71.7
2	Tay Ho, Vietnam	61.5
3	Tangerang, Indonesia	54.1
4	Chiang Rai, Thailand	50.8
5	Pai, Thailand	50.3
6	Hoan Kiem, Vietnam	50.2
7	Bekasi, Indonesia	49.9
8	Wiang Phang Kham, Thailand	43.9
9	Jakarta, Indonesia	43.8
10	Hanoi, Vietnam	43.7
11	Pong Yang Khok, Thailand	40.1
12	Nai Wiang, Thailand	39.9
13	Bandung, Indonesia	39.6
14	Wiang Nuea, Thailand	39.4
15	Nong Jom, Thailand	38.1

Least Polluted Regional Cities

Rank	City	2023
1	Mamuju, Indonesia	3.7
2	Kupang, Indonesia	4.6
3	Tra Vinh, Vietnam	5.6
4	Bongawan, Malaysia	6.7
5	Ban Klang, Thailand	8.1
6	Calamba, Philippines	8.2
7	Kendari, Indonesia	8.5
8	Kathu, Thailand	8.5
9	Carmona, Philippines	8.9
10	Indrapuri, Indonesia	9.1
11	Balanga, Philippines	9.2
12	Sandakan, Malaysia	9.6
13	Banda Aceh, Indonesia	9.8
14	Balikpapan, Indonesia	9.8
15	Kapit, Malaysia	10.3

SUMMARY

Climate conditions intensified existing air quality issues in Southeast Asia in 2023, with El Niño conditions delaying the onset of the rainy season and its mitigating impact on PM2.5 levels. The primary sources of PM2.5 in the region continue to be power generation, industry, vehicle emissions, and open burning. Transboundary haze has become a critical regional issue, leading the Association of Southeast Asian Nations (ASEAN) to establish the Coordinating Center for Transboundary Haze Pollution Control (ACC THPC) in 2023. ACC THPC aims to coordinate regional efforts in combating this problem.[24]

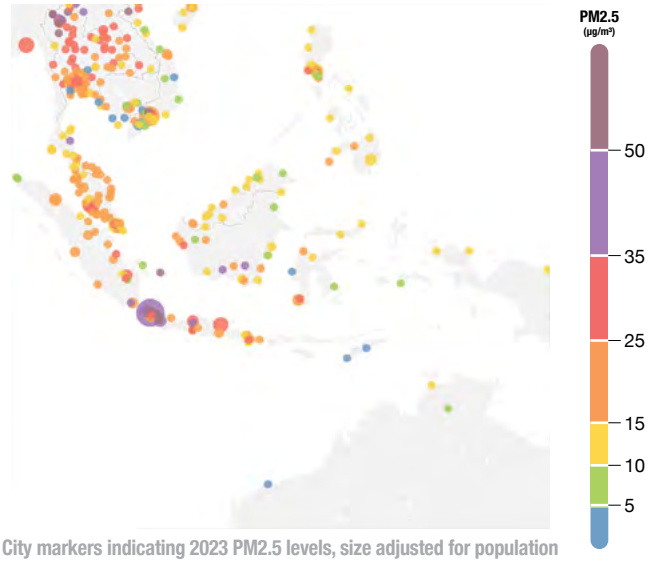
PM2.5 concentrations rose in eight of nine countries in the Southeast Asia region compared to 2022; only the Philippines experienced a reduction in annual average concentrations, with a 10% drop in annual average PM2.5 levels compared to 2022. Indonesia again ranked as the region's most polluted country (ranking 14th globally), 2023 experiencing a 20% increase in PM2.5 levels compared to 2022. Despite being the region's least polluted country in 2022, Cambodia saw annual average PM2.5 levels nearly triple in 2023 resulting in Singapore ranking as the least polluted regional country in 2023.

Of the 357 cities included in Southeast Asia, only three achieved the WHO annual PM2.5 guideline value of 5 µg/m³, down from eight regional cities in 2022. Broad increases in PM2.5 levels were seen in 2023 as seven regional cities in Indonesia, Vietnam, and Thailand exceeded the WHO annual PM2.5 guideline recommended levels by more than ten times in 2023, compared to 2022 when no city exceeded an annual average concentration of 50 µg/m³.

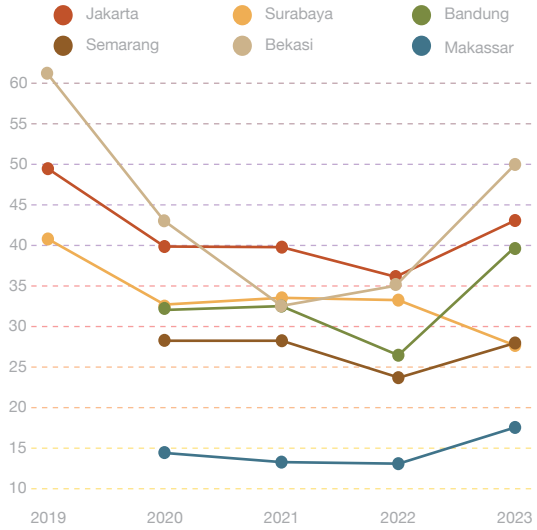
MONITORING STATUS

The Southeast Asia region is represented in 2023 by 357 cities in nine countries, a 51 city increase from 2022. Thailand has the greatest number of ground-based monitors in the region, hosting more than 67% of all air quality stations producing publicly available air quality data in Southeast Asia. This region depends heavily on non-government operated air quality monitoring stations to provide publicly available air quality data for its citizens. Non-government operated air quality monitoring stations produce more than 60% of each country's data for Southeast Asia. Malaysia is the outlier with 19% non-government operated station data, showing a strong government commitment to monitoring air quality.

INDONESIA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Jakarta	43.8	20.6	19.2	31.2	28.4	49.8	48.7	55.3	58.3	53.0	61.1	53.0	44.3	36.2
Surabaya	27.6	25.3	18.4	24.1	16.4	19.9	21.2	31.3	31.2	26.2	36.9	39.8	39.7	34.4
Bandung	39.6	23.0	17.8	31.2	30.2	43.3	43.1	37.3	52.7	42.5	53.1	49.8	49.1	26.1
Semarang	28.1	20.8	18.6	23.4	24.1	31.6	24.7	20.0	37.2	31.4	38.2	35.4	30.4	24.3
Bogor	49.9	34.1	22.9	39.6	38.0	71.5	76.9	76.6	60.4	51.4	46.8	47.2	36.6	35.4
Makassar	17.4	10.4	9.5	11.3	11.7	18.4	17.7	20.5	22.6	27.1	26.8	24.8	11.9	13.2

PROGRESS

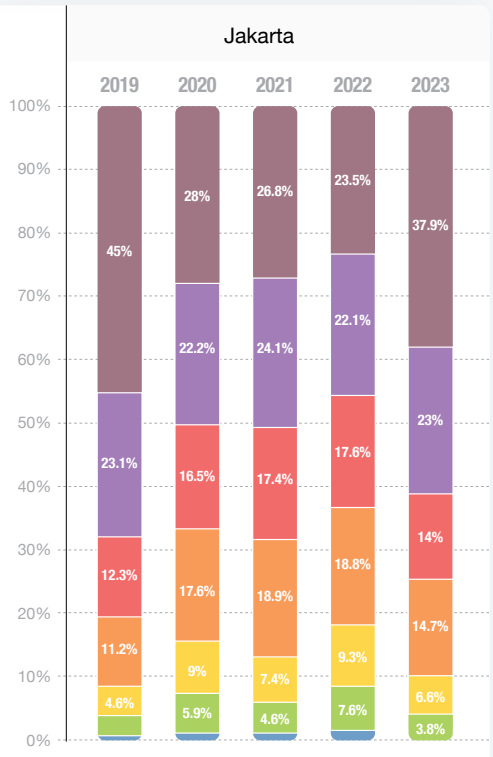
Indonesia's annual average PM2.5 concentration rose sharply in 2023 to 37.1 μg/m³, up more than 20% compared to 2022. The capital city of Jakarta increased by the same proportions, with a 21% increase in concentration from 36.2 μg/m³ in 2022 to 43.8 μg/m³ in 2023. in 2023, El Niño conditions extended the dry season later into the year contributing to Jakarta's air pollution levels peaking later than usual.[25] In 2022, monthly average PM2.5 levels peaked from June through July; however, in 2023 peak PM2.5 levels did not occur until October. The delayed start of the rainy season contributed to October's average monthly concentration nearly doubling from the same time in 2022 (2023: 61.1 μg/m³, 2022: 32.1 μg/m³).

CHALLENGES

Most air pollutants in Indonesia come from coal-fired power plants, forest fires, and peatland slash and burn clearing in Sumatra and Kalimantan for agricultural development.[26,27] Air pollution can be most acute during the country's dry season, typically occurring from July to September, but can be impacted by changing meteorological conditions.[28] Major cities also struggle with vehicle emissions. Officials have responded by promoting electric vehicles, creating bike lanes in Jakarta, and encouraging public transportation. Though no new coal-fired power plants can be built after 2023, those currently under construction can be completed and operated until 2050.

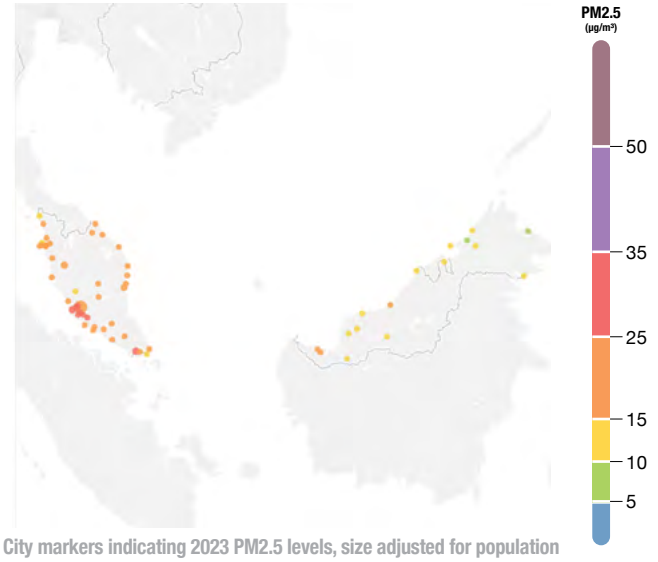
HIGHLIGHT: SUPREME COURT RULES AGAIN FOR ACTIVISTS

The Indonesian government has been criticized by activists for being slow to respond to a landmark case following the 2021 ruling issued by the Central Jakarta District Court finding central and local government officials guilty of negligence for failing to improve air quality in the capital city of Jakarta.[29] Ongoing legal battles have delayed the enforcement of the ruling, including a provision for revision of the country's PM2.5 air quality standard in accordance with the WHO annual PM2.5 guideline. In November 2023, appeal attempts by the administration of President Widodo were exhausted when the Supreme Court rejected a cassation petition, thereby finalizing the original ruling from 2021.

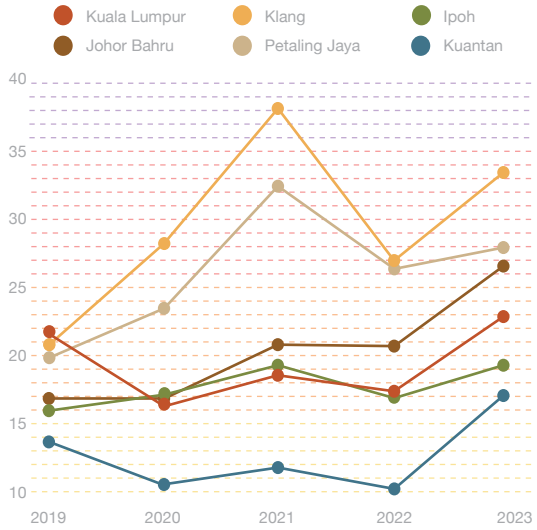


Annual hours spent at different PM2.5 pollution levels

MALAYSIA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Kuala Lumpur	22.9	18.1	16.9	19.7	27.1	18.0	23.4	18.9	23.9	35.3	43.0	16.3	13.5	17.6
Klang	33.5	34.5	23.9	29.1	36.4	28.0	31.8	26.6	32.1	33.5	62.7	27.5	34.5	27.1
Ipoh	19.3	16.3	14.3	21.0	25.1	18.1	21.1	22.4	19.4	23.8	24.6	13.3	12.1	16.9
Johor Bahru	26.6	19.6	14.7	17.7	35.3	24.6	26.6	26.4	32.0	37.7	52.8	18.5	13.4	20.6
Petaling Jaya	28.0	21.6	20.4	21.9	35.3	28.6	31.9	22.5	27.6	38.3	46.7	20.0	20.2	26.5
Kuantan	17.1	9.6	10.2	12.1	21.2	18.0	25.1	15.1	18.4	28.5	30.8	7.8	6.1	10.3

PROGRESS

PM2.5 levels increased by nearly 30% in Malaysia in 2023, with annual averages rising to 22.5 μg/m³ compared to 17.7 μg/m³ in 2022. Nearly tripling 2022's monthly average of 14.5 μg/m³, October was the most polluted month in 2023 for Kuala Lumpur, the nation's capital, with a monthly average of 43 μg/m³. While annual averages increased for all 63 cities publicly reporting air quality data in 2023, Sungai Petani, the largest city in the state of Kedah, showed the smallest relative concentration increase with a rise of less than 1% with an annual average of 15.8 μg/m³. Kuching, the most populous city in the state of Sarawak, experienced the greatest increase in annual PM2.5 levels with a rise of nearly one and a half times compared to 2022. This increase was largely driven by the drastic rise in PM2.5 levels during the month of October when concentrations peaked at 51.8 μg/m³, exceeding the WHO annual PM2.5 guideline by more than ten times. No Malaysian city met the WHO annual PM2.5 guideline level in 2023.

CHALLENGES

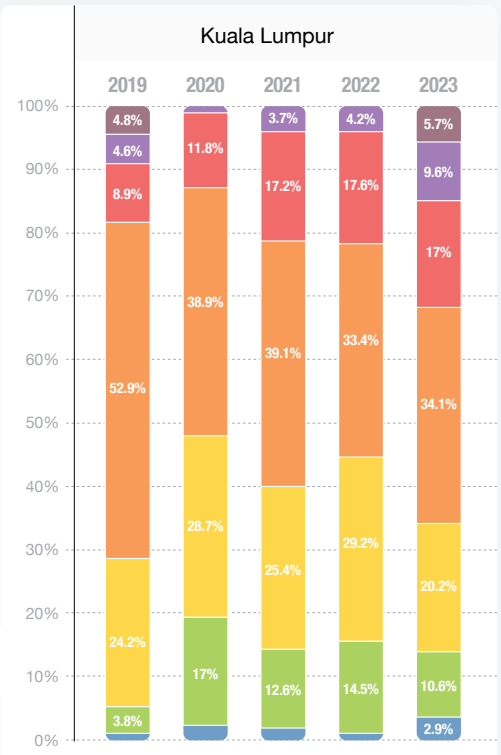
Vehicle emissions, rapid industrial growth and slash and burn agriculture (both domestic and foreign through transboundary smoke) are serious threats to air quality in Malaysia.[30] The strong El Niño weather pattern in 2023 extended the dry season, exacerbating air quality issues in the region. Deteriorating air quality conditions led to school closings in October to protect the health of children by limiting exposure to air pollution.[31]

Malaysia's Ministry of Natural Resources, Environment and Climate Change (NRECC) is trying to curb vehicular air pollution by promoting low carbon transportation projects, including turning to biodiesel for buses.[32] The country also intends to reduce vehicle emissions by deploying 885,000 EV cars by 2030.[33]

HIGHLIGHT: TRANSBOUNDARY HAZE FROM BURNING PEATBOGS

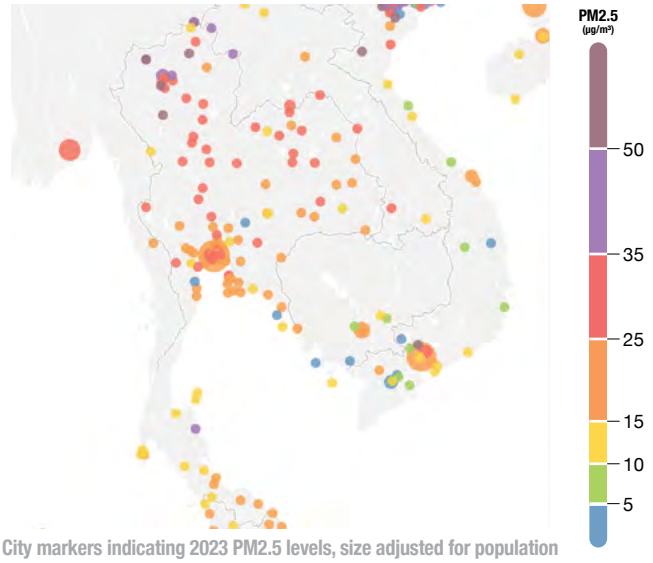
During Southeast Asia's dry season, plantation companies burn peatbogs for palm oil and paper products.[34] In 2023, Malaysia considered penalizing foreign companies for their contributions to transboundary haze[35]; however, the strategy was not pursued due to enforcement and evidence gathering difficulties.

In 2023 the Association of Southeast Asian Nations (ASEAN) established the Coordinating Center for Transboundary Haze Pollution Control (ACC THPC), an initial step to coordinate efforts in the region.[36] Greenpeace Southeast Asia has petitioned these governing bodies to address haze pollution sources through a regional legal framework, by regulating transparency and traceability from plantation companies, agribusiness, and supply chains, and for standardizing air quality indicators in ASEAN member states.[37]

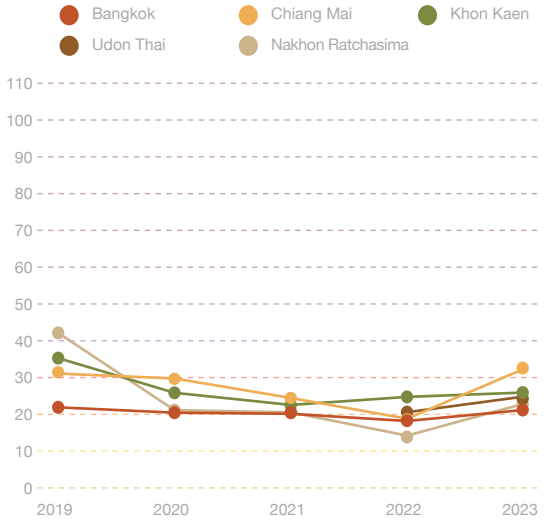


Annual hours spent at different PM2.5 pollution levels

THAILAND



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Bangkok	21.3	28.6	34.7	37.4	38.4	20.1	8.7	7.3	9.4	8.7	17.5	21	25.2	18.0
Chiang Mai	33.4	34.7	56.7	97.8	104.2	27.2	8.9	5.3	10.8	6.4	9.0	16.8	24.8	18.4
Khon Kaen	26.2	40.7	46.8	49.7	44.8	26.6	11.8	6.9	12.6	6.9	14.6	21.4	24.7	25.1
Udon Thani	24.2	29.0	39.2	50.3	49.8	26.2	12.7	9.6	14.3	9.7	13.6	18..0	19.3	21.6
Nakhon Ratchasima	22.7	19.9	42.7	51.5	41.3	24.0	9.9	7.0	10.2	7.4	13.7	20.8	24.2	13.9

PROGRESS

The annual average PM2.5 concentration rose 28% in Thailand in 2023, climbing from 18.1 µg/m³ in 2022 to 23.3 µg/m³. 2023 concentrations have returned to pre-pandemic levels and are on track to exceed 2019's recorded concentration of 24.3 µg/m³. The annual average in the capital city of Bangkok was up more than 20%, with an annual average PM2.5 level of 21.7 µg/m³ in 2023. The months of February to April were the most polluted period in 2023, when monthly averages for the 24 reporting cities in Chiang Mai province ranged from 53.4 to 106.4 µg/m³. For March and April this represents a 150% increase in PM2.5 concentrations compared to the same period in 2022. One city met the WHO annual PM2.5 guideline value of 5 µg/m³; the Bang Sao Thong district of Samut Prakan province southeast of Bangkok saw a 20% decrease in its annual average due to significant drops in PM2.5 concentrations from June to December in 2023 as compared to 2022.

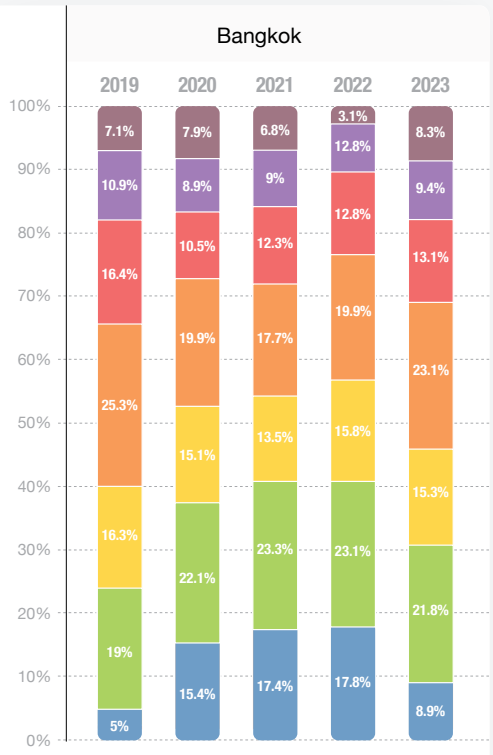
CHALLENGES

Agricultural burning, forest fires, industrial pollution, and vehicle emissions are all serious air quality and health concerns in Thailand.[38] Dry air from 2023's El Niño climate pattern has worsened the impacts. From December through April, smoke from stubble burning can make the Chiang Mai and northern Thailand particularly polluted. In April, authorities encouraged people to avoid going outdoors as the city became one of the most polluted cities in the world.[39] In November, Thailand's cabinet approved a draft clean air act designed to reduce industrial, agricultural, and transportation pollution.[40]

HIGHLIGHT: ACTIVISTS WIN KEY AIR QUALITY LAWSUITS

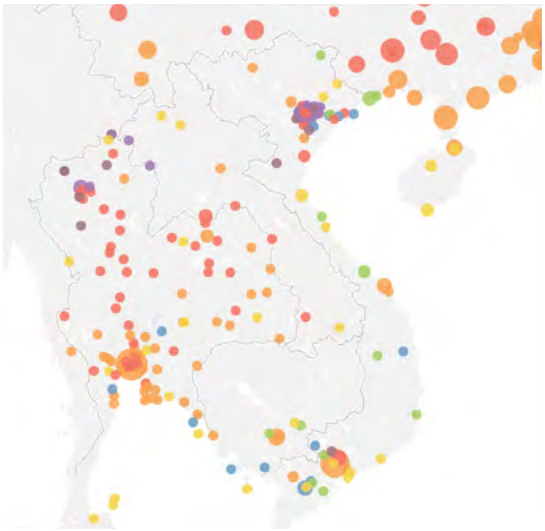
There were two significant air pollution lawsuit rulings in Thailand in 2023. In July, the Administrative Court in Chiang Mai ruled against the government for failing to control PM2.5 from factories and from large maize and sugar cane farms in Chiang Mai.[41,42]

The Central Administrative Court ruled in August that the government was required to release PM2.5 air pollution data gathered from a Pollutant Release and Transfer Register (PRTR) to the public by the end of October.[43,44] The registry documents which chemicals are being released by which factories, including where and how much of the pollutant has been released.

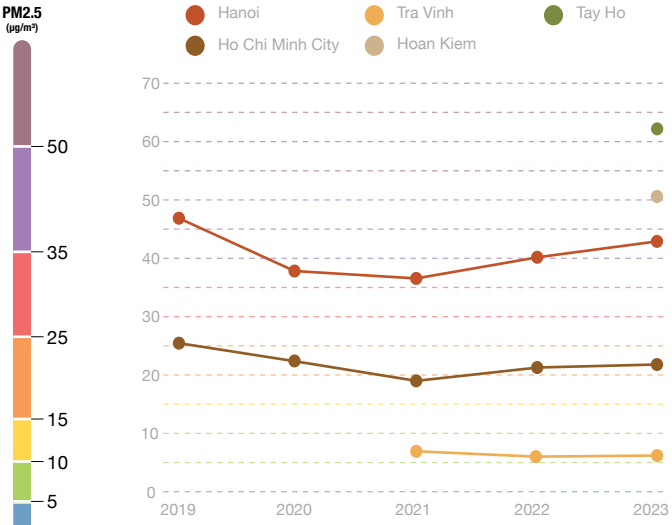


Annual hours spent at different PM2.5 pollution levels

VIETNAM



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Hanoi	43.7	73.8	46.1	54.4	47.3	33.8	27.0	22.0	28.2	30.8	40.7	58.6	61.3	40.1
Tra Vinh	5.6	NO DATA	5.9	6.2	6.1	5.7	4.6	5.5	6.2	5.7	5.1	5.5	5.2	5.5
Tay Ho	61.5	117.2	80.7	88.4	72.2	43.6	33.3	26.4	38.6	41.5	50.0	72.5	74.6	NO DATA
Ho Chi Minh City	21.8	21.1	24.8	24.1	26.4	19.8	15.5	15.5	14.8	17.1	26.3	31.9	24.4	21.2
Hoan Kiem	50.2	86.8	73.2	59.0	44.5	35.6	32.8	29.5	33.0	37.2	51.0	74.1	62.7	NO DATA

PROGRESS

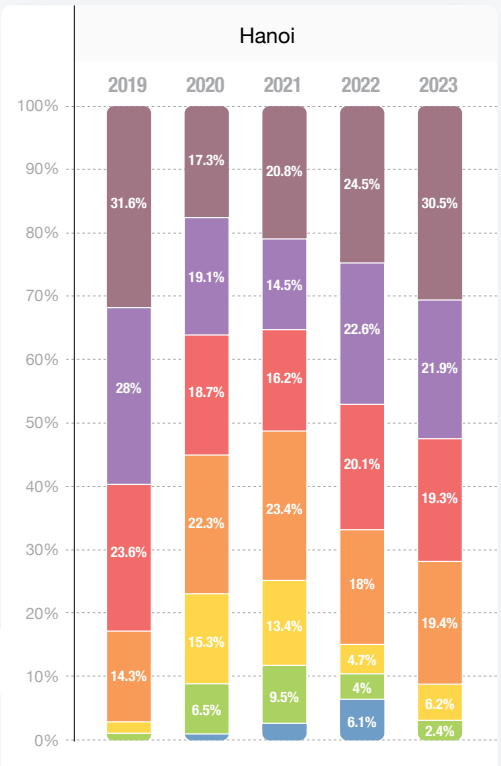
Vietnam's PM2.5 levels increased nearly 9% in 2023, now back to pre-pandemic concentrations, to an annual average of 29.6 µg/m^3 and tying with Laos as the second most polluted country in the region. For the third year in a row, nearly eight million people in Hanoi experienced escalating PM2.5 concentrations with levels rising 9% to 43.7 µg/m^3 in 2023, nearly nine times the WHO annual PM2.5 guideline. Every Vietnamese city with historical data for comparison experienced increased PM2.5 concentrations in 2023, with a third of included cities reporting annual concentrations exceeding the annual WHO annual PM2.5 guideline by seven to ten times. No city in Vietnam attained the WHO annual PM2.5 guideline level in 2023.

CHALLENGES

Air pollution sources in Vietnam include an aging fleet of vehicle, coal power plants, industrial activities, indoor coal and biomass cooking stoves, ineffective waste management practices, and agriculture.[45,46] According to the World Bank, 80% of rice straw is burned in the Mekong Delta after harvest, significantly contributing to pollution in the region.

HIGHLIGHT: JUST ENERGY TRANSITION PARTNERSHIP PROGRESS

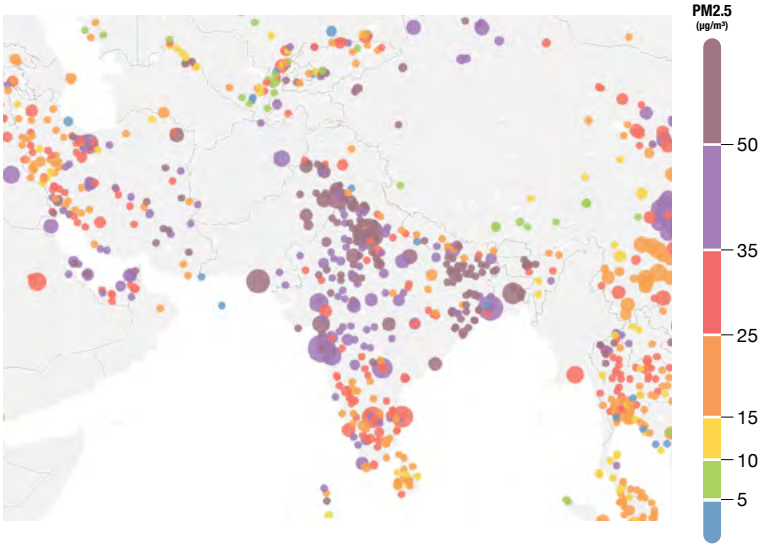
The launch of the Resource Mobilization Plan (RMP) in December 2023 marked a major milestone towards the implementation of Just Energy Transition Partnership (JETP). The RMP identified and prioritized key policy actions and regulatory reforms necessary to ensure the success of JETP, a multilateral program financing $15.8 billion in resources aimed at equitably reducing the country's reliance on fossil fuels, a key source of air pollution. The European Commission launch statement reiterated language from the JETP Political Declaration on the necessity of transparent involvement by civil society "at all stages of the JETP to make sure the necessary transition will be just and inclusive,"[47] possibly in response to the recent arrest and imprisonment of key NGO environmental leaders that have sparked public outcry.[48]



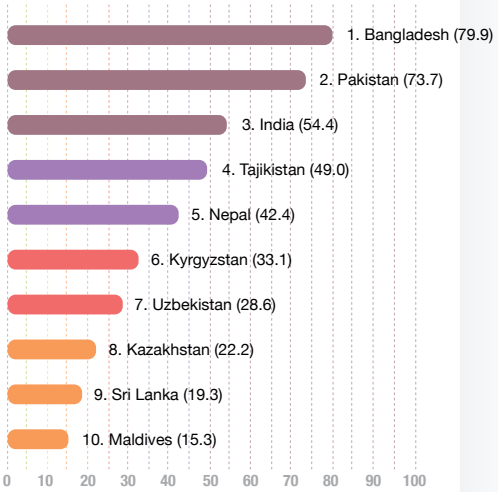
Annual hours spent at different PM2.5 pollution levels

CENTRAL & SOUTH ASIA

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



City markers indicating 2023 PM2.5 levels, size adjusted for population



0.9%

Regional cities that met the WHO annual PM2.5 guideline in 2023

1.5
Chu, Kazakhstan

118.9
Begusarai, India

5 10 15 25 35 50

Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Begusarai, India	118.9
2	Guwahati, India	105.4
3	Delhi, India	102.1
4	Lahore, Pakistan	99.5
5	Siwan, India	90.6
6	Saharsa, India	89.4
7	Goshaingaon, India	89.3
8	Katihar, India	88.8
9	Greater Noida, India	88.6
10	Bettiah, India	85.7
11	Samastipur, India	85.3
12	Muzaffarnagar, India	85.0
13	Gurugram, India	84.0
14	Arrah, India	83.6
15	Dadri, India	83.6

Least Polluted Regional Cities

Rank	City	2023
1	Chu, Kazakhstan	1.5
2	Shchuchinsk, Kazakhstan	3.0
3	Pervomayka, Kazakhstan	6.5
4	Kyzyl-Orda, Kazakhstan	6.9
5	Aktau, Kazakhstan	8.5
6	Zhanaozen, Kazakhstan	9.7
7	Silchar, India	10.1
8	Aizawl, India	11.3
9	Aqtobe, Kazakhstan	12.6
10	Turkestan, Kazakhstan	12.7
11	Kostanay, Kazakhstan	14.2
12	Pavlodar, Kazakhstan	14.3
13	Shetpe, Kazakhstan	15.4
14	Kokshetau, Kazakhstan	15.7
15	Damoh, India	16.1

SUMMARY

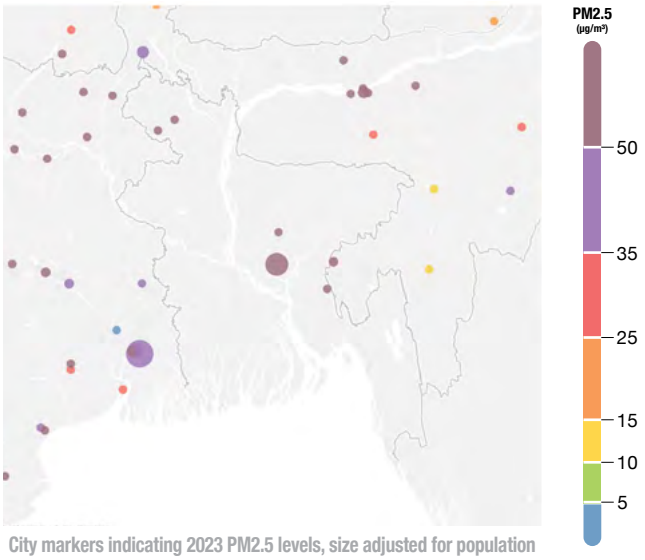
The Central and South Asia region reports data from ten nations. All four of 2023's most polluted countries in the world are hosted in this region, including Bangladesh, India, Tajikistan, and Pakistan. In addition, this region is home to the top ten most polluted global cities. Included are highly populated and historically polluted cities such as Delhi, India and Lahore, Pakistan. A breakdown of annual average PM2.5 concentrations per city indicates 31% of the region's cities reported concentrations more than ten times the WHO annual average guideline value, a proportion vastly exceeding any other region in the report. These cities include some of the region's most densely populated urban centers and are home to more than 44% of the region's population. Conversely, two cities in Kazakhstan reported annual average PM2.5 concentrations below 5 µg/m³, meeting the WHO annual PM2.5 guideline.

Consistent exposure to poor air quality can impact health outcomes for people exposed to polluted air. Brick kiln and other industrial emissions, agricultural waste burning, and cremation practices are common in the region. Combustion of solid fuel sources for cooking and heating during cold months creates an additional pollution burden. Geographical and climatological factors lead to the accumulation of air pollution in the densely populated Indo-Gangetic Plain. This low-lying landscape spans northern India, eastern Pakistan, and parts of Bangladesh. Pollutants generated in the region combine with pollutants brought into the region by winds blowing in from the coast where they become trapped by the Himalayas bordering the north. Temperature inversions further exacerbate the trapping effect by decreasing atmospheric mixing holding pollutants close to the earth's surface resulting in the worst air pollution conditions in the world.

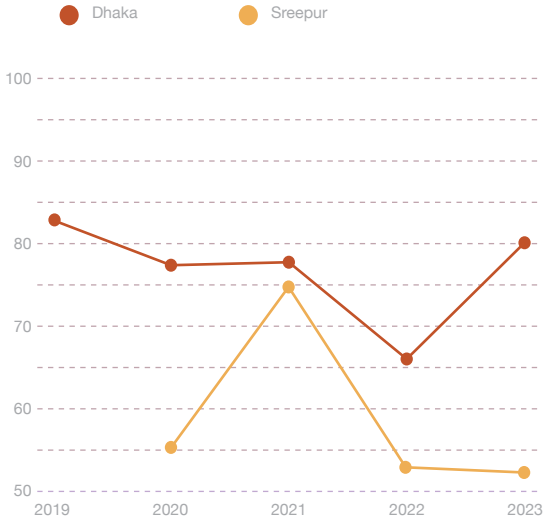
MONITORING STATUS

Across the region, most real-time data remains produced by government-operated monitoring stations, with more than 70% of the region's data coming from these sources. However, cities that have some of the highest pollution levels in the world, such as Lahore in Pakistan, Dhaka in Bangladesh, and Peshawar in Pakistan, have a much higher ratio of non-government-operated stations. 96% of the stations reporting data in those cities are not government-operated. This highlights the citizens' desire to monitor their own air in these areas and an example of places where government-operated station network expansion is needed.

BANGLADESH



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Dhaka	80.2	175.5	107.0	82.5	61.6	49.2	42.7	23.6	44.8	39.0	74.9	101.6	160.3	65.8
Sreepur	52.0	82.2	NO DATA	130.5	76.1	59.7	45.7	15.7	39.8	24.9	52.5	58.0	68.6	53.6

PROGRESS

Bangladesh recorded an annual average PM2.5 concentration of 79.9 µg/m^3, ranking number one among countries and territories in 2023. This marks the first increase in their average concentration since 2018. Dhaka, the capital and most populous city, recorded an annual average PM2.5 concentration of 80.2 µg/m^3. This represents pollution levels more than 16 times the concentration recommended by the WHO annual PM2.5 guideline. The city's concentration increased over 20% from 2022's mark of 65.8 µg/m^3. There were four months in 2023 where the monthly concentration averages were above 100 µg/m^3 and two months where the average breached 150 µg/m^3.

CHALLENGES

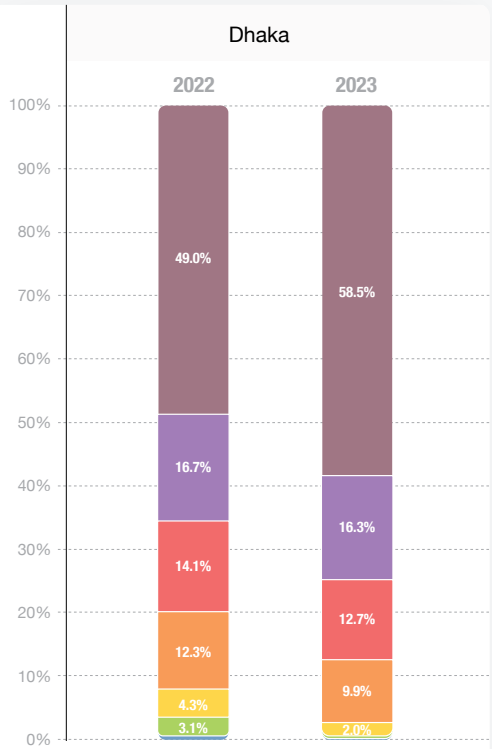
Bangladesh's air pollution is largely sourced from brick kilns and vehicle emissions.[49] Other factors impacting the country's air quality include surface dust, factories, household cookstoves, plastic trash incineration, and unlined landfills.

Air pollution in northern South Asia can be transboundary in nature, as pollutants converge and drift across the shared Indo-Gangetic Plain. Smoke from countries, including India, Nepal, and Pakistan, can drift into Bangladesh during crop burning season.[50,51]

HIGHLIGHT: EMISSIONS FROM BRICK KILNS

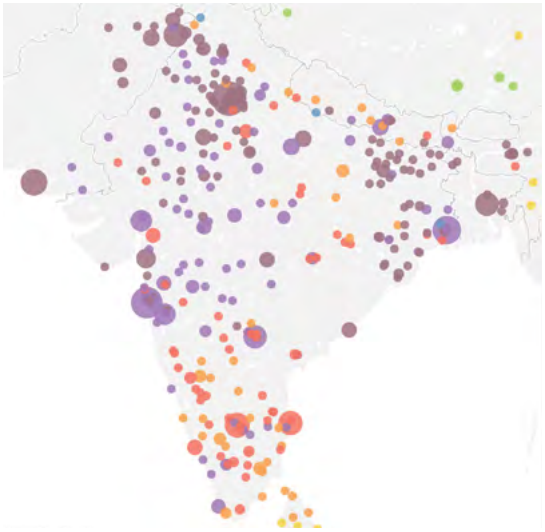
Bricks play an essential role in Bangladesh's construction sector due to a lack of naturally occurring rock in the flat alluvial plain which dominates up most of the country's geography.[52] Rapid urbanization has increased the demand for bricks, spurring the growth of widespread informal brick manufacturing during the dry winter months from November to April. Consequently, there are an estimated 8,000 brick kilns operating across the country. Most Bangladeshi kilns operate illegally; despite a 2013 law restricting where they can be built, 95% of the population lives within one kilometer of a brick kiln.[53]

Bangladesh's Department of the Environment under the Ministry of Environment, Forest and Climate Change has identified brick manufacturing as a major source of the country's air pollution.[54,55] To reduce the number of illegal kilns, the Ministry intends to use a brick kiln tracker to help improve enforcement and reduce pollution at the source.[56]

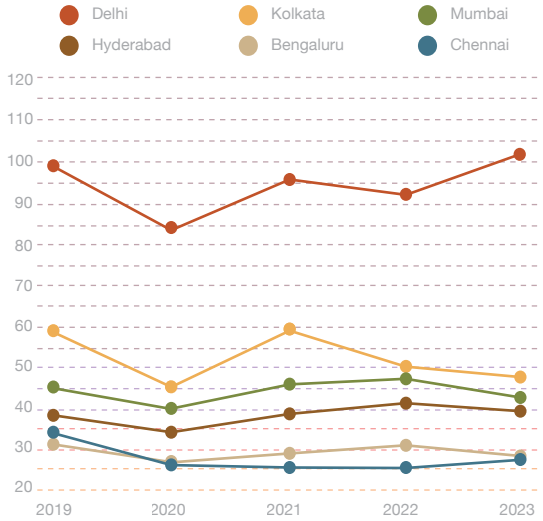


Annual hours spent at different PM2.5 pollution levels

INDIA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Delhi	102.1	171.8	114.3	77.4	71.0	67.4	42.9	35.3	34.8	39.7	106.3	255.1	210.0	92.6
Kolkata	47.8	98.2	54.6	44.5	42.7	27.6	24.8	13.1	31.2	20.1	50.5	80.8	85.9	50.2
Mumbai	43.8	85.5	77.6	61.0	34.9	21.4	17.1	14.6	16.5	20.4	59.7	58.5	60.2	46.7
Hyderabad	39.9	56.8	54.1	48.6	42.1	35.5	24.2	18.2	27.3	19.0	43.2	51.5	58.9	42.4
Bengaluru	28.6	42.9	40.9	36.2	35.0	23.6	16.1	12.4	19.3	14.6	35.8	31.4	35.8	31.5
Chennai	28.0	46.1	35.5	24.7	19.5	26.9	24.6	20.4	23.7	17.1	28.4	28.9	40.1	25.3

PROGRESS

Ranking as the third most polluted country in the region and world in 2023, India continues to struggle with drastically poor air quality. Annual average PM2.5 concentrations rose slightly in 2023 to 54.4 µg/m^3 compared to 53.3 µg/m^3 in 2022. PM2.5 levels in the National Capital Territory, Delhi, rose by 10% in 2023, with levels peaking in November which saw a monthly average of 255 µg/m^3. It is estimated that 1.36 billion people in India experience PM2.5 concentrations exceeding the WHO recommended annual guideline level of 5 µg/m^3; furthermore, 1.33 billion, or 96% of the population, experience PM2.5 levels more than seven times the WHO annual PM2.5 guideline.[57] This trend is reflected in city-level data with more than 66% of the country's cities reporting annual averages greater than 35 µg/m^3.

India has an extensive air quality monitoring network, hosting more air quality monitoring stations than all other countries in the region combined. The vast monitoring network has contributed data from 256 cities in 2023, representing 74% of cities in the Central and South Asia region. A nearly commensurate proportion of Indian cities has ranked in the region's most polluted cities list, with 13 of the 15 ranked cities located in India.

CHALLENGES

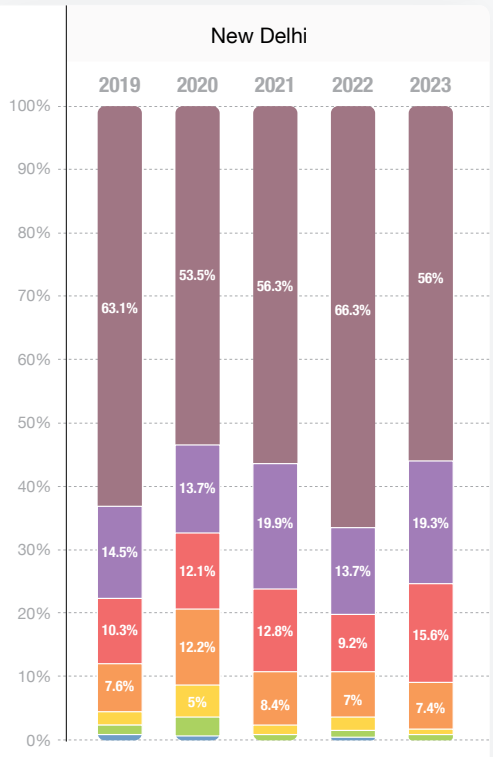
Northern India and Delhi struggle with smoke from crop burning, vehicle emissions, coal burning, waste burning, and biomass burning for heat and cooking. Annual crop burning in northern India and neighboring Pakistan regularly results in Delhi experiencing emergency-level air quality days.[58] Indian scientists have turned to cloud seeding as a possible solution to help clear up Delhi's smog in November.[59]

Vehicle emissions are responsible for 40% of PM2.5 emissions in the nation's capital.[60] In response, older vehicles were banned in Delhi.[61] The number of cars on the road has dropped by 35% since the ban took effect in late 2018.[62]

HIGHLIGHT: CAPITAL AREA COAL BURNING BAN

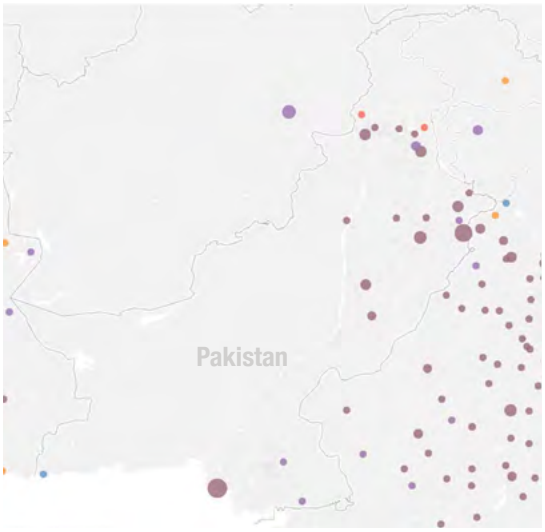
Coal burning was banned in the NCR (National Capital Region) effective January 1, 2023.[63] The NCR is a planning region that includes the National Capital Territory of Delhi, New Delhi, and several districts in neighboring states. Coal use was banned for most commercial and industrial concerns in the area and accompanied by a heavy fine for offenders. The region burns 1.87 million tons of coal annually.

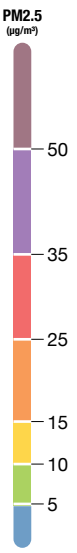
Even with the reduction in coal dependency, there are challenges to the region and the country. Natural gas cost and access, as well as emissions from biomass burning have posed new challenges for the NCR. Meanwhile, the national government's policy remains fixed on increasing coal-fired power plant investment even though it has pledged to shift to 50% non-fossil fuel-based power capacity.[64]



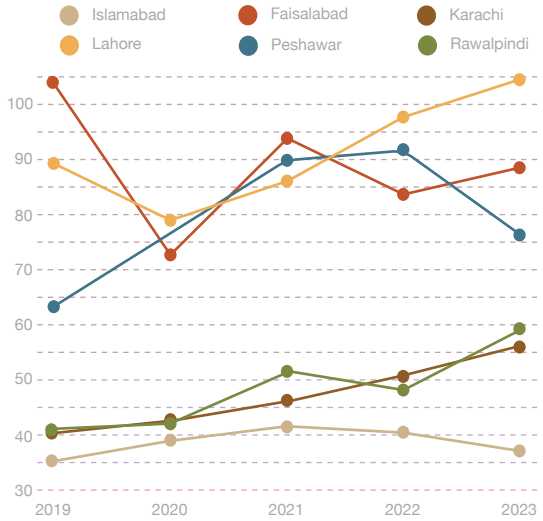
Annual hours spent at different PM2.5 pollution levels

PAKISTAN





City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Islamabad	42.4	70.4	47.5	32.4	21.2	21.5	27.8	23.3	31.9	31.4	41.2	66.7	93.6	40.6
Faisalabad	88.2	92.0	106.5	66.5	44.5	42.9	43.8	NO DATA	38.9	46.0	70.4	196.8	204.2	84.5
Karachi	56.4	98.9	65.1	53.5	28.2	27.0	30.2	32.1	30.1	43.2	38.2	121.0	109.7	50.6
Lahore	99.5	143.2	117.3	73.8	52.9	52.4	46.4	39.8	42.2	53.8	125.9	251.0	197.5	97.4
Peshawar	76.5	135.9	78.7	53.3	34.2	39.0	42.9	35.5	44.0	52.8	83.1	155.8	166.3	91.8
Rawalpindi	59.5	87.8	72.7	43.5	26.2	26.8	30.5	29.8	41.7	48.1	61.6	106.7	139.7	48.5

PROGRESS

Pakistan remains one of the world's most polluted countries, ranking in second place behind Bangladesh in 2023. With a 2023 annual concentration of 73.7 µg/m³, PM2.5 levels continue to rise, and are on target to eclipse 2018's peak reported value of 74.3 µg/m³ by early 2025. In 2023, annual PM2.5 concentrations in the country's capital, Islamabad, have risen to the highest level in the city's seven-year history in this report at 42.4 µg/m³ or nearly eight and a half times the WHO annual PM2.5 guideline level. Although Lahore is no longer the most polluted city in the world, the city's annual average PM2.5 concentration has risen by more than 20 µg/m³ over the past four years, with PM2.5 levels in 2023 reaching 99.5 µg/m³. In November, Lahore's monthly average soared to 251 µg/m³, spawning an environmental health emergency. In contrast, Peshawar has reported a 16% decrease with an annual PM2.5 levels dropping to 76.5 µg/m³. Every city in Pakistan included in the 2023 report measured concentrations above 30 µg/m³, at least six times the recommended WHO annual PM2.5 guideline.

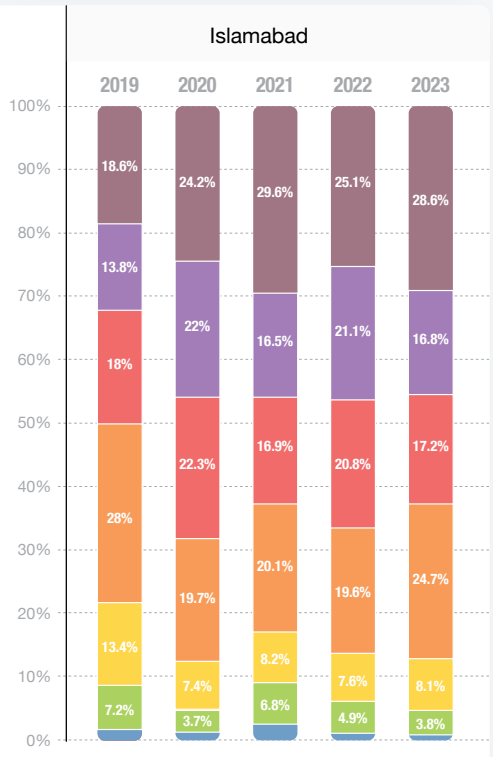
CHALLENGES

Pakistan can often experience hazardous levels of air quality, from a combination of pollutant sources – crop burning stubble and deforestation have played a role in impacting air quality in rural areas. Winter temperatures and temperature inversions combine with crop burning smoke, industrial and vehicle emissions, and brick kiln activity to create severely smoggy conditions in Punjab Province.[65,66]

In response, Punjab Province has banned crop burning, prioritized reforestation, and launched public transportation projects.

HIGHLIGHT: LAHORE CITYWIDE SHUTDOWN

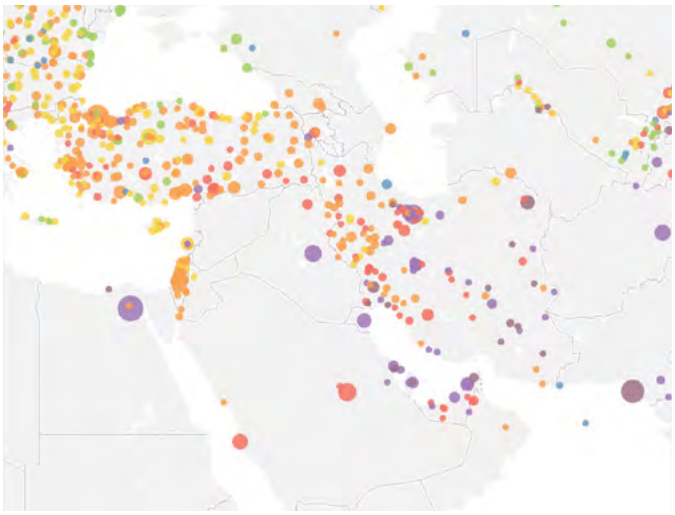
Pakistan's Punjab province declared an environmental and health emergency in three cities in early November. Lahore, Gujranwala, and Hafizabad shut down their cities as all public spaces were closed due to hazardous levels of air pollution.[67] Later in November, Punjab made face masks mandatory for a week in smog-impacted communities, including Lahore.[68] While the public health measures are a positive step towards protecting health, stronger measures are needed to stop the region's frequently very unhealthy and hazardous air quality at their sources - vehicle pollution, crop burning, and industrial pollution.



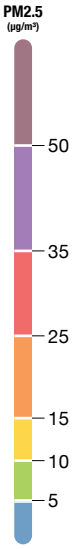
Annual hours spent at different PM2.5 pollution levels

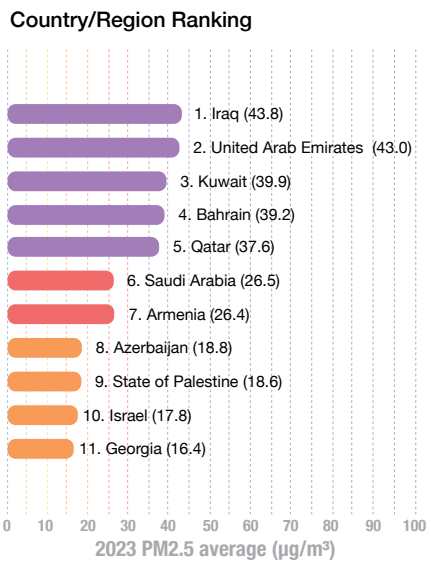
WEST ASIA

Armenia | Azerbaijan | Bahrain | Georgia | Iraq | Israel | Kuwait | Qatar | Saudi Arabia | State of Palestine | United Arab Emirates



City markers indicating 2023 PM2.5 levels, size adjusted for population





0%

Regional cities that met the WHO annual PM2.5 guideline in 2023

10.5
Mi'ilya, Israel

52.0
Ras Al Khaimah, UAE

5 10 15 25 35 50

Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Ras Al Khaimah, UAE	52.0
2	Dhahran, Saudi Arabia	46.5
3	Baghdad, Iraq	45.8
4	Dubai, UAE	43.6
5	Kuwait City, Kuwait	39.9
6	Manama, Bahrain	39.2
7	Abu Dhabi, UAE	38.2
8	Doha, Qatar	37.6
9	Ash Shihaniyah, Qatar	37.2
10	Erbil, Iraq	30.4
11	Or Yehuda, Israel	26.9
12	Bat Yam, Israel	26.8
13	Yerevan, Armenia	26.4
14	Riyadh, Saudi Arabia	26.1
15	Gödekli, Armenia	25.0

Least Polluted Regional Cities

Rank	City	2023
1	Mi'ilya, Israel	10.5
2	Meirav, Israel	13.0
3	Caesarea, Israel	13.3
4	Mitzpe Netofa, Israel	13.3
5	Nesher, Israel	13.8
6	Haifa, Israel	15.1
7	Kiryat Shmona, Israel	15.2
8	Isfaya, Israel	15.3
9	Kiryat Ata, Israel	15.4
10	Kiryat Tiv'on, Israel	15.4
11	Gush Etzion, Israel	15.4
12	Zikhron Ya'akov, Israel	15.4
13	Kfar Menahem, Israel	15.4
14	Tbilisi,Georgia	15.5
15	Ein Tamar, Israel	15.6

SUMMARY

In 2023, two West Asia countries, Iraq (43.8 µg/m³) and United Arab Emirates (43.0 µg/m³) ranked among the ten most polluted countries in the world. Five of the top eight most polluted cities in the region are capital cities: Baghdad, Kuwait City, Manama, Abu Dhabi, and Doha. However, there was a reduction in the annual average PM2.5 concentrations for the nine most polluted cities in West Asia. In 2023, there is only one city with an annual average above 50 µg/m³, whereas there were five such cities in 2022. Baghdad, previously the most polluted city, saw a reduction of over 25%, dropping from 62.8 µg/m³ in 2022 to 46.5 µg/m³ in 2023. Ras al Khaimah in the United Arab Emirates recorded the highest annual average PM2.5 concentration in West Asia in 2023, with 52 µg/m³.

The region witnessed improvements in air quality compared to 2022. Out of the cities included in 2022's report, only four experienced an increase in their annual averages, while 17 showed decreased concentrations. Similarly, all countries featured in the 2023 and 2022 reports demonstrated a decrease in their annual weighted PM2.5 concentrations, with reductions ranging from 0.2 µg/m³ to 36.3 µg/m³. However, there is still ample room for improvement. None of the cities in the region recorded an annual average concentration lower than 10 µg/m³, while no country reported an annual average concentration below 15 µg/m³.

MONITORING STATUS

There remains a pressing need for more robust monitoring in the area. Israel and the United Arab Emirates contribute to over two thirds of the stations providing data to the region. Israel also has the highest monitoring spatial resolution in the region by providing data for 64 cities, which represents an increase of 12 cities from 2022. There continues to be an increase in non-government operated stations in the region, which demonstrates citizens' desire to know more about the breathability of their air. In a change from 2022, there are more non-government operated stations reporting data than government operated stations, with a ratio of 54% non-government to 46% government operated stations.

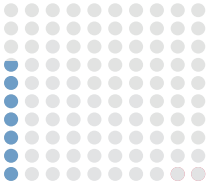
EUROPE

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 | Turkey | Ukraine | United Kingdom

City markers indicating 2023 PM2.5 levels, size adjusted for population

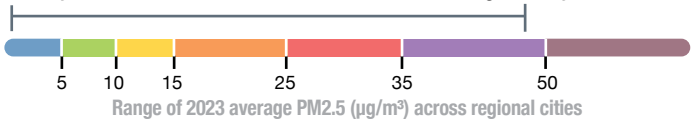
6.7%

Regional cities which met the WHO annual PM2.5 guideline in 2023



0.3
Sodankylae, Finland

47.2
Igdir, Turkey



Range of 2023 average PM2.5 (µg/m³) across regional cities

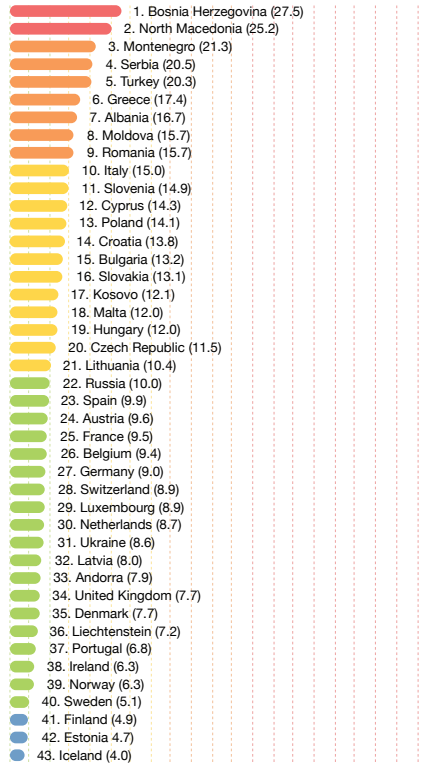
Most Polluted Regional Cities

Rank	City	2023
1	Igdir, Turkey	47.2
2	Pljevlja, Montenegro	40.1
3	Osmaniye, Turkey	38.5
4	Hendek, Turkey	37.3
5	Tuzla, Bosnia Herzegovina	36.2
6	Zenica, Bosnia Herzegovina	36.1
7	Gaziantep, Turkey	35.0
8	Bijelo Polje, Montenegro	34.5
9	Niluefer, Turkey	33.7
10	Konya, Turkey	33.2
11	Alasehir, Turkey	32.9
12	Strumica, North Macedonia	31.6
13	Cacak, Serbia	31.1
14	Tetovo, North Macedonia	30.9
15	Banja Luka, Bosnia Herzegovina	30.1

Least Polluted Regional Cities

Rank	City	2023
1	Sodankylae, Finland	0.3
2	Utsjoki, Finland	0.3
3	Kuusamo, Finland	0.3
4	Húsavik, Iceland	2.3
5	Vaasa, Finland	2.8
6	Lamas de Olo, Portugal	2.8
7	Vaqueiros, Portugal	2.9
8	El Grao de Castellon, Spain	3.0
9	Sainte-Ode, Belgium	3.1
10	Bredkalen, Sweden	3.1
11	Kouvola, Finland	3.2
12	Saint-Joseph, France	3.2
13	Bodø, Norway	3.2
14	Kuyulusebil, Turkey	3.2
15	Santana, Portugal	3.4

Country/Region Ranking



2023 PM2.5 annual average (µg/m³)

SUMMARY

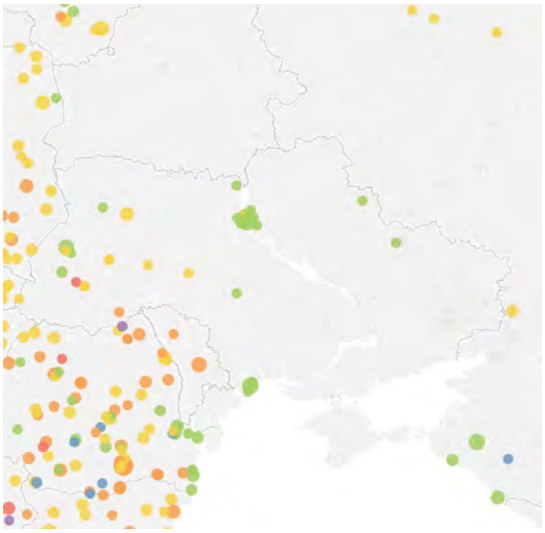
In 2023, the region of Europe is represented by 2,006 cities in 43 countries. Despite a slight increase in annual average PM2.5 levels, Iceland remains the least polluted country in the region with an average concentration of 4 µg/m³. Bosnia Herzegovina saw an 18% decrease in PM2.5 levels in 2023 compared to 2022, but remains the most polluted country in the region, reporting an annual average concentration of 27.5 µg/m³. In a repeated trend from 2022, Iceland, Estonia, and Finland are the only countries in the region to achieve the WHO annual PM2.5 guideline level. Croatia showed the most progress in 2023 in lowering PM2.5 levels with the annual average dropping more than 40% compared to 2022. Montenegro experienced the greatest absolute increase in PM2.5 concentrations with annual levels rising by more than 4 µg/m³ in 2023 for an annual average of 20 µg/m³. Annual average PM2.5 levels fell in 2023 for 36 countries in the region, increased for six countries, and remained constant for one country.

In 2023, 7% (135) of the cities in the region achieved the WHO annual PM2.5 guideline of 5 µg/m³, including every city in Iceland. The United Kingdom had the highest number of cities in the region to achieve the WHO annual PM2.5 guideline level, with 30 cities reporting annual averages less than 5 µg/m³, followed by Finland with 27, and Sweden with 14. Overall, there was a general trend of lower annual average PM2.5 levels for European cities in 2023. There was a substantial shift in the number of cities previously classified in the yellow (2 to 3 times the WHO annual PM2.5 guideline) and orange (3 to 5 times the WHO annual PM2.5 guideline) breakpoint ranges in 2022, shifting to the green range (1 to 2 times the WHO annual PM2.5 guideline) in 2023. While 39% of European cities were classified in the green breakpoint in 2022, more than half (54%) of European cities fell within this range in 2023.

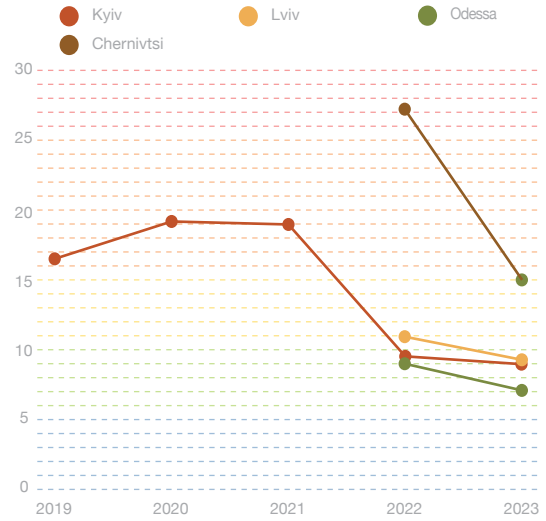
MONITORING STATUS

A dense monitoring network continues to provide high geospatial resolution for air quality data in Europe with 73% of data for this region generated by government-operated stations. In 2023, Slovakia added 22 cities, and Germany had the highest number of cities included for this region with data from 260 cities reported. Data from government-operated stations in Russia were bolstered by non-government operated stations providing 83% of the country's data for the 2023 report.

UKRAINE



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Kyiv	8.9	13.9	11.2	13.4	8.1	6.1	7.3	6.7	8.0	7.6	6.3	7.6	10.8	9.5
Lviv	9.3	11.4	11.8	11.4	8.8	7.2	7.6	7.6	9.2	9.9	7.5	8.6	10.9	10.8
Odessa	7.1	9.2	10.0	9.5	5.5	5.4	6.2	6.0	7.5	6.9	4.7	6.1	10.0	9.0
Chernivtsi	15.1	20.5	21.5	19.7	14.6	10.1	8.1	9.6	10.2	12.8	13.8	16.9	23.4	27.3

PROGRESS

Despite the intensive hardships faced, the dedicated air quality professionals and citizen scientists in Ukraine have maintained and expanded air quality monitoring networks in 2023. In 2023, data was sufficient to expanded coverage to 28 cities from only 22 cities in 2022. PM2.5 levels have continued to fall across most of the country due to war-based deindustrialization with the annual average dropping 11% in 2023 down to 8.6 µg/m^3, compared to 9.7 µg/m^3 in 2022. Attacks on Ukraine's energy infrastructure in the winter season of 2022-2023 resulted in a severe energy crisis requiring the use of solid fuel sources to heat homes.[69] This trend is seen nationwide where monthly PM2.5 levels peaked in January 2023, with cities in the province of Kyiv seeing on average a 65% increase in monthly average concentrations compared to 2022. The onset of the cold months in the 2023-2024 winter season again correspond to increasing PM2.5 levels with a secondary annual peak in the month of December.

CHALLENGES

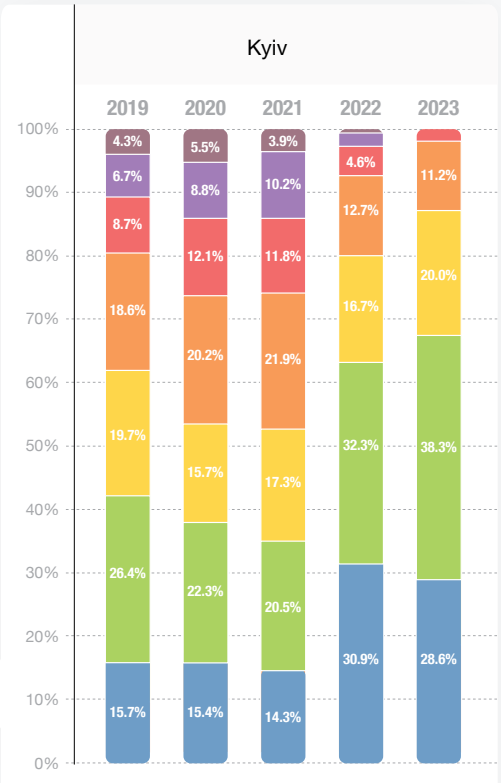
Ukraine has endured two years of war, during which time the ongoing Russian invasion has harmed air quality. Military vehicle and aircraft emissions continue to pollute the skies. On December 28, Russia launched 122 missiles at cities across Ukraine, killing 24 civilians.[70] While it was the largest missile attack of 2023, the country has been subjected to hundreds of missile and drone attacks throughout the year.

Energy generation and industry have historically been leading emission sources, including coal mining, metals, machinery, and chemical processing sectors.[71] In Kyiv, pre-war pollutant sources included motor vehicles, construction, and industrial activity.[72]

HIGHLIGHT: INDUSTRIAL POLLUTION

Ukraine's occupied eastern region is the nation's mining country and industrial heartland. Prior to the war, eastern cities like Donetsk and Mariupol were the most polluted in the country due to coal-fired power plants, mining, and metallurgy activity.[73] However, a study utilizing satellite data found an overall reduction in nitrogen dioxide (NO_2) emissions (which correlates with burning of fossil fuels and the generation of soot) in urban and industrial centers in comparison to peacetime.[74] As is common in war zones, the NO_2 decrease is likely due to facility shutdowns and population displacement.

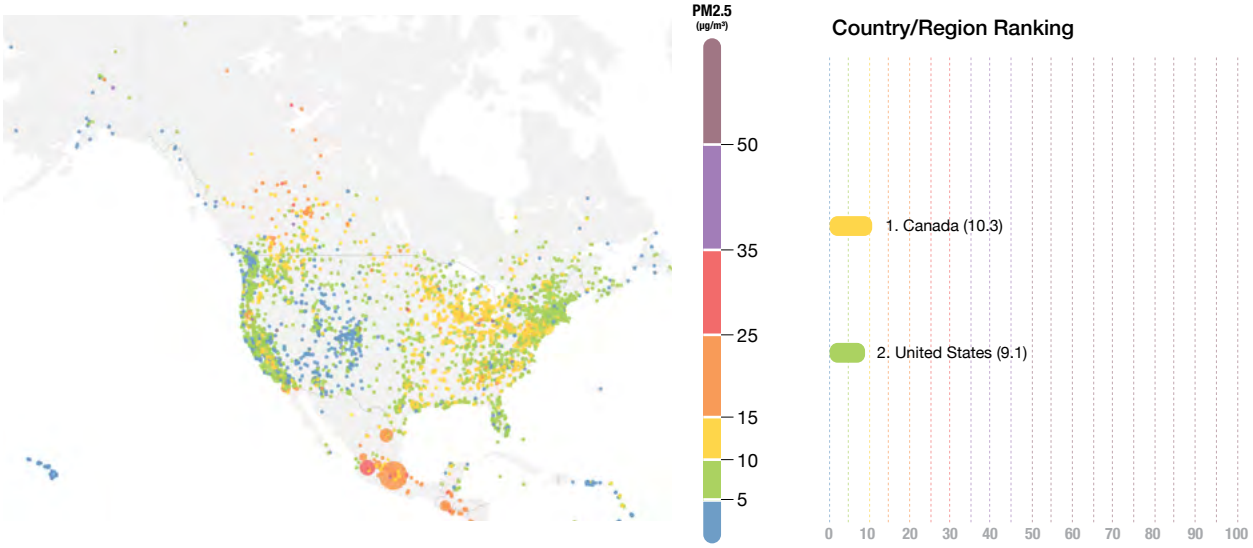
These findings suggest that enhanced pollution monitoring and a focus on sustainable industrial and energy production practices must play an important role in the post-war rebuilding period.



Annual hours spent at different PM2.5 pollution levels

NORTHERN AMERICA

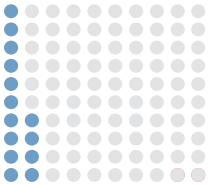
Canada | United States

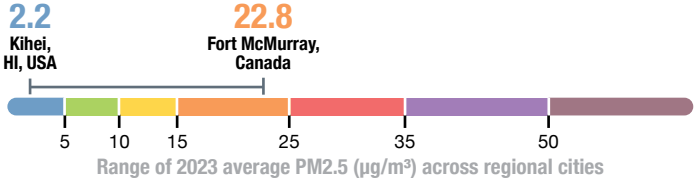


City markers indicating 2023 PM2.5 levels, size adjusted for population

14.0%

Regional cities that met the WHO annual PM2.5 guideline in 2023





Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities*

Rank	City	2023
1	Fort McMurray, Canada	22.8
2	Peace River, Canada	22.4
3	Yellowknife, Canada	20.8
4	Fort St John, Canada	18.7
5	Fort Saskatchewen, Canada	16.8
6	Spruce Grove, Canada	16.8
7	Edmonton, Canada	16.6
8	St. Albert, Canada	15.8
9	Sherwood Park, Canada	15.7
10	Saskatoon, Canada	15.5
11	Camrose, Canada	15.3
12	Cold Lake, Canada	14.8
13	Leduc, Canada	14.8
14	Beloit, WI, USA	14.8
15	Prince George, Canada	14.1

Least Polluted Regional Cities

Rank	City	2023
1	Kihei, HI, USA	2.2
2	Waimea, HI, USA	2.2
3	Durango, CO, USA	2.5
4	Gypsum, CO, USA	2.5
5	Silverthorne, CO, USA	2.5
6	Hilo, HI, USA	2.5
7	Mountain View, HI, USA	2.5
8	Lander, WY, USA	2.5
9	Prince Rupert, Canada	2.7
10	Aspen, CO, USA	2.8
11	Steamboat Springs, CO, USA	2.8
12	Ocean View, HI, USA	2.8
13	Anchorage, AK, USA	2.9
14	Santa Fe, NM, USA	2.9
15	Prescott, AZ, USA	3.0

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

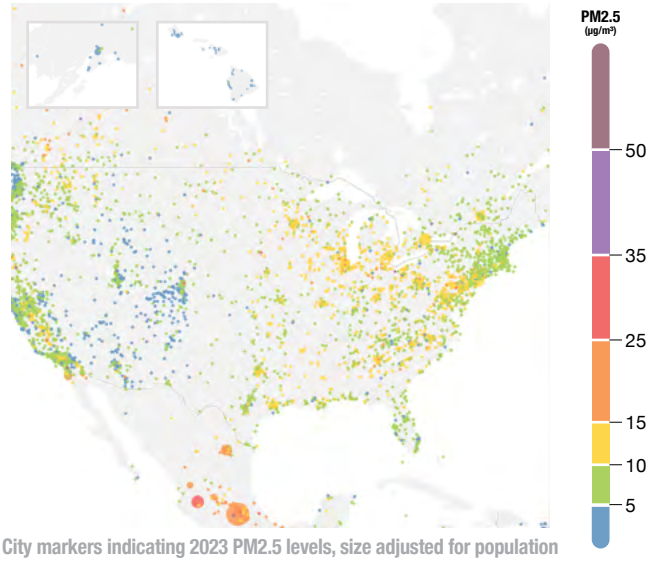
SUMMARY

In 2023, air quality in Northern America was significantly influenced by extensive Canadian wildfires that raged from May to October, burning an area roughly half the size of Germany.[75] During May, the monthly average PM2.5 levels in Alberta, Canada, surged almost ninefold compared to the same period in 2022. This trend persisted through late spring and summer, with the state experiencing PM2.5 levels nearly three times higher than those recorded in 2022. Consequently, 2023 marked the first instance in this report's history where Canada surpassed the United States in regional pollution rankings, with Canada's annual PM2.5 concentration of 10.3 µg/m³ exceeding the U.S. level of 9.1 µg/m³. In 2023, 41% of Canadian cities recorded annual PM2.5 levels exceeding 10 µg/m³, or twice the WHO annual guideline level, with 11% (35 cities) exceeding three times the guideline value. In contrast, only one Canadian city in 2022 had an annual PM2.5 concentration surpassing 15 µg/m³. The total number of cities meeting the WHO annual PM2.5 guideline decreased from 514 to 454. Furthermore, Canada witnessed a one-third reduction in cities meeting the WHO annual PM2.5 guideline, dropping from 61 in 2022 to 23 in 2023.

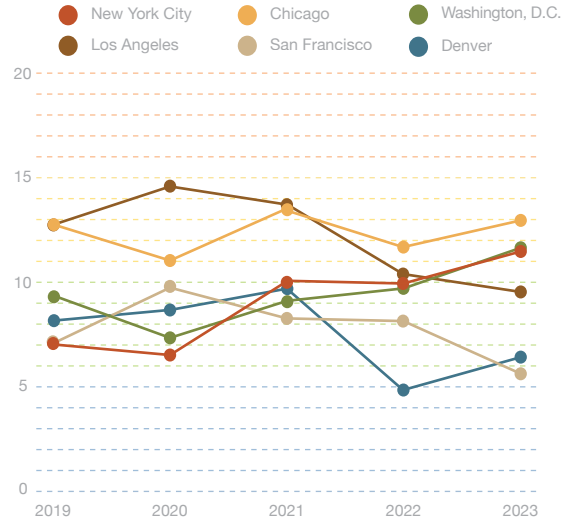
MONITORING STATUS

Northern America maintains its status as the most extensively monitored region on the basis of city count. 3,242 cities are included for the region in 2023, representing 40% of the total number of global cities included in the report. The vital role of non-government-operated air quality monitors became evident in monitoring fire and smoke plume progression across Northern America, where these monitors played a crucial part in supplying a significant portion of the region's data, contributing 90% of real-time data for the United States and 77% for Canada. Specifically, in the Canadian province of Alberta, 76% of real-time data originates from non-government-operated air quality monitors. In British Columbia, an even higher percentage, 87%, is sourced from these monitors.

UNITED STATES



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Washington, D.C.	11.7	10.1	9.3	8.2	8.6	9.8	26.6	16.6	13.4	9.9	7.4	10.0	10.1	9.8
New York City	11.6	10.7	11.8	8.0	9.4	8.0	24.8	17.4	12.3	10.9	8.3	7.9	10.3	9.9
Los Angeles	9.5	5.7	6.0	5.9	12.0	10.1	9.3	13.5	11.2	13.8	8.7	7.4	9.9	10.5
Chicago	13.0	14.6	9.4	10.1	9.0	9.8	28.4	17.4	16.8	12.6	7.9	9.9	9.8	11.8
San Francisco	5.8	3.7	6.8	2.6	3.3	4.2	4.3	5.8	9.1	10.9	5.5	6.3	7.4	8.1
Denver	6.4	10.0	4.6	6.5	3.5	10.9	4.5	6.4	6.3	5.7	5.7	5.4	6.7	4.9

PROGRESS

In 2023, the United States experienced a slight increase in annual average PM2.5 levels, climbing from 8.9 µg/m³ in 2022 to 9.1 µg/m³. The Upper Midwest and Mid-Atlantic states were notably affected by smoke from Canadian wildfires, causing a significant surge in PM2.5 levels. In some cities, including Minneapolis and Detroit, annual averages rose by 30 to 50% compared to the previous year. Milwaukee, Wisconsin, was particularly impacted, with a substantial increase of 51%, closing 2023 with an annual average of 11.8 µg/m³. For a second year in a row, the most polluted major city in the U.S. was Columbus, Ohio.

The West Coast experienced a less severe wildfire season in 2023, due in part to the implementation of aggressive mitigation strategies, including the utilization of technology for early warning systems and the allocation of additional ground resources to enable earlier deployments. Portland, Oregon; Seattle, Washington; and Los Angeles, California experienced major improvements with 37%, 36%, and 10% drops in annual average PM2.5 levels respectively. Of the nation's 25 most populous cities, Las Vegas was the least polluted major city in the country with an annual average PM2.5 concentration of 4.9 µg/m³. The states of Wyoming and Colorado in the Mountain West, along with the states of Arizona and New Mexico in the Desert Southwest, experienced the lowest PM2.5 levels in the continental United States with Tucson, Arizona (3.5 µg/m³) and Albuquerque, New Mexico (4 µg/m³) both reporting annual averages that meet the WHO annual PM2.5 guideline levels.

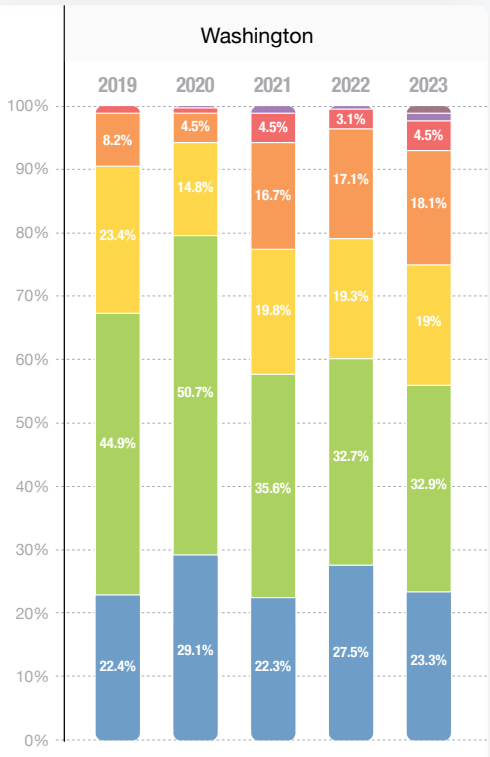
CHALLENGES

Though overall wildfires in the United States were reduced in 2023, the Lahaina fire in Hawaii killed 100 people,[76] making it the deadliest U.S. fire since the 2018 Camp Fire in Paradise, California.

Other emission sources leading to poor air quality in the U.S. include vehicle emissions, power plants, industrial and agricultural activities, wood burning fireplaces, and wind-blown dust. Ground-level ozone, a known respiratory irritant, is formed when combustion-related pollutants react with sunlight. Data from the U.S. EPA indicates that approximately 115 million Americans reside in regions that do no meet the federal ozone standard.[77]

HIGHLIGHT: TRANSBORDER WILDFIRE SMOKE

Over the course of Canada's wildfire season, about 4% of the country's forests were burned. The entire Northwest Territories city of Yellowknife had to be evacuated.[78] Unhealthy and hazardous air quality was recorded in the Great Lakes, Midwest, East Coast, and Pacific Northwest after Canadian wildfire smoke drifted south. Schools closed and companies encouraged employees to work from home.[79] In one incident, wildfire smoke traveled from Alberta to Quebec, over the Atlantic Ocean, and returned west, leading to hazy skies and poor air quality in Florida.[80]



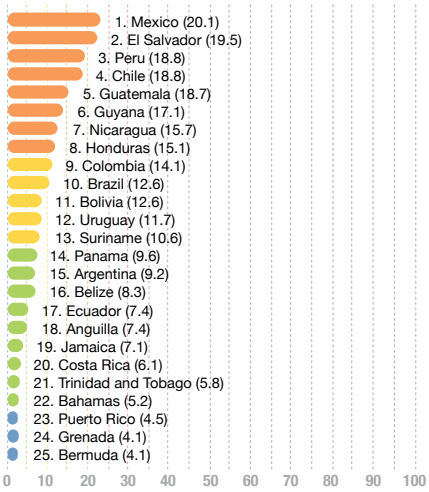
Annual hours spent at different PM2.5 pollution levels

LATIN AMERICA & CARIBBEAN

Anguilla | Argentina | Bahamas | Belize | Bermuda | Bolivia | Brazil | Chile | Colombia | Costa Rica | Ecuador | El Salvador | Grenada | Guatemala | Guyana | Honduras | Jamaica | México | Nicaragua | Panama | Perú | Puerto Rico | Suriname | Trinidad and Tobago | Uruguay

City markers indicating 2023 PM2.5 levels, size adjusted for population

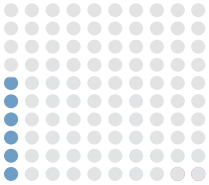
Country/Region Ranking



2023 PM2.5 average (µg/m³)

5.9%

Regional cities that met the WHO annual PM2.5 guideline in 2023



2.7
San Juan, Puerto Rico

33.2
Coyhaique, Chile

5 10 15 25 35 50

Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Coyhaique, Chile	33.2
2	Nacimiento, Chile	32.4
3	Padre las Casas, Chile	29.4
4	Xonacatlan, Mexico	29.2
5	Toluca de Lerdo, Mexico	28.3
6	Carabayllo, Peru	28.0
7	Victoria, Chile	27.4
8	Puente Piedra, Peru	27.4
9	Guadalajara, Mexico	25.8
10	Pudahuel, Chile	25.7
11	Atotonilco de Tula, Mexico	25.1
12	Llaillay, Chile	25.0
13	Rancagua, Chile	24.2
14	Celaya, Mexico	24.2
15	Quilicura, Chile	24.0

Least Polluted Regional Cities

Rank	City	2023
1	San Juan, Puerto Rico	2.7
2	Caguas, Puerto Rico	3.6
3	Puntas Arenas, Chile	3.8
4	Nassau, Bahamas	5.2
5	Cuncumen, Chile	5.5
6	Cordoba, Argentina	5.7
7	Port of Spain, Trinidad and Tobago	5.7
8	San Jose, Costa Rica	6.1
9	Chaguanas, Trinidad and Tobago	6.7
10	Brasilia, Brazil	6.8
11	Cuidad Juarez, Mexico	6.8
12	Merida, Mexico	6.8
13	General Pico, Argentina	6.9
14	Calama, Chile	7.0
15	Puno, Peru	7.0

SUMMARY

Deforestation, wildfires, emissions from mobile sources, and pollution from mining operations are significant sources of PM2.5 air pollution in the Latin American and Caribbean region. Climate change exacerbates some of these issues to threaten human health through extreme weather events and the PM2.5 emissions associated with them. Citizen activism and government action to shift energy policies to more renewable resources continue to be at the forefront of the region's air quality policy.

In 2023, the region is represented by 26 countries and territories. New regional countries added in 2023 include Bahamas and Ecuador. Exactly half of this region's countries and territories, 13 out of 26, showed increases in their average annual PM2.5 concentrations ranging from a 0.3% increase in Guatemala to a 72.2% increase in Bolivia. Grenada and Puerto Rico meet the WHO annual PM2.5 guideline with annual average PM2.5 concentrations of 4.1 µg/m³ and 4.5 µg/m³ respectively.

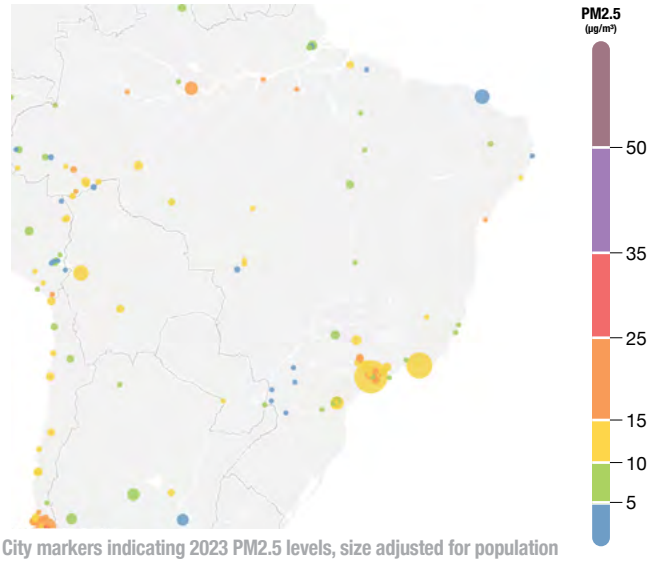
This represents a reduction in the number of countries in the region that meet the WHO annual PM2.5 guideline from 2022. Additionally, there was a decrease in the percentage of cities in the region that met the WHO annual PM2.5 guideline: 5.8% in 2023 compared to 9.3% in 2022. The least polluted city in the region is Puerto Rico's capital, San Juan, with an annual average PM2.5 concentration of 2.7 µg/m³.

MONITORING STATUS

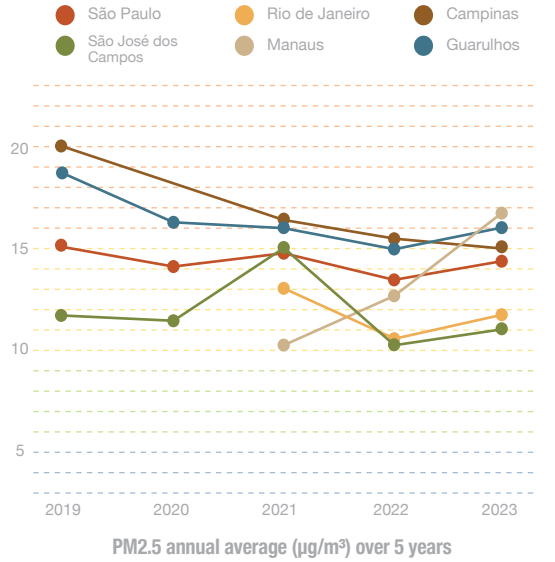
This region continues to expand its monitoring network as evidenced by the 38 new cities included in 2023. These new cities house a total of 81 government-operated and non-government-operated stations. This carries on the trend from 2022 and previous years of expanding air quality monitoring coverage into previously underrepresented places. Mexico is home to the newest cities in the region with ten, while Colombia is close behind with nine new cities. Continued support for the air monitoring network Aires Nuevos helps to maintain and expand the region's monitoring capabilities.

Non-government-operated stations make up the majority of Latin American and Caribbean region stations. Government-operated stations account for 30.2% of the total stations. This ratio demonstrates citizens' involvement in measuring their communities' air quality.

BRAZIL



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
São Paulo	14.3	9.7	10.0	12.6	11.3	16.9	18.9	17.9	19.6	17.5	12.0	12.1	11.7	13.5
Rio de Janeiro	11.7	7.7	9.0	10.1	8.6	10.8	16.1	14.1	13.9	14.1	11.1	13.8	11.7	10.6
São José dos Campos	11	6.5	7.3	9.2	10.5	11.5	15.4	13.5	14.8	12.7	7.3	10.7	9.4	10.2
Campinas	15	9.5	9.9	12.2	12.1	18.0	19.0	19.4	21.5	17.4	13.5	13.7	13.1	15.5
Manaus	16.8	5.0	3.9	6.1	4.7	5.0	7.9	12.8	19.0	33.0	53.6	39.8	6.9	12.7
Guarulhos	16	10.5	10.3	12.8	11.8	18.6	21.3	19.8	20.3	19.6	13.1	16.2	15.9	15.0

PROGRESS

The annual PM2.5 concentration average for Brazil increased by 6%, rising from 12.2 µg/m³ in 2022 to 12.9 µg/m³ in 2023. However, the capital city Brasilia showed a 32% decrease in 2023 with an annual average PM2.5 concentration of 6.8 µg/m³. The most populous city in Brazil, Rio de Janeiro, showed a slight increase, going from 10.6 µg/m³ in 2022 to 11.7 µg/m³ in 2023. A winter heatwave and dry climate drove an intensive wildfire period in September for western Brazil's Amazon states, with nearly twice as many wildfires recorded this month than in previous years.[81] This resulted in peak PM2.5 levels for cities in Acre, Rondonia, and Tocontins, with monthly averages for all reporting cities ranging between 22 and 43 µg/m³. September was also the most polluted month for the city of Fortazela, located on the northeastern coast of the country, and Brazil's only city to achieve the WHO annual PM2.5 guideline in 2023.

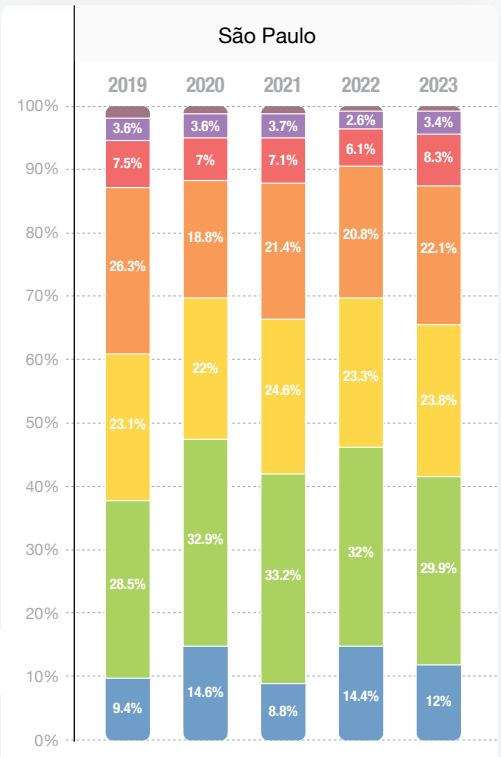
CHALLENGES

In Brazil's north, deforestation and wildfires in the Amazon rainforest have heavily impacted the country's air quality. Deforestation is being driven by cattle, soybean, and sugarcane production, land speculation, as well as the wood charcoal industry.[82,83] Though annual forest clearances were recently reduced, 26% of the 8 million square kilometer region has already experienced severe land degradation. Meanwhile, air pollution from the region's wildfires poses a significant health hazard for the country.[84]

Urban air pollution can be traced to a variety of sources. In São Paulo, most air pollution stems from vehicle emissions.[85] In the nearby town of Betim, pollution has been traced to metallurgical companies and a refinery.

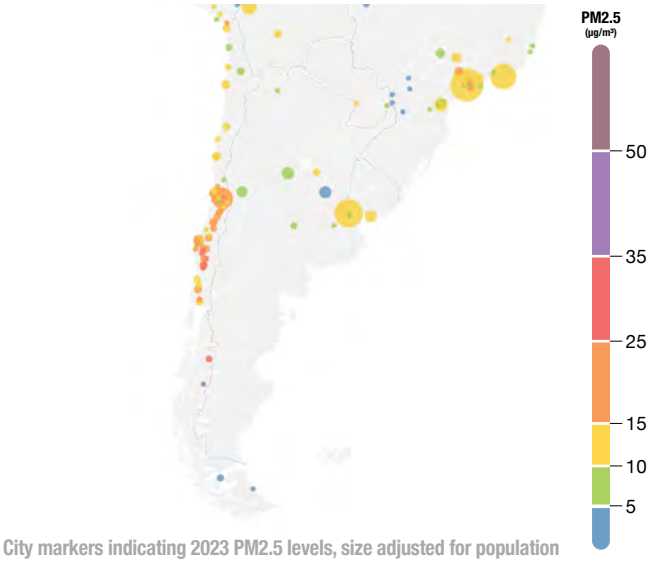
HIGHLIGHT: DROUGHT FUELS FOREST FIRES

Brazil experienced a brutal heat wave in late 2023.[86] The heat wave increased the number of wildfires across the north and in the southeastern Pantanale biome, adding understory wildfires to the annual mix of intentional deforestation fires.[87] Amazonas State experienced 2,700 fires in early October alone, more fires than in any other month since 1998.[88] The fire season's peak coincided with a drought in the north and west of the Amazon basin. Brazil's deeply interwoven crises of drought, heat waves, poor air quality, significant fires and a strengthening El Niño can all be attributed to human-driven climate change.[89]

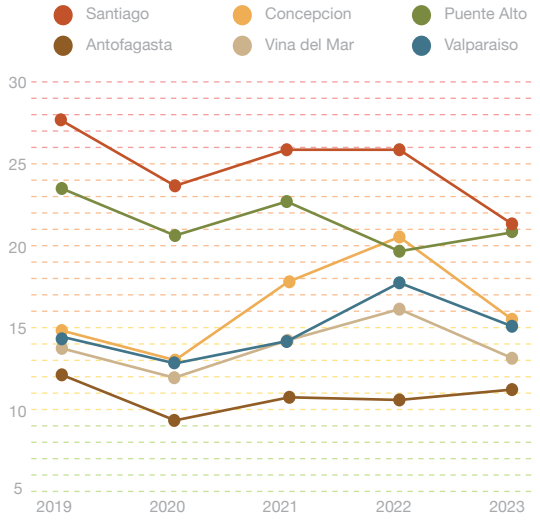


Annual hours spent at different PM2.5 pollution levels

CHILE



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Santiago	21.3	11.1	27.5	12.8	20.5	40.2	31.0	32.5	23.8	19.1	14.5	9.9	13.2	25.8
Concepcion	15.5	6.6	20.2	8.2	14.2	25.6	24.8	28.0	23.3	14.8	9.3	5.2	4.0	20.6
Puente Alto	20.8	11.8	26.5	14.1	17.2	31.7	27.4	30.6	21.1	19.6	15.5	NO DATA	13.0	19.7
Antofagasta	11.2	7.9	8.2	8.1	12.2	15.6	16.2	13.7	13.9	12.6	11.3	8.5	7.0	10.6
Vina del Mar	13.1	9.8	22.0	13.6	14.1	19.1	17.5	15.5	12.2	7.8	8.8	7.8	9.1	16.2
Valparaiso	15.1	10.9	21.9	13.2	14.3	22.4	21.5	17.8	12.5	10.1	10.9	9.2	10.8	17.7

PROGRESS

Despite wildfires doubling February's PM2.5 monthly average concentrations relative to 2022, the country of Chile reported a 15% decrease in annual PM2.5 concentrations, falling from 22.2 µg/m^3 in 2022 to 18.8 µg/m^3 in 2023. This trend was mirrored in the capital city of Santiago, which saw a 17.4% decrease in PM2.5 levels, closing 2023 with an annual average concentration of 21.3 µg/m^3. Although 37 cities nationwide recorded decreases in annual levels in 2023, the key cities of Puente Alto and Antafagasta saw increases in annual average PM2.5 concentrations. As in 2022, Punta Arenas remained the only city in the country to meet the WHO annual PM2.5 guideline. Nationwide, air quality monitoring coverage expanded in 2023, with four additional cities contributing data, bringing the total up to 63 included in 2023's report. Chile has the densest air quality monitoring coverage in the region, comprised of both government and non-government operated air quality monitoring stations. It hosts more government-operated monitoring stations than any other country in the region and has nearly the equivalent number of non-government operated stations.

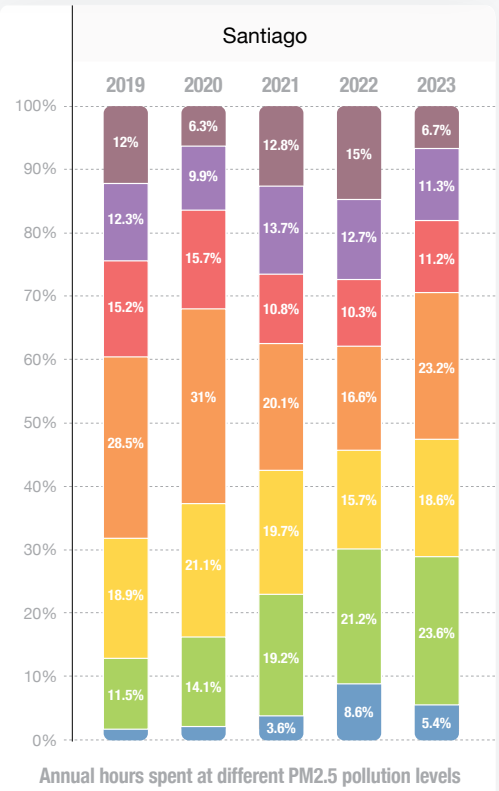
CHALLENGES

Climate change and decades of mining-related pollution are taking an extreme toll on Chile's environment and on marginalized communities.[90] In 2023, Chile faced severe weather events that were greatly intensified by climate change and by a strong El Niño weather pattern. In February, the Andean country experienced devastating wildfires that killed 26 people and directly impacted another 7,835.[91,92] Over 439,000 hectares of land were burned. Other sources of poor air quality include the mining industry and wood burning stoves.[93]

HIGHLIGHT: CHILE'S MINING INDUSTRY

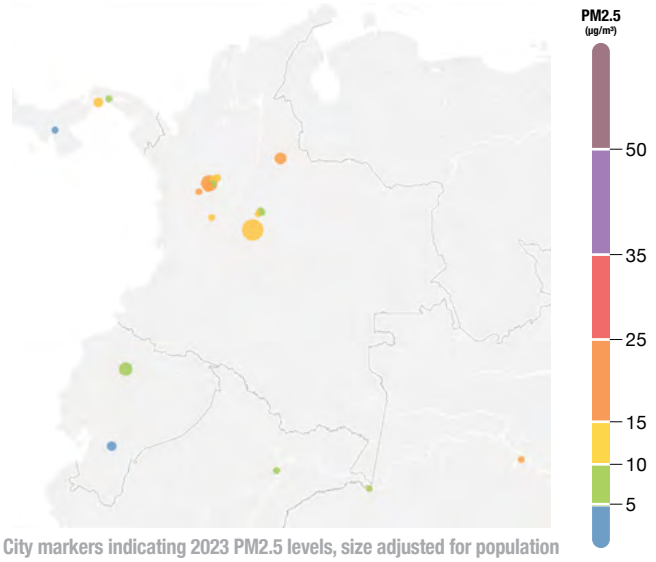
Chile is addressing air pollution from its mining industry, with mixed effectiveness. The state-owned Ventana copper smelter, a long-standing source of over 60% of all sulfur dioxide emissions in and around Quintero Bay, was shut down in June.[94] Operations harmed the health of marginalized and vulnerable communities for decades.[95]

However, in a move criticized by environmentalists and social groups, the Chilean government provided an environmental permit for an extension of the Los Brances open-pit copper mine northeast of Santiago. Activists are concerned that the mine, operating near Andean glaciers, will increase regional glacial melt through snow pollution and that mining dust will severely harm air quality. As part of the approved plan, the mine owners have committed to replacing 70,000 Santiago wood-burning stoves with electric burners.[96,97]

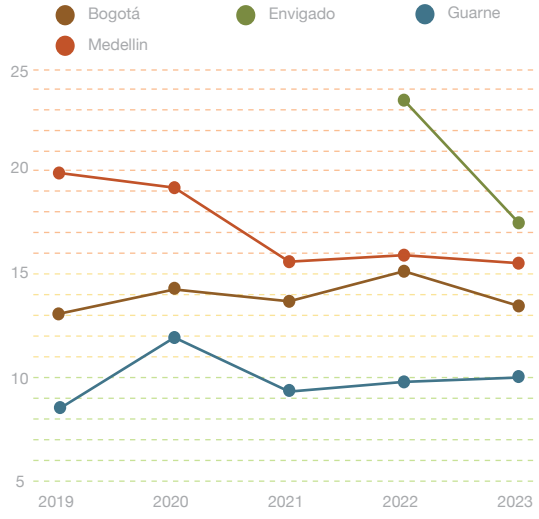


Annual hours spent at different PM2.5 pollution levels

COLOMBIA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Bogotá	13.4	15.8	20.0	21.1	16.6	11.4	6.9	7.5	9.7	11.3	14.4	11.9	14.9	15.1
Medellin	15.5	16.2	23.0	21.1	15.3	15.0	11.7	12.0	14.4	15.8	15.4	11.5	14.7	15.9
Guarne	10.0	NO DATA	21.2	12.9	8.5	9.9	8	8.4	10.4	10.7	11.5	8.6	11.4	9.8
Envigado	17.4	20.6	26.9	23.4	17.3	15.3	12.5	12.2	15.5	17.9	17.6	12.9	16.6	23.5

PROGRESS

Colombia's annual average PM2.5 concentration dropped by 10% in 2023, down to 14.1 µg/m³ to achieve the WHO interim target 3 level. This improvement was bolstered by decreases in PM2.5 levels in Envigado, Medellin, and the capital city Bogotá. Bogotá showed an 11% decrease in PM2.5 levels relative to 2022 with an annual average concentration of 13.4 µg/m³, the lowest value reported in the past four years. Meteorological conditions resulting in temperature inversions contributed to poor air quality conditions in March for Bogotá, resulting in the highest recorded monthly averages for the city in 2023. Monitoring network coverage nearly tripled the number of cities reporting data in Colombia in 2023, with nine new cities being added to 2023's report. Despite the overall improvement in air quality levels for the country of Colombia, no city met the WHO annual PM2.5 guideline.

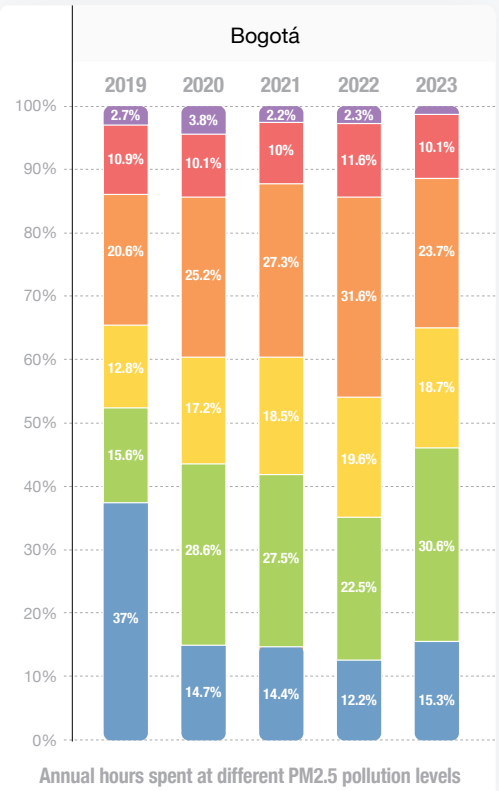
CHALLENGES

Colombians are often exposed to air pollution, though from divergent sources. Vehicle emissions and industrial pollution account for much of city air pollution, while wood and other solid fuel used for cooking and heating are the dominant sources in the countryside.[98] Both environs struggle with air quality during wildfire season.

The El Niño weather phenomenon has worsened the nation's air quality.[99] There were 2,378 wildfires recorded by early October 2023, 69% more than in 2022. And though El Niño brought rain to some parts of the country, 10 drier departments in northern and central Colombia endured the most fires. Annually, fires usually start through arson, urban sprawl, and cattle ranching; in 2023, dry conditions were a likely factor in the increased number of fires.

HIGHLIGHT: BOGOTÁ TEMPERATURE INVERSION

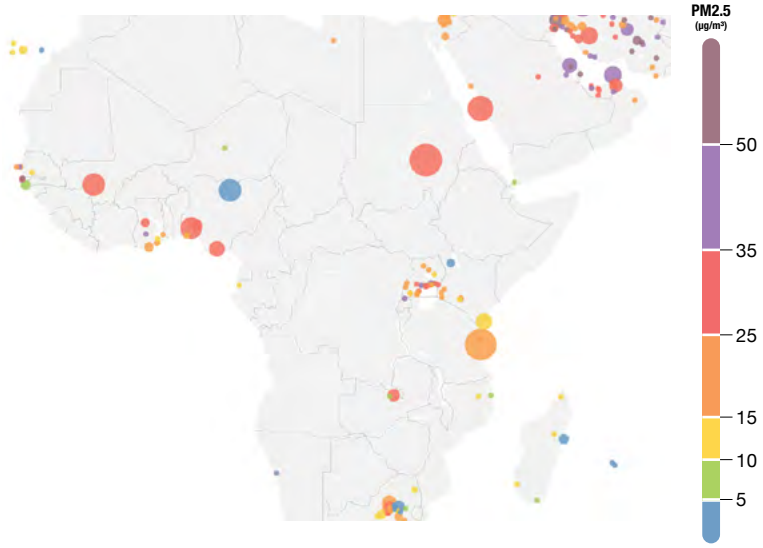
Located on a plateau between mountains, Bogotá experiences temperature inversions in which a warm atmospheric layer traps a colder layer. This weather phenomenon traps and prevents ground-level pollutants from dispersing. Temperature inversions were visible in Bogotá during March, November, and December. On some days, local environmental authorities tightened existing vehicle restrictions and required face masks on public transportation.[100,101] To help reduce they city's car dependency, work began to build a city bus rapid transit system, while heavy rail line financing was approved by the Inter-American Development Bank (IDB).[102,103]



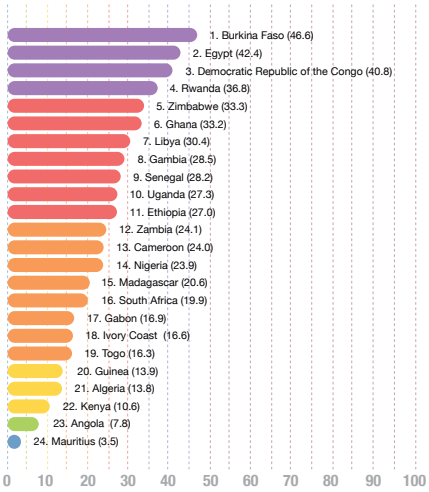
Annual hours spent at different PM2.5 pollution levels

AFRICA

Algeria | Angola | Burkina Faso | Cameroon | Democratic Republic of the Congo | Egypt | Ethiopia | Gabon | Gambia | Ghana | Guinea | Ivory Coast | Kenya | Libya | Madagascar | Mauritius | Nigeria | Rwanda | Senegal | South Africa | Togo | Uganda | Zambia | Zimbabwe

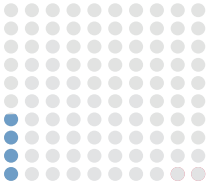


City markers indicating 2023 PM2.5 levels, size adjusted for population



3.8%

Regional cities that met the WHO annual PM2.5 guideline in 2023



2.1
Nieuwoudtville, South Africa

54.9
Benoni, South Africa

Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Benoni, South Africa	54.9
2	Bloemfontein, South Africa	49.4
3	Ouagadougou, Burkina Faso	46.6
4	Abuja, Nigeria	45.4
5	Cairo, Egypt	42.4
6	Kinshasa, Democratic Republic of the Congo	40.8
7	Kigali, Rwanda	36.8
8	Brits, South Africa	33.6
9	Harare, Zimbabwe	33.3
10	Accra, Ghana	33.2
11	Olifantsfontein, South Africa	32.7
12	Vereeniging, South Africa	32.4
13	Akasia, South Africa	32.3
14	Vereeniging NU, South Africa	31.8
15	Alexandra, South Africa	31.6

Least Polluted Regional Cities

Rank	City	2023
1	Nieuwoudtville, South Africa	2.1
2	Bot River, South Africa	2.8
3	Lichtenburg, South Africa	5.1
4	Cape Town, South Africa	5.9
5	Pietermaritzburg, South Africa	6.8
6	George, South Africa	7.9
7	Gqeberha, South Africa	8.6
8	Port Elizabeth, South Africa	9.5
9	Port Shepstone, South Africa	9.6
10	Kraaifontein, South Africa	9.6
11	Hendrina, South Africa	10.0
12	Nairobi, Kenya	10.5
13	Klerksdorp, South Africa	10.6
14	Mokopane, South Africa	11.3
15	Kapsabet, Kenya	11.5

SUMMARY

Across 24 countries, data from 80 cities are included in the 2023 global report, yet about 34% of Africa's population remains unrepresented due to a lack of publicly available air quality data. This limited data perpetuates inequality as communities lack crucial information to address air pollution issues effectively. Accurate measurement of air pollution is essential for developing and implementing policies to safeguard human health in the region. By 2060, it is expected that over 65% of the continent's population will reside in urban areas[104], where air pollution levels tend to rise due to increased energy demand, expanded industrial activity, and a growing number of vehicles. A 2023 report by the Clean Air Fund warns that without key urban development interventions during this period, the economic cost of air pollution in six rapidly expanding urban cities - Accra, Cairo, Johannesburg, Lagos, Nairobi, and Yaounde - could reach a total of $137.8 billion by 2040.[105] Despite a 10.5% decrease in 2023, PM2.5 levels in Cairo continue to exceed the WHO annual PM2.5 guideline by more than eight times, with an annual average of 42.4 µg/m³. PM2.5 levels also rose by 10.3% in Accra, Ghana, with an annual average concentration of 33.2 µg/m³.

Benoni, a South African town 26 miles east of Johannesburg, was the most polluted city in the region in 2023, with an annual average PM2.5 concentration of 54.9 µg/m³. There are two cities in the region that met the WHO annual PM2.5 guideline of 5 µg/m³: two cities in South Africa.

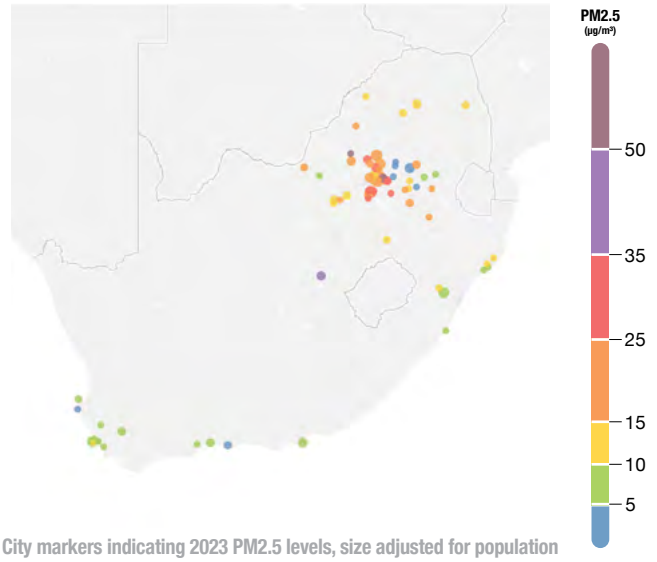
MONITORING STATUS

Publicly available air quality monitoring data is not keeping pace with Africa's rapid urbanization, and most countries in Africa continue to be underrepresented due to a lack of consistently reported data. Notable countries not included in 2023's report due to a lack of publicly available monitoring data include the African nations of Chad (2022 rank: 1) and Sudan (2022 rank: 12). This impacts the ability of people in the region to make informed decisions about their health regarding their local air quality.

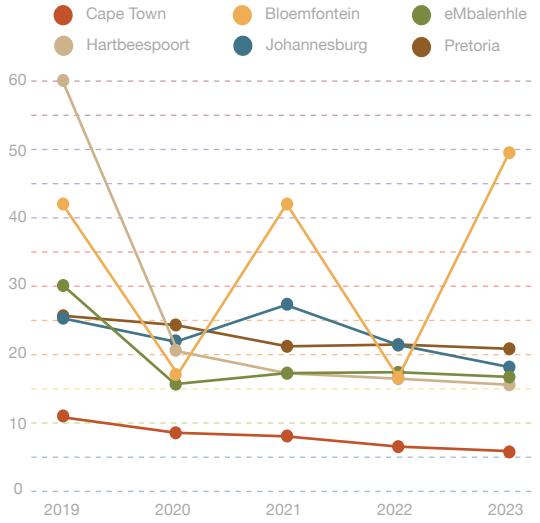
The data in this region is sourced almost evenly from both government and non-government-operated sources, with 58.2% of stations being government-operated. The continued operation and maintenance of non-government operated stations speaks to the desire of the people to be informed on the quality of air they breathe.

Countries and territories included in 2023 that were not in the 2022 report are Cameroon, Gambia, Guinea, Libya, Mauritius, Togo, and Zimbabwe. The represented cities include three capital cities: Conakry in Guinea, Lome in Togo, and Harare in Zimbabwe. Gambia reported data for three cities in 2023.

SOUTH AFRICA



City markers indicating 2023 PM2.5 levels, size adjusted for population



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

City	2023	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2022
Cape Town	5.9	2.8	3.1	4.9	7.8	6.1	8.5	6.3	9.2	5.0	5.1	6.7	5.2	6.7
Bloemfontein	49.4	19.1	14.0	20.0	66.8	78.8	97.9	106.6	83.1	55.7	21.8	15.6	12.0	16.2
eMbalenhle	16.5	8.5	6.2	5.2	3.2	16.6	22.7	34.4	28.5	23.7	17.7	17.2	14.2	16.3
Hartbeespoort	15.6	9.7	8.7	9.9	18.6	15.2	26.2	25.9	27.0	20.5	13.9	6.5	5.4	21.7
Johannesburg	18.7	15.2	14.4	13.9	21.8	19.8	22.7	26.6	23.0	21.1	15.1	15.9	13.0	21.7
Pretoria	21.1	11.2	10.4	11.9	22.5	21.1	35.0	37.5	38.2	28.3	17.3	10.6	8.5	21.7

PROGRESS

The air quality in South Africa as a whole has improved significantly from 2022. The country's annual average PM2.5 concentration showed a 14.8% decrease going from 23.4 µg/m³ in 2022 to 19.9 µg/m³ in 2023. Although there are roughly equal numbers of cities whose PM2.5 concentration increased and decreased, 18 cities and 17 cities respectively, there were improvements in key cities across the country. Cape Town, eMbalenhle, Harbeespoort, Johannesburg, and the capital city Pretoria all showed decreases in annual average PM2.5 concentrations from 2022. Pretoria continues its long-term trend of air pollution reduction through a 17.2% overall decrease from the data reported in 2019.

South Africa has two cities that met the WHO annual PM2.5 guideline of having an annual average PM2.5 concentration at or below 5 µg/m³: Nieuwoudville and Bot River. Cape Town met these requirements for four months but reported an annual average concentration of 5.9 µg/m³ for the entire year.

CHALLENGES

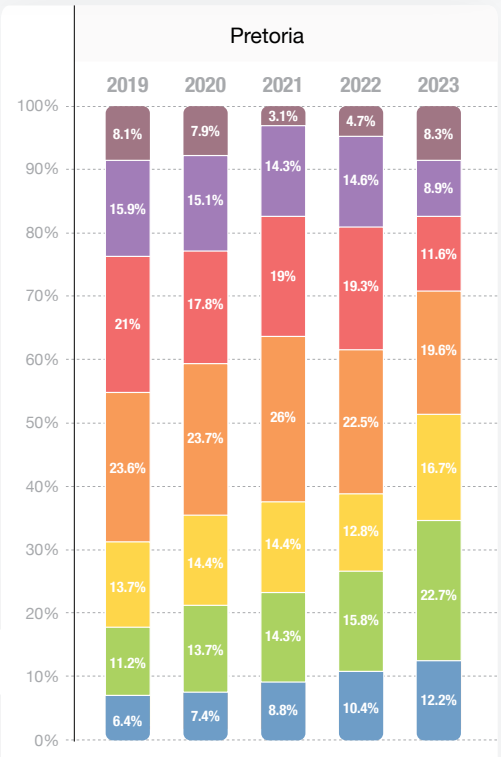
Two of the biggest contributors to air pollution in South Africa are coal-powered and industrial plants, especially in Mpumalanga Province near Johannesburg.[106] Fossil fuels fulfill 90% of the country's energy demand, leading to South Africa being the continent's largest emitter of sulfur dioxide.[107] As a major carbon dioxide emitter, the country is the 12th biggest greenhouse gas polluter in the world.

A 2022 Pretoria High Court ruling found that air quality in the region violated the constitutional right to "an environment not harmful to their health or wellbeing."[108] The court ordered the government to improve air quality in the area.

Other air pollution sources in South Africa include vehicle exhaust, coal mines, metal smelters, and petrochemical facilities.[109] Coal is often used for domestic cooking and heating.[110]

HIGHLIGHT: CHILDREN'S HEALTH

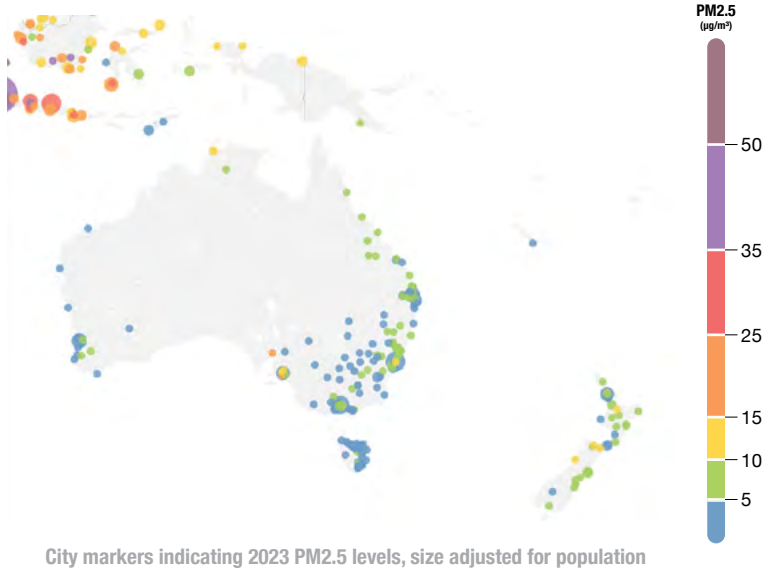
Two studies conducted in the Highveld - the industrial region surrounding Johannesburg – found that lax emission standards harmed children's health. Children in the Highveld were afflicted with greater susceptibility to allergens, respiratory inflammation, and increased asthma cases.[111] Though commissioned by the South African government and released in 2016 and 2019, the study results weren't made widely available to the public. The South African government has faced two lawsuits over not enforcing existing air pollution laws and failing to mitigate air pollution. United Nations (UN) Special Rapporteur on toxics and human rights Marcos Orellana noted in August that while South Africa has strong environmental laws on its books, the government fails to enforce them.[112]



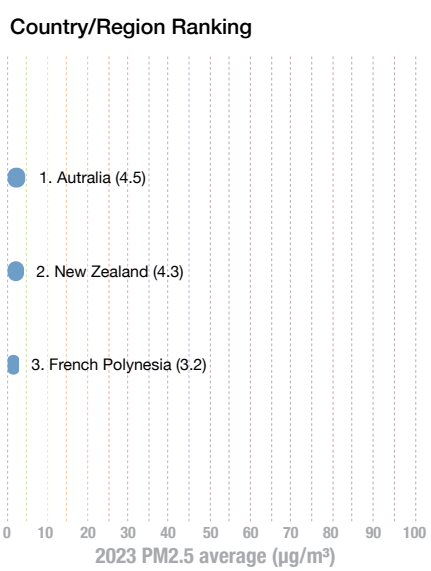
Annual hours spent at different PM2.5 pollution levels

OCEANIA

Australia | French Polynesia | New Zealand

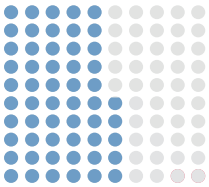


City markers indicating 2023 PM2.5 levels, size adjusted for population



54.9%

Regional cities that met the WHO annual PM2.5 guideline in 2023



1.7 Underwood, Australia

10.6 Tokoroa, New Zealand

Range of 2023 average PM2.5 (µg/m³) across regional cities

Most Polluted Regional Cities

Rank	City	2023
1	Tokoroa, New Zealand	10.6
2	Rocklea, Australia	10.5
3	Nelson, New Zealand	10.2
4	Richmond, New Zealand	9.7
5	Stockton, Australia	9.5
6	Kaiapoi, New Zealand	9.0
7	Taupo, New Zealand	9.0
8	Collie, Australia	8.8
9	Timaru, New Zealand	8.8
10	Waimate, New Zealand	8.4
11	Armidale, Australia	8.3
12	Muswellbrook, Australia	8.3
13	Geraldine, New Zealand	8.1
14	Singleton, Australia	7.9
15	Taihape, New Zealand	7.9

Least Polluted Regional Cities

Rank	City	2023
1	Underwood, Australia	1.7
2	Broken Hill, Australia	1.8
3	Rufus, Australia	1.9
4	Emu River, Australia	1.9
5	Judbury, Australia	1.9
6	Fingal, Australia	2.1
7	Exeter, Australia	2.2
8	Mornington, Australia	2.2
9	Euston, Australia	2.3
10	Gretna, Australia	2.3
11	Walpeup, Australia	2.3
12	Condobolin, Australia	2.4
13	Hay, Australia	2.5
14	Walgett, Australia	2.5
15	New Town, Australia	2.5

SUMMARY

In 2023, Oceania remains the world's cleanest region. Despite slight increases in average PM2.5 concentrations for Australia (+0.3 µg/m³) and French Polynesia (+0.7 µg/m³) compared to 2022, all countries in the region achieved the WHO annual PM2.5 guideline. Despite a nearly 1 µg/m³ increase in PM2.5 concentration in Wellington, New Zealand's capital, the overall country average fell by approximately half that amount to 4.3 µg/m³. This region distinguishes itself by having the largest proportion of cities meeting the WHO annual PM2.5 guideline, with 55% of the 207 reporting cities having annual averages below 5 µg/m³. Australia has experienced three years of La Niña conditions, bringing significant amounts of rain during the summer months in some areas leading to increased vegetation and increased risk of severe brushfires under hot and dry conditions. Prescribed burns around the country in late Autumn and through winter months (April-August) resulted in peak PM2.5 pollution periods.[113]

Despite the overall positive results, there is still progress to be made. Annual concentrations for nearly 100 cities in the region continue to exceed the WHO annual PM2.5 guideline, indicating a significant portion of the region's population is still exposed to air quality conditions that pose a risk to their health.

MONITORING STATUS

Non-governmental monitoring sources continue to provide air quality information for numerous areas without government-operated monitors in Australia. In six of the country's nine states and internal territories, over 60% of the reported data originates from non-government sources. The data generated by these non-government-operated monitors has facilitated the inclusion of 47 Australian cities in the 2023 report. However, it's noteworthy that data from Guam and New Caledonia was not sufficiently complete for inclusion in the 2023 report, underscoring the significance of expanding monitoring efforts and ensuring the continuity of existing monitoring networks.

Next Steps

What can governments do?

Decrease air pollution emissions

- Incorporate the WHO air quality guideline into forthcoming air quality standards
- Allocate resources to fund renewable energy initiatives
- Broaden the adoption of renewable, clean energy in public transportation systems
- Introduce incentive programs to stimulate the adoption of clean air vehicles for commercial and personal purposes
- Implement trade-in initiatives and other financial encouragement programs to facilitate the shift away from internal combustion engines
- Provide subsidies for battery-powered and human-powered modes of transportation
- Champion infrastructure projects that enhance pedestrian mobility
- Strengthen air pollutant emission restrictions for both vehicles and industrial operations
- Adopt responsible forest management strategies to mitigate the risk of wildfires
- Prohibit agricultural and biomass burning practices
- Promote groundbreaking, problem-solving approaches to address local air quality concerns and enhance air quality

Expand the air quality monitoring framework

- Enhance the scope and reach of government-operated air quality monitoring stations
- Financially incentive community-based organizations, university groups, and individuals who host personal air quality monitoring stations

What can I do?

- Promote local and national air quality endeavors, including initiatives, proposals, and actions focused on addressing air pollution
- Back groups, community influencers, and policymakers who prioritize improving air quality
- Advocate and inform on air quality issues to regional representatives

Limit your exposure to air pollution

- Get the free IQAir AirVisual app to access up-to-the-minute information on current air quality conditions
- Reduce outdoor activities during periods of unhealthy air quality
- Put on a high-quality face mask when outdoors under unhealthy air quality conditions
- Monitor real-time outdoor air quality data and forecasted pollution levels
- Choose eco-friendly alternatives to wood-burning stoves for heating and cooking
- Enhance indoor air quality with air filtration devices and purification systems
- If outdoor air quality reaches unhealthy levels, put A/C systems in recirculation mode and secure doors and windows to prevent contaminated air infiltration
- When outdoor air quality is at healthy levels, allow fresh air intake in A/C systems and open doors and windows for interior ventilation

Lower your personal air pollution footprint

- Bike, walk, or utilize public transportation when feasible
- Economize and lower energy consumption by reducing energy use
- Manage individual waste by reducing purchases and engaging in upcycling, recycling, and reusing existing items

Become an air quality data contributor

Raising air pollution global awareness, understanding pollution's impact on human health, and increasing the accessibility of air quality data represent critical steps in addressing the collective challenge of poor air quality. Access to localized air quality information can empower individuals to advocate for cleaner air initiatives within their own communities.

While the number of air quality monitoring stations and represented regions continues to grow, there are still areas worldwide lacking real-time air quality data. Local initiatives aimed at strengthening air quality monitoring are vital, whether they are led by governmental bodies, community organizations, educational institutions, or concerned citizens.

Advancements in low-cost sensor technology have expanded global capacity to collect accurate air quality data using devices that can be installed without specialized training. With the expansion of monitoring stations, a wealth of data becomes accessible to researchers, policymakers, businesses, and community members, facilitating a deeper understanding of global air quality conditions. This, in turn, promotes informed discussions and decision-making that can drive improvements in air quality and healthier communities.

To learn how to become a contributor, please visit our **website**.

Methodology

Data sources

The 2023 World Air Quality Report exclusively relies on ground-level air quality monitoring stations for PM2.5 data. Among these stations, 39% are under government operation, while the remaining 61% are managed by non-profit community organizations, educational institutions, and individual citizens employing low-cost sensors.

Real-time data collection forms the foundation of our air quality dataset, complemented by supplementary year-end data. The amalgamation of historical data sources with real-time PM2.5 measurements enriches the global dataset, rendering the most complete global data set for analysis.

Data validation

Both regulatory-grade air quality monitors and low-cost sensors can be susceptible to data anomalies arising from inherent defects or short-term environmental disruptions. In response to these challenges, IQAir's cloud-based data platform executes rigorous quality control procedures on the provided air quality readings. Abnormal measurements from individual sensors are flagged and isolated before the data is added to the IQAir platform. These measurements undergo cross-validation, comparing them against data sourced from the same sensor and pollutant concentrations recorded by neighboring sensors. Data points failing to meet the stringent quality control criteria are omitted from both the IQAir platform and this report.

Data calibration

In this report, data from low-cost air quality sensors gauge airborne PM2.5 levels through laser scattering technology. Correction factors are applied to calibrate data from low-cost sensors, mitigating potential biases stemming from environmental variables.

Data calculation

The annual average PM2.5 concentrations in this report result from data gathered by individual air quality monitoring stations located within specific geographical areas. These stations regularly capture and timestamp PM2.5 concentration readings from the surrounding atmosphere.

To derive the hourly average PM2.5 concentration for each station, validated data points from the previous 60 minutes are consolidated and averaged. This value signifies the immediate area's hourly average PM2.5 concentration. Over the span of a year, a resulting series of hourly averages is collected to calculate annual average PM2.5 concentrations for cities. Subsequently, this data is weighted by population demographics to establish annual averages for countries, territories, and regions.

City level data

This report provides city-level data, showcasing both annual and monthly average PM2.5 concentrations. Monthly averages are calculated by taking the average of all hourly average PM2.5 concentrations recorded within the city's boundaries during a given month. This method maintains a uniform data weighting across diverse monitoring stations and various hours. Similarly, annual average PM2.5 concentrations are determined using the average of all hourly average PM2.5 concentrations recorded within the city's limits throughout the year.

Country/region data

Annual average PM2.5 concentrations for countries, territories, and regions are derived by considering the city-level annual average PM2.5 concentration and the total population of all cities within a region, territory, or country. Cities lacking sufficient PM2.5 data do not contribute to the population aggregations within these areas. In the following section, we will use the term "area" in lieu of "country, territory, and region."

IQAir's objective is to provide a comprehensive overview of global air quality, facilitating meaningful comparisons of ambient air quality conditions across diverse locations, with a particular focus on airborne pollutant exposure and its implications for human health. A simple average calculation of all city-level PM2.5 concentrations within an area falls short in offering valuable insights into the relative air quality experienced by individuals throughout that region.

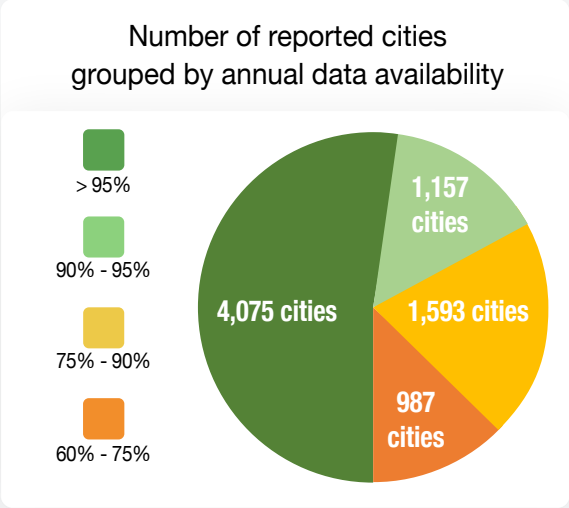
Therefore, we incorporate population data from cities reporting PM2.5 concentrations to present a more accurate representation of the human perspective on air quality within an area. Population weighting as a normalization factor allows us to better convey air quality conditions. This approach ensures that densely populated cities proportionally impact an area's reported annual average, enabling air quality information from more populous cities to exert a more significant influence. This more accurately reflects individual experiences in the local area and provides a contextual basis for global air quality comparisons.

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

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

Data availability

The key metric for evaluating the representation of a city's reported annual average PM2.5 concentration in the 2023 World Air Quality Report was the availability of annual data. To qualify for inclusion in the report, cities were required to have hourly average PM2.5 data for a minimum of 60% of the year, equivalent to at least 5,256 hours out of a total of 8,760 hours. The 2023 data availability for the PM2.5 data utilized in this report is outlined below.



The pie chart shows the distribution of the total number of reported cities (7,812) by annual data availability.

Disclaimer

The PM2.5 data featured in this report originates from ground-level air quality monitoring stations, encompassing both regulatory-grade monitors and low-cost sensors. The entirety of this data was compiled during the calendar year of 2023.

IQAir is a politically neutral organization. The maps, graphs, and other content incorporated into this report are designed to offer perspective on the global data set and do not reflect any political position. Regional maps were generated using 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 2023 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 2023 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% is required for inclusion in the 2023 World Air Quality Report. Cities represented in the report must possess at minimum, hourly PM2.5 data from 60% of the total number of hours in 2023. The 60% 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.

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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.