

10

Frequently Asked

Questions on

Air Quality Index



UrbanEmissions (UEinfo) was founded in 2007 with the vision to be a repository of information, research, and analysis related to air pollution. UEinfo has four objectives: (1) sharing knowledge on air pollution (2) science-based air quality analysis (3) advocacy and awareness raising on air quality management and (4) building partnerships among local, national, and international airheads.

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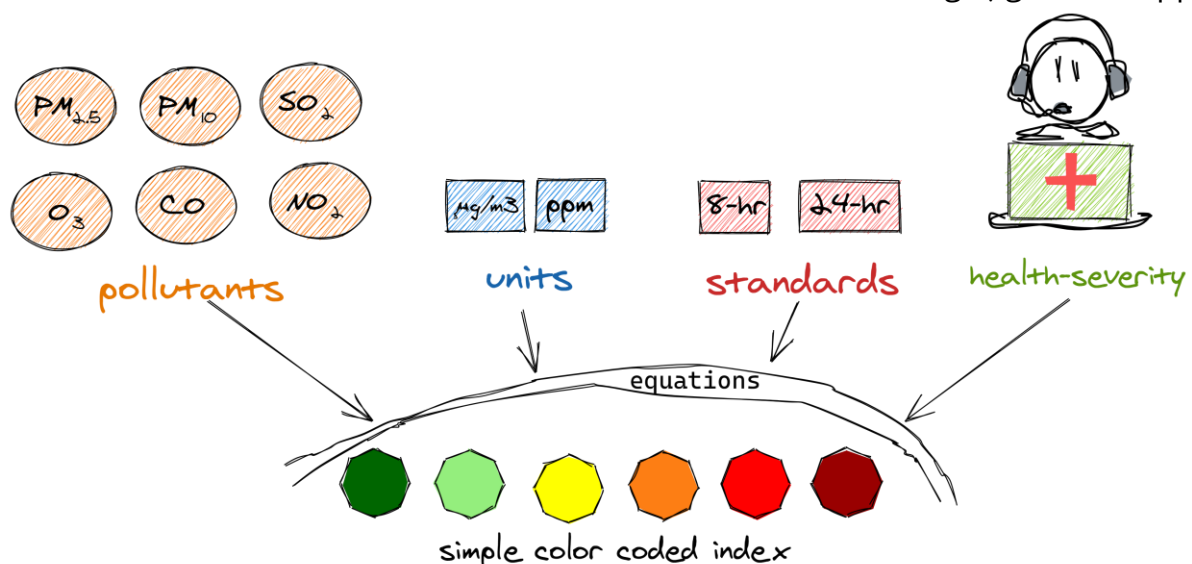
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# What is an Air Quality Index?

There are many saying like “seeing is believing”, “picture is worth a thousand words”, and “what we cannot measure, cannot be managed”. **This “air quality index” (AQI) falls under the same umbrella which allows us to see and understand the breadth and depth of air quality at a location or a city**, as a simple coloured symbol. This is part of a pollution-health alert system for managing personal air pollution exposure levels.

Air pollution includes aerosols and gaseous components.

- Each of these components affect our health differently at various degrees of exposure rates.
- Some pollutants can lead to an immediate response like carbon monoxide (CO) and Ozone (O<sub>3</sub>) and are presented on a short time scale (8-hourly) compared to other pollutants at 24-hourly time scale.
- Finally, aerosol concentrations are reported as mass fractions and gaseous concentrations as volumetric fractions in a unit volume of air (e.g.,  $\mu\text{g}/\text{m}^3$  and ppm).



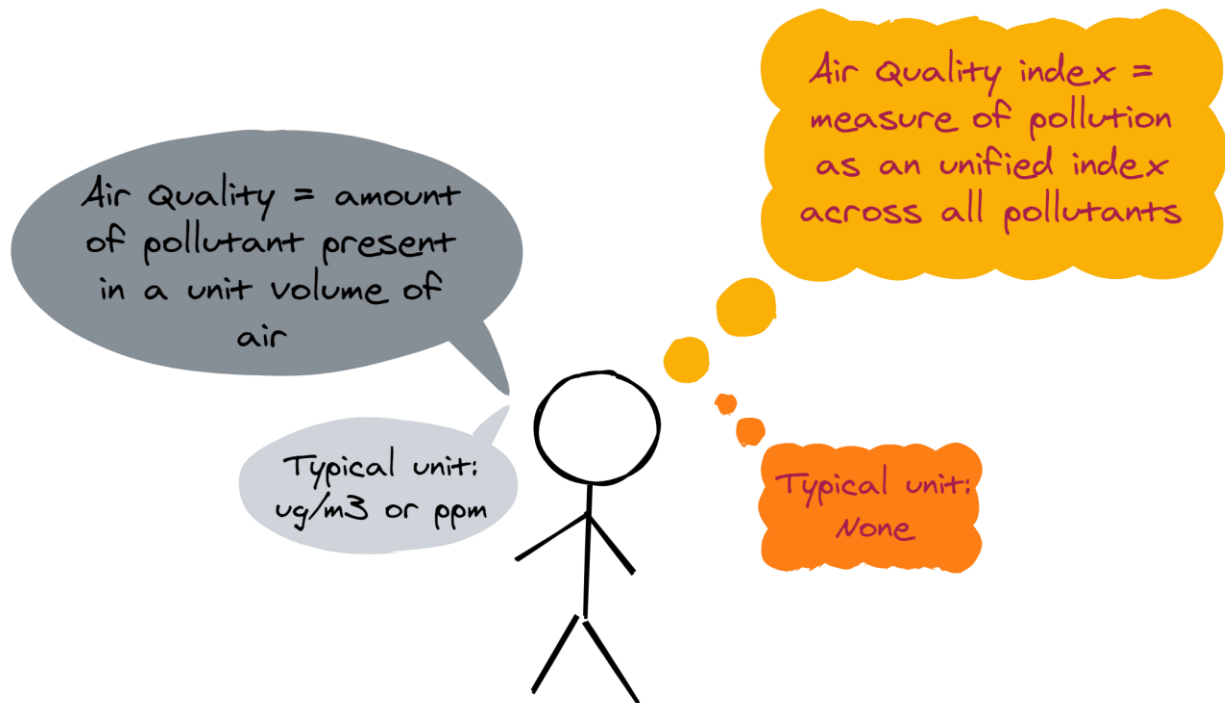
AQI unifies all this complicated science of pollution composition, exposure rates-based health severity, ambient standards, measurements, and standard protocols, into simple colour coded bins for everyone to see how good or bad or ugly the pollution levels are.



While simple, this topic still raising some confusing questions during a conversation. This publication answers [10 Frequently Asked Questions \(FAQs\) on AQI](#).

## FAQ#01 - What is the difference between air quality and AQI?

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It is common to hear conversations where air quality and air quality index are used synonymously, but these numbers come from two contrasting worlds.

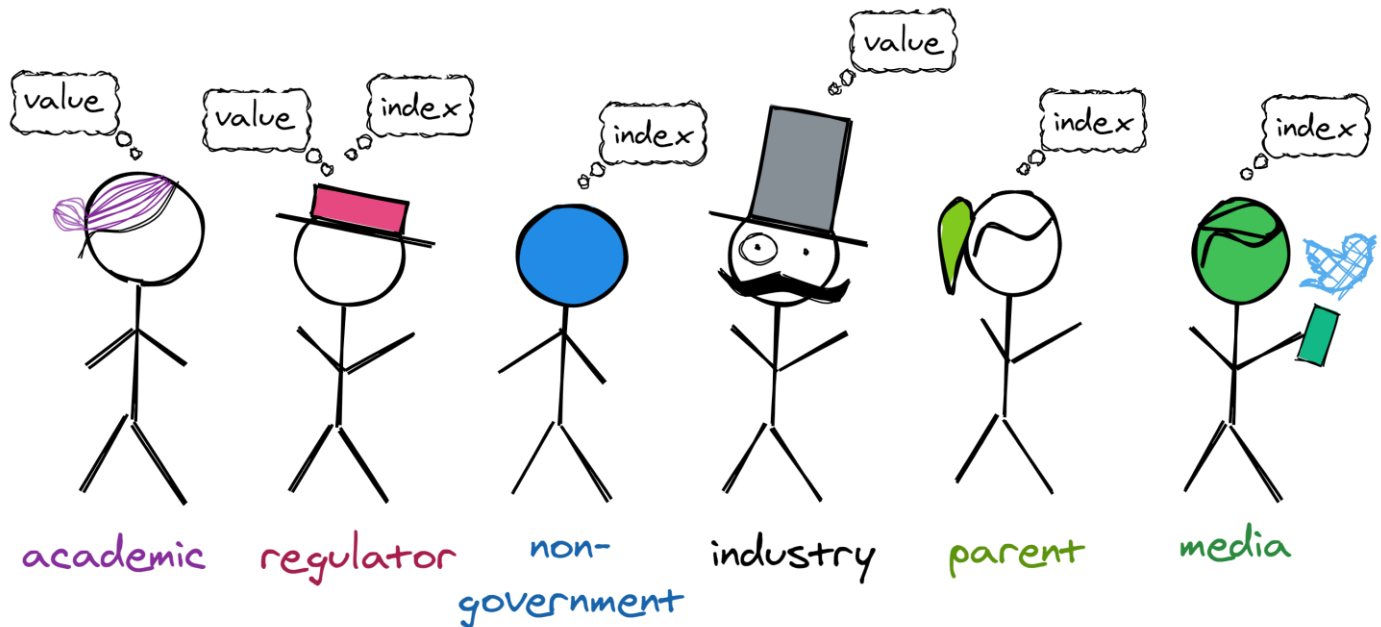
“Air Quality” is a necessary number to support regulatory and science discussions as it represents the absolute nature of air pollution.

“Air Quality Index” is an extract from air quality used as a number to simplify the pollution alert system to support public awareness.

## FAQ#02 – Is it better to report air quality or AQI values?

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The response to this question varies greatly depending on the individual speaking or being addressed.



Here are some examples:

- Academic/Scientist – absolute values are preferred, which help validate the modelling efforts, build a better understanding of how pollution effects the environment, health, and our overall well-being.
- Regulator – both the numbers are crucial. While the absolute values are necessary for understanding the emission and pollution loads, exceedances, and corresponding impacts, the index value is necessary for communicating the severity of the pollution levels to the public.
- Non-government staff/parents/media – an index is preferred as it helps with communicating the severity of the pollution levels, without the science jargon behind the absolute values and trends.
- Industry – absolute values are preferred by the industry, as they are mandated to portray and discuss the true value of emissions and pollution originating from their sources.

## FAQ#03 - How is AQI calculated?

### Formula to calculate Air Quality Index (AQI)

$$AQI = \frac{AQI_{hi} - AQI_{lo}}{BP_{hi} - BP_{lo}} * (CONC - BP_{lo}) + AQI_{lo}$$

CONC = concentration of the pollutant

AQI = air quality index corresponding to CONC

BP<sub>hi</sub> = break-point concentration of the pollutant greater than CONC

BP<sub>lo</sub> = break-point concentration of the pollutant less than CONC

AQI<sub>hi</sub> = AQI value corresponding to BP<sub>hi</sub>

AQI<sub>lo</sub> = AQI value corresponding to BP<sub>lo</sub>

Every pollutant has pre-defined breakpoint and AQI ranges for each of the colour codes. Table below presents an example from India.

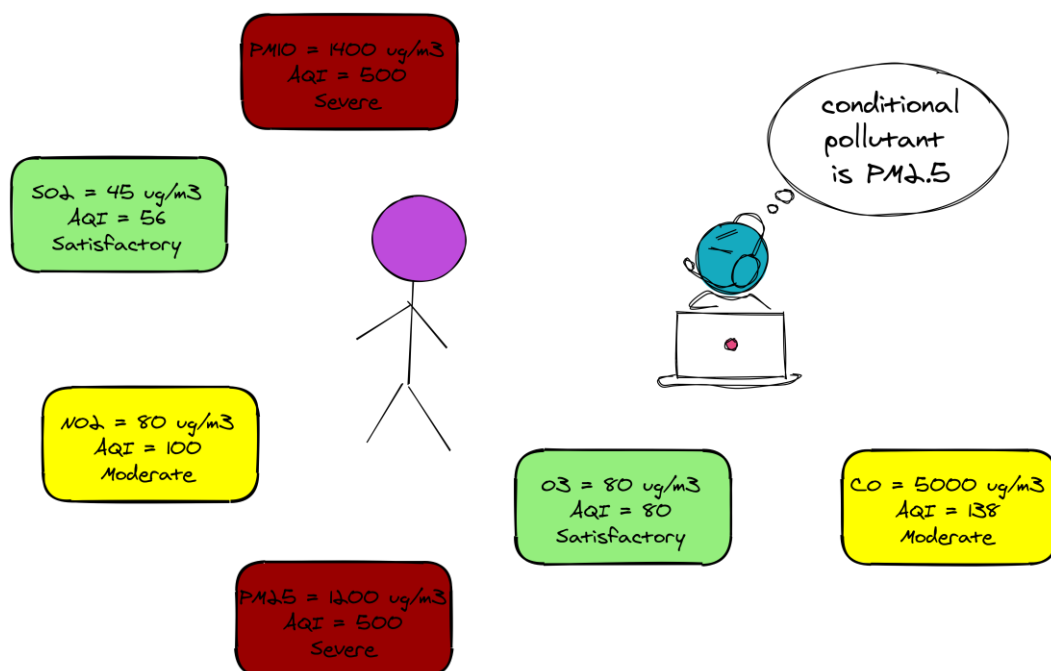
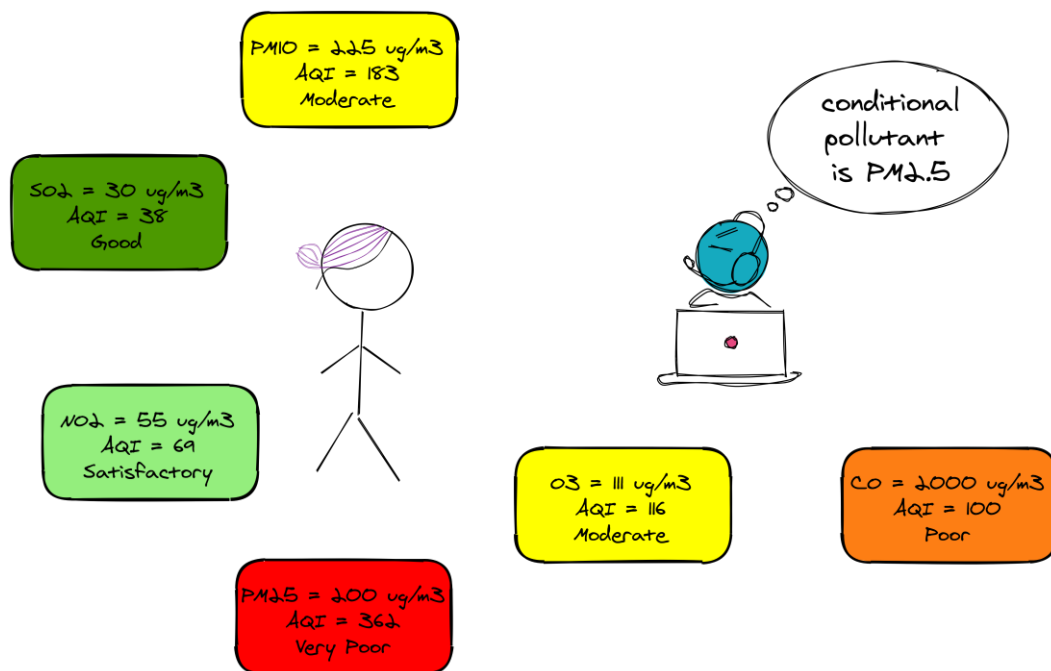
AQI Category (Range)	PM <sub>10</sub> 24-hr	PM <sub>2.5</sub> 24-hr	NO <sub>2</sub> 24-hr	O <sub>3</sub> 8-hr	CO 8-hr (mg/m <sup>3</sup> )	SO <sub>2</sub> 24-hr	NH <sub>3</sub> 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6-1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

*\*One hourly monitoring (for mathematical calculation only)*

The numbers in the first column represent the AQI bins (lo and hi values to be used in the calculator). The number ranges under each of the pollutants represent the corresponding breakpoint concentrations (lo and hi). In this table, all the breakpoint concentrations are in µg/m<sup>3</sup>, except for CO in mg/m<sup>3</sup>.

The top of the AQI scale is 500, which means there will be a point in the calculation when the AQI value itself will not change above (for say) 1000 µg/m<sup>3</sup> of PM<sub>2.5</sub> or PM<sub>10</sub>. Once the colour code reaches the top of the severe category, there is no change in the AQI value.

Here are some example calculations using India's AQI methodology.



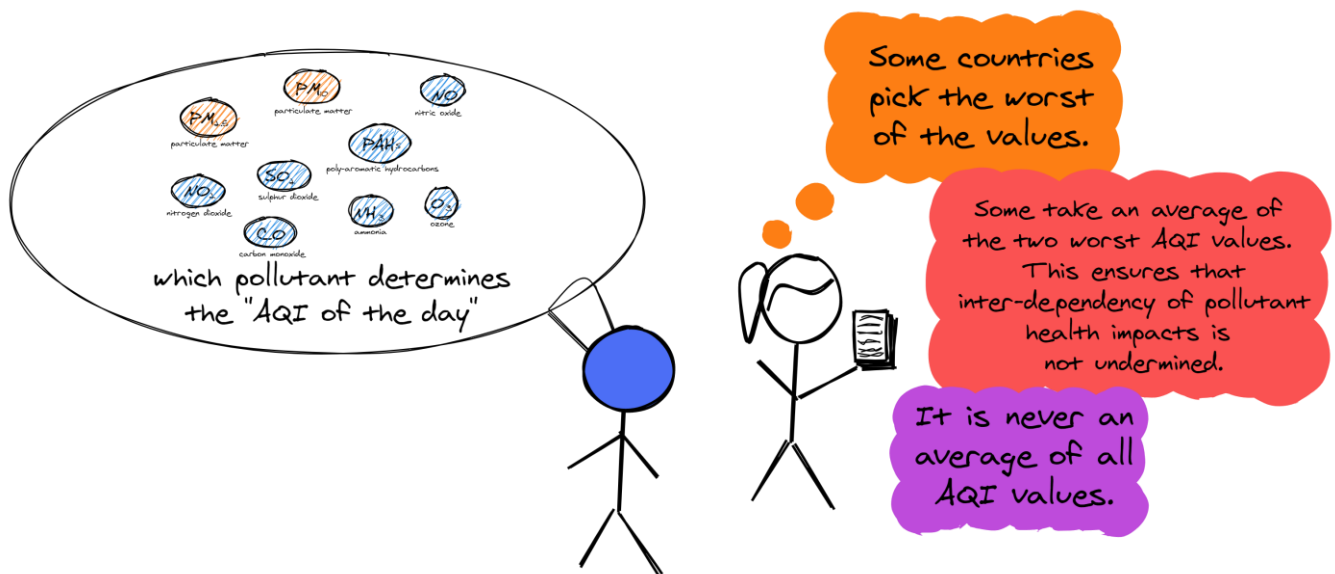
PM<sub>2.5</sub> is the most common pollutant that dictates "AQI of the day" in most countries.

In the United States and the European Union countries where industrial activities are minimum and most of the pollution is sourced from vehicle exhaust, NO<sub>2</sub> and/or O<sub>3</sub> either precede or follow PM<sub>2.5</sub>.

Other typical occurrences include PM<sub>10</sub> during a dust storm, SO<sub>2</sub> for an area dominated by coal combustion activities, and CO during an open biomass burning days.

## FAQ#04 - Every criteria pollutant has an index value, then which one decides “AQI of the day”?

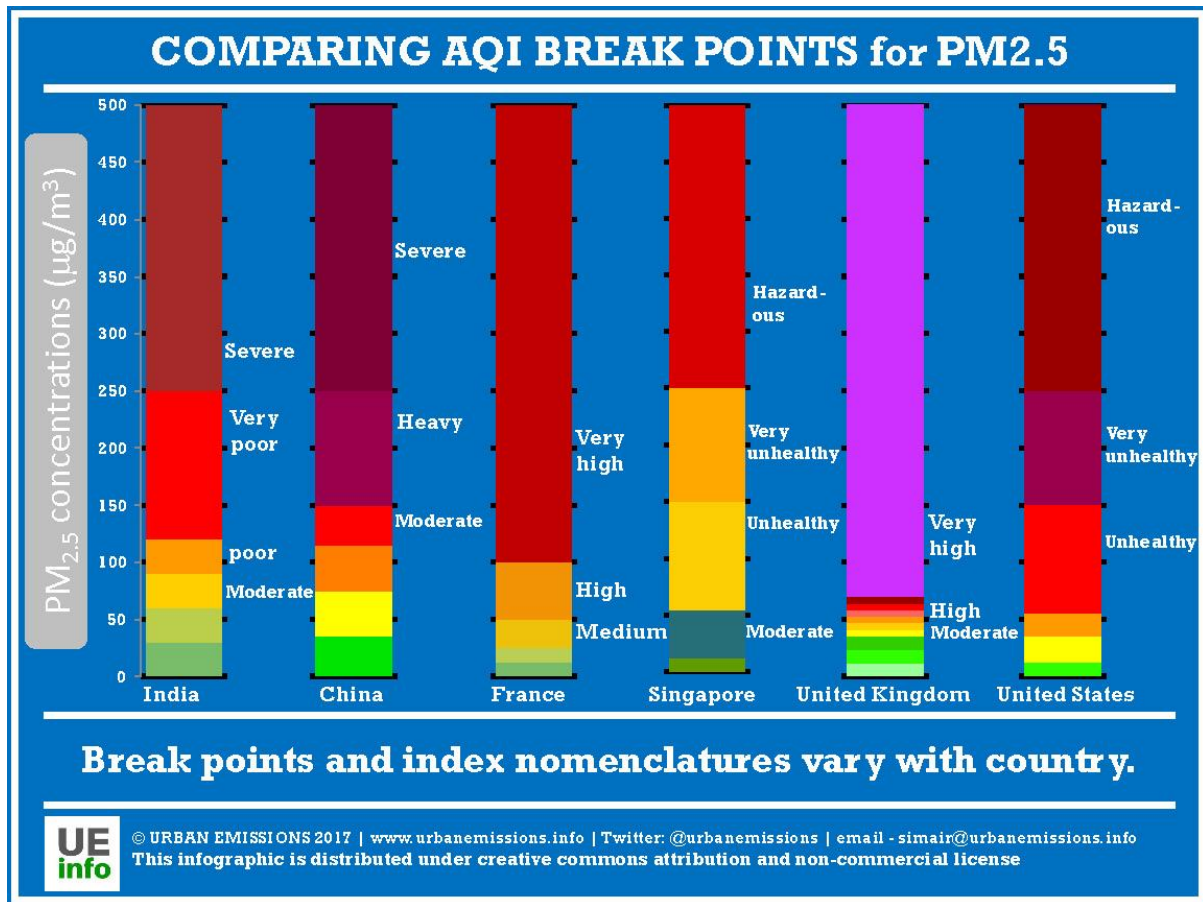
Typically, AQI is calculated for six pollutants – PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub>, CO, and Ozone. Where available, some countries also include measurements of NH<sub>3</sub> and some carcinogens. If AQI is calculated for more than 2 pollutants, following are the two known methods for picking “AQI of the day”.



- Picking the worst AQI value, ensures that the worst pollutant of the day is immediately highlighted.
- Picking an average of the two worst AQI values accounts for inter-dependency of pollutant health impacts. This method ensures that we do not over-emphasize the importance of the worst pollutant and do not under-estimate the importance of the second worst pollutant.
- Averaging all the pollutants is not advised, as this method has the tendency to nullify the overall severity of the pollutants.



## FAQ#05 - What is the difference between AQI methodologies of various countries?



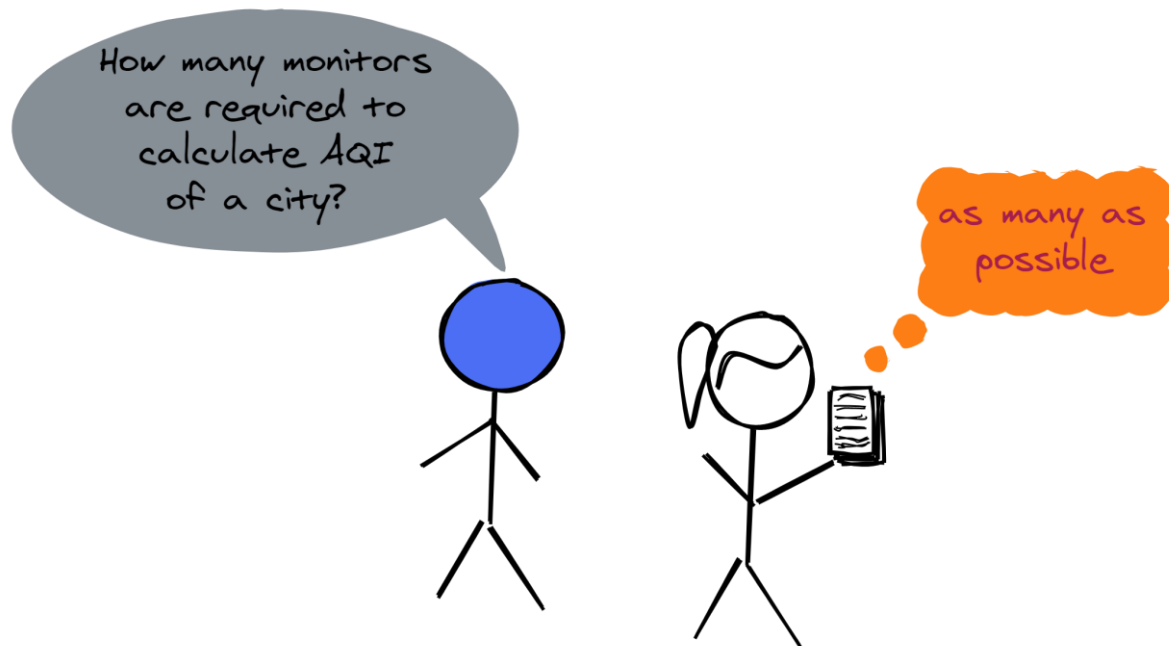
While the impacts of air pollution on human health are common across the globe, these metrics are interpreted differently for regulatory purposes from country to country.

This is primarily driven by pre-determined local standards and the feasibility of reaching the lowest possible pollution levels. For example, in a region where presence of dust is natural (like the Middle East and the Subcontinent), it is not possible to reach WHO guidelines for PM<sub>10</sub> and PM<sub>2.5</sub>. This is one of reasons for India's annual standard for PM<sub>2.5</sub> being 8 times the WHO guideline (40 vs 5 µg/m<sup>3</sup>, as of September 2023).

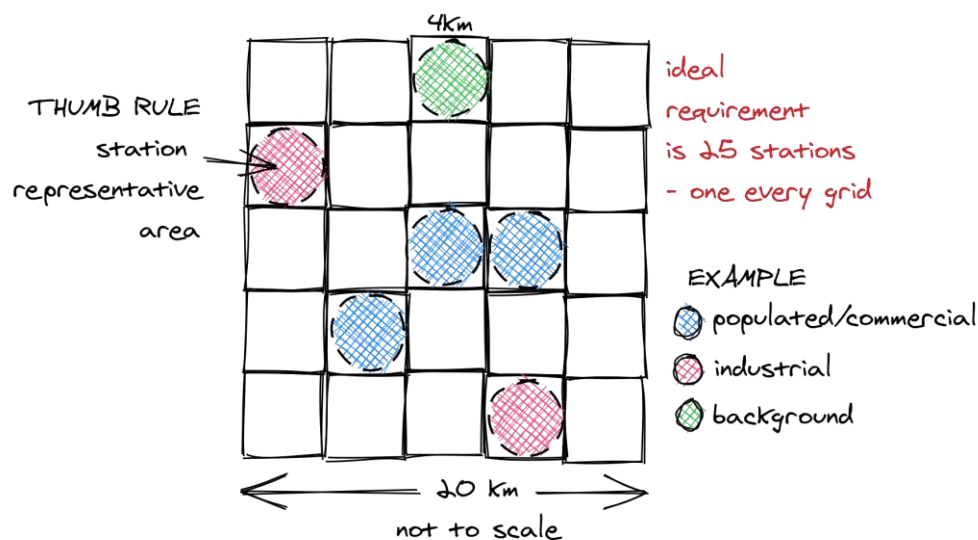
The same principle also trickles into the formulation of AQI by individual countries, which notionally resembles their standards (see the infographic above).

## FAQ#06 - How many monitors are required to calculate AQI of a city?

"How many monitors to operate" primarily depends on the financial status of the city or the concerned institution. It is important that as many monitoring stations as possible are established, to create a representative pollution map for the city or the area of interest.



Typically, a thumb rule for representativeness of a continuous monitoring station is 2-km radius (see figure below). This representative area could be smaller inside the city with multiple obstructions like tall buildings and trees or could be more outside the city, which is commonly referred to as "background".

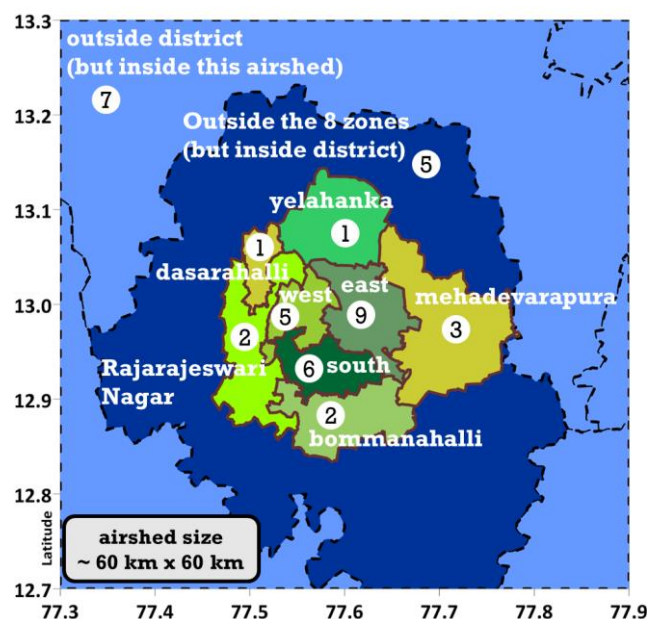


Placing a monitor every 9-km<sup>2</sup> is financially and technically prohibitive for any city. So, a representative sample set will include more stations in densely populated and commercially active areas and lesser number of stations outside the main urban areas. This is a compromise between technical needs and financial obligations for operating a network.

Countries have their own thumb rules to determine the number of recommended monitoring stations to represent the air pollution trends spatially and temporally. India's Central Pollution Control Board created some guidelines summarized below for SPM, SO<sub>2</sub>, NO<sub>2</sub>, and CO (and other oxidants).

Pollutant	Population in the airshed	Number of stations
<b>Suspended particulate matter (SPM)</b>	< 100,000	4
	100,000 to 1,000,000	4 + 0.6 per 100,000 population
	1,000,000 to 5,000,000	7.5 + 0.25 per 100,000 population
	> 5,000,000	12 + 0.16 per 100,000 population
<b>Sulfur dioxide (SO<sub>2</sub>)</b>	< 100,000	3
	100,000 to 1,000,000	2.5 + 0.5 per 100,000 population
	1,000,000 to 10,000,000	6 + 0.15 per 100,000 population
	> 10,000,000	20
<b>Nitrogen dioxide (NO<sub>2</sub>)</b>	< 100,000	4
	100,000 to 1,000,000	4 + 0.6 per 100,000 population
	> 1,000,000	10
<b>Carbon monoxide (CO) and Oxidants</b>	< 100,000	1
	100,000 to 5,000,000	1 + 0.15 per 100,000 population
	> 5,000,000	6 + 0.05 per 100,000 population

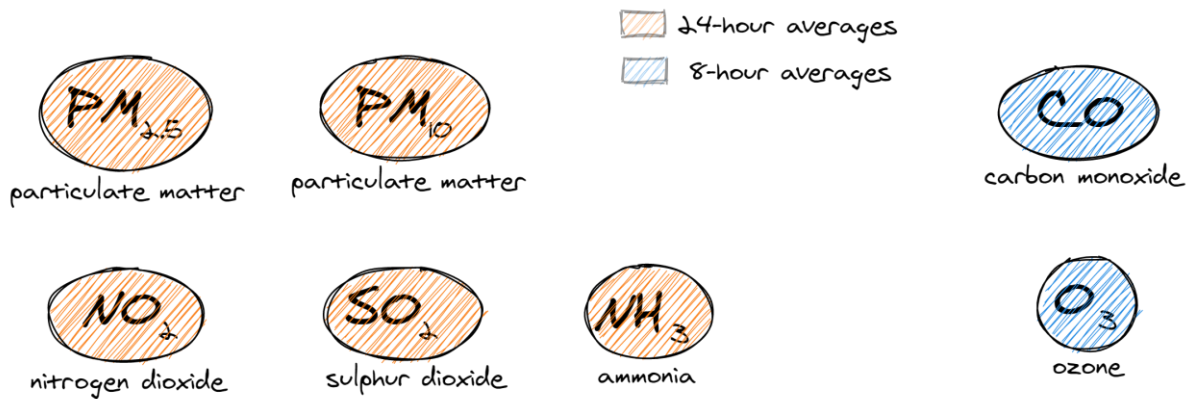
Using these guidelines, an example for the city of Bengaluru is presented below. This assessment used information on gridded population and gridded urban settlements area to estimate the recommended number of 41 particulate monitors for the city's airshed.



## FAQ#07 - What is the difference between hourly and daily AQI?

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While AQI values change every hour for a city (as an average of all the stations data) or for a station, the index does not represent the air quality at that hour alone.



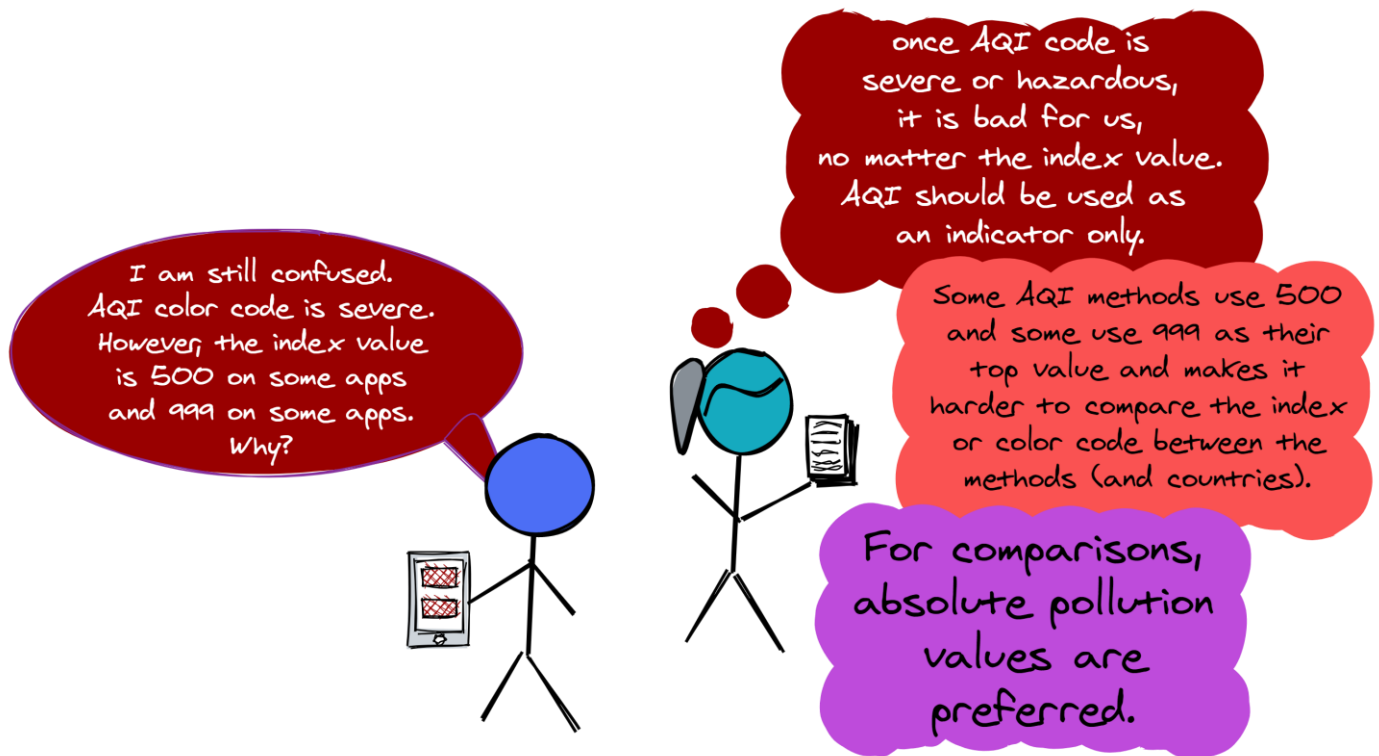
There is no hourly and daily AQI. There is only AQI.

If AQI is reported every hour, then it is an index value calculated using the average concentrations data of last 24-hours for aerosols and of last 8-hours for gases.

If AQI is reported only once every day, then it is an index value calculated using concentrations data of that day's 24-hour average for aerosols and daytime 8-hour average for gases.

## FAQ#08 - What is the meaning of AQI=500 or AQI=999?

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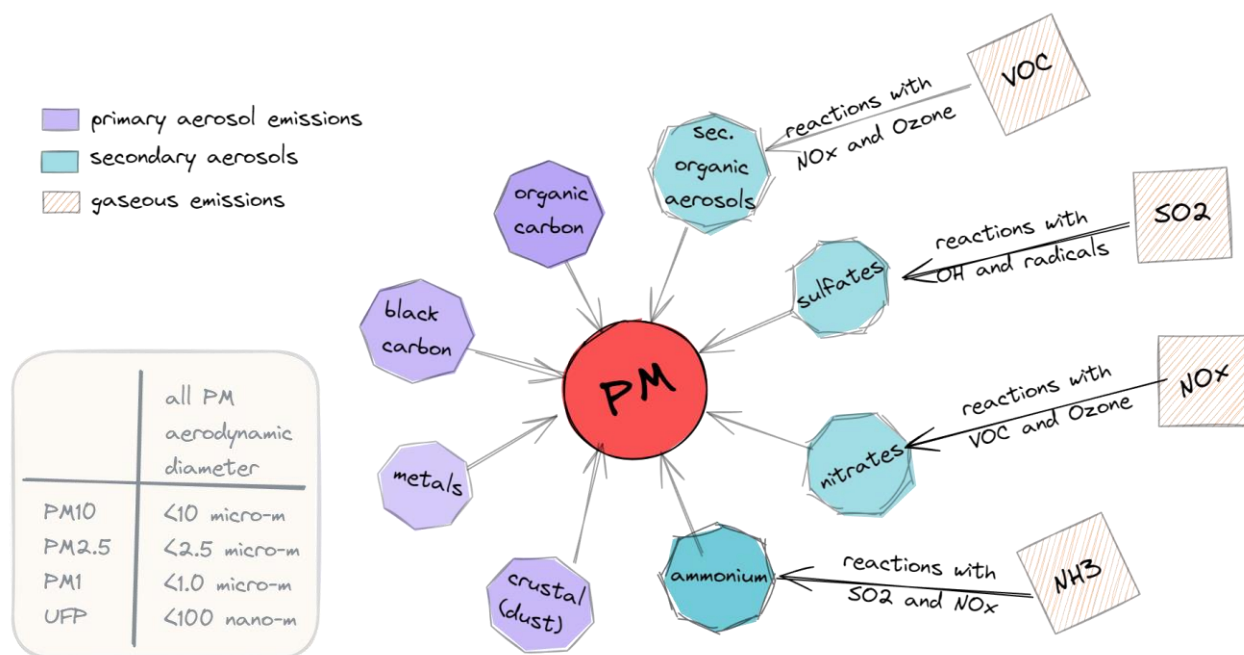
Variations in AQI values arise due to countries and different data analytical groups employing their preferred methodologies in calculating and presenting them. Some methods use 500 and some use 999 as the top AQI value to present the severe or hazardous category.

However, since AQI is only an index to provide some guidance on what the pollution levels are, once the index reaches the last category, it does not matter what the absolute value is – the bottom line is that “air pollution is severe or hazardous or at the emergency levels”.

It is important to understand AQI masks the true severity of the pollution levels. If absolute  $\text{PM}_{2.5}$  concentration is 500 or 1000 or 3000  $\mu\text{g}/\text{m}^3$ , the AQI index will show 500 or 999, depending on the selected scale. However, breathing air at 3000  $\mu\text{g}/\text{m}^3$  is more dangerous than 500 and needs immediate attention.

## FAQ#09 - Is PM<sub>2.5</sub> the most harmful of all air pollutants?

Among the environmental risks, exposure to outdoor and indoor air pollution is in the top 10. Several studies are conducted worldwide to understand the epidemiological nature of air pollution and the Global Burden of Diseases study, which is updated every year, provides a library of such studies and a synthesis of results in the form integrated exposure response (IER) curves linking particulate matter (PM) and ozone to various health endpoints<sup>1</sup>.



PM is the most important pollutant, primarily because of its chemical composition linked to other pollutants (like SO<sub>2</sub>, NO<sub>x</sub>, and VOC's), its tendency to stay in the air for longer periods, and its tendency to go deeper into human body parts and result in chronic diseases. PM<sub>2.5</sub> pollution is directly linked to cause or exacerbate asthma, collapsed lung, chronic bronchitis, pneumonia, blocked lung artery, lung cancer, diabetes, blood pressure, complications during pregnancy, early childhood brain function impairment, and even hair loss.

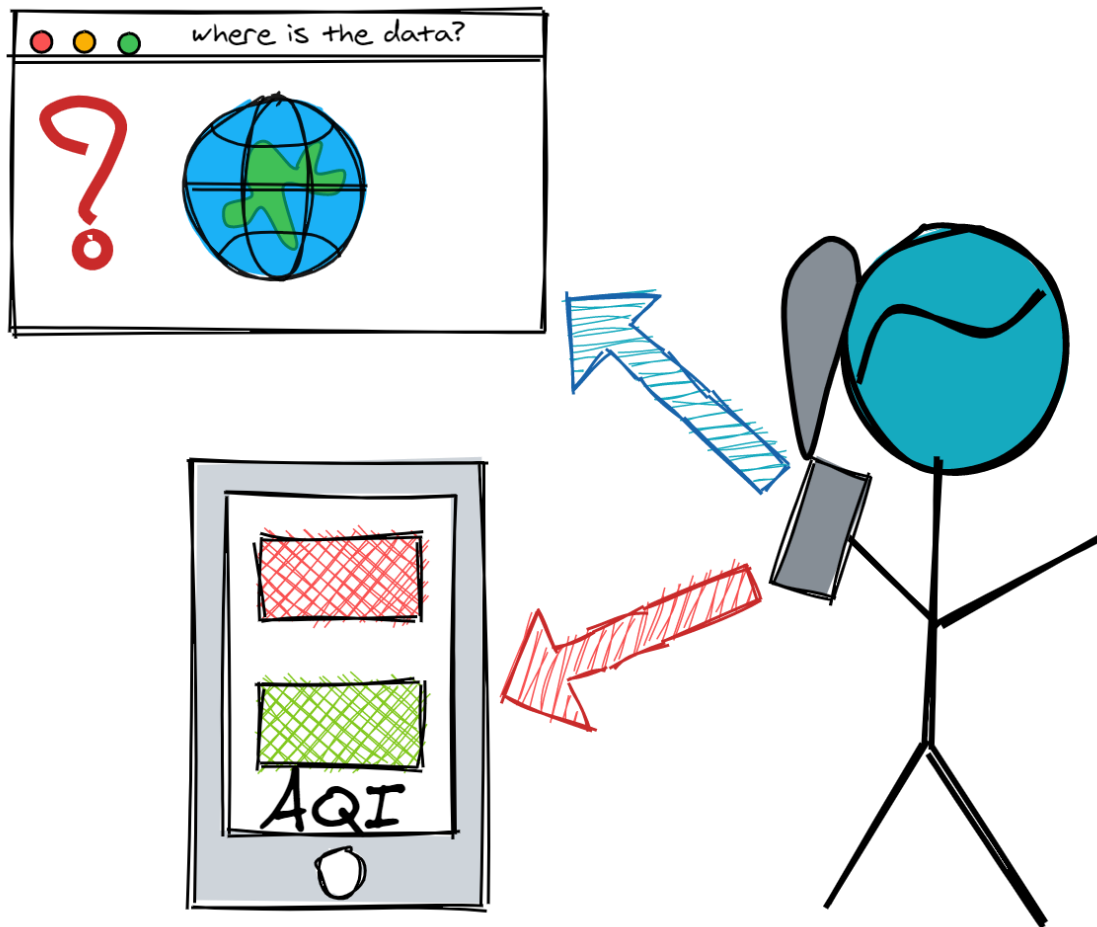
While the IER curves give an indication of the possible impacts of air pollution on human health, there are other impacts which also need attention, such as smog (visibility impacts), agricultural yield (linked to ozone), and climate change (like changes in monsoon patterns).

<sup>1</sup> Global Burden of Diseases visualization platform @ <https://vizhub.healthdata.org/gbd-compare> and @ <https://www.stateofglobalair.org/resources>



## FAQ#10 - Where can we access real time AQI updates?

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Example websites (and phone apps):

- <https://openaq.org> - aggregator of official real-time monitoring data across the globe
- <https://waqi.info> - aggregator of real-time AQI values only
- <https://www.iqair.com> - aggregator of official and unofficial data across the globe
- <https://www.purpleair.com> - a network of low-cost sensors

A MS Excel based AQI calculator with methodologies from 7 countries China, India, Singapore, South Korea, the European Union, the United Kingdom and the United States is part of the SIM-air family of tools @ <https://www.urbanemissions.info> along with a trove of data resources for energy and emissions analysis.



[www.urbanemissions.info](http://www.urbanemissions.info)