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An Overview of Air Quality Index (AQI) Standards and Health Implications

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Abstract:
The Air Quality Index (AQI) is used for reporting daily air quality. It tells us how clean or polluted air is and what associated health effects might be a concern for us. The AQI focuses on health effects one may experience within a few hours or days after breathing polluted air. Number of countries has their own air quality indices corresponding to a variety of national air quality standards. Various air quality monitoring agencies like CPCB, EPA calculates the AQI for major pollutants for clean air i.e. ground level ozone, particulate matter pollution, carbon monoxide, sulfur dioxide and nitrogen dioxide. For each of these pollutants various air quality monitoring agencies have established air quality standards to protect public health. Ground level ozone and airborne particles are the two pollutants that pose the greatest threat to human health.

Keywords: *AQI-Air Quality Index, SO_2, NOx, Particulate pollutants*

Introduction:
The AQI is introduced in 1968 when the National Air Pollution Control Administration started an initiative to develop an air quality index and to apply the methodology to Metropolitan Statistical Areas. The drive was to describe public attention to the issue of air pollution and indirectly move forward responsible local public officials to take appropriate action to control sources of pollution and increase air quality within their authorities.
The initial systems of the air quality index used standardized ambient pollutant concentrations to yield individual pollutant indices. These indices were then weighted and summed to form a single total air quality index. The overall methodology could use concentrations that are taken from ambient monitoring data or are predicted by means of a diffusion model. The concentrations were then converted into a standard statistical distribution with a preset mean and standard deviation. The resultant individual pollutant indices are assumed to be equally weighted, although values other than unity can be used. Likewise, the index can incorporate any number of pollutants although it was only used to combine SO_x, CO, and TSP [1] because of a lack of available data for other pollutants.
Although the methodology was designed to be robust, the practical application for all metropolitan areas proved to be inconsistent due to the scarcity of ambient air quality monitoring data, lack of agreement on weighting factors, and non-uniformity of air quality standards across geographical and political boundaries. In spite of these issues, the publication of lists ranking metropolitan areas achieved the public policy objectives and led to the future development of improved indices and their usual application. In Continuation of our earlier work [2-8] the current paper insights on an overview of Air Quality Index (AQI) standards across the world and health effects associated with high AQI values.

Results and Discussion:
An air quality index (AQI) is an indicator developed by government agencies [9] to converse to the public how polluted the air currently is or how polluted it is forecast to happen

to.[10][11] As air pollution levels increase, so does the AQI, along with the related public health risk. Children, the elderly and individuals with respiratory or cardiovascular troubles are typically the first groups influenced by poor air quality. When the AQI is high, governmental bodies generally promote people to lessen physical activity outdoors, or even stay away from going out altogether. When wildfires result in a high AQI make use of of masks such as N95 respirators outdoors and air purifiers incorporating HEPA filters also known as high-efficiency particulate absorbing filter and high-efficiency particulate arrestance filter, is an efficiency standard of air filters encouraged[10] indoors also.

Number of countries has their own air quality indices corresponding to various national air quality standards. Some of these are Canada's Air Quality Health Index, Malaysia's Air Pollution Index, and Singapore's Pollutant Standards Index.

Measurement of the AQI involves an air pollutant concentration over a particular averaging period obtained from an air monitor or model. Taken together concentration and time characterize the dose of the air pollutant. Health effects corresponding to a given amount are recognized by epidemiological research.[12] Air pollutants vary in potency and the function used to replace from air pollutant concentration to AQI differ by pollutant. Its air quality index values are typically composed into ranges. Every range is assigned a descriptor, a color code and a consistent public health advisory.

The AQI can amplify due to an increase of air emissions i.e. during rush hour traffic or as there is an upwind forest fire or from a lack of dilution of air pollutants. Stagnant air- Air stagnation is a meteorological condition that occurs when there is a lack of atmospheric movement, leading to the accumulation of pollutants and particles that can decline the air quality in a particular region. This condition typically correlates with air pollution and poor air quality due to the possible health risks it can cause to humans and the environment. Due to light winds and lack of precipitation, pollutants cannot be cleared from the air, either gaseous (such as ozone) or particulate (such as soot or dust) often caused by an anticyclone, temperature inversion, or low wind speeds lets air pollution remain in a local area, leading to high concentrations of pollutants, chemical reactions between air contaminants and hazy conditions.[13]

On a day when the AQI is predicted to be high due to fine particle pollution, an agency or public health organization might:

- Recommend sensitive groups, such as the elderly, children and those with respiratory or cardiovascular problems, to avoid outdoor exertion.[14]
- Announce an "action day" to encourage voluntary measures to reduce air emissions, similar to as using public transportation.[15]
- Propose the use of masks outdoors and air purifiers indoors to prevent fine particles from entering the lungs[16]

All through a period of very poor air quality, such as an air pollution episode, when the AQI indicates that acute exposure may cause significant harm to the public health, agencies may appeal to emergency plans that allow them to order major emitters (such as coal burning industries) to restrain emissions until the hazardous conditions subside.[17]

The majority of air contaminants do not have an associated AQI. Many countries monitor ground-level ozone, particulates, sulfur dioxide, carbon monoxide and nitrogen dioxide and compute air quality indices for these pollutants.[18]

The definition of the AQI in a particular nation reflects the talk surrounding the progress of national air quality standards in that nation.[19] A website allowing government agencies wherever in the world to submit their real-time air monitoring data for display using a widespread definition of the air quality index has in recent times become accessible.[20]

Australia

Every state and territories of Australia is liable for monitoring air quality and publishing data in line with the National Environment Protection (Ambient Air Quality) Measure (NEPM) standards.[21] Each state and territory issue air quality data for individual monitoring locations and nearly all states and territories circulate air quality indexes for each monitoring location.

Across Australia, a reliable approach is taken with air quality indexes by means of a simple linear scale where 100 represent the maximum concentration standard for every pollutant, as laid down by the NEPM.

These maximum concentration standards are:

Pollutant	Averaging period	Maximum concentration standard
Carbon monoxide	8 hours	9 ppm
Nitrogen dioxide	1 hour	0.12 ppm
	1 year	0.03 ppm
Ozone	1 hour	0.10 ppm
	4 hours	0.08 ppm
Sulphur dioxide	1 hour	0.20 ppm
	1 day	0.08 ppm
	1 year	0.02 ppm
Lead	1 year	0.50 µg/m^3
PM 10	1 day	50 µg/m^3
	1 year	25 µg/m^3
PM 2.5	1 day	25 µg/m^3
	1 year	8 µg/m^3

The air quality index (AQI) for an individual location is simply the highest of the air quality index values for each pollutant being checked at that location.

AQI bands with health guidance for each:[22]

AQI	Description	Health advice
0–33	Very Good	Enjoy activities
34–66	Good	Enjoy activities
67–99	Fair	People unusually sensitive to air pollution: Plan strenuous outdoor activities when air quality is better
100–149	Poor	Sensitive Groups: Cut back or reschedule strenuous outdoor activities
150–200	Very Poor	Sensitive groups: Avoid strenuous outdoor activities. Everyone: Cut back or reschedule strenuous outdoor activities
200+	Hazardous	Sensitive groups: Avoid all outdoor physical activities. Everyone: Significantly cut back on outdoor physical activities

Canada

In Canada Air quality has been reported for several years with provincial air quality indices (AQIs). Extensively AQI value reveals air quality management objectives, which are based on the lowest attainable emissions rate, rather than restricted concern for human health. The Air Quality Health Index (AQHI) is a scale intended to help realize the impact of air quality on health. It is a health protection means used to make decisions to reduce short-term exposure to air pollution by adjusting activity levels during increased levels of air pollution. The Air Quality Health Index also offers advice on how to develop air quality by proposing a behavioral change to reduce the environmental footprint. This index focuses particular attention to people who are sensitive to air pollution. It provides them advice on how to protect their health during air quality levels associated with low, moderate, high and very high health risks.

The AQHI offers a number from 1 to 10+ to indicate the level of health risk associated with local air quality. When the amount of air pollution is abnormally high, the number may exceed 10. The AQHI provides a local air quality present value as well as a local air quality maximums forecast for today, tonight and tomorrow and provides related health advice.[23]

Health risk	AQHI	Health messages	
		At risk population	General population
Low	1–3	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities
Moderate	4–6	Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7–10	Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very high	Above 10	Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

China Hong Kong

On December 30, 2013, Hong Kong changed the Air Pollution Index with a new index called the *Air Quality Health Index*.[24] This index accounted by the Environmental Protection Department is measured on a scale of 1 to 10+ and considers four air pollutants: ozone; nitrogen dioxide; sulphur dioxide and particulate matter (including PM_{10} and $PM_{2.5}$). For every given hour the AQHI is calculated from the sum of the percentage excess risk of daily hospital admissions attributable to the 3-hour moving average concentrations of these four pollutants. The AQHIs are grouped into five AQHI health risk categories with health advice provided:[25]

Health risk category	AQHI
Low	1
	2
	3

Moderate	4
	5
	6
High	7
Very high	8
	9
	10
Serious	10+

For every health risk categories provided advice associated with it. At the *low* and *moderate* levels the public are advised to continue normal activities. For the *high* category, children, the elderly and people with heart or respiratory illnesses are advised to lessen outdoor physical exertion. Beyond this (*very high* or *serious*), the common public are also advised to reduce or avoid outdoor physical exertion.

Mainland China

China's Ministry of Environmental Protection (MEP) is accountable for measuring the level of air pollution in China. As of January 1, 2013, MEP monitors every day pollution level in 163 of its major cities. The AQI level is dependent on the level of six atmospheric pollutants, namely sulfur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulates smaller than 10 μm in aerodynamic diameter (PM_{10}),[26] suspended particulates smaller than 2.5 μm in aerodynamic diameter ($PM_{2.5}$),[26] carbon monoxide (CO), and ozone (O_3) calculated at the monitoring stations throughout each city.[27]

AQI mechanics

An individual score (Individual Air Quality Index, IAQI) is calculated using breakpoint concentrations below and using same piecewise linear function to calculate intermediate values as the US AQI scale. The final AQI value can be calculated either per hour or per 24 hours and is *the max* of these six scores.[27]

Chinese AQI category and pollutant breakpoints [27]

Individual index	Units are in μg/m³ except CO, which is in mg/m³									
IAQI	Sulfur dioxide (SO_2) 24 hour mean	Sulfur dioxide (SO_2) 1 hour mean (1)	Nitrogen dioxide (NO_2) 24 hour mean	Nitrogen dioxide (NO_2) 1 hour mean (1)	PM_{10} 24 hour mean	Carbon monoxide (CO) 24 hour mean	Carbon monoxide (CO) 1 hour mean (1)	Ozone (O_3) 1 hour mean	Ozone (O_3) 8 hour moving average	$PM_{2.5}$ 24 hour mean
0	0	0	0	0	0	0	0	0	0	0
50	50	150	40	100	50	2	5	160	100	35
100	150	500	80	200	150	4	10	200	160	75
150	475	650	180	700	250	14	35	300	215	115
200	800	800	280	1200	350	24	60	400	265	150
300	1600	(2)	565	2340	420	36	90	800	800	250
400	2100	(2)	750	3090	500	48	120	1000	(3)	350
500	2620	(2)	940	3840	600	60	150	1200	(3)	500
Notes:	(1) SO_2, NO_2, and CO 1 hour average concentrations are only for real time reporting. For daily reports, use the 24 hour average concentrations. (2) If the SO_2 1 hour concentration exceeds 800μg/m³, use the index from the 24 hour concentration instead. (3) If the O_3 8 hour moving average exceeds 800μg/m³, use the index from the 1 hour concentration instead.									

The score for each pollutant is non-linear as is the final AQI score. So an AQI of 300 does not indicate twice the pollution of AQI at 150 nor does it mean the air is twice as harmful. The concentration of a pollutant when its IAQI is 100 does not equal twice its concentration when its IAQI is 50, nor does it mean the pollutant is twice as harmful. Whereas an AQI of 50 from day 1 to 182 and AQI of 100 from day 183 to 365 do provide an annual average of 75, it does *not* mean the pollution is satisfactory even if the benchmark of 100 is considered safe. Since the benchmark is a 24-hour target and the annual average must match the annual target, it is completely possible to have safe air every day of the year but still fail the annual pollution benchmark.[27]

AQI and health implications (HJ 633–2012)[27]

AQI	Air pollution level	Air pollution category	Health implications	Recommended precautions
0–50	Level 1	Excellent	No health implications.	Everyone can continue their outdoor activities normally.
51–100	Level 2	Good	Some pollutants may slightly affect very few hypersensitive individuals.	Only very few hypersensitive people should reduce outdoor activities.
101–150	Level 3	Lightly Polluted	Healthy people may experience slight irritations and sensitive individuals will be slightly affected to a larger extent.	Children, seniors and individuals with respiratory or heart diseases should reduce sustained and high-intensity outdoor exercises.
151–200	Level 4	Moderately Polluted	Sensitive individuals will experience more serious conditions. The hearts and respiratory systems of healthy people may be affected.	Children, seniors and individuals with respiratory or heart diseases should avoid sustained and high-intensity outdoor exercises. General population should moderately reduce outdoor activities.
201–300	Level 5	Heavily Polluted	Healthy people will commonly show symptoms. People with respiratory or heart diseases will be significantly affected and will experience reduced endurance in activities.	Children, seniors and individuals with heart or lung diseases should stay indoors and avoid outdoor activities. General population should reduce outdoor activities.

>300	Level 6	Severely Polluted	Healthy people will experience reduced endurance in activities and may also show noticeably strong symptoms. Other illnesses may be triggered in healthy people. Elders and the sick should remain indoors and avoid exercise. Healthy individuals should avoid outdoor activities.	Children, seniors and the sick should stay indoors and avoid physical exertion. General population should avoid outdoor activities.

Europe

The *Common Air Quality Index* (CAQI)[28] is an air quality index used in Europe ever since 2006.[29] In November 2017, the European Environment Agency declared the *European Air Quality Index* (EAQI) and started encouraging its use on websites and for other ways of informing the public about air quality.[30]

CAQI

As of 2012, the EU-supported project *CiteairII* argued that the CAQI had been estimated on a "large set" of data and expressed the CAQI's motivation and definition. *CiteairII* stated that having an air quality index that would be easy to present to the general public was a major motivation, leaving aside the more complex question of a health-based index, which would require, for example, effects of combined levels of different pollutants. The main aim of the CAQI was to have an index that would encourage wide comparison across the EU, without replacing local indices. *CiteairII* stated that the "main goal of the CAQI is not to warn people for possible adverse health effects of poor air quality but to attract their attention to urban air pollution and its main source (traffic) and assist them decrease their exposure."[29]

The CAQI is a number on a scale from 1 to 100, anywhere a low value means good air quality and a high value means bad air quality. The index is defined in both hourly and daily accounts and separately near roads (a "roadside" or "traffic" index) or away from roads (a "background" index). As of 2012, the CAQI had two compulsory components for the roadside index, NO_2 and PM_{10} and three fixed components for the background index, NO_2, PM_{10} and O_3. It also included optional pollutants $PM_{2.5}$, CO and SO_2. A "sub-index" is calculated for each of the mandatory (and optional if available) components. The CAQI is defined as the sub-index that characterizes the worst quality among those components.[29]

Some of the key pollutant concentrations in $\mu g/m^3$ for the hourly background index, the corresponding sub-indices and five CAQI ranges and verbal descriptions are as follows.[29]

Qualitative name	**Index or sub-index**	**Pollutant (hourly) concentration**			
		NO_2 µg/m^3	**PM_{10} µg/m^3**	**O_3 µg/m^3**	**$PM_{2.5}$ (optional) µg/m^3**
Very low	0–25	0–50	0–25	0–60	0–15
Low	25–50	50–100	25–50	60–120	15–30
Medium	50–75	100–200	50–90	120–180	30–55
High	75–100	200–400	90–180	180–240	55–110
Very high	>100	>400	>180	>240	>110

A separate *Year Average Common Air Quality Index* (YACAQI) is also defined, in which different pollutant sub-indices are separately normalized to a value typically near unity. For example, the yearly averages of NO_2, PM_{10} and $PM_{2.5}$ are divided by 40 µg/m^3, 40 µg/m^3 and 20 µg/m^3 respectively. The overall background or traffic YACAQI for a city is the arithmetic mean of a defined subset of these sub-indices.[29]

India

The National Air Quality Index (NAQI) was launched in New Delhi on September 17, 2014, under the Swachh Bharat Abhiyan.[31][32][33][34] The Central Pollution Control Board along with State Pollution Control Boards has been operating National Air Monitoring Program (NAMP) covering 240 cities of the country having more than 342 monitoring stations.[35] An Expert Group comprising medical professionals, air quality experts, academia, advocacy groups, and SPCBs was constituted and a technical study was awarded to IIT Kanpur. IIT Kanpur and the Expert Group recommended an AQI scheme in 2014.[36] Whereas the earlier measuring index was restricted to three indicators, the new index measures eight parameters.[37] The continuous monitoring systems that offer data on near real-time basis are installed in New Delhi, Mumbai, Pune, Kolkata and Ahmedabad.[38]

There are six AQI categories, namely Good, Satisfactory, Moderate, Poor, Severe and Hazardous. The proposed AQI will consider eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3 and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are approved.[39] Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. Probable health impacts for different AQI categories and pollutants have also been recommended with primary inputs from the medical experts in the group. The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated possible health impacts for the identified eight pollutants are as follows:

AQI category, pollutants and health breakpoints

AQI category (range)	PM_{10} (24hr)	$PM_{2.5}$ (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)
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	0.5–1.0
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	10–17	381–800	801–1200	2.1–3.0
Very Poor (301–400)	351–430	121–250	281–400	209–748	17–34	801–1600	1200–1800	3.1–3.5
Severe (401–500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+

AQI definitions

AQI	Associated health impacts	Colour
Good (0–50)	Minimal impact	Deep green
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people.	Light green

Moderate (101–200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.		Yellow
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.		Orange
Very Poor (301–400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.		Red
Severe (401–500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.		Maroon

Japan

According to Japan Weather Association, Japan utilizes a different scale to measure the air quality index.

AQI	AQI type	Health information
0–50	Good	There is no impact on humans. Outdoor activities are always allowed.
51–100	Moderate	Outdoor activities are often allowed because air is seldom considered unhealthy.
101–200	Unhealthy	Outdoor activities are sometimes allowed because air is sometimes considered unhealthy.
201–350	Very unhealthy	There are serious health hazards. Outdoor activities are seldom allowed.
351–500	Hazardous	Pollutants trigger extremely serious health hazards to humans. Outdoor activities are never allowed.

Mexico

The air quality in Mexico City is reported in Imagining Mono Emeis Collective Association IMECAs. The IMECA is measured using the measurements of average times of the chemicals ozone (O_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), particles smaller than 2.5 micrometers ($PM_{2.5}$) and particles smaller than 10 micrometers (PM_{10}).[40]

Singapore

Singapore exercises the Pollutant Standards Index (PSI) to report on its air quality,[41] with details of the calculation alike but not identical to those used in Malaysia and Hong Kong.[42] The PSI chart below is grouped by index values and descriptors according to the National Environment Agency.[43]

PSI	Descriptor	General health effects
0–50	Good	None
51–100	Moderate	Few or none for the general population

101–200	Unhealthy	Mild aggravation of symptoms among susceptible persons i.e. those with underlying conditions such as chronic heart or lung ailments; transient symptoms of irritation e.g. eye irritation, sneezing or coughing in some of the healthy population.
201–300	Very Unhealthy	Moderate aggravation of symptoms and decreased tolerance in persons with heart or lung disease; more widespread symptoms of transient irritation in the healthy population.
301–400	Severe	Early onset of certain diseases in addition to significant aggravation of symptoms in susceptible persons; and decreased exercise tolerance in healthy persons.
Above 400	Hazardous	PSI levels above 400 may be life-threatening to ill and elderly persons. Healthy people may experience adverse symptoms that affect normal activity.

South Korea

The Ministry of Environment of South Korea uses the Comprehensive Air-quality Index (CAI) to describe the ambient air quality based on the health risks of air pollution. The index aims to help the public easily realize the air quality and protect people's health. The CAI is on a scale from 0 to 500, which is divided into six categories. The higher the CAI value the greater the level of air pollution. Of values of the five air pollutants, the highest is the CAI value. The index also has associated health effects and a colour representation of the categories as shown below.[44]

CAI	Description	Health implications
0–50	Good	A level that will not impact patients with diseases related to air pollution.
51–100	Moderate	A level that may have a meager impact on patients in case of chronic exposure.
101–250	Unhealthy	A level that may have harmful impacts on patients and members of sensitive groups (children, aged or weak people), and also cause the general public unpleasant feelings.
251–500	Very unhealthy	A level that may have a serious impact on patients and members of sensitive groups in case of acute exposure.

The N Seoul Tower on Namsan Mountain in central Seoul, South Korea, is lighted up in blue, from sunset to 23:00 and 22:00 in winter, on days where the air quality in Seoul is 45 or less. During the spring of 2012, the Tower was lit up for 52 days, which was four days more than in 2011.[45]

United Kingdom

The most commonly used air quality index in the UK is the *Daily Air Quality Index* suggested by the Committee on the Medical Effects of Air Pollutants (COMEAP).[46] This index has ten points which are additionally grouped into four bands: low, moderate, high and very high. Each of the bands comes with advice for at-risk groups and the general population.[47]

Air pollution banding	Value	Health messages for at-risk individuals	Health messages for general population
Low	1–3	Enjoy your usual outdoor activities.	
Moderate	4–6	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.	Enjoy your usual outdoor activities.
High	7–9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

The index is based on the concentrations of five pollutants. The index is calculated from the concentrations of the following pollutants: ozone, nitrogen dioxide, sulphur ioxide, $PM_{2.5}$ (particles with an aerodynamic diameter less than 2.5 μm) and PM_{10}. The breakpoints between index values are defined for each pollutant separately and the overall index is defined as the maximum value of the index. Different averaging periods are used for different pollutants.[47]

Index	Ozone, running 8 hourly mean ($\mu g/m^3$)	Nitrogen dioxide, hourly mean ($\mu g/m^3$)	Sulphur dioxide, 15 minute mean ($\mu g/m^3$)	$PM_{2.5}$ particles, 24 hour mean ($\mu g/m^3$)	PM_{10} particles, 24 hour mean ($\mu g/m^3$)
1	0–33	0–67	0–88	0–11	0–16
2	34–66	68–134	89–177	12–23	17–33
3	67–100	135–200	178–266	24–35	34–50
4	101–120	201–267	267–354	36–41	51–58
5	121–140	268–334	355–443	42–47	59–66
6	141–160	335–400	444–532	48–53	67–75
7	161–187	401–467	533–710	54–58	76–83
8	188–213	468–534	711–887	59–64	84–91
9	214–240	535–600	888–1064	65–70	92–100
10	≥ 241	≥ 601	≥ 1065	≥ 71	≥ 101

United States

United States Air Quality Index		
AQI	**Level of health concern**	**Color**
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for sensitive groups	Orange
151–200	Unhealthy	Red
201–300	Very unhealthy	Purple
301–500	Hazardous	Maroon
501-1000	Very Hazardous	Brown

The United States Environmental Protection Agency (EPA) has build up an Air Quality Index that is used to report air quality. This AQI is divided into six categories indicating increasing levels of health concern. An AQI value over 300 represents hazardous air quality and below 50 the air quality is good.[18]

The AQI is based on the five "criteria" pollutants regulated under the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The EPA has established National Ambient Air Quality Standards (NAAQS) for each of these pollutants in order to protect public health. An AQI value of 100 generally corresponds to the level of the NAAQS for the pollutant.[18] The Clean Air Act (USA) (1990) requires the EPA to review its National Ambient Air Quality Standards every five years to reflect evolving health effects information. The Air Quality Index is adjusted periodically to reflect these changes.

Vietnam

Vietnam Environment Administration issued Decision on November 12, 2019 and propagated Technical Guidelines for calculation and publication of Vietnam Air Quality Index (VN_AQI).

AQI range	Air quality	Color
0–50	Good	Green
51–100	Moderate	Yellow
101–150	Bad	Orange
151–200	Unhealthy	Red
201 – 300	Very unhealthy	Purple
301 – 500	Hazardous	Brown

Calculation of the AQI

The air quality index is a piecewise linear function of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. To convert from concentration to AQI this equation is used:[48]

(If multiple pollutants are measured, the calculated AQI is the highest value calculated from the above equation applied for each pollutant.)

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

Where,

I = the (Air Quality) index,
C = the pollutant concentration,
C_{low} = the concentration breakpoint that is ≤ C,
C_{high} = the concentration breakpoint that is ≥ C,
I_{low} = the index breakpoint corresponding to C_{low},
I_{high} = the index breakpoint corresponding to C_{high}.

The EPA's table of breakpoints is:[49][50][51]

O_3 (ppb)	O_3 (ppb)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	CO (ppm)	SO_2 (ppb)	NO_2 (ppb)	AQI	AQI
C_{low} – C_{high} (avg)							I_{low} – I_{high}	Category
0–54 (8-hr)	—	0.0–12.0 (24-hr)	0–54 (24-hr)	0.0–4.4 (8-hr)	0–35 (1-hr)	0–53 (1-hr)	0–50	Good
55–70 (8-hr)	—	12.1–35.4 (24-hr)	55–154 (24-hr)	4.5–9.4 (8-hr)	36–75 (1-hr)	54–100 (1-hr)	51–100	Moderate
71–85 (8-hr)	125–164 (1-hr)	35.5–55.4 (24-hr)	155–254 (24-hr)	9.5–12.4 (8-hr)	76–185 (1-hr)	101–360 (1-hr)	101–150	Unhealthy for sensitive groups
86–105 (8-hr)	165–204 (1-hr)	55.5–150.4 (24-hr)	255–354 (24-hr)	12.5–15.4 (8-hr)	186–304 (1-hr)	361–649 (1-hr)	151–200	Unhealthy
106–200 (8-hr)	205–404 (1-hr)	150.5–250.4 (24-hr)	355–424 (24-hr)	15.5–30.4 (8-hr)	305–604 (24-hr)	650–1249 (1-hr)	201–300	Very unhealthy
—	405–504 (1-hr)	250.5–350.4 (24-hr)	425–504 (24-hr)	30.5–40.4 (8-hr)	605–804 (24-hr)	1250–1649 (1-hr)	301–400	Hazardous
—	505–604 (1-hr)	350.5–500.4 (24-hr)	505–604 (24-hr)	40.5–50.4 (8-hr)	805–1004 (24-hr)	1650–2049 (1-hr)	401–500	

Suppose a monitor records a 24-hour average fine particle ($PM_{2.5}$) concentration of 24.0 micrograms per cubic meter. The equation above results in an AQI of:

$$\frac{100-51}{35.4-12.1}(24-12.1)+51=78.673$$

Which rounds to index value of 79, corresponding to air quality in the "Moderate" range.[52] To convert an air pollutant concentration to an AQI, EPA has developed a calculator.[53]

If multiple pollutants are measured at a monitoring site, then the largest or "dominant" AQI value is reported for the location. The ozone AQI between 100 and 300 is computed by selecting the larger of the AQI calculated with a 1-hour ozone value and the AQI computed with the 8-hour ozone value. Eight-hour ozone averages do not define AQI values greater than 300; AQI values of 301 or greater are calculated with 1-hour ozone concentrations. 1-hour SO_2 values do not define higher AQI values greater than 200. AQI values of 201 or greater are calculated with 24-hour SO_2 concentrations.

Real-time monitoring data from continuous monitors are typically available as 1-hour averages. However, computation of the AQI for some pollutants requires averaging over multiple hours of data. (For example, calculation of the ozone AQI requires computation of an 8-hour average and computation of the $PM_{2.5}$ or PM_{10} AQI requires a 24-hour average.) To accurately reflect the current air quality, the multi-hour average used for the AQI computation should be centered on the current time, but as concentrations of future hours are unknown and are difficult to estimate accurately, EPA uses surrogate concentrations to estimate these multi-hour averages. For reporting the $PM_{2.5}$, PM_{10} and ozone air quality indices, this surrogate

concentration is called the NowCast. The Nowcast is a particular type of weighted average that provides more weight to the most recent air quality data when air pollution levels are changing.[54][55]

Conclusion:

The global burden of disease associated with air pollution exposure exacts a massive toll on human health worldwide: exposure to air pollution is estimated to cause millions of deaths and lost years of healthy life annually. The burden of disease attributable to air pollution is now estimated to be on a par with other major global health risks such as unhealthy diet and tobacco smoking, and air pollution is now recognized as the single biggest environmental threat to human health. Despite some notable improvements in air quality, the global toll in deaths and lost years of healthy life has barely declined since the 1990s. While air quality has markedly improved in high-income countries over this period, it has generally deteriorated in most low- and middle-income countries, in step with large-scale urbanization and economic development. Air pollution increases morbidity and mortality from cardiovascular and respiratory disease and from lung cancer, with increasing evidence of effects on other organ systems. The burden of disease resulting from air pollution also imposes a significant economic burden. As a result, governments worldwide are seeking to improve air quality and reduce the public health burden and costs associated with air pollution. Since 1987, WHO has periodically issued health-based air quality guidelines to assist governments and civil society to reduce human exposure to air pollution and its adverse effects. The WHO air quality guidelines were last published in 2006. Air quality guidelines – global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide (WHO Regional Office for Europe, 2006) provided health-based guideline levels for the major health-damaging air pollutants, including particulate matter (PM)[56], ozone (O3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). Global update 2005[57] has had a significant impact on pollution abatement policies all over the world. Their publication led to the first universal frame of reference.

In various ways, these guidelines have stimulated authorities and civil society alike to increase efforts to control and study harmful air pollution exposures. In response to this growing awareness, the Sixty-eighth World Health Assembly adopted resolution WHA68.8, Health and the environment: addressing the health impact of air pollution, which was endorsed by 194 Member States in 2015 (WHO, 2015). This resolution stated the need to redouble efforts to protect populations from the health risks posed by air pollution. In addition, the United Nations (UN) Sustainable Development Goals (SDGs) were designed to address the public health threat posed by air pollution via specific targets to reduce air pollution exposure and the disease burden from household and ambient exposure. More than 15 years have passed since the publication of Global update 2005. In that time there has been a marked increase in evidence on the adverse health effects of air pollution, built on advances in air pollution measurement and exposure assessment and an expanded global database of air pollution measurements. New epidemiological studies have documented the adverse health effects of exposure to high levels of air pollution in low- and middle-income countries, and studies in high-income countries with relatively clean air have reported adverse effects at much lower levels than had previously been studied. In view of the many scientific advances and the global role played by the WHO air quality guidelines, this update was begun in 2016.

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