

## Review of an Air Quality Index (AQI) for Bangladesh

### Introduction

An Air Quality Index (AQI) is a communication vehicle to quickly and effectively describe ambient air quality relative to the relevant national air quality standards. It helps to warn sensitive populations that they should take appropriate measures to reduce their exposure to the ambient air and to inform the general public that there are serious problems with air quality that need to be addressed as a societal responsibility to the whole population. Different countries affix different colors and assign different values to the same descriptor of potential risk. Thus, this report will begin with a review of AQI approaches for a series of countries and then provide a recommendation relative to the Bangladesh National Ambient Air Quality Standards.

### General Philosophy of an AQI

The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects that you may experience within a few hours or days after breathing polluted air. It is based on the exposure to all of the criteria pollutants (PM, CO, O<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>) with the AQI based on the worst exposure concentration for any of these pollutants. A segmented linear function is used to relate the actual air pollution concentrations (of each pollutant) to a normalized number. The largest value is then the reported AQI for that time interval. These values are then related to a series of intervals with health descriptors attached to each interval. The breakpoints between the intervals are typically set relative to the ambient air quality standard values for each pollutant. This system was first developed by the United States Environmental Protection Agency (US EPA) and has now been adapted to the standards applied in a number of other countries.

### Existing AQI Systems

#### *United States*

The cut-off values for the various AQI categories for the United States are provided in Table 1. The US EPA philosophy is to set the good category cut off for a given measurement period in terms of the NAAQS for a longer time interval. Thus, the 24-hr PM good criteria are set at the annual average value cut-offs. For example, in the case of PM<sub>10</sub>, the 54 µg/m<sup>3</sup> value rounds down to the criterion value of 50 µg/m<sup>3</sup>. Thus, although values of the pollutant below the averaging times noted in the table are allowed for those time intervals, they are not designated as “good” since a reasonable number of such periods would likely lead to violations of longer time interval standards. The AQI values in the US range from “good” to “hazardous.” For most locations in the US, the AQI is driven by either PM<sub>2.5</sub> or O<sub>3</sub> because there are now very few areas of non-attainment of the NAAQS for the other criteria pollutants. It can be seen that there is some degree of arbitrariness in these cut-off values such that a PM<sub>2.5</sub> value of 35.4 µg/m<sup>3</sup> is assigned a label of “moderate” quality while a value of 35.5 µg/m<sup>3</sup> is deemed “unhealthy for sensitive groups.” This conservative approach is adopted because US law requires that EPA protect public health with an “adequate margin of safety.”

Table 1. AQI values in the United States of America

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PM <sub>2.5</sub>	PM <sub>10</sub>	Ozone	Ozone	CO,	SO <sub>2</sub>	SO <sub>2</sub>	NO <sub>2</sub>
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Descriptor	AQI	24 hr	24 hr	8 hr	1 hr	8 hr	1 hr	24 hr	1 hr
		$\mu\text{g}/\text{m}^3$							
Good	50	15.4	54	25		3.8	13.4		28.2
Moderate	51	15.5	55	26		3.9	13.7		28.7
	99	35.0	152	38		8.1	28.2		52.7
Unhealthy for Sensitive Groups	100	35.4	154	38		8.2	28.6		53.2
	101	35.5	155	38	63	8.3	29.0		53.7
	149	64.8	252	48	82	10.7	69.8		188.8
	150	65.4	254	48	82	10.8	70.6		191.5
Unhealthy	151	65.5	255	48	83	10.9	71.0		192.0
	199	148.7	352	58	102	13.4	115.3		342.6
	200	150.4	354	58	102	13.4	116.0		343.1
Very Unhealthy	201	150.5	355	58	103	13.5		116.4	343.1
	299	249.4	423	186	201	26.4		229.4	658.5
	300	250.4	424	187	202	26.6		230.5	661.7
Hazardous	301	250.5	425		203	26.6		230.9	662.2
	500	500.4	604		302	44.0		383.2	1087.2

### United Kingdom

The most commonly used air quality index in the UK is the *Daily Air Quality Index* recommended by the Committee on Medical Effects of Air Pollutants (COMEAP). This index has ten points, which are further grouped into 4 bands: low, moderate, high and very high. Each of the bands comes with advice for at-risk groups and the general population. This system has more gradations and is slightly less cautious in relating various concentrations to potential adverse health outcomes.

Table 2. Relationship of Index values to Health Outcomes

Air pollution banding	Value	Health messages for At-risk individuals	Health messages for General population
<b>Low</b>	<b>1-3</b>	Enjoy your usual outdoor activities.	Enjoy your usual outdoor activities.
<b>Moderate</b>	<b>4-6</b>	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.
<b>High</b>	<b>7-9</b>	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing

**Very High 10**

People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.

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.

activity, particularly outdoors.

Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

The index is based on the concentrations of 5 pollutants. The index is calculated from the concentrations of the following pollutants: Ozone, Nitrogen Dioxide, Sulphur Dioxide, PM2.5 (particles with an aerodynamic diameter less than 2.5 µm) and PM10. 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

Table 3. AQI Values in the United Kingdom

Index	Ozone, Running 8 hourly mean (µg/m <sup>3</sup> )	Nitrogen Dioxide, Hourly mean (µg/m <sup>3</sup> )	Sulphur Dioxide, 15 minute mean (µg/m <sup>3</sup> )	PM <sub>10</sub> Particles, 24 hour mean (µg/m <sup>3</sup> )	PM <sub>2.5</sub> Particles, 24 hour mean (µg/m <sup>3</sup> )
1	0-33	0-66	0-88	0-11	0-16
2	34-65	67-133	89-176	12-23	17-33
3	66-99	134-199	177-265	24-34	34-49
4	100-120	200-267	266-354	35-41	50-58
5	121-140	268-334	355-442	42-46	59-66
6	141-159	335-399	443-531	47-52	67-74
7	160-187	400-467	530-708	53-58	75-83
8	188-213	468-534	709-886	59-64	84-91
9	214-239	535-599	887-1063	65-69	92-99
10	≥240	≥600	≥1064	≥70	≥100

It is hard to see how having more gradations within the major categories provides significantly more information to the public and could be a source of confusion.

*South Korea*

The Republic of Korea represents a country that has come through a period of development with high levels of air pollution and now wishes to reduce the exposure and associate risk to its population. The Ministry of Environment 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 understand 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 color representation of the categories as shown in Table

4. It can be seen that they use categories similar to those in the US, but adjust the index values relative to what is seen in Table 1.

Table 4. Relationship between South Korean CAI values and Observable Health Effects

CAI	Description	Health Implications
0-50	Good	A level that will not impact patients suffering from diseases related to air pollution.
51-100	Moderate	A level that may have a meager impact on patients in case of chronic exposure.
101-150	Unhealthy for sensitive groups	A level that may have harmful impacts on patients and members of sensitive groups.
151-250	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.
251-350	Very unhealthy	A level that may have a serious impact on patients and members of sensitive groups in case of acute exposure.
351-500	Hazardous	A level that may need to take emergency measures for patients and members of sensitive groups and have harmful impacts on the general public.

The CAI values are related to the pollutant concentrations as shown in Table 5.

Table 5, Breakpoint pollutant concentrations for the various CAI index values

Value	SO <sub>2</sub> , 1 hr ppm	NO <sub>2</sub> , 1 hr ppm	CO, 1 hr ppm	O <sub>3</sub> , 1 hr ppm	PM <sub>10</sub> , 24 hr µg/m <sup>3</sup>
50	0.020	0.030	2.0	0.040	30
51	0.021	0.031	2.0	0.041	31
100	0.050	0.060	9.0	0.080	80
101	0.051	0.061	9.0	0.081	81
150	0.100	0.150	12.0	0.120	120
151	0.101	0.151	12.0	0.121	121
250	0.150	0.200	15.0	0.300	200
251	0.151	0.201	15.0	0.301	201
350	0.400	0.600	30.0	0.500	300
351	0.401	0.601	30.0	0.501	301
500	1.000	2.000	50.0	0.600	600

These values are again somewhat less stringent than those used in the US.

*Thailand*

As an example of a developing country that has achieved a moderate level of affluence and started to develop a greater interest in the health effects of air pollution, Thailand has established the AQI values and color scheme presented in Table 6.

Table 6. AQI values and breakpoint concentrations for Thailand

AQI	PM10 (24 hr.) µg./m <sup>3</sup>	O3 (1 hr.) µg./m <sup>3</sup>	O3 (1 hr.) ppb	SO2 (24 hr.) µg./m <sup>3</sup>	SO2 (24 hr.) ppb	NO2 (1 hr.) µg./m <sup>3</sup>	NO2 (1 hr.) ppb	CO (8 hr.) µg./m <sup>3</sup>	CO (8 hr.) ppb
0-50	40	100	51	65	25	160	85	5.13	4.48
51-100	120	200	100	300	120	320	170	10.26	9.00
101-200	350	400	203	800	305	1130	600	17.00	14.84
201-300	420	800	405	1600	610	2260	1202	34.00	29.69
301-400	500	1000	509	2100	802	3000	1594	46.00	40.17
401- 500	600	1200	611	2620	1000	3750	1993	57.50	50.21

In this table, it can be seen that the breakpoint values are substantially higher than in the prior systems. For example, prior schemes have had a maximum 1 hr ozone concentration of 80 ppb for the 50 to 100 (moderate) category (although South Korea assigns this to a green color).

*India*

The final example of other AQI systems is taken from India. Table 7 presents their system.

Index	Category	SO <sub>2</sub>	NO <sub>2</sub>	SPM	CO	CO	O <sub>3</sub>	NH <sub>3</sub>	PM <sub>2.5</sub>	Pb	PM <sub>10</sub>
		24 hr µg/m <sup>3</sup>	1-hr µg/m <sup>3</sup>	24-hr µg/m <sup>3</sup>	1-hr µg/m <sup>3</sup>	8-hr µg/m <sup>3</sup>	1-hr µg/m <sup>3</sup>	24-hr µg/m <sup>3</sup>	24-hr µg/m <sup>3</sup>	24-hr µg/m <sup>3</sup>	24-hr µg/m <sup>3</sup>
0-100	Good	0-80	0-80	0-200	0-4.0	0-2.0	0-180	0-60	0-400	0-1.0	0-100
101-200	Moderate	81-367	81-180	201-260	4.1-25.0	2.1-12.0	180-225	61-90	400-550	1.0-1.5	101-150
201-300		368-786	181-564	261-400	25.1-35.0	12.1-17.0	225-300	91-210	550-700	1.5-2.25	151-350
301-400	Very poor	787-1572	565-1272	401-800	35.1-75	17.1-35	301-800	211-250	700-900	2.25-3.25	351-420
401-500		Severe	>1572	>1272	>800	>75	>35	>800	>250	>900	>3.25

It can be observed that India has added several pollutants (suspended particulate matter, ammonia, and lead) to the index. They have also changed the nature of the descriptors for the lowest air quality categories to poor, very poor and severe compared to unhealthy, very unhealthy, and hazardous. The choice of words to describes the categories sets the tone for the degree of danger and the urgency with respect to taking both personal actions to protect one’s own health and societal actions to reduce the threat of these more hazardous air pollution days.

It can be seen that within the general framework of an AQI system ranging from 0 to 500, there are choices to be made in the breakpoint concentrations associated with the major categories of hazard and the risk communication based choice of words to describe these categories.

### AQI System for Bangladesh

The first step is to review the Ambient Air Quality Standards. These are presented in Table 8. Given the continuing observation of occasional high lead concentrations, it may be reasonable to include lead in the AQI system. These values are not very different from the NAAQS values for the United States. Thus, the relationships between the observed concentrations and the associated AQI values should be similar to those presented in Table 1.

Table 8. Bangladesh National Ambient Air Quality Standards

Pollutant	Objective	Averaging time
Carbon Monoxide (CO)	10 mg/m <sup>3</sup> (9 ppm)	8-hour
	40 mg/m <sup>3</sup> (35 ppm)	1-hour
Nitrogen Dioxide (NO <sub>2</sub> )	100 µg/m <sup>3</sup> (0.053 ppm)	Annual
Ozone (O <sub>3</sub> )	157 µg/m <sup>3</sup> (0.08 ppm)	8-hour
	235 µg/m <sup>3</sup> (0.12 ppm)	1-hour
Sulfur Dioxide (SO <sub>2</sub> )	365 µg/m <sup>3</sup> (0.14 ppm)	24-hour
	80 µg/m <sup>3</sup> (0.03 ppm)	Annual
PM <sub>10</sub>	150 µg/m <sup>3</sup>	24-hour
	50 µg/m <sup>3</sup>	Annual
PM <sub>2.5</sub>	65 µg/m <sup>3</sup>	24-hour
	15 µg/m <sup>3</sup>	Annual
Lead (Pb)	0.5 µg/m <sup>3</sup>	Annual

The currently approved AQI scheme in terms of the health effect descriptors and associated AQI values is presented in Table 9. However, there are some significant concerns that should be raised regarding these descriptors. The use of “good” as a descriptor for values above the long term standard concentration are not appropriate. There is risk of extended exposures at elevated concentrations. Occasional higher exposures (but below the 24 hour standard) are not expected to represent a serious health threat. If chronic exposure to higher values represented little or no risk, then the NAAQS value would be raised. However, the values are typically being lowered as we obtain more health outcome data and improve our exposure assessments. To then label exposure to AQI values between 51 and 100 is to underreport the potential hazard associated with such concentrations and will not provide the public with appropriate information for them to

make informed health protective decisions. Similarly, suggesting that AQI values from 101 to 150 represent only a moderate health threat is clearly not recognizing the likely effects on susceptible populations including children and the elderly. In the United States, it has been observed that children living within 150 m of major highways have an average decrease in lung capacity of 40%. Given the pollution concentrations in Dhaka, it can be expected that there are many serious health impacts on the general public. Thus, it is imperative to have an AQI approach that adequately informs the public of the risks from diminished air quality. The final three categories (unhealthy, very unhealthy, and extremely unhealthy) are adequately informative of the risks. However, it is strongly recommended that 0-50, 51 to 100, and 101 to 150 categories be relabeled with more appropriate descriptors of the likely air quality impacts. The 0-50 category should be “good.” The range of 51 to 100 should be labeled “moderate” and the 101 to 150 range should be label “Caution for sensitive individuals” or some similar term that indicates that there are likely to be consequences for children, particularly infants, elderly with chronic lung or heart disease, and people who will be working hard in the ambient air.

AQI Value	Level of Health Concern (স্বাস্থ্যগত উদ্বেগের অবস্থান)		Colours
	English	উইংলা	
0 - 100	GOOD	খাল	GREEN
101-150	MODERATE	মধ্যম	YELLOW
151 – 200	UNHEALTHY	অস্বাস্থ্যকর	ORANGE
201 – 300	VERY UNHEALTHY	খুব অস্বাস্থ্যকর	RED
301 – 500	EXTREMELY UNHEALTHY	অত্যন্ত অস্বাস্থ্যকর	PURPLE

AQI Value	Level of Health Concern (স্বাস্থ্যগত উদ্বেগের অবস্থান)		Colours
	English	উইংলা	
0 - 50	GOOD	খাল	GREEN
51-100	MODERATE	মধ্যম	YELLOW GREEN
101-150	CAUTION		YELLOW
151 – 200	UNHEALTHY	অস্বাস্থ্যকর	ORANGE
201 – 300	VERY UNHEALTHY	খুব অস্বাস্থ্যকর	RED
301 – 500	EXTREMELY UNHEALTHY	অত্যন্ত অস্বাস্থ্যকর	PURPLE