Acid Rain & Atmospheric Pollution
Indian Institute of Tropical Meteorology, Pune

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Contents

Editorial Team

Editor's Desk:

Once again, we are happy to bring out this ENVIS Newsletter Vol. 8, No.1. So far in our previous newsletters we have tried to cover the topics related to different pollutants and their effects on human beings. The issues gave a glimpse of the pollutants and their hazards over the surroundings. However, the topic will remain incomplete if we do not focus on how the pollutant levels are actually measured. Hence in this issue we have tried to elucidate in brief, as to how the measurements of the pollutant levels are carried out in everyday life. The issue will provide some basic understanding of the Air Quality Index and its related calculations in addition to different pollutants, their emission sources and effects on health and environment which are also discussed in brief.

We thank to all those who contributed valuable articles and suggestions for our Newsletters, it would be highly appreciated if you could keep up for our future improvement. Readers are invited to contribute articles, review papers, successful case studies or news items relevant to Acid Rain & Atmospheric Pollution Issues for publishing in the next edition of Newsletter of IITM, ENVIS Centre.

AIR QUALITY INDEX (AQI)

The **Air Quality Index** (**AQI**) (also known as the **Air Pollution Index** (**API**) or **Pollutant Standard Index** (**PSI**)) is a nationally uniform index, established by the Federal Environmental Protection Agency (EPA), for providing the public with information on air pollutants. It tells how clean or polluted the air is, and what associated health effects might be a concern. The AQI is calculated for five major air pollutants as regulated by the Clean Air Act. The five major air pollutants regulated by the Clean Air Act are: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health. The purpose of the AQI is to help one understand what local air quality can mean to your health. For ease of understanding, the AQI is divided into six categories as shown in table I.

Table I: AQI Chart

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

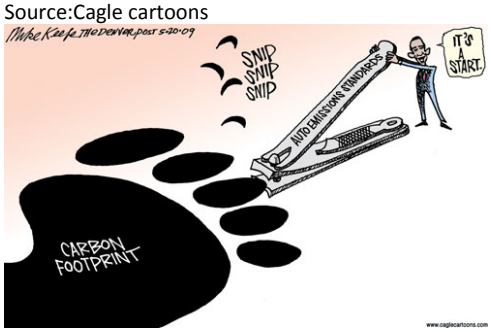
Each category corresponds to a different level of health concern. The six levels of health concern and their details are as follows:

- **Good:** The AQI value between 0 and 50. Here, air quality is considered satisfactory, and air pollution poses little or no risk.
- **Moderate:** The AQI between 51 and 100. Here, air quality is acceptable however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups:** When AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- **Unhealthy:** Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.

- **Very Unhealthy:** AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.
- **Hazardous:** AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

Thus, such forecasts are meant to help the local residents to protect their health by alerting them to plan their strenuous activities for a time when air quality is better. In this regards, the Government of India is also planning to revise the air quality assessment parameters in 2009 for the control of air pollution in India and the protection of public health.

Source:Cagle cartoons



AIR QUALITY INDEX (AQI) CALCULATION

An air quality index is calculated on the basis of the five pollutants: ozone, fine particulate matter, sulfur dioxide, nitrogen dioxide and carbon monoxide. For each of the pollutants measured at an air monitoring station, a sub-index is calculated first.

Roughly, one can calculate the AQI by using the pollution concentration data in the equation below (linear interpolation):

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}$$

where,

I_P = Index for pollutant p

C_P = the rounded concentration of pollutant p

BP_{Hi} = the breakpoint that is greater than or equal to C_P

BP_{Lo} = the breakpoint that is less than or equal to C_P

I_{Hi} = the AQI value corresponding to BP_{Hi}

I_{Lo} = the AQI value corresponding to BP_{Lo}

The breakpoints for the respective pollutants are shown in the table below:

Source: US, EPA

This Breakpoint...						...equal this AQI		...and this category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)	AQI	
0.000 - 0.064	-	0 - 54	0.0 - 15.4	0.0 - 4.4	0.000 - 0.034	([2])	0 - 50	Good
0.065 - 0.084	-	55 - 154	15.5 -40.4	4.5 - 9.4	0.035 - 0.144	([2])	51 - 100	Moderate
0.085 - 0.104	0.125 - 0.164	155 - 254	40.5 - 65.4	9.5 - 12.4	0.145 - 0.224	([2])	101 - 150	Unhealthy for Sensitive Groups
0.105 - 0.124	0.165 - 0.204	255 - 354	65.5 - 150.4	12.5 - 15.4	0.225 - 0.304	([2])	151 - 200	Unhealthy
0.125 - 0.374 (0.155 - 0.404)[4]	0.205 - 0.404	355 - 424	150.5 - 250.4	15.5 - 30.4	0.305 - 0.604	0.65 - 1.24	201 - 300	Very unhealthy
([3])	0.405 - 0.504	425 - 504	250.5 - 350.4	30.5 - 40.4	0.605 - 0.804	1.25 - 1.64	301 - 400	Hazardous
([3])	0.505 - 0.604	505 - 604	350.5 - 500.4	40.5 - 50.4	0.805 - 1.004	1.65 - 2.04	401 - 500	Hazardous

The results of the highest sub-index are then used as the air quality index for that station. For calculating the AQI it is not necessary to monitor all the pollutants at one station.

In India, after 15 years, it is being said that Government is looking forward

towards revising the air quality standards. Thus for the first time we will be having a uniform health-based National Ambient Air Quality Standard (NAAQS). It is thus likely to discontinue the old practice of setting air quality standards for different land use classes like residential and industrial. It will thus provide a legal framework for controlling the air pollution and thus protecting public health.

POLLUTANTS, EMISSION SOURCES & THEIR EFFECTS ON HEALTH & ENVIRONMENT

Air pollutants are generally defined as substances of gaseous, solid or liquid nature emitted into the atmosphere by both natural and anthropogenic (human-caused) sources, that are capable of causing harm to the environment in general, and living organisms in particular. In other words, these pollutants are the agents that change the normal functioning of the atmosphere and have a negative impact on all life forms including animals and plants. In this article, we try to summarize the emission sources of the pollutants and the direct effects of the pollutants on health and environment.

1. **Ozone (O_3):** It is unstable and reacts easily to other gases. At high altitudes, it provides protection by absorbing large amounts of ultraviolet radiation. However, at ground level, high concentrations pose a health and environmental threat. It is also one of the principal components of smog. The levels of Ozone are generally higher in summer, and during hot sunny weather. The concentrations are usually highest in late afternoon.

Sources of Emission**:** Although not directly emitted into the air, ozone is produced through a photochemical transformation of precursor pollutants: nitrogen oxides and volatile organic compounds. Human activity accounts for most of these pollutants, including transportation, industry and heating.

Effects on Health and the Environment: Ozone is an oxidizing agent which at high concentrations irritates the nose, throat, skin and eyes. Over short periods of exposure, it can cause coughing, headaches or breathing problems due to constriction of the airways and bronchioles. Ozone can weaken a body's immune defense functions and open the way to infection.

Ground-level ozone is linked to higher numbers of hospitalizations and emergency room visits for respiratory disorders. People who play outdoor sports and children may be more prone to the effects of ozone because their activities are more intense and they spend more time outdoors. The elderly or people with respiratory ailments may notice their symptoms worsen.

Episodes of high ozone levels usually coincide with heat waves, which makes people sensitive to pollutants more vulnerable. Over long-term exposure, the lungs of an adult can become permanently impaired. Ozone can also damage vegetation and affect crop yields.

2. **Fine Particulate Matter ($PM_{2.5}$):** Fine particulate matter is airborne microscopic dust and droplets smaller than 2.5 microns ($PM_{2.5}$) in diameter. The composition of particulate matter depends on its source, the season and atmospheric conditions. Fine particulate matter is comprised primarily of sulfates, nitrates, carbon, organic substances, ground minerals and metals. Particulate matter can travel long distances and is a year-round pollutant common to urban and rural communities. It is a principal component of smog.

Sources of Emission: Particulate matter is generally the product of residential wood burning (47.5%), industry (32.6%), and transportation (17.1%). Particulates also form in the air through the chemical reactions of precursor pollutants, including sulfur and nitrogen oxides. Open sources, such as forest fires, material and soil erosion, quarries and sandpits, farming and volcanic eruptions also contribute to particulate matter emissions.

Effects on Health and the Environment: As it is so fine, particulate matter less than 2.5 µm in diameter can penetrate into the deepest recesses of the lungs and remain there. Short exposures can produce coughing, irritation and bronchial inflammation. Children and the elderly are particularly sensitive to fine particulate matter, as are people with asthma, pneumonia, bronchitis, emphysema or chronic respiratory ailments. Particulate matter is also a contributing factor to respiratory infections. In sensitive individuals, fine particulates may also cause disease and cardiovascular accidents.

Epidemiological health studies reveal that emergency room visits, hospital admissions and deaths peak during periods when particulate levels are high. The effects of long-term exposure, which are not as well documented, show a permanent loss of lung function and higher rates of cardiovascular and lung cancer deaths. The characteristics of chemicals in particulate matter are an important determining factor in their toxicological effect. The presence of polycyclic aromatic hydrocarbons, dioxins and metals on particulate matter explains their carcinogenic effect. Recent studies have begun to shed light on the mechanisms of how fine particulate matter alone or a possible interaction with other

pollutants affects health. Vegetation is also altered by the deposit of particulates on leaves, which reduce light absorption and impede photosynthesis. Due to their composition, particulate matter can also directly attack leaf structure (necrosis) and affect soil composition. A weakened plant is more vulnerable to diseases and parasites.

By absorbing and diffusing light, fine particulate matter creates a type of fog that reduces visibility.

3. **Sulfur Dioxide (SO_2)**: Sulfur dioxide is a colorless gas with a pungent and suffocating odour. It is dangerous air pollutant because it is corrosive to organic materials and it irritates eyes, nose and lungs. High levels of this pollutant are found near industrial sources. Chemical reactions in the atmosphere transform SO_2 into sulfates (liquid or solid form).

Sources of Emission: The principal sources of SO_2 are industry (88.3%) and transportation (7.6%). Declines in industrial SO_2 emissions over the last 25 years can be attributed to improved industrial processes and better filtration systems.

Effects on Health and the Environment: SO_2 is an irritant gas that acts in combination with other pollutants, most notably particulate matter. Exposure produces symptoms that include coughing, reduced lung capacity and aggravated lung and cardiovascular disease. Asthmatics are particularly sensitive to SO_2. Long-term exposure to SO_2 increases the risk of developing a chronic respiratory illness. It also contributes to acid rain and the formation of suspended fine particulate matter.

4. **Nitrogen Dioxide (NO_2)**: Nitrogen dioxide (NO_2) is an irritant gas which is a by-product of combustion. At high temperatures, airborne nitrogen and oxygen combine to form nitric oxide (NO), which transforms relatively quickly into NO_2. Both of these substances, NO_2 and NO, are the principal components of the family of nitrogen oxides (NO_x). NO_2 is responsible for the distinctive brownish colour of smog, reduces visibility and at high concentrations contributes to the formation of ozone. Chemical reactions in the atmosphere transform NO_2 into nitrates (liquid or solid form).

Sources of Emission: The principal sources of nitrogen oxides are transportation and industrial burning.

Effects on Health and the Environment: Nitrogen dioxide can irritate the lungs, cause coughing and weaken resistance to respiratory tract infections. In high concentrations, NO_2 can cause pulmonary edema. Asthmatics and people with bronchitis are most sensitive to NO_2. It also contributes to

acid rain and suspended particulate matter.

Related references:

1. Guideline for Reporting of Daily Air Quality –Air Quality Index (AQI), David Mintz, EPA-May 2006.

2. Abstracts: Air Quality Index and Emission Inventory for Delhi, Air Quality Workshop 2000, New Delhi.

3. A Comparative Study of Air Quality Index Based on Factor Analysis and US-EPA Methods for an Urban Environment, Biswanath Bishoi, Amit Prakash, V.K. Jain, Aerosol and Air Quality Research, Vol. 9, No. 1, 1-17, 2009.

4. A Novel Air Pollution Index Based on the Relative Risk of Daily Mortality Associated with Short-term Exposure to Common Air Pollutants, Cairncross, E.K., John, J. and Zunckel, M., Atmos. Environ. 41: 8442-8454, 2007.

5. Comparison of Revised Air Quality Index with the PSI and AQI indices, Cheng, W., Chen, Y., Zhang, J., Lyons, T.J., Pai, J. and Chang, S., *Sci. Total Environ*. 382: 191-198, 2007.

Other Related Links for AQI:

1. http://www.airnow.gov/
2. http://www.wbea.org/content/view/29/69/
3. http://www.environmentalinfobank.com/
4. http://www.charmeck.org/Departments/LUESA/Air+Quality/Air+Quality+Data/Home.htm
5. http://library.thinkquest.org/06aug/02304/final/measurements.html
6. http://home.iitk.ac.in/~mukesh/air%20quality%20index/BASIS.html

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