

**Air Pollution:**

- By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide.
- According to Section 2(b) of Air (Prevention and control of pollution) Act, 1981 'air pollution' has been defined as 'the presence in the atmosphere of any air pollutant.'
- As per Section 2(a) of Air (Prevention and control of pollution) Act, 1981 'air pollutant' has been defined as 'any solid, liquid or gaseous substance [(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment'.
- Therefore, ambient air quality standard is developed as a policy guideline that regulates the effect of human activity upon the environment so that pollutant emission into the air can be regulated. Standards may specify a desired state or limit alterations.

**National Ambient Air Quality Standards (NAAQS)**

The objectives of air quality standards are:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property;
- To assist in establishing priorities for abatement and control of pollutant level;
- To provide uniform yardstick for assessing air quality at national level;
- To indicate the need and extent of monitoring programme.

**Parameters monitored under NAMP**

To check air quality of the country, Central Pollution Control Board initiated National Air Quality Monitoring Programme (NAMP) under which three air pollutants viz.,

- Sulphur Dioxide (SO<sub>2</sub>),
- Nitrogen Dioxide (NO<sub>2</sub>) and
- PM 10 (Particulate Matter size equal to or less than 10 micron)
- PM<sub>2.5</sub> (Particulate Matter having an aerodynamic diameter less than or equal to 2.5 µm),
- Carbon monoxide (CO),
- Ammonia (NH<sub>3</sub>)
- Lead (Pb)
- Ozone (O<sub>3</sub>),
- Benzene (C<sub>6</sub>H<sub>6</sub>)
- Benzo(a)pyrene (BaP)
- Arsenic (As) and
- Nickel (Ni)

**Air Pollutants, Sources and Their Effects:**

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
<b>Sulphur dioxide (SO<sub>2</sub>)</b> SO <sub>2</sub> is the chemical compound produced by volcanoes and in various industrial processes and are also a precursor to particulates in the atmosphere.	• Volcanoes (67%)	• combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories) • paper Industry • extraction & distribution of fossil fuels • smelting of metals (sulfide ores to produce copper, lead and zinc) • Petroleum refining • combustion process in diesel, petrol, natural gas driven vehicles	• respiratory illness • visibility impairment • aggravate existing heart and lung diseases	• acid rain • aesthetic damage
<b>Oxides of Nitrogen (NO<sub>x</sub>)</b> Oxides of nitrogen are a generic term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. NO <sub>x</sub> are emitted as nitrogen oxide (NO) which is rapidly oxidized to more toxic nitrogen dioxide (NO <sub>2</sub> ). Nitrogen dioxide (NO <sub>2</sub> ) is a reddish-brown toxic gas with a characteristic sharp, biting odor and is a prominent air pollutant.	• Lightning • Forest fires • Bacterial activity of soil	• High temperature combustion (internal combustion engines, fossil fuel-fired power stations, industrial) • Burning of Bio-mass and Fossil Fuels	• irritates the nose and throat • increase susceptibility to respiratory infections	• Precursor of ozone formed in the troposphere • Form atmospheric fine particulate matter burden as a result of oxidation to form nitrate aerosol • acid Rain
<b>Respirable Suspended Particulate Matter (PM<sub>10</sub>)</b> , size ≤10µm, coarse fraction PM <sub>10</sub> - PM <sub>2.5</sub> ). called thoracic fraction) Particulate matter (PM) is a complex mixture of suspended solid and liquid particle in semi equilibrium with surrounding gases. The major constituents of RSPM are organic and elemental carbon, metals/elements like silicon, magnesium, iron, ions like sulphates, nitrates, ammonium etc. PM <sub>10</sub> can settle in the bronchi and lungs and cause health problems	• Coarse particles are produced by the mechanical break-up of larger solid particles. Wind blown dust such as road dust, fly ash, soot, agricultural processes • physical processes of crushing, grinding and abrasion of	• Road traffic emissions particularly from diesel vehicles • Industrial combustion plants some public power generation • Commercial and residential combustion • Non-combustion processes (e.g. quarrying) • agricultural activities	• cardio-pulmonary problems • asthma, bronchitis, and pneumonia in older people	Visibility reduction

	<p>surfaces.</p> <ul style="list-style-type: none"> <li>• photochemically produced particles, such as those found in urban haze</li> <li>• Pollen grains, mould spores, and plant and insect parts</li> <li>• Non-combustible materials released when burning fossil fuels.</li> </ul>			
<p><b>Particulate Matter 2.5</b> (PM<sub>2.5</sub>, size ≤ 2.5 μm, fine fraction size up to 2.5 μm, respirable fraction) Airborne particles smaller than 2.5 μm called fine particles. Composed mainly of carbonaceous materials (organic and elemental), inorganic compounds (sulfate, nitrate, and ammonium), and trace metal compounds (iron, aluminium, nickel, copper, zinc, and lead). pose the greatest problems, PM<sub>2.5</sub>, tend to penetrate into the gas exchange regions of the lung, and very small particles (&lt; 100 nanometers) may pass through the lungs to affect other organs. The smallest particles, however, less than 100 nm (nanoparticles) can get into the bloodstream and affect the cardiovascular system</p>	<ul style="list-style-type: none"> <li>• Fine particles are largely formed from gases.</li> <li>• Ultrafine particles are formed by nucleation, which is the initial stage in which gas becomes a particle. These particles can grow up to a size of 1 μm either through condensation, when additional gas condensates or coagulation</li> </ul>	<ul style="list-style-type: none"> <li>• Vehicular emission</li> <li>• Industrial combustion plants some public power generation</li> <li>• Commercial and residential combustion</li> </ul>	<ul style="list-style-type: none"> <li>• oxidative stress</li> <li>• respiratory symptoms such as irritation of the airways, coughing, or difficulty breathing</li> <li>• decreased lung function</li> <li>• aggravated asthma</li> <li>• chronic bronchitis</li> <li>• irregular heartbeat cardio-pulmonary disorders</li> <li>• premature death in people with heart or lung disease</li> </ul>	<ul style="list-style-type: none"> <li>• aesthetic damage</li> <li>• visibility reduction</li> </ul>
<p><b>Ozone(O<sub>3</sub>)</b> Ozone is a pale blue gas, soluble in water and non-polar solvents with specific sharp odor somewhat resembling chlorine bleach. Ozone is a secondary pollutants formed in the atmosphere by reaction between oxides of nitrogen and volatile organic compounds (VOCs) in the presence of sunlight. Peak O<sub>3</sub> levels occur typically during the warmer times of the year.</p>	<ul style="list-style-type: none"> <li>• ozone is present in the atmosphere in the stratosphere, in a region also known as the ozone layer between about 10 km and 50 km above the surface</li> </ul>	<ul style="list-style-type: none"> <li>• formed by the reaction of sunlight on air containing hydrocarbons and nitrogen oxides emitted by car engines, industrial operations, chemical solvents to form ozone</li> <li>• electronic equipment such as photocopiers</li> </ul>	<ul style="list-style-type: none"> <li>• lung function deficits</li> <li>• respiratory illness</li> <li>• premature death, asthma, bronchitis, heart attack, and other cardiopulmonary problems.</li> <li>• ground-level ozone and pollution which interferes with photosynthesis and stunts overall growth of some plant species</li> </ul>	<ul style="list-style-type: none"> <li>• Ozone cracking in car tires, gaskets, O-rings is caused by attack of ozone on any polymer possessing olefinic or double bonds within its chain structure,</li> <li>• ozone present in the upper troposphere acts as a greenhouse gas, absorbing some of the infrared energy emitted by the earth.</li> </ul>
<p><b>Lead(Pb)</b> Lead is a bright silvery soft, dense, ductile, highly malleable, bluish-white metal that has poor electrical conductivity heavy metal and is highly resistant to corrosion.</p>	<ul style="list-style-type: none"> <li>• food (lead is absorbed by plants)</li> </ul>	<ul style="list-style-type: none"> <li>• Waste incineration</li> <li>• Metal processing</li> <li>• Paint Industry</li> <li>• lead solder in food cans, breast milk, drinking water, Cosmetics, ceramic pottery, burning of firewood or kerosene, indigenous remedies, tobacco and tobacco products, contaminated drinking water, toys, industrial effluents, lead acid batteries, ammunition, paints and varnishes, water pipes</li> <li>• automobile exhaust,</li> </ul>	<ul style="list-style-type: none"> <li>• Pb is rapidly absorbed into the bloodstream and is believed to have adverse effects on the central nervous system, the cardiovascular system, kidneys, and the immune system</li> <li>• causes blood disorders like anemia increase in blood pressure.</li> <li>• potent neurotoxin that accumulates both in soft tissues and the bones.</li> <li>• causes nephropathy, and colic-like abdominal pains.</li> <li>• weakness in fingers, wrists, or ankles.</li> <li>• Miscarriage and reduction of fertility in males, delayed puberty in girls</li> <li>• permanently reduce the cognitive capacity of children</li> </ul>	
<p><b>Carbon monoxide (CO)</b> also called carbonous oxide, is a colorless, odorless and tasteless gas which is slightly lighter than air. It is highly toxic to humans and animals in higher quantities. Mainly formed by incomplete combustion of carbon containing fuels.</p>	<ul style="list-style-type: none"> <li>• produced during normal animal metabolism (by the action of heme oxygenase 1 and 2 on the heme from hemoglobin breakdown and produces carboxyhemoglobin in normal persons) in low quantities and has some normal biological functions (signalling molecule)</li> <li>• volcanic activity</li> <li>• forest and bushfires</li> </ul>	<ul style="list-style-type: none"> <li>• Exhaust of internal combustion engines, especially of vehicles with petrol engines</li> <li>• Burning of carbon fuels</li> <li>• organic combustion in waste incineration</li> <li>• power station processes</li> <li>• Iron smelting</li> <li>• burning of crop residues</li> </ul>	<ul style="list-style-type: none"> <li>• CO enters the bloodstream through lungs and combines with hemoglobin forms carboxyhemoglobin. This condition is known as anoxemia, which inhibits blood's oxygen carrying capacity to organs and tissues.</li> <li>• Persons with heart disease are sensitive to CO poisoning and may experience chest pain if they breathe the gas while exercising.</li> <li>• adverse effects on the fetus of a pregnant woman</li> <li>• Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive.</li> <li>• anti-inflammatories, vasodilators and encouragers of neovascular growth</li> </ul>	

<b>Ammonia (NH3)</b> A compound of nitrogen and hydrogen, a colourless gas with a characteristic pungent odour. Contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers, and either directly or indirectly, isalso a building block for the synthesis of many pharmaceuticals.	<ul style="list-style-type: none"> <li>• putrefaction of nitrogenous animal and vegetable matter Ammonia and ammonium salts are also found in smallquantities in rainwater, fertile soil andin seawater</li> <li>• during volcanic eruption</li> <li>• The kidneys secrete NH3 to</li> <li>• neutralize excess acid</li> </ul>	<ul style="list-style-type: none"> <li>• Farms</li> <li>• Fertilizers Industry</li> <li>• Industrial sites that store ammonia or use it as a refrigerant can release high levels if the chemical leaks or is spilled</li> </ul>	<ul style="list-style-type: none"> <li>• irritating to skin, eyes, throat, and lungs and cause coughing</li> <li>• burns</li> <li>• Lung damage and death may occur after exposure to very high concentrations of ammonia</li> </ul>	Odour
<b>Benzene (C6H6)</b> Benzene is a colorless, sweet smelling liquid. Benzene is generated whenever carbon-rich materials undergo incomplete combustion. Benzene is generated whenever carbon-rich materials undergo incomplete combustion.	<ul style="list-style-type: none"> <li>• volcanoes</li> <li>• forest fires</li> </ul>	<ul style="list-style-type: none"> <li>• Combustion of fuel (automotive fuel, wood and stationary fossil fuel, other aromatics</li> <li>• evaporation (fuel storage containers, during refueling</li> <li>• Industrial emission</li> <li>• Coke oven</li> <li>• Perchlorethlyene is emitted from some dry cleaning facilities</li> <li>• tobacco smoke, wood smoke</li> <li>• glues, paints, furniture wax, and detergents</li> </ul>	<ul style="list-style-type: none"> <li>• Hematotoxic, neurotoxic, leukemogenic, carcinogenic effects</li> <li>• Chronic exposure to benzene may causechromosomal damage, immune suppression, aplastic anemia, myelodysplastic syndrome, leukemia, non-Hodgkins’s lymphoma, and cancer of the lung and nasopharynx</li> <li>• Effect the Reproductive system, developing fetus and fertility in men, low birth weights, delayed bone formation, and bone marrow damage</li> </ul>	
<b>Polyaromatic hydrocarbons (BaP)</b> (particulate phase only) is a five-ring polycyclic aromatic hydrocarbon whose metabolitesare mutagenic and highly carcinogenic	<ul style="list-style-type: none"> <li>• coal tar (after a forest fire),</li> <li>• eruption of volcanoes</li> </ul>	<ul style="list-style-type: none"> <li>• Incomplete combustion of</li> <li>• fuels (processing of coal and crude oil)</li> <li>• Combustion of natural gas</li> <li>• Road transport</li> <li>• Industrial plant</li> <li>• Tobacco smoke</li> <li>• coal tar</li> <li>• automobile exhaust fumes (especially diesel engines), inall smoke resulting from the combustion of organic material</li> <li>• charbroiled food, burnt toast, cooked meat products, in burnt foods such as coffee</li> </ul>	<ul style="list-style-type: none"> <li>• Mutagenic and highly carcinogenic (skin, lung, and bladder cancer in humans and in animals)</li> <li>• skin rash or eye irritation</li> <li>• Bronchitis</li> </ul>	
<b>Arsenic (As)</b> is a solid layered, a ruffled analogue of graphite, metallic gray in color and is a semiconductor. It is a potent poison IARC) recognizes arsenic and group 1 carcinogen (IARC)	<ul style="list-style-type: none"> <li>• volcanic ash, weathering of the arsenic- containing mineral and ores as well as groundwater.</li> <li>• food, water, soil and air</li> </ul>	<ul style="list-style-type: none"> <li>• Smelting of metals,</li> <li>• Combustion of fuels (especially of low-grade brown coal)</li> <li>• Use of pesticides.</li> <li>• wood preservation, glass production, nonferrous metal alloys, electronic semiconductor manufacturing.</li> <li>• coke oven emissions associated with the smelter industry</li> </ul>	<ul style="list-style-type: none"> <li>• epigenetic changes</li> <li>• multi-system organ failure</li> <li>• As poisoning</li> </ul>	
<b>Nickel (Ni)</b> a silvery-white lustrous corrosion-resistant metal with a slight golden tinge	<ul style="list-style-type: none"> <li>• urease (an enzyme which assists in the hydrolysis of urea) contains nickel</li> </ul>	<ul style="list-style-type: none"> <li>• Combustion of fossil fuels</li> <li>• Nickel plating</li> <li>• Metallurgical processes</li> </ul>	<ul style="list-style-type: none"> <li>• Nickel sulfide fume and dust is believed to be carcinogenic</li> <li>• allergy, dermatitis. Sensitivity to nickel may also be present in patients with pompholyx.</li> </ul>	<ul style="list-style-type: none"> <li>• explosive in air</li> </ul>

National Ambient Air Quality Standards (NAAQS)

S. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential ,Rural and other Areas	Ecologically Sensitive Area(notified by Central Government )	
1	Sulphur Dioxide (SO2), µg/m³	Annual*	50	20	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
		24 Hours**	80	80	
2	Nitrogen Dioxide (NO2 ), µg/m³	Annual*	40	30	1. Modified Jacob & Hochheiser 2. Chemiluminescence
		24 Hours**	80	80	
3	Particulate Matter (Size <10µm) or PM10 µg/m³	Annual*	60	60	1. Gravimetric 2. TEOM 3. Beta attenuation
		24 Hours**	100	100	
4	Particulate Matter (Size <2.5 µm) or PM2.5 µg/m³	Annual*	40	40	1. Gravimetric 2. TEOM 3. Beta attenuation
		24 Hours **	60	60	
5	Ozone (O3), µg/m³	8 hours**	100	100	1. UV photometric 2. Chemiluminescence 3. Chemical Method
		1 hours **	180	180	
6	Lead (Pb), µg/m³	Annual *	0.50	0.50	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
		24 Hour**	1.0	1.0	

7	Carbon Monoxide (CO), mg/m <sup>3</sup>	8 Hours **	02	02	Non dispersive Infra Red (NDIR) Spectroscopy
		1 Hour**	04	04	
8	Ammonia (NH <sub>3</sub> ), µg/m <sup>3</sup>	Annual*	100	100	1. Chemiluminescence 2. Indophenol blue method
		24 Hour**	400	400	
9	Benzene (C <sub>6</sub> H <sub>6</sub> ) , µg/m <sup>3</sup>	Annual *	05	05	1. Gas chromatography based continuous analyzer 2. Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP)- particulate phase only, ng/m <sup>3</sup>	Annual*	01	01	Solvent extraction followed byHPLC/GC analysis
11	Arsenic (As), ng/m <sup>3</sup>	Annual*	06	06	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m <sup>3</sup>	Annual*	20	20	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

\* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.\*\* 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

### **National Air Quality Index**

- National Air Quality Index (NAQI) has the objective of dissemination of Air Quality information to the public. Computation of AQI is done using real-time data of Continuous Ambient Air Quality Monitoring Stations.
- The AQI consider eight pollutants (PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, O<sub>3</sub>, NH<sub>3</sub>, and Pb), it is calculated only if data are available for minimum three pollutants out of which one should necessarily be either PM<sub>2.5</sub> or PM<sub>10</sub>.
- The Sub-indices for individual pollutants at a monitoring location are calculated using its 24-hourly average concentration value (8-hourly in case of CO and O<sub>3</sub>) and health breakpoint concentration range. The worst sub-index is the AQI for that location.
- There are six AQI categories namely, Good, Satisfactory, Moderate, Poor, Very Poor, and Severe. The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated likely health impacts are as follows:

AQI Category, Pollutants and Health Breakpoints								
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	0.5 –1.0
Moderately polluted (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	Associated Health Impacts
Good(0–50)	Minimal Impact
Satisfactory(51–100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted(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.
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease
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.
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity