

## Black Carbon [UPSC Environment & Ecology Notes]

Black carbon is in the news off late with studies showing it is contributing to air pollution majorly. It is also significant in that reducing black carbon is shown to have immediate effects on air pollution mitigation. In this article, you can read all about black carbon (BC) for the [UPSC exam](#) environment and ecology segment.

### What is Black Carbon?

Black carbon is a component of soot emitted by the incomplete combustion of fossil fuels, biofuel and biomass.

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- Chemically, it is a component of fine particulate matter ( $PM \leq 2.5 \mu m$ ).
- It is a kind of aerosol that is emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel.
- Black carbon particles consist of nearly pure elemental carbon with some oxygen and hydrogen bound into layered, hexagonal structure.
- **How is black carbon formed?**
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  - BC may be formed either by carbonization (charring) of organic matter during combustion (charcoal particles) or by condensation from the gas phase in reducing flames (soot particles).
  - It is formed by the incomplete combustion of fossil fuels, wood and other fuels.
  - The complete combustion of fossil fuels would convert all the carbon present in the fuel into carbon dioxide but combustion is never complete.
  - Therefore, in the process of combustion, carbon dioxide, volatile organic compounds, carbon monoxide and organic carbon and black carbon particles are all formed.
  - All these together form soot and BC is a component of it.
- Black carbon is a climate pollutant. Although it has a short life span (4 – 12 days) after it is released, it has a significant direct and indirect impact on the climate, agriculture and human health.
- According to some estimates, black carbon is the second-largest contributor to global warming after carbon dioxide.

### Major Sources of Black Carbon Emission

Black carbon is produced both naturally and anthropogenically (out of human activities) by the incomplete combustion of fossil fuels, biomass, etc.

- The major sources are emissions from diesel engines, cooking stoves, wood burning and forest fires.
- Household cooking and heating account for 58% of global black carbon emissions.

- The developing world contributes to almost 88% of black carbon emissions as a result of open biomass burning and residential solid fuel combustion.
- China and India together account for 25-35% of global BC emissions.
- India is the second largest emitter of BC in the world with the emissions expected to increase in the coming years. The largest contributor in India is the Indo-Gangetic Plains.
- BC emissions are the highest around the major source regions of this pollutant. Because of this, there are regional hotspots of atmospheric solar heating. Some of these hotspot areas are the Indo-Gangetic Plains, most of Indonesia and SE Asia, eastern China, Mexico and Central America, equatorial regions of Africa and most of Peru and Brazil.

Also read: [Air Pollutants](#)

## Impact of Black Carbon

Black carbon has impacts on human health, climate as well as vegetation and ecosystems.

### Impact on health

- Black carbon is a major component of fine PM air pollution which is the leading environmental cause of poor health and premature deaths.
- Being extremely fine (2.5 micrometres or smaller) these particles can penetrate the deepest parts of the lungs and enable the transport of toxic compounds into the bloodstream.
- It causes a range of ill-effects on health and has been linked to premature deaths with lung and heart disease, heart attacks, strokes, aggravated asthma, chronic respiratory disease including bronchitis, and other cardio-respiratory symptoms.
- It can also lead to premature deaths in children due to acute lower respiratory infections such as pneumonia.

### Impact on climate

- **Direct warming effect:** Black carbon absorbs solar energy and warms the atmosphere. It is very effective in absorbing light and heating up its surroundings. Its warming impact is 460-1,500 times stronger than carbon dioxide.
- **Indirect warming effect:** When BC falls to earth with precipitation, it darkens the surface of snow and ice, reducing their [albedo](#), warming the snow, and hastening melting.
  - The Arctic and glaciated regions such as the Himalayas are particularly vulnerable to melting as a result.

### Impact on vegetation and ecosystems

- BC has effects on vegetation because it can deposit on plant leaves and increase their temperatures.
- It can reduce the amount of sunlight that reaches the earth and modify rainfall patterns, which can have far-reaching consequences on human lives and the environment.

## Mitigating Black Carbon Pollution

Since black carbon remains in the atmosphere only for a few weeks, reducing BC emissions will immediately reduce the rate of global warming. Controlling black carbon particularly from fossil fuel burning could be the swiftest way to slow down global warming according to many scientists. Targeted strategies to mitigate black carbon emissions can lead to climate and health benefits within a relatively short time period.

The following table gives possible solutions to reduce black carbon emissions.

Source	Solutions
Household energy	<ul style="list-style-type: none"><li>• Replacing traditional stoves with clean modern cooking stoves or clean biomass stoves</li><li>• Removing kerosene lamps</li></ul>
Industrial production	<ul style="list-style-type: none"><li>• Modernising coke ovens to recovery ovens</li><li>• Modernising traditional brick kilns to vertical shaft brick kilns</li></ul>
Agriculture	<ul style="list-style-type: none"><li>• Prohibiting stubble burning</li></ul>
Transportation	<ul style="list-style-type: none"><li>• Using diesel particulate filters for vehicles</li><li>• Faster transition to BS VI norms</li><li>• Eliminating high-emitting diesel vehicles</li></ul>
Fossil fuels	<ul style="list-style-type: none"><li>• Capturing and improving oil flaring and gas production</li></ul>
Waste management	<ul style="list-style-type: none"><li>• Prohibiting open burning of municipal waste</li></ul>