

Black Carbon

[UPSC Notes]

What is Black Carbon?

A portion of the smoke released by the combustion of fossil fuels, renewables, and wood is Black Carbon. An organic compound with the formula falls under the fine particles category (PM 2.5 m). It refers to a type of aerosol produced from burning hydrocarbon fuels like gasoline, diesel coal, and other products.

- Black Carbon is composed of essentially pure oxygen and hydrogen linked into stacked hexagonal configurations. Black Carbon, after carbon dioxide, is believed to be responsible for global warming.
- Black Carbon damages the environment. It only remains for four to twelve days after emission, yet it nonetheless significantly affects the environment, ecosystem, economy, and population health directly or indirectly.

Formation of Black Carbon (BC):

- BC can be produced by condensing from the gaseous phase in reducing flames or by activated carbon (charring) of organic matter during combustion (charcoal particles) (soot particles).
- It is created as an energy source. Unfortunately, wood, as well as other fuels, fires inefficiently.
- All the carbon in fossil fuels will be broken down into carbon dioxide if burning is complete. But when burning is not complete, volatile organic compounds, carbon monoxide, organic carbon, and Black Carbon particles are all generated during the combustion reaction.
- Black Carbon is a composition of soot, which would also be composed of all these harmful elements.

Causes of Black Carbon Emissions

Black Carbon is a by-product of inefficient combustion of fossil biomass and other fuels, which can occur naturally and as a consequence of human activity (as a result of human activity).

- Diesel engine pollutants, cooking fire emissions, burning wood pollutants, and wildfires are significant sources.
- Fifty-eight percent of the world's most significant Black Carbon emissions come through households' cooking and heating.
- Due to open forest fires and solid domestic combustion, the rest of the world is responsible for roughly eighty-eight percent of Black Carbon releases.
- Together, China and India were responsible for twenty-five– thirty-five percentage points of the world's BC emission.
- India is the second-largest contributor to the global Black Carbon count, and BC production is expected to intensify in the coming years. The Indo-Gangetic Plains are India's primary contributor.

- The primary source of this pollutant is in British Columbia, where emissions were highest. Consequently, there are localized areas where the environment is warmed by the sun. The Indo-Gangetic Plains of India, Eastern China, maximum parts of Indonesia and South-Eastern Asia, Mexico, Central America, and tropical parts of Africa, as well as the majority of Peru and Brazil, are a few of these hotspot regions.

Adverse Effects of Black Carbon

Black Carbon impacts flora, habitats, people's health, and the weather.

Effects on Health

- A substantial part of fine PM air quality, the primary environmental cause of ill health and premature death, includes Black Carbon.
- These nanoparticles, which are extremely small (2.5 micrometers or less), may enter the lowest parts of the lungs, thus enabling the passage of dangerous substances into the blood.
- Numerous health problems have been related, including heart and lung illness, strokes, heart attacks, worsened asthma, chronic respiratory diseases like pneumonia, and other complaints about endurance.
- Acute lower respiratory infections, including pneumonia, can also lead to early death in youngsters.

Impacts on the Climate

- Direct: Black Carbon captivates solar energy and directly increases the air temperature. It is very good at absorbing light and heating the area around it. It has a 460 to 1500 times greater potential for global warming than carbon dioxide.
- Indirect: By darkening the top of the snow and ice, BC reduces its albedo, warms the snow, and accelerates melting when it falls to the ground as precipitation. Consequently, the Arctic and glaciated regions like the Himalayas are especially vulnerable to melt.

Effects on Ecosystems and Vegetation

- Because BC may deposit onto plant leaves & raise their temperature, and it impacts the flora.
- It can alter rain patterns and the amount of sunlight reaching the earth, which can have a massive effect on human and ecological health.

Black Carbon Pollution Reduction

Reducing Black Carbon emissions will immediately slow the global warming rate because BC only stays in the air for a few weeks. According to several experts, reducing Black Carbon, particularly from the combustion of fossil fuels, maybe the quickest approach to slowing global warming. In addition, targeted mitigation strategies for Black Carbon emissions can positively affect the environment and human health.

The following table lists possible ways to cut back on the emission of Black Carbon.

Source	Solutions
Domestic Energy	Use clean, modern cooking or spotless biomass stoves to replace conventional stoves. Taking out kerosene lights
Production within the industry.	Converting modern recovered ovens from blast furnaces Converting conventional brick kilns to vertical kilns for contemporary use
Agriculture	Banning the flaming of branches
Infrastructure	Fitting automobiles with diesel particulate filters A quicker conversion to BS VI standards Ditching diesel autos with emission of pollutants
Finite supplies	Maximizing and raising oil and gas production
Management of waste	Banning the open burning of garbage

Four Subgroups of Carbon

The four subgroups of carbon include Black, Brown, Blue and Green carbon.

Black Carbon:

- An element of tiny particulates with a diameter of about 2.5 μ m is Black Carbon (BC). It is entirely composed of carbon from the incomplete combustion of fossil fuels, coal,

biofuels, cellulose, wood, rubber, and other materials. Soot is the by-product that's also produced.

- The inefficient combustion of hydrocarbons generates soot, a flying mass of impure catalyst particles. It originates from slow pyrolysis.

Brown Carbon:

- Brown carbon is the brown smoke generated when organic material burns. After being released, it co-exists in the atmosphere with Black Carbon.
- It is one of the primary causes of global warming because it interacts with both the formation of clouds and the pattern of the atmosphere. Additionally, it changes the way of solar absorbance and cloud structure.

Blue Carbon:

- The carbon hoarded by the oceans and shoreline habitats is known as Blue Carbon. Aquatic biomass is carbon stored in the sea after being ingested by living things.
- Mangroves, marshes, and seagrass beds were three examples of vegetated coast blue carbon ecosystems.
- Collectively, these ecosystems span around forty-nine million hectares of land worldwide.
- The blue carbon environment is the primary sink for absorbing carbon from the atmosphere and lessening climate change impacts.

Green Carbon:

- A significant aspect of the global carbon cycle is the carbon that is captured into the biomass of terrestrial plants through photosynthesis and stored inside the soil and plants of ecological systems.

Global Carbon Project:

An organization known as the Global Carbon Project (GCP) aims to determine the total amount of emissions of greenhouse gases as well as its origins.

- It was founded in the year 2001, and its efforts include complementary work on urban, regional, cumulatively, and harmful emissions, in addition to global budgets for the three major greenhouse gases—carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O).
- The group's principal goal was to understand the carbon cycle fully. To tackle the rising concentrations of greenhouse gases. The project has gathered experts on emissions, earth sciences, and economists.
- The project published its most recent numbers of global gas and nitrous oxide emissions in 2020, the two anthropogenic gaseous pollutants that add to warming next to carbon dioxide.
- To collect, evaluate, and publish information on greenhouse gas emissions transparently and openly, the Global Carbon Project collaborates with various organizations. It renders information available on its site and through its publications.
- Underneath the guidance of the Earth System Science Partnership, this was established as a cooperation between the International Geosphere-Biosphere Programme, the World Climate Programme, the Global Human Dimensions Scheme, and diversity. Several of the partnership's core initiatives eventually joined Future Earth in 2014.

Recent Happenings Concerning Black Carbon

With the help of an optical instrument, it is now possible to accurately estimate Black Carbon (BC), the second-most significant global heating pollution after CO₂ in regions of the great Himalayas.

Some of the New Observations:

- The mass absorption cross-section (MAC), a metric peculiar to the Himalayan region, has been employed by researchers to estimate it.
- Black Carbon mass concentrations are determined using MAC, a crucial parameter.
- In tandem with students from the University of Delhi, IIT Kanpur, as well as the Space Physics Laboratory of ISRO, scientists just at Aryabhata Research Institute of Observational Sciences (ARIES) have done extensive observational data on Black Carbon as well as total organic carbon in addition to the first estimates of monthly and wavelength-dependent MAC values so over the central Himalayan region.
- These estimated MAC values show a significant seasonal variation, the analysis revealed. Furthermore, it is found that these changes are driven about by seasonal fluctuations in biomass combustion, air mass changes, and weather parameters.

Importance of the Observations:

- The accuracy of numerical weather forecasting and climate models in predicting the warming effects caused by BC emission will be improved by these higher resolutions of multi-wavelength and lengthy observations used in MAC computations.
- Studies to restrict the sources of BC emission levels will profit from the precise understanding of Black Carbon at multiple wavelengths.
- As a result, this can be helpful info for developing mitigation efforts.