



DARKENING THE ARCTIC AND THE RISING THREAT OF BLACK CARBON EMISSIONS

- Dr. Vivek Panwar
Sri Venkateswara College
University of Delhi

In the vast white silence of the Arctic, change is often invisible until it is sudden and irreversible. Ice that once seemed eternal is thinning, retreating, and in some places vanishing altogether. Scientists have long warned that the Arctic is warming nearly four times faster than the global average. While carbon dioxide usually takes centre stage in discussions about climate change, another, less discussed pollutant is quietly accelerating the transformation of the far north: black carbon.

Black carbon is a component of fine particulate matter produced when fossil fuels, biofuels, and biomass burn incompletely. It is commonly known as soot. Unlike carbon dioxide, which can remain in the atmosphere for centuries, black carbon has a relatively short atmospheric lifetime lasting only days to weeks. Yet its impact is disproportionately powerful. It absorbs sunlight efficiently, warming the air directly. When it settles on snow and ice, it darkens the surface, reducing reflectivity and causing faster melting. In a region defined by its whiteness, even a thin layer of soot can dramatically alter

the balance between reflection and absorption of solar energy.

Recent research indicates that black carbon emissions in and around the Arctic are rising, driven largely by expanding shipping routes, increased oil and gas extraction, flaring activities, and forest fires that are becoming more frequent and intense in a warming world. As sea ice retreats, new maritime corridors are opening across the Arctic Ocean, shortening travel times between Asia and Europe. Cargo ships and tankers, many of which run on heavy fuel oil or marine diesel, emit black carbon that can travel long distances before settling on ice sheets and glaciers. The very melting that enables more ships to pass through is intensified by the pollution those ships release.

The Arctic's vulnerability to black carbon is rooted in a simple physical principle. Fresh snow reflects up to 90 percent of incoming sunlight. When soot particles accumulate on the surface, that reflectivity declines. Darker surfaces absorb more heat, which leads to more melting. As ice melts, it exposes darker ocean

water beneath, which absorbs even more solar radiation. This feedback loop known as the ice-albedo effect magnifies warming. Black carbon acts as a catalyst in this process, speeding up changes that might otherwise unfold more gradually.

The sources of Arctic black carbon are both local and distant. Some emissions originate from communities within the Arctic region, where diesel generators and heating systems are still widely used. Oil and gas operations, particularly gas flaring in northern Russia and parts of North America, contribute significantly. At the same time, soot from wildfires in boreal forests and even industrial regions thousands of kilometres away can be transported northward by atmospheric circulation patterns. The Arctic is not isolated from the rest of the world; it is deeply connected to global systems of trade, energy, and climate.

Wildfires deserve special attention. As temperatures rise, forests in Siberia, Alaska, and northern Canada are burning more frequently and more intensely. These fires release massive amounts of black carbon into the atmosphere. Once airborne, the particles can drift over sea ice and Greenland's ice sheet, accelerating melt during the summer months. In some years, satellite observations have detected large plumes of smoke traveling across the Arctic Ocean. Fire seasons that once were limited to a few months are now extending longer, compounding the problem.

The consequences of rising black carbon emissions extend far beyond the Arctic itself. The region plays a crucial role in regulating global climate. Its reflective ice cover helps stabilize temperatures, and its cold waters influence ocean circulation patterns that shape weather worldwide. As Arctic ice diminishes, sea levels rise due to melting glaciers and ice sheets, threatening coastal communities from Mumbai to Miami. Changes in Arctic warming also influence the jet stream, potentially contributing to extreme weather events in mid-latitude regions, including prolonged heatwaves, cold spells, and heavy rainfall.

For Indigenous communities in the Arctic, these changes are immediate and personal. Thinning sea ice makes travel and hunting more dangerous, while altered wildlife migration disrupts traditional livelihoods. Coastal erosion, driven by melting permafrost and stronger wave action, is forcing some villages to consider relocation. Black carbon may be invisible, but its impacts are tangible in daily life.

One striking feature of black carbon is that reducing it offers relatively quick climate benefits. Because it remains in the atmosphere for a short time compared to carbon dioxide, cutting emissions can lead to noticeable cooling within years. This makes it a powerful target for near-term climate action. Technologies to reduce emissions from ships, such as cleaner fuels, filters, and improved engines, already exist. Limiting gas flaring and transitioning Arctic communities to cleaner energy can also make a difference.

International cooperation is essential. The Arctic is bordered by eight nations, but its stability depends on global decisions. Agreements under bodies like the Arctic Council recognize the need to reduce black carbon, yet implementation remains uneven as economic and strategic interests expand. Balancing development with protection is increasingly urgent.

There is also a moral dimension. The Arctic has contributed little to global emissions yet faces some of the earliest consequences. Addressing black carbon is about equity, responsibility, and foresight.

The story of rising Arctic black carbon emissions shows that climate change is shaped by everyday choices. As the Arctic warms, the window for action narrows, and reducing these emissions offers one of the clearest opportunities for rapid climate gains.