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# Black Carbon - A dangerous climate forcerer mitigating strategies

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**Abstract-**"Human activities are changing the earth's climate in two ways:
1) By way of greenhouse gas emission -$CO_2$etc.
2) By changing the atmospheric aerosol load (BC etc.) -Richard Black

Black Carbon is released during incomplete combustion of fossil fuels or biomass, is a component of soot (from inefficient cooking stoves, diesel emissions from vehicles and from generators etc.), ultrafine particles or PM 0.1 posing health risks, strongly absorb light and convert the energy to heat. It has a brief atmospheric life and its climatic effects seem to be regional yet due to strong wind may be driven to far flung areas and unfortunately it covers the ice or snow, it would darken them thereby increasing the absorption of sunlight. This would in turn increase heat absorption and melt the ice or snow. It is therefore, a significant contributor of recent warming in changing Arctic which has accelerated sea ice loss and melting Himalayan Glaciers. Contrarily $CO_2$, a greenhouse gas has much longer lifetime (over 100 years) and has significant influence on the global temperature. The present authors have dealt with the black carbon emission in rural and urban area of chotanagpur area, how black carbon impacts cloud formation and rainfall etc. and remedial strategy in reducing Black Carbon emission

**Key words: Black Carbon, Soot, Remedial measures**

## INTRODUCTION

Black Carbon (BC) a short lived climate forcer (SLCF) is a charcoal like residue left by burning fuels that are rich in carbon often seen in fires/ fire places, due to incomplete combustion of fossil fuels, biomass and biofuels. It is an ultrafine fraction of the particulate matter emitted by diesel driven vehicles, ships on seas, coal or wood burning, stoves used in residential premises from forest fires or burning of agricultural wastes (open biomass burning).

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There are two terms often used while reading black carbon. These are:

**A. Black Carbon** - It is dark, light absorbing components of aerosol that contain two forms of elemental carbon.

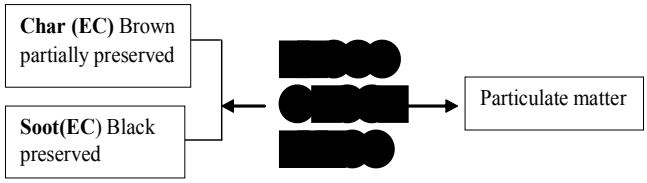
**1. Char-** It is the carbonaceous material obtained by partially heating / burning organic substances with limited access of air. This results into an impure form of graphite carbon. [Exp. Burning Vegetation or wood in residential houses]

**2. Soot-** It is carbon particles that form at high temperature via gas phase process. [Exp. From diesel engines]

**B. Elemental Carbon (EC)-** It is atmospheric particulate matter (PM) derived from varieties of combustion sources and contains:-

**1. Char-** The graphite like structure of natural carbon having brown colour (partially preserved)

**2. Soot-** This is original structure of carbon not preserved which is black in colour.




The above two types possess different chemical and physical properties and different light absorbing properties.[1,2]

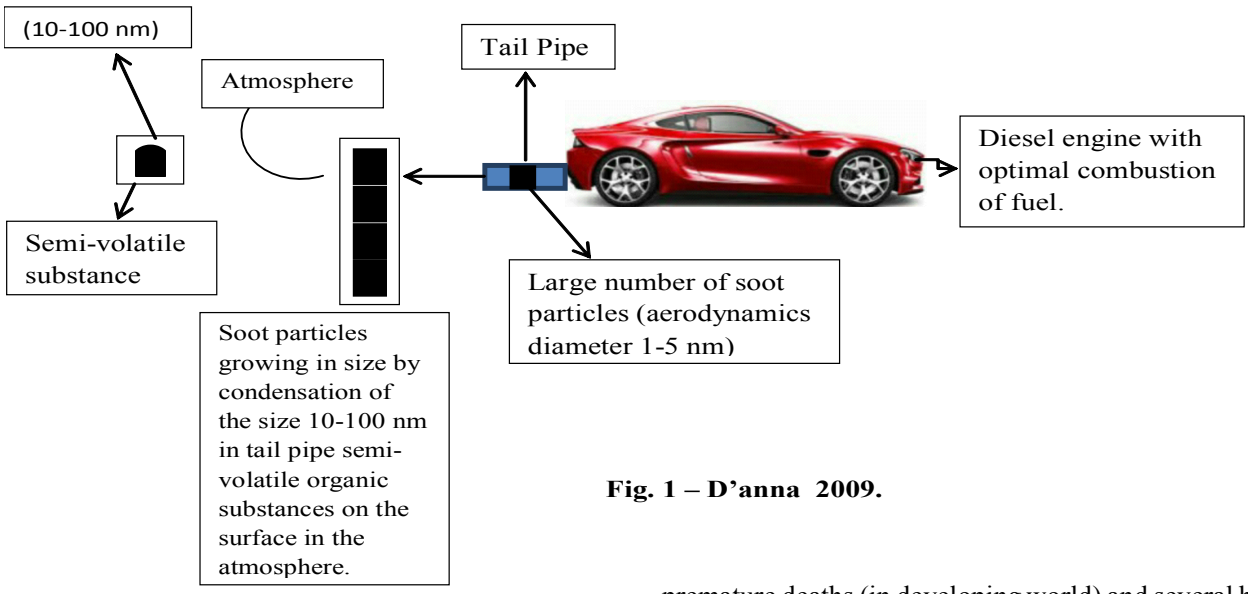



**Fig. 1 – D'anna 2009.**

**A)** When fuel undergoes optimal combustion at high temperature (as in diesel engine), emits large number of small soot particles (aerodynamic diameter being 1-5 nm). These soot particles grow in size (10-100 nm) in tail pipe and undergoes simultaneous condensation of semi-volatile organic substances in the atmosphere.[3] (Fig. 1) He further opines that the speed of growth is dependent upon air temperature, sunlight & the concomitant oxidants etc.

**B)** Contrarily due to incomplete combustion of solid fuel (wood, coal), the emitted particulate matters have aerodynamic diameter 150-16- nm which continue to grow taking semi-volatile organics on their surface (wood and coal produce large amounts of semi-volatile organics).

Such particles, in due course of time (short period to several days) become upto 1µm as inorganic salts emerging from $NO_2$ and $SO_2$ and atmospheric water attach to the surface of hydroscopic carbonaceous particles.

Black Carbon (a charcoal like residue) emitted by burning fuels are rich in carbon (seen in fires or fire places etc) and stays in the atmosphere for a short time (several hours or days). Particulate Matter (PM) of which Black Carbon (BC) is a main constituent responsible for premature deaths (in developing world) and several health complications.

Black Carbon has been also called Elemental Carbon (EC), its effects should not be underestimated as it can remain in the air for months and travel hundreds of kilometres. Its coarse particles though settle on the ground and do not get easily transported to large area or beyond as courser particles fail to be driven by air streams and thus get easily removed on contact with surfaces.

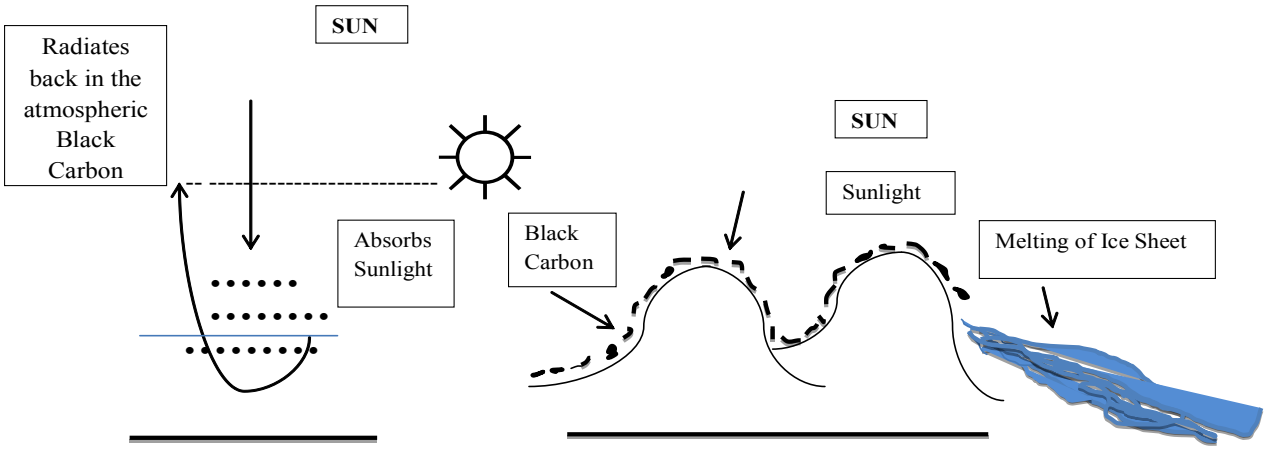
**Black Carbon vis a vis– climate change / global warming:**

Some scientists believe that it does have major role to play in the climate change yet others believe it does.

Jacobson (2007)[4] estimated that "Black Carbon accounts for about 40% of net global warming or 16% of gross global warming" whereas $CO_2$ is the major player. Therefore Black Carbon is placed 2nd as 'Warming agent'.

Chow *et al.*(2009)[5] however, had left technical problems in the instruments used in the calculation and intercomparision studies.

Black Carbon absorbs sunlight and radiates it back in the atmosphere as heat, it also affects cloud and rainfall patterns.




In colder regions, Black Carbon settles on ice and snow as well as on other surface of the earth. If increases the melting rate of ice and snow.

D'Anna, (2009)[3] reported that half or more of the warming measured in Aretic from 1976-2007 is due to Black Carbon plus Organic Carbon. Black Carbon coming from fuel combustion has been implicated in reducing reflectivity rate and increasing the rate of melting of ice.

Arctic and Himalayan region is covered by ice/ snow, when Black Carbon deposits, it darkens the surface and increases the absorption of solar radiation. This Black Carbon ice Albedo* effect leads to warming of the lower atmosphere and melting of snow /ice sheets.

Ice and snow covered areas showing light coloured surfaces show higher albedo reflecting much of the sun's rays (radiations) which get absorbed by the oceans resulting into heating up the earth surface.

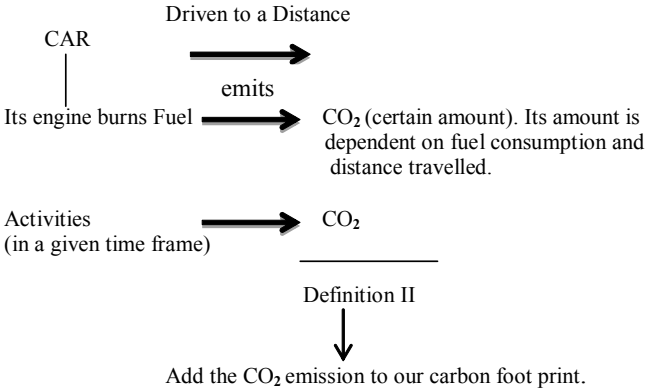
Contrarily dark surface (showing low albedo) absorbs higher energy from the sun and has thus warming effect.

**Carbon Foot Print:**

Carbon Foot Print is defined as the total amount of greenhouse gases produced, to directly and indirectly support human activities, usually expressed in equivalent tons of $CO_2$. Or

It is the sum of all emissions of $CO_2$ which are induced by activities performed in a given time frame (usually calculated for the time period of a year)

*Albedo effect is the ability of the surface to reflect sunlight (heat from the sun). Light coloured surface return a large part of the sun's rays back in the atmosphere (HIGH ALBEDO) whereas dark surface absorbs higher energy from the sun's rays (LOW ALBEDO)




Example:

| Fuel | Amount of $CO_2$ |
|---|---|
| UK 1 gallon Petrol | 10.4 kg $CO_2$ |
| US 1 gasoline | 8.7 kg $CO_2$ |
| A car with diesel (7.5 L) | travel 100 Km |
| ↓ Multiply by a factor 0.27 | Then for 300 Km it will consume 3 x 7.5= 22.5 L Diesel i.e, 22.5 x 2.7 Kg = 60.75 Kg $CO_2$ (Personal Carbon Foot Print) = 16.40 Carbon |
| (Note: 1000 kg $CO_2$= 270 Kg Carbon) | |

If a car is driven, its engine burns fuel and emit certain amount of $CO_2$. Its amount is dependent on the fuel consumption and distance travelled.

Similarly, in a given time frame certain activities (burning) have been performed. Therefore its Carbon Foot Print will be equal to sum of all emissions of $CO_2$ which have been induced by the activities.

**CALCULATION OF $CO_2$ EMISSION:**

Some examples,

| Fuel | Emitted Amount of $CO_2$ |
|---|---|
| UK 1 gallon Petrol consumed | 10.4 kg $CO_2$ |
| US 1 gasoline consumed | 8.7 kg $CO_2$ |
| Car in India | |

Diesel car supposing it consumes 7.5 litres of diesel for travelling 100 km.

- A drive of 300 will consume
  7.5 x 3 = 22.5 litre diesel

This is multiplied by 2.7 Kg

22.5 x 2.7 Kg = 60.75 Kg $CO_2$

Becomes the personal Carbon Foot Print

By multiplying 60.75 Kg $CO_2$ with a factor 0.27
(1000 Kg $CO_2$ equals to 270 Kg Carbon)

- 60.75 x 0.27 = 16.4 Kg Carbon

Unfortunately, conventional Carbon Foot Print account for only homogenous greenhouse gases (GHGs) specified by the IPCC (Intergovernmental Panel on Climate Change) as global warmers: $CO_2$, $CO_4$, $N_2O$ & halocarbons. Foot prints generally do not include gases or particles not specified by the IPCC such as Black Carbon and other heterogenous species such as Carbon-mono-oxide (CO), Hydrogen ($H_2$), Organic Carbon (OC), Ozone ($O_3$), Nitrogen Oxide (NOx) or Sulphates (SOx)- vide www. WORLDLPGAS.Com.

**METHODS GENERALLY USED**

1) Light transmission through integrated Particulate Matter samples collected at 24 hours intervals on thin cellulose fibre filter and subsequent convention of the optical measurement units to man based unit.

2) Photometer absorption of Particulate Matter sample spots (Black Carbon) at 1-5 minute intervals and automatic readings in mass based unit.

3) Chemical determination Elemental Carbon and Organic Carbon using thermal optical analysis either semi-continuously with mass based reading given every 30 minutes to 3 hours, or from integrated Particulate Matter samples collected at 24 hours intervals on quartz filter.[4]

**REMEDIAL STRETEGIES:**

Since Black Carbon is a component of particulate matter, hence particulate matter can be minimised. Jacobson (2002,2005)[6,7] suggested converting vehicles from fossil fuel to electric, plug in hybrid or hydrogen fuel cell vehicles. He opines that such conversion would eliminate 160 G g/yr (24% of United States or 1.5% of world) fossil fuel soot and 26% of us (or 5% of world $CO_2$ emission by 1.63 Gt $CO_2$ eq per year). He felt that "the elimination of hydrocarbons and nitrogen oxides would also eliminate some cooling particles, reducing the net benefit by at most, half but improving human health."

**DIESEL PARTICULATE FILTER:**

Technologies are available for replacing the diesel vehicles where diesel particulate filter can be used which in turn eliminate 90% of Black Carbon.[8] Ultra Low Sulphur Diesel (ULSD) is a form of diesel fuel with exceedingly lower sulphur content which is comparatively better compared to petroleum based diesel. Enactment of Acts/ Laws: Strict Act has to brought for implementing such fuel.

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