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Institute of Green Economy

C-312, Defence Colony
New Delhi 110024, India
Telephone: +91-11-46103509
Email: contact@igrec.in
Website: www.igrec.in

Do Forests Provide Mitigation Benefits Twice Over?

by

Dr. Promode Kant[1]

Abstract

The Biogenic Volatile Organic Compounds (BVOCs) are emitted by trees in large quantities and these compounds reacts with the exhausts from the vehicles and the industries causing dense aerosol clouds over the earth that have a cooling effect.The largest quantities emitted are of isoprenes and monoterpenes that have a very short lifetime with some breaking up as soon as they are emitted while the others may last less than a day. One way of deriving additional mitigation benefits from forest, apart from carbon sequestration, would be to have high density of forests particularly of species that emit higher quantity of BVOCs, like pines, poplars, casuarinas, eucalyptus and ficus among many more, near the industrial zones which would increase aerosol thickness working to reflect sunlight back. In populated areas, however, where the priority is to provide a good environment for the large population living there, keeping the ozone level down has to be higher priority and there the forest planted should be rich in biodiversity and low in BVOC emission rates. Keeping forests young by earlier harvesting and operations like thinning, coppicing and pollarding that produces consumable forest product replacing fossil fuel based products and increases subsequent carbon sequestration while emitting higher quantities of BVOCs that have the opportunity to deepen aerosol thickness over the earth may perhaps provide a management tool to enhance forest based mitigation of climate change. But it would require much research before such an idea can be put into practice

Key words: BVOCs, Mitigation, Aerosol, Forest management.

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[1] Director, Institute of Green Economy, C-312, Defence Colony, New Delhi, India-110024, Ph: +911146103509, email: director@igrec.in

In the run up to his first Presidential election, Ronald Regan became the butt of jokes and night time comedies when he said that trees cause more pollution than the cars. This bloomer sank the hearts of Republicans and raised the hopes of his opponents who thought it would be easy to prove he was a nut case. Of the many controversial things he did, and said, not many would match the longevity of this one in people's memory even if it did no harm to him. But that is a different story because, as the next eight years of his presidency were to show, no blame could ever stick to this genial old man.
But Regan may not have been altogether wrong in his claim. Trees emit a big range of volatile organic compounds (VOCs) in large quantities and these compounds, by reacting with the exhausts from the vehicles, agriculture and the industries, are the cause of smogs across the continents. The Biogenic Volatile Organic Compounds (BVOCs), to distinguish them from those of anthropogenic origin, are a large number of saturated and unsaturated organic compounds including alkanes, alkenes, carbonyls, alcohols, esters and ethers. The largest quantities emitted are of isoprenoides which includes isoprenes and monoterpenes. By their very nature the BVOCs have a very short lifetime with some breaking up as soon as they are emitted while the others may last less than a day. The daytime half-lives of these compounds are usually double than nighttime half-lives which probably serves a purpose in the life cycle of the plants because during day time the plants need the support of BVOCs more.

The supports that the BVOCs provide to the plants are many. These are the agents of the trees outreach to the environment, the plants' means of communication with the environment through which it attracts the pollinators at the right time while keeping the harmful insects away. These also serve the purpose of suppressing competition from the neighbouring flora while encouraging the companions which it needs. The BVOCs are also signals of stress, a tree crying out in pain, and is emitted in profusion when there is a mass outbreak of insect and pest attack and fires and drought.

Seasons have high impact on isoprenoide emissions as has the various stages in the plant life like budding, flowering, fruiting, dormancy and leaf senescence etc. Generally speaking, higher temperatures lead to higher emissions of BVOCs and similar is the effect of higher moisture content in the atmosphere. The emission differ with the age of the trees, usually rising as the trees grow fast in the younger stages and then stabilizing as the trees mature. Summer heat causes higher emission of BVOC and the early summer monsoon period with its higher moisture and high temperature is usually the peak season for BVOC emissions in monsoon tropics of Asia.

The emission also differs greatly from species to species. Some of the species which have the highest rates of BVOC emissions are *Eucalyptus, Causarina*, pines, rubber, *Ficus* and poplars all of which emit high levels of isoprenes which in turn creates an environment in which non isoprene emitting vegetation is suppressed. Thus, the overall effect of planting large number of such species leads to a reduction in the biodiversity. That is why these plants do very well in monoculture plantations and in nature also they are found in pure stands or in predominance.

The BVOCs have low life spans and wither away into a host of more stable chemical components. But in areas where there are nitrogen and sulfur pollutants from industries and vehicles, an interesting phenomenon occurs. The nitrogen and sulfur compounds react with the

BVOCs forming more stable sulfur compounds that are lighter in color and form aerosols that reflect sunlight back to the outer atmosphere.

This leads to a cooling effect. The IPCC has assessed the overall cooling effect from aerosol as 0.7 watt per square meter. In a study of aerosol optical thickness over North America reported by Goldstein et al at University of California, Berkley, it was observed that the thickness of aerosol could not be explained only by the pollution from vehicles, industries and agriculture alone, but that the presence of forests had to be taken into consideration. When the emission of BVOC from forest was integrated in the model, not only the thickness of aerosol could be explained but also the seasonal variations in it. It is because there is a strong seasonality in the BVOC emitting events in a forest area like fruiting, flowering, emergence of new leaves and leaf shedding as also fires and increased incidence of pests and diseases.

Mass outbreak of pest and disease attack cause stress to the trees which is expressed in terms of increased emissions of BVOCs as the trees struggle to unload themselves of the stress causing factors. In a study conducted on the mass outbreak of Gypsy Moth (*Lymantria dispar*) in France on the effect of Gypsy Moth feeding on the apices and leaves of Mediteranean Oak (*Quercus ilex*) it was noticed that a new volatile organic compound was emitted after the delay of a few hours subsequent to infestation and the emission declined rapidly when the caterpillars were removed. During the period of infestation the temporary emission of BVOC was higher by as much as 30 percent.

But this is not the end of the story. The chemical reaction between the sulfur and nitrate particles with BVOCs also leads to the formation of ozone which has not only a measurable greenhouse gas effect but is also harmful to life on earth. However, on balance, unless the level of sulfur pollutants is very high, the warming effect of the ozone formed in this manner is lesser than the cooling effect of aerosols formed through the same process given that ozone has a very short chemical life in contrast to the aerosol particles which live many times longer. But pollutants with very high levels of sulfur can easily tilt this balance.

If the amount of nitrogen pollutants in the atmosphere is high, the amount of ozone released in reaction with BVOC can significantly alter the nature of ecosystem by suppressing many plant life forms and specifically more micro flora and fauna rather quickly. When the nitrogen content is low, the BVOCs can remove the ozone from the surroundings.

This leads us to an interesting conclusion that while the BVOCs emitted from interior remote forest areas may simply vanish due to their extreme volatility that in and close to urban areas and industries can lead to formation of aerosol clouds as well as higher ozone concentrations on the earth's surface. Of these the aerosols perform the function of cooling and thus mitigating climate change while higher concentration of ozone near the land surface can be both harmful to the human life as also have a greenhouse effect of warming. One could thus say that one way of deriving double mitigation benefits from forest would be to have high density of forests particularly of species that emit higher quantity of BVOCs, like pines, poplars, casuarinas, eucalyptus and ficus among many more, near the industrial zones which would increase aerosol particles of light color that would work to reflect sunlight back. In populated areas, however, where the priority is to provide a good environment for the large population living there, keeping

the ozone level down has to be higher priority and there the forest planted should be rich in biodiversity and low in BVOC emission rates.

Fires cause higher emissions of BVOCs but any advantage that may accrue from aerosol formation would be far outweighed by the greenhouse gas effect of the carbon dioxide and methane emitted in the process. Pest attack also causes increased BVOC emission but here too there would be increased mortality of trees and the decay would result in increased CO_2 emission even if less dramatically, and much delayed, compared to fires.

Keeping forests young by earlier harvesting and operations like thinning, coppicing and pollarding that produces consumable forest product replacing fossil fuel based products and increases subsequent carbon sequestration while emitting BVOCs that have the opportunity to deepen aerosol thickness over the earth may perhaps provide a management tool to enhance forest based mitigation of climate change. But it would require much research before such an idea can be put into practice.

So trees do pollute, but this pollution can be turned to an advantage by getting a double climate change mitigation benefit, one by way of taking away the carbon dioxide from the atmosphere and the other by providing aerosols reflectors to reflect the sun's rays back and deeping the earth cool.

References and further readings:-

Kesselmeier, J and M. Staudt. 1999. Biogenic Volatile Organic Compounds (VOC): An Overview on Emission, Physiology and Ecology, Journal of Atmospheric Chemistry 33: 23–88, 1999.

Staudt, M. and L, Lhoutellier. 2007. Volatile organic compound emission from holm oak infested by gypsy moth larvae: evidence for distinct responses in damaged and undamaged leaves. Tree Physiology 27, 1433–1440, Heron Publishing, Victoria, Canada.

Goldstein, A.; C.H. Koven; C.L. Heald; and I.Y. Fung. 2009. Biogenic carbon and anthropogenic pollutants combine to form a cooling haze over the southeastern United States, PNAS.

H.K. Lappalainen.; S. Sevanto; J. B¨ack; T. M. Ruuskanen; P. Kolari; R. Taipale; J. Rinne; M. Kulmala; and P. Hari. 2009. 3Day-time concentrations of biogenic volatile organic compounds in a boreal forest canopy and their relation to environmental and biological factors, Atmos. Chem. Phys., 9, 5447–5459, 2009. Copernicus Publications on behalf of the European Geosciences Union.

J. Lathi`ere.; D.A. Hauglustaine; A. D. Friend; N. De Noblet-Ducoudr´e; N. Viovy; and G. A. Folberth. 2005. Impact of climate variability and land use changes on global biogenic volatile organic compound emissions. Atmos. Chem. Phys. Discuss., 5, 10613–10656, 2005. Copernicus GmbH on behalf of the European Geosciences Union.