Indian Pollution Control Association (IPCA)

NEWS LETTER

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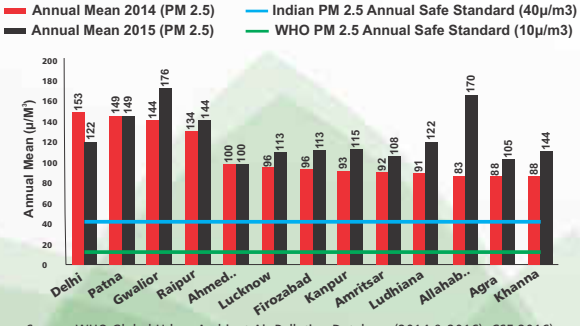
URBAN TREES FOR BETTER AIR QUALITY

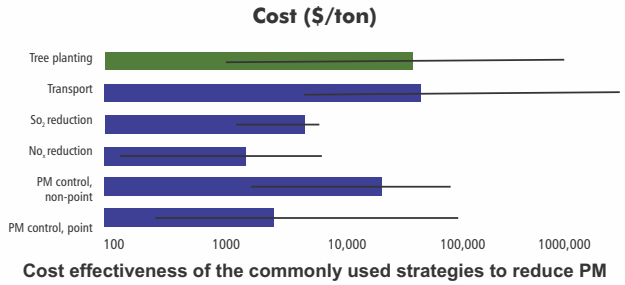
Introduction

India has witnessed an explosive growth of popultion (0.3 billion in the year 1950 to 1.3 billion in the year 2016) accompanied by uncontrolled urbanization over the last five decade placing it as fifth in the world's population. Rapid industrialization and population growth especially in the last decade has adversely affected urban climate, air quality and has caused imbalances in the urban climate at large. Air quality has degrade from moderate to critical level in major Indian cities with increase in the consumption of fossil fuel (coal and petroleum) especially in transportation sector, thermal power plants, smelters, and industries. Major air pollutant are particulate matter, SO_X NO_X, lead, CO, ozone, and bio aerosols. WHO has ranked India as world's worst country in terms of air pollution, with 13 out of 20 most polluted cities of the world are in India alone. More than 80 percent of people living in urban areas in India are exposed to air quality levels that exceed WHO limits.



Source: WHO Global Urban Ambient Air Pollution Database (2014 & 2016), CSE 2016)

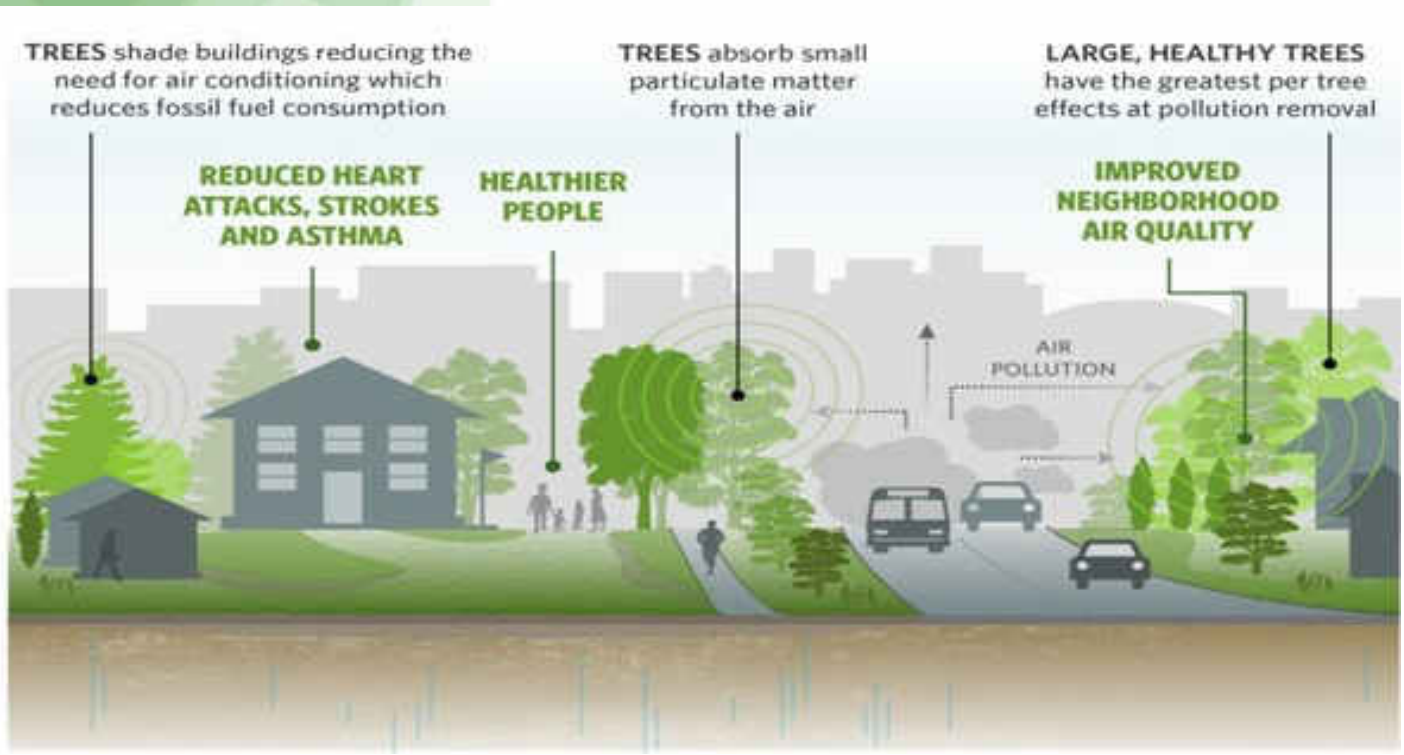
Despite mitigatory efforts undertaken by government and various other organizations to reduce air pollutant emissions and to improve air quality, urban population in India are still exposed to high levels of pollutants concentrations. A large number of strategies have been used to reduce air pollutant, if we compare the cost of implementing the strategy and the level of pollutant reduced, planting trees in urban areas i.e Urban forestry has emerged as one of the most appropriate and cost-effective strategy.



Cost effectiveness of the commonly used strategies to reduce PM

Source: The nature conservancy

Urban forestry i.e growing & management of trees in urban areas in gradually being incorporate in urban planning to combat the menace of urban pollution in India. The urban forest can help improve air quality by reducing air temperature, removing pollutants from the air, and reducing energy consumption in buildings. Trees help cleanse the air by intercepting airborne particles, reducing heat, and absorbing pollutants such as carbon monoxide, sulfur dioxide, nitrogen dioxide and particulate matter.



Urban trees removing air pollution

Trees also reduce the amount of carbon in the atmosphere by sequestering carbon in tissue every year. The amount of carbon annually sequestered is increased with healthier trees having larger diameter trees.

As per the study conducted by Nature conservancy in 2016 a massive tree-planting campaign in the world's 245 largest cities, costing around $3.2 billion have the ability to save 11,000 to 36,000 lives per year worldwide from pollution. These trees can also prevent 200 and 700 heat-wave deaths per year.

Research published from the London i-Tree Eco Urban Forest Survey, quantified the benefits of ecosystem services provided by London's urban forests (including removal of air pollution) at £6 billion, highlighting the economic as well as health and environmental benefits of planting more trees in cities.

The planting Healthy Air report found that the average reduction of particulate matter near a tree is between 7-24%, while the cooling affect is upto 2°C.

Tree planting in the urban areas should be seen as a complement rather than a replacement to other strategies to reduce pollution.

Some amazing facts about Trees vs Pollution !

Strategic placement of trees in urban areas can cool the air by 2°C to 8°C.

A tree can absorb upto 150 kg of Co_2/year.

Trees properly placed around buildings can reduce air conditioning need by 30% and save energy used for heating by 20-50%.

A single tree produces approximately 260 pounds of oxygen per year.

One tree can absorb as much carbon in a year as a car produces while driving 26,000 miles.

Urban trees can also cool temperatures from 0.5 degrees celsius to 2 degrees celsius on the hottest summer days.

Source: FAQ (http://www.fao.org/resources) http://www.savatree.com/tree-facts.html

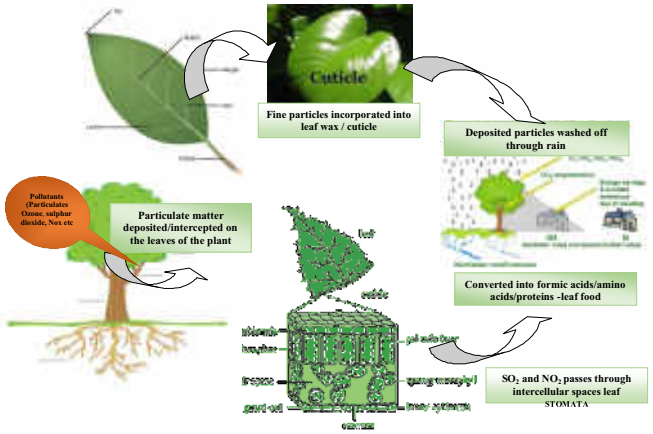
Role played by the trees in air purification

Trees play a important role in purifying the ambient air through the following ways:

1) Removal of particulate pollution by tree leaves

Trees play an important role in removal reduction of

particular matter from the atmosphere through a process known as dry deposition in which the particles in the atmosphere deposit or intercept themselves on a surface, decreasing the atmosphere concentration of particular matter (Litschke etal. 2008). Much of the fine fraction ($PM_{2.5}$) becomes permanently incorporated into leaf wax or cuticle, while a portion of the coarse fraction is re-suspended as a function of wind speed (nowak et.al, 2013: Nicolson, 1998), the remainder of the coarse fraction is eventually washed off to the ground by precipitation (pretzsch etal, 2015; Matzka, and Maher, 1999) or dropped to the ground with leaf and twig fall. During precipition, particles can be washed off and either dissolved or transferred to the soil.



Process of removal of particulate materials by the tree leaf

Factors influencing PM removal by trees

Pollutant concentration: Higher the concentration of particulate matter greater is the rate of dry deposition.

Leaf area: More leaf area offers more surface area on which dry deposition or absorption can take place.

Earlier studies have revealed that extent of dust deposition on plants also depends on the morphology structure and arrangement of leaves (Pattanayak et al. 1994). It is known that vegetation can filter out dust, shoot, smoke and many other fine particulate matters present in air by process of absorption, detoxification, accumulation or metabolisation (Maiti, 1992). Dust particulates remain in air for varying lengths of time and get settled out on various parts of plant, especially on leaf surface, which affects the vegetation of the area.

2) Removal of gaseous pollutant by trees

In contrast to persistent pollutants which are mainly deposited on tree leaves by interception, impaction or sedimentation of airborne particles, the gaseous pollutants such as NO_2 and SO_2 are primarily absorbed through leaf stomata (Tallis et.al, 2011). Stomata are microscopic pores on the underside of the leaf which allows air into and out of the leaf through which the plant takes in CO_2 and lets out O_2, and allows water vapor out in the process of transpiration. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces. Nitrogen dioxide in leaves dissolves in the extracellular water of the sub-stomatal cavity and forms both nitrite (NO_2^-) and nitrate (NO_3^-). Through a series of enzymatic reactions, NO_2^- and NO_3^- are metabolized to amino acids and proteins (Amundson & Mclean 1982).

3) Removal of Benzene by trees

Studies have also shown that transgenic species of poplar (Populus tremula × Populus alba) have the ability to remove VoC like Benzene from the atmosphere (Doty et. al, 2007).

4) Removal of Carbon monoxide by trees

Trees play an important role in removing ambient CO concentrations which are higher in urban areas because a majority of CO emissions come from transport. These pollutants are taken in primarily through the leaf stomata (pores) which diffuse into intercellular spaces, get absorbed by water films to form acids or react with inner-leaf surfaces (Smith, 1990).

5) Removal of Ammonia by trees

Trees can play a key role as additional means to help mitigate the effects of atmospheric ammonia (Theobald et al., 2001). The leaves of the plant absorb significant quantities of NH_3 from the air. Species like Populus deltoides, Salix purpurea etc play an important role in controlling ammonia pollution from the atmosphere.

6) Trees role in temperature reduction

Trees play an important role in reducing and regulating the temperature. Trees and other vegetation have the capacity to mitigate extreme air temperatures either by cooling the air by evaporating water through their leaves or by moderating the temperature of the ground surface by shading it from direct sunlight. Both of these processes have the greatest impact on sunny summer afternoons. Trees that are tall enough to create a large shaded area under their canopy are more useful than short vegetation. Tree's canopy acts like a parasol, blocking out up to 90 percent of the sun's radiation. The cooling intensity of the trees larger the canopy the greater the cooling intensity.

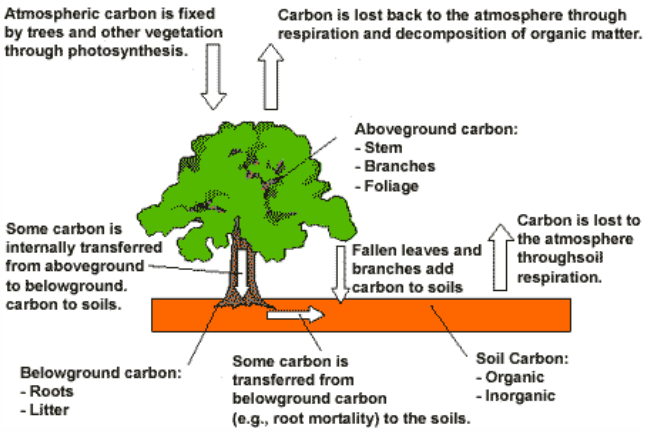
Statistics of Pollution Absorption by the Trees

In 1994, trees in New York City removed an estimated 1,821 metric tons of air pollution at an estimated value to society of $9.5 million. The standardized pollution removal rates differ among cities according to the amount of air pollution, length of in-leaf season, precipitation, and other meteorological variables. Large healthy trees greater than 77 cm in diameter remove approximately 70 times more air pollution annually (1.4 kg/yr) than small healthy trees less than 8 cm in diameter (0.02 kg/yr). Air quality improvement in New York City due to pollution removal by trees during daytime of the in-leaf season averaged 0.47% for particulate matter, 0.45% for ozone, 0.43% for sulfur dioxide, 0.30% for nitrogen dioxide, and 0.002% for carbon monoxide. Air quality improves with increased percent tree cover and decreased mixing-layer heights. In urban areas with 100% tree cover (i.e., contiguous forest stands), short-term improvements in air quality (one hour) from pollution removal by trees were as high as 15% for ozone, 14% for sulfur dioxide, 13% for particulate matter, 8% for nitrogen dioxide, and 0.05% for carbon monoxide.

Trees transpire water through their leaves, increasing the surface area contributing to evaporation. When a molecule of water evaporates, it takes with it some heat that could otherwise be used to warm the nearby environment. Trees provide an evaporative cooling effect that can decrease local air temperatures by several degrees Fahrenheit. This effect typically reaches its peak when evaporation levels are highest, usually in afternoons. Both the transpirative cooling and the shading effect of trees individually can substantially lower maximum summer daytime air temperatures in streets at pedestrian level.

7) Trees sequestering carbon

It is estimated that the total carbon stored by trees in urban areas is 23.89 million tonnes from an estimated 7.79 million ha urban area (Saibal, 2008). The mechanism for carbon sequestration in trees and plants is photosynthesis, the conversion of atmospheric carbon dioxide into plant material using energy from the sun, releasing oxygen in the process.



Source: https://teeic.indianaffairs.gov/er/carbon/apptech/terrapp/index.htm

Air improving qualities of plants

A single hectare of mature trees absorbs approximately 6.4 tonnes of CO_2 per year. Trees play a specific and important role in the global carbon cycle by absorbing carbon dioxide during photosynthesis, storing carbon above and below ground, and producing oxygen as a by-product of photosynthesis.

Species helping in combating pollution

Research has shown that trees can act as biological filters, removing large quantities of particles from the urban atmosphere. This is predominately due to their large leaf areas relative to the ground on which they stand, and the physiological properties of their surfaces i.e. the presence of trichomes or waxy cuticles on the leaves of some species. Plants species chosen for pollution control in the urban areas should

be evergreen, large leaved, having rough bark, indigenous, ecologically compatible, having low water requirement, requiring minimum care, high absorption of pollutants, resistant to pollutants, agro-climatically suitable, having height spread, canopy architecture, growth rate and habit (straight undivided trunk), aesthetic effect (foliage, conspicuous and attractive flower colour), pollution tolerant and dust scavenging capacity.

Free hanging leaves of Dalbergia sisso

Dust deposition on plant depends on the morphological structure and arrangement of leaves (Pattanayak et al. 1994). Studies have revealed that smooth and flexible leaves like Indian cork tree/Tree Jasmine (Millingtonia hortensis) and Neem (Azadiracta indica) do not hold dust to the same degree compared to horizontally arranged leaves of Grevillea robusta, Flame Tree (Delonix regia), Kaju (Anacardium occidentale), Tamarind (Tamarindus indica) species bearing stiff, horizontal and elevated leaves with rough and hairy surface which hold large amount of dust particles (Nayek et.al, 2006) should be preferred.

Elevated leaves of Delonix regia

Free hanging leaves as well as swirling leaves are the main morphological characteristics of dust escaping efficiency as in Dalbergia sisso, Eucalyptus globulus, Acacia auriculiformis etc.

Leaves of Tamarind

Trees such as Tamarind (Tamarindus indicus) having smaller compound leaves are generally more efficient particle collectors than larger leaves. Particle deposition is heaviest at the leaf tip and along leaf margin. Ashoka (Saraca asoca), Pongamia (Pongamia pinnata) and Umbrella/ Portia tree (Thespepsia populnea) are most favourable to capture higher amounts of dust as compared to other neighbouring plants.

Alternate phllotaxy of the leaves

The phyllotaxy of leaf also plays important role in this regard. It has been found that alternately arranged leaves have acquired highest dust collecting capacity; this is because in alternate phyllotaxy there is only one leaf in each node.

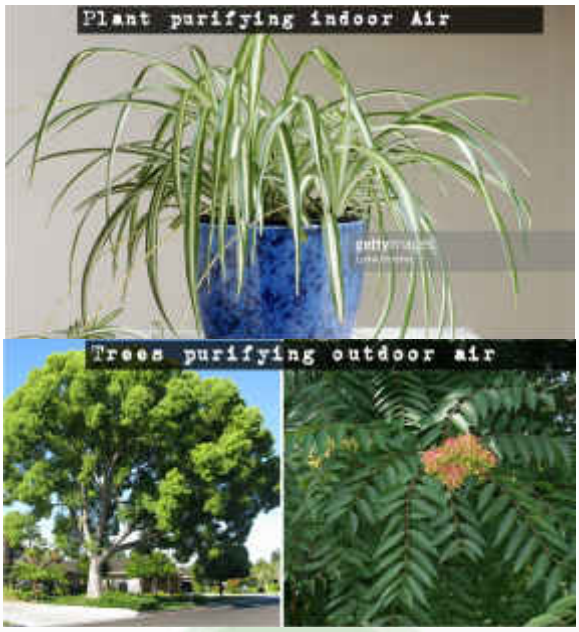
Similarly the shape of the leaf is also important.

Lanceolate type of the leaf shows highest dust collecting capacity e.g Arjuna (Terminalia arjuna). The lowest dust collecting capacity of Manilla tamarind/ Jangal Jalebi (Pithacolobium dulse) species can be attributable to its arrangement of leaves. In whorled phyllotaxy there are more than two leaves present at each node. Therefore each leaf at each node receives lesser amount of pollutants than one leaf at each internode (Kumar et.al,2012).

A list of trees and plants preferred for controlling outdoor and indoor air pollution is tabulated below:

	Trees for controlling Outdoor Air Pollution	Pollutant	Plants/trees for controlling Indoor Air Pollution	Pollutant
1.	Morus alba (Mulberry tree)	SO_2	Phoenix roebelenii (Dwarf date palm)	Formaldehyde, Xylene, Toluene
2.	Cinnamomium camphora (Kapoor)	SO_2	Dypsis lutescens (Areca palm)	Formaldehyde, Xylene, Toluene
3.	Ailianthus excelsa (Indian tree of heaven)	PM	Hedera helix (English ivy)	Formaldehyde, Benzene, Xylene, Toluene
4.	Juglans regia (Persian walnut)	PM	Liriope spicata (Lilyturf)	Formaldehyde, Ammonia, Xylene, Toluene
5.	Populus deltoides (Eastern cotton wood)	SO_2, NO_2, NH_3	Chlorophytum comosum (Spider plant)	Formaldehyde, Xylene, Toluene
6.	Abies alba (Silver fir)	PM	Philodendron domesticum (Elephant ear philodendron)	Formaldehyde and CO
7.	Fraxinus chinensis (Chinese ash)	SO_2, NO_2	Spathiphyllum (Peace lily)	Benzene
8.	Plumeria rubra (Temple tree)	SO_2	Chamaedorea seifrizii (Bamboo Palm)	Benzene
9.	Magnolia grandiflora (Bull bay)	SO_2	Ficus benjamina (Weeping Fig)	Formaldehyde, Xylene, Toluene
10.	Celtis sinensi (Chinese hackberry)	SO_2	Epipremnum aurem (Devils Ivy)	Benzene, formaldehyde
11.	Livistona Chinensis (Fountain palm)	SO_2	Anthurium andraeanum (Flamingo Lily)	Formaldehyde, Xylene, Toluene, Ammonia
12.	Fagaus grandiflora (American beech)	So_2, NO_2	Rhapis excelsa (Broad Leaf)	Formaldehyde, Xylene, Toluene, Ammonia
13.	Liriodendron tulipifera (Lily tree)	CO	Gerberia Jamesonii (Barberlon Daisy)	Benzene, formaldehyde
14.	Dalbergia Species	Dust Capture	Draceana fragrans (Comstalk Dracaena)	Benzene, formal dehyde
15.	Gulmohar (Delonix regia)	Dust Capture	Sansevieria trifasciata (Varigated Snake Plant)	Benzene, formal dehyde

Source: Nowak, 2000 and NASA, 1989



Initiatives taken by Governement of India

As per international minimum standard suggested by World Health Organization (WHO) and United

Nations Food and Agriculture Organization (FAO) minimum availability of green open space per city dweller is 9 m^2 (Kuchelmeister 1998). But the scenario is very different in India as per the State Forest Report 2013 Urban tree cover exists on 12,790 sq km of urban areas which is around 16% of the urban area covered by the trees which is below the global standards of 20-40% forest coverage.

In India rapid rise in population, urbanization and land scarcity has resulted in dwindling of the urban green spaces and trees are being sacrificed for the development of infrastructures like road widening, parking space, flyover construction, hospitals, public transport etc. Due to ignorance and attitudinal indifference the willingness to compensate for the loss of the urban green space is lagging behind in the cities. Besides, there is absence of long term urban planning. Land covered with trees are still considered to be less profitable in comparison to land put for commercial use. Urban forest coved has not yet been inventoried properly in any of the cities in India.

In order to promote the concept of growing trees in urban areas the environment ministry launched an urban forestry scheme "Urban Forest Garden" project at Warje near Pune as a part of the urban afforestation programme to increase tree cover around 200 cities, which aimed at creating forest parks at available land in urban areas with people's participation. This scheme will act against climate change by creating a carbon sink and against air pollution in cities. The scheme will include a "Smriti Van" service where any resident can plant a sapling in memory of his or her loved one by paying Rs 2000 to the state forest department.

The ministry is also considering starting tree surveys in cities which can be conducted by residents and college or school students. A plan is being worked to create small nurseries of about 1000 to 2000 plants in government schools where there is some extra space. Most of the urban forestry projects would be availed form the Compensatory Afforestation Fund Management and Planning Authority and (CAMPA) and Green India Mission (GIM).

Role of IPCA

In view of the increasing level of atmospheric pollution in the urban areas there is an urgent need for creating awareness amongst the people about the concept and importance of urban forestry since urban forests are fundamentally a human dominated ecosystem where the role played by human beings in the urban forestry environment is critical.

The educational level and environmental awareness of urban residents play a crucial role in determining species composition, management and overall demand for urban forests. Urban greenery development relies not only on investment and technology, but largely on the attitude and involvement of urban residents. The need of the hour in India is to educate people and policy makers about the utility of urban green spaces, because public knowledge of the connection between human well being and ecosystem services is limited. There is an urgent need for integrating urban forestry into overall planning of the urban areas in advance otherwise greening of the urbanized area becomes more difficult once the settlement takes place. Inorder to combat the menace of air pollution in the urban areas an integrated approach needs to be adopted in which besides other methods like promoting the use of cleaner fuel, low–cost environmental friendly technologies etc urban forestry needs should be made an integral part of urban planning in all the cities. In this respect Indian Pollution control Association which is working intensively around Delhi NCR region on ambient and indoor air pollution monitoring, control and solutions can play an important role in promoting, advocating and adopting the concept of urban forestry in urban planning and landscaping amongst different stakeholders involved. IPCA proposes to network and collaborate with Ministry of Urban Development (MOUD), Ministry of Environment, Forest and Climate Change (MoEFCC) and other organizations for undertaking urban forestry related projects. around the Delhi NCR region.

Editorial Committee

4, DDA Shopping Complex, Hargobind Enclave, Vikas Marg Extn., Delhi-110092
Tel.: 011 - 42207478
e-mail: Info@ipcaworld.co.in | web: Http://www.ipcaworld.co.in