

Review Article

<https://doi.org/10.20546/ijcmas.2017.604.113>

Use of Tree Species in Controlling Environmental Pollution-A Review

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ABSTRACT

Air pollution is a heterogeneous, complex mixture of gases, liquids, and particulate matter. Air pollution has become increasingly visible in cities and towns across world. Many factors contribute to air pollution including industry, lack of vehicular emission controls, dirt roads, poor fuel quality, open burning agricultural dust and pesticides and an expanding maquiladora industry. Our plan will lead to reductions in air pollutant emissions that cause smog and acid rain by up to 55% as early as 2018. To get there, our plan will set national caps for industrial emissions of four air pollutants commonly associated with smog and acid rain, namely nitrogen oxides, sulphur oxides, volatile organic compounds, and particulate matter. Caps will also be set for other air pollutants such as mercury from electricity produced by combustion, and benzene emissions from the natural gas, and iron and steel sectors. Plants plays significant role in mitigation the air pollution and maintains ecological balance. Plants acts as the scavengers for air pollution as they are the initial acceptors. Various pollutants can be absorbed accumulated by the plants results in reducing the pollutant levels in the environment. The identification of the tolerant plant species suggests suitable plant species to green-belt development and social-forestry programs.

Keywords

Environmental
Pollution,
Air pollution.

Article Info

Accepted:
06 March 2017
Available Online:
10 April 2017

Introduction

Air is important for life on the earth. Rapid increasing of population and development leads to the deterioration of quality of air. From one year to next year, the concentration of pollutions are increasing even there is some differences in between the nations. Every year, more than 308 crore tons of CO₂ and other pollutants are releasing into the earth's atmosphere. Plants are very important to maintain ecological balance but they can severely get effect directly or indirectly by air pollution (Steubing *et al.*, 1989; Agbaire, 2009). Plants acts as the scavengers for air pollution as they are the initial acceptors (Joshi and Swami, 2009). Various pollutants

can be absorbed accumulated by the plants results in reducing the pollutant levels in the environment (Liu and Ding, 2008). Now a day, urban vegetation became very important because it affects the local and regional air quality (Jissy Jyothi and Jaya, 2010). The impact of air pollution on plants can be evaluated by manipulating the tolerance levels of plant species.

Many factors contribute to air contamination on the border including industry, lack of vehicular emission controls, dirt roads, poor fuel quality, open burning (Crespin, 1994), agricultural dust and pesticides, and an

expanding maquiladora industry (English, 1998). Especially vulnerable to these environmental problems is the large low-income population that lives along the border. Like many low-income minority groups, low income border residents are more likely to be exposed to outdoor air pollutants and live in substandard housing with inadequate air circulation and filtration (Alexander *et al.*, 2000).

Air Pollution

The ambient air quality at various locations, a monitoring network has been established comprising of 295 stations covering 98 cities/towns in 29 States and three Union Territories under the Air (Prevention and Control of Pollution) Act, 1981, as amended in 1988. Under this programme, four criteria air pollutants viz. Sulphur dioxide (SO₂), oxides of nitrogen (NO_x), Suspended Particulate Matter (SPM) and Desirable Suspended Particulate Matter (RSPM) are regularly monitored at all the locations. Besides this, additional parameters such as desirable lead and other toxic trace matters and polycyclic aromatic hydrocarbons are also being monitored in 10 metro cities of the country. The ambient air quality is monitored by Central Pollution Control Board (CPCB) in coordination with the State Pollution Control Boards, Pollution Control Committees and some of the universities and research institutes.

Effect of Vegetation on Air Quality

Removal of dust particles by vegetation through interception from the atmosphere enhances air quality in urban areas (Beckett *et al.*, 1998, 2000; Freer-Smith *et al.*, 2005), near roadways (Smith, 1971; Freer-Smith *et al.*, 1997). Properties of both particles and the vegetation are important in deciding their interactions, and consequently the

effectiveness of particle removal from atmosphere. Leaves, susceptible and highly exposed parts of a plant, may act as persistent absorbers in a polluted environment (Maiti, 1993). Small vegetation elements are more effective in removing small particles from an air stream than are large elements. They act as pollution receptors and decrease dust concentration of the air. The capability of leaves as dust receptors depends upon their surface geometry, phyllotaxy, epidermal and cuticular features, leaf pubescence, and height and canopy of trees (Fowler *et al.*, 1989; Nowak, 1994; Beckett *et al.*, 2000; Raupach *et al.*, 2001). Prajapati and Tripathi (2008a-d) have shown that pollution tolerant tree species can be used for green belt development.

Effects of Particulate Matter on Vegetation

Exposure to a given mass concentration of airborne PM may lead to widely differing phototoxic responses, depending on the particular mixture of deposited particles. Particulate deposition and effects on vegetation unavoidably include (1) Nitrate and sulfate and their associations in the form of acidic and acidifying deposition and (2) Trace elements and heavy metals, including lead.

While size is related to mode and magnitude of deposition, and may be a useful substitute for chemical composition (Whitby, 1978). Mineral dusts in general are less soluble and less reactive than the anthropogenic acid-forming sulfate and nitrate particles (Fowler *et al.*, 1989; Grantz *et al.*, 2003). Dusts with pH values of ≥ 9 , may cause direct injury to leaf tissues on which they are deposited (Vardak *et al.*, 1995) or indirectly through alteration of soil pH (Hope *et al.*, 1991; Auerbach *et al.*, 1997) and dusts that carry toxic soluble salts will also have adverse effects on plants (Prajapati and Tripathi, 2008a-d).

Selection of planting material

Selecting trees for urban planting in order to have the highest establishment rate and growth performance and to lowest maintenance costs (From Harris *et al.*, 2004). Aesthetics certainly have high relevance in plant selection, but the value of a plant should go far beyond aesthetic appeal. Function guides the selection of a species and we all know that the choice of high quality planting material is the first link to establish a sustainable urban landscape and its importance is obvious. Planting projects can fail because of poor quality plants and when the wrong species or variety is planted.

The first step is to analyze the sensitivity of the different species to the urban conditions and to global change (Ferrini *et al.*, 2008). The assessment should identify whether these factors could cause significant negative impacts on tree growth and physiology. If a species appears to be insensitive to climate change and to the typical urban stress, city planners and arborists should move on the next step—that is site assessment and modification (if needed) and planting. If a species appears to be sensitive to climate change, there will be a need to select potential alternative species. As reported by Schutzki and Tripp (2008), function, aesthetics, site adaptability and management form the foundation of Right Plant/Right Place/Right management adage and have been used for years to identify appropriate plants for a given landscape.

Recurrent human health disturbances related with seasonal shedding of pollen are common results of improper selection of tree species for urban planting. As underlined by Sogni (2000), pollen responsible for the principal allergic reactions comes mostly from anemophilous species which, in general, produce large quantities of pollen and depend

on poorly selective diffusion agents such as wind. Typically, grains of such pollen are very light and small with a smooth, dry surface. Their diameters usually range from 20-30 μm with maximums of 150 μm in some *Coniferous* species. In contrast, *Entomophilous* species produce pollen which is frequently bigger and heavier. As poorly dispersed through the air, it is rarely present in the atmosphere at concentrations sufficient to trigger an allergic reaction. However, there are exceptions such as *Tilia*, an *Entomophilous* genus that can also cause an allergic response. In cases where air-borne spread of pollen is limited, violent allergic reactions are recorded mainly after direct contacts with the pollen producing plant.

Tree stability assessment

This subject was already reviewed by Ferrini *et al.*, (2008) who underlined its importance when selecting trees in a global change scenario. The need to rethink tree stability assessment to meet changing objectives lies at the heart of the research into sustainable urban forest management. We know that trees in the urban environment often have to face very harsh conditions. They can easily acquire mechanical defects, which may cause hazard in areas where people and property are present. According to the existing definition: “hazard is a disposition of a thing, condition, or situation to produce injury” (Health and Safety Executive, 1995), in a more specific way a tree is considered to be hazardous, if it is structurally unsound and there is a possible target, like vehicles or people. An unsound tree in an area with no target is not hazardous (Dujesiefken *et al.*, 2005). Although all trees have a potential to fail and become hazardous in particular conditions, senescent trees are most prone to acquire these characteristics. In such trees all functions, including photosynthesis, production of roots, stem growth and branching, resistance to

pathogens, and others are gradually reduced or disorganized.

Tree selection and maintenance in the urban environment

Tree planting in the urban environment is particularly effective because: 1) They have a direct effect of CO₂ by fixing it through photosynthesis; 2) Through shading and wind-screening they can effectively reduce the need of fossil fuels for house-warming and summer cooling. The net save in carbon emissions that can be achieved by urban planting can be up to 18 kg CO₂/year per tree (Rosenfeld *et al.*, 1998), and this benefit corresponds to that provided by 3 to 5 forest trees of similar size and health (Akbari, 2002).

Most of the existing models for estimating CO₂ sequestration by trees are generally based on above-ground biomass production as stem diameter, plant height, crown size and age (Nowak, 1994; Nowak e Crane, 2002; Banks *et al.*, 1999; Brack *et al.*, 1999; Brack, 2002). Errors of such estimates can be substantial: Nowak (2002) calculated an average yearly CO₂ uptake of 30 kg by a healthy 23-30 cm caliper tree. The uptake rate of a similar tree was quantified in 4-10 kg/year by Akbari (2002). Moreover many models don't take account of carbon store in roots, which may be up to 23% of total carbon storage, depending also on the growing condition (i.e. a tree grown in full sun or in water-limiting conditions will allocate more carbon to below-ground parts than an identical tree grown in optimal conditions).

Ambient air quality

Under the National Ambient Air Quality Monitoring (NAAQM) network, three criteria air pollutants, namely, SPM, SO₂, and NO₂ have been identified for regular monitoring at

all the 290 stations spread across the country. CPCB (2000c) analyses the status and trends of air quality at various cities in India for the period 1990-98. Annual averages of SPM, SO₂, and NO₂ in 16 cities in the country between 1990 and 1998, the most prevalent form of air pollution appears to be SPM although there are many stations at which SO₂ and NO₂ levels exceed permissible limits.

SPM

Suspended particulate matter is one of the most critical air pollutants in most of the urban areas in the country and permissible standards are frequently violated several monitored locations. Its levels have been consistently high in various cities over the past several years. The annual average minimum and maximum SPM concentration in residential areas of various cities ranged from 60 µg/m³ (at Bangalore during 1991) to 521 µg/m³ (at Patna during 1995), while in industrial areas the annual average ranged between 53 µg/m³ (Chennai during, 1992) and 640 µg/m³ (Calcutta during, 1993). The mean of average values of SPM for nine years (1990 to 1998) ranged between 99 µg/m³ and 390 µg/m³ in residential areas and between 123 µg/m³ and 457 µg/m³ in industrial areas indicating that the annual average limit of suspended particulate matter for residential areas (140 µg/m³) and for industrial areas (360 µg/m³) had been frequently violated in most cities. The maximum suspended particulate matter (SPM) values were observed in Kanpur, Calcutta, and Delhi, while low values have been recorded in the south Indian cities of Chennai, Bangalore, and Hyderabad.

Status of other air pollutants

The salient results of additional parameters at some stations in the metropolitan cities of Delhi, Calcutta, Mumbai, and Chennai for the

years 1996-97 are as follows (CPCB 1998): The annual mean concentration of desirable particulate matter (RPM) is much higher than the prescribed limits of $120 \mu\text{g}/\text{m}^3$ (industrial) and $60 \mu\text{g}/\text{m}^3$ (residential and other uses) in Delhi and Calcutta. However, RPM in Mumbai and Chennai is not very high but is greater than prescribed ambient air quality standards though particulate lead in the ambient air of Calcutta and Delhi is higher as compared to the other two cities (Chennai and Mumbai), it is well within the prescribed limits for the different area classes. The concentration of polycyclic aromatic hydrocarbons (PAHs) is showing an upward trend. However, at present permissible limits for PAHs have not been notified, it may be noted that lead free gasoline has been introduced throughout the country w.e.f. February 1, 2000, and in all metropolitan cities since 1995. This has resulted in a downward trend in the lead concentrations in the ambient air (CPCB 2000c).

Air quality at traffic intersections

Air quality monitoring conducted at different traffic intersections in Delhi (MoEF, 2000a) revealed the following:

Respirable particulate matter was excessively high at all the monitoring locations.

Sulphur dioxide was recorded within limits at all the locations.

Nitrogen dioxide was recorded well within the limits except a few locations.

Air pollution and health impacts

In India, millions of people breathe air with high concentrations of dreaded pollutants. The air is highly polluted in terms of suspended particulate matter in most cities. This has led to a greater incidence of

associated health effects on the population manifested in the form of sub-clinical effects, impaired pulmonary functions, and use of medication, reduced physical performance, frequent medical consultations and hospital admissions with complicated morbidity and even death in the exposed population. As per a World Bank (1993) study, respiratory infections contribute to 10.9% of the total burden of diseases, which may be both due to presence of communicable diseases as well as high air pollution levels, while cerebral vascular disease (2.1%) ischemic heart disease (2.8%) and pulmonary obstructions (0.6%) are much lower. The prevalence of cancer is about 4.1% amongst all the diseases indicating that the effects of air pollution are visualized on the urban population (CPCB, 2000c). A WHO /UNEP study compared standardized prevalence of respiratory diseases in different areas of Mumbai, classified according to ambient average concentrations of sulphur dioxide. The study revealed a relatively higher prevalence of most respiratory diseases in polluted urban areas than in the rural control area (WHO/UNEP, 1992, cited in Repetto, 1994). In India, in a study of 2031 children and adults in five mega cities, of the 1852 children tested, 51.4% had blood lead levels above $10\mu\text{g}/\text{dl}$. The percentage of children having $10\mu\text{g}/\text{dl}$ or higher blood lead levels ranged from 39.9% in Bangalore to 61.8% in Mumbai.

In conclusion, tree impacts on important atmospheric trace chemicals such as carbon dioxide and U.S. Environmental Protection Agency criteria air pollutants (ozone, particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead) will have greater significant impacts on human health and environmental quality. The exposure to dust pollution stress provoked important reductions in photosynthesis in most studied plants except *Polyalthia*

longifolia. Moreover, accumulation of dust particulates on studied plant leaves could be a major problem in their production. Plants plays significant role in mitigation the air pollution and maintains ecological balance. The determination of Air Pollution Tolerance Index (APTI) to the plant species in urban area is important to implement pollution control methods. The identification of the tolerant plant species suggests suitable plant species to green-belt development and social-forestry programs.

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How to cite this article:

Nithya, R., S.Poonguzhali and Kanagarasu, S. 2017. Use of Tree Species in Controlling Environmental Pollution-A Review. *Int.J.Curr.Microbiol.App.Sci*. 6(4): 893-899. doi: <https://doi.org/10.20546/ijcmas.2017.604.113>