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Research article

Response of dust accumulation on roadside plant species due to open cast mining at Jhansi-Allahabad NH-76, Uttar Pradesh, India

Priyanka Singh and Amit Pal*

Institute of Environment & Development Studies, Bundelkhand University, Jhansi-284128, India

*****Corresponding Author: apu13@rediffmail.com [Accepted: 12 December 2017]

Abstract: Deposition of dust on roadside plant and its impact on leaf *i.e.* leaf pigment concentration, the carotenoid and protein has been investigated on fifteen selected roadside plants species namely *Ailanthus excelsa, Azadirachta indica, Butea monosperma, Calotropis procera, Cassia fistula, Datura metel, Ficus benghalensis, Ficus hispida, Ficus infectoria, Ficus religiosa, Holoptelea integrifolia, Millettia pinnata, Nerium oleander, Phoenix dactylifera* and *Psidium guajava* respectively at Jhansi-Allahabad National Highway-76. The variation in terms of dust deposition with species specific result observed during the entire study. Declination of leaf pigment concentration, carotenoid content and protein content indicate the positive impact of dust pollution. Above findings may be helpful to find out some species which is resistant or to cope with open cast mining generated dust pollution in and around mining areas as well as beautification of adjacent highways. The maximum deposition was found in *Ficus hispida* followed by *Calotropis procera, Butea monosperma, Ficus benghalensis, Ailanthus excelsa, Azadirachta indica*.

Keywords: Dust pollution - Chlorophyll - Carotenoid - Protein - *Ficus* spp.

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INTRODUCTION

Dust is an important abiotic factor and has a key influence on the various plant species. The severe pressure of dust may be responsible for the biochemical and morphological changes in the plant species which further initiated adaptive evolution to merge with the changing environment. Based on the source of generation as well as the structure of road, the role of dust may be variable (Farmer 1993, Anthony 2001). Vehicles are the prime source of dust generation for roadside plants. Vehicular exhaust adds up huge amounts of soot particles, smoke, poisonous gases (SO_2, NO_2, CO_2, VOCs etc.), heavy metals and organic molecules on the roads all over the world. All these air pollutants are known to produce adverse effects on the health of plants, animals and humans (Kulshreshtha *et al.* 2009, Rezaei *et al*. 2010, Atkinson *et al*. 2012). Due to dryness of soil in the arid ecosystem, the windblown dust is a common feature and plays a great role in increasing dust pollution in the environment (Younis *et al*. 2013). Similarly, high-speed vehicles and agricultural activities also generate too much high dust pollution in the air (Manins *et al*. 2001, Van Jaarsveld 2008). The response of the plant to dust accumulation may vary according to different species, as dust deposition fluctuates with plant species due to leaf orientation, leaf surface geometry, phyllotaxy, epidermal and cuticular features, leaf pubescence, height and canopy of roadside plants (Davison & Blakemore 1976, Chaphekar *et al*. 1980, Farmer 1993, Rai *et al.* 2010, Chaturvedi *et al*. 2013). This accumulation mainly depends on vegetation type. Previous research has shown that at high concentrations, many of the pollutants present in the exhaust gases can be damaging to plants (Wellburn 1990, Ackerly & Bazzaz 1995, Pal *et al*. 2002, Grantz *et al*. 2003).

Basically, the outer surface of the plants like leaves plays a role in absorbance of these dust particles (Samal & Santra 2002). Thus in these areas, the quality of air can be improved by planting more trees near road and farm sides (Beckett *et al*. 2000, Raupach *et al*. 2001, Freer-Smith *et al*. 2005). Plants act as a sink in the

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environment, so they are useful in reducing dust concentration and other particulate matters of air. Plants can act as great candidates for reduction of air pollution at a particular place by absorption, deposition, accumulation and detoxification of harmful pollutants (Prajapati & Tripathi 2008). Dust pollution causes a negative impact on plants as it reduced photosynthesis and cause leaf fall with tissue death (Farooq *et al*. 2000, Shrivastava & Joshi 2002). Dust affects the synthesis of chlorophyll and resulted in leaf chlorosis (Seyyednejad *et al*. 2011). Similarly, morphology and anatomy of leaves are also altered by dust (Gostin 2009, Sukumaran 2012). At the same time, many plants are able to survive in high dust load due to the synthesis of carotenoids and proteins which give non-enzymatic resistance to plants to numerous abiotic stresses (Prajapati & Tripathi 2008). The present study emphasized the impact of dust deposition in terms of chlorophyll contents, carotenoids content and protein content upon the roadside plant and their adaptive responses to cope with the vehicular dust deposition. Fifteen different plant species have been selected to study the impact of vehicular as well as opencast mining generated dust deposition on roadside plants.

MATERIALS AND METHODS

Based on the frequency of occurrence on the roadside of NH-76 adjacent to opencast granite mining areas of Bhagawantpura of Jhansi district of Uttar Pradesh, India (Fig. 1), matured fifteen plant species have been selected to study the accumulation of dust and its impacts on the selected plant species growing along with the roadside. Leaves were collected randomly of from plants with equal height from each roadside of NH-76 and as well as from the Bundelkhand University campus (as control). Three replicates of the leaves of each species have been analyzed. After removing leaves from branches they were packed in pre-weight polythene and brought to the laboratory. Here the dust on the leaves was carefully cleaned by using the fine brush in polythene and again taken the weight. The dust accumulation was calculated by using following formula (Prajapati and Tripathi 2008),

$$W = (w_2 - w_1)/a$$

Where, w is dust content (g/m), w_1 is initial weight, w_2 is final weight with dust and 'a' total area of the leaf (m^2).

Fresh weights of leaves were taken then oven dried at 70ºC for 72 hrs for dry weight measurements. The leaf area (cm^2) was recorded with a leaf area meter (CI-203, CID inc. USA). Leaf pigments *i.e.* chlorophyll, carotenoid and protein concentration was counted with the method described by (Arnon 1949) and the pigment concentration was expressed in the $mg.g^{-1}$ tissue. Selected plant species are: *Ailanthus excelsa* Roxb., *Azadirachta indica* A.Juss., *Butea monosperma* (Lam.) Taub., *Calotropis procera* (Ait.) Dryand., *Cassia fistula* L., *Datura metel* L., *Ficus benghalensis* L., *Ficus infectoria* Roxb., *Ficus hispida* L.f., *Ficus religiosa* L., *Holoptelea integrifolia* Planch., *Millettia pinnata* (L.) Panigrahi, *Nerium oleander* L., *Phoenix dactylifera* L. and *Psidium guajava* L.

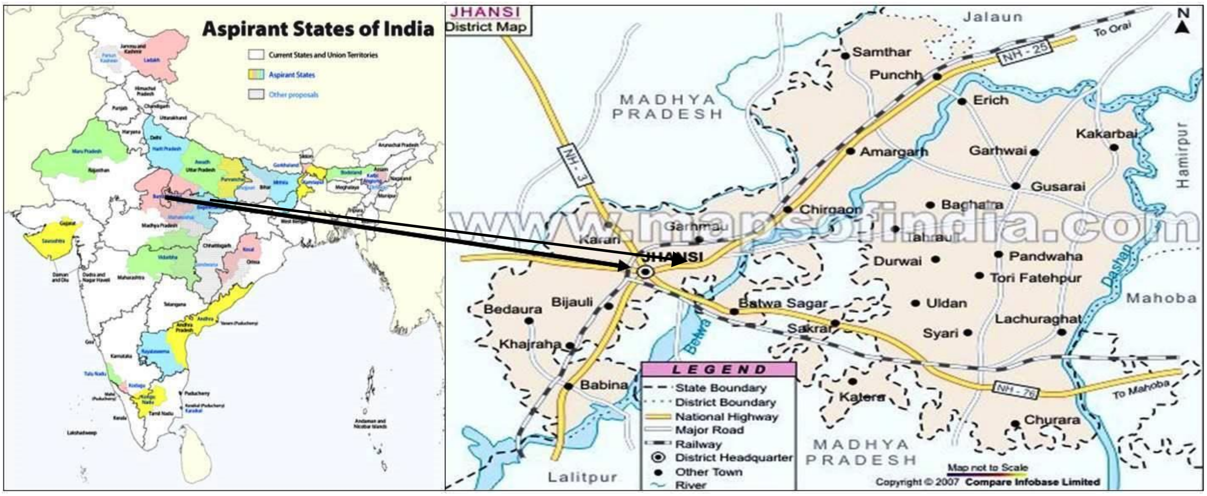

Figure 1. Map showing the location of study area.

RESULTS

In present study, the maximum dust deposition has been observed in leaf of *Ficus hispida* (18.44 $mg.cm^{-2}$) followed by *Calotropis procera* (16.46 $mg.cm^{-2}$), *Butea monosperma* (10.25 $mg.cm^{-2}$), *Ficus benghalensis* (9.11

mg.cm^{-2}), *Ficus infectoria* (5.30 mg.cm^{-2}) respectively (Fig. 2). Lowest dust deposition has been found in *Nerium oleander i.e.* 0.34 mg.cm^{-2}.

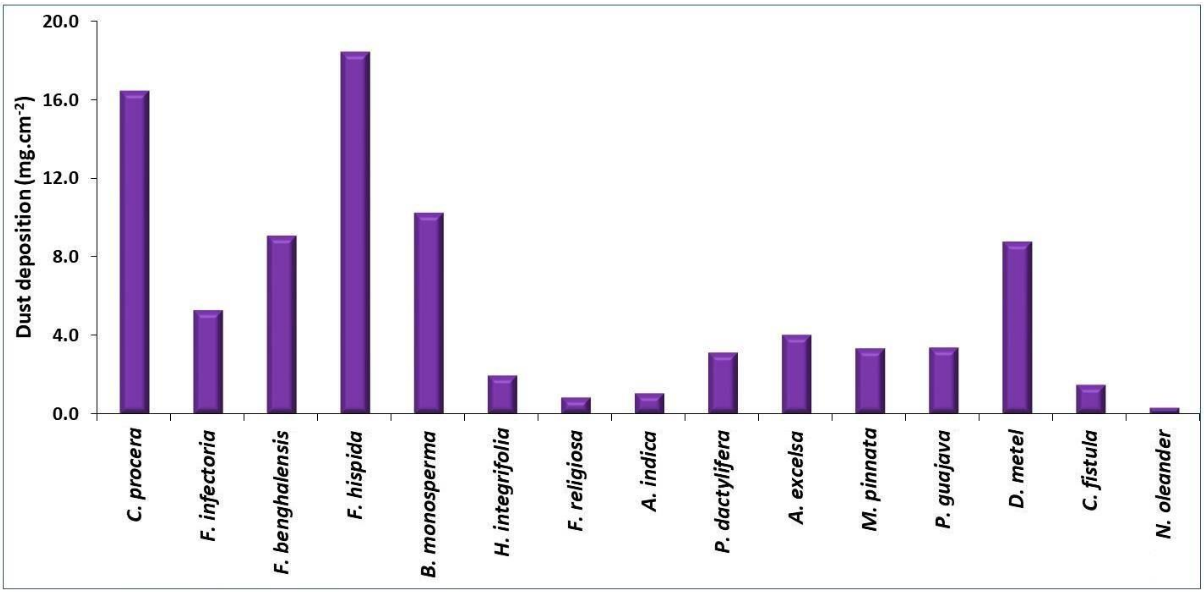

Figure 2. Dust deposition on leaves of selected plant species.

Roadside plant species shows the reduction of chlorophyll contents in compare to dust free site (*i.e.* Bundelkhand University campus). Dust particles physically obstruct sunlight as well as block stomatal pore of leaf and thus dust deposition hampered photosynthetic activities of the plant. Effect of dust degrades leaf pigment concentration has been reported earlier. In present study maximum chlorophyll content has been observed in leaf of *Ficus hispida* in polluted site (13.632 mg.g^{-1}) and in unpolluted site (19.227 mg.g^{-1}); it was followed by *Calotropis procera* (12.616 mg.g^{-1} and 16.778 mg.g^{-1}), *Butea monosperma* (8.508 mg.g^{-1} and 15.122 mg.g^{-1}), *Ficus benghalensis* (7.511 mg.g^{-1} and 14.641 mg.g^{-1}), *Ailanthus excelsa* (7.184 mg.g^{-1} and 11.685 mg.g^{-1}), *Datura metel* (7.715 mg.g^{-1} and 14.468 mg.g^{-1}) respectively (Fig. 3). Lowest chlorophyll content has been found in *Nerium oleander* and in *Azadirachta indica*.

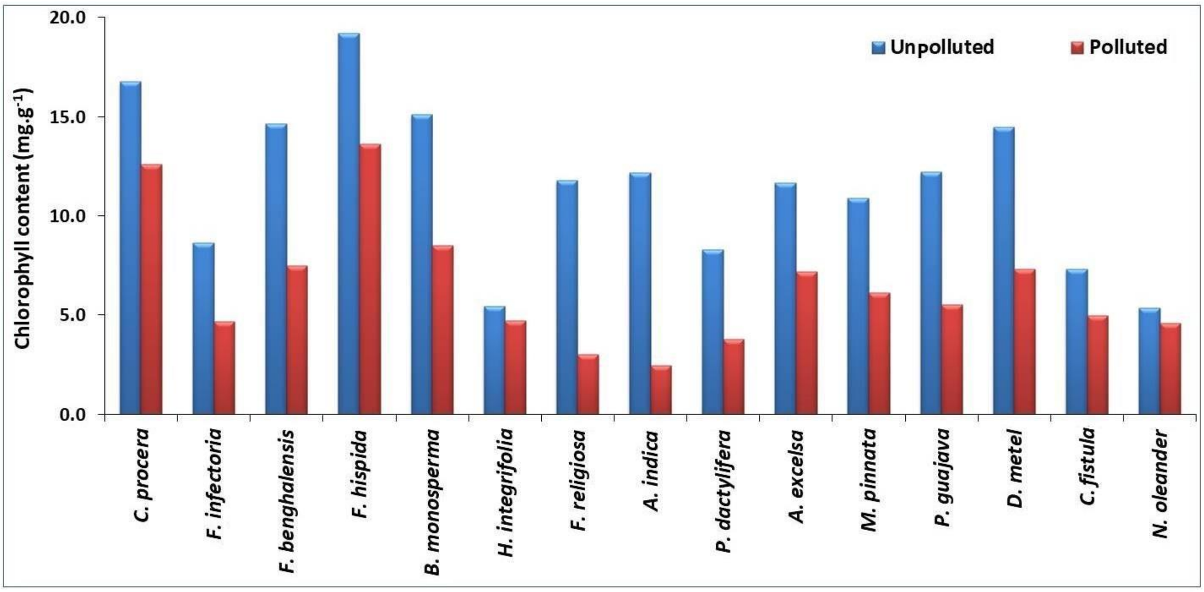

Figure 3. Chlorophyll content in leaves of selected plant species.

The maximum carotenoid content has been observed in the leaf of *Ficus hispida i.e.* unpolluted (0.4772 mg.g^{-1}) and in polluted (0.366 mg.g^{-1}) followed by *Calotropis procera* (0.426 mg.g^{-1} and 0.3288 mg.g^{-1}), *Butea monosperma* (0.3584 mg.g^{-1} and 0.3252 mg.g^{-1}), *Ficus benghalensis* (0.3244 mg.g^{-1} and 0.284 mg.g^{-1}), *Datura metel* (0.3144 mg.g^{-1} and 0.1684 mg.g^{-1}), *Ailanthus excelsa* (0.2964 mg.g^{-1} and 0.1404 mg.g^{-1}). The lowest carotenoid content was recorded in *Ficus religiosa* and *Nerium oleander* (Fig. 4). The carotenoid content is less in roadside plant species as compared to control site due to dust particles settled on the leaf surface regularly although deposition was not uniform in all the 15 plant species.

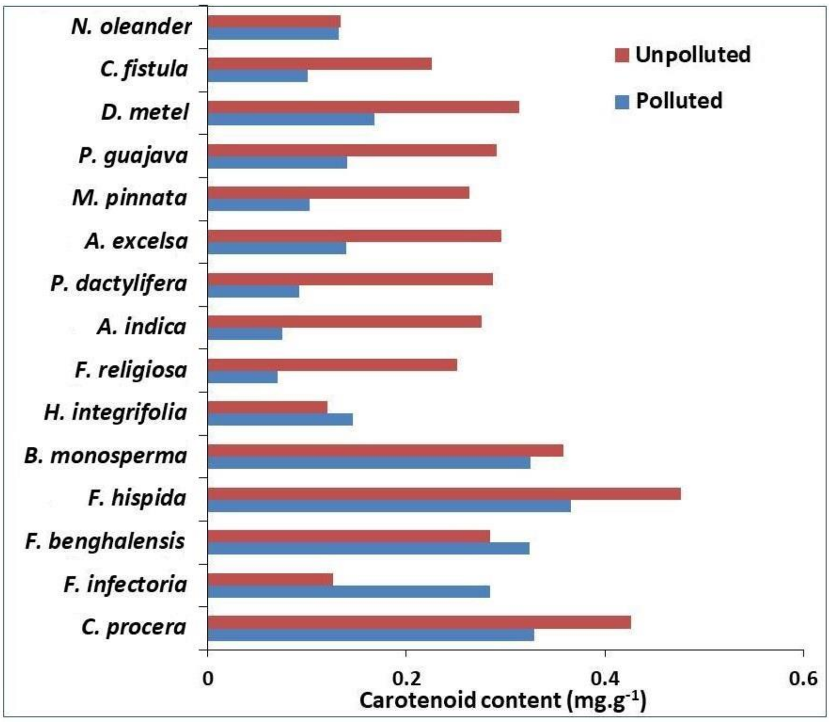

Figure 4. Carotenoid content in leaves of selected plant species.

In present investigation maximum protein content has been found in leaf of *Ficus hispida* (1.261 mg.g^{-1}) in unpolluted site and in polluted it was 0.504 mg.g^{-1} followed by *Calotropis procera* (0.744 mg.g^{-1} and 0.234 mg.g^{-1}), *Butea monosperma* (0.344 mg.g^{-1} and 0.184 mg.g^{-1}), *Ficus benghalensis* (0.292 mg.g^{-1} and 0.151 mg.g^{-1}), *Datura metel* (0.244 mg.g^{-1} and 0.137 mg.g^{-1}), *Ailanthus excelsa* (0.187 mg.g^{-1} and 0.116 mg.g^{-1}). Lowest protein content in unpolluted is *Azadirachta indica* (0.055 mg.g^{-1}) and in polluted it was recorded in *Holoptelea integrifolia* (0.045 mg.g^{-1}). Overall the protein content is less in roadside plant species as compared to control site *i.e.* unpolluted areas (Fig. 5).

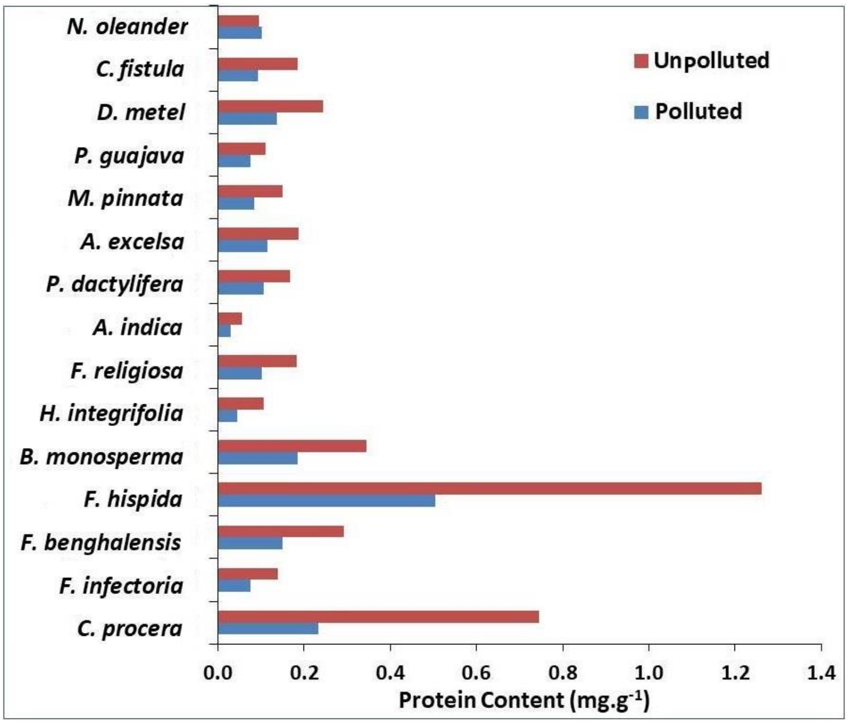

Figure 5. Protein Content in leaves of selected plant species.

DISCUSSION

The maximum amount of dust deposition in the roadside plant was found to increase with time. The dust particles settled in the leaf surface regularly, but deposition was not uniform in all the 15 selected plant species in our study. Settlement of dust particles on the leaf surface mainly depends on the phyllotaxy of leaf, smoothness of the leaf surface (*i.e.* presence of trichome), the shape of the leaf, petiole length as well as its position on the plant (Davison & Blackmore 1976).

Continuous exposure to dust in leaf surface leading to the formation of dense dust layers, which reduce light capturing capacity of plants and finally hamper plant photosynthetic activity (Prajapati & Tripathi 2008, Pourkhabbaz *et al*. 2010). Decreased rate of photosynthesis and alteration of stomatal conductance are responsible for the reduction of the stomatal index as well as dry matter content of leaf (Khan *et al*. 2015). Reduction of the stomatal index of the roadside plant may be due to shading effect of dust layers, which may block the stomata and reduce the photosynthesis rate of roadside plants (Sharma *et al*. 2017).

The leaf is influenced by deposition of dust, which may lead to lower photosynthesis activity (Pourkhabbaz *et al*. 2010). The present study shows that the chlorophyll content of all these selected plants was less in comparison to the plants from the control site *i.e.* collection from University Campus. Degradation of chlorophyll contents in the leaf is a common phenomenon from dust deposition on the leaf (Prajapati & Tripathi 2008). A plenty of studies reviewed declination of chlorophyll concentration due to deposition of dust in a number of annual non- leguminous crop (Satao *et al*. 1993, Prusty *et al*. 2005, Gostin 2009).

The study revealed the definite correlation between the plant canopy and foliar morphological traits and amount of dust captured by them. Morphological characteristics which have been found to play a significant role in intercepting particulates are: orientation of leaf on the main axis, size (leaf area), shape, nature of the surface, venation pattern, presence and absence of trichomes, morphology and frequency of trichomes, wax deposition, etc.

CONCLUSION

Based on extensive field observations and laboratory investigations, a few plant species have been identified which possess high dust filtering capacity. These species may be raised in green belts around granite mining areas and both sides of the national highway to lessen the dust load of the surrounding environment. The species with better dust filtering capacity are*: Ficus hispida, Calotropis procera, Butea monosperma, Ficus benghalensis, Datura metel, Ailanthus excelsa* respectively and could be considered as first choice species. Other species like- *Phoenix dactylifera, Nerium oleander, Ficus religiosa, Cassia fistula, Millettia pinnata* are considered as second choice species and *Psidium guajava, Ficus infectoria, Holoptelea integrifolia, Azadirachta indica* are considered as third choice species for the designing of green belt in and around mining industries as well as beautification of roadsides.

Plants on both sides of a national highway or in the city not only have an ornamental function but they have also an important role in mitigation of air pollution in terms of gaseous pollutants and filtration of air-borne particles that allows characterizing air pollutants and determine the source of their elemental and mineral profiles. Thus, plants with suitable traits for air pollution mitigation may be used for urban tree planting, roadside plantation programs, green belt in an around mining areas to improve air quality and at the same time such plants may be utilized for passive monitoring of air pollution.

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REFERENCES

Ackerly DD & Bazzaz FA (1995) Plant-growth and reproduction along CO gradients -nonlinear responses and implications for community change. *Global Change Biology* 1: 199–207.

Anthony P (2001) *Dust from walking tracks: Impacts on rainforest leaves and epiphylls*. Cooperative Research Centre for Tropical Rainforest Ecology and Management, Australia.

Arnon DI (1949) Copper enzymes in isolated chloroplasts: polyphenoloxidase in *Beta vulgari* L. *Plant Physiology* 24: 1–15.

Atkinson RW, Yu D, Armstrong BG, Pattenden S, Wilkinson P, Doherty RM, Heal MR & Anderson HR (2012)

Concentration- Response function for Ozone and daily mortality: Results from five urban and five rural U.K. populations. *Environmental Health Perspectives* 120(10): 1411–1417.

Beckett KP, Freer-Smith PH & Taylor G (2000) Particulates pollution capture by urban trees: effect of species and wind speed. *Global Change Biology* 6: 995–1003.

Chaphekar SB, Boralkar DB & Shetye RP (1980) Plants for air monitoring in industrial area. In: Furtado JI (ed) *Tropical Ecology* and *Development*. I.S.T.E. Kuala Lampur, pp. 669–675.

Chaturvedi RK, Prasad S, Rana S, Obaidullah SM, Pandey V & Singh H (2013) Effect of dust load on the leaf attributes of the tree species growing along the roadside. *Environmental Monitoring and Assessment* 185(1): 383–391.

Davison AW & Blakemore J (1976) In: Mansfield TA (ed) *Effects of air pollutions on plants*. Cambridge University Press, Cambridge, 209 p.

Farmer AM (1993) The effects of dusts on vegetation; A review. *Environmental Pollution* 79: 63–75.

Farooq M, Arya KR, Kumar S, Gopal K, Joshi PC & Hans RK (2000) Industrial pollutants mediated damage to mango (*Mangifera Indica*) crop: A case study. *Journal of Environmental Biology* 21: 165–167.

Freer-Smith PH, Beckett KP & Taylor G (2005) Deposition velocities to *Sorbus aria*. *Acer campestre, Populus deltoids trichocarpa* 'Beaupre', *Pinus nigra* and *Cupressocyparis leylandii* for coarse, fine and ultra-fine particles in the urban environment. *Environmental Pollution* 133: 157–167.

Gostin IN (2009) Air pollution effects on the leaf structure of some Fabaceae species. *Notulae Botanicae Horti Agrobotanici Cluj- Napoca* 37: 57–63.

Grantz DA, Garner JH & Johnson DW (2003) Ecological effects of particulate matter. *Environment International* 29: 213–239.

Khan ZS, Wolfram S, Yang P, Xiaoning Z, Hussein O, Xiongkui H & Muller J (2015) Effect of Dust Deposition on Stomatal Conductance and Leaf Temperature of Cotton in Northwest China. *Water* 7: 116–131.

Kulshreshtha K, Rai A, Mohanty CS, Roy RK & Sharma SC (2009) Particulate pollution mitigating ability of some plant species. *International Journal of Environmental Research* 3: 137–142.

Manins P, Allan R, Beer T, Fraser P, Holper P, Suppiah R & Walsh K (2001) *Atmosphere*. Australia State of the Environment Rep. 2001 (Theme Rep.). CSIRO Publ., Melbourne.

Pal A, Kulshreshtha K, Ahmad KJ & Behl HM (2002) Do leaf surface characters play a role in plant resistance to auto-exhaust pollution? *Flora Morphology, Distribution, Functional Ecology of Plants* 197: 47–55.

Pourkhabbaz A, Rastin N, Olbrich A, Langenfeld-Heyser H & Polle A (2010) Influence of Environmental Pollution on Leaf Properties of Urban Plane Trees, *Platanus orientalis* L. *Bulletin of Environmental Contamination and Toxicology* 85: 251–255.

Prajapati SK & Tripathi BD (2008) Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. *Journal of Environmental Quality* 37: 865–870.

Prusty BA, Mishra PC & Azeez PA (2005) Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India. *Ecotoxicology and Environmental Safety* 60: 228–235.

Rai A, Kulshreshtha K, Srivastava PK & Mohanty CS (2010) Leaf surface structure alterations due to particulate pollution in some common plants. *The Environmentalist* 30: 18–23.

Raupach MR, Woods N, Dorr G, Leys JF & Cleugh HA (2001) The entrapment of particles by windbreaks. *Atmospheric Environment* 35: 3373–3383.

Rezaei M, Arzani A & Sayed-Tabatabaei BE (2010) Meotic behavior of tetraploid wheats (*Triticum turgidum* L.) and their synthetic hexaploid wheat derivates influenced by meiotic restitution and heat stress. *Journal of Genetics* 89: 401–407.

Samal AC & Santra SC (2002) Air Quality of Kalyani township (Naida, West Bengal) and its impact on surrounding vegetation. *Indian Journal of Environmental Health* 44: 71–76.

Satao RN, Kene HK, Nalamwar RV & Ulemale RB (1993) Effect of cement dust pollution on growth and yield of cotton. *Annual Review of Plant Physiology* 7: 73–77.

Seyyednejad SM, Niknejad M & Koochak H (2011) A review of some different effects of air pollution on plants. *Research Journal of Environmental Sciences* 5: 302–309.

Sharma B, Chanda SK & Bhuyan M (2017) Impact of dust accumulation on three road side plants and their adaptive responses at National Highway 37, Assam, India. *Tropical Plant Research* 4(1): 161–167.

Shrivastava N & Joshi S (2002) Effect of automobile air pollution on the growth of some plants at Kota. *Geobios* 29: 281–282.

Sukumaran D (2012) *Effect of Particulate Pollution on various Tissue Systems of Tropical Plants*. Central Pollution Control Board (CPCB), Zonal Office, Kolkata, India.

Van Jaarsveld F (2008) *Characterizing and mapping of wind transported sediments associated with opencast gypsum mining, MS Thesis*. University of Stellenbosch, South Africa.

Wellburn AR (1990) Why are atmospheric oxides of nitrogen usually phytotoxic and not alternative fertilizers? *New Phytologist* 115: 395–429.

Younis U, Bokhari TZ, Malik SA, Ahmad S & Raja R (2013) Variation in leaf dust accumulation, foliage and pigment attributes in fruiting plant species exposed to particulate matter pollution from Multan. *International Journal of Scientific Research* 3: 1–12.