An Evaluation of Air Pollution Tolerance Index and Anticipated Performance Index of Some Tree Species Considered for Green Belt Development: A Case Study of Nandesari Industrial Area, Vadodara, Gujarat, India

Dhruti Patel*, **J. I. Nirmal Kumar**

Department of Environmental Science & Technology (DEST), Institute of Science and Technology for Advanced Studies & Research (ISTAR), Vallabh Vidyanagar, India
Email: *dhrcho@gmail.com

How to cite this paper: Patel, D. and Nirmal Kumar, J.I. (2018) An Evaluation of Air Pollution Tolerance Index and Anticipated Performance Index of Some Tree Species Considered for Green Belt Development: A Case Study of Nandesari Industrial Area, Vadodara, Gujarat, India. *Open Journal of Air Pollution*, **7**, 1-13.
https://doi.org/10.4236/ojap.2018.71001

Received: June 13, 2017
Accepted: January 2, 2018
Published: January 5, 2018

Abstract

It is well renowned that trees have capacity to reduce the air pollution. It is mandatory to expand tree plantation in industrial area to minimize the threat of pollutants. For green belt development, it is necessary to use plants that are tolerant to air pollution. The present study includes Air pollution tolerance index (APTI) of selected plant species with the help of biochemical analysis. On the basis of APTI and some other socioeconomic and biological parameters of plants, Anticipated Performance Index (API) was calculated. Out of twelve species, *Ficus benghalensis* showed to be the most efficient among others. As per classification of API, *Ficus religiosa* tree species is classified into the moderate category. Based on the APTI and API, appropriate plant species for green belt development in industrial area were identified and recommended for mitigating the pollution.

Keywords

Air Pollution, APTI, API, Nandesari, Green Belt

1. Introduction

The status of air quality in every part of the world always parallels the changes in development of surrounding area [1]. Industrial area exhibits major sources of Particulate Matter, SOx and NOx. Depending upon the type of raw material used emission of one or more of these pollutants is obvious. The problem of declining air quality is mainly the result of anthropogenic emissions from traffic, industry and domestic heating, especially affecting the world's urban residents [2] [3]. Air pollution can have profound effects on the health of the entire planet. Increasing human population with decreasing green environment has produced ambient air polluted. Mainly increasing number of industries, vehicular exhaust, and fossil fuels to nuclear energy produces air heavily polluted day by day [4]. The air pollution causes health problems in the workers and residents in places near the industrial area, therefore it is essential to study the air quality in the surroundings of the industries [5] [6]. To terminate the impact of air pollutants, environmentalists and decision makers have long been emphasizing the need for a "perennial green envelop" in and around industrial areas as well as along roadsides [7] [8]. The plant has capacity to provide one of the natural ways of cleaning the atmosphere by absorption, reflection, diffusion of gaseous through their leaves. Heumann (2002); Psaras and Christodoulakis (1987) have shown the interactions between plant and different types of pollutants with the influence of environmental pollution on physiological and ultrastructural aspects [9] [10].

Based on responses of plants towards a particular stress as well as gaseous stress, they can be categorized into "sensitive" and "tolerant". Sensitive species are early indicators of pollution, and the tolerant species help in reducing the overall pollution load [11]. Moreover, the present investigation is based on identification of stress tolerant plant species (noise and air pollution) from the study area to develop green belt. By the help of the Natural processes, air pollution level can be reduced by precipitation, Chemical reaction and sedimentation [12].

In present study emphasis is given on evaluation of tolerance level in plant species against air pollution and calculation of air pollution tolerance index (APTI) [11]. Air Pollution Tolerance Index (APTI), an index developed by Singh and Rao (1983), is used for the evaluation of the tolerance level of plant species from leaf [13]. The parameters used in defining sensitivity or resistance of plants towards different air pollutant concentration includes, Total Chlorophyll, Ascorbic acid, leaf pH, relative water content. Plant sensitivity and tolerance to air pollutants vary with these above parameters. Chlorophyll content decreases due to production of reactive oxygen species (ROS) in the chloroplast underwater stress condition. (ROS is very small reactive molecules that can effect to cell structure during the stress condition). It also imparts leaf injury and causes change in stomatal movements, Changes in Chlorophyll content causes change in the rate of photo-synthesis. In the plant, higher ascorbic acid concentration of leaves might be an effective strategy to protect thylakoid membranes from oxidative damage under such water stress [14]. Alkaline particles such as limestone and dust particle may damage plant surfaces [15], and high pH improves tolerance against air pollution [1]. Based on APTI (**Table 1**) and some relevant biological and socio-economic characters (**Table 2**), the Anticipated Performance Index (API) (**Table 3**), of various plant species was determined. By measuring these parameters we can predict the effectiveness of plant as possibly being suitable in terms of pollution abatement.

Table 1. Air pollution tolerance index of tree species studied in Nandesari industrial area, Gujarat.

Sl. no.	Name of species	A	P	T	R	APTI
1	*Michelia champaca* L.	7.31	5.68	6.2	56	13.26
2	*Polyalthia longifolia* Sonn.	6.42	6.89	5.78	60.25	15.68
3	*Azadirachta indica* A. Juss.	6.79	6.2	3.87	54.21	12.98
4	*Ficus religiosa*	6.98	6.98	9.87	60.54	14.42
5	*Ficus benghalensis*	6.65	5.93	6.54	55.65	18.65
6	*Cassia fistula* L.	6.07	5.43	4.44	54.24	13.65
7	*Spathodea campanulata* P. Beauv.	5.54	6.65	4.65	55.24	11.46
8	*Adina cordifolia* Hook. f.	5.05	6.87	3.98	51.35	12.05
9	*Cassia siamea* Lamk.	6.19	5.68	4.55	52.18	12.05
10	*Nerium odorum* Sonnad.	4.08	6.54	3.52	53.54	8.65
11	*Alstonia scholaris* (L.) R.Br.	5.26	6.05	3.81	50.42	9.01
12	*Cascabela thevetia* L.	5.9	5.98	4.73	50.15	9.54

A = Ascorbic Acid , P = pH, T = Total Chlorophyll, R = Relative Water Content (Average mean value).

Table 2. Gradation of plant species based on air pollution tolerance index (APTI) as well as biological parameters and socio-economic importance.

Grading characters		Pattern of assessment	Grade allotted
1) Tolerance	APTI	9.0 - 12.0	+
		12.1 - 15.0	++
		15.1 - 18.0	+++
		18.1 - 21.0	++++
		21.1 - 24.0	++++
2) Biological and socio-economic	Plant habit	Small	-
		Medium	+
		Large	++
	Canopy structure	Sparse/irregular/globular	-
		Spreading crown/open/semi-dense	+
		Spreading dense	++
	Type of plant	Deciduous	-
		Evergreen	+
3) Laminar structure	Size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Coriaceous	+
	Hardiness	Delineate	-
		Hardy	+
	Economic value	Less than three uses	-
		Three or four uses	+
		Five or more uses	+ +

Table 3. Anticipated performance index (API) of plant species.

Grade	Score (%)	Assessment category
0	Up to 30	Not recommended
1	31 - 40	Very poor
2	41 - 50	Poor
3	51 - 60	Moderate
4	61 - 70	Good
5	71 - 80	Very good
6	81 - 90	Excellent
7	91 - 100	Best

2. Materials and Methods

2.1. Study Area

The study was carried out in and around the Nandesari industrial area, which is situated in the Vadodara district. Nandesari has a large notified industrial area comprising of large amount of chemical factories. It homes Gujarat first GIDC (**Gujarat Industrial Development Corporation)** with concrete roads and storm water drains. Nandesari is a small town of Gujarat, located at 22.4103˚ north latitude and, 73.0913˚ east longitude. It has an average elevation of 34 meters. Climate is subtropical, with mild winters and warm summers. The city is situated between 18˚96' north latitude and 72˚81' east longitude. The weather is typical coastal sultry and humid. The city receives average rainfall in the range of 1500 mm to 2000 mm. The place experiences the onset of the monsoon in the month of June and experiences monsoon till the end of September. The average minimum temperature is recorded between 25˚C to 37˚C.

2.2. Air Pollutants Sampling and Measurement

The study was carried out on twelve plant species growing along polluted and non-polluted sites during the year 2014-2015 (Figure 1). The road side was selected as a polluted area for case study, because numerous sources emit dust and smoke including vehicles. For ambient air quality monitoring three sites has been selected in and around the Nandesari industrial area. The control site was selected 3 km away from the Nandesari industrial area with good greenery and lesser nearby air pollutants. For collection of gaseous and particulate pollution, HVAS (2.5 High Volume air Sampler) was used for 24 Hours with flow rate of one liter per minute. $PM_{2.5}$ was sampled by PM2.5 HVAS and estimated by gravimetric analysis [16]. SO_2 was estimated by West-Geake method using sodium tetra-chloromercurate. In case of NO_2, estimation was based on Jacob and Hoccheiser method using sodium Hydroxide as an absorbing medium. Rapid industrialization, expansion of the road network and infrastructure has resulted in severe air pollution problem and adverse effects on exposed residents.

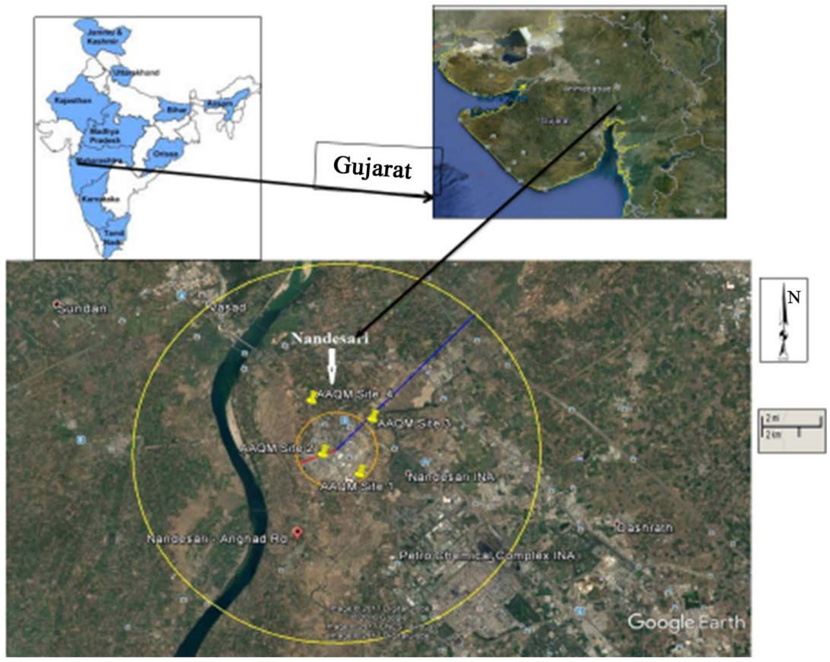

Figure 1. Map showing study area of Nandesari industrial area.

2.3. Biochemical Characteristics Analysis

In order to collect the plant leaf samples, a plant survey was made at the three selected sites, *i.e.*, Site 1, Site 2, Site 3 and on that basis twelve common plants of same age were elected for the foliar biochemical studies. The matured leaves from each plant species were plucked from individual sites. These leaves were placed into the polythene bags and brought to the laboratory to preserve at 25 ± 0.5˚C until analysis. The plant samples were analyzed for different parameters within 24 hours of their harvesting. The leaf samples were analyzed for pH (P) of leaf extract [13], Chlorophyll (T), Ascorbic acid (A) [17] [18], and Relative Water Content (R) [19]. The APTI, an empirical value representing tolerance level of a Plant to air pollution, was used to interpret the impact of pollution on the plants [13]. The APTI was calculated by using the following formula for a given plant species.

$$\text{APTI} = \frac{A(T+P)+R}{10}$$

where, A = Ascorbic acid content ($\text{mg}\cdot\text{gm}^{-1}$),

T = total chlorophyll ($\text{mg}\cdot\text{g}^{-1}$),

P = pH of leaf extract, and

R = Relative water content of leaf (%).

2.4. Evaluation of API

For determining which plant species are most suitable for the development of green belts, experiment needed to calculate the Anticipated Performance Index (API). All 12 plants selected for green belt development were evaluated in terms of their API. The API values were calculated by using various biological and socioeconomic, as well as some biochemical characteristics, such as APTI, plant habit, canopy structure and economic value (see **Table 1**). The method to calculate API value is in the table. Based on this pattern grading of 12 plant species, promising plants were recommended for green belt development.

3. Result and Discussion

As shown in **Table 1**, the highest chlorophyll content (mg·g^{-1} dry weight) was observed in *Ficus religiosa* (9.87) followed by *Ficus benghalensis* (6.54), *Michelia champaca* (5.45). Chlorophyll estimation is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism so that any drop in chlorophyll content indicates direct impact on plant growth [20]. In the present investigation, the total chlorophyll content was found comparatively higher at control site and lower at polluted site. The higher the level of pollutants, the lower the chlorophyll content as certain pollutants diminishes the total chlorophyll content [21]. Many previous APTI studies have shown similar findings [22]. Agbaire *et al*., (2014) & Prabhatkumar *et al*. (2013) also suggested that high levels industrial pollution reduces chlorophyll content of plant leaves around the industrial area [19] [23].

3.1. Biochemical Analysis of Plants

Results from biochemical analysis of plants revealed that higher ascorbic acid contents were recorded in *Michelia champaca* (7.31), followed by *Ficus religiosa* (6.98), *Azadirachta indica* (6.79), *Polyalthia longifolia* (6.42), *Cassia siamea* (6.19), *Cassia fistula* (6.09)) [19] **Table 1** Ascorbic acid is concentrated mostly in chloroplasts that act as an antioxidant. It is mostly found in growing parts of the plant and enhances resistance to adverse environmental conditions, including air pollution [23] [24]. Earlier Air pollution and soil contamination results have showed a decrease in leaf ascorbic acid content in exposed *Tibouchina pulchra* samplings [25].

In this study, *Ficus religiosa* has the maximum relative water content of 64% and followed by *Polyalthia longifolia* 60%, *Spathodea campanulata* 55%, *Ficus benghalensis* 55%. High water content within a plant body helps to maintain its physiological balance under stressful conditions, such as exposure to air pollution [26] (**Table 1**). The highest Relative Water Content (RWC) was found in response to the high availability of soil, water content and lower evaporation and transpiration rate. RWC of a leaf is the water present in response to its full turgidity. Under air polluted conditions, transpiration rates are frequently high, which leads to dryness. Therefore, the maintenance of RWC by the plant may determine its relative tolerance to pollution. Therefore, the high RWCs of plants in an industrial area sample may be responsible for the normal function of plant biological processes [27].

The plant samples of the study exhibited an acidic pH. This might be due to presence of certain air pollution in the atmosphere. As leaf pH values increased in the polluted area compared with that of control. Similarly, rise in pH values in polluted site was observed [27]. The lowest pH concentration was found in case of *Michelia champaca* (5.68) followed by *Cassia fistula* (5.43), *Cassia siamea* (5.68), *Cascabela thevetia* (5.98). The plants were observed to have lower pH as washing of leaves lowers dust accumulation. On unalike, where dust accumulation is more, dust particle dissolution in cell sap is higher which results in rise in the pH [28]. It has been reported that the lower leaf pH is due to presence of acidic pollutants [29]. Swami *et al.*, (2004) also observed similar results. The changes in leaf-extract pH might influence the stomata sensitivity in presence of air pollutants. Consequently, sensitive plants had higher leaf-extract pH than tolerant plants. Low leaf pH extract showed good correlation with sensitivity to air pollution and also reduces photosynthetic process in plants [30].

The NO_x, SO_2 and $PM_{2.5}$ content estimated in the ambient air of the study stations were within the NAAQS limits for residential area and industrial areas [31]. The main air pollutants in Nandesari industrial area are SO_2, NO_2, $PM_{2.5}$. The concentrations of all of these pollutants were within the limits prescribed by CPCB. The average concentrations of three study area were SO_2, NO_2, $PM_{2.5}$ in the Nandesari industrial area are 52, 46, and 35 μg/m^3, correspondingly. Higher concentrations in winter season may be credited to the atmospheric inversion [32].

During inversion the normal atmospheric conditions *i.e.* cool air above and warm air below gets inverted. This condition leads to trap an intense layer of cold air under a layer of warm air. This dormant condition of atmosphere traps the pollutants close to the surface of the earth. Dust interception ability of plants depends on their surface geometry, phyllotaxy, leaf external characteristics (such as hairs, cuticle, etc.), and height and canopy of trees [6] [13]. The methodology of APTI and API can be used globally as they are based on parameters and universally significant biological and socio-economic characters. The planting of larger tree has been avoided because of their thick canopy structures and too close with each other, as this may lead to chances of obstructing the scattering of pollutants, thus provoking the pollution problem. Leaf petioles have more capacity to eliminate particulate than either twigs (stem) or leaf lamina [33]. Green belts offer one of the natural ways of cleaning the atmosphere by absorption of gaseous pollutants, particulates and noise through their leaves. Plants with bulky leaves can act as efficient pollutant trapping device.

3.2. Air Pollution Tolerance Index

Presence of plants and trees in the industrial area can improve air quality through uptake of pollutant gases and particles. Air pollution tolerance index (APTI) was calculated for each plant. Species studied at different sites is mentioned in the above **Table 1**. The highest APTI value is found in the winter season. On the basis of calculated APTI with respect to season, the plants were found to follow this order; *Ficus benghalensis* showed the highest APTI value at all the sites followed by *Polyalthia longifolia* > *Ficus religiosa* > *Cassia fistula* > *Michelia champaca* > *Azadirachta indica* > *Adina cordifolia* > *Cassia siamea* > *Cascabela thevetia* > *Alstonia scholaris* > *Nerium odorum*. Different plant species show substantial variation in their susceptibility towards air pollution. The plants with high and low APTI can serve as tolerant and sensitive species respectively. All other plants were found to be sensitive and accommodating as air pollution indicator [34].

The linear regression plots of individual variables with APTI (**Figure 2**) show

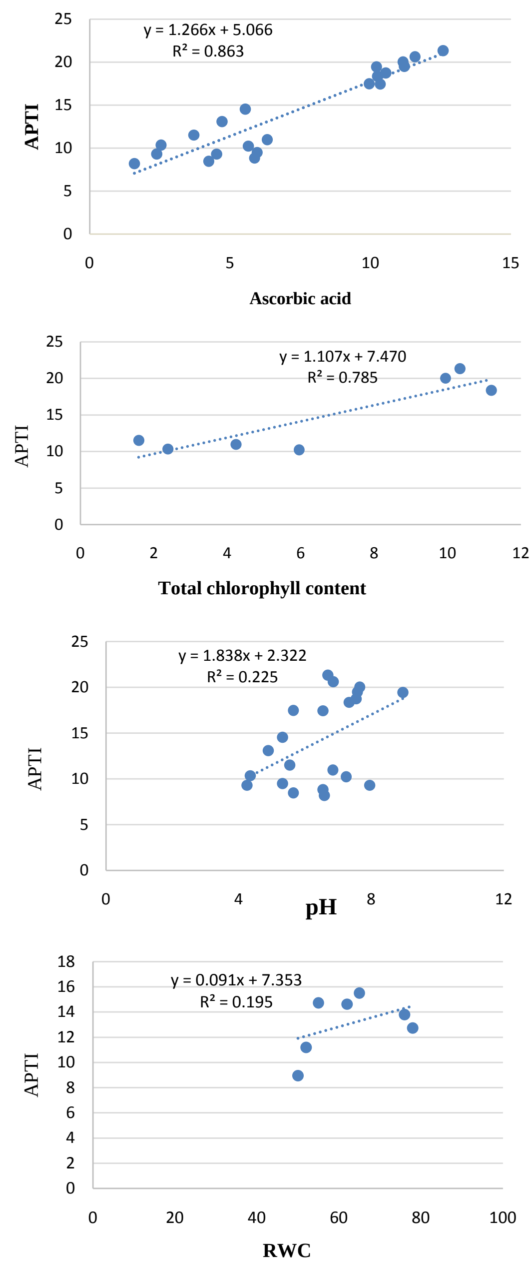

Figure 2. Linear regression plots of APTI with individual variables like ascorbic acid, chlorophyll content, PH and relative water contents.

that a significant correlation exists between APTI and ascorbic acid content (R^2 = 0.86387) while a positive correlation was found between APTI and total chlorophyll content (R^2 = 0.7853). On the contrary, a non-significant & low correlation with leaf extract pH (R^2 = 0.2254) and relative water content (R^2 = 0.1952) were observed. It brings to knowledge that ascorbic acid and chlorophyll content of the leaf are responsible factors on which the APTI relies [35].

3.3. Estimation of API

Out of above mentioned *Ficus benghalensis* rank first among all plants studied and is a keystone species [24]. Keystone species can be expressed as species which play a key role in the sustenance of ecosystems; it has a consistent effect on its environment relative to its abundance. An ecosystem may experience a remarkable shift if a keystone species is removed, even if that species is a minute part of the ecosystem on account of productivity. Henceforth, it will be highly appropriate for planting this in industrial area to assist improvement in pollution. *F. religiosa* was judged to be in the "Very Good" category and was recommended for plantation (**Table 4**). These species have an intense canopy of evergreen foliage and is well known for its economic and aesthetic value [16] [36]. Apart from this investigation, 4 of the 13 tree species drops in the moderately suitable category, but can be recommended for plantation due to their aesthetic value (**Table 4**). The rest of the naturally growing species in the study area was not recommended for planting due to their particularly poor pollution tolerance indices or their very low API values (**Table 5**).

Table 4. Anticipated performance index (API) of different tree species in Nandesari industrial area.

Plant species	Grade		API value	Assessment
	Total Plus	Percentage		
Michelia champaca L.	9	52.94	3	Moderate
Polyalthia longifolia Sonn.	10	58.82	3	Moderate
Azadirachta indica A. Juss.	8	47.06	2	Poor
Ficus religiosa L.	12	70.59	5	Very good
Ficus Bengalensis L.	14	82.35	6	Excellent
Cassia fistula L.	7	41.18	2	Poor
Spathodea campanulata P. *Beauv.*	4	23.53	0	Not Recommended
Adina cordifolia Hook. f.	10	58.82	3	Moderate
Cassia siamea Lamk.	9	52.94	3	Moderate
Nerium odorum Sonnad.	5	29.41	0	Not Recommended
Alstonia scholaris (L.) R.Br.	6	35.29	1	Very Poor
Cascabela thevetia L.	7	41.17	2	Poor

Table 5. Assessment of plant species based on their APTI values and some biological and socio-economic characters.

S. No.	Name of Plant	APTI	Tree Habit	Canopy Structure	Type of Tree	Laminar		Economic Importance	Hardiness	Grade Allotted		API Grade
						Size	Texture			Total Plus (+)	% scoring	
1	*Michelia champace* L.	++	+	+	+	+ +	+	-	+	9	52.94	3
2	*Polyalthia longifolia* Sonn.	++	+	+	+	+ +	-	+	+	10	58.82	3
3	*Azadirachta indica* A. Juss.	+	++	+ +	-	-	-	+ +	+	8	47.06	2
4	*Ficus religiosa*	++	++	+ +	+	+ +	+	+	+	12	70.59	5
5	*Ficus benghalensis*	++++	++	+ +	+	+ +	+	+	+	14	82.35	6
6	*Cassia fistula* L.	++	+	+	-	+	-	+	+	7	41.18	2
7	*Spathodea campanulata* P. Beauv.	+	+	-	+	+	-	-	-	4	23.53	0
8	*Adina cordifolia* Hook. f.	+	++	++	-	++	+	+	+	10	58.82	3
9	*Cassia siamea* Lamk.	++	+	+	+	+	+	+	+	9	52.94	3
10	*Nerium odorum* Sonnad.	+	+	+	-	+	+	-	-	5	29.41	0
11.	*Alstonia scholaris* (L.) R.Br.	+	+	+	+	-	-	+	+	6	35.29	1
12.	*Cascabela thevetia* L.	+	-	+	+	+	+	+	+	7	41.17	2

4. Conclusion

For the green belt development in the industrial area, our study reveals that evaluation of anticipated performance of plants might be very useful in the selection of appropriate tree species. Some plants have been classified according to their degree of sensitivity and tolerance towards various air pollutants. The present study indicated that *Ficus benghalensis* L. species is most suitable sink for air pollution, which acts as key stone species. These plants can be utilized for green belt development in industrial area for reduction of the level of the air pollution. Further recommended species were of high aesthetic and socio-economic values. Plants with high APTI and API values are suggested for the development of green belts in the area. Therefore, these plant species may be integrated into a green belt design to assist in the long term air pollution planning of this industrial area.

References

[1] Agarwal, S.K. (1986) A New Distributional Function of Foliar Phenol Concentration in the Evaluation of Plants for Their Air Pollution Tolerance Index. *Acta Ecology*, **1986**, 29-36.

[2] Rayfield, D., Longhurst, J., Watson, A., Hewison, T., Raper, D.W., Conlan, D.E. and Owen, B. (1998) A Methodology for Estimation of Vehicle Emissions in an Urban Environment: An Example from Greater Manchester. *Environmentalist*, **18**, 175-182. https://doi.org/10.1023/A:1006602217842

[3] Moreno, T., Lavín, J., Querol, X., Alastuey, A., Viana, M. and Gibbons, W. (2009) Controls on Hourly Variations in Urban Background Air Pollutant Concentrations. *Atmospheric Environment*, **43**, 4178-4186. https://doi.org/10.1016/j.atmosenv.2009.05.041

[4] Foley, J.A. (2005) Global Consequences of Land Use. *Science*, **309**, 570-574. https://doi.org/10.1126/science.1111772

[5] Sarasamma, J.D. and Narayanan, B.K. (2014) Air Quality Assessment in the Surroundings of KMML Industrial Area, Chavara in Kerala, South India. *Aerosol and Air Quality Research*, **146**, 1769-1778.

[6] Nowak, D. (1994) Air Pollution Removal by Chicago's Urban Forest. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. 63-81.

[7] Chaulya, S.K., Chakraborty, M.K. and Singh, R.S. (2001) Air Pollution Modelling for a Proposed Limestone Quarry. *Water, Air, & Soil Pollution*, **126**, 171-191. https://doi.org/10.1023/A:1005279819145

[8] Rao, P.S., Gavane, A.G., Ankam, S.S., Ansari, M.F., Pandit, V.I. and Nema, P. (2004) Performance Evaluation of a Green Belt in a Petroleum Refinery: A Case Study. *Ecological Engineering*, **23**, 77-84. https://doi.org/10.1016/j.ecoleng.2004.06.013

[9] Heumann, H.-G. (2002) Ultrastructural Localization of Zinc in Zinc-Tolerant *Armeria maritima* ssp. halleri by Autometallography. *Journal of Plant Physiology*, **159**, 191-203. https://doi.org/10.1078/0176-1617-00553

[10] Psaras, G.K. and Christodoulakis, N.S. (1987) Air Pollution Effects on the Ultrastructure of *Phlomis fruticosa* Mesophyll Cells. *Bulletin of Environmental Contamination and Toxicology*, **38**, 610-617. https://doi.org/10.1007/BF01608593

[11] Rao, D.N. (1983) Sulphur Dioxide Pollution versus Plant Injury with Special Reference to Fumigation and Precipitation. *Proceedings Symposium on Air Pollution Control*, **1**, 91-96.

[12] Rasmuseen, K.H., Taheri, M. and Kabel, R.L. (1974) Source of Natural Removal Processes for Some Atmospheric Pollutants. PA Publication, Washington DC.

[13] Singh, S.K. and Rao, D.N. (1983) Evaluation of Plants for Their Tolerance to Air Pollution. *Symposium on Air Pollution Control*, **1983**, 218-224.

[14] Tambussi, E.A., Bartoli, C.G., Beltrano, J., Guiamet, J.J. and Araus, J.L. (2000) Oxidative Damage to Thylakoid Proteins in Water-Stressed Leaves of Wheat (*Triticum aestivum*). *Physiologia Plantarum*, **108**, 398-404. https://doi.org/10.1034/j.1399-3054.2000.108004398.x

[15] Prajapati, S.K. and Tripathi, B.D. (2008) Anticipated Performance Index of Some Tree Species Considered for Green Belt Development in and around an Urban Area: A Case Study of Varanasi City, India. *Journal of Environmental Management*, **88**, 1343-1349. https://doi.org/10.1016/j.jenvman.2007.07.002

[16] Pathak, V., Tripathi, B.D. and Mishra, V.K. (2011) Evaluation of Anticipated Performance Index of Some Tree Species for Green Belt Development to Mitigate Traffic Generated Noise. *Urban Forestry & Urban Greening*, **10**, 61-66. https://doi.org/10.1016/j.ufug.2010.06.008

[17] Sadasivam, S. and Manickam, A. (1996) Biochemical Methods. New Age International.

[18] Patel, A.M. and Kousar, H. (2011) Assessment of Relative Water Content, Leaf Extract pH, Ascorbic Acid and Total Chlorophyll of Some Plant Species Growing in Shivamogga. *Plant Archives*, **11**, 935-939.

[19] Agbaire, P.O. (2009) Air Pollution Tolerance Indices (APTI) of Some Plants around

Erhoike-Kokori Oil Exploration Site of Delta State, Nigeria. *International Journal of Physical Sciences*, **4**, 366-368.

[20] Joshi, P.C. and Swami, A. (2009) Air Pollution Induced Changes in the Photosynthetic Pigments of Selected Plant Species. *Journal of Environmental Biology*, **30**, 295-298.

[21] Allen, L.H., *et al.* (1987) Response of Vegetation to Rising Carbon Dioxide: Photosynthesis, Biomass, and Seed Yield of Soybean. *Global Biogeochemical Cycles*, **1**, 1-14. https://doi.org/10.1029/GB001i001p00001

[22] Bakiyaraj, R. and Ayyappan, D. (2014) Air Pollution Tolerance Index of Some Terrestrial Plants around an Industrial Area. *International Journal of Modern Research and Reviews*, **2**, 1-7.

[23] Chen, Y.M., Lucas, P.W. and Wellburn, A.R. (1990) Relative Relationship between Foliar Injury and Change in Antioxidants Levels in Red and Norway Spruce Exposed to Acidic Mists. *Environmental Pollution*, **69**, 1-15. https://doi.org/10.1016/0269-7491(91)90159-T

[24] Keller, T. and Schwager, H. (1977) Air Pollution and Ascorbic Acid. *Forest Pathology*, **7**, 338-350. https://doi.org/10.1111/j.1439-0329.1977.tb00603.x

[25] Klumpp, G., Furlan, C.M., Domingos, M. and Klumpp, A. (2000) Response of Stress Indicators and Growth Parameters of *Tibouchina pulchra* Cogn. Exposed to Air and Soil Pollution near the Industrial Complex of Cubatão, Brazil. *Science of the Total Environment*, **246**, 79-91. https://doi.org/10.1016/S0048-9697(99)00453-2

[26] Innes, J.L. and Haron, A.H. (2000) Air Pollution and the Forests of Developing and Rapidly Industrializing Regions. Report No. 4 of the IUFRO Task Force on Environmental Change. CABI, Wallingford.

[27] Rai, P., Panda, L., Chutia, B. and Singh, M. (2007) Comparative Assessment of Air Pollution Tolerance Index (APTI) in the Industrial (Rourkela) and Non-Industrial Area (Aizawl) of India: An Eco Management Approach. *African Journal of Environmental Science and Technology*, **7**, 944-948.

[28] Katiyar, V. and Dubey, P.S. (2001) Sulphur Dioxide Sensitivity on Two Stage of Leaf Development in a Few Tropical Tree Species. *Indian Journal of Environment and Toxicology*, **11**, 78-81.

[29] Scholz, F. and Reck, S. (1977) Effects of Acids on Forest Trees as Measured by Titration *in Vitro*, Inheritance of Buffering Capacity in *Picea abies*. *Water*, *Air*, *& Soil Pollution*, **8**, 41-45.

[30] Yan, D. and Hui, J. (2008) Variation in Air Pollution Tolerance Index of Plants near a Steel Factory. Implications for Landscape-Plant Species Selection for Industrial Areas. *Wseas Transactions on Environment and Development*, **1**, 24-30.

[31] C. Pollution C. B. and Ministry of Forest and Climate Change (2014) Revised National Ambient Air Quality Standards (NAAQS).

[32] Wong, N.H., *et al.* (2010) Thermal Evaluation of Vertical Greenery Systems for Building Walls. *Building and Environment*, **45**, 663-672. https://doi.org/10.1016/j.buildenv.2009.08.005

[33] Ingold, C.T. (1971) Fungal Spores: Their Liberation and Dispersal.

[34] Seyyednjad, S.M., Majdian, K., Koochak, H. and Niknejad, M. (2011) Air Pollution Tolerance Indices of Some Plants around Industrial Zone in South of Iran. *Asian Journal of Biological Sciences*, **4**, 300-305. https://doi.org/10.3923/ajbs.2011.300.305

[35] Pandey, A.K., Pandey, M. and Tripathi, B.D. (2015) Air Pollution Tolerance Index of Climber Plant Species to Develop Vertical Greenery Systems in a Polluted Tropi-

cal City. *Landscape and Urban Planning*, **144**, 119-127.
https://doi.org/10.1016/j.landurbplan.2015.08.014

[36] Shannigrahi, A.S., Fukushima, T. and Sharma, R.C. (2004) Anticipated Air Pollution Tolerance of Some Plant Species Considered for Green Belt Development in and around an Industrial/Urban Area in India: An Overview. *International Journal of Environmental Studies*, **61**, 125-137.
https://doi.org/10.1080/0020723032000163137