Identification of Air Pollution Index of certain local available plants at industrial area on the basis of Air Pollution Tolerance index

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Abstract. Air pollution is a grave problem which affects the health of living organisms (human, animal and plants). Plants act as bio indicator and reduces air pollution due to their physiological and biochemical characteristic. The study was conducted at Talkatora industrial area, Lucknow, Uttar Pradesh, India. The ambient air quality status and annual average concentration of major air pollutants (SO\textsubscript{2}, NO\textsubscript{2} and PM\textsubscript{2.5}) was monitored for 2019 at the Industrial site. The annual average concentration of PM\textsubscript{2.5} was reported 119.54 µg/m\textsuperscript{3}, and for NO\textsubscript{2} was 42.69 µg/m\textsuperscript{3} which is higher than the prescribed CPCB limits. The concentration of gaseous pollutant (SO\textsubscript{2}) is found to be within the permissible range of 50µg/m\textsuperscript{3} at the industrial site as concentration of sulphur dioxide was 13.34 µg/m\textsuperscript{3}. Air Pollution Tolerance Index (APTI) of 6 plant species which was pick out from both experimental as well as control site was calculated to determine their biochemical parameters viz. Total chlorophyll content, leaf extract pH, ascorbic acid and RWC (relative water content). According to APTI Ficus religiosa and Azadirachta indica were tolerant species as their APTI was greater than 17 and P. pinnata be the sensitive species reporting APTI lower than 11. In Pearson correlation of biochemical parameter, it shows that Ascorbic acid (R\textsuperscript{2} = 0.9763) shows significance correlation with APTI.

Keywords: Ambient Air Quality, APTI, Ascorbic Acid, Relative water content, Pearson Correlation.

1. Introduction
With the growth of population in the country like India the number of automobile and the construction has also increased which directly affects the air quality in the near vicinity [1]. Due to increased air pollution various air pollutants viz. oxides of sulphur (SOx), oxides of nitrogen (NOx), suspended particulates matter (SPM), and heavy metals etc. emits [2, 3]. In the India primary as well as secondary air pollutants cause extremely bad smog condition during the winter season [4]. It not only affects air quality but also deteriorate human health mainly to those who are suffering from Asthma, Bronchitis, lung cancer, and chronic obstructive pulmonary disease (COPD) [5].

Plant shows certain characteristics response and symptom to particular types and level of air pollution. Reduction in plant height, canopy structure, plant biomass, Ascorbic acid, plant chlorophyll and Nitrogen content of plants are among the most common responses against air pollution [6]. The cost effective measure to extenuate air pollution is to increase green cover in and around the area.
which are most populated [7]. Green belt plays an important role in balancing the ecological system by progressively take part in nutrient cycling and imitation of air pollution through active accretion, deposition, and assimilation [8]. Debris and particulate matters get adsorb on the leaf surface or get absorbed inside the leaf through stomatal pores [9]. Vegetation can also eliminates pollutants like SO$_2$, HF (Hydrogen Fluoride), PAN (Peroxyacetyl nitrate) and heavy metals such as Hg, Pb from the air [10, 11, 12, and 13]. Sensitivity and tolerance of air pollution varies from plants to plants [14]. Therefore the role of plants in elimination of air pollution have been growing more and more in the upcoming years [14].

Due to exposure towards industrial and vehicular pollution plant shows different changes in physicochemical (relative water content, leaf extract pH) and biochemical characteristics (chlorophyll content, and Ascorbic acid) [18]. Indicator of tolerance of plant is assessed by Air pollution Tolerance Index (APTI) [19, 20]. Plants with APTI Index of $\leq$11 as sensitive, 12-16 as moderately tolerant and $\geq$17 as tolerant towards air pollution [21].

In the present study evaluation of major air pollutants like SO$_2$, NO$_2$, and PM$_{2.5}$ for 12 month at the experimental site was done to examine the air quality. Biochemical parameter (Tch, pH, RWC, AA) were assessed in six selected plants found commonly growing at experimental as well as control site in the Lucknow city. These biochemical parameters were used to determine APTI. It can be helpful to grade the plants in sensitive, moderate and tolerant to pollution. Damage caused by air pollutants to sensitive plants can be quite grievous while as on tolerant trees damage is to a lesser extent. Sensitive plants can be used as early warning flags of air pollution. The APTI of various species shall be useful to suggest the green belt in vicinity.

2. Materials and Methods

2.1. Study Area

Lucknow is the capital of Uttar Pradesh and second largest city in the state. Lucknow has always been known as a multicultural city and thrive as a cultural, industrial and aesthetic capital of North India. This city is situated at the bank of Gomati River 123m above MSL from 26°30-27°10 N and 80°30-81°13E. According to World Air Quality Report 2018 Lucknow ranked as 9th most polluted city in the world. The study areas were classified into 2 zone (1) Talkatora Industrial Area 26°83N, 80°89E as experimental site (E) having different types of industries and (2) Campus of Institute of Engineering and Technology 26°54N, 80°56E (C) with lots of green cover (Figure 1).

2.2. Plant sampling

Fresh leaves of six commonly growing plants *Azadirachta indica* (Neem), *Polyalthia longifolia* (Ashok), *Ficus religiosa* (Peepal), *Alstonia scholoris* (Devil tree), *Pongamia pinnata* (Karanja), and *Mangifera indica* (Mango) were selected from Experimental site as well as from control site. Healthy, mature and fully developed leaves were chosen. At least 20g of each sample were collected in the morning (8:00 AM to 10:00 AM) and immediately placed in the zip lock bag and transferred to the refrigerator in the laboratory for further analysis within 30 minutes.
2.3. Ambient air quality assessment
Ambient air quality was assessed by monitoring the major pollutants (SO$_2$, NO$_2$, and PM$_{2.5}$) for 12 months from January to December of 2019 through the data provided by Central Pollution Control Board (CPCB) India at the Experimental site.

2.4. Biochemical parameters determination

2.4.1. Total chlorophyll content
Total chlorophyll content was determined by the method given by Arnon [22]. For analysis 3g fresh leaves were crushed in mortar and pestle and then extracted with 20 ml of 80% acetone. The liquid portion was poured out into another test tube and centrifuged at 3000 rpm for 5 min, the supernatant was collected [23]. The absorbance of the extracted solution were measured at 643nm, 645nm and 663nm on the UV spectrophotometer. Calculation were done using the formula below:

$$\text{Chlorophyll a} = \frac{(12.7 \times D_{663} - 2.69 \times D_{645}) \times V}{1000 \times W} \text{mg/g}$$

$$\text{Chlorophyll b} = \frac{(22.9 \times D_{645} - 4.68 \times D_{663}) \times V}{1000 \times W} \text{mg/g}$$

$$\text{total Chlorophyll} = \frac{(20.2 \times D_{645} + 8.02 \times D_{663}) \times V}{1000 \times W} \text{mg/g}$$

Where,
- $V$ = total volume of the chlorophyll solution (ml)
- $D_x$ = Absorbance of the extract at the wavelength X nm
- $W$ = Weight of the leaf extract (g)

2.4.2. Relative water content
Relative water content (%) was analysed by following the method of Sen and Bhandari [24]. Fresh leaves of selected species were cleaned and weighed. The leaves were
then immersed in beaker all-night, took blotted dry weight next day and then leaves were dried at 80°C for 24 hour and weighed again. Then RWC were calculated by:

$$\text{Relative water content} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{dry weight}} \times 100$$

2.4.3. Leaf extract pH To determine the pH 1g of leaves were ground in mortar to make a paste and dissolved in 50 ml of deionized water, and extract pH were measured by using calibrated digital pH meter [25].

2.4.4. Ascorbic acid The ascorbic acid content (mg/g) was determined by following Sadasivam [26], using calorimetric 2,6-dichlorophenol indophenol as dye. 1g leaf sample is extracted in 4% oxalic acid and made up to a known volume of 20 ml and centrifuge at 4500 rpm for 5 min. pipette out 5 ml of the supernatant, and add 10 ml oxalic acid and titrated against the dye.

$$\text{Ascorbic acid} = \frac{0.5 mg \times V2 \times 20ml}{V1 ml \times 5ml \times \text{wt of sample}} \text{mg/g}$$

Where,

$V1 = \text{Volume of dye titrated against the working standard}$

$V2 = \text{Volume of dye titrated against the sample}$

2.4.5. APTI Determination APTI was determined by Singh and Rao [19] by using the following formula

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

Where,

$A = \text{Ascorbic acid (mg/g)}$

$T = \text{Total chlorophyll (mg/g)}$

$P = \text{Leaf extract pH}$

$R = \text{relative water content (%) }$

Table 1. Level of plants tolerance towards air pollution.

| S.No. | APTI value or range | Degree/Response or level of tolerance |
|-------|---------------------|--------------------------------------|
| 1.    | <11                 | Sensitive or bio-indicator           |
| 2.    | 11-17               | Moderate                             |
| 3.    | >17                 | Tolerant                             |
Figure 2. Monthly average concentration of air pollutants (a) NO\textsubscript{2} (b) SO\textsubscript{2} (c) PM\textsubscript{2.5} at experimental site.
3. Result and Discussion

3.1. Air Pollution status
The annual average concentration of SO$_2$ for the experimental site was 13.34 µg/m$^3$, and annual average concentration of NO$_2$ was 42.69 µg/m$^3$ (Figure 2). PM$_{2.5}$ has annual average concentration 119.54 µg/m$^3$ (Figure 2). The NAAQS (National Ambient Air Quality Standard) value prescribed by CPCB for industrial, residential and rural areas for SO$_2$ is 50 µg/m$^3$, NO$_2$ is 40µg/m$^3$, and for PM$_{2.5}$ is 40µg/m$^3$. The Value of SO$_2$ found was within permissible limit, but NO$_2$ was slightly above than permissible limit and PM$_{2.5}$ was much higher than permissible limit. Figure 2 (c) shows that PM$_{2.5}$ has maximum value in winter season (November, December, and January) because these particles get trapped due to inversion and valley effect of city.

3.2. Total Chlorophyll content
The table 2 shows the chlorophyll values at both experimental and control site. The minimum value has been shows by P. longifolia at experimental as well as at control site being 0.35mg/g and 1.29mg/g respectively. F. religiosa shows the maximum value at experiment time as 4.24 mg/g and A. indica juss at control site as 6.20 mg/g. Total chlorophyll content predicate photosynthetic activity and growth of plants. The variation in Tch content in plants gets deviated/altered in accordance with plant species and pollution level. Increase in pollution level at a site make a relative negative effect on Tch content of plants. Due to pigments systematic organisation. Tch can resist considerable interference in many photochemical processing/reactions like pheophytinisation, redox reaction, and reverse bleaching [27]. SO$_2$ have strong influence on chlorophyll content of leaves because it attacks on chloroplast and decreased its synthesis [28]. Higher chlorophyll value shows the high tolerance of the plant [29].

3.3. pH
Leaf extract pH as shows in table 2, at experimental site A. scholoris shows minimum value of 6.62 and F. religiosa shows maximum value of 7.67. At control site minimum value shown by A. indica juss as 6.28 and maximum value 8.07 of F. religiosa. In the present study pH range of 5-7 is shows by maximum plants. According to (Scholz and Reck) leaf pH is reduced in the presence of an acidic pollutants like So$_x$ and NO$_x$, and this reduction rate is less in tolerant plant species than sensitive plant species [30]. Prominent decrease in pH value shows the sensitive species hence minimum change in pH indicates tolerant species [30].

3.4. Relative water content
Variation in RWC in the leaf sample of experimental and control site shows in table 2. P. pinnata shows minimum RWC 65.92% and M. indica gives maximum 85.30% and at control site, P. pinnata minimum of 69.24% and maximum by F. religiosa as 83.67%. Result shows unevenness in RWC both at experimental as well as control site. RWC of a leaf shows the presence of water with respect to its fully blotted condition. And it also consociate with protoplasmic permeability in cells which affects the dissolved nutrients and water loss hence early ageing of leaves [31]. As RWC value increases tolerance capacity of plant is also increases [32].

3.5. Ascorbic acid
P. longifolia shows the least amount of Ascorbic Acid as 2.30 mg/g and 2.47mg/g at both experimental as well as control site in reference to table 2 respectively. Whereas A. indica juss shows 17.286mg/g and 19.25mg/g at both the studied sites. Increment in level of AA in tense conditions protects the chloroplast against SO$_2$ stimulate H$_2$O$_2$, O$_2$ and OH collection [33, 34].Study shows that
species having higher AA value have higher tolerance in agreement with the findings of Rai and Panda and Noor [14, 35].

Table 2. The bio-chemical parameter of plant species at experimental and control site.

| S.No. | Plant species  | site | TCH (mg/g) | pH | RWC (mg/g) | AA (mg/g) | APTI (mg/g) |
|-------|----------------|------|------------|----|------------|-----------|-------------|
| 1.    | *A. indica juss*| *E*  | 4.11± 0.75 | 6.83± 0.06 | 68.68± 0.39 | 17.28± 0.44 | 25.66± 2.94 |
|       |                | *C*  | 6.20± 0.608| 6.28± 0.075| 74.53± 0.35 | 19.25± 0.35 | 31.79± 2.94 |
| 2.    | *P. longifolia* | *E*  | 0.35± 0.023| 6.77± 0.087| 80.20± 1.08 | 2.03± 0.624 | 9.66± 0.822 |
|       |                | *C*  | 1.29± 0.091| 7.20± 0.30  | 76.15± 1.06 | 2.47± 0.451 | 9.73± 0.829 |
| 3.    | *F. religiosa* | *E*  | 4.24± 0.24 | 7.67± 0.05  | 78.46± 0.91 | 15.83± 0.21 | 26.82± 1.57 |
|       |                | *C*  | 4.85± 0.05 | 8.07± 0.076 | 83.67± 1.83 | 12.73± 0.59 | 24.82± 1.57 |
| 4.    | *A. scholoris* | *E*  | 3.27± 0.03 | 6.62± 0.203 | 73.70± 1.47 | 6.58± 0.48  | 13.89± 1.09 |
|       |                | *C*  | 2.63± 0.112| 7.12± 0.104 | 79.42± 1.06 | 5.20± 0.414 | 13.02± 0.89 |
| 5.    | *P. pinnata*   | *E*  | 3.21± 0.14 | 7.04± 0.212 | 65.92± 1.26 | 2.87± 0.70  | 9.56± 1.33  |
|       |                | *C*  | 2.30± 0.095| 7.60± 0.265 | 69.24± 1.02 | 2.56± 0.412 | 9.47± 0.849 |
| 6.    | *M. indica*    | *E*  | 1.57± 0.16 | 7.20± 0.21  | 85.30± 1.09 | 5.68± 0.88  | 13.54± 1.53 |
|       |                | *C*  | 1.84± 0.106| 6.54± 0.169 | 80.90± 0.47 | 5.68± 0.887 | 14.41± 0.72 |

3.6. Air pollution tolerance index of plant species

APTI of selected species at experimental site was recorded as *P. pinnata* (9.56) < *P. longifolia* (9.66) < *M. indica* (13.54) < *A. scholoris* (13.89) < *A. indica juss* (25.66) < *F. religiosa* (26.67). But at control site it was *P. pinnata* (9.47) < *P. longifolia* (9.73) < *A. scholoris* (13.02) < *M. indica* (14.412) < *F. religiosa* (24.82) < *A. indica* (31.79) shows in Table 2. Entire result obtained from this study suggest that *A. indica juss* and *F. religiosa* are tolerant species as their APTI is >17. Whereas *P. pinnata* and *P. longifolia* are sensitive or bio- indicator shows APTI is <11. High APTI in combination with efficient impact of pollution on membrane lipid peroxidation give a better evidence of tolerant plant. So that from this study *F. religiosa* and *A. indica juss* can be suggested to develop green belt in the vicinity.

3.7. Statistical analysis of bio chemical parameter and APTI

Statistical analysis was done by SPSS and Excel analysis and result shows in the fig. 2. A very high positive correlation was shown between Ascorbic acid and APTI (R²=0.9854) and pH of leaf extract (R²=0.2279), and Total Chlorophyll content (R²=0.5301) shows lesser significance and insignificant correlation exist between RWC (R²=0.0062). These correlation indicates that as air pollution increases Ascorbic acid also increases to counteract the tense condition.
4. Conclusion
The present study concluded that the Talkatora industrial area have high pollution level, which affect the health of human, and plants. Plant can be used as cost effective measure to mitigate air pollution. APTI is a very useful tool to identify the tolerant and sensitive plant. Geography plays an important role on the behaviour of a plant to be tolerant or sensitive. In the same light the results found for a plant in this study shows difference to air pollution at both the sites. Thus for the green belt development F. religiosa and A. indica juss prove to be high tolerant species towards air pollution.

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