Air Pollution Resistance assessment of existing plants near Talkatora Industrial Area, Lucknow, India

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Abstract. According to recent reports India is considered as 5th most polluted country of the world. Being a developing country, growing industrialization is a prime reason of pollution in India. Green vegetation plays an important role in reducing the air pollution through active absorption and accumulation. Thus the presence of greenery in concerned areas provides a cost-effective and environmentally benign way to remediate air pollution. The presented investigation was conducted to estimate air pollution by evaluating Air Pollution Tolerant Index (APTI) and Anticipated Performance Index (API) of 6 plant species in experimental area Talkatora industrial area, Lucknow, and control area IET college campus, Lucknow. Study revealed APTI of selected plants as *Ficus religiosa* (26.69) > *Azadirachta indica* (25.66) > *Alstonia scholaris* (13.89) > *Mangifera indica* (13.89) > *Polyalthia longifolia* (9.66) > *Pongamia pinnata* (9.56) at the experimental site and *Azadirachta indica* (31.79) > *Ficus religiosa* (24.82) > *Mangifera indica* (14.41) > *Alstonia scholaris* (13.02) > *Polyalthia longifolia* (9.73) > *Pongamia pinnata* (9.47) at control site. Supported by assessment of API, it was observed that *Ficus religiosa* (81.25%), *Azadirachta indica* (75%) and *Mangifera indica* (75%) were highest scoring plants thus can be suggested for development of green belt in the pollution concerned areas.

Keywords: Air pollution, APTI, API, Biochemical parameter, Socio-economic character, plant.

1. Introduction

There are encroachment of air pollution on our surrounding such as natural ecosystem, human health and recent most problematic agenda climate change [1], as developing country India is having speedy industrialisation and vehicular traffic mainly in metropolitan area is great menace to air quality [2]. Air pollution Tolerance Index (APTI) is dependable for screening of plants to know their tolerance and sensitivity towards air pollution [3]. APTI is efficient to assess the effect of air pollutant only on biochemical parameters such as Total chlorophyll content, Ascorbic acid, Relative water content and pH. To fight air pollution by green belt development, some socio-economic and biological features are taken in account to develop Anticipated Performance Index (API) [4]. A study conducted by Ogunkunle[5] shows that the given combination of Air Pollution Tolerance Index (APTI) and Anticipated Performance index (API) is of great significance since only biochemical parameters cannot be taken as ideal for development of plant reaction to pollutants for green belt development. Jointure of these biochemical and physiological parameters gives undeviating result as individual parameters can
be fallible [6]. For selection of plant species intended for improvement in air quality API in particular proves to be of more effective. This selection is even useful for offering aesthetic and recreational values [7].

APTI and API are assessed by biochemical parameters and universally relevant biological and socio-economic character respectively thus can be oriented worldwide. For evaluating biochemical and socio-economic parameter, selected plant species were measured by various biochemical factors. These parameters are made accountable for grading scale to establish API [8]. Lucknow being the capital of state it grows rapidly because of urbanisation and industrialisation that emits various pollutants in the air and affect the ambient air quality [9, 10]. Hence the present study conducted to assess the APTI and API indexes for the suitability of plant for mitigation of air pollution in the vicinity.

2. Materials and Methods

2.1. Description of study site

Lucknow city is located in Uttar Pradesh, India (Figure 1). This city is lies between 26°30'-27°10' N and 80°30'-81°13' E. Two sites were selected for the study, (a) Talkatora Industrial Area as polluted site (P) (26°83'N, 80°89'E) having various kind of industries and (b) Institute of Engineering and Technology campus as control site (C) (26°54'N, 80°56'E) having least pollution and more green cover.

![Map of polluted site and control site.](image)

Figure 1. Map of polluted site and control site.

2.2. Sample collection

Fresh leaves of six plants *Azadirachta indica* (Neem), *Polyalthia longifolia* (Ashok), *Ficus religiosa* (Peepal), *Alstonia scholoris* (Devil tree), *Pongamia pinnata* (Karanja), and *Mangifera indica* (Mango) were collected from both the sites. Three samples from each plants were randomly selected from lower most position at least 1.8-2.1m from ground level [11]. All the samples were collected in the morning between 8:00 AM-10:00 AM, placed in zip lock bag and taken to laboratory for further biochemical analysis.
2.3. Estimation of biochemical parameters

2.3.1. Total Chlorophyll content 2g of fresh leaves were picked out and cleaned thoroughly with distilled water and dried out at room temperature. Then leaves were crushed in mortar and pestle by adding 20ml of 80% acetone. To prevent impairment a pinch of MgCO₃ was added before extraction. Liquid portion was pour out in a test tube and centrifuged at 3000 rpm for 5 min, supernatant were collected [11] and absorbance was measured at 643nm and 645nm on the UV spectrophotometer. The calculation of total chlorophyll determination was done by Arnon [12].

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

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)

2.3.2. Ascorbic acid - 1g of sample was collected and extracted with 4% of oxalic acid prepare a known solution of 20ml and centrifuge at 4500 rpm for 15 min. supernatant of 5 ml was pipette out and add 10 ml oxalic acid and titrate against calorimetric 2,6-dichlorophenol indophenol dye. AA was calculated by following Sadasivam [13].

\[
\text{Ascorbic acid} = \frac{0.5 \times V_2 \times 20\text{ml}}{V_1\text{ml} \times 5\text{ml} \times \text{wt of sample}} \text{ mg/g}
\]

Where
- \(V_1\) = Volume of dye titrated against the working standard
- \(V_2\) = Volume of dye titrated against the sample

2.3.3. pH 2.5 g of sample was homogenized in 10 ml double distilled water. Mixture was filtered and pH was measured after PH meter was calibrated with pH 4 and pH 9 buffer solution [9].

2.3.4. Relative Water content Fresh sample were cleaned and weighed (FW). Then the leaves were immersed in water over night, next day these leave were dried with blotted paper and weighed (TW). After this samples were placed in oven for 24 hour at 80 °C and then take weight (DW). RWC was calculated by following Sen and Bhandari [14].

\[
RWC (\%) = \frac{FW - DW}{TW - DW} \times 100
\]

Where,
- \(FW\) = Fresh weight
- \(DW\) = dry weight
- \(TW\) = Turgid weight

2.4. Air Pollution Tolerance Index (APTI) determination Formula was given by Singh and Rao [15] for the calculation of APTI,
\[ APTI = \frac{A(T + P) + R}{10} \]

Where,
- \( A \) = Ascorbic acid (mg/g)
- \( P \) = pH
- \( T \) = Total chlorophyll content (mg/g)
- \( R \) = Relative water content (%)

Table 1. Gradation of APTI value by Padmavath [16].

| S. No. | APTI value | Response |
|--------|------------|----------|
| 1.     | ≤11        | Sensitive|
| 2.     | 12-16      | Intermediate|
| 3.     | ≥17        | Tolerant |

2.5. Anticipated performance Index (API) assessment

API was determined for plant species based on their APTI and Biological and socio-economical character, based on these characteristics Grade (+ or -) were allotted and plants were scored using these grades (Table 2, table 3). API assessment category were determined by percentage scoring. These plants were assessed according to different score classify as “Not recommended to Best”.

\[ \% \text{ Scoring} = \frac{\text{Grades obtained by plant species}}{16} \times 100 \]

Maximum grades that can be allotted to a Tree species = 16

Table 2. API assessment category of plant species.

| S.No. | Score (%) | Assessment category |
|-------|-----------|----------------------|
| 1.    | >30       | Not recommended       |
| 2.    | 31-40     | Very poor            |
| 3.    | 41-50     | Poor                 |
| 4.    | 51-60     | Moderate             |
| 5.    | 61-70     | Good                 |
| 6.    | 71-80     | Very good            |
| 7.    | 81-90     | Excellent            |
| 8.    | 91-100    | Best                 |

\textit{Source:} Govindaraju, Prajapati and Tripathi [4, 17]
Table 3. Gradation of plant species on the basis of APTI as well as biological parameters and socioeconomic importance.

| Grading Character | Pattern of assessment | Grade allotment |
|-------------------|-----------------------|-----------------|
| Tolerance         | APTI                  |                 |
|                   | 9.0-12.0              | +               |
|                   | 12.1-15.0             | ++              |
|                   | 15.1-18.0             | +++             |
|                   | 18.1-21.0             | ++++            |
|                   | 21.1-24.0             | +++++           |
| 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             | +               |
| Laminar structure | Size                  | Small           | -               |
|                   |                      | Medium          | +               |
|                   |                      | Large           | ++              |
| Texture           | Smooth                | -               |
|                   | Coriaceous            | +               |
| Hardiness         | Delineate             | -               |
|                   | Hardy                 | +               |
| Economic value    | less than 3           | -               |
|                   | 3 or 4 uses           | +               |
|                   | 5 or more uses        | ++              |

Source: Prajapati and Tripathi [4, 17]

3. Result and discussion
Impact of biochemical parameters and APTI of different plants species at polluted and control site are given in table 1 and Comparison between biochemical parameters were concludes in Figure 2.

3.1. pH
pH of leaf samples collected from both polluted as well as control site were given in table 4. At polluted site pH varies from 6.62 to 7.67 and at control site from 6.28 to 8.07. The maximum pH was found in F. religiosa (7.67), whereas minimum was observed in A. scholoris (6.62) at polluted site. At control site, A. indica juss have minimum value as 6.28 and maximum pH 8.07 observed in F. religiosa (Figure 2). pH plays an important role to modulate the sensitivity of plant towards pollution [18]. Gaseous air pollutants like SO$_2$, NO$_2$ and CO$_2$ diffused in the cell sap of plants thus pH changes into acidic nature [18, 19, and 20]. Conversion of hexose sugar to AA is reduced by low pH [21, 22]. Plant species having high pH have high tolerance towards air pollution [23, 24].
3.2. Total chlorophyll content
Table 4 shows the Chlorophyll values of samples at experimental and control site. The maximum value has been shown by *F. religiosa* and *A. indica juss* at both the sites with the value being 4.24 mg/g and 4.11 mg/g at polluted site and 20 mg/g and 4.85 mg/g at control site, respectively (Figure 2). Total chlorophyll content was seen to be decreasing at the polluted site, because various air pollutants attacked the chloroplast of leaf and decrease the synthesis of chlorophyll [25].

Table 4. The bio-chemical parameter and APTI of plant species at Polluted and control site.

| S.No. | Plant species | site | TCH (mg/g) | pH | RWC (%) | AA (mg/g) | APTI (mg/g) |
|-------|---------------|------|------------|----|---------|-----------|-------------|
| 1.    | *A. indica juss* | P    | 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* | P    | 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* | P    | 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* | P    | 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*  | P    | 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*   | P    | 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   |

3.3. Ascorbic acid
AA is a potent antioxidant and efficiently scavenge the free radical and reactive free oxygen produced due to photo-oxidation of chemical pollutants like SO\(_2\) and N\(_2\)H\(_3\). This action of Ascorbic acid aids greatly into maintaining cell wall in the process of cell multiplication into stress conditions [22, 26, 27, and 28]. Ascorbic acid plays a vital role in calculation of APTI because it can preclude plant tissues from unfavourable effect of pollutant [29]. Highest and lowest total AA content of 17.286 mg/g and 2.30 mg/g recorded in *A. indica juss* and *P. longifolia* respectively from polluted area (Table 4). Whereas *A. indica juss* and *P. longifolia* have maximum and minimum value at control site as 19.25mg/g and 2.47mg/g respectively given in Table 4 and (Figure 2).

3.4. Relative water content
Relative water content of plant sample from polluted and control site was shown in table 4. *M. indica* and *F. religiosa* have high RWC at Polluted and control site as 85.30% and 83.67% respectively. And *P. pinnata* shows minimum value 65.92% and 69.24% at both polluted as well as control site, respectively (Figure 2). In plants, various physiological conditions like respiration, transpiration and growth was directly related [8]. High percentage of RWC under tense conditions can increase the tolerance of plants [15, 22].
3.5. APTI

APTI of selected plants from polluted and control site were shown in table 4. APTI of plants from control site ranged from 9.47 to 31.79. APTI of plants from polluted site were ranged from 9.56 to 26.69.

At polluted site APTI value was varied as $P. \text{pinnata} (9.56) < P. \text{longifolia} (9.66) < M. \text{indica} (13.54) < A. \text{scholoris} (13.89) < A. \text{indica juss} (25.66) < F. \text{religiosa} (26.69)$. Whereas APTI value at control site were $P. \text{pinnata} (9.47) < P. \text{longifolia} (9.73) < A. \text{scholoris} (13.02) < M. \text{indica} (14.41) < F. \text{religiosa} (24.82) < A. \text{indica} (31.79)$. APTI value at polluted site and control site categorized $A. \text{indica juss}$ and $F. \text{religiosa}$ as tolerant species and $p. \text{pinnata}$ as sensitive species.

Figure 2. Comparison of Biochemical parameters at polluted and control site.
3.6. Anticipated Performance Index (API)

The API values of all six plant species from polluted site and control site was shown in table (5 and 6).

Table 5. Evaluation of API of plant species on the basis of their APTI and Biological and socio-economic characteristics.

| Plant species | APTI | Plant canopy Type of Laminar Hardiness Economic Importance |
|---------------|------|------------------------------------------------------|
|               | Habit structure | plant Texture | Size |
| F. religiosa  | ++++ | ++ | + | + | ++ | + | + |
| A. indica juss| ++++ | ++ | ++ | - | - | - | + | ++ |
| P. longifolia | + | ++ | - | + | + | + | + |
| A. scholoris  | ++ | + | ++ | + | + | + | - | + |
| P. pinnata    | + | + | ++ | - | - | + | - | ++ |
| M. indica     | ++ | ++ | ++ | + | + | + | + | ++ |

Table 6. Assessment of API of plant species.

| Plant species | Grade | API value | Assessment |
|---------------|-------|-----------|------------|
|               | Total plus (+) | Percentage |            |
| F. religiosa  | 14 | 87.5% | 6 | Excellent |
| A. indica juss| 12 | 75% | 5 | very good |
| P. longifolia | 8 | 50% | 2 | poor |
| A. scholoris  | 9 | 56.25% | 3 | moderate |
| P. pinnata    | 7 | 43.75% | 2 | poor |
| M. indica     | 12 | 75% | 5 | very good |

API has been determined by various researchers Pandey, Sahu and Sahu and Dhankhar [7, 8, and 30]. According to API, F. religiosa (87.5%) was the highest scoring plant which is categorized as excellent species. A. indica juss and M. indica have the same score (75%) which is very good for Green belt recommendation while A. scholoris with the score of (56.25%) classified as moderate, whereas P. longifolia and P. pinnata with the lowest score (50% and 43.75%) respectively, categorized as poor species.

4. Conclusion

The present study shows that APTI of a plant may not give the significant result as it was calculated only by Biochemical parameters. But Anticipated performance index of plant with the Air Pollution Tolerance Index can be of immense importance. It covers all parameters like Biochemical, Biological and socio-economic aspect of plants. This study can be used as better understanding of selection of plants based on APTI and API. Study suggested that Ficus religiosa, Azadirachta indica juss, and Mangifera indica should be planted in the Talkatora Industrial estate of Lucknow for better air quality.
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