

# Some roadside medicinal weeds as bio-indicator of air pollution in Kolkata

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## ABSTRACT

Air pollution is a significant matter of concern in today's world. The current study objective is to determine the air pollution tolerance index (APTI) of Kolkata from five roadside medicinal plants, namely, *Heliotropium indicum*, *Tridax procumbens*, *Cleome rutidosperma*, *Commelina benghalensis*, and *Euphorbia hirta*. APTI was determined by fresh leaves extracts using four important plants physiological parameters such as relative water content, ascorbic acid (AA) content, total chlorophyll (Chl) content, and pH of leaf extracts. Three sites or areas were selected for the study in Kolkata. It includes a control area (Jadavpur), a moderately polluted area (Salt Lake, Sec V), and highly polluted area (Dunlop Bridge) based on the West Bengal State Pollution Control Board databases and previous study reports. For estimating Chl and AA content spectrophotometer and titration method were used, respectively. A higher APTI value was found in plants located at the control area and moderately polluted area. However, the lower amount of APTI value was found in plants located in the polluted area. The study concludes that air pollution has a severe impact on plant and human health. The plant species with high APTI value can be planted around industrial complexes, roadsides, and urbanized sites to monitor air pollution in greener and cost-effective way.

## 1. INTRODUCTION

Air pollution is a severe global problem faced by developing as well as developed nations. It is also an increasing threat to human health. Air pollution increases the chance for several health ailments and even mortality, approximately 9% of global mortality. Simultaneously it plays a vital role for other secondary health disorders and related deaths [1]. The close relationships among air pollution, particulate matters (PM), and human health such as heart disorders, pulmonary, and other associated diseases are discussed in several previous studies [2-4]. Current research highlighted that among the several environmental factors, the air pollution, primary causative agent for respiratory disorders such as bronchitis and asthma and it was noticed to aggravate the risk of infection by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) and the fatality of the COVID-19, particularly for infants and lactating women [5-8]. This may be due to air pollution's negative impact and the COVID-19 shares the same target, respiratory tracts, for their pathogenesis [9].

A considerable amount of smokes emitted from vehicles, household, and industries which are making India's metropolitan cities an intolerable location for living systems in the present scenario.

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Therefore, it is mandatory to find out the places which are much polluted so that proper remedial steps can be taken to reduce the high air pollution level. Vehicles are the primary source of air pollutants such as carbon monoxide, nitrogen oxide, sulfur oxide, as well as suspended PM (SPM). Among different plans to control environmental pollution, absorption of several air pollutants (gaseous) by plants provides one of the best natural methods of cleaning the environment or urban atmosphere [10-14]. The forests or plantation naturally clears the environment by absorbing various gases and SPM through the leaves. Sensitive plants are suggested as prime biological indicators of air and environment pollution [15-17]. Plants sensitivity and responses toward different pollutants (gaseous and SPMs) are variable. Some species may be tolerant while others may be sensitive to air pollution. The much sensitive plant toward pollutants can play a bio-indicator of air or environment pollution [18].

Four biochemical and major plant physiological parameters such as ascorbic acid (AA) and total chlorophyll (Chl) content and leaf relative water content (RWC) as well as pH of leaf extracts were used to calculate the air pollution tolerance index (APTI). Understanding the responses or sensitiveness of plants to air and environment pollution at its physiological and biochemical level determination of APTI value is highly necessary. Environment planners and greenbelt developers can use the plants as bio-monitors to abate urban air pollution [11-13].

This current study aims at the determination of APTI from five common roadside medicinal weeds. For the study, three sites were selected from

Kolkata. It includes a control area, a moderately polluted area, and highly polluted area based on the West Bengal State Pollution Control Board databases and previous study reports [19,20]. From the current research knowledge's and information, it can be stated that the present study is the first research investigation report on APTI in Kolkata Metropolitan City.

## 2. MATERIALS AND METHODS

### 2.1. Chemicals

The analytical reagent graded chemicals were used in the current experiments. For quantitative assays in the present study, a spectrophotometer (Systronics 117) was used to measure the particular optical density (OD).

### 2.2. Study Site

Kolkata is the highly populated metropolitan city (area of 1887 sq.km) with a population of 1.49 crores. The 3<sup>rd</sup> most populous city in India positioned at 22.5726° N, 88.3639° E. Kolkata is situated 9.15 m from the sea level. The areas which were selected for the current investigation from Kolkata include a control area Jadavpur (JP), a moderately polluted area Salt Lake, (SL) Sec V, and highly polluted area Dunlop Bridge (DB). The study was done in August and September month of 2019.

### 2.3. Plants

The plant species which were selected for the current study are given in Table 1 [21-24].

### 2.4. Identification

Five roadside medicinal weeds fresh leaves were collected from Salt Lake Sector-V, Kolkata, and authenticated by Botanical Survey of India.

### 2.5. Determination of Chl Content

Determination of Chl content was carried out by a standard method of D.I. Arnon (1949) [19,25-28]. Seventy milligrams of leaves samples were extracted using 10–15 ml of 80% acetone solution, and it was centrifuged. The extracts' supernatant was collected in a separate falcon tube and it was repeated till the final residue becomes colorless. The final volume of the supernatant was made up to 30 ml. The OD was taken at a wavelength of 645 nm and 663 nm in triplicates. The amount of Chl content was determined by the help of the following formula:

$$\text{Chl a (mg/g tissue): } [12.7 * (A663) - 2.69 * (A645)] * \text{FV}/1000 * \text{FW}$$

$$\text{Chl b (mg/g tissue): } [22.9 * (A645) - 4.68 * (A663)] * \text{FV}/1000 * \text{FW}$$

$$\text{Chl (a + b) (mg/g fresh tissue): } [20.21 * (A645) + 8.02 * (A663)] * \text{FV}/1000 * \text{FW}$$

A = Absorbance, FV = Final volume (Chl extracts), FW = Fresh weight (leaves extracts).

### 2.6. Estimation of RWC

The fresh plant leaves' RWC was determined with the standard method of Singh (1997) [29]. Leaves fresh weight was taken and it was immersed in water for overnight. Then, the leaves turgid weight was taken. Again the leaves were dried for an overnight period at 70°C and then finally the dry weight of the leaves was obtained. The RWC is calculated as:

$$\text{RWC} = (\text{FW} - \text{DW}) / (\text{TW} - \text{DW}) * 100$$

Where, FW, TW, and DW indicates the fresh weight, turgid weight, and dry weight of the leaves samples

### 2.7. Determination of pH of the Plant Leaves Extracts

To evaluate the pH of plant leaves aqueous extracts, the standard method of Aremu *et al.*, 2010 was used [30]. One gram of the fresh plant leaves was crushed in 10 ml of double-distilled water, and then it was filtered. The pH was taken after calibrating the pH meter with a standard buffer solution of pH of 4 and 9.

### 2.8. Estimation of AA Content

The AA content was quantified using a standard iodine titration technique. Five grams of leaves were extracted with 100 ml of double-distilled water. A blue color formed and that persists up to 20 s of swirling. The final volume of the iodine solution was recorded. The calculation was carried out using the equation:  $V_1S_1 = V_2S_2$ . The AA amount was showed in mg AA equivalent/g fresh weight [31,32].

### 2.9. Calculation of APTI

The APTI values were evaluated using the following standard method (Singh and Rao, 1983) [33].

$$\text{APTI} = [\text{AA (Chl+pH)} + \text{RWC}]/10$$

Where,

APTI = Air pollution tolerance index

AA = Ascorbic acid amount (mg/g)

Chl = Total chlorophyll content (mg/g)

pH = pH of extracts (leaves)

RWC = Relative water content of leaves (%)

### 2.10. Calculation of % Reduction over Control (ROC)

The % ROC value was calculated using the standard method [11,13].

### 2.11. Statistical Analysis

The current experiments' measurements were done in triplicates and expressed as the averages of all the three statistical analyses  $\pm$  standard deviations. The means and standard deviations of the current research study results were calculated using MS Excel Software (Microsoft Corporation, Redmond, WA, USA).

**Table 1:** The plants' species selected for the present study.

Botanical name	Family	Common name	Local name
<i>Heliotropium indicum</i>	Boraginaceae	Indian heliotrope	Hatishur
<i>Tridax procumbens</i>	Asteraceae	Coat buttons	Tridhara
<i>Cleome rutidosperma</i>	Cleomaceae	Fringed spider flower	Nil Hurhure
<i>Commelina benghalensis</i>	Commelinaceae	Bengal day flower	Kanshira
<i>Euphorbia hirta</i>	Euphorbiaceae	Asthma plant	BoroKeru

### 3. RESULTS

The highest and lowest quantity of AA was observed in case of *C. benghalensis* at the control site (JP) and moderately polluted site (SL), and it is  $10.56 \pm 1.45$  and  $1.51 \pm 0.24$  mg/g of FW, respectively [Table 2]. Quantity of Chl was recorded as the highest amount in *E. hirta* at the control area (JP), and it is  $9.64 \pm 0.08$  mg/g of FW. The lowest content was observed in *C. benghalensis* at the polluted site (DB), and it is  $1.53 \pm 0.01$  mg/g of FW [Table 3]. The pH of the *H. indicum* was found to be the maximum at the control site (JP), and it is  $8.65 \pm 0.04$ . The minimum was observed in *E. hirta* at the moderately polluted site (SL), and it is  $5.26 \pm 0.05$  [Table 4]. The maximum RWC was showed in *C. benghalensis* at the polluted site (DB), and it is  $93.84 \pm 2.26\%$ , whereas the lowest value was observed in *E. hirta* at the control site (JP) and it is  $36.60 \pm 5.18\%$  [Table 5].

**Table 2:** Ascorbic acid content (mg/g of fresh weight) of plants leaves.

Plant name	Jadavpur	Salt lake	Dunlop bridge
<i>Heliotropium indicum</i>	4.94±0.82	4.25±0.63	3.29±0.41
<i>Tridax procumbens</i>	1.92±0.24	3.70±0.82	2.06±0.41
<i>Cleome ruidosperma</i>	6.31±1.26	3.43±0.63	1.78±0.63
<i>Commelina benghalensis</i>	10.56±1.45	1.51±0.24	2.33±0.63
<i>Euphorbia hirta</i>	3.84±0.63	2.74±0.86	6.72±0.63

**Table 3:** Total chlorophyll content (mg/g of fresh weight) of plants leaves.

Plant name	Jadavpur	Salt lake	Dunlop bridge
<i>Heliotropium indicum</i>	3.79±0.18	5.12±0.15	3.82±0.13
<i>Tridax procumbens</i>	3.01±0.15	1.69±0.07	1.80±0.05
<i>Cleome ruidosperma</i>	3.41±0.25	4.12±0.08	2.14±0.06
<i>Commelina benghalensis</i>	3.39±0.16	7.05±0.01	1.53±0.01
<i>Euphorbia hirta</i>	9.64±0.08	3.94±0.04	2.02±0.33

**Table 4:** pH of plant leaves extracts.

Plant name	Jadavpur	Salt lake	Dunlop bridge
<i>Heliotropium indicum</i>	8.65±0.04	7.38±0.06	7.76±0.04
<i>Tridax procumbens</i>	6.70±0.06	6.09±0.04	6.77±0.07
<i>Cleome ruidosperma</i>	5.84±0.04	5.68±0.04	5.84±0.04
<i>Commelina benghalensis</i>	6.60±0.05	6.45±0.05	6.51±0.06
<i>Euphorbia hirta</i>	5.70±0.05	5.26±0.05	6.43±0.02

**Table 5:** Relative water content (%) of plant leaves.

Plant name	Jadavpur	Salt lake	Dunlop bridge
<i>Heliotropium indicum</i>	75.80±6.40	83.31±2.87	43.92±3.37
<i>Tridax procumbens</i>	82.68±3.52	72.07±0.96	66.30±3.04
<i>Cleome ruidosperma</i>	62.57±7.67	74.21±3.80	70.78±5.61
<i>Commelina benghalensis</i>	76.04±10.49	73.46±1.51	93.84±2.26
<i>Euphorbia hirta</i>	36.60±5.18	70.04±1.77	37.34±0.82

**Table 6:** Air pollution tolerance index and reduction over control (ROC %) of plants leaves.

Plant name	Jadavpur	Salt lake	% ROC	Dunlop bridge	% ROC
<i>Heliotropium indicum</i>	13.72	13.64	0.58	8.20	40.23
<i>Tridax procumbens</i>	10.14	10.09	0.49	8.40	17.16
<i>Cleome ruidosperma</i>	12.10	10.78	10.91	8.50	29.75
<i>Commelina benghalensis</i>	18.16	9.39	48.29	11.26	37.10
<i>Euphorbia hirta</i>	9.55	9.53	0.21	9.41	1.47

The APTI of medicinal weeds was decreased from control to polluted sites except in case of *C. benghalensis* at the moderately polluted site (SL). The maximum reduction was observed at the highly polluted site (DB). The APTI of *H. indicum* showed a maximum decrease from control to the highly polluted site (DB), followed by *C. benghalensis*, *C. ruidosperma*, *T. procumbens*, and *E. hirta*. The mean % reduction of APTI over control expressed maximum decrease in *C. benghalensis* and the lowest reduction in *T. procumbens* at the moderately polluted site (SL). The mean % reduction of APTI over control described the maximum reduction in *H. indicum* and the lowest decrease in *E. hirta* at the highly polluted site (DB) [Table 6].

### 4. DISCUSSION

The decrease in AA content signifies the increased generation of reactive oxygen species at the time of photo-oxidation of  $\text{SO}_2$  to  $\text{SO}_3$ . AA promotes several physiological and defense procedures and it is a potent reducing agent as a previous study reported that it has a crucial role in the decrease of  $\text{SO}_2$  [34]. Chl is the primary photosynthetic pigments. Its content determines the normal growth, function, and development of the entire ecosystem and biomass and the complete health condition of vegetation. Reduction in Chl amount indicates  $\text{SO}_2$  pollution. It is the main target of the gaseous pollutants such as  $\text{CO}$ ,  $\text{NO}_2$ , and SPM [35]. In general, pH is an indicator of pollution level. It changes toward acidic range as the  $\text{SO}_2$  takes an entry to the leaf mesophyll tissues [11]. The current study results found some exceptions to these previous observations. RWC of a plant leaves helps control the normal physiological condition at various stress situations, and it indicates disturbed physiological states due to pollution [36,37]. APTI highly depends on plants' basic properties as the physiological and biochemical parameter levels vary highly from species to species [11,38].

COVID-19 infection rate and air pollution observed to have strong interrelations among each other, and it has been reported at the pandemic periods from many parts of the world [39]. SARS-COV-2 induced lockdowns and restrictions had very positive effects on decreasing the air pollution level [40-42]. The places where air pollution level and patients with comorbidities were high are observed with an increased rate of infection and severity and mortality of SARS COV-2 compared to the less polluted regions among different age groups [39,43,44]. Minimum SARS-COV-2 fatality rate was found in vegetated or forested areas that indicate the importance cleanliness of environment from gaseous pollutants. This critical finding also suggests the vital immunoprotection by the Mediterranean plants [45]. The previous study also indicated that some important plant species have a high absorption capacity of particular air pollutants. APTI value is generally applied to measure various plants' susceptibility or resistance limits for specific gaseous pollutants. The plantation of greenery of tolerant plant species can resist air or environment pollution to a particular limit. APTI is applied to choose the tolerant plants specifically for decreasing the various air pollution modes in the urban surroundings of Kolkata Metropolitan City, which supports the present research investigation's main objectives, too [10-12]. From the

current study results, it can be said that the medicinal weeds present in the highly polluted Metropolitan Cities with high APTI value may be able to reduce the severe COVID-19 infections and mortality rate and other respiratory disorders, too.

## 5. CONCLUSION

The present study results reflected the air pollutants positively influence that plant leaves' physiological and biochemical parameters. In the conclusion of the present study, it can be said that the plants with higher APTI value can be applied for the plantation in and around the industrial complexes, roadsides, and urbanized areas for reducing the heavy impact of air pollution. It will also help to decrease the chance of various human health ailments, including severe lung diseases.

## 6. FUNDING

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## 7. CONFLICTS OF INTEREST

The authors of the study declare that they have no conflicts of interest.

## 8. AUTHORS' CONTRIBUTIONS STATEMENT

Concept and Design, PG, SC; Data Acquisition, PG, SDC, TS, AS, SP; Data Analysis and Interpretation, PG, SDC, TS, AS, SP; Drafting Manuscript, PG, SDC, TS; Critical Revision, SC; Statistical Analysis, PG; Funding, No external funding received, chemical, and instruments support from the university, publication, and other fees from authors accumulated fund; Admin, Technical, or Material Support, Techno India University; Supervision, SC; Final Approval, PG, SC, SDC, TS, AS, SP.

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