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# STUDY ON AIR QUILITY AND AIR POLLUTION TOLERANCE INDEX OF SOME ROAD SIDE TREE PLANTS AT SATNA CITY M.P.

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## ABSTRACT

Air pollution tolerance index is very effective and important for selection of plants in order to check their susceptibility against any environmental stress like air pollution. This is a simple and easy method to adopt on different types of field conditions and reduced the use of costly environmental monitoring equipment's. To develop the usefulness of plants as bio-indicators requires an appropriate selection of plant species which entail an utmost importance for a particular situation. Air pollution tolerance index is used to select plant species tolerant to air pollution. Four physiological and biochemical parameters namely, leaf extract pH, ascorbic acid, total chlorophyll and relative water content were combined together in a formulation signifying the air pollution tolerance index of plants.

Air pollution tolerance index (APTI) is natural quality of plants to face problem of air pollution stress therefore, APTI of the plants needs to be checked properly especially of economically important plant species. Since plants are stationary and continuously exposed chemical pollutants from the surrounding atmosphere, air pollution injury to plants is proportional to the intensity of the pollution. Air pollution has become a major problem arising mainly from industrialization and urbanization during the last few decades. Particulate matter is of great concern in relation to their adverse impact on vegetation. The particulates and gaseous pollutants, alone and in combination can cause serious setbacks to the overall physiology of plants. Therefore, APTI of the plants monitored that are present in the road side and control areas.

**Key words:** air pollution, tolerance index, particular matter, chlorophyll, ascorbic acid.

## INTRODUCTION:

Air pollution is one of the severe problem world is facing today. Over the years, there has been a continuous growth in human population, road transportation, vehicular traffic and industries which increases the concentration of gaseous and particulate pollutants **(chaurasia et al 2013)**.Besides all

human activities which are the major cause of air pollution, there are some natural activities too which increase the air pollution. Thus, source of air pollution can be grouped into two major categories natural source and manmade source. Gasses Pollutant are NOx ( Oxides of Nitrogen), Sox (Oxides of Sulphur) and Particulate Matter($PM_{10,}$ $PM_{2.5}$).

**Air Pollution Tolerance Index (APTI):**

APTI is a species dependent plant attribute which expresses the inherent ability of the plant to encounter stress emanating from pollution. According to Mashita and Pise, 2001 there is a scale of APTI value which indicates the APTI value between 30-100 the species is tolerant ; APTI value 17- 29 as intermittently tolerant and plants registering APTI **(Agbaire & Esiefarierrhe 2009**)value in the range of 1-16 are considered as sensitive ;APTI value lower than 1 is branded as highly sensitive (table-2).

**Study Area**

Satna is a city in the Satna District of Madhya Pradesh in India, which shares a border with neighboring Uttar Pradesh. It is located at $24.34^0$ N $80.55^0$ E with an average elevation of 317 meters (1033 feet). Satna is the limestone belts of India. The location is renowned for dolomite mines and limestone. As a result, it contributes around 8%–9% of India's total cement production. There is an abundance of dolomite and limestone in the area and the city has many cement factories producing and exporting cement to other parts of the country. The electrical cable company Universal Cabale, Satna is among the pioneers in the country. Satna is known as the cement city of India.

**Objectives of study**

1. To know the Road side ambient air quality at Satna.
2. To determine air pollution tolerance index (APTI) of some road side plants.
3. To compare the air quality with standards.

**MATERIALS AND METHOD:**

Five sampling locations were selected for ambient air quality monitoring at road side to generate representative ambient air quality data. A control site was also monitored for ambient air quality. The sampling locations are shown in table (1).

**Table-1 Showing sampling stations for ambient air quality monitoring**

| S.N. | Name of Station | Station code | Type of Station |
|---|---|---|---|
| **1.** | Semariya Chowk | S1 | Commercial |
| **2.** | Sindhi Campus | S2 | Industrial |
| **3.** | Gahra Nalla | S3 | Commercial |
| **4.** | Ramtekari | S4 | Commercial |
| **5.** | Utaily | S5 | Residential |

The study was conducted in 2017 .Weekly air quality was monitored at all the five sampling station to determine ambient air quality $PM_{10}$, PM2.5, SOx and, NOx. Ambient air quality was monitored according to the CPCB (Central pollution control board) the methods prescribed for the pollutant gases and the particulate pollutants. Five tree sp. were selected to study air pollution tolrence index i.e *Psiduim guajava ,Mangifera indica ,Delbergia sisoo ,Madhuka indica , and Tectona grandis* . Ascorbic acid, $P^H$, relative water Content, and Total Chlolorophyll was measured in all the selected plants.

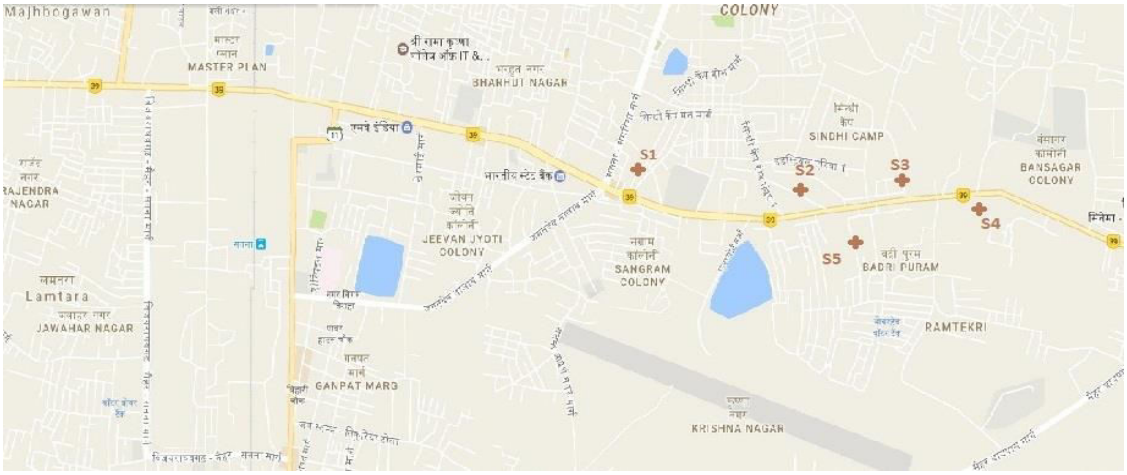



**Fig -1 Map of Satna showing sampling stations.**

**Plant Study**

On the basis of dominance, frequency of damage and economic importance five plants were selected *Psiduim guajava, Mangifora indica, Delbergia sisoo, Madhuka indica, Tectona grandis* from both road side and control site. pH, ascorbic acid, total chlorophyll, relative water content.

In the present study, fresh leaves were collected during pre-monsoon season (March to June) from road side from road side selected sampling station and control station (Away from 500 m from road side in Satna area) by following necessary precautionary measures plant sample were brought to the laboratory for analysis. Common plants identified were selected from both areas and leaf samples were immediately brought to the laboratory in polythene bag, kept in ice box for further analysis of various biochemical parameters.

**Biochemical parameters**

***pH***

100 mg of fresh leaves was homogenized in 10ml deionized water. This was filtered and pH of the leaf extract was determined after calibrating pH meter with buffer solution pH 4 and pH 9.

**Relative water content**

Fresh weight was obtained by weighing the leaves. The leaf samples were then immersed in water over night blotted dry and then weighed to get the turgid weight. The leaves were then dried overnight in a hot air oven at 70 0C and reweighed to obtain the dry weight. RWC was determined and calculated by the method as described by Singh 1977.

RWC= [(FW-DW) / (TWDW)] x 100.

Where: FW-Fresh weight, DW-Dry and TW-Turgid weight.

**Ascorbic acid content**

Ascorbic acid content was measured by Titrimetric method of Sadasivam 1987, using 2,6, Dichlorophenol indo phenol dye. 500mg of leaf sample was extracted with 4% oxalic acid and then titrated against the dye until pink color develops. Similarly a blank is also developed.

**Total chlorophyll and carotenoid content**

This was carried out according to the method described by Arnon 1949. 500mg of fresh leaves were blended and then extracted with 10 ml of 80% acetone and left for 15min. The liquid protein was decanted into another test tube and centrifuged at 2,500 rpm for 3 min. The supernatant was then collected and the absorbance was taken at 645 nm and 663 nm for chlorophyll a, b and 480, 510 nm for carotenoid using a micro controller based visible spectrophotometer (340- 990 nm).

Calculations were done by using the formula given below:

Total chlorophyll: Chlorophyll a + Chlorophyll b;

**Calculation of Air Pollution Tolerance Index (APTI)**

Air pollution tolerance index was assessed by Singh and Rao 1983. The air pollution tolerance index was calculated using the following formula:

APTI = A (T+ P) + R/10

Where:

A =Ascorbic Acid (mg/g)

T =Total Chlorophyll (mg/g)

P = pH of the leaf extract,

R = Relative water content of leaf (%)

**Table -2 APTI values are rated as follows;**

| APTI values | Response |
|---|---|
| 30-100 | Tolerant |
| 29-17 | Intermediate |
| 16-1 | Sensitive |
| <1 | Very Sensitive |

## RESULT AND DISCUSSION

### AMBIENT AIR QUALITY

**Particulate matter ($PM_{10}$):-** The $PM_{10}$ was measures at five ambient air quality station within the help of RDS .$PM_{10}$ the concentration from 75.72 – 213.00 µg/$m^3$ (table 3). The minimum concentration was found **75.72** µg/$m^3$ at S5 (Utaily) residential area within in the limit and maximum value was found 213.00 µg/$m^3$ at Sindhi Campus industrial beyond the limit prescribed by NAAQM (100 µg/$m^3$)

**Particulate matter ($PM_{2.5}$):-**$PM_{2.5}$ was measures at five ambient air quality station within the help of ambient fin dust sampler control module.$PM_{2.5}$ the concentration ranged from 44.32–80.76 µg/$m^3$ (table 4) . The minimum concentration was found 44.32 µg/$m^3$ at S5 (Utauly) residential area within the limit and maximum value was found 80.76 µg/$m^3$ at S4 (Ramtekari) commercial area beyond the limit prescribed by NAAQM (60 µg/$m^3$)

**Gaseous pollutant:-**Gaseous pollutant was measures at five ambient air quality stations with the help of RDS. Sulphur dioxide ($SO_2$) the concentration ranged from 4.77–17.15 µg/$m^3$ (table 5). The minimum concentration was found 4.77 µg/$m^3$ at S5 (Utaily) area and maximum value was found 17.15 µg/$m^3$ at Sindhi campus industrial area within the limit prescribed by NAAQM (80 µg/$m^3$)

**Nitrogen dioxide** ($NO_2$). The $NO_2$ concentration ranged from 9.19–26.80 µg/$m^3$ (table 6)**.** The minimum concentration was found 9.19 µg/$m^3$ at S5 (Utaily) residential area and maximum value was found 26.80 µg/$m^3$ at Sindhi Campus industrial within limit prescribed by NAAQM (80 µg/$m^3$).

**Table - 3. $PM_{10}$ at various sampling station**

| S. no | Month | Station code | | | | |
|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 |
| 1 | March | 134.12 | 180 | 112.33 | 111.32 | 69.21 |
| 2 | April | 154.54 | 212.8 | 120.80 | 122.43 | 74.48 |
| 3 | may | 166.55 | 220 | 131.45 | 129.99 | 75.67 |
| 4 | June | 177.80 | 243 | 147.22 | 143.78 | 83.55 |
| | Min | 134.12 | 180 | 112.33 | 111.32 | 69.21 |
| | Max | 177.8 | 243 | 147.22 | 143.78 | 83.55 |
| | Mean (±) | 158.25±18.68 | 213.95±26.04 | 127.95±15.04 | 126.88±13.62 | 75.72±5.92 |
| | Standard Error | 9.34 | 13.02 | 7.52 | 6.81 | 2.96 |

**Table- 4. $PM_{2.5}$ at various sampling station**

| S. no | Month | Station code | | | | |
|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 |
| 1 | March | 64 | 87 | 77.5 | 73.58 | 38.97 |
| 2 | April | 65 | 81 | 78.11 | 78.11 | 41.88 |
| 3 | may | 78 | 76 | 81.50 | 85.53 | 46.74 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | June | 84 | 75 | 84.76 | 88.78 | 49.70 |
| | Min | 64 | 75 | 77.5 | 73.58 | 38.97 |
| | Max | 84 | 87 | 84.76 | 88.78 | 49.7 |
| | Mean (±) | 72.75±9.84 | 79.75±5.5 | 80.46±3.35 | 81.5±6.91 | 44.32±4.80 |
| | Standard Error | 4.92 | 2.75 | 1.67 | 3.45 | 2.40 |

**Table- 5. SOx at various sampling station**

| **S. no** | **Month** | **Station code** | | | | |
|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 |
| 1 | March | 14.6 | 16.56 | 11.80 | 10.82 | 3.92 |
| 2 | April | 15.7 | 16.38 | 13.21 | 11.22 | 4.24 |
| 3 | may | 16.48 | 17.12 | 12.32 | 14.33 | 4.85 |
| 4 | June | 16.98 | 18.54 | 14.24 | 14.94 | 6.10 |
| | Min | 14.6 | 16.38 | 11.8 | 10.82 | 3.92 |
| | Max | 16.98 | 18.54 | 14.24 | 14.94 | 6.1 |
| | Mean (±) | 15.94±1.03 | 17.15±0.97 | 12.89±1.07 | 12.82±2.10 | 4.77±0.96 |
| | Standard Error | 0.51 | 0.48 | 0.53 | 1.05 | 0.48 |

**Table-6. NOx at various sampling station**

| **S. no** | **Month** | **Station code** | | | | |
|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 |
| 1 | March | 20.3 | 26.7 | 13.72 | 12.73 | 8.17 |
| 2 | April | 21.87 | 25 | 14.66 | 13.45 | 8.13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | may | 19.6 | 28.2 | 13.98 | 13.98 | 9.69 |
| 4 | June | 18.34 | 27.32 | 16.32 | 15.38 | 10.8 |
| | Min | 18.34 | 25 | 13.72 | 12.73 | 8.13 |
| | Max | 21.87 | 28.2 | 16.32 | 15.38 | 10.8 |
| | Mean (±) | 20.02±1.47 | 26.80±1.35 | 14.67±1.16 | 13.88±1.12 | 9.19±1.29 |
| | Standard Error | 0.73 | 0.67 | 0.58 | 0.56 | 0.64 |

**Table:-8. Average ambient air quality at various sampling stations.**

| S.N. | Name of Station | $PM_{10}$ ( µg/$m^3$) | $PM_{2.5}$ (µg/$m^3$) | $SO_2$ ( µg/$m^3$) | $NO_x$ ( µg/$m^3$) |
|---|---|---|---|---|---|
| 1. | Semariya Chowk | 158.25 | 72.75 | 15.94 | 20.02 |
| 2. | Sindhi Campus | 213.00 | 79.75 | 17.15 | 26.80 |
| 3. | Gahra Nalla | 127.95 | 80.46 | 12.89 | 14.67 |
| 4. | Ramtekari | 126.88 | 81.5 | 12.82 | 13.88 |
| 5. | Utaily | 75.72 | 44.32 | 4.77 | 9.19 |

**Table:-9 National ambient air quality (NAAQM) standards**

| S.No. | Parameters | Standards |
|---|---|---|
| 1 | $PM_{10}$ | 100 |
| 2 | $PM_{2.5}$ | 60 |
| 3 | $SO_x$ | 80 |
| 4 | $NO_x$ | 80 |

**Fig. 1:- Ambient air quality at Semaria Chowk**

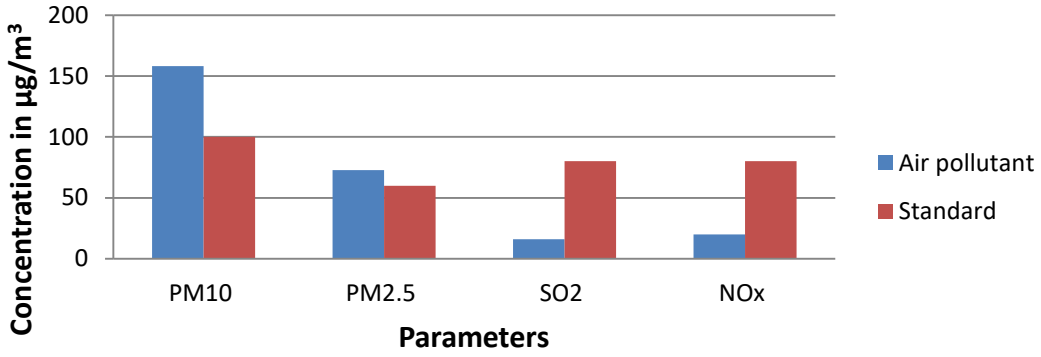



**Fig. 2:- Ambient air quality at Sindhi Campus**

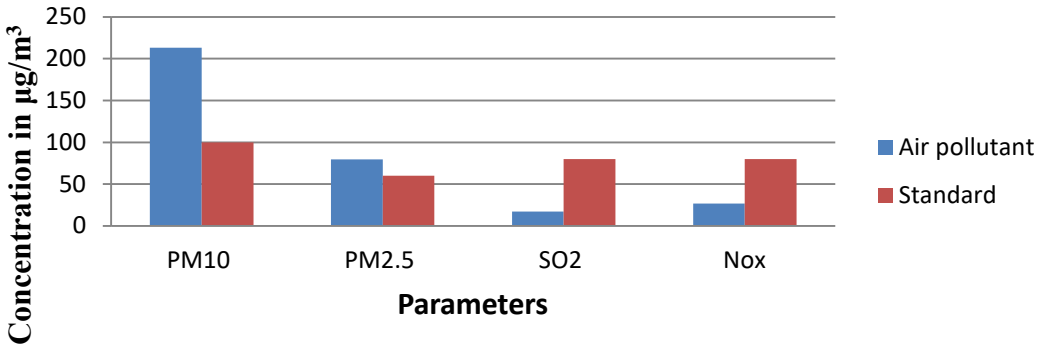
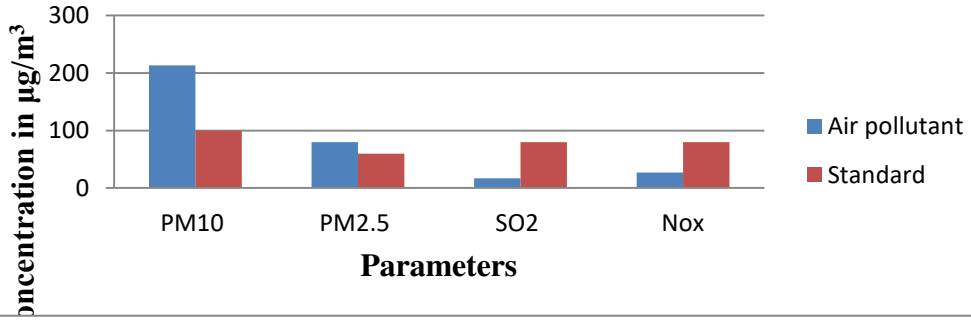



**Fig. 3:- Ambient air quality at Gahra Nalla**



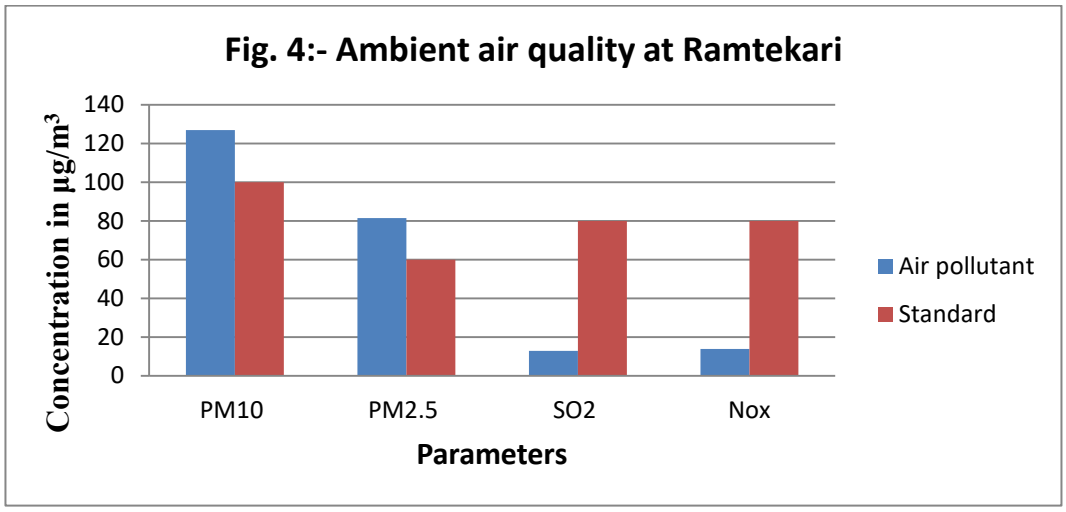


Fig. 4:- Ambient air quality at Ramtekari
Concentration in µg/m3
140
120
100
80
60
40
20
0
PM10
PM2.5
SO2
Nox
Parameters
Air pollutant
Standard

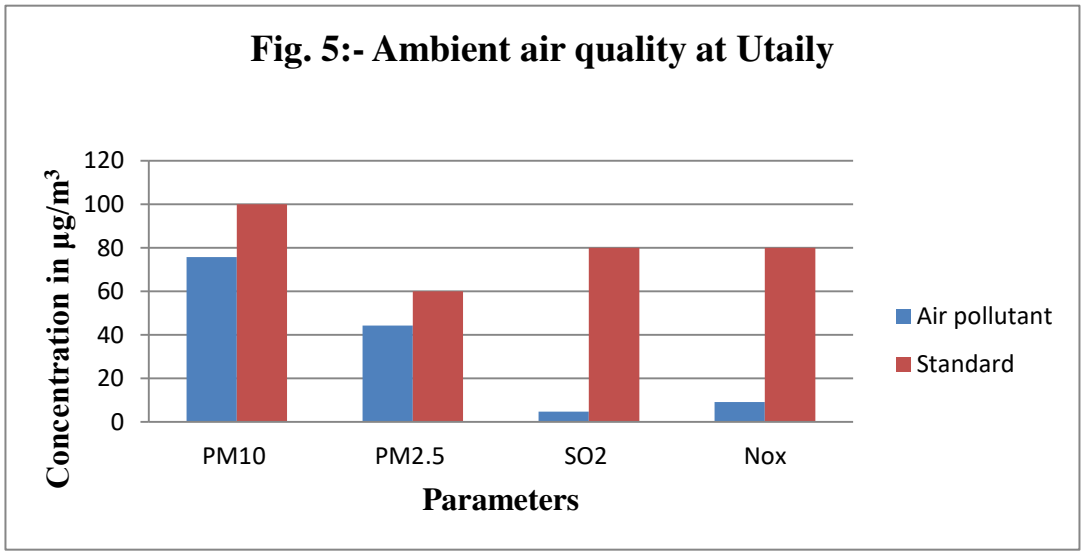


Fig. 5:- Ambient air quality at Utaily
Concentration in µg/m3
120
100
80
60
40
20
0
PM10
PM2.5
SO2
Nox
Parameters
Air pollutant
Standard

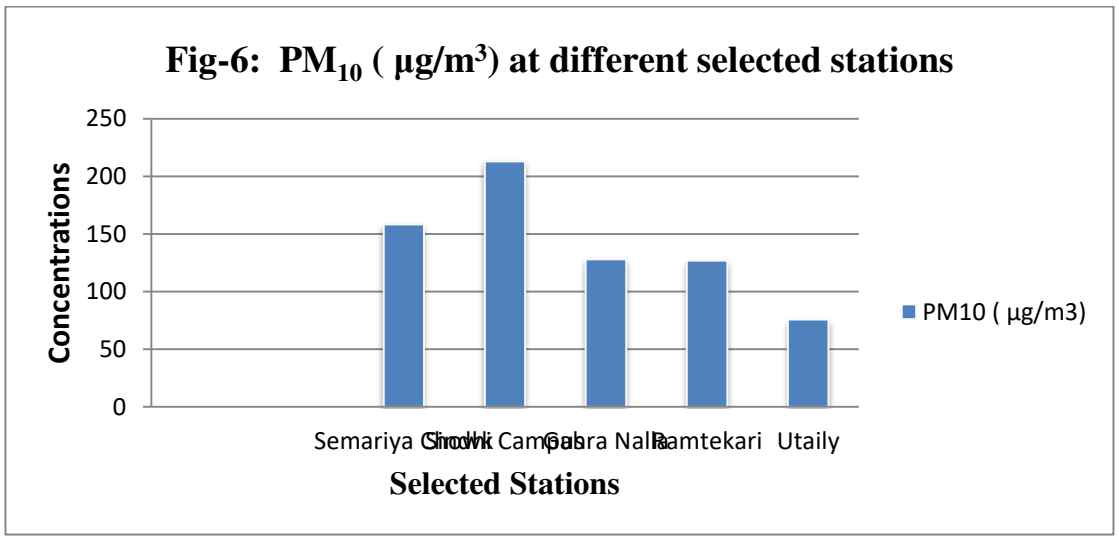


Fig-6: PM10 ( µg/m3) at different selected stations
Concentrations
250
200
150
100
50
0
Semariya
Chowki
Campus
Gabra Nala
Ramtekari
Utaily
Selected Stations
PM10 ( µg/m3)

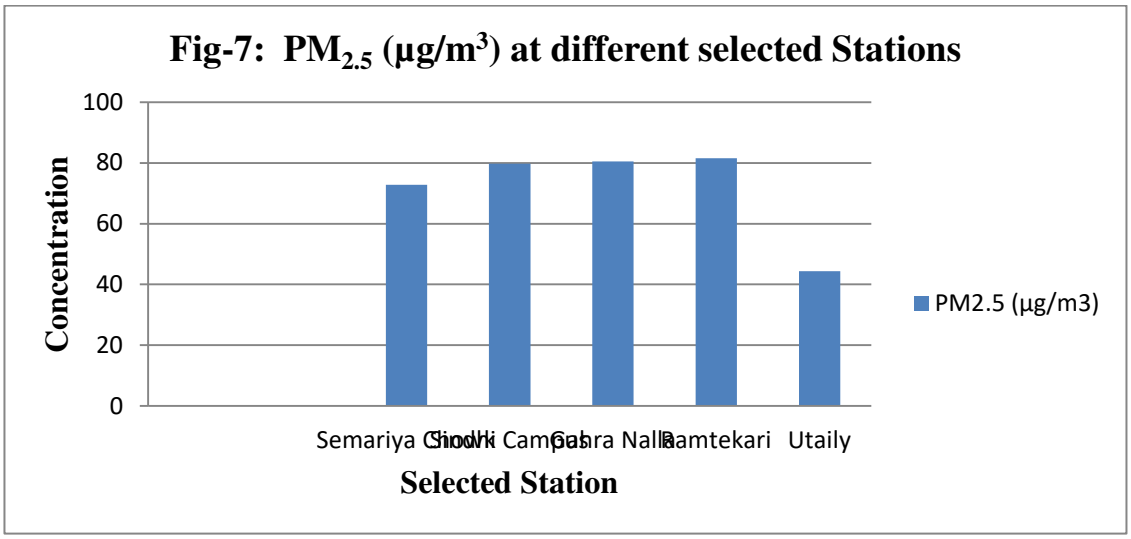


Fig-7: PM2.5 (µg/m3) at different selected Stations
100
80
60
40
20
0
Concentration
Semariya
Chindwi
Camp
Gabra Nalla
Ramtekari
Utaily
Selected Station
PM2.5 (µg/m3)

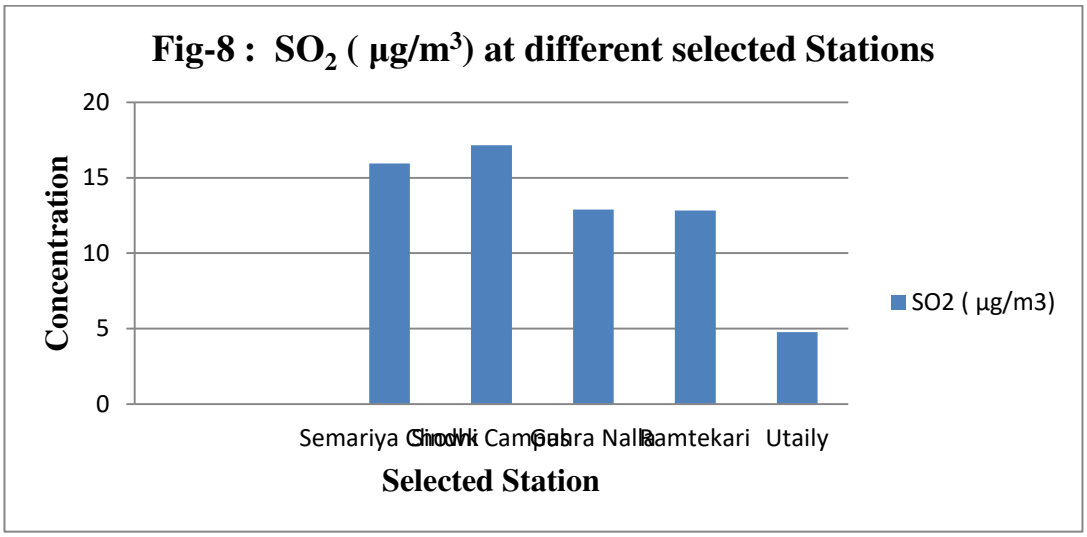


Fig-8 : SO2 ( µg/m3) at different selected Stations
20
15
10
5
0
Concentration
Semariya
Chindwi
Camp
Gabra Nalla
Ramtekari
Utaily
Selected Station
SO2 ( µg/m3)

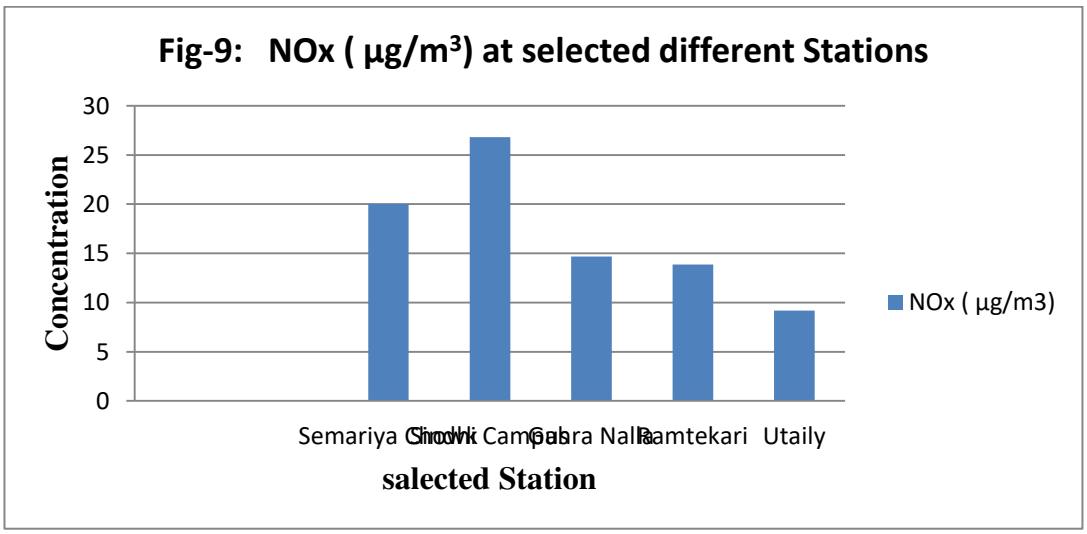


Fig-9: NOx ( µg/m3) at selected different Stations
30
25
20
15
10
5
0
Concentration
Semariya
Chindwi
Camp
Gabra Nalla
Ramtekari
Utaily
salected Station
NOx ( µg/m3)

## AIR POLLUTION TOLERANCE INDEX (APTI)

The biochemical characteristics and the APTI for plants from road site and control site are given in table 7.

**P$^{H}$**

pH of road site range was found 06.08-08.85. The minimum pH was observed 06.08 in Mangifora *indica* while maximum pH was 08.85 in Tectona *grandis* whereas pH of control site range was 05.28-07.26. The minimum pH of control site was observed 05.28 in Mangifora *indica* while maximum was 07.26 in Delbergia *sisoo*. Hence the leaf extract pH on the higher side gives tolerance to plants species against pollution **(Bell & Mudd 1976)**.

**Relative Water Content**

RWC of all plants species of control site were higher compared to road site plant species. At road site minimum RWC was found 64.76 % in Psiduim *guajava* while maximum RWC was 78.23 % in Mangifora *indica*. Whereas at control site minimum RWC was found 72.33 % in Delbergia *sisoo* while maximum was 87.45 % in Mangifora *indica*. The RWC indicates change in leaf matrix hydration condition and will generate higher acidity condition when RWC is low. More water will dilute acidity.

**Ascorbic acid**

Ascorbic acid of road site range was found 04.40-06.56 mg/g. The lower ascorbic acid was observed 04.40 mg/g in Delbergia *sisoo* while higher was 06.56mg/g in Mangifora *indica*. Whereas ascorbic acid of control site range was 05.17-08.72 mg/g. The lower ascorbic acid of control site was observed 05.17 mg/g in Delbergia *sisoo* while higher was 08.72 mg/g in Mangifora *indica*. Plants maintaining high ascorbic acid under pollutant conditions are considered to be tolerant to air pollution. Pollution load dependent increase in ascorbic acid content of all the plant species may be due to the increased rate of production of reactive oxygen species (ROS) during photo-oxidation of $SO_2$ to $SO_3$ where sulfites are generated from $SO_2$ absorbed **(Chaurasia et al. 2014)**. Higher ascorbic acid content of the plant is a sign of its tolerance against sulphur dioxide pollution **(Ashenden & willams 1980)**.

**Total chlorophyll (TC)**

Total chlorophyll of road site range was found 08.30-11.11 mg/g. The lower chlorophyll was observed 08.30 in Delbergia *sisoo* while higher was 11.11 in Mangifora *indica*. Whereas chlorophyll of control site range was 10-11-14.10. The lower chlorophyll of control site was observed 10-11 mg/g in Delbergia *sisoo* while higher was 14.10 in Mangifora *indica*.. Chlorophyll take part in Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass.

**Air Pollution Tolerance Index (APTI)**

Air pollution tolerance index is not an independent component but it involves four components such as pH, ascorbic acid, chlorophyll, relative water content. Any observed changes in these components lead to alteration in the level of air pollution tolerance index.

High dust collecting capacity may be one of the reasons for the sensitive plant species studied to become highly susceptible to the auto-exhaust pollutants, making reduction or increase of different biochemical and physiological parameters **(Farook et al. 2000)**.

APTI value of road site is lower as compared to the control site. The APTI of plant species from road site ranged from 13.59-18.96. The lower APTI was observed 13.59 in Delbergia *sisoo* while higher was 18.96 in Mangifora *indica*. The APTI value of control site ranged from 16.12-25.64. The lower APTI was observed 16.12 in Delbergia *sisoo* while higher was 25.64 in Mangifora *indica*. Dust pollution and chronic concentration of gaseous pollutants may affect the biochemical make up and tolerance capacity of plants to the air pollution (Rai et al., 2013).

Based on the previous studies (Lakshmi *et al*., 2008; Agbarie and Esiefarienrhe, 2009), APTI values can be utilized as bio-indicators of the air quality, while those species in the tolerant group can be used for development of streetscape greening.

**Table: 10. Air pollution tolerance index in different selected plant pollution and control side.**

| S.No. | Plant Name | pH | | Relative Water Content (%) | | T. Chlorophyll (mg/g) | | Ascorbic Acid (mg/g) | | APTI | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PS | CS | PS | CS | PS | CS | PS | CS | PS | CS |
| **1.** | *Psiduim guajava* | 7.39 | 6.2 | 68.76 | 79.28 | 09.67 | 12.65 | 4.76 | 6.43 | 15.7 | 21.93 |
| **2.** | *Mangifora indica* | 6.08 | 5.28 | 76.89 | 87.45 | 11.11 | 14.10 | 6.56 | 8.72 | 18.96 | 25.64 |
| **3.** | *Delbergia sisoo* | 8.23 | 7.26 | 64.00 | 72.33 | 08.13 | 10.71 | 4.40 | 5.17 | 13.59 | 16.52 |
| **4.** | *Madhuka indica* | 6.91 | 6.08 | 78.23 | 86.28 | 10.62 | 13.54 | 5.34 | 6.12 | 17.18 | 20.63 |
| **5** | *Tectona grandis* | 8.85 | 7.21 | 75.23 | 87.23 | 09.23 | 12.85 | 5.89 | 7.00 | 18.17 | 22.76 |

**PS** = Polluted site, **CS** = Control site

**Table 11. Selected plant of road side and observed APTI value**

| S.N. | Name of Plant | APTI Value | Response |
|---|---|---|---|
| **1.** | *Psiduim guajava* | 15.70 | Sensitive |
| **2.** | *Mangifora indica* | 18.96 | Intermediate |
| **3.** | *Delbergia sisoo* | 13.59 | Sensitive |
| **4.** | *Madhuka indica* | 17.18 | Intermediate |
| **5** | *Tectona grandis* | 18.17 | Intermediate |

## CONCLUSION & SUGGESTION

**Ambient air quality** : From the result of average value of one month (March to June, 2017, four times weekly) it was concluded that $PM_{10}$ was found (213.00) at Sindhi Campus (Industrial area) and $PM_{2.5}$ (80.46) at Ramtekari (Commercial area). $PM_{10}$ and $PM_{2.5}$ at all sampling station was found beyond the limit prescribed by NAAQM (100 μg/$m^3$ and 60 μg/$m^3$) except Utaily station. Gasses pollutant was found within the limit at all sampling station.

**Air pollution tolerance index (APTI):** The air pollution tolerance index was Sensitive for Mangifora *indica and* Psiduim *guajava in* road side plant and APTI was found intermediate in Mangifora *indica and* Tectona *grandis* .Plants that are continuously exposed to pollutants leads to accumulation of pollution, integration of pollutants in to their own system, thereby altering the nature of leaf and make them more sensitive. This sensitivity is measured through various biochemical changes and finally to air pollution tolerance index. In our study two plant species *Psiduim guajava*, and *Delbergia sisoo* were found sensitive and three plant species *Mangifora indica*, *Madhuka indica*, *Tectona grandis* were found intermediat.

Rapid urbanization, industrialization and population growth are associated with increase in air pollution. However trees play crucial roles in mitigation and indicating air pollution. The selection of trees that are tolerant of air pollution will benefit urban planning, design and environmental management. APTI of plants provides a simple and convenient method of achieving this. In the present study none of the tree species screened can be considered tolerant of air pollution in the study area. However, the intermediate species may be useful in mitigating air pollution.

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