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Air Pollution Tolerance Index of Some Terrestrial Plant Species of Government Arts College (Nandanam) Chennai

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Abstract: **Air pollution has own peculiarities due to its transboundary dispersion of pollutants over the entire world. In any well planned urban set up, industrial pollution takes a back seat and vehicular emissions take precedence as the major cause of urban air pollution. In the present study, Air pollution tolerance index was calculated for various plant species growing at Government Arts College, Chennai, India. The results showed significant effects of various air pollutants on the vegetation in terms of four biochemical parameters analyzed. Four biochemical parameters, which are leaf relative water content, Ascorbic acid content, total leaf chlorophyll content and leaf extract pH were used to compute the air pollution tolerance index values. On the basis of air pollution tolerance index values for above mentioned four tree species, *Polyalthia longifolia* exhibited the highest degree of tolerance at all the sites followed by *Peltophorum pterocarpum*, *Guazuma ulmifolia* and *Morinda tinctoria*.**

Keywords: **Air pollution tolerance index (APTI), Ascorbic acid content (AAC), Leaf extract pH, Relative water content (RWC), Total leaf chlorophyll content (TLC).**

1. INTRODUCTION

Air pollution is one of the serious problems around the world. The problem of air pollution derives its importance and severity through the activities of human. In economic point of view, industrial development is essential for the better development of every country, by the maximum use of natural resources (Nuzhat parveen Khan, 2005). In recent times there has been significant development activity in terms of industrialization and urbanization in almost all cities, medium and small towns in India. While the development of industrialization has contributed significantly to the economic growth, it has done so at a price to the environment. Most of the areas in India and other countries, the environment have reached its carrying capacity in terms of air pollutants like nitrous oxide (NO_2), sulfur dioxide (SO_2), carbonmonoxide (CO), carbondioxide (CO_2). Suspended particles and the toxic heavy metals like lead .the impact of such emission into the atmosphere and their movement into the biosphere by transformation, reaction and modification is responsible for variety of chronic and acute diseases at the local, regional and global scale (Rawat and banerjee, 1996).

Not only industrial pollution increases public health risk, it also consumes significant portion of India's gross domestic product, by the way of abatement effort. So an urgent need for preventing and controlling, of air pollution is essential for the country, which can be done only with the proper and strict implementation of environmental law. The Ministry of Environment and Forest (MoEF) tasked with the overall responsibility for administering and enforcing laws and policy, by adopting integrated environmental strategies into any development plan for the country. As such, the reduction of industrial pollution has become the main responsibility of MoEF (Morgenstern and William Pizar and Jhih, 1998).

Plants are an important basis for all ecosystems and also most likely to be affected by airborne pollution which are identified as the organisms with most potential to receive impacts from ambient air pollution .The effects are most apparent on the leaves which are the primary receptors of large number of air pollutants. Biomonitoring of plants is an important tool to evaluate the impact of air pollution. The response of plants towards air was assessed by air pollution tolerance index (Camargo and Alonso, 2006). These studies provided valuable informations for using them to identify the pollution loads of urban/industrial areas, and also to use the tolerant varieties for curbing the menace of air pollution. On the basis of air pollution indices, different plants can be categorized into sensitive, intermediate, and moderate tolerant plant groups. To screen plants for their sensitivity tolerance level to air pollutants, a large number of plant parameters have been used including ascorbic acid content (AA), relative water content, chlorophyll content, and leaf extract pH. Hence the present study was undertaken to elucidate the tolerance levels of air pollution in selected plants from Government Arts College, Nandanam, Chennai.

2. MATERIALS AND METHODS

Four different plant species were selected from the college campus namely, *Morinda tinctoria* Roxb, *Peltophorum pterocarpum*, (DC.) Backer ex K.Heyne, *Guazuma ulmifolia* Lam and *Polyalthia longifolia*, (Sonn) Thwaites during October to November. The screening and selection of the plant species were based on available literature and guidelines of Central Pollution Control Board (CPCB guidelines, 1996-2001).Native plant species available within our college campus were selected for analysis .

PLANT 1 *Morinda tinctoria*, Roxb..

PLANT 2 *Peltophorum pterocarpum*, (DC.) Backer ex K.Heyne

PLANT 3 *Guazuma ulmifolia*, Lam.

PLANT 4 *Polyalthia longifolia*, (Sonn.) Thwaites.

3. COLLECTION AND ANALYSIS OF LEAVES

Leaves of all species were collected from each zone at regular intervals .Duplicates of fully mature leaves of each species were collected in the morning hours from trees of almost same diameter at breast height (DBH). Leaf samples were quickly transported to the laboratory in heatproof container and their weight were taken. Air pollution Tolerance Index (APTI).was calculated by analyzing the biochemical parameters of leaf, namely pH, ascorbic acid, relative water content and total chlorophyll.

1. pH:

5 gm of fresh leaf material was homogenized with 50 ml of deionized water and the samples of the homogenate were centrifuged at 5000rpm for 10 mins and pH value of leaf extract was determined using pH meter(Barrs and Weatherly,1962).

2. ASCORBIC ACID (AA):

Take 1 ml of sample add 1.5 ml of distilled water add2 ml of 10 % TCA. Centrifuge at 8000 rpm for 20 min. Collect the supernatant add 0.2 ml of DTC reagents add 1ml of distilled water. Incubate at 37˚C for 3 hrs. add 1.5 ml of ice cold H_2SO_4. Incubate at RT for 30 min . Read at 520nm.

3. RELATIVE WATER CONTENT:

Relative water content was estimated by gravimetric method by determining the leaf weight under different condition like initial, turgid and dry weight (Varshney,1992).It is calculated using the formula.

RWC (%) = (FM – DM) / (TM – DM) * 100.

4. TOTAL CHLOROPHYLL:

Total chlorophyll of leaf extract was determined spectrophotometrically after extraction with 80%acetone (Sadasivam and Manickam,1996).

APTI CALCULATION:

The range of APTI was calculated by the formula proposed by Singh and Rao (1983).The range of APTI was divided into 4 grades of air pollution tolerance viz., tolerant (T), Moderately tolerant (M), Intermediate (IM) and Sensitive(S) (Liu and Ding, 2008). The air pollution tolerance index (APTI) was computed by the method suggested by Singh and Rao (1983) using the equation.

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

where A - ascorbic acid (mg g-1 FW),

T - total chlorophyll (mg g-1FW),

P - leaf extract pH,

R - relative water content (%) of the leaves.

STATISTICAL ANALYSIS:

Zone wise comparison of various analytical parameters (pH,RWC,AA,TC) and APTI were calculated and their standard deviation was calculated zone wise. Values are expressed in triplicates.

4. RESULTS AND DISCUSSION

Morinda tinctoria, Roxb, *Peltophorum pterocarpum*, (DC) Backer ex K.Heyne., *Guazuma ulmifolia*, Lam and *Polyalthia longifolia*, (Sonn.) Thwaites were selected from Government Arts College, Nandanam, Chennai. These plants were analyse the various aspects of leaves like pH, Ascorbic acid, Relative water content and Total chlorophyll by standard methods for the above selected plants around our college campus. First ,the parameter pH is estimated for all the selected plants from all the five zones and results are tabulated and discussed.

pH:

The pH of plant 1 is found to be acidic at all the zones. The pH of plant 2 is found to be acidic at zone 1 but as the distance increases from the road and to the place of plants the pH gradually increases and it reaches near neutral pH. Plant 3 shows neutral pH at zone II and zone v only. At all other zones it shows acidic pH and with respect to plant 4 it shows slightly alkaline pH only at zone II, at zone III and zone V it shows acidic pH whereas at zone II it shows slightiy alkaline pH.(Table 1 and fig 1). Plants with lower pH are more susceptible,while those with pH around 7 are tolerant. Leaf extract pH plays a significant role in regulating SO2 sensitivity of plants. In the presence of an acidic pollutant, the leaf pH is lowered and the decline is greater in sensitive species. In the presence of an acidic pollutant, cell sap pH shifts toward acid which might decrease the efficiency of conversion of hexose sugar to AA. However, the reducing activity of AA is pH controlled being more at higher and less at lower pH. Hence, the leaf extract pH on the higher side gives tolerance to plants against pollution (Krishnaveni and Kiran kumar, 2017).

TOTAL CHLOROPHYLL:

Plant 1 shows maximum chlorophyll content at zone IV and minimum at the control zone whereas plant 2 shows maximum chlorophyll content at zone IV and minimum at zone II .Plant 3 shows maximum chlorophyll content at zone I and minimum chlorophyll content at zone III and plant 4 shows maximum chlorophyll content at zone IV and minimum at zone I (Table 2 and fig 2). Similar reports was observed in *S. cumini* (32.58 mg/g) and minimum in *M. zapota* (3.64 mg/g) (Krishnaveni and Kiran kumar, 2017). Chlorophyll content of plants varies from species to species, age of leaf, and also with the pollution level as well as with other biotic and abiotic conditions. Thus, plants having high chlorophyll content show tolerance to air pollution (People's Education Press, 1980).

RELATIVE WATER CONTENT:

For all the four plants the Relative water content is found to be maximum at thecontrol zone whereas minimum at zone I .Here Plant 1shows the maximum Relative water content of 87 % and the lowest Relative water content is found with plant 3 which is of 46%.(Table.3 and fig 3). Similarly, Krishnaveni and Kiran kumar (2017) reported that the relative water content was found to be maximum (88.71%) in *E. officinalis* and minimum (21.77%) in *P. cineraria*. Water is crucial prerequisite for plant life. RWC of a leaf is the amount of water present in it relative to its full turgidity. Relative water content is associated with protoplasmic permeability in cells and causes loss of water and dissolved nutrients, resulting in early senescence of leaves. Under stress conditions of air pollution when the transpiration rates are usually high, higher water content in a leaf will help to maintain its physiological balance (Tiwari et al., 2006; People's Education Press, 1980).

ASCORBIC ACID:

Ascorbic acid is also found to be increasing from zone I to zone V for all the four plants .the ascorbic acid content is found to be more for plant 4 at zone V ,which is nearly 8mg/g .and it is found to be minimum of 4mg/g for plant 1 at zone I.(Table.4 and fig.4). AA being a strong reductant protects chloroplasts against SO2-induced H2O2, O2 and OH-accumulation and thus protects the enzymes of the CO2 fixation cycle and chlorophyll for inactivation (Tiwari and 2006). Its reducing power is directly proportional to its concentration. However, its reducing activity is pH dependent, being more at higher pH may increase the efficiency of conversation of hexose sugar to AA is related to the tolerance to pollution. AA plays an important role in cell division, defense, and cell wall synthesis. It is a natural detoxicant, which may prevent the effects of air pollutants in the plant tissues. Thus, plants maintaining high AA under pollutant conditions are considered to be tolerant to air pollution

APTI:

Plants that are continuously exposed to pollutants lead to accumulation of pollution, integration of pollutants into 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 APTI. APTI gives an empirical value for tolerance level of plants to air pollution. With the above four parameters the APTI is calculated and it is found to be maximum of 14.9 for plant 3 at zone 5 and the APTI is found to be minimum for plant 3 at zone 1.(Table.5 and fig-5). Plants with high index values are tolerant to air pollutants, whereas low index values were generally sensitive to air pollutants (Singh and Rao, 1983).

SD is done for all four parameters and for APTI and also mean APTI is also calculated. From the above estimated mean APTI and SD , the plants could be categorized as tolerant, moderately tolerant, intermediate and sensitive (Liu and Ding, 2008). The categorization is based on mean APTI and SD as follows.

- Tolerant :APTI >mean APTI +SD
- Moderately Tolerant: mean APTI < APTI <mean APTI +SD
- Intermediate :mean APTI –SD <APTI <mean APTI
- Sensitive: APTI <mean APTI-SD.

In the present study plant 1 shows APTI 13 and plant II, plant III and plant IV shows APTI values of 14.6, 14.9, &15.2 respectively. From the results it could be concluded that all the four plants are tolerant to air pollution. Cultivation of such tolerant species in polluted habitats leads to rapid amelioration of habitats to cope with the polluted environment. APTI values of plants can be used as an indicator of the presence of air pollutants and they are also very helpful in greenbelt development in the Government Arts College, Nandanam, Chennai.

5. CONCLUSION

Based on the percentage increase in APTI values calculated for the seven different plant species it can be concluded that *Polyalthia longifolia* is the most tolerant species followed by *Peltophorum pterocarpum*, *Guazuma ulmifolia* and *Morinda tinctoria*. Hence these species can be grown in the city road sides as well as in industrial zones for controlling the effect of air pollution. Air pollution tolerance index determination is important because with increased urbanization, industrialization and traffic population increase in Chennai city, there will be more air pollution. The results of such studies are therefore handy for future planning. The present study recommends various tree species for urban planting so that a wider usage of local, as well as exotic tree species, can be explored for controlling air borne pollution in urban climate.

Table 1: Leaf pH of plant species in the different zones around college campus

	Zone I	Zone II	Zone III	Zone IV	Zone V	SD
Plant 1	5.61	5.97	5.8	5.53	5.34	0.24
Plant 2	5.89	6.66	6.19	6.16	6.22	0.27
Plant 3	6.96	7.26	6.72	6.73	7.14	0.24
Plant 4	6.1	7.23	5.67	6.72	5.7	0.67

Table 2: Total chlorophyll of plant species in the different zones around college campus

	Zone I	Zone II	Zone III	Zone IV	Zone V	SD
Plant 1	2.7	3.05	2.34	3.49	1.82	0.64
Plant 2	2.99	2.14	2.49	3.38	3.13	0.5
Plant 3	1.41	0.98	0.87	0.91	1.05	0.21
Plant 4	1.53	2.74	3.05	3.46	3.06	0.73

Table 3: Water content of plant species in the different zones around college campus

	Zone I	Zone II	Zone III	Zone IV	Zone V	SD
Plant 1	71	72	77	78	87	6.36
Plant 2	66	64	68	69	75	4.15
Plant 3	46	69	71	79	86	15.12
Plant 4	62	71	76	76	78	6.4

Table 4: Ascorbic acid of plant species in the different zones around college campus

	Zone I	Zone II	Zone III	Zone IV	Zone V	SD
Plant 1	4	4.3	4.5	5	6	0.78
Plant 2	3.8	5	6	7	7.6	1.52
Plant 3	5.2	6.2	6.5	7.2	7.8	0.99
Plant 4	5.8	6	6.8	7.5	8	0.94

Table 5: APTI of plants in different zones around the college campus

	Zone I	Zone II	Zone III	Zone IV	Zone V	SD
Plant 1	10.42	11	11.3	12.3	13	1
Plant 2	10	10.8	12	13.5	14.6	1.88
Plant 3	9	12	12	13.4	14.9	2.18
Plant 4	10.6	13	13.5	15.2	14.8	1.81

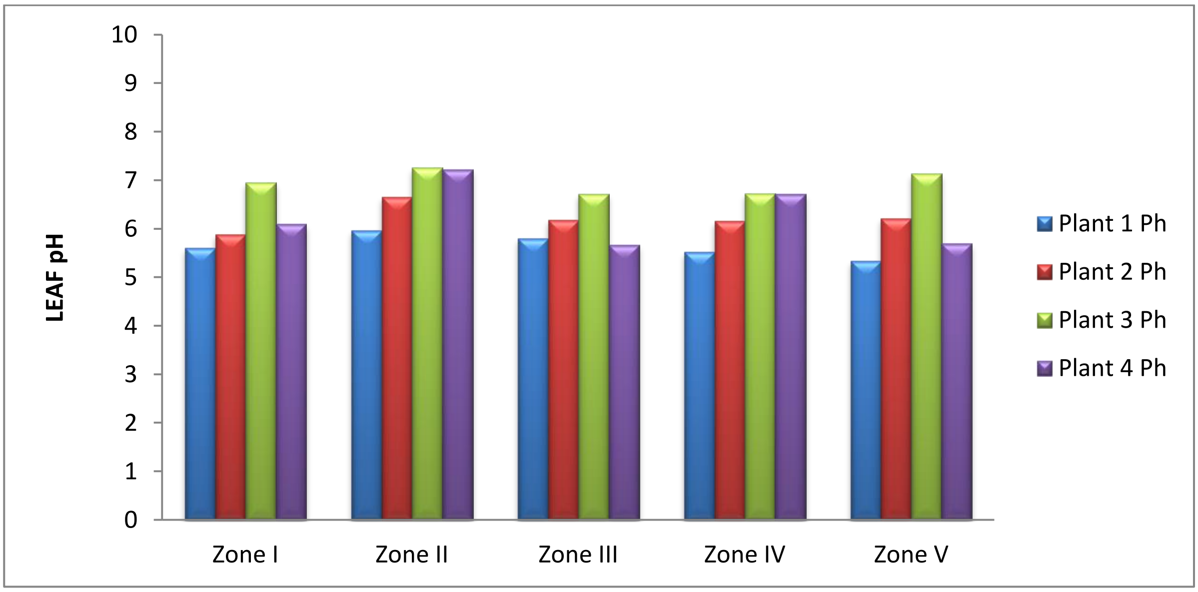

Fig 1: Leaf pH of plants in different zones around the college campus

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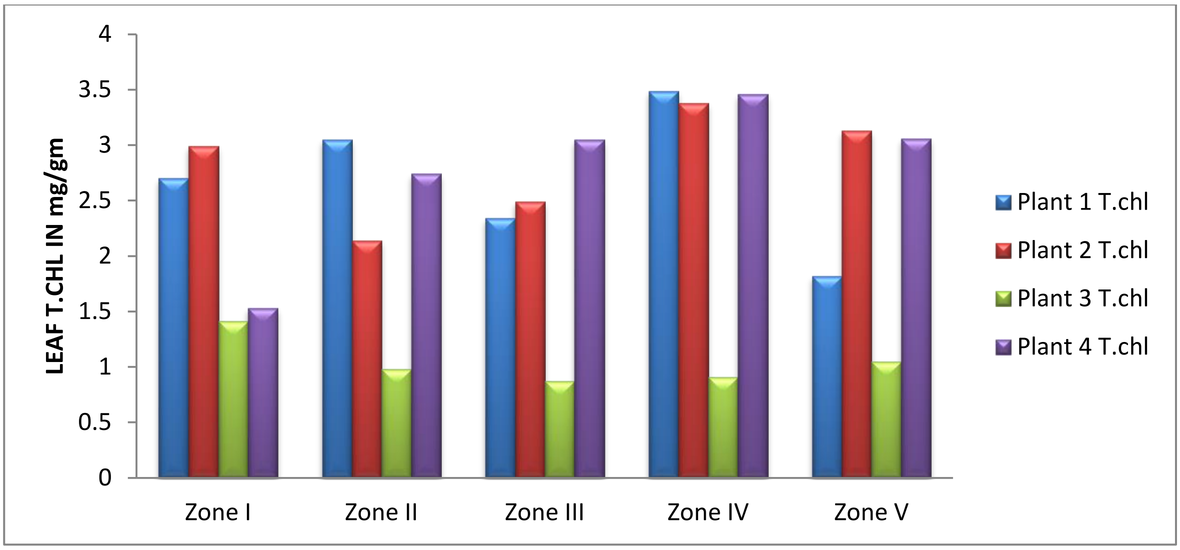

Fig 2: Total chlorophyl of plants in different zones around college campus

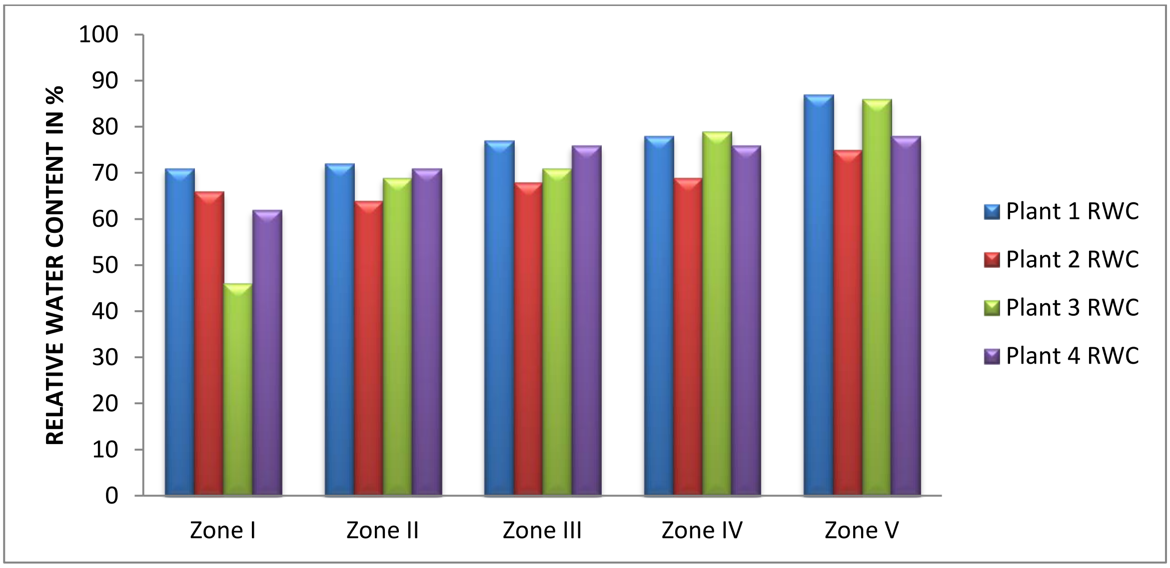

Fig 3: Leaf relative water content of plant in the different zones around college campus

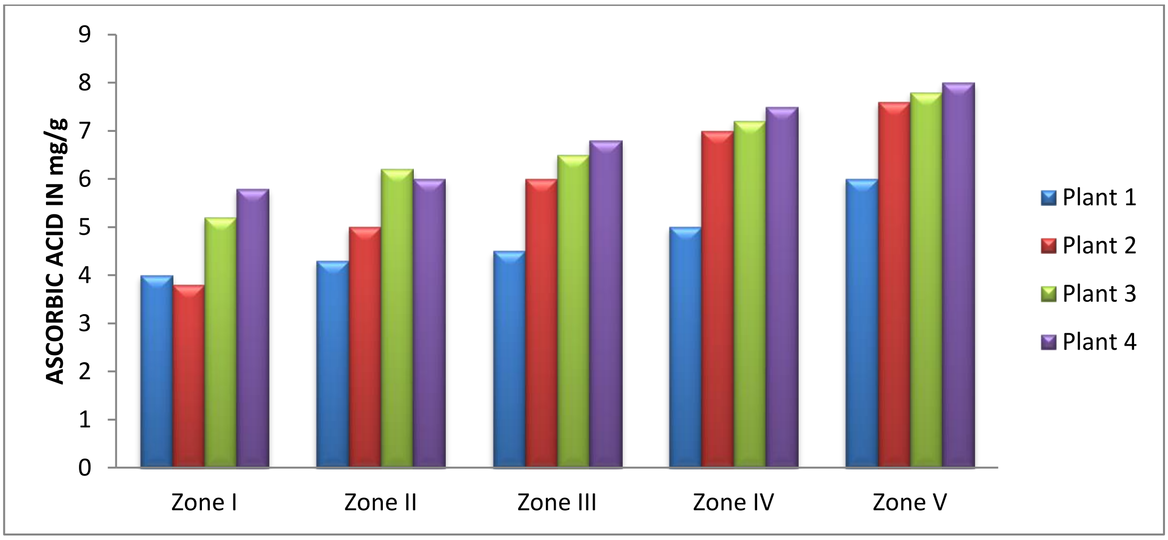

Fig 4: Leaf ascorbic acid content of plants around college campus

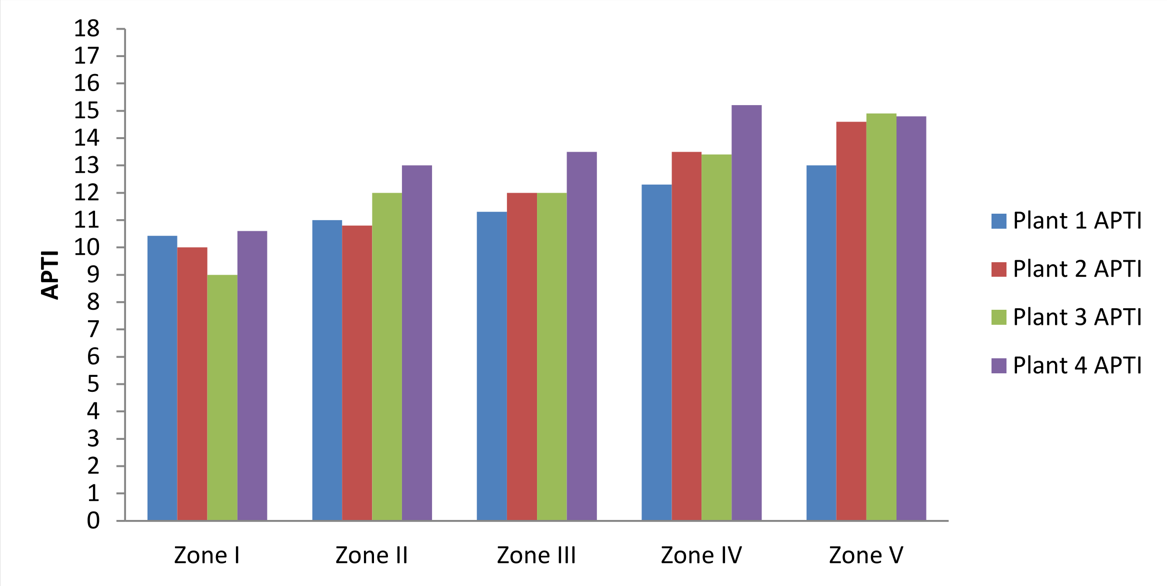

Fig 5: APTI of plants in different zones around college campus

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