Explorematics
Journal of Innovative
Engineering and Technology

Volume: 05 No: 01 | April -2024
ISSN (Online) 2636 – 590
ISSN (Print) 2636 - 591X

ASSESSING AIR POLLUTION TOLERANCE INDEX OF SELECTED PLANTS NEAR 9TH MILE INDUSTRIAL COMPLEX IN ENUGU STATE

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Abstract - The role of vegetation in mitigation of industrial pollution is well documented. Air Pollution Tolerance Indices (APTI) of several plant species were evaluated to identify plants with high tolerance indices that may be used for air pollution mitigation. Air Pollution Tolerance Index (APTI) for each plant was calculated based on four biochemical parameters: the pH of the leaf extract (P), Relative Water Content of the plant's leaf (R), Ascorbic Acid Content (A), and Total Chlorophyll Content (T). The pH of the leaf extract was determined using the Direct Reading Engineering Method (DREM). using an electronic pH meter; relative leaf water content was calculated from the ratio of two weights; ascorbic acid of the leaf extract was determined using titremetric means and the chlorophyll A and B of the leaf extract was determined by spectrophotometric method at the absorbancies of 645nm and 663nm. APTI was calculated according to standard methods: APTI = $\frac{[A(T+P)+R]}{10}$ and plants were classified as sensitive (APTI < 10), intermediate (APTI 10-16), and tolerant (APTI ≥ 16). All the plants studied except *P.rubra* (9.52) recorded inter-mediate tolerance ability, while *A.wilkesiana* recorded the highest value (13.56), followed by *F.microcarpa* (12.50), *I.coccinia* (12.50), and *A.hispda* (10.17). therefore the cultivation of the tolerant plants was recommended, especially *A.wilkisiana, F.microcarpa and I.coccinia*, and their applications in industrial landscaping of 9th mile industrial environment to curtail the negative impacts of air pollution that were ascertained there.

Keywords: Environmental pollution, vegetation, anthropogenic, phytoremediation, landscaping

1. Background of the Study

Anthropogenic pollution of industrial origin remains one of the major environmental problems confronting the global community. Increased concentration of industries in the 9th mile, Enugu has created pollution stress in the air, soil, and water of the 9th mile environment (Essaghah and Ugwu 2008). In the past two decades, the 9th mile area has experienced ongoing inflows of industrial pollutants primarily linked to breweries and bottling companies in the 9th Mile area, with several studies connecting these industries to environmental degradation that impacts both terrestrial and aquatic ecosystems in nearby communities. (Onwe 2004, Planscape Associates 2005; Essaghah and Ugwu 2008, Efeoghene and Alabi 2013). While some of the studies recommended improvement of effluent treatment facilities and updated environmental control strategies for the factories as mitigating measures against industrial pollution of the 9th mile environment, none considered the adoption of structured industrial landscaping in pollution abatement.

The role of vegetation in mitigating industrial pollution is well documented (Singh, 1991; Enete and Ogbonna, 2012; Rai *et al*., 2013). Plants, due to their stationary nature, serve as the primary recipients of environmental pollutants. They adapt to pollution-induced stress by modifying their biochemical, anatomical, and physiological characteristics as a coping mechanism. (Otuu *et al*., 2014). The Air Pollution Tolerance Index (APTI) assesses the plants' vulnerability to air pollution and takes into account four biochemical variables: ascorbic acid content (AA), total leaf chlorophyll (TCh), leaf relative water content (RWC), and the leaf extract's pH. (Agrewal *et al*.,1991). Emerging literatures point to the usefulness of high air pollution tolerant plants in pollution mitigation of industrial and domestic environments. In terrestrial plant species, the extensive foliar surface area serves as a natural absorber for pollutants, particularly gaseous pollutants. Srinivas et al.'s work in 2008 computed the Air Pollution Tolerance Index (APTI) for various plant species thriving in industrial zones located in Visakhapatnam. This study assessed the Air Pollution Tolerance Indices (APTI) of select plant species (*Acalypha wilkesiaria*, *Plumeria rubra*, *Ficus microcarpa, Ixora coccinia, Acalypha hispida*) to identify plants with high tolerance indices that may be used for air pollution mitigation of the 9th mile industrial complex

2. Methodology

2.1: Study Area Description

The 9th Mile area, originally referred to as 9th Mile Corner, is a large industrial complex situated in Udi, Enugu, Nigeria. It is located at geographic coordinates of 6° 25' 0" North and 7° 25' 0" East (Ani et al., 2022). It is among the rapidly developing communities in Enugu State, it has a population of 25,000 people as of 2006 (NPC 2006). It originated as a transit center for travelers between the east and north regions of Nigeria in the early 1930s, the 9th mile area has evolved into a significant industrial hub. It now hosts major industries. Industries in the area include the Nigerian Brewery Plc Plant, Seven-Up Bottling Company Production Plant, AMA Brewery Plant, Nigeria Bottling (NB) Company Plant, and other related establishments. (Ani *et al*., 2022). Currently, the 9th mile area stands as the industrial epicenter of the State, marked by lively environmental and social engagements, serving as a significant source of revenue for the Udi Local Government Council, Enugu State, and the Federal Government of Nigeria. (Efeoghene and Alabi 2013).

2.2: Sampling

Random and purposive sampling techniques were adopted. The wild plants were randomly selected from different points within the agricultural farmlands in the vicinity of the industrial environment. The leaves of the plants were carefully removed from the stalk using a sharp kitchen knife. The leaves from each plant were stored in an "A4" size brown envelope, perforated for air circulation, and labeled with alphabet (A-E). The plants were collected in triplicate. A single set of the triplicate samples was forwarded to the Plant Science and Biotechnology Department of the University of Nigeria, Nsukka, for purpose of identification.

2.2.1: pH Determination

The pH measurement utilized the Direct Reading Engineering Method (DREM) in conjunction with an electronic pH meter. Leaf liquids (extract) were obtained by squeezing fresh leaves with both hands into a 10ml beaker carefully labeled with the same alphabet on each plant. The PH meter was calibrated in advance using buffer solutions with PH values of 4 and 9. Subsequently, the PH electrode was submerged carefully into the extract within a 10ml beaker. The PH meter's crystal liquid display panel (CLD) showed the stabilized PH value, which was considered the accurate PH reading. This procedure was repeated three times, and the mean of the readings was used.

2.2.2: Calculation of Relative Water Content (RWC)

The method outlined in the works of Singh (1977) and Agbaire and Esiefarenrhe (2009) was employed to measure and compute the relative water content of the leaf in the following manner:

The fresh samples of leaf were initially weighed and noted down as FW (fresh weight) Subsequently, were immersed in distilled water within a sealed petri dish, and left at room temperature for 24 hours. After this incubation period, the leaf sample was dried and reweighed, and this new weight was documented as the turgid weight (TW). The leaf was then subjected to a heated oven at 80°C for 48 hours. It was weighed again, and the resulting weight was recorded as DW (dry weight). Using the formula below RWC was determined:

$$RWC = \frac{FW-DW}{TW-DW} \times \frac{100}{1} \quad (1)$$

FW = Fresh Weight
DW = Dry Weight
TW = Turgid Wight

2.2.3: Measurement of Ascorbic Acid (AA)

Ascorbic Acid was quantified by iodometric titration method following AOAC, 2005 guidelines. The extraction process involved mixing 20ml of distilled water, 30ml of H_2SO_4, and 0.5mol of oxalic acid with 2g of the plant sample, which was stirred thoroughly for 10 minutes. After filtration, 10 ml of the filtrate underwent titration against a 0.05 mol iodine solution, using starch mucilage as the endpoint indicator. The value for ascorbic acid was determined using the conversion rate:

1 ml of 0.05 mol iodine = 0.008806 g = 8.806 mg (2)

2.2.4: Calculation of the Total Chlorophyll (Tch)

The determination was carried out using the spectrophotometric method. Three grams of the leaf sample were blended and subsequently extracted with 10 ml of 80% acetone. The liquid portion was decanted after allowing it to stand for 15 minutes. The remaining solution underwent centrifugation at 2,500 RPM for 3 minutes, following which the supernatant was collected. The absorbance of the supernatant was measured at wavelengths of 645 nm and 663 nm using a spectrophotometer. The total chlorophyll content was then calculated as the sum of chlorophyll A and chlorophyll B

2.2.4: Calculation of APTI

The APTI (Air Pollution Tolerance Index) was determined using standard methods (Agrawal et al., 1991) with the expression:

$$APTI = \frac{A(T+P)+R}{10} \quad (3)$$

A+T+P+R
A represents the ascorbic acid content,
T represents the total chlorophyll content,
P represents the pH of the plant leaf, and
R represents the relative water content.

Plants were categorized based on their APTI values as follows:
Sensitive: APTI < 10
Intermediate: APTI between 10 and 16
Tolerant: APTI ≥ 16**3.0 Results**

The results of the research are shown in Table 1 and Figure 1**.**

Two plants, Ixora coccinia (6.2±0.09) and Acalypha hispida (6.6±0.05), had slight acidic foliar pH. All the plants had high foliar relative water content and *P.rubra* (0.88±0.00) had the least ascorbic acid content. The total chlorophyll ranged from 3.84±0.00 in *Ficus microcarpa* **t**o 10.03±0.00 in *Acalypha wilkesiara.* All the plants except *P.rubra* (APTI < 10) recorded intermediate APTI (>10)

Table 1: Four Biochemical Parameters and APTI of the Plants

S/N	Plants	pH	RWC	AA	Tch	$APTI = \frac{[A(T+P)+R]}{10}$
1	*AcalyphawilkesiaraPlumeria*	7.0±0.09	90.68±0.00	2.64±0.00	10.03±0.00	13.56±0.00
2	*rubra*	7.0±0.09	85.65±0.00	0.88±0.00	3.84±0.00	9.36±0.00
3	*Ficus microcarpa*	7.3±0.05	97.14±0.00	1.76±0.00	8.55±0.00	12.50±0.00
4	*Ixora coccinia*	6.2±0.09	94.74±0.00	1.76±0.00	8.48±0.00	12.05±0.00
5	*Acalypha hispida*)	6.6±0.05	80.30±0.00	1.76±0.00	6.56±0.00	10.17±0.00

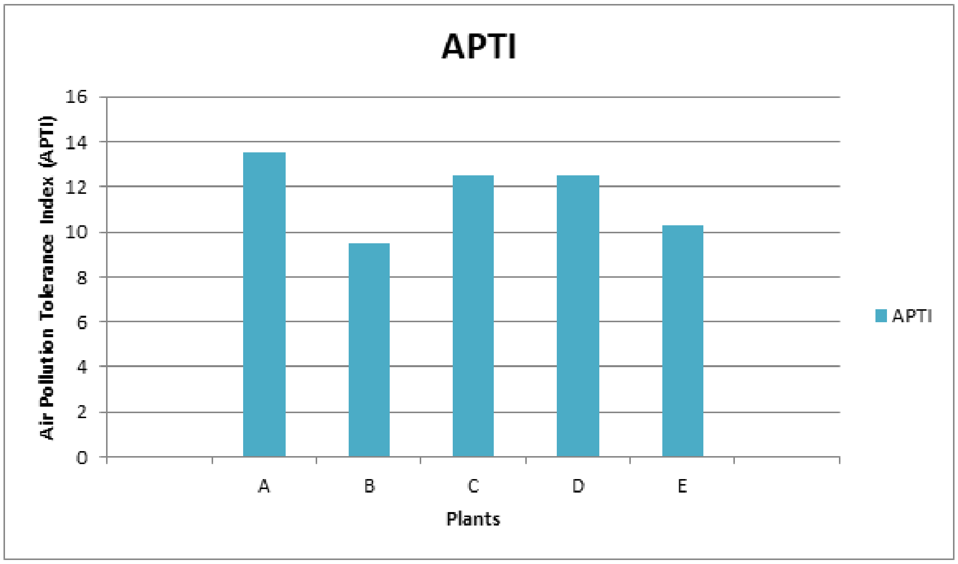

Figure 1: APTI of the Five Plants

Legend
A = Acalypha wilkesiaria
B = Plumeria rubra
C = Ficus microcarpa
D = Ixora coccinia
E= Acalypha hispida

4.0 Discussion and Conclusion

The study assessed the Air Pollution Tolerance Indices (APTI) of five ornamental plants. (*Acalypha wilkesiaria, Plumeria rubra, Ficus microcarpa, Ixora coccinia, Acalypha hispida*) randomly selected from the environment of the bottling companies at 9th Mile, Udi Local Government Area of Enugu State. The Air Pollution Tolerance Index (APTI) for each plant was calculated based on four biochemical parameters: pH of the plant, Relative Water Content, Ascorbic Acid Content, and Total Chlorophyll Content The plants had varying biochemical parameters.

The pH levels of the plants varied, with I. cocinia showing a moderately acidic pH of 6.2±0.09, while the other plants had neutral pH values. pH is crucial for various physiological processes in living organisms. Enzymes, which regulate biological activities, typically operate optimally within specific pH ranges in their surroundings.Certain enzymatic activities are favored by low pH environments, whereas others necessitate higher or neutral pH levels for optimal functionality. Cowling, (2000) pointed out that sulphates, one of the major pollutants primarily lower the P^{H} while nitrate not only lowers the soil P^{H} more than sulphate but can also act as a nutrient stimulating growth, leading to faster consumption and possible depletion of base cat ions. Nitrates are able to lower soil P^{H} to the point where it then displaces base cat ions from the soil solution and inhibits the uptake of the base cat ions by the roots and their trans-location to the leavesElevated pH levels can indeed improve the efficacy of converting hexose sugars into ascorbic acid (AA). Conversely, research has indicated a robust association between low pH levels in leaf extracts and heightened sensitivity to air pollution (Escobedo et al., 2008; Conklin, 2001; Lui and Ding, 2008).

The plants showed relatively high values of RWC. Relative water content of plant leaves is a measure of the water content of plant relative to its total turgidity. Plants with high relative water content stand the chance of containing more water soluble vitamins and other phyto-compounds that may provide buffering effects against pollution-induced oxidative stress Water scarcity can lead to severe stress in plants, whereas adequate water content within the plant body plays a crucial role in maintaining physiological balance, particularly during stressful conditions such as exposure to air pollution, when transpiration rates are usually elevated.

Ascorbic acid is a defensive macro-molecule which is secreted in plants to counteract the offensive free radicals during plant stress. Air pollution is a stress factor. The relative high ascorbic acid content in *A.wilkesiana* compared to other plants studied is an indication that the plant has better adaptation for survival in an unfriendly environment. This is reflected in its APTI value of 13.56. APTI values of ≥10 are considered moderately tolerant. The neutral pH, the relatively higher ascorbic acid, and RWC are biochemical properties favorable to plants tolerant ability in polluted environment.

Chlorophyll is an important plant macromolecule, without which photosynthesis will not occur. All the plants except *P.rubra* had relatively high chlorophyll. The survival of plants in an adverse environment hinges among other things, on their chlorophyll contents. This is because plants use environmental elements of sunlight, carbon II oxide, and water, for carbohydrate fixation is chlorophyll dependent. In this study, the total chlorophyll contents of the plants could be contributive to APTI, since *P.rubra*, with the least chlorophyll, recorded the least APTI.

All the plants studied except *P.rubra* recorded inter-mediate tolerance ability, while *A.wilkesiana* recorded the highest value, followed by *F.microcarpa*, *I.coccinia* and *A.hispda*. Using ornamental plants for landscaping in built-up areas has evolved beyond mere aesthetics to include pollution abatement, microclimate stabilization, and the creation of comfort zones. While the sensitive plant species serve as indicator of air pollution, tolerant species help to ameliorate the impacts of environmental pollution (Enete and Ogbonna, 2012). APTI is an effective tool for selecting tolerant ornamental plants for cultivation, aiding in the reduction of environmental air pollution in the 9th Mile area. Additionally, these plants can create canopy effects to mitigate office heat and contribute to the development of comfort zones throughout the entire 9th Mile environment

Conclusion and Recommendations

The continuous use of ornamental plants for the beautification of 9th mile industrial environment, provision of shades against solar energy discomfort, abatement of air pollution from vehicular tail-pipe emission, and electric power generating sources will be much more beneficial if the plants are selected based on longevity and beauty. The need for repeated replanting of plants with short life spans will be avoided in the industrial environment if plants of high tolerant values are used in the beautification of industrial environment. In this study, four of the plants recorded intermediate tolerant ability (APTI>10), while one plant recorded sensitive value (APTI<10) to air pollution.

We therefore recommend the cultivation of the tolerant plants, especially *A.wilkisiana, F.microcarpa and I.coccinia* and their plantation within and around the industrial complex. This will create more conducive environment, minimize the use of air conditioning devices in the offices and will mitigate the negative impacts of pollution arising from high vehicular traffic load and other anthropogenic activities associated with the 9th Mile industrial environment.

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