

ASSESSMENT OF AIR POLLUTION TOLERANCE INDEX OF THREE SELECTED PLANT SPECIES FROM DIFFERENT LOCATIONS IN SOKOTO, NIGERIA

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Abstract

Air pollution tolerance index is used to find out the level of air pollution in many areas with the help of plants. Plants are categorised as sensitive, intermediate and tolerance based on their APTI value. The present study assesses three native plant species' resilience to pollution and adaptability for various environments by evaluating their Air Pollution Tolerance Index (APTI). Four biochemical parameters—pH, ascorbic acid levels, chlorophyll, and relative water content—were examined in order to determine APTI. The investigation was carried out at Usmanu Danfodiyo University, Sokoto utilizing conventional techniques for chemical analysis. The results indicate that, in line with the lower pollution level, Calotropis procera had the highest APTI value across three locations (13.71),(10.52) and (4.15) respectively, then followed by polyalthia longifolia across all three location with APTI value of (12.36),(7.49) and (3.45) respectively, whereas Nerium oleander has the lowest with APTI value of (12.07),(7.42) and (2.16) across three locations respectively. It is recommended that these plants can be grown on national highways to combat air pollution in arid areas and used in the development of green belt and phytoremediation.

Keywords: Air pollution tolerance index (APTI), *Calotropis procera*, *Polyalthia longifolia*, *Nerium oleander*, Air pollution.

INTRODUCTION

In developing countries factors responsible for environmental degradation include rapid urbanisation, industrialisation, and increase number of vehicles on the road (Malav *et al.*,2022). These activities are also responsible for increase in air pollution. Physiological, morphological, and biological changes in plants are significantly affected by air pollution (Patil *et al.*,2021). Exposure to air borne pollutants conveys physiological changes to plants and it may show physical damages (Molnara *et al.*, 2020). Several research studies have indicated that the plants are inhibitors and also act as indicator for air pollution (Tak and Kakde,2020). Plants play an important role in reducing air pollution as they absorb pollutants in the atmosphere and also, they are good receptors to all types of air pollutants (Shahu *et al.*, 2020). Plants can be used as a bio-air pollutants and sensitive indicator for monitoring the local air quality (Akilan and Nandhakumar, 2016).

The relationship between air pollution and vegetation impacts has gained increasing attention throughout the last 20 years. Three main issues are driving the present interest in the impacts of air pollution on plants: ecological, aesthetic, and economic. The most evident issue is the economic one (Ukaogo,2020). The harvestable product's yield has decreased or its quality has

been compromised due to air pollution, most of the air pollutant have effect on the plant's photosynthetic activities. It can also have an impact on the product's internal components, which may have an impact on its nutritional content, or its look, which may have an impact on its marketability. Economic losses resulting from air pollution in horticulture and other agricultural enterprises reach hundreds of millions of dollars per year. Air pollution can cause foliar symptoms and development abnormalities that differ from how native plants look in natural areas or ornamental plants in landscaped properties, public parks, and along highways, the nature of the effects are not known until 20th century (Dubey,2022).

Most of the Nigerian cities are suffering from air pollution due to emission of toxic gases by industrial activities within the cities (Dubey,2022). The majority of industries disregard environmental rules, regulations, and recommendations. In Nigeria, a lot of taxis and auto rickshaws run on tainted fuel. Although the price has being fluctuating, in the end, the environment and will bear the cost. Since they release dangerous pollutants into the air, certain adulterants are truly highly damaging to the environment and aggravate the already poor quality of the air.

Due to human activities, a variety of pollutants are released into the atmosphere. Most of these pollutants directly influence plants, including carbon dioxide (CO₂), the substrate for photosynthesis, and ozone (O₃), a dangerous oxidant (Filonchyk, *et al.*,2024). Air pollution is a huge worry for all living things, including humans, animals, and plants, as well as the ecosystem. Plants have a crucial role in lowering air pollution. Given that air pollution is a major problem worldwide, screening sensitive and tolerant plants is essential for their role as bio indicators and sinks for pollutants (Walia, 2019). Air pollution is a serious problem in many heavily industrialized and populated areas of the world. The environmental stress on the flora is measured by APTI and the four bio-chemical parameters viz, pH(p), relative water content (RWC), ascorbic acid (AA), and total chlorophyll (TC) are used to calculate APTI (Sarkar *et al.*, 2021). These biochemical traits provide an easy-to-use, non-invasive way to assess how plants respond to environmental stressors; these traits may also be used to analyse responses in other species. Plants absorb and integrate environmental pollutants into their systems due to their constant exposure to them. Depending on their sensitivity level, plants have been seen to display visible variations, such as changes in metabolic processes.

MATERIALS AND METHODS

Description of Study Area

The study was conducted in phases, phase one (1) was the sample collection from location namely; Wamakko local government area along kalambaina and Cement industrial located approximately 13°07' 16 N, 5°05' 37 E and covers a total land area of 697km², whereas the second phase of the study was conducted at the Central laboratory Faculty of Life Science Usmanu Danfodiyo University, Sokoto.

Sample Collection

Averagely, 10-15 Fresh healthy leaves were selected from *Nerium*, *Ashapala* and *calotropis* plant species for the analysis. The selection of this plant species was based on their availability in the study areas. The samples were placed in sampling envelopes and transported back to the

laboratory for proper storage and subsequent analysis for different parameters in the laboratory.

Materials, Equipment and Reagents

During the research the following materials, equipment and reagents were used; Leaves sample, mortar and pestle, conical flask, measuring cylinder, micropipette, micropipette tips, Acetone (80%), Oxalic Acid, Ascorbic Acid, 2, 6-dichlorophenolindophenol (DCPIP dye), Sodium Bicarbonate, Distilled Water, Centrifuge, Spectrophotometer.

Air Pollution Tolerance Index (APTI) Determination

Four key biochemical characters—pH, ascorbic acid concentration, relative water content, and chlorophyll—are needed to estimate the APTI value. The following describes the specific techniques used to extract and calculate those parameters. Throughout the whole investigation, aqueous extract of fresh leaves was utilized.

Evaluation of APTI Value

The formula $APTI = \frac{A(T+P)+R}{10}$(1)

Where;

A = is the ascorbic acid content of leaf mg/g dry wt.

T = is the total chlorophyll content of leaf mg/g dry w.

P = is the pH of the leaf extract, and

R = is the relative water content of the leaf. The total sum is divided by 10 to get a manageable value.

Plant tolerance measured by the APTI scale: Depending on the APTI value, different plant groupings (Deciduous, Evergreen, Herbs, and Crops) may have different tolerance categories. Based on the declining APTI score, there are four kinds of tolerance level: tolerant, somewhat tolerant, intermediate, and sensitive.

RESULT

Table 1: Results of APTI Values for Three Different Sample Species from Usmanu Danfodiyo University campus and Kalambaina Wamakko area along cement industry

Location	Name of Specie	Total Chlorophyll (mg/g)	Relative Water Content (%)	Ascorbic Acid Conc. (A) (mg/g)	pH of Leaf Extract (P)	APTI Value
Usmanu Danfodiyo University campus	<i>Calotropis Procera</i>	5.4	85	4.5	6.18	13.71
	<i>Polyalthia longifolia</i>	4.5	55	6.5	6.06	12.36
	<i>Nerium Oleander</i>	4.8	70	5.0	6.34	12.07
	<i>Calotropis Procera</i>	4.02	62	4.0	6.78	10.52
	<i>Polyalthia longifolia</i>	3.81	40	3.2	7.10	7.49
Wamakko/kalambaina	<i>Nerium Oleander</i>	2.91	51	4.5	6.70	7.42
	<i>Calotropis Procera</i>	1.20	30	2.02	4.5	4.15
	<i>Polyalthia longifolia</i>	1.00	28	0.90	6.2	3.45
	<i>Nerium Oleander</i>	0.12	15	1.21	5.3	2.16
	<i>Calotropis Procera</i>	1.20	30	2.02	4.5	4.15
Cement Industrial Area	<i>Polyalthia longifolia</i>	1.00	28	0.90	6.2	3.45
	<i>Nerium Oleander</i>	0.12	15	1.21	5.3	2.16
	<i>Calotropis Procera</i>	1.20	30	2.02	4.5	4.15
	<i>Polyalthia longifolia</i>	1.00	28	0.90	6.2	3.45
	<i>Nerium Oleander</i>	0.12	15	1.21	5.3	2.16

Table 1 above represent the APTI values of *calotropis procera*, *Polyalthia longifolia* and *Nerium oleander* from three different sampling locations. The final APTI value of each specie was obtained through the evaluation of four different parameters from the plant samples namely: pH, ascorbic acid, chlorophyll and relative water content.

Table 2: Results of APTI for Three Different Sample Species from Cement industry, Usmanu Danfodiyo University campus and Outside University Campus

S		N		Species	APTI Value
1	Usmanu Danfodiyo University Campus			<i>Calotropis Procera</i>	13.71
				<i>Polyalthia longifolia</i>	12.36
				<i>Nerium Oleander</i>	12.57
2	Outside University Campus			<i>Calotropis Procera</i>	10.52
				<i>Polyalthia Longifolia</i>	7.49
				<i>Nerium Oleander</i>	9.42
3	Cement Industrial Area			<i>Calotropis Procera</i>	4.15
				<i>Polyalthia Longifolia</i>	3.45
				<i>Nerium oleander</i>	2.16

Table 2 shows the comparison between APTI values of three different species across three different sampling locations. *Calotropis procera* has the highest APTI value from all the three sampling locations.

DISCUSSION

The study's findings demonstrate that the APTI and dust carrying capacity of plant species examined from various places varied. It was discovered that the same species was intermediately or tolerant in one location and sensitive in another. In contrast to research by (Shahrulkh, 2023) that found some plant species, such *Ficus benghalensis*, grow well in a contaminated environment, it was discovered that the studied plant species in this study were not doing well in the contaminated surroundings. Table 1 displays the biochemical properties and the APTI for plants from the Cement industrial area, the Usmanu Danfodiyo University campus, and locations outside the university campus.

The pH range of 4.5 to 6.2 is acidic for all plant species obtained from the industrial site in Cement. On the other hand, the pH range of 6.0 to 7.10 is neutral to slightly acidic for plant species gathered from non-industrial areas in university and outside university campus. Pollutants like SOX and NOx in the surrounding air can alter the pH of leaf extract to an acidic state, which could be the source of the more acidic medium in industrial species (Antenzio, 2024).

Relative water content (RWC) of plant species collected from non-industrial sites (University and Outside University Campus), where found to be within range of 40% to 85%, all plant species obtained from industrial sites were lower in this study (15% to 30%).

The result of this study is in contrary to the findings of (Correa, *et al.*, 2022) where he concluded that some plant species exhibit higher relative water content in industrial areas compared to species found in non-industrial areas. The contradictions might be due the type of species used for the study.

Ascorbic acid is an antioxidant that is largely present in all of a plant's growth sections and aids in resistance to harsh climatic circumstances. Table 1 lists the average amount of ascorbic acid in plant leaves from both industrial and non-industrial areas. It was shown that ascorbic acid concentrations in leaves of plants from non-industrial areas (University and Outside University Campus) were greater than those in leaves from industrial areas, ranging from 0.9 to 2.0, this finding also contradicts the research by (Ishfaq and Wani,2024) which finds that ascorbic acid concentration rises as pollution rates rise, However, this study demonstrates that, depending on the kind of pollutant present in the environment and the species of plant, the ascorbic acid concentration of leaves falls in extremely highly contaminated situations (Ishfaq and Wani,2024).

Chlorophyll concentration affects both the growth and development of biomass as well as its photosynthetic activities. Plant species differ in their levels of chlorophyll content, which is influenced by environmental factors and pollution levels (Ahire, 2024). The current investigation found that, in comparison to plant species examined both inside, outside of Usmanu Danfodiyo University campus and Cement industrial area, the chlorophyll content of every investigated species of plants in the Cement Industrial Area was lower. *Calotropis procera* from University Campus (control) had the maximum chlorophyll content (4.8), whereas *Nerium oleander* from the Cement industrial area (polluted region) had the lowest chlorophyll content (0.12). This finding's outcome confirms the research or conclusions of (Josh,2009) which shows that the higher the pollution in an area, the lower the concentration of chlorophyll in the plant species found within that area. Reduction of chlorophyll content in variety of plants due to NO_x and Sox have also been recorded by (Athira, *et al.*,2022).

The APTI values calculated for each plant species at three sites are presented in table one (1). Table 1 clearly showed the APTI values of plant species studied within and Outside University Campus is higher compared to plant species obtained from Cement industrial area. *Calotropis Procera* has the highest APTI value of 13.71 at university campus and lowest at industrial area (Polluted environment), the findings of this study indicates that *calotropis procera* is sensitive due to air pollution, which is why the APTI value in the control region is greater and the APTI value in the polluted area is lower. Severe air pollution can harm the physiological processes of plant leaves, which lowers the plants' tolerance to air pollution. As indicators, sensitive plant species can warn the public or a community about rising pollution levels.

Plants growing along the roadsides and industrial areas becomes easily affected at a maximum level as they are the first recipients of different air pollutants and show varied levels of tolerance and sensitivity. Certain plants have an increased APTI score when exposed to high levels of air pollution because they become more tolerant of it (Gautam and Shukla,2020). This high APTI value at Usmanu Danfodiyo University can be attributed to the plants high relative water content (85%), and substantial total chlorophyll content (5.4). The ascorbic acid concentration is also significant, although it is the lowest among the three species, suggesting that other factors such as high-water content and chlorophyll levels play a more dominant role in raising the APTI value. The pH of 6.18 indicates a slightly acidic leaf environment which might help in neutralizing some pollutants.

Polyalthia longifolia (Ashapala) has an air pollution tolerance index that is modest at university campus with an APTI value of 12.36. It has the highest ascorbic acid concentration (6.5 mg/g) among the three species, indicating strong antioxidant properties which help in combating oxidative stress caused by pollutants. Ascorbic acid is a potent antioxidant, protecting plant cells from oxidative stress by scavenging reactive oxygen species (ROS). This helps in maintaining cellular health and mitigating damage from environmental stressors such as drought, extreme temperatures, and pathogen attacks. However, its relative water content is the lowest (55%), which might reduce its overall pollution tolerance. The total chlorophyll content is also lower compared to *Calotropis procera*, further impacting its APTI value (Table 2). The pH of 6.06 is close to neutral, which is generally favourable for metabolic processes.

Nerium Oleander has an APTI value of 12.57 within Mewar Campus, Several studies have indicated that *Nerium oleander* exhibits a high APTI value, suggesting its strong tolerance to air pollutants, For instance, research conducted in urban areas with high vehicular emissions showed that oleander maintained high levels of ascorbic acid and total chlorophyll content, indicating its robust defence mechanisms against oxidative stress caused by pollutants (El Moukhtari, 2024) but in contrary to this research, *Nerium oleander* is less tolerant to air pollution because it has lower APTI value and grows badly in the industrial area which is likely affected by severe industrial pollution. Its relative water content is 70%, which is significant and helps maintain cellular functions under stress conditions. The total chlorophyll content is moderate at 4.8, which contributes to its photosynthetic efficiency and overall health. The ascorbic acid concentration is 5.0 mg/g, which provides a good level of antioxidant protection. The pH of 6.34 is slightly more alkaline compared to the other species, which might influence its enzymatic activities and metabolic processes. This research proves that *Nerium oleander* is more susceptible to air pollution than *Calotropis procera* and *Polyalthia longifolia*.

Based on this research, when compared to the industrial region, the three examined species were shown to be growing more effectively on the university campus and in the near vicinity this research contradicts the findings of (Shahrukh, 2023) which concluded that plants found in polluted areas tend to have higher APTI values compared to those found in a clean environment (Table 2). However, this research is limited to few numbers of species, more plant species should be included in future studies to broaden the coverage.

CONCLUSION

The effects of air pollution on people, plants, and animals are widespread. The ability of different plant species to absorb dust and their tolerance to pollution vary. Higher values on the Air Pollution Tolerance Index (APTI) indicate plants that are appropriate for polluted locations, while lower values may indicate contamination. The APTI is a helpful indication. This study looks at three species from Wamakko and finds that because of pollution, plants in industrial regions have lower APTI values than those in control zones. The plants with the greatest capacity to capture dust were discovered to be *Calotropis procera*, *Polyalthia longifolia*, and *Nerium oleander*.

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