Air Pollution Tolerance Index of some selected medicinal plants around oil-producing Community of Asah, Abia State, Nigeria.

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ABSTRACT: Air pollution causes harm to plants and other living organisms or damage to the environment. It may cause diseases, allergies or death in humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Human activity and natural processes can both generate air pollution. Plants play a key role in the control of air pollution; hence they may be adversely affected especially in their phytochemical constituents which are the bedrock for their therapeutic uses as alternative medicines. In this study, four biochemical parameters (relative water content, total chlorophyll content, pH, and ascorbic acid content) were used to determine the air pollution tolerance index (APTI) of four selected medicinal plants around oil-producing community of Asaa, Abia State, Nigeria. The four plant species used were *Mangifera indica*, *Anacardium occidentale*, *Azadiractaindica*, and *Carica papaya*. These plants were selected based on their relative abundance in the area under investigation. The result showed the APTI values of the plant specimen as follows: *Mangifera indica* (7.38), *Anacardium occidentale* (7.41), *Azadiracta indica* (4.53), and *Carica papaya* (6.99). This indicates that the f our plant specimen used were sensitive to air pollutants, hence can serve as bio-indicators.

KEY WORDS: Air pollution, biochemical, oil-producing, phytochemical, therapeutic, sensitive, bio-indicators.

INTRODUCTION

Air pollution have been described as the introduction into the atmosphere of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms or damage to the environment[18]. The major factors that increase air pollutants may include industrialization, increase in traffic, rapid economic development, and petrochemical industries[16]. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on the planet earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the earth's ecosystem. Plants serve as the main Green Belt (GB) component, that act as a sink and living filters to minimize air pollution by absorption, adsorption, accumulation and metabolism of pollutants, thus improving air quality by providing oxygen to the atmosphere [23]. Phytochemicals contained in plants serve as sources of drugs or alternative medicines for various ailments in local communities in Nigeria and beyond. For instance, *Carica papaya* leaves are prepared as tea for the treatment of malaria [25]. The leaf extracts from neem (Azadiractaindica) are often used as remedy for gastrointestinal upsets, diarrhea, intestinal infections, skin ulcer, and malaria [22]. The bark of *Anacardium occidentale* (cashew) is scraped and soaked overnight or boiled and the extract is used for the treatment of diarrhea [5]. The decoctions of the leaves of *Mangifera indica* have been in use to relieve abscesses, rabid dog, tumor, snakebite, datura poisoning, miscarriage, anthrax, wounds, blisters as well as stings. It is also an important remedy for relieving colic, bacillosis, bloody dysentery, excessive urination, indigestion, tumpanitis, asthma, glossitis and tetanus.[28]

Most Plant species are adversely affected by air pollutants especially in their phytochemical compositions [3], which are responsible for their medicinal properties. It is on this background that this study sought to determine the air pollution tolerance index (APTI) of four selected medicinal plants around Assa community, Abia State, Nigeria, where considerable oil exploration activities exist as indicated by the significant presence of oil firms such as Nigeria Agip Oil Company (NAOC), and Shell Petroleum Development Company of Nigeria (SPDC). APTI measures the ability of plants to withstand the impact of air pollution. In other words, it's an indicator of the degree of tolerability or sensitivity of plants to air pollution in the environment.

MATERIALS AND METHODS

Sample Specimen: The leaves of four plant species were used in this study, they include: *Carica papaya, Azadirachta indica, Mangifera indica,* and *Anacardium occidentale*.

Area of study: The experimental site for the study was around the Nigerian Agip Oil Company (NAOC), located in Assa community, in Ukwa North local government area of Abia state, Nigeria. NAOC and SPDC Oil companies operate in the community. It is situated in the western part of the state, near its boundary with Rivers state and Imo state. The medicinal plant species used were randomly collected from at least five different trees of the four species selected around the study area in the morning hours (9 – 10 am). This study was conducted in the month of July, 2014. The control plants were collected from the Botanical Garden of the Abia State University, Uturu. The plant species used were submitted and stored in the Herbarium of the Department of Plant Science and Biotechnology, Abia State University, Uturu.

Determination of the Relative Water Content

To determine the relative water content of the plant leaves, the fresh weight (FW) was obtained by weighing the fresh leaves as soon as they were collected. The leaves were then immersed in water overnight, blotted dry and then weighed to get the turgid weight (TW). The leaves were dried overnight in an oven at 70 ^{0}C and reweighed to obtain the dry weight. Thereafter, the relative water content of each plant was calculated using the formula below.

$$RWC = [(FW - DW)/(TW - DW)] \times 100$$

Where FW=Fresh weight, DW=Dry weight, and TW=Turgid weight (Singh et al., 1991).

Determination of pH of the Leaf Extract

Five (5) grams of the fresh leaf were homogenized in 10ml de-ionized water. The resulting mixture was filtered and the pH of the leaf extract was determined using the pH meter, after calibrating the pH meter with buffer solution of pH 4 and 9.

Determination of Total Chlorophyll Content

To determine total chlorophyll content of the plant leaves, three (3) grams of the fresh leaves were blended and extracted with 10ml of 80% acetone and left for 15 minutes for thorough extraction to take place. The liquid portion was decanted into another test tube and centrifuged at 2500 rpm for 3 minutes, and the supernatant was then collected and the absorbance taken at 645 nm and 663 nm using a visible spectrophotometer. The total chlorophyll content was then computed as shown below.

$$Chlorophylla = 12.7Dx663 - 2.69Dx645V/1000w \quad (mg/g)$$

$$Chlorophyllb = 22.9Dx645 - 4.68Dx663V/1000w \quad (mg/g)$$

$$TCH = Chlorophylla + b \quad (mg/g)$$

Where: Dx=Absorbance of the extract at the wavelength X nm, V= Total volume of the chlorophyll solution (ml), W=Weight of the tissue extracted (g) [13].

Determination of ascorbic acid content

Ascorbic acid content of the plant leaves was determined using the spectrophotometeric method (10). One (1) gram of the fresh foliage was put in a test tube, followed by the successive addition of 4 ml oxalic acid-EDTA, 1 ml of orthophosphoric acid, 2 ml of ammonium molybdate, and then 3 ml of water. The mixture was then shaken thoroughly and allowed to stand for 15 minutes. The mixture was then filtered and its absorbance determined at 760 nm using the visible spectrophotometer. The concentration of ascorbic acid in the sample was then extrapolated from the standard ascorbic acid curve [4].

Computation of Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index (APTI) of plants are commonly computed using four biochemical parameters which are Ascorbic acid content, Chlorophyll content, pH of the leaf extract and Relative water content as stated in the study of Singh [24]. The air pollution tolerance index (APTI) was thus calculated using the formula shown below:

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

Where A=Ascorbic acid content (mg g^{-1} dry weight), T=Total chlorophyll (mg g^{-1} dry weight), P=pH of leaf extract, R=Relative water content of leaf (%).

RESULTS AND DISCUSSION

In the present study, the result as shown in table 1 revealed that relative water contents (RWC) of the plant samples from the experimental site were quite higher compared to those of the control site. The highest and lowest recorded RWC of plants from the experimental site were that of *Carica papaya* (66.67%) and *Azadiractaindica* (40.74%). Similar findings where higher relative water content was observed in the experimental plants than in the control plants have been well reported in literature 1,8. Relative water content is associated with protoplasmic permeability in cells that causes loss of water and dissolved nutrients, resulting in early senescence of leaves [3]. Therefore the plants with high relative water content under polluted conditions are more likely tolerant to air pollutants. This may explain why plant samples from the experimental site had higher relative water content than those of the control site.

The pH of plants plays an important role in determining the plant susceptibility towards pollution [6]. The cells system functions well at optimum pH but being exposed to acidic pollutants over a long period will reduce pH levels in fewer tolerant species thus interrupt the biological activities of the plants [21]. In this study, pH of the leaf extract of samples from the experimental site were found to have a slightly lower pH values compared to those of the control samples. The decreasing order of the pH values of the experimental samples as observed in the present study were *Azadiractaindica* (5.9), *Mangiferaindica* (5.6), *Carica papaya* (4.8) and then *Anacardiumoccidentale* (4.5). High pH level will increase the efficiency for the conversion of hexose sugar into ascorbic acid (Liu and Ding, 2008). In the presence of an acidic pollutant, the plant pH is decreased, and the decline is greater in sensitive species [11]. Therefore, observed lower pH values in the experimental plants may thus be as a result of exposure to acidic air pollutants.

The total chlorophyll contents of the experimental (polluted) site were found to be lower compared to those of the control plants. As shown in Table 1, the experimental plant with the least chlorophyll content was *Azadiractaindica* (11.60), followed by Carica papaya (13.54), *Mangiferaindica* (23.69) and *Anacardiumoccidentale* (26.32) in that order. The most significant decrease in total chlorophyll content occurred with *Azadiractaindica*. Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass. Total chlorophyll content in plants varies with the pollution status of the area i.e. higher the pollution level in the form of vehicular exhausts lower the chlorophyll content [11]. Similar trend were observed by other studies [1,17]. Chlorophyll is known as an important stress metabolites and higher chlorophyll content in plants might favor tolerance to pollutants [10]. In the present study, the experimental plants had lower chlorophyll content, perhaps due the adverse consequences of their exposure to air pollutants. Perhaps, this may as a result of greater sensitivity of experimental plants to air pollutants compared with the control.

Ascorbic acid is a strong reducing agent, and it activates many physiological and defense mechanism. Its reducing power is directly proportional to its concentration [20]. Ascorbic acid is an antioxidant that increases the resistance of plants against air pollutants. Its reducing activity is pH dependent, being more at higher pH levels [7]. Increase in pollution load increases ascorbic acid content of plant species due to the increased rate of production of reactive oxygen species (ROS) during photo-oxidation process [26]. Plant species with high amount of ascorbic acid are considered to be tolerant to air pollutants [12]. This study revealed that the ascorbic acid content of the experimental plants (polluted site) were lower than those of the control. Table 1 showed that the experimental sample with the highest and lowest ascorbic acid content were *Mangiferaindica* (0.66) and *Carica papaya* (0.18) respectively, while that of the control were *Mangiferaindica* (0.94) and *Carica papaya* (0.54). However, some studies reported an increase in ascorbic acid content of the plant samples collected from the industrial or polluted site [1,14,19].

APTI measures the inherent quality of plants to counter air pollution stress, which is presently a primary concern, particularly in industrial areas. Hence, the APTI needs to be monitored and checked in predominant species that are present in polluted and non-polluted areas. In the present study, the APTI of the experimental plants (polluted area) were observed to be slightly lower than those of the control plants (Table 1). The computed APTI result showed that *Azadirachtaindica*(4.53) was the most sensitive plant species followed by *Carica papaya (6.99)*, *Mangiferaindica*(7.38), and then *Anacardiumoccidentale*(7.41). All the plant species used were sensitive to air pollutants as their APTI values are less than sixteen (16). Some other reported an APTI of 8.98 for *Mangiferaindica* [19]. and 3.470 for *Anacardiumoccidentale* [15]. Some studies documented higher APTI values for plants at the experimental site (polluted area) compared with those of the control site [8,19,15]. Plants that have higher APTI values are more tolerant to air pollution, whereas plants with lower APTI values show generally lower tolerance and more sensitivity to air pollutants [24]. Furthermore, based on the observed APTI values in this study, the experimental plants were found to be more sensitive compared with the control plants. This could probably be attributed to the adverse consequences of air pollutants on the plant specimen used for the study.

Table 1: Air Pollution Tolerance Indices (APTI) of Experimental and Control plants

Plant Species	Control					Experimental				
	RWC	TCH	pH	AA	APTI	RWC	TCH	pH	AA	APTI
Mangifera indica	41.00	40.65	7.5	0.94	9.07	50.44	21.59	6.3	0.66	7.98
Anacardium occidentale	62.94	30.40	5.3	0.72	7.96	60.28	29.22	4.7	0.38	7.42
Azadiracta indica	51.93	30.55	7.1	0.62	6.06	49.94	12.50	5.4	0.96	4.43
Carica papaya	67.26	22.64	9.8	0.54	7.41	63.57	14.51	4.9	0.17	6.89

Key: RWC=Relative water content (%), TCH=Total chlorophyll content (mg/g), pH=pH of leaf extract, AA=Ascorbic acid content (mg/g), APTI=Air pollution tolerance index

CONCLUSION

The air pollution tolerance indices of *Mangiferaindica*, *Anacardiumoccidentale*, *Azadiractaindica*, and *Carica papaya* showed that they are sensitive to air pollution. Hence, they are more likely to be adversely affected by air pollutants from industrial waste emission. However, they may be recommended for use as bio-indicators of air pollution load around this area of study and/or similar environment.

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