TITLE PAGE

AIR POLLUTION TOLERANCE INDEX OF PLANTS AROUND SELECTED SITES IN DELTA STATE

BY

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CERTIFICATION

This is to certify that this is the original research work carried out by Osaigu U.B Ebruba under the supervision of Dr O. O Emoyan in partial fulfillment of the requirements for the award of Master of Science (M.Sc) degree in Chemistry.

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DEDICATION

This Project work is dedicated to God almighty from whom all blessings flow.

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ABSTRACT

The study examined the air pollution tolerance indices (APTI) of ten plant species around Ebedei (gas faring site) and Issele-Azagba (foundry site), Delta state, Nigeria. Four physiological and biochemical parameters, which are relative water content (RWC), ascorbic acid content (AA), total leaf chlorophyll (TCh) and leaf extract pH were used to compute the value of the APTI values. The result showed order of tolerance in plant when both the foundry and gas flaring sites is compared to the control site (Abraka). For *Manihot esculenta*, the APTI increase with 33.9% at the foundry site while the APTI reduce with 15.2% at the gas flaring site. The *Chromoalaena*

odorata species has a decrease percentage of 34.7% at the foundry site and an increase of 27.4% at the gas flaring site. The *Musa paradisica* species for the APTI shows a decrease of 21.2% (foundry site) and an increase of 17.6% (gas flaring site). Other results show an increase in the APTI for both the foundry site and the gas flaring site apart from *Psidium guayava* and *Centrosema pubescens* plant species which were at a decrease both in the foundry and gas flaring sites.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: MATERIALS AND METHOD

CHAPTER FOUR: **RESULTS AND DISCUSSION**

CHAPTER FIVE

CHAPTER ONE

INTRODUCTION

1.1 **Background of Study**

Air pollution is the human introduction to the atmosphere of chemicals, particulate matter or biological gaseous materials that cause harm or discomfort to human or other living organisms, or damage to the natural environment (Ali, 2012). The atmosphere is a complex dynamic natural system that is essential to support life on planet earth, but this had since been contaminated due to environmental pollution associated with the 21^{st} century industrialization (Ali, 2008, Okunola et al, 2011)

Air pollution is one of the severe problems facing the world today due to the continual change in concentration levels of some gaseous and trace metals in the environment resulting from man’s activities such as road transportation, vehicular traffic and increased industrialization (Johan and Igbal, 1992; Joshi & Swami, 2009). Air pollution can directly affect plant via leaves or indirectly via soil acidification. Most plants experienced physiological changes before exhibiting visible damage to leaves when exposed to air pollutants (Liu and Ding, 2008). Pollutants can cause leaf injury, stomatal damage, premature senescence, decrease photosynthetic activities, disturb membrane permeability and reduce growth and yield in sensitive plant species (Tiwari et al, 2006). Reduction in leave area and petiole length was observed under pollution stress conditions (Dineva, 2004; Tiwari et al, 2006). Certain air pollutants have been reported to reduce chlorophyll content (Tiwari et al, 2006; Joshi and Swami, 2009), while others increase it (Tripathi and Gantam, 2007; Agbaire and Esiefarienrhe, 2009).

Plants are the only living organisms which have to suffer a lot from automobile exhaust pollution because they remain static at their habitat (Mandal, 2006). But roadside plants can easily avoid the effect of air pollution by altering their photosynthesis and respiration. Stomatal clogging and closure help these plants in preventing the entry of poisonous gases (Mandal, 2006). Responses of plants towards air pollutants were assessed by air pollution tolerance index (APTI). Air pollution tolerance index (APTI) is an index which denotes capability of a plant to combat against air pollution (Chanhan, 2010). The use of plants as monitor of air pollution has long been established as plants are the first interceptors of air pollutants. Presence of trees in the urban environment can improve air quality through enhancing the uptake of gases and particles (Joshi and Swami, 2009).

Various strategies exist for controlling atmospheric pollution, but vegetation provides one of the natural ways of cleaning the atmosphere by providing an enormous leaf area for impingement, absorption and accumulation of air pollutants level in the environment to various extent (Varshney, 1985; Lui and Sing, 2008; Escobeto et al, 2008; Das, 2010). Plants are very important for determining and maintaining ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide and oxygen etc, but air pollution can directly affect plants via leaves or indirectly via soil acidification (Sterbing et al, 1989; Agbaire, 2009; Kumar and Nandini, 2013). Several contributors agree that air pollutants affect plant adversely (Rao, 2006; Horsefall, 1998). Plants acts as the scavengers for air pollution as they are the initial acceptors (Joshi and Swami, 2009; Randhi and Reddy. 2012).

Trees act as air pollution sinks but the better performance comes from the tree with high pollution tolerance index (Miria and Khan, 2013). By monitoring plants tolerance toward air pollution they can be screened and can be employed as biological indicators or monitors of air pollution. They can be used effectively by planners and green belt developers in managing the urban air pollution.

Another parameter that may decide the tolerance of plant to air pollution is ascorbic acid (vitamin C). It play a significant role in light reaction of photosynthesis (Singh and Verma, 2007) activities, defense mechanism (Arora et al, 2002) and under stress condition, it can replace water from light reaction (Singh and Verma, 2007). Ascorbic acid, a natural antioxidant in plants has shown to play an important role in pollution tolerance (Joshi and Swami, 2007). It plays a role in cell wall synthesis, defense and cell division. It is also strong reducer and plays important roles in photosynthetic carbon fixation.

Also water is a crucial prerequisite for severe stress to terrestrial plant (Singh and Verma, 2007). High water content within the plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are high.

These effects of air pollution on plants are usually applicable to plants in foundry and gas flaring sites. Hence, this study examines the air pollution tolerance index of plants in Ebedei and Issele-Azagba

1.2 Aim

This research is aimed at determining the air pollution tolerance index value of plants in Ebedei and Issele-Azagba, both in Delta State in order to ascertain the plants that are more tolerable to the prevailing atmospheric conditions.

1.3 Statement of Problems

Air pollution has become a serious environmental stress to plants due to increase in industrialization and urbanization during the last few decades. The particulate and gaseous pollutants, alone and in combination, can cause serious setback to the overall physiology of plants. Gas flaring may further contribute to local and regional environmental problems with attendant impact on agriculture, forests and other physical infrastructure. The research work attempts to prove the impact of air pollution on plant in the selected sites, and to determine the air pollution tolerance index value of plant in the study area.

1.4 Objectives of the study

The objectives of the study are to:

1. Determine the air pollution tolerance index value of plants in Ebedei and Issele-Azagba

2. Investigate the change in the chlorophyll, ascorbic acid content, leaf extract and relative water content in plant.

1.5 Scope of Study

This research work is restricted to ten plant species around the Ebedei gas flaring and Eastern Metals Plants, Asaba, using the same plant species from Abraka as the control site. The species of plants used for this study are: Cassava - *Manihot esculenta,* Plantain - *Musa paradisica,* Oil palm - *Elaeis guineensis,* Spear grass -*Imperata cylindrical*, Mango - *Magnifera indica*, Awolowo weed - *Chromolaena odorata*, Guava - *Psidium guayava*, Sunflower - *Helianthus annuus*, Wireweed -*Sida acuta*, Butterfly peas - *Centrosema pubescens*

CHAPTER TWO

LITERATURE REVIEW

2.1 The Environment

The natural environment encompasses all living things and non-living things occurring naturally on the earth. It is an environment that encompasses the interaction of all living species, Climate, weather, and natural resources that affect human survival and economic activity.

One of the greatest problems that the world is facing today is that of environmental pollution increasing with every passing years and causing grave and irreparable damage to the earth. Environmental pollution consists of five basic types of pollution, namely air, water, soil, noise and light.

Air pollution is by far the most harmful form of pollution in our environment. Air pollution is caused by injurious smoke emitted by cars, buses, trucks, trains, and factories, namely sulphur dioxide, carbon monoxide and nitrogen oxides.

Evidence of increasing air pollution is seen in lung cancer, asthma, allergies, and various breathing problems along side with severe irreparable damage to flora and fauna (university of California centre for environmental engineering)

Air pollution is a serious problem throughout the world. Rapid industrialization and vehicular traffic especially in the urban areas of India lead to the deterioration of air by adding toxic gases and other substances to the atmosphere (Thambavai and Maheswari 2012). All combustion releases gases and particulate matter into the air which includes SOx, NOx, CO and soot particles as well as smaller quantities of toxic metals, organic molecules and radioactive isotopes (Bhattacharya et al. 2013, Agbaire and Esiefarienrhe 2009, Chouhan et al. 2011). The degradation of air quality is major environmental problem that affects many urban and industrial sites and the surrounding regions worldwide (Kuddus et al. 2011). Although various efforts have been done for environmental restoration in India but still it seems to be a formidable task (Thambavai and Maheswari 2012).

Plants are very important for determining and maintaining ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide and oxygen etc., but air pollution can directly affect plants via leaves or indirectly via soil acidification (Steubing et al. 1989, Agbaire 2009, Kumar and Nandini 2013). Several contributors agree that air pollutants affect plant growth adversely (Rao 2006, Horsefall 1998). Plants act as the scavengers for air pollution as they are the initial acceptors (Joshi and Swami 2009, Randhi and Reddy 2012).

Trees act as air pollution sinks but the better performance comes from the pollution tolerant species. (Miria and Khan 2013). By monitoring plants tolerance toward air pollution they can be screened and can be employed as biological indicators or monitors of air pollution. Then they can be used effectively by planners and green belt developers in managing the urban air pollution. Study of single parameter may not provide a clear picture of the pollution induced changes; so air pollution tolerance index which was based on four parameters has been used for identifying tolerance levels of plants species. The usefulness of evaluating APTI for the determination of tolerance as well as sensitiveness of plant species were followed by several authors (Agrawal and Tiwari 1997, Dwivedi and Tripathis 2007, Yan-Ju and Ding 2008, Lui and Ding 2008, Dwivedi et al. 2008, Jyothi and Jaya 2010).

2.2 Effects of air pollution sources on humans and the environment

Apart from compounding the element of the atmosphere, most air pollutants in the region are found to have limited and sectional effects such as the acid rain formation, global warming, climate change, water pollution, and impacts on plants and wild life. While uttermost of these may be true while some has not been affirmed scientifically and is rather based on assumptions or being speculative. There are numerous setbacks facing air quality studies, like in most developing nations like Nigeria (Victor O. and Ejikeme N, 2011). These challenges include the lack of infrastructure, inadequate expertise, weak policy framework.

2.2.1 Effects of air pollution on human health

The respiratory system is the primary indicator of air pollution effects in human as carbon dioxide diffuses through the capillary wall into the alveolus while oxygen diffuses out of the alveolus into the blood cell. The difference in partial pressure of each of the gases causes it to move from higher to lower respiratory track causing a great cardio-respiratory ailment amongst the heavy smokers and people living in industrial areas. Some chronic respiratory diseases like Bronchial, Asthma are aggravated by air pollution, example, former workers of Nkalagu cement industry in Ebonyi state (Victor, Nwajuaku and Ejikeme, 2011)

In recent years, several epidemiological studies have emerged showing adverse health effects associated with short term and long term exposure to air pollutants. Time series studies conducted in Asian cities also showed similar health effects on mortality associated with exposure to particulate matter, NO_2, SO_2, O_3.

Ali and Ather, 2010, Ali and Ather, 2008, Ghauri et al, 2007, Kumar and Joseph, 2006 to those explored in Europe and north America. William 2012, Menezes etal, 2012, Vlatka etal, 2011, Icage and Sabah 2009, Osuji and Avwiri 2005, monitored the ambient air quality of industrial areas of Nigeria for criteria pollutants: CO, NO_2, SO_2, O_3 particulate matter, and Pb and found all of them to be very high as compared to world health organization air quality guideline. This means that these pollutants are already of risk to the teaming Nigerian population. Nwachukwu and Ugwuanyi (2010) studied air pollution and its possible effects on rural dwellers in Rivers state, Nigeria and found that the lower atmosphere of the state is already affected by air pollution and that this is already affecting the health of its habitats.

The Beijing Capital Iron & Steel Factory (BCISF) in the west of Beijing, China is a significant and long term point source for air pollutants such as $S0_2$, CO, $N0_2$ and heavy metals. Mitigating this pollution is a high priority for both health of residents around the factory and amelioration of environmental conditions in the city. The reduction of emission either through curtailment of industrial activity or scrubbing has been suggested. However, neither offers a complete solution and both require significant economic costs. Therefore, landscape plantings in the factory's vicinity may offer an accessorial option. Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollutant level in the air environment, with a various extent for different species.

Air pollutants can directly affect plants via leaves or indirectly via soil acidification. When exposed to airborne pollutants, most plants experienced physiological changes before exhibiting visible damage to leaves. Leaf conductance, membrane permeability, glutathione (GSH) concentration, peroxidase activity and ö 13C of leaf tissue were used to estimate plant's tolerance. In addition, other studies showed that the impacts of air pollutants could have on the parameters also included ascorbic acid (AA), chlorophyll content, leaf-extract pH, and relative water content. However, these separate parameters gave conflicting results for same species, for example, Ailanthus altissima identified as sensitive to pollution using one parameter but a tolerant using another. For the reason that single parameter may not provide a clear picture of the pollution-induced changes, air pollution tolerance index (APTI) based on four important parameters has been used for identifying tolerance levels of plant species.

Vegetation near BCISF has been exposed to a cocktail of air pollutants for more than 80 years. The ability of plant species to remove pollutants has been evaluated. In this study, we aim to evaluate pollution tolerance of 23 plant species currently growing in the vicinity of BCISF by using the APTI method during the growing season, from the hot summer to the cooler autumn months. Thus, we could analyze seasonal variation of the parameters which influence pollution tolerance. The goal of this study was also to develop a gradation of air pollution tolerance that can be applied broadly in the selection of species in urban planting. Based on the previous view, the developmental stage, nutritional status and environmental factors were important factors in tolerance analysis. The materials were thus collected from the site with similar environmental factors.

Plants which are an important part of all ecosystems play a crucial role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen. They are most likely to be affected by airborne pollutants, and the effects are widely observed on the leaves which are usually the most abundant and most obvious primary receptors of large number of air pollutants. The plants provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment. Since air pollutants affect germination of seeds, length of pedicles, and, number of flowers in inflorescence, the plant species can be used as a bio-monitor to evaluate the impact of air pollution. The direct impact of air pollutants on the plants can be seen on leaves, while the indirect effect can be seen through soil acidification. The previous studies on the effect of air pollution have reported the physiological changes in plant before exhibiting visible damage to leaves.

The study also reported the air pollution impact on Ascorbic acid content chlorophyll content, leaf extract pH and relative water content. These separate parameters have indicated contrasting results for same species.

However, the air pollution tolerance index (APTI) calculated by considering all the four parameters have been used for identifying tolerance levels of plant species. Previous researchers have reported the visible and non visible effects of automobile exhaust on road side vegetation. The studies have pointed gradual disappearance of chlorophyll and concomitant yellowing of leaves, which may be associated with a consequent decrease in the capacity for photosynthesis. Some researchers have ranked the different plant species in order of tolerance to air pollution based on Air pollution tolerance. In the present study, we aim to evaluate air pollution tolerance of four plant species growing in the vicinity of Bhavan's College Campus, Andheri, by using the Air Pollution Tolerance Index (APTI) method during the growing season, from the hot summer to the cooler autumn months. Thus we could analyze seasonal variation of the parameters which influence pollution tolerance. The APTI determinations of the present investigation are of importance because with increase urbanization, there is increasing danger of deforestation due to air pollution. Thus APTI results of the present investigation are therefore handy for future planning of air.

Emission of greenhouse gases is one of the major problems arising from human population explosion and industrialization. The use of fossil fuels such as petroleum hydrocarbons and coal for transport, electricity generation for industries and households; land clearing, deforestation, agriculture and land use, produce large quantities of oxides of carbon, nitrogen and sulphur, as well as methane, aerosol particulates, etc. These pollute the environment; destroy the atmospheric ozone shield that protects organisms from high levels of ultraviolet radiation, resulting in global warming and climate change. Hence, the study focuses on the determination of air pollution tolerance index of six selected tree species (Anacardium occidentale, Azadiracta indica, Cassia angustifolia, Eucalyptus spp, Khaya senegalensis, Mangifera indica) commonly found in selected locations of different pollution concentration in Maiduguri city.

The relative leaf water content (RWC), total chlorophyll content (Tch), pH of leaf extract, and ascorbic acid content (AAC) were determined to calculate the air pollution tolerance index of the selected tree species in automobile repair garage, road sides, commercial areas, as highly polluted areas (HP) where most pollutants are emitted into the atmosphere, residential areas as moderately polluted areas (MP) and city outskirts as low polluted areas (LP). Pollutants that are pumped into the atmosphere and directly pollute the air are primary pollutants while those that are formed in the air when primary pollutants react or interact are known as secondary pollutants. Also the effects are most often apparent on the leaves which are usually the most abundant and most obvious primary receptors of large number of air pollution.

Studies show that air pollution has an impact on the ascorbic acid content, total chlorophyll content, leaf extract pH, and relative water content of plants. Therefore, air pollution tolerance index (APTI) was computed based on all four parameters that have been used to identify the tolerance of plant species.

Many workers like to use ascorbic acid, chlorophyll, relative water content and leaf extract pH to evaluate the susceptibility of some plants to air pollutants by computing these four physiological parameters together in a formation signifying their air pollution tolerance index (APTI). Plants with higher APTI values are more tolerant to air pollution than those with low APTI values. Those with low APTI values are sensitive plants and may act as bio-indicators of pollution. Hence, on the basis of their indices, different plants may be categorized into tolerant, moderately tolerant, intermediate and sensitive plants.

Ascorbic acid is an antioxidant, which contributes in protecting the plants against oxidative damage resulting from aerobic metabolism, photosynthesis arid a range of pollutants. Reactive oxygen species are produced in plants after exposure to environmental conditions like drought, cold or air pollution by building up reactive oxygen species and then respond by reducing the amount of water that escapes from leaves. The water content of the plant tissues helps to maintain the physiological balance of the plant when subjected to the stress of air pollution. Hence, the water content is related to the degree of pollution. The pH of the plant tissue is also related to the degree of air pollution since air pollutants interact with rainwater to form mixtures and solutions with pH, depending on the type of pollutant. Chlorophyll is involving in the productivity of the plants and its level is a direct measure of leaf damage by pollution. Its measurement is an important tool for evaluating the effects of air pollutants on plants since it plays an essential role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth.

CHAPTER THREE

MATERIALS AND METHOD

3.1 Description of study area

Ebedei oil fields is located within latitudes 6.400^0 – 6.285^0 and longitudes 5.823^0 – 6.212^0 in Ukwuani Local Government Area and Eastern Metals Limited located at K.M.16, Asaba-Benin expressway, Issele-Azagba, Delta state, Nigeria

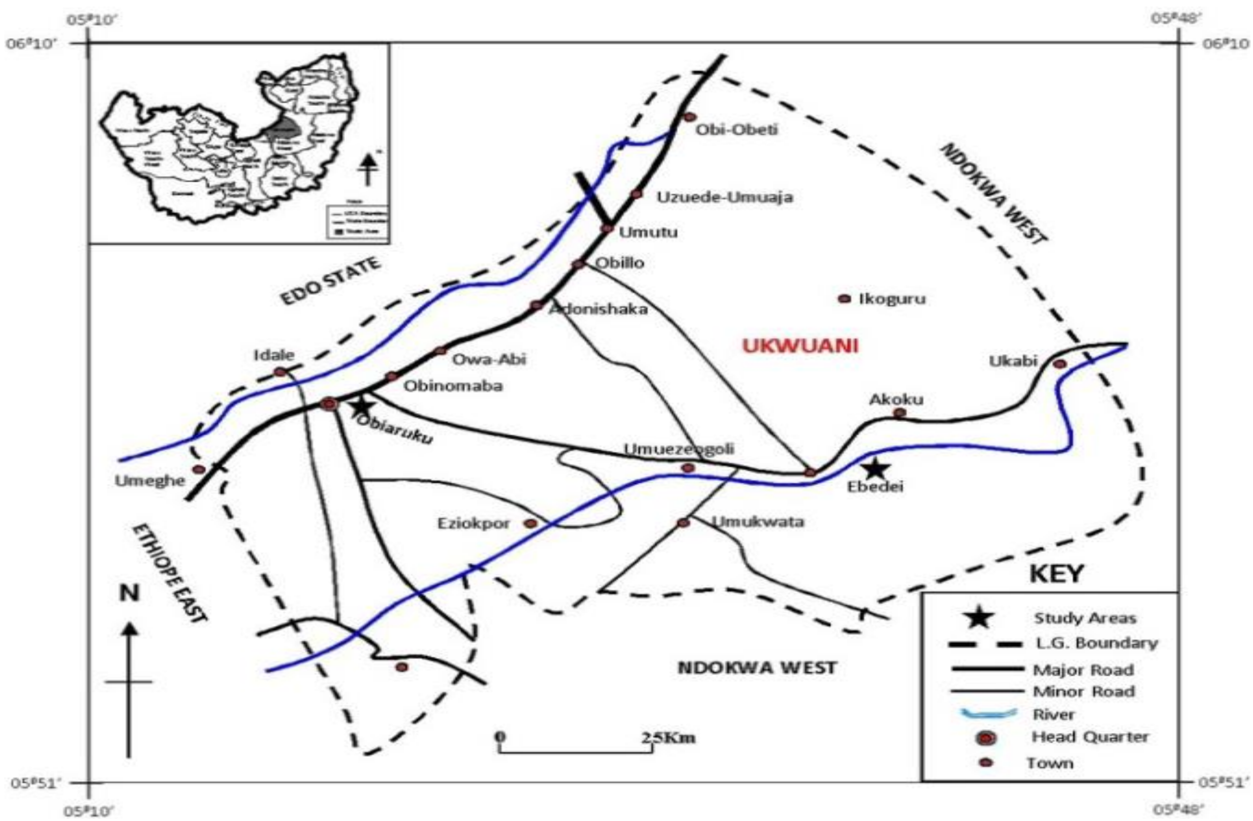

Figure 3.1 Map of delta state showing the study areas

List of plant species and their botanical names

The species of plants used for this study are:

PLANT SPECIES	BOTANICAL NAMES
Cassava	*Manihot esculenta*
Plantain	*Musa paradisiac*
Oil palm	*Elais guinea*
Spear grass	*Imperata cylindrical*
Mango	*Magnifera indica*
Awolowo weed	*Chromoalaena odorata*
Guava	*Psidium guayava*
Sunflower	*Helianthus annuus*
Wireweed	*Sida acuta*
Butterfly peas	*Centrosema pubescens*

3.2 Sample collection

Leaves of ten plant species each were collected randomly in triplicate for analysis from the Ebedei oil field, located within latitudes 6.400^0 – 6.285^0 and longitudes 5.823^0 – 6.212^0 in Ukwuani Local Government Area and Eastern Metals Limited , located at K.M.16, Asaba-Benin expressway, Issele-

Azagba. They were immediately brought to the laboratory in a polythene bag for analysis. Fresh weights for the samples were immediately taken. Samples were preserved in refrigerator for further analysis.

3.3 AIR POLLUTION TOLERANCE INDEX (APTI)

The air pollution tolerance indices of the plant species was determined following the method adopted by Singh and Rao (1983).

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

Where AA= Ascorbic acid in mg/g

T= Total Chlorophyll in mg/g

P= pH of leaf extract

R= Relative water content in mg/g

3.4 Relative water content (RWC)

This was obtained by the method described by Singh, 1997. Fresh weights (FW) were obtained by weighing the fresh leaves. The leaves were immersed in water over night, plotted dry and then weighed to get the turbid weight

(TW). The leaves were then oven-dried at 105^0C for 2hrs and re -weighed to get dry weight (DW). Thus the relationship below is used to calculate RWC

$$RWC = \frac{FW - DW}{TW - DW} X \frac{100}{1}$$

3.5 Ascorbic acid

Preparation of reagent

1. **PREPARATION OF OXALIC ACID (0.5) EDTA SOLUTION**

0.6335g of oxalic acid salt was dissolved in 100ml distilled water. To the solution, 0.0058g of EDTA salt was dissolved.

Determination of Vitamin C (Ascorbic Acid)

This was obtained using the spectrophotometric method. 1ml of the samples was measured into test tubes. The solution was allowed to stand for 15minutes after which the absorbance at 760nm was measured with a spectrophotometer. The concentration of ascorbic acid in the samples was determined by exploration from a standard ascorbic acid curve.

II. **PREPARATION OF 5% SULPHURIC ACID SOLUTION**

5ml of concentrated suiphuric acid (98%) was taken (using a pipette) and added to 80ml of water and made up to 100ml mark in the volumetric flask.

III. **PREPARATION OF ORTHOPHOSPHORIC – ACETIC ACID SOLUTION**

3ml of orthophosphoric acid and 8ml of acetic acid was mixed with 20ml of water (distilled). The mixtures ws diluted to 100ml with distilled water.

IV. preparation of 5% ammonium molybdate solution

5g of ammonium molybdate was dissolved in 20ml of distilled water and was made up to 100ml with distilled water.

V. preparation of 1% l-ascorbic acid

1g of L-ascorbic acid was dissolved in 90ml of distilled water and made up to 100ml of distilled water.

Methods

Determination of ascorbic acid content in different species of plant: spectrophotometric method.

4ml of oxalic acid-EDTA solution was added to 1ml extract of each plant sample. Then, 1mlof the orthosphosphoric-acetic acid solution was added to each sample, 1ml of 5% sulphuric acid solution was added to the mixture, followed by 2ml of ammonium molybdate. 5ml of distilled water was lastly added.

The flasks containing the plant extract were allowed to stand for 15minutes, before measuring the absorbance in a spectrophotometer at 760nm

3.6 Determination of pH of Leaf extract

5g of the fresh leaves was grinded to paste and then dissolved in 50ml of distilled water. The pH of the leaf extract was then measured using a calibrated pH meter.

3.7 Total Chlorophyll Content

This was done according to the method described by Agbaire and Esiefarienrhe (2009). 3g of the fresh leaves was weighed and blended. This was extracted with 10ml of 80% acetone. This was left for 15minutes for thorough extraction. The liquid portion was decanted into another test tube and was centrifuged for three minutes. The supernatant was collected and the absorbance was taken at 645nm and 663nm using a spectrometer. The total chlorophyll is calculated by using the formulae

$$Tch = 20.2(\mathrm{D645}) - 8.02(\mathrm{D663}) \mathrm{x} \frac{\mathrm{V}}{1000\mathrm{W}} \quad (mg/g)$$

D645=absorbance of leaf extract at 645nm

D663=absorbance of leaf extract at 663nm

V= Volume of leaf extract of $4cm^3$

W= weight of the tissue extracted (g)

3.8 Data Analysis: Data collected were subjected to statistical tools of mean, standard deviation and statistical tests of significance using the student t-test and analysis of variance (ANOVA). All statistical analyses were done by SPSS software for windows.

CHAPTER FOUR

RESULTS AND DISCUSSION

The study which was conducted at three sites in Delta state (Abraka, Ebedei and Asaba) representing the control site, gas flaring site and foundry site respectively investigated the Air Pollution Tolerance by determining the changes in chlorophyll, ascorbic acid content, leaf extract pH and the relative water content. Below is the result of the analysis.

Table 4.1 below shows the Air Pollution Tolerance Index (APTI) of some selected plant in both the foundry and gas flaring site. As Sharma and Butter (1973) have reported that plants usually absorbs, accumulate and integrate environmental pollutant which they are expose to and that most plant can be sensitive to the extent that there is alteration in the biochemical processes. The result above shows the difference in plant when both the foundry and gas flaring sites is compared to the control site. For the *Manihot esculenta* species the APTI increase with 33.9% at the foundry site while the APTI reduce with 15.2% at the gas flaring site. The *Chromoalaena odorata* species has a decrease percentage of 34.7% at the foundry site and an increase of 27.4% at the gas flaring site. The *Musa paradisica* species for the APTI shows a decrease of 21.2% (foundry site) and an increase of 17.6% (gas flaring site). Other results show an increase in the APTI for both the foundry site and the gas flaring site apart from *Psidium guayava and Centrosema pubescens* plant species which were at a decrease both in the foundry and gas flaring sites. An overview of the entire result indicates that different plants respondents differently to air pollution. The APTI determinations are of importance because with increase industrialization, there is increasing danger of deforestation due to air pollution. The study has also help to shows plants that last the best of time as industrial activities increases. In essences, plants species like *Elais guinea*, *Helianthus annuus, Magnifera indica, Imperata cylindrica, Sida acuta* and partly *Manihot esculenta* (only in the foundry site) and *Chromoalaena odorata* (gas flaring site) are more tolerant to the prevailing atmospheric conditions.

Table 4.1: Air Pollution Tolerance Index (APTI) of some plant in the foundry and gas flaring site (Result of composite sample-mean)

Species	Site	pH	RWC (%)	Ascorbic Acid mg/g	Total Chlorophyll mg/g	APTI	% increase in APTI
M esculenta	C	6	29.5	4.6	1.6	6.45	
	E1	5.90	54.30	5.80	1.60	9.75	33.9%
	E2	5.6	54.8	11.6	1.5	5.6	-15.2%
C odorata	C	5.7	35.1	1.3	1.4	4.43	
	E1	5.60	14.80	2.60	1.40	3.29	-34.7%
	E2	6.1	62.8	8	1.3	6.1	27.4%
M paradisica	C	6	38.4	1.4	1.3	4.86	
	E1	6.10	30.50	1.40	.80	4.01	-21.2%
	E2	5.9	41.7	1.2	0.8	5.9	17.6%
E guinea	C	5	3.9	2.1	1.2	1.69	
	E1	5.90	17.80	1.30	.40	2.60	35.0%
	E2	6	48.5	1.7	1.8	6	71.6%
H annuus	C	6.8	24	1.4	1.3	3.53	
	E1	7.60	19.40	3.30	.70	4.64	23.9%
	E2	6.7	32.2	2.3	0.4	6.7	47.3%
P guayava	C	5.7	35.8	6.6	1.1	8.07	
	E1	6.00	35.40	4.10	1.10	6.45	-25.1%
	E2	6.2	39.5	3.2	1	6.2	-30.2%
I cylindrica	C	5.1	7.8	0.2	1.8	0.92	
	E1	5.60	74.20	1.20	1.70	8.30	88.9%
	E2	6.1	57	1.9	1.3	6.1	84.9%
M indica	C	5	39.5	1.3	1.8	4.83	
	E1	4.9	3	1.4	1.3	4.9	1.4%
	E2	5.7	68.7	2.9	1.2	5.7	15.3%
Sida acuta	C	6.1	6.1	2.5	1.1	2.41	
	E1	6.3	31.4	1.1	1.2	6.3	61.7%
	E2	6.8	53.9	0.9	1.5	6.8	64.6%
C pubescens	C	6	83.2	2	1.4	9.8	
	E1	5.9	21.2	1.6	1.3	5.9	-66.1
	E2	6.7	47.2	1.6	1.1	6.7	-46.3

Note: C=Control Site, E_1= Foundry Site, E_2=Gas flaring Site

Table 4.2: Mean Scores of Leaf Extract pH, RWC, Ascorbic Acid, Total Chlorophyll and APTI in the Control Site

Control Site	Mean	Standard Deviation	Minimum	Maximum
pH	5.74	.57	5.00	6.80
RWC	30.33	23.17	3.90	83.20
Ascorbic Acid mg/g	2.34	1.88	.20	6.60
Total Chlorophyll mg/g	1.40	.26	1.10	1.80
Air Pollution Tolerance Index (APTI	4.70	2.80	.92	9.80

Table 4.3: Mean Scores of Leaf Extract pH, RWC, Ascorbic Acid, Total Chlorophyll and APTI in the Foundry Site

Foundry Site	Mean	Standard Deviation	Minimum	Maximum
pH	5.98	.68	4.90	7.60
RWC	30.20	20.75	3.00	74.20
Ascorbic Acid mg/g	2.38	1.57	1.10	5.80
Total Chlorophyll mg/g	1.15	.41	.40	1.70
Air Pollution Tolerance Index (APTI)	4.74	2.66	1.15	9.75

Table 4.4: Mean Scores of Leaf Extract pH, RWC, Ascorbic Acid, Total Chlorophyll and APTI in the Gas Flaring Site

Gas Flaring Site	Mean	Standard Deviation	Minimum	Maximum
pH	6.18	.42	5.60	6.80
RWC	50.63	11.07	32.20	68.70
Ascorbic Acid mg/g	3.53	3.48	.90	11.60
Total Chlorophyll mg/g	1.19	.40	.40	1.80
Air Pollution Tolerance Index (APTI)	7.63	3.07	4.84	13.78

Table 4.2, 4.3 and 4.4 show the mean score of leaf extract pH, RWC, ascorbic acid Chlorophyll and the APTI the three sites. Mean score of pH in the control site is (5.74±0.57) which is relatively lower than that of the foundry site (5.98±0.64) and gas flaring site (6.18±0.42).

The relative water content (RWC) has a mean score of (30.33±23.17) for the control site slightly higher than the foundry site (30.20±20.75) but lesser than that of the gas flaring site (50.63±11.07). Ascorbic acid mean score varies among the 3 sites. The control site (2.34±1.88) is lower that the foundry site

(2.38±1.57) and gas flaring site (3.53±3.48). The mean score of Total Chlorophyll for control site (1.40±0.26) is higher than that of the foundry site (1.15±0.41) and the gas flaring site (1.19±0.40). The mean scores for the Air pollutant Tolerance Index (APTI) in the control site is (4.70±2.80) which is lower than that of the foundry site (4.74±2.66) and gas flaring site (7.63±3.07).

Table 4.5: Determining The Significant difference in the Air Pollution Tolerance Index (APTI) value of plant around the Gas flaring Site and the Foundry Site

	Paired Differences					t	df	P-value
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
(APTI) Gas Flaring Site-(APTI) Foundry Site	-2.89195	3.32279	1.05076	-5.26893	-.51497	-2.752	9	.022

P-value<0.05(Level of Significant)

The result above shows that there is a significant difference between the Air Pollution Tolerance Index in the gas flaring site and foundry site. The t-statistics value (2.752) with a probability level of 0.022 (which is less than 0.05) explains the significance. Furthermore, the mean difference of (-2.89±3.32) implies that the tolerance level of the foundry site was higher than that of the gas flaring site. This could be explains to be caused by the several industrial activities and the release of Air Pollutants that affects the environment where plant grows.

CHAPTER FIVE

5.1 CONCLUSION

Based on the result gathered from the experiment undergone in this study, the following conclusions were made:

Plants respond differently to air pollution. Plant species like *Elais guinea, Helianthus annuus, Magnifera indica, Imperata cylindrica, Sida acuta and* partly *Manihot esculenta* (only in foundry site) and *Chromoalaena odorata* species (gas flaring site) are tolerable in prevailing atmospheric conditions. And as such, they can last the best of time as industrial activities increases.

The study revealed the changes in the chlorophyll, ascorbic acid content, leaf extract pH and relative water content in plant. Mean score of pH in the foundry site is relatively lower than that of the gas flaring site. The relative water content (RWC) has a mean score higher in the gas flaring site compared to the foundry site. Ascorbic acid mean score varies among the 3 sites. The control site is lower than the foundry site and gas flaring site. The mean score of Total Chlorophyll for control site is higher than that of the foundry site and the gas flaring site.

The study also revealed that there is a significant difference between the air pollution tolerance index in the gas flaring site and foundry site. The t-statistics value (2.752) with a probability level of 0.022 (which is less than 0.05) explains the significance. Furthermore, the mean difference of (-2.89±3.32) implies that the tolerance level of the foundry site was higher than that of the gas flaring site. This could be explains to be caused by the several industrial activities and the release of air pollutants that affects the environment where plant grows.

5.1 Recommendations

It is therefore recommended that the agencies with the responsibility to monitor gas plant station that flare gas should monitor their activities in Ebedie gas plant to avoid or reduce the increase in air pollution which endanger both plant and animal life.

It is also recommended that plants that have higher tolerance ability should be planted around Ebedie areas.

Finally, seminar and workshop should be organized with the aim of enlightening people living within that environment about the health hazard and the economic effect of the environment.

5.1 Contribution to Knowledge

This research work has also help to shows plants that last the best of time as industrial activities increases. In essences, plants species like *Elais guinea*, *Helianthus annuus*, *Magnifera indica*, *Imperata cylindrica*, *Sida acuta* and partly *Manihot esculenta* (only in the foundry site) and *Chromoalaena odorata* (gas flaring site) are more tolerant to the prevailing atmospheric conditions. The result of this study is therefore handing for landscaping and biomonitoring of air pollution.

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APPENDIX

Samples: Abraka

Location: $5^0$47'0''N$6^0$6'0''E

S/N	Plant Species	pH			RWC (%)			Ascorbic Acid mg/g			Total Chlorophyll mg/g		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1.	*M esculenta*	6.0	5.8	6.2	29.53	29.61	29.46	4.59	4.58	4.60	1.61	1.60	1.63
2.	*C odorata*	5.7	5.8	5.6	35.00	35.10	35.05	1.30	1.32	1.28	1.39	1.38	1.39
3.	*E guineensis*	5.9	6.0	6.0	38.38	38.40	38.37	1.36	1.35	1.34	1.26	1.24	1.28
4.	*M paradisica*	5.0	4.8	5.1	3.93	3.76	4.10	2.11	2.06	2.16	1.23	1.25	1.22
5.	*H annuus*	6.8	6.6	6.9	23.99	23.94	24.03	1.37	1.37	1.35	1.32	1.30	1.34
6.	*P guayava*	5.7	5.6	5.8	35.90	35.76	35.63	6.58	6.59	6.56	1.13	1.11	1.15
7.	*I cylindrica*	5.2	5.2	5.0	7.75	7.90	7.71	0.22	0.21	0.24	1.80	1.79	1.82
8.	*M indica*	5.1	50	5.0	39.46	39.50	39.41	1.27	1.29	1.26	1.81	1.80	1.82
9.	*Sida acuta*	6.1	6.3	6.0	6.08	6.13	6.04	2.55	2.53	2.53	1.05	1.10	1.00
10.	*Centrosima probensis*	5.9	6.0	6.0	83.15	83.29	83.01	1.98	1.99	2.00	1.38	1.36	1.40

Samples: Ebedei

Location: 5.900^{0}N 5.6332^{0}E

S/N	Plant Species	pH			RWC (%)			Ascorbic Acid mg/g			Total Chlorophyll mg/g		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1.	*M esculenta*	5.7	5.9	6.1	54.26	54.20	54.32	5.75	5.76	5.74	1.62	1.61	1.64
2.	*C odorata*	5.3	5.6	5.9	14.90	14.80	14.70	2.57	2.59	2.61	1.38	1.40	1.37
3.	*E guineensis*	6.1	6.3	5.8	30.46	30.20	30.72	1.41	1.44	1.37	0.79	0.80	0.79
4.	*M paradisica*	5.9	5.8	6.0	17.60	17.80	18.00	1.31	1.31	1.32	0.36	0.37	0.35
5.	*H annuus*	7.2	7.6	7.9	19.32	19.36	19.40	3.26	3.25	3.27	0.74	0.75	0.73
6.	*P guayava*	5.9	6.0	6.2	35.38	35.40	35.36	4.07	4.08	4.07	1.12	1.12	1.11
7.	*I cylindrica*	5.6	5.8	5.4	74.23	74.30	74.16	1.21	1.22	1.20	1.66	1.67	1.65
8.	*M indica*	4.9	5.0	4.7	2.99	3.00	3.02	1.38	1.37	1.39	1.30	1.33	1.27
9.	*Sida acuta*	6.3	6.4	6.1	31.40	31.25	31.55	1.14	1.12	1.15	1.22	1.20	1.24
10.	*Centrosima probensis*	5.9	5.6	6.1	21.18	21.23	21.13	1.55	1.54	1.57	1.34	1.35	1.33

Samples: Asaba

Location: 6.2823^{0}N, 6.5529^{0}E

S/N	Plant Species	pH			RWC (%)			Ascorbic Acid mg/g			Total Chlorophyll mg/g		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1.	*M esculenta*	5.6	5.9	5.4	54.80	55.01	54.60	11.63	11.65	11.61	1.50	1.52	1.49
2.	*C odorata*	6.1	6.0	6.2	62.80	62.90	62.71	8.03	8.02	8.05	1.33	1.38	1.27
3.	*E guineensis*	5.8	5.9	6.0	41.31	41.70	42.00	0.94	1.20	1.31	0.72	0.73	0.81
4.	*M paradisica*	6.2	6.0	5.9	48.47	48.52	48.42	1.72	1.71	1.74	1.78	1.80	1.76
5.	*H annuus*	6.7	6.8	6.7	32.20	32.10	32.30	2.26	2.29	2.24	0.43	0.44	0.42
6.	*P guayava*	6.2	6.3	6.1	41.31	34.00	43.10	3.17	3.21	3.30	0.94	0.97	1.03
7.	*I cylindrica*	6.1	6.0	6.1	56.98	56.96	57.01	1.94	1.95	1.93	1.33	1.31	1.35
8.	*M indica*	5.7	5.6	5.8	68.66	68.62	68.69	2.87	2.86	2.89	1.20	1.21	1.19
9.	*Sida acuta*	6.8	6.6	6.9	53.89	53.96	53.83	0.89	0.89	0.88	1.50	1.55	1.46
10.	*Centrosima probensis*	6.7	6.7	6.7	47.20	47.30	47.10	1.62	1.61	1.64	1.11	1.10	1.11

PHOTO OF PLANTS USED

Manihot esculenta

Musa paradisiac

Elais guinea

Imperata cylindrica

Magnifera indica

Chromoalaena odorata

Psidium guayava

Helianthus annuus

Sida acuta

Centrosema pubescens