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Dust Pollution Reduced Stomatal Conductance and Photosynthetic Pigments of Selected Medicinal Plants Growing at Lokpa Ukwu Quarry Site in Abia State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author CEO designed the study and wrote the protocol. Author FIN performed that laboratory tests and statistical analysis and wrote the first draft of the manuscript. Author NON managed the literature searches and wrote the final draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: We investigated the influence of dust pollution on stomatal conductance and photosynthetic pigments in some medicinal plants growing at Lokpa Ukwu quarry site, Abia State, Nigeria.
Place and Duration of Study: Samples were collected from Lokpa Ukwu, Abia State while laboratory analyses were carried out in the Department of Pharmacognosy and Environmental Medicines, University of Nigeria, Nsukka between February and April, 2019.
Methodology: A total of nine (9) plants were sampled for the study. Leaf epidermises were prepared by clearing method and stomata were observed and studied quantitatively. Stomatal conductance was estimated from the anatomical variables following standard procedures. Total chlorophyll and β-carotene contents were also analysed and compared with control groups.

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Results: We observed some physiological changes in the plants from dust-polluted site such as stretched epidermal cells, deformed stomata and plasmolysed guard cells. It reduced the potential conductance indices (PCI) of the plants by 87.4% in *Aspilia africana* and 67% in *Chromolaena odorata.* The least reduction in PCI was observed in *Celosia trigyna* (7.2%). Operating conductance (g_{op}) and maximum conductance (g_{max}) were reduced by 69.2% and 72.3% in *C. odorata* and *A. africana* respectively. *Celosia trigyna* was least affected with percentage reductions of 18.3% and 1.4% for g_{op} and g_{max} respectively. Reduction in PCI and g_{max} followed the order: *C. trigyna* < *C. papaya* < *P. discoideus* < *D. oliveri* < *T. rhomboidea* < *T. orientalis* < *V. doniana* < *C. odorata* < *A. africana.* Total chlorophyll and β-carotene contents were reduced the most in *V. doniana* (45.73%) and *C. odorata* (40.31%) respectively and least reduced in *T. orientalis* by 19.54% and 13.24% respectively.
Conclusion: Our findings validate previous reports of negative effects of dust pollution from quarry industries on both humans and plants alike.

Keywords: Dust pollution; stomatal conductance; medicinal plants; total chlorophyll; β-carotene.

1. INTRODUCTION

The most important tissue components found in the leaf epidermis of every plant are arguably the stomata. This is largely due to the enormous role they play in the plants. Stomata provide the avenue by which gaseous exchange occurs between the plant and the atmosphere [1]. They control the amount of CO_2 that enters into the plant and also regulate the rate at which water leaves the plant body. These make them valuable to terrestrial plants, and their various properties have led to important ecological studies [1-2]. The stomata complex basically comprises of the stomatal pore and a pair of guard cells. Their diverse morphological characteristics have become determining factors that affect their function, and these structures are often affected by the environment in which the plant grows. Stomatal parameters such as size and density can have direct effect on transpiration and photosynthesis in plants [3-5]. Researchers have proven that plants with larger stomata would more likely have more channels for gaseous exchange and the smaller the size of the stomata the more resistance in the process of gas and moisture exchange. Similarly, it is likely that plant with denser stomata would lose more moisture and gas through the leaves [2,6]. Studies have shown that stomata characteristics can also affect other important processes such as nutrient absorption, metabolism, water use, and organic matter accumulation; and their development are affected by their response to environmental changes, such as light intensity, temperature, drought, atmospheric CO_2, humidity, pollution, and so forth [7]. This makes them potential indicators of environmental pollution and climate change [8-9].

Quarrying is one of the industrial activities that employ a large number of skilled and unskilled labour. Unfortunately, it also comes with side effects in the form environmental pollution from dust particles. Operations in quarry industries release dust particles in the environment that could be detrimental to humans and plants alike [10]. Dust particulate matter and smoke released from operating machineries and automobiles within the quarrying vicinity contain toxic substances such as heavy metals and polycyclic aromatic hydrocarbons. These toxins, when inadvertently inhaled by human habitants, could cause respiratory problems, cardiac diseases, lung cancer, and chronic pulmonary damages [10-12]. Plants, on the other hand, have developed adaptive measures that take care of the pollutants, thereby serving as air purifiers and natural bio-filters. However, because they are immobile, they can also be harmed as a result of continuous exposure to dust pollution [12]. Dust particles clog the stomata openings; cover the lamina surface, reducing the pore size and intensity of light, resulting in reduced respiration process and net photosynthesis. Other chemical components of the dust could also cause serious physiological changes in the plant such as gaseous exchange imbalance, deformed tissues, reduced carbon assimilation, and poor productivity and yield [13-15].

Stomatal conductance is the phenomenon that estimates the rate of gas exchange in plants. It gives a quantitative calculation of CO_2 uptake and water loss by the leaf stomata aperture. Hence, stomatal conductance is a function of the size, density and the degree of opening of the stomata. It can therefore be deduced that, every other factors being constant, more open stomata will allow greater conductance and consequently,

higher potential for transpiration and photosynthesis [1,16].

The contribution of medicinal plants in traditional healthcare delivery cannot be overemphasized. It is estimated that 80% of the world's population make use of herbal remedies, in one form or the other, to manage and/or treat ailments [17]. Furthermore, an appreciable number (about 25%) of modern drugs commonly prescribed today as well as some other pharmaceutical products have at least one ingredient in them derived from a medicinal plant [18,19]. However, emphasis has been placed on good agricultural and wild collection practices for medicinal plants.

Scientists have overtime become aware that the environment from which medicinal plants are collected is as much important as the medicinal plants themselves. It was on this note that embarked on this research to investigate how dust pollution could influence stomatal conductance in plants found around a quarry site in Lokpa Ukwu in Abia State, Nigeria, through stomata anatomical studies and its consequent effects on some of the photosynthetic pigments. To the best of our knowledge this has not yet been investigated in the study area. We bear in mind that altered photosynthetic activity could affect productivity of these plants, and possibly reduce their medicinal values.

2. METHODOLOGY

2.1 Study Site

This study was conducted at the Lokpa Ukwu quarry site, Abia State, Nigeria. State, Nigeria. The study area lies between located between latitudes 05º55'00''N and 06º03'00''N, and longitudes 07º21'05''E and 07º31'33''E. The area is in the derived Savanna vegetation with predominantly grasses and scattered trees, shrubs and low herbs. The area lies mainly on the lower cuesta, formed by the more resistant sandstones of the Agwu and Eze-aku shale with elevations as low as 200 m above sea level [12].

2.2 Plants Sampling and Collection

The sampling and plant samples collection were carried out within 150 metres circumference of the quarry site boundary, in February, 2018, between 12 noon and 1:00 pm. A transect of 50 m by 50 m was formed within the perimeter and plant samples were selected based on their frequency of occurrence and medicinal uses. From over 30 medicinal plants encountered, lucky dip method was employed in selecting the test samples without replacement [12]. The plant samples were properly identified using relevant literature [20]. They were *Aspilia africana* (Asteraceae), *Chromolaena odorata* (Asteraceae), *Celosia trigyna* (Amaranthaceae), *Carica papaya* (Caricaceae), *Daniellia oliveri* (Fabaceae), *Phyllanthus discoideus* (Phyllanthaceae), *Trema orientalis* (Ulmaceae), *Triumphetta rhomboidea* (Malvaceae) and *Vitex doniana* (Lamiaceae). Control samples were collected within the premises of Abia State University, Uturu, about 15 km away from the quarry site. Mature leaf samples from the plants were collected and laboratory analyses were carried out on them without further delay.

2.3 Leaf Epidermal Studies

The fresh leaf fragments were prepared for foliar epidermal studies by clearing method [12]. They were soaked in prior-labeled Petri dishes containing a solution of 3.5% sodium hypochlorite. Evidence of complete clearing was noticed between 15 and 24 hours depending on the nature of each particular leaf sample. The cleared samples were rinsed several times with tap water before the epidermises were carefully scrapped with the aid of a sharp razor blade. Both the adaxial and abaxial epidermises were stained with 10% safranin solution and mounted on glass slides for microscopy. They were observed on a light microscope (Olympus Tokyo - Japan no. 271961) at X 100 and X 400 magnifications.

2.4 Measurement of Stomata Parameters

The stomata were observed, counted and measured with the help of camera (Motic 3.0) attached to the microscope eyepiece. The Motic software was used to measure the lengths, widths and sizes (product of length and width) of the stomata. Stomata density was expressed as the number of stomata per square millimeter [12].

2.5 Estimation of Stomatal Conductance

2.5.1 Measurement of Potential Conductance Index (PCI)

The method we used to measure *PCI* was those of Holland and Richardson [21]. This was based on the assumption that the stomatal aperture area is proportional to the guard cell length (stomata length) squared. Potential conductance index was therefore calculated as follows:

PCI = (Guard cell/Stomata length)^2 X Stomatal density X 10^{-4}

2.5.2 Measurement of operating and maximum stomatal conductance (g_s)

The method of Fanourakis, et al. [16] with slight modifications was used to estimate the operating and maximum stomatal conductance (g_s) (expressed in mmol H_2O $m^{-2}s^{-1}$). The computing followed the formula:

$$g_s = \frac{\left(\text{diffusion coeffient}\right) X \left(\text{Stomatal density}\right) X \left(\text{Pore area}\right)}{\left(\text{molar volume of air}\right) X \left[\left(\text{Pore depth}\right) + \frac{\pi}{2} X \sqrt{\frac{\left(\text{Pore area}\right)}{\pi}}\right]}$$

Where pore area was used for calculating operating g_s. Pore depth was estimated with the following expression: [(stomatal width – pore width)/2]. Pore area [⍰(stomatal length/4)2] and pore depth (stomatal width/2) were estimated based on stomatal size when calculating the maximum g_s. The values of the volume of air and the effective diffusion coefficient for water vapour in air were 0.032 m^3mol^{-1} and 3.24 x $10^{-5}m^2$ s^{-1} respectively [16].

2.6 Estimation of Plant Pigments

The plant pigments (β-carotene and total chlorophyll) were estimated as follows:

2.6.1 Determination of β-carotene content

This was carried out according to Mustapha and Babura [22]. The pigment was extracted with 95% ethanol at 70ºC for 20 minutes, then the extract was poured in a separating funnel and extracted with petroleum ether. The pet-ether fraction was further washed with 80% ethanol until the extract became light yellow in colour. Absorbance was read at 436 nm using a UV/Vis spectrophotometer. β-carotene content was calculated using Bear-Lamberts Law, which states that the absorbance (A) is proportional to the concentration of the pigment.

2.6.2 Determination of Total Chlorophyll Content (TCH)

Three (3) grams of the leaf sample was macerated with 10 ml of 80% acetone and the liquid portion was decanted after allowing it to settle for 15 minutes, then centrifuged at 2,500 rpm for 3 minutes. The absorbance of the supernatant was measured at 663 nm using UV-Vis spectrophotometer [12].

2.7 Data Processing and Statistical Analysis

Completely randomized design of nine plant samples with 5 replicates each was adopted for this study. Data computation and processing were done on Microsoft Excel Spreadsheet 2010. Test for significance was carried out with SPSS version 20, software for statistical analyses. Analysis if variance (ANOVA) was used to check for significant difference (at $P < .05$) in parameters among the plants while students' independent t-test was used to check for significance (at $P < .05$) between samples from polluted and control sites.

3. RESULTS AND DISCUSSION

3.1 Effects on Micro-morphology of the Leaf Epidermises

It has been established that dust pollution as a result of quarry activities has several negative effects on both humans and plants alike. It affects the respiratory and cardiovascular health, as well as the general wellbeing of the inhabitants [10]. When plants are continuously exposed without protection, their physiological traits are also seriously affected. These include changes in the anatomical features of stomata (including the size, pore dimensions and density), resulting in poor conductance and photosynthetic activities [16]. In this study, our aim was to assess the extent dust pollution could influence conductance in medicinal plants found around a quarry industry through stomata anatomical studies and investigate their consequent effects on some of the photosynthetic pigments.

Photomicrographs taken from the prepared epidermal layers revealed that in plants collected from the polluted sites, epidermal cell walls were stretched and interrupted at some points. The damaging effect of dust pollution was evident on the epidermal tissues of the leaves collected from the quarry site as the epidermal cells were stretched and had series of interruptions on their cell walls as compared to the control samples as a result of stress. Furthermore, the stomata openings appeared to be clogged and reduced. The guard cells were also affected as they appeared plasmolysed and shrunk (Plates 1 and 2).

This agrees with previous authors [12,23-29] who reported similar results. Sett [15] stressed that

dust particles could induce some mechanical injury or produce necrotic spots on leaves, especially when they contain soluble chemical toxicants. Ogbonna, et al. [12] also reported deformed guard cells and necrotic tissues in plants exposed to dust pollution.

These effects were also indicated in the quantitative stomata features (Tables 1 and 2). We found out through t-test that, even though, stomata size, density and pore size varied among the species, plants collected from the quarry site generally had smaller stomata and narrower stomata pores. Density was more or less affected as there was no significant difference at $P \leq .05$ in some of the plants from the two study sites. As a matter of fact, only *A. africana, C. odorata, T. rhomboidea* and *V. doniana* had significantly fewer stomata from the polluted site. Ogbonna, et al. [12] reported the same trend of results. This result is also in concordance with Fanourakis, et al. [16] who opined that under environmental stress, the size of stomata and stomata pore reduce as a result of plasmolysed guard cells. Singh and Pal [25] also recorded that stomatal index in plants could be significantly reduced as dust particles clog on leaf surfaces and reduce their light capturing activity. This reduced light capturing activity and its consequent effects on the anatomical features of stomata result to alteration of stomata conductance [14,16].

3.2 Effects on Stomatal Conductance

The potential conductance indices of the plants varied among them. *A. africana* had the highest PCI (18.92) while *C. trigyna* was the lowest (3.71). It was observed that plants collected from the unpolluted site had higher PCI than those from the polluted site. This means that dust pollution reduced the PCI of these plants. For example, the PCI of *A. africana* was reduced by 87.4% (18.92–2.38), followed by that of *C. odorata* (67%; 11.14–3.66). The least reduction in PCI was observed in *C. trigyna* (7.2%) as shown in Table 3.

Similarly, dust pollution from quarrying activities reduced both the operating and maximum stomatal conductance in a significant manner. The highest reductions were observed in *C. odorata* (69.2%) and *A. africana* (72.3%) based on the values of operating and maximum conductance respectively. Again, *C. trigyna* was least affected by dust pollution with percentage reductions of 18.3% and 1.4% for operating and maximum conductance respectively. The rest of the results are presented in Figs.1 – 3.

We noticed from this study that dust pollution reduced the potential conductance indices, and the operating and maximum stomatal conductance of the plants. The operating conductance (g_{op}) is said to be constrained by maximum stomatal conductance (g_{max}), that is determined by stomata size and density. However, g_{max} is distinguished from g_{op} because g_{max} relates to stomata opened to their widest possible limit, which is not attainable under typical operating conditions[1]. Our result showed reduction in operating stomatal conductance in the following order: *C. trigyna* < *P. discoideus* < *D. oliveri* < C. papaya < *T. orientalis* < *T. rhomboidea* < *V. doniana* < *A. africana* < *C. odorata* while both PCI and g_{max} followed the same order: *C. trigyna* < *C. papaya* < *P. discoideus* < *D. oliveri* < *T. rhomboidea* < *T. orientalis* < *V. doniana* < *C. odorata* < *A. africana.* It shows that there was direct positive correlation between PCI and g_{max} in all the species. This could be attributed to the fact that stomata size and density were the main factors considered for calculating PCI and g_{max} whereas pore size regulates $g_{op.}$ This is in agreement with Fanourakis, et al. [16] who argued that maximum (potential) conductance is calculated by taking into account the stomatal (and not pore) size and as such would be a very poor indicator of operating conductance, which is estimated based on pore dimensions.

3.3 Effects on Photosynthetic Pigments

Plants collected from the quarry site showed reduction in chlorophyll and β-carotene content compared to those from the control site. Table 4 shows that the highest chlorophyll content was observed in *T. rhomboidea* (31.65±0.33) from the control site and *C. odorata* had the least (13.25± 0.00). However, the highest percentage reduction was found in *V. doniana* (45.73%) whereas chlorophyll had the least reduction in *T. orientalis* (19.54%). Furthermore, the maximum β-carotene content was also observed in the leaf of *T. rhomboidea* (12.47±0.16) and the leaf of *C. odorata* had the least (6.40±0.00). As was the case for total chlorophyll, β-carotene content was reduced the most in *C. odorata* (40.31%) whereas the effect of dust pollution on β-carotene was least in *T. orientalis* (13.24%).

Table 1. Adaxial surfaces stomata parameters of the leaves from control and polluted sites

Plant	Site	Length (µm)	Width (µm)	Size/Area (μm^2)	Density (mm^{-2})	Pore area (μm^2)
A. africana	C	24.27± 2.80*	16.07±0.31*	390.28±47.35*	4.99±0.28	109.30 ± 9.97*
	P	14.96 ± 0.60	11.28 ± 0.52	169.38 ± 14.56	4.56 ± 0.46	54.64 ± 4.70
C. odorata	C	26.03±1.01	16.62±0.17*	423.98±20.19*	6.79±0.11*	103.09 ± 4.81*
	P	24.84 ± 1.26	13.56 ± 0.40	337.57 ± 24.91	1.49 ± 0.11	80.37 ± 5.93
C. trigyna	C	11.02±0.55	4.31±0.19	47.64±4.37	2.44±0.21	15.37 ± 1.41*
	P	9.68 ± 0.52	3.91 ± 0.15	38.04 ± 3.38	2.76 ± 0.11	12.27 ± 1.09
T. rhomboidea	C	17.22±0.66	12.26±0.70	210.61±11.35	1.49±0.28	60.96 ± 0.59*
	P	16.36 ± 0.41	11.95 ± 0.41	195.06 ± 1.88	1.49 ± 0.11	56.92±3.07

** Significantly higher at P ≤ .05; values expressed as mean ± SEM of 5 replicate data*

Table 2. Abaxial surfaces stomata parameters of the leaves from control and polluted sites

Plant	Site	Length (µm)	Width (µm)	Size/Area (μm^2)	Density (mm^{-2})	Pore area (μm^2)
A. africana	C	47.01±0.86*	16.01±1.03*	342.02±9.58*	84.31±1.96*	92.44±2.59*
	P	19.34 ± 0.35	12.59 ± 0.26	243.36 ± 6.05	60.78 ± 5.19	62.51 ± 2.57
C. odorata	C	30.92 ± 0.74	21.76±0.28*	673.31±24.25*	111.76±3.40*	177.19±6.38*
	P	28.77 ± 0.43	18.41 ± 0.73	529.00 ± 15.52	43.14 ± 1.96	120.26 ± 3.53
C. trigyna	C	31.44±1.67	16.36±2.46*	518.28±93.23*	37.25±1.96	136.39±24.53*
	P	30.29 ± 0.68	13.51 ± 0.38	409.72 ± 20.67	37.25 ± 3.92	93.12 ± 4.70
C. papaya	C	22.88±1.25	13.72±0.75	315.11±30.61*	86.27 ± 1.96	85.16 ± 8.27*
	P	22.85 ± 0.67	11.66 ± 0.47	266.57 ± 13.71	74.51 ± 5.19	65.02 ± 3.34
D. oliveri	C	22.14±1.57*	13.87±0.71	308.17±32.16*	207.84 ± 1.96	81.10±8.46*
	P	20.84 ± 0.41	12.90 ± 0.48	202.72 ± 32.01	194.12 ± 3.40	57.23 ± 2.97
P. discoideus	C	19.13±1.03	11.82±0.63	227.28±24.14*	135.29±3.40	61.43±6.53
	P	18.49 ± 0.50	10.46 ± 0.50	192.94 ± 4.10	123.53 ± 3.40	47.06 ± 1.00
T. orientalis	C	23.46±0.24*	18.12±0.69	425.47±20.24*	109.80 ± 1.96	114.99±5.47*
	P	20.18 ± 1.15	16.95 ± 0.91	344.05 ± 37.50	98.04±5.19	88.22 ± 9.61
T. rhomboidea	C	20.14±0.18	16.75±1.06*	337.17±19.70*	127.45 ± 1.96*	82.24±4.81*
	P	18.34 ± 0.40	13.35 ± 0.87	244.92 ± 18.14	101.96±1.96	63.31 ± 4.41
V. doniana	C	20.32±1.34*	11.74±1.01*	239.93±31.27*	127.45 ± 1.96*	61.12±10.04*
	P	17.48 ± 0.90	8.92 ± 0.05	155.87 ± 8.08	107.84±1.96	41.02 ± 2.13

** Significantly higher at P ≤ .05; values expressed as mean ± SEM of 5 replicate data*

Table 3. Potential conductance indices of the plants from quarry and control sites

Plant	Control site	Quarry site	% reduction
A. africana	18.92	2.38	87.4
C. odorata	11.14	3.66	67.1
C. trigyna	3.71	3.44	7.2
C. papaya	4.52	3.89	13.9
D. oliveri	10.19	8.43	17.2
P. discoidea	4.95	4.22	14.7
T. orientalis	6.04	3.99	33.9
T. rhomboidea	5.21	3.47	33.5
V. doniana	5.26	3.30	37.4

Since stomatal conductance is the measure of CO_2 uptake or the amount of water vapour leaving the plant through the stomata pore, it can be said that reduced stomata conductance would negatively affect photosynthetic activities in the same plant. Chlorophyll-a is the main pigment responsible for photosynthesis by trapping photons of light and use them to produce food. Other chlorophylls and plant pigments such as carotenoids are called accessory pigments because they pass on the light they absorbed to chlorophyll-a and also protect it from excess light and oxidation [15, 22]. This means that they all contribute to

efficient photosynthetic activity. Dust loads on leaves truncate this objective by preventing them from acquiring sufficient light and there by suppressing their biosynthesis. Alkaline conditions created by chemical substances in dust also cause chlorophyll degradation [13,15]. Our result showed that dust pollution reduced the total chlorophyll and β-carotene contents of the plants obtained from the quarry site. While percentage of this reduction varied among the plants, *T. orientalis* was the least affected as it recorded the least percentage reductions of 19.5% and 13.2% for total chlorophyll and β-carotene respectively.

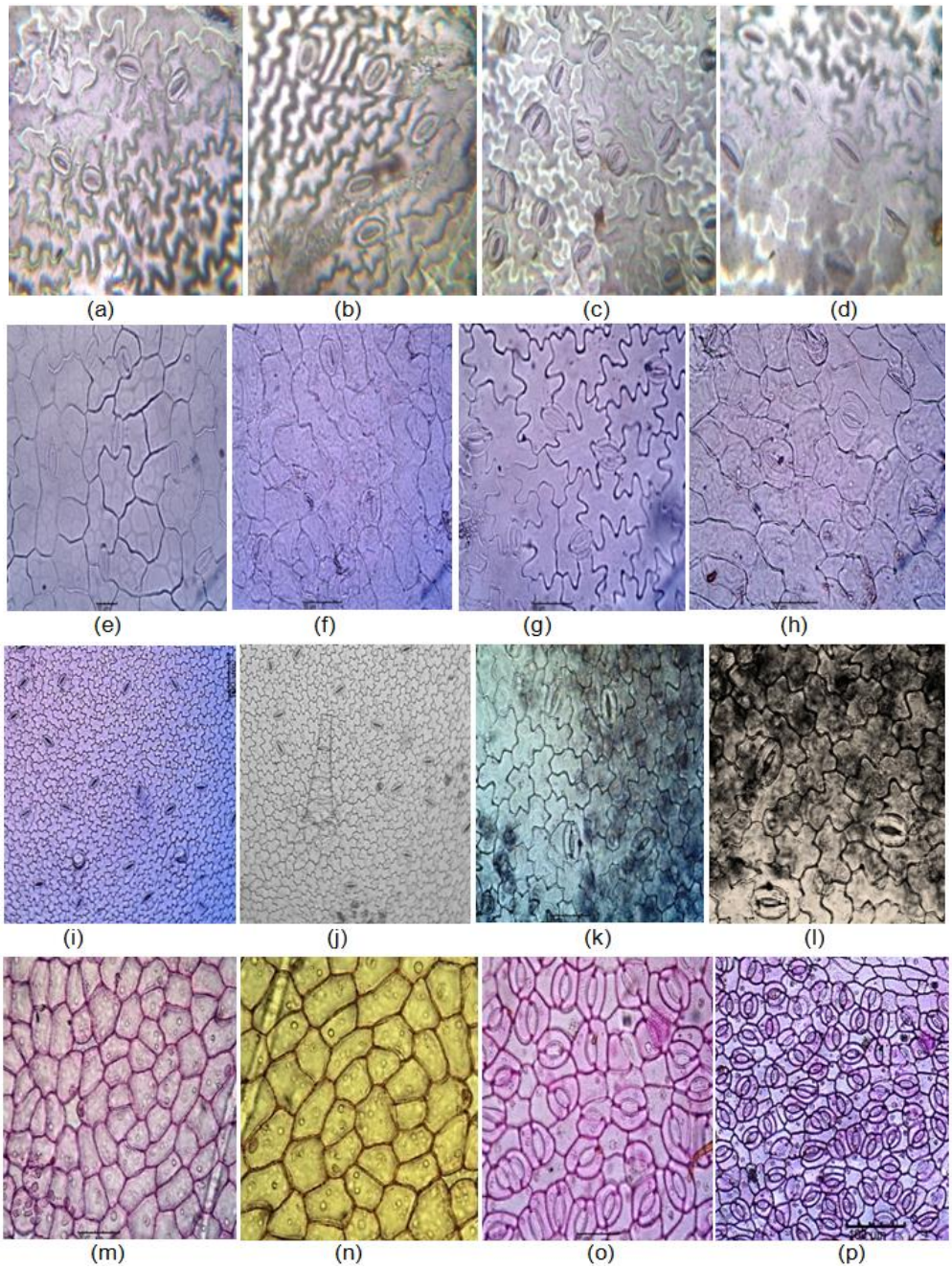

Plate 1. Photomicrographs of the epidermal strips of the plants. Adaxial and abaxial leaf surfaces from control and polluted sites respectively for *A. africana* (a – d); *C. odorata* (e – h); *C. trigyna* (i – l) and *D. oliveri* (m – p)

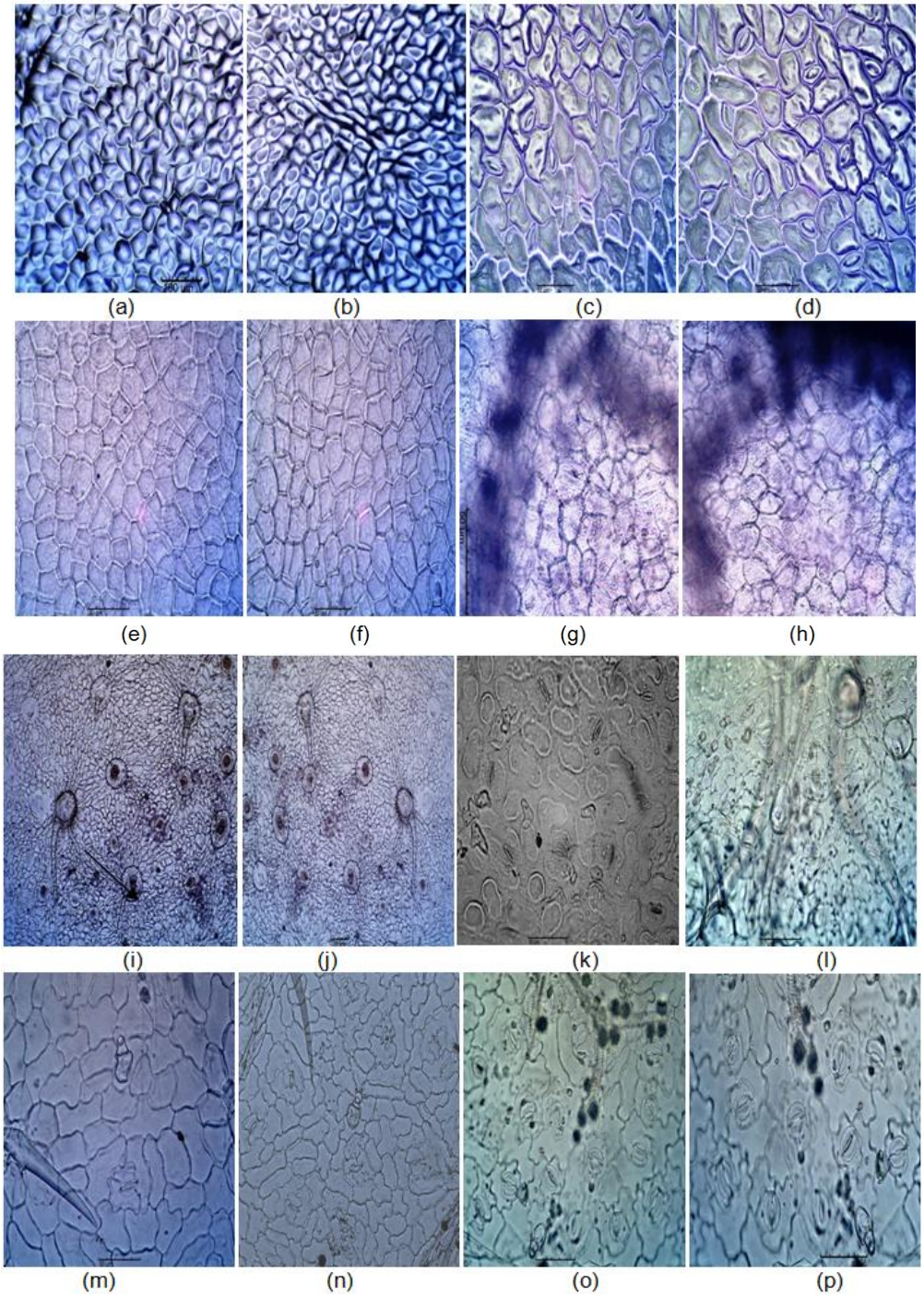

Plate 2. Photomicrographs of the epidermal strips of the plants. Adaxial and abaxial leaf surfaces from control and polluted sites respectively for *C. papaya*(a – d); *P. discoideus*(e – h); *T. orientalis*(i – l) and *T. rhomboidea*(m – p)

Similar results where dust pollution reduced the amounts of plant pigments and photosynthetic activity have been recorded by several authors [15,25-28].

Generally, the effects of dust pollution on the stomata variables, conductance and pigmentation as we have recorded in this study varied greatly among these plants. That is to say

that the degree at which they were affected was on individual plant basis. This agrees with previous authors [15,23,25] who reported that plants are affected differently from others as a result of their varying morphological traits such as phyllotaxy, leaf texture, leaf size, petiole length and so forth. Plants with longer petiole length would absorb more dust particles as they will be more exposed than those with shorter petiole length. Similarly, larger and rougher leaf surfaces tend to attract more dust particles that smaller and smother leaf surfaces [25].

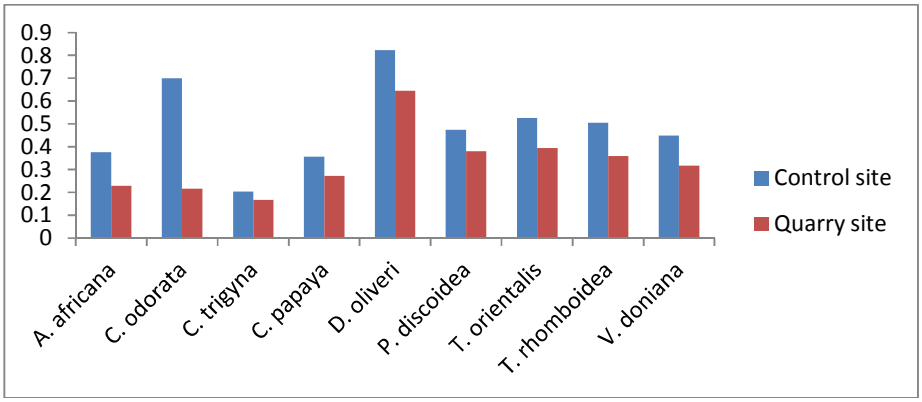

Fig. 1. Effect of dust pollution on the operating stomatal conductance of plants

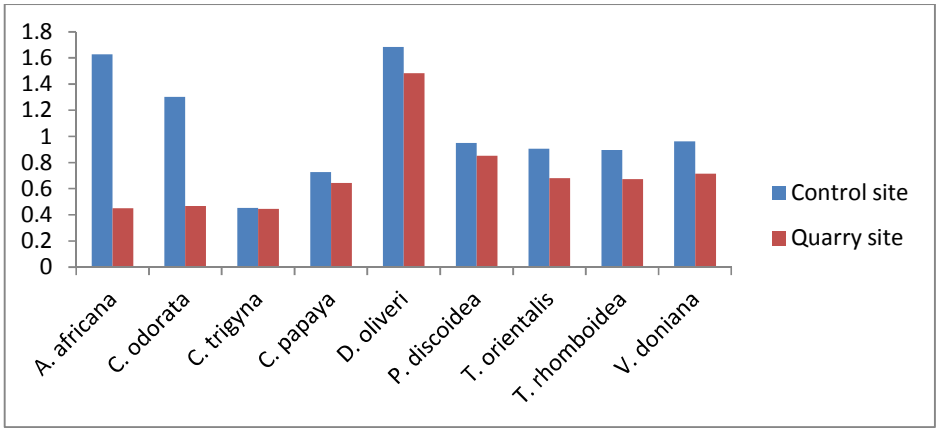

Fig. 2. Effect of dust pollution on the maximum stomatal conductance of plants

Table 4. Reduction in total chlorophyll and β-carotene contents of the plants

Plant sample	Total chlorophyll content (mg/100 g)			β-carotene content (mg/100 g)		
	Quarry site	Control site	% reduction	Quarry site	Control site	% reduction
A. africana	12.13 ± 0.00	16.95 ± 0.03*	28.43	5.47 ± 0.002	7.66 ± 0.003*	28.59
C. odorata	10.02 ± 0.00	13.25 ± 0.00*	24.38	3.82 ± 0.00	6.40 ± 0.00*	40.31
C. trigyna	14.22 ± 0.00	22.75 ± 0.00*	37.49	6.01 ± 0.01	9.81 ± 0.21*	38.74
C. papaya	16.15 ± 0.00	24.34 ± 0.12*	33.65	8.05 ± 0.06	11.90 ± 0.08*	32.35
D. oliveri	9.54 ± 0.00	16.19 ± 0.00*	41.07	4.48 ± 0.00	6.73 ± 0.00*	33.43
P. discoideus	13.31 ± 0.00	21.29 ± 0.00*	37.48	6.13 ± 0.002	9.80 ± 0.00*	37.45
T. orientalis	20.55 ± 0.00	25.54 ± 0.01*	19.54	9.76 ± 0.00	11.25 ± 0.003*	13.24
T. rhomboidea	23.73 ± 0.00	31.65 ± 0.33*	25.02	7.84 ± 0.002	12.47 ± 0.16*	37.13
V. doniana	10.24 ± 0.00	18.87 ± 0.04*	45.73	4.56 ± 0.002	7.07 ± 0.001*	35.50

** Significantly higher at P ≤ .05; values expressed as mean ± SEM of 5 replicate data*

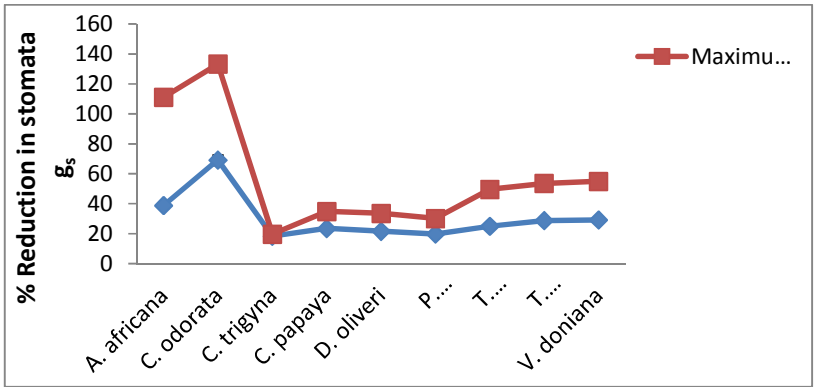

Fig. 3. Percentage reduction in operating and maximum stomatal conductance

4. CONCLUSION

This study investigated the influence of dust pollution on stomatal conductance in some medicinal plants growing in a quarry site in Lokpa Ukwu Abia State, Nigeria, and its consequent effects on some of the photosynthetic pigments. Our results validate previous reports on the negative effects of dust pollution from quarry industries on the lives of humans and plants. We showed that dust particles greatly reduce stomatal conductance and consequently alter photosynthetic activities in plants collected from Lokpa Ukwu quarry site. These effects were attributed to the shading effect created by dust loads on the leaf surface and chemically active toxicants they may contain. These findings therefore suggest that altered photosynthetic activity could affect productivity and medicinal properties of these plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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