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Effect of Quarrying Dust on Leaves Weight and Plants Chlorophyll Content of Pawpaw (*Carica papaya*), Cassava (*Manihot esculenta*) and Okra (*Abelmoschus esculentus*) in Akamkpa, Cross River State, Nigeria

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ABSTRACT: Accumulation of dust and other particulate matter on crops could affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants, hence the agricultural crops show stunted growth, minimum leaf area, less number of leaves and block the stomata opening. The objective of this study is to determine the effect of quarrying dust on leaves weight and selected plants chlorophyll content of Pawpaw (*Carica papaya),* Cassava (*Manihot esculenta*) and Okra (*Abelmoschus esculentus*) in Akamkpa, Cross River State, Nigeria using standard methods. The plant species were obtained at distances of 300m, 600m and 900m away from the quarry site. Higher chlorophyll contents were recorded in wet season than in the dry season, with total chlorophyll ranging between 2.25-2.81mg/g, 2.23-2.89mg/g and 1.87-2.24mg/g for *Carica papaya*, *Manihot esculenta* and *Abelmoschus esculentus* respectively in the dry season and then 2.43-3.01mg/g, 2.68-3.19mg/g and 2.16-2.77mg/g for *Carica papaya*, *Manihot esculenta* and *Abelmoschus esculentus* respectively in the wet season. Results of chlorophyll a and b in the sampled plants indicated lower effects of dust on chlorophyll contents of the plant leaves with distance away from the quarry site.

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Over the years, there have been many issues, concerns and challenges in the rock quarry industry. Like many other anthropogenic activities, rock quarrying activities cause significant impacts on human health and the environment (Okafor, 2006). These activities have lots of environmental impacts which include air pollution. During quarrying activities, the frequent release of particulate matter and dust into the atmosphere is inevitable (Enoh, 2016). Air quality is majorly affected by quarry activities and it causes severe atmospheric pollution within and around the quarry area. The release of dust particles (such as; particulate matters – $PM_{2.5}$ and PM_{10}) from quarry operations has contributed to the contamination of air quality within these areas (Nwaugo *et. al.*, 2007). Air pollutants are majorly formed from dust particles which arise from various industrial activities and they pose serious threat to the environment generally, and Grantz *et al.* (2003) reports that dust particles comprise about 30-35% of pollutants in the air. Tiny dust particles which can be described as aerosols do not have the capacity to remain suspended in the air for a longer time and as such, falls on surfaces which include plants and plant leaves. These dust particles have the potency of sticking to leaves surface for a long time unless they are washed away by precipitation. The settlement of dust on vegetation and plant leaves reduces the photosynthetic process of

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these plants. Some of these dust particles have sizes that are smaller than the diameter of leaves stomata. They get into the sub-stomata cavity and then reach the spongy parenchyma of the tissue of leaves. The larger dust particles dissolve in carbonic acid and water and then get into the interior of these leaves. These processes can affect the chlorophyll contents of the plants and thus interfere with the process of photosynthesis (Butz, 2017). There is a relationship between dust deposition on leaves and the corresponding degradation of the chlorophyll content of such leaves. When there is dust deposition, it leads to an alkaline condition due to solubility in the sap of the cells, which is then responsible for the degradation of the chlorophyll contents and thus reduction in photosynthesis (Gunamani *et al.,* 1991). Dust deposition on leaves which are alkaline can lead to the loss of the normal green colouration of plant leaves, which is termed as chlorosis and the death of leaf tissues by alkaline toxicity. An indicator commonly used to detect the increment in air pollutants with respect to its impact on tree growth is the net photosynthetic rate of the plants. Plants show changes in their biochemical processes as they are frequently exposed to air pollutants and these pollutants react with their metabolisms, including their pigment formation rate. Joshi and Swami (2007) reports that a common air pollution impact involves loss of chlorophyll colouration and yellowing of leaves which is linked to reduced process of photosynthesis. Measurement of chlorophyll can be used as a tool or an indicator to ascertain the effects of air pollution on plants because chlorophyll is important in the metabolism of plants, and when it is reduced, can affect the productivity of such plants directly (Joshi and Swami, 2009). Quarrying contributes a large amount of dust particles into the atmosphere. Therefore, the objective of this study is to determine the effect of quarrying dust on leaves weight and selected plants chlorophyll content of Pawpaw (*Carica papaya)*, Cassava (*Manihot esculenta*) and Okra (*Abelmoschus esculentus*) in Akamkpa, Cross River State, Nigeria.

MATERIALS AND METHODS

The Study Area: Geographically, Akamkpa is located between longitudes 8º12'E and 8º75'E and latitudes 5º14'N and 5º40'N. Akamkpa is a Local Government Area in Cross River State. It has an area of approximately 5,003km^2 and comprises many areas that are being linked up by major and minor roads. (Figure 1).

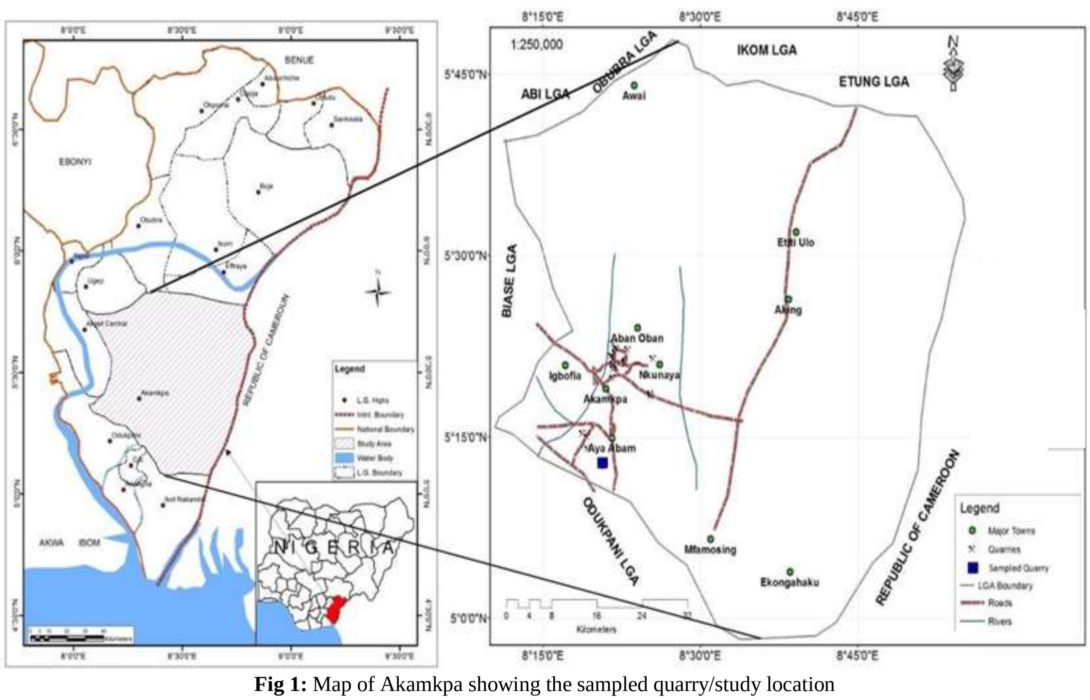

Fig 1: Map of Akamkpa showing the sampled quarry/study location

Vegetation and Resources: The vegetation in the study area is predominantly the disturbed lowland forest. The plant cover is predominantly a mosaic of farmlands (mainly cassava) and fallow vegetation at various stages of regrowth. The forests in the study area have been largely exploited of commercial species and trees of timber size. Apart from the abundance of granite rocks which has led to the establishment of many quarry companies in Akamkpa, there are said to abound other solid minerals like limestone, kaolin and others yet to be exploited (Kekerete, 2014).

Climate: The rainfall pattern in Akamkpa exhibits a bimodal pattern, with peaks in June-July and September. It has average annual temperature of 26-27ºC with 35ºC during February to April (Bulktrade, 1989). Akamkpa is located in the rainforest zone and shares similar climatic conditions with the Southern part of the State. The yearly rainfall is not less than 2000mm with peak periods observed between the months of July and September. The relative humidity of the area is between 79% and 87% daily.

Sampling: Leaf samples of three (3) different plant species were collected and analyzed. The plant species are Pawpaw (*Carica papaya*), Cassava (*Manihot esculenta*) and Okra (*Abelmoschus esculentus*). The reason for choosing these plants was because of its availability at the four (4) locations where the samplings took place. The same plant species were collected at 3 different points away from the quarry site at distances of 300m apart from each other (300m, 600m and 900m from site). These plant species were also collected in a control location away from the quarry site. This was to enable a correlation study between the chlorophyll content of plants in the study area and that of the control location. Samplings were done in both dry and wet seasons.

Method: The sampled leaves were weighed before and after washing off the dirt and dust particles. To determine the chlorophyll content of the leaves, 50mg of fresh leaf tissue were weighed accurately. Chlorophyll was extracted by crushing the leaf and then suspended in test tubes containing 10ml of dimethyl sulfoxide (DMSO). Test tubes were incubated at 60˚C to 65˚C for 4 hours in a hot air oven. The supernatants were decanted and the chlorophylls extracted were transferred to a cuvette and the absorbance was read in spectrophotometer at 645 and 663 nm against DMSO blank (Sumitra *et al.*, 2013). Chlorophyll a and b were recorded and then total chlorophyll was calculated.

RESULTS AND DISCUSSION

Chlorophyll contents: The results of the chlorophyll contents of the leaves for dry and wet season measured in milligram per gram (mg/g) are presented in table 1 and 2 respectively.

Weight and Dust Load: The results for the weight and dust load measured in gram (g) for both dry and wet seasons are presented in table 3 and 4 respectively. Results for the pH of the distilled water used for washing of the leaves are also presented.

Table 1: Leaf chlorophyll contents analyzed for dry season

Parameters		**300m from site (mg/g of leaf)**	**600m from site (mg/g of leaf)**	**900m from site (mg/g of leaf)**	**Control site (mg/g of leaf)**
Pawpaw Leaf (*Carica papaya*)	Chlorophyll a	1.82	1.98	2.10	2.42
	Chlorophyll b	0.43	0.57	0.71	0.85
	Total Chlorophyll	**2.25**	**2.55**	**2.81**	**3.27**
Cassava Leaf (*Manihot esculenta*)	Chlorophyll a	1.91	1.93	2.26	2.34
	Chlorophyll b	0.32	0.39	0.63	0.70
	Total Chlorophyll	**2.23**	**2.32**	**2.89**	**3.04**
Okra Leaf (*Abelmoschus esculentus*)	Chlorophyll a	1.66	1.73	1.79	2.08
	Chlorophyll b	0.21	0.32	0.45	0.72
	Total Chlorophyll	**1.87**	**2.05**	**2.24**	**2.80**

Table 2: Leaf chlorophyll contents analyzed for wet season

Parameters		**300m from site (mg/g of leaf)**	**600m from site (mg/g of leaf)**	**900m from site (mg/g of leaf)**	**Control site (mg/g of leaf)**
Pawpaw Leaf (*Carica papaya*)	Chlorophyll a	1.87	2.04	2.19	2.65
	Chlorophyll b	0.56	0.74	0.82	0.96
	Total Chlorophyll	**2.43**	**2.78**	**3.01**	**3.61**
Cassava Leaf (*Manihot esculenta*)	Chlorophyll a	2.09	2.11	2.35	2.60
	Chlorophyll b	0.59	0.74	0.84	0.99
	Total Chlorophyll	**2.68**	**2.85**	**3.19**	**3.59**
Okra Leaf (*Abelmoschus esculentus*)	Chlorophyll a	1.75	1.86	1.96	2.25
	Chlorophyll b	0.41	0.53	0.81	0.88
	Total Chlorophyll	**2.16**	**2.39**	**2.77**	**3.13**

The values of chlorophyll a, b and total chlorophyll in the 3 different plants (*Carica papaya*, *Manihot esculenta* and *Abelmoschus esculentus*) from the different locations (300m, 600m, 900m and control) exhibited the same trend for both dry and wet seasons. Plant leaves further away from the quarry site had higher chlorophyll contents than plant leaves nearer to the quarry site. The results showed that the plants at locations nearer to the quarry site had more dust particles settled on their leaves than plants at locations further away from the quarry site. The quarry site is the main source of dust particles present in the environment of the study area, as such, the transportation of these dust particles by wind to distances away from the quarry site is inevitable, and they settle on different surfaces including plant leaves.

Table 3: Weight of leaves and dust load for dry season

		Weight of leaf before wash (g)	Weight of leaf after wash (g)	Difference in weight and dust load (g)	pH of water after washing of leaves
Pawpaw Leaf (*Carica papaya*)	300m from site	100.00	87.60	12.40	7.9
	600m from site	100.00	93.40	6.60	7.8
	900m from site	100.00	94.80	5.20	7.6
	Control site	100.00	96.80	3.20	7.2
Cassava Leaf (*Manihot esculenta*)	300m from site	100.00	85.20	14.80	7.8
	600m from site	100.00	89.00	11.00	7.4
	900m from site	100.00	92.30	7.70	7.3
	Control site	100.00	93.90	6.10	7.3
Okra Leaf (*Abelmoschus esculentus*)	300m from site	100.00	91.10	8.90	7.5
	600m from site	100.00	91.70	8.30	7.4
	900m from site	100.00	94.00	6.00	7.2
	Control site	100.00	94.30	5.70	7.1

Table 4: Weight of leaves and dust load for wet season

		Weight of leaf before wash (g)	Weight of leaf after wash (g)	Difference in weight and dust load (g)	pH of water after washing of leaves
Pawpaw Leaf (*Carica papaya*)	300m from site	100.00	90.30	9.70	7.8
	600m from site	100.00	94.60	5.40	7.5
	900m from site	100.00	95.80	4.20	7.1
	Control site	100.00	97.33	2.67	6.9
Cassava Leaf (*Manihot esculenta*)	300m from site	100.00	88.20	11.80	7.3
	600m from site	100.00	91.60	8.40	7.0
	900m from site	100.00	94.89	5.11	6.9
	Control site	100.00	94.92	5.08	6.8
Okra Leaf (*Abelmoschus esculentus*)	300m from site	100.00	94.17	5.83	7.0
	600m from site	100.00	95.20	4.80	6.8
	900m from site	100.00	96.30	3.70	6.5
	Control site	100.00	96.45	3.55	6.3

Thus, for both dry and wet seasons, plant leaves at 300m had more dust particles settled on them than on plant leaves at 600m, and then more dust particles settled on plant leaves at 600m than on plant leaves at 900m. Plant leaves at the control location had lesser dust particles on them, as such; plant chlorophylls were higher in all the sampled leaves for both dry and wet seasons in the control location. The differences in weight and dust loads were higher in plant leaves nearer to the quarry site because the amount of dust deposited on plant leaves nearer to the quarry site were more than the amount of dust deposited on plant leaves further away from the quarry site. Distilled water used for washing of the leaves were more alkaline for plants nearer to the quarry site, and thus, the further the plant leaves from the quarry site, the less alkaline the water used for washing the sampled leaves (Sandeep *et. al*., 2019). Generally, the results indicated that plant leaves nearer to the quarry sites had more dust particles settled on them than those further away from the quarry site.

Conclusion: Results of chlorophyll a and b in the sampled plants indicated lower effects of dust on chlorophyll contents of the plant leaves with distance away from the quarry site. Higher chlorophyll contents were recorded in the wet season than the dry season because of the low concentration of dust particles in the wet season.

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