

# IMPACT OF CEMENT DUST ON PLANTS AROUND LAFARGE CEMENT, EWOKORO, NIGERIA

<sup>1</sup>Chukwu, M. N. and <sup>2</sup>Edwards, A. W. A.

<sup>1</sup> Department of Pure and Applied Science, Faculty of Science, National Open University of Nigeria Headquarters, Jabi – Abuja

<sup>2</sup> Department of Cell Biology and Genetics, Faculty of Science, University of Lagos

email:mchukwe@noun.edu.ng.

Accepted 26th July, 2018

## Abstract

The study investigated the effect of cement dust on plants growing around Lafarge cement factory at Ewekoro in Ogun state. *Chromolaena odorata* and *Manihot esculenta* were used as indicators for the effect of cement dust on plants because of their prevalence in the study site. The quantity of dust deposited on plant leaves, quantity of chlorophyll per leaf area, the number of stomata per leaf area and the rate of photosynthesis were measured. Result showed that accumulation of cement dust on leaves of plants lowered their photosynthetic rates and chlorophyll synthesis was impaired as a result of high concentrations of dust on the surfaces of the leaves. The number of stomata per leaf area was also reduced by cement dust accumulation. Seasonal changes and location of plants from the source of dust emission influenced the distribution of the dust. The plants experienced more damages and reduction in the rate of photosynthesis as well as the quantity of chlorophyll content during the dry than wet season. Plants located at the Northern direction of the factory were found to be more prone to cement dust attack with severe adverse effects than those at the Southern direction. The effects were more pronounced in *Manihot esculenta* than in *Chromolaena odorata* due to their morphological differences. Results obtained from this study will provide baseline information in developing an effective pollution control device to avert the adverse effects of the dust on the plants.

**Keywords:** Seasonal, chlorophyll, stomata, photosynthesis, morphological

## Introduction

The rate at which man exploits the resources of the earth has accelerated since industrial revolution. Industrialization has led to widespread of contaminants in the environment. The developments of large cities and huge factories together with large human populations producing vast quantities of sewage have led to severe problems of sewage disposal and pollution. Presently, the world's population is so vast and man's impact on the biosphere so great that the environment may be harmed beyond repair. Industrial wastes are principally gases, particulate matters and effluents which are discharged through chimneys and pipes (Kumaret al.,2008). Among the particulate matters are fumes, dusts, soot and solids such as fly-ash, fibers of wool, cotton, glass and asbestos. Pollutants in the cement industry are emitted from the

various production processes which include extraction of raw materials, crushing, blending, storage and packing sections (Gbadebe and Bankole, 2007; Mutlu et al., 2013).

Cement manufacturing plants are known to produce a number of emissions which include particulate matter, gases and various heavy metals which are hazardous to vegetation, humans, animals and the ecosystem as a whole (Baby et al., 2008; Kampa and Castanas, 2008).

Tijani et al. (2005) reported the destruction of vegetation and general environmental degradation by cement dust. Furthermore, Kumaret al.(2008) showed that exposure of plants to pollutants above the normal physiologically acceptable range inactivates photosynthesis. Cement dust has been shown to reduce the yield of crops growing in the general region of cement

plants through stomatal clogging and thus reducing photosynthesis (Bower, 2011; Raajasubramanian *et al.*, 2011; SaralaThambavani and Saravanakumar, 2011). Ade-Ademilua and Obalola, (2008) reported that cement dust reduced weights of polluted plants, gaseous exchange and transpiration and also inhibited intercellular processes. Chlorophyll content of plants has been found to decrease with increasing dust deposition (Singh and Srivastava, 2002; Ramanathan *et al.*, 2006; Nanos and Illas, 2007; Santoch and Tripathi, 2008; Thambani and Kumar, 2011). There is dearth of information on the effects of cement dust on *Chromolaena odorata* and *Manihot esculenta*, consequently, the objective of this study is to evaluate the impact of cement dust on the photosynthetic apparatus of the plant species around a cement factory in Nigeria. Information obtained from this study is useful for designing pollution control strategies and local environmental quality management.

## Materials and Methods

### Study Area

The study area was Lafarge cement factory Ewekoro, which is 38.4 km south of Abeokuta, the capital of Ogun state and 64 km north of Lagos, Lagos state at the coordinates of at 6°56'00"N 3°13'00"E and an altitude of about 30 m above sea level, and its geology is igneous and metamorphic rocks. The soil is generally of loose sandy clay type. The climate is characterized by two seasons; dry and rainy (wet) seasons. Relative humidity is high, about 85% except during the harmattan period. The vegetation is of southern guinea savanna.

### Selection of study sites and vegetation records:

Five locations designated A, B, C, D and E North and South of the factory were selected as sampling sites. Sites A and B were 200 m and 400 m North of the factory while sites C and D were 200 m and 400 m South of the factory and site E 2,000 m South of the factory was used as the control,

the wind direction being North-East. The North and South of the factory were selected for the study because of their being thickly populated with plants. Two common plants were selected as study plants because of their abundance. These are *Chromolaena odorata*, a perennial woody herbaceous plant and *Manihot esculenta*, a crop plant. Plant samples were collected every three weeks for a period of fifteen weeks.

### Dust deposit on the leaves

For the dust particulate estimation, deposited on the leaf surfaces 5g samples of leaves of each species were selected from each of the sites. The initial weight of leaf samples with dust particles was measure. Then the leaf samples were washed thoroughly with distilled water in a beaker. The leaf samples were afterwards wiped with a clean cotton cloth and dried for few seconds. The dried leaf samples were reweighed and the final weight was calculated. The leaf area (cm<sup>2</sup>) was measured with a leaf area analyzer (Biovis, Mumbai, India). The total quantity of dust deposited was calculated by difference. The amount of dust was calculated thus:

$$W = \frac{(W_2 - W_1)}{n}$$

Where W = amount of dust deposit (g cm<sup>-2</sup>), W<sub>1</sub> = Initial weight of the leaf sample with dust particles, W<sub>2</sub> = Initial weight of the leaf sample without dust particles, n = total area of leaves (cm<sup>2</sup>) (Prusty *et al.*, 2005).

### Chlorophyll extraction and Determination

Total chlorophyll content analysis was done according to Arnon (1949) as described by Shradhanjaliet *al.* (2016). 0.5g of fresh leaves were blended and then extracted with 10 ml of 80% chilled acetone and left for 15 min. The liquid portion was decanted and centrifuged at 2,500 rpm for 15 min. The supernatant was then collected and the abundance (Optical Density) was then determined at 645nm and 663nm using a spectrophotometer. Calculations were made using the formula given below:

Total Chlorophyll Content = (20.2XO.D. at 645nm) + (8.02XO.D. at 663nm).

#### *Leaf stomata count*

Impressions of the negative film of the lower surface of the leaf 1 x 2 cm were made on ten leaves at a time with a nail polish avoiding the ribbed veins. This was allowed to dry, then a tape was placed on the polish still on the leaf and the polish replica of the leaf was lifted and taped to a slid in a slide perpendicular to the long axis of the slide to accommodate the replicas to speed up the counting. Five counts were taken per replica at Mag. 400x.

#### *Rate of Photosynthesis*

The rate of photosynthesis was determined using a Gilson Respirometer. This method assumes that the quantity of Carbon IV oxide used in photosynthesis is equivalent to the quantity of Carbon IV oxide produced in respiration. The Respirometer comprises a manometer fitted with two plastic three-way taps, two test tubes each containing two perforated metal discs and fitted with rubber stoppers. Into one of the test tubes was placed 5 cm<sup>3</sup> of 40% Sodium hydroxide. Three leaf discs of known area were placed on the metal discs introduced into the tube to about 25 mm above the surface of the Sodium hydroxide. The three-way plastic tap was removed from the right hand limb of the manometer by gentle rotation. The bung and the connecting manometer tube were then inserted. To the second tube was added 5 cm<sup>3</sup> of distilled water. This tube acting as a blank was also connected to the manometer which had been filled with methylene blue in alcohol. Using the taps, the liquid in the two arms of the U-shaped manometer was equilibrated. As the leaf discs respired, a change in the volume of the liquid in the manometer was observed and recorded every ten minutes for one hour.

The rate of photosynthesis was calculated as follows:

Rate of photosynthesis =  $\frac{\text{Volume of Oxygen consumed}}{\text{Area of leaf disc used} \times \text{time}}$  (SaralaThambavan i and Saravanakumar, 2011).

#### *Direction of wind*

The direction of wind was measured using a wind vane

#### *Farmers' interview*

Oral interviews were conducted for the farmers in the area on one on one basis throughout the period of the study.

#### *Analysis of results*

Data collected were analyzed using two way analysis of variance (ANOVA) at 5% level of significance.

### **Results**

#### *Dust deposition on the leaves*

Figures 1a and 1b showed the average quantity of dust (g cm<sup>-2</sup>) on leaves of *Chromolaena odorata* and *Manihot esculenta* at the various sites. For both plant species, site A had the highest accumulation of dust while site E (control) accumulated the least quantity of dust in both the dry and wet seasons. The highest dust accumulation was recorded at the peak of dry season and the least in the middle of the wet season at all the sites, Although the amount of dust deposit were considerably lower in the wet season, there is no significant difference between the dust accumulation in dry and wet seasons (P<0.05). Sites C and D which were in the southern direction had considerably lower dust accumulation compared with the north facing sites. *Manihot esculenta* had greater dust accumulation than *Chromolaena odorata* in both dry and wet seasons ranging from 60% in site A to 75% in site D.

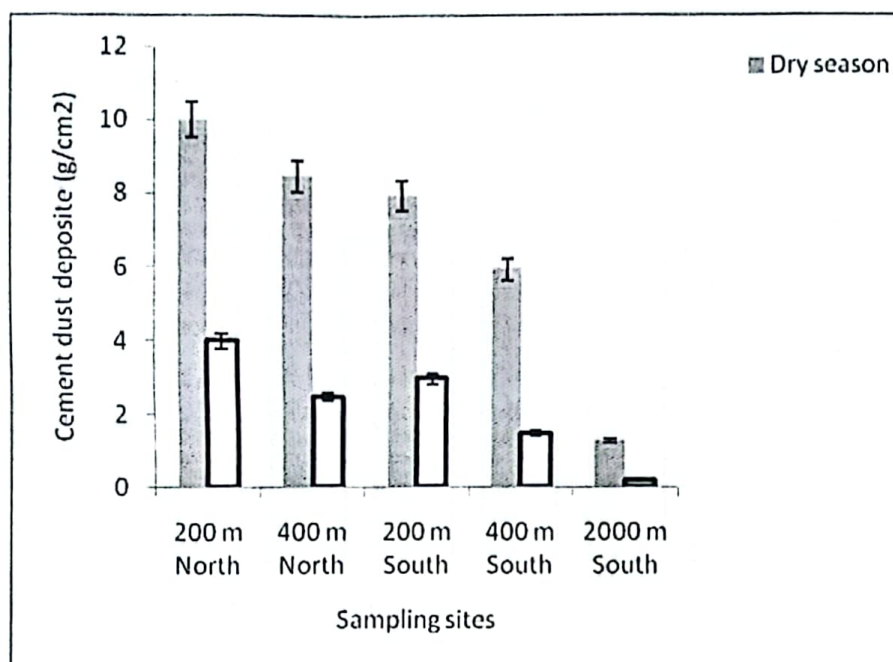


Figure 1a: Cement dust deposit ( $\text{g cm}^{-2}$ ) on leaves of *Chromolaena odorata* at various sites. Values shown are Mean  $\pm$  SE.

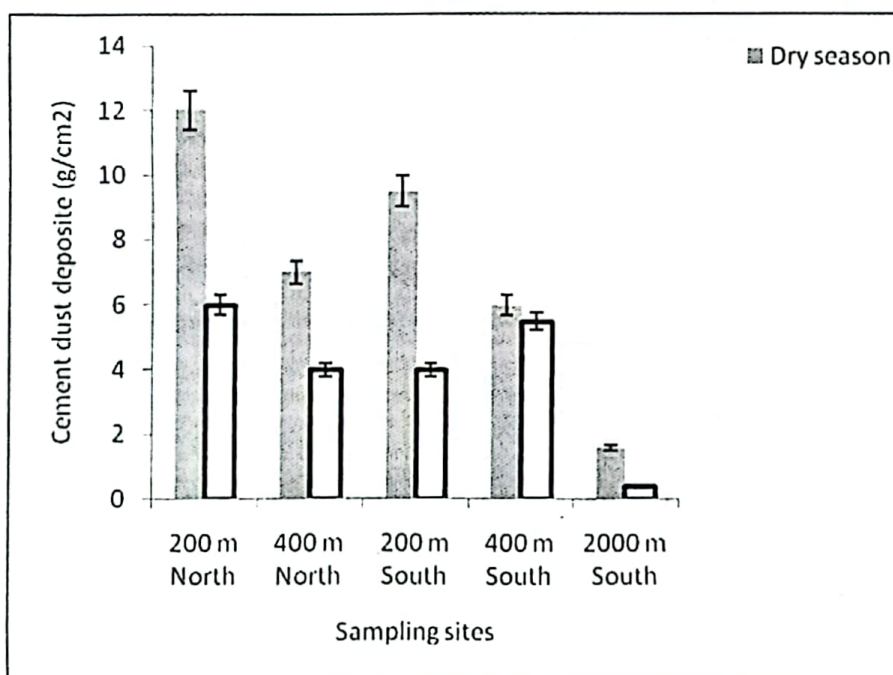


Figure 1b: Cement dust deposit ( $\text{g cm}^{-2}$ ) on leaves of *Manihot esculenta* at various sites. Values shown are Mean  $\pm$  SE.

#### Total Chlorophyll content

Figures 2a and 2b showed the total chlorophyll contents of *Chromolaena odorata* and *Manihot esculenta* at various sites. Site A had the lowest chlorophyll content and site E the highest. The chlorophyll content of the plants appeared not

to be affected by the nearness of the plants to the cement factory with no significant difference ( $P < 0.05$ ) in the values at the various sites. There are however significant differences in the chlorophyll content of plants growing at the different sites in-between seasons ( $P < 0.05$ ).

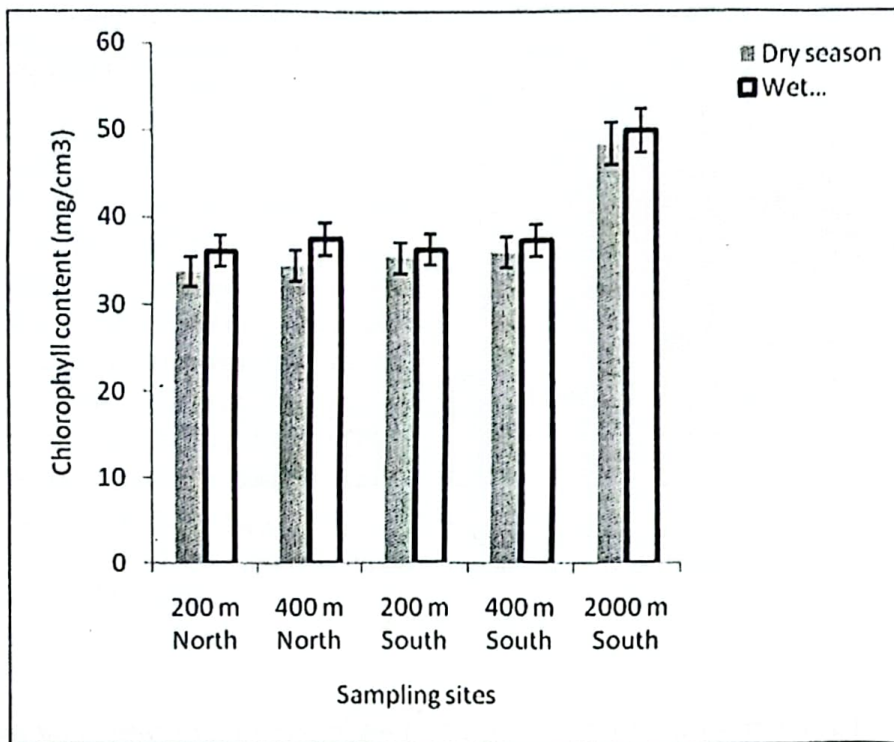


Figure 2a: Chlorophyll content (mg cm<sup>-3</sup>) of leaves of *Chromolaena odorata* at various sites. Values shown are Mean ± SE

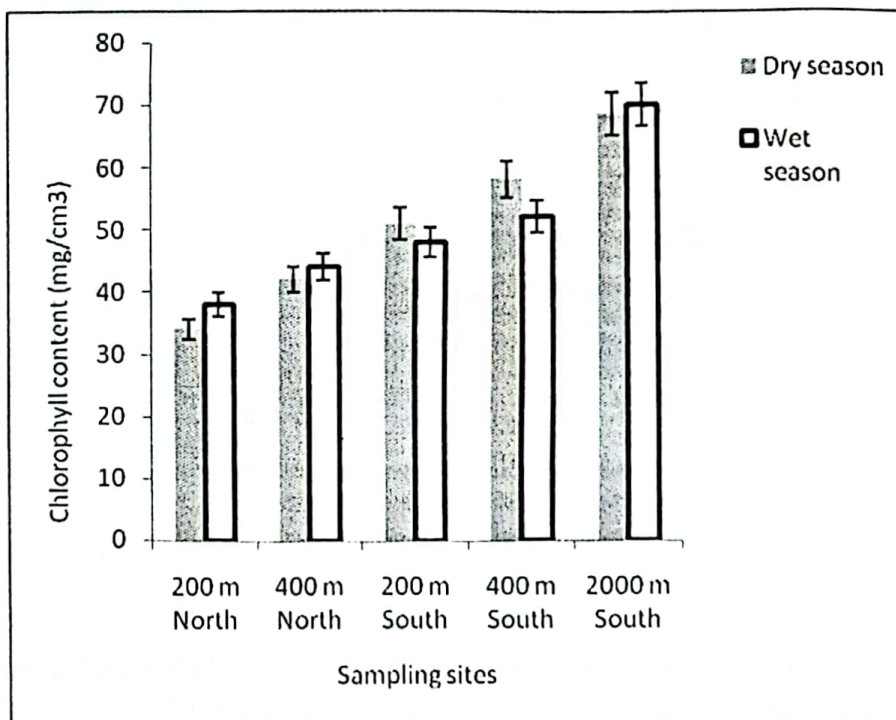


Figure 2b: Chlorophyll content (mg cm<sup>-3</sup>) of leaves of *Manihot esculenta* at various sites. Values shown are Mean ± SE.

*Number of stomata per microscopic field of view*

The number of stomata per microscopic field of view in *Chromolaena odorata* and *Manihot esculenta* at various sites were

shown in Figures 3a and 3b. The number of stomata was low for plants in site A and high at other sites. *Manihot esculenta* had more stomata per field of view ranging from 17 in site A during the dry season to 34 in

site E during the wet season. Stomatal number for *Chromolaena odorata* however ranged from 2 in site A during the dry season to 14 in site E during the wet season. There is no significant difference in the number of stomata per field of view

in *Manihot esculenta* while there is significant difference in the number of stomata per field of view of *Chromolaena odorata* in the Northern side of the factory and those of the control ( $P < 0.05$ ).

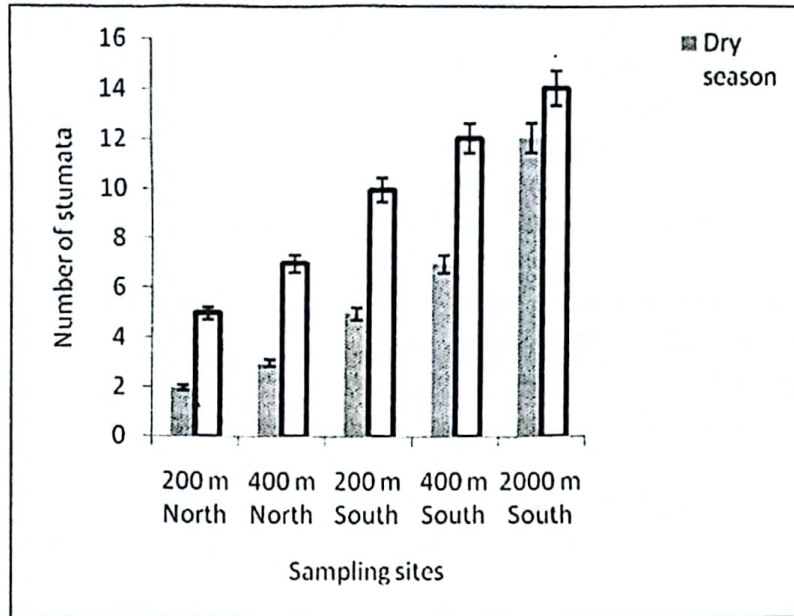


Figure 3a: Number of stomata per microscopic field of view of leaves of *Chromolaena odorata* at various sites. Values shown are Mean  $\pm$  SE.

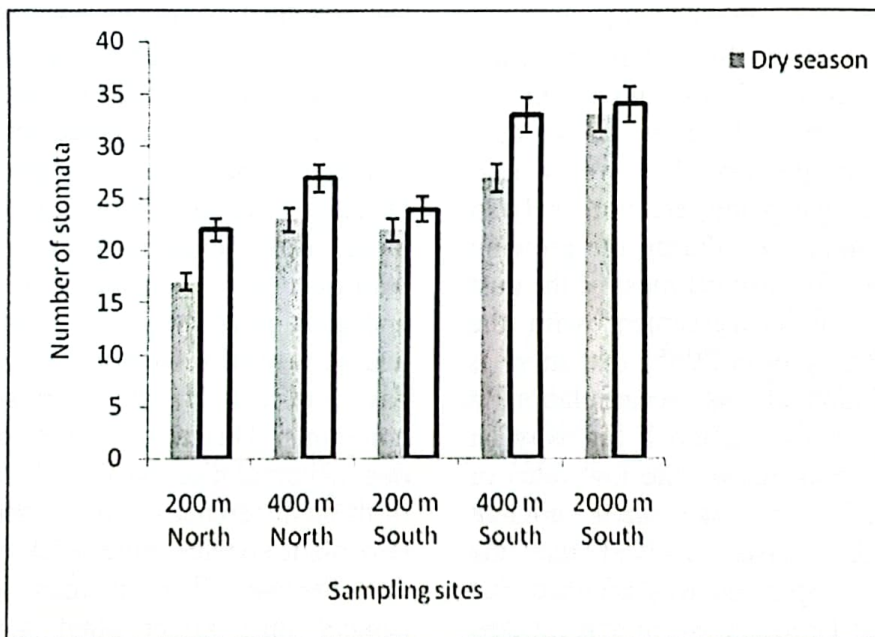


Figure 3b: Number of stomata per microscopic field of view of leaves of *Manihot esculenta* at various sites. Values shown are Mean  $\pm$  SE

**Rate of photosynthesis**

The result of the rates of photosynthesis of *Chromolaena odorata* and *Manihot esculenta* at various sites and seasons were shown in Table 1. In both plant species, the rate of photosynthesis was lowest at the peak of dry season. Plants in site D had the highest rate of photosynthesis at all sampling periods. Plants in the southern sites had higher rates of photosynthesis than those at the corresponding northern sites. The rates of photosynthesis increased sharply between the end of dry season and

the beginning of wet season. *Manihot esculenta* had higher photosynthetic rates than *Chromolaena odorata* at all sampling periods. In *Manihot esculenta*, the mean change from dry to wet season ranged from 58.8% in site A through 56.6% in site B to 22.2% in site D. Site D which is 400 m south had the least dust deposit, hence no appreciable difference in photosynthetic rates between the dry and wet seasons. On the other hand, there were significant differences in the rates of photosynthesis between the sampling periods and sites.

**Table 1: Mean rates of photosynthesis of *Chromolaena odorata* and *Manihot esculenta* at the four different sites at various seasons**

Sampling periods	Rate of photosynthesis ( $\times 10^{-2} \text{ cm}^3 \text{ m}^{-2} \text{ sec}^{-1}$ ) at various sites									
	<i>Chromolaena odorata</i>					<i>Manihot esculenta</i>				
	A	B	C	D	E	A	B	C	D	E
Dry season	8.84± 0.85	11.50 ± 0.22	18.00± 0.81	22.70± 0.34	32.50± 0.42	9.65 ±0.72	16.30± 0.35	20.50 ±0.64	28.20 ±0.42	35.60± 0.14
Wet season	12.00 ± 1.64	13.50 ± 1.5	20.70 ± 1.41	25.70 ± 1.24	34.30± 0.22	15.30 ±1.33	25.50 ±1.22	26.20± 1.20	34.50± 1.00	40.20± 0.24

**Discussion**

Plants close to the cement factory suffered more damages than those farther away. Substantial amount of dust moved in the northern direction. There is more dust accumulation in the dry than wet season suggesting that the plants are not likely to have dust accumulation during the growing season as rain will wash off most of the dust particles. This is in agreement with the findings of Prusty *et al*(2005) that there is seasonal variation of dust accumulation in vegetation near the national highway at Sambalpur, Orissa, India. The low rates of photosynthesis and chlorophyll content during the dry season showed that the photosynthetic apparatus was affected due to the fact that large deposit of cement dust during that season reduced light penetration. This is in line with the findings of Santosh and Tripathi (2008) that there is seasonal variation in pigment content of plants exposed to urban particulate pollution. Low

number of stomata per field of view of leaves with high dust also reduced the rate of photosynthesis. This is also in agreement with the findings of Nonas and Illas (2007) that dust deposit affected photosynthesis, stomatal opening and productivity of *Oleanur opaea* L. *Manihot esculenta* had more dust deposit than *Chromolaena odorata* due to their large surface leaf area and incision of the leaves. The hairs on the leaf surface of *Chromolaena odorata* might have prevented the dust from settling on the epidermis. This also accounted for the less dust accumulation on their leaves. In spite of these differences in their morphology, the two plant species were affected by cement dust deposit. There is thus no doubt that cement dust affect plant activities. This agrees with the findings of Ade-Ademilua and Obalola, (2008) that cement dust reduced weights of polluted plants, gaseous exchange and transpiration and also inhibited intercellular processes. The extent

of injury to plants depends on the proximity of the plants to the source of dust emission.

### Conclusion

It has been established that cement dust has some adverse effects on plants; reducing the visible number of stomata, total chlorophyll content and rate of photosynthesis there is thus the need for the management of Lafarge cement to employ some pollution control devices. Farmers should at the same time be advised to relocate their farmlands to a distance of at least 5 km away from the factory to reduce the effect of the cement dust pollution on the plants.

### References

- Ade-Ademilua, O. E. and Obalola, D. A. (2008). The effect of cement dust pollution on *Celosia Argentea* (Lagos spinach). *Plant Journal of Environmental Science and Technology* 1(2):47 – 55.
- Arnon, D. I. (1949). Copper enzyme in isolated chloroplast. *Plant Physiology*, 24:1-15.
- Baby, S., N.A. Singh, P. Shrivastava, S.R. Nath, S.S. Kumar, S. S.(2008). Impact of dust emission on plant vegetation of vicinity of cement plant. *Environmental Engineering Management Journal*, 7: 31-35.
- Bower, J. P. (2011). Potential effects of Emission from NPC – CIMPOR (PTY) Ltd. Simuma plant, Portshepstone on plant health of surrounding areas. Final Environmental Impact Assessment- SRK Consulting Africa.
- Gbadebe, A.M., and Bankole, O.D. (2007). Analysis of potentially toxic metals in airborne cement dust around Sagamu, South Western Nigeria. *Journal of Applied Science* 7 (1): 35-40.
- Kampa, M. and E. Castanas, 2008. Human health effects of air pollution. *Environmental Pollution* 151: 362-367.
- Kumar, S. S. Singh, N. A. Kumar, V. Sunisha, B. Preeti, S. Deepali, S. and Nath, S. R. (2008). Impact of dust emission on plant vegetation in the vicinity of cement plant. *J. Environ. Engin. and Manage.*, 7(1): 31-35.
- Mutlu, S., O. Atici and Y. Gulen, 2013. Cement dust pollution induces toxicity or deficiency of some essential elements in wild plants growing around a cement factory. *Toxicol. Ind. Health*, 29: 474-480.
- Nonas, G. D. and Illas, I. F. (2007). Effects of inert dust on Olive (*Olea europaea* L.) leaf physiological para. *Environmental Science Pollution Research International* 14(3): 212- 214.
- Prusty, B. A., Mishra, P. C. and Azeez, P. A. (2005). Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur Orissa, India. *Ecotoxicological Environmental Safety* 60: 228-235.
- Raajasubramanian, D., Sundaramoorthy, P., Baskaran, L., Sankar, G.K., Chidambaram. A. A. and Jeganathan, M. (2011). Cement dust pollution on growth and yield attributes of groundnut (*Arachis hypogaea* L.). *International Multidisciplinary Research Journal* 1 (1): 31-36.
- Ramanathan, R. Jeyakavitha, T. and Jeganathan, M. (2006). Impact of cement dust on *Azadirachta indica* leaves – a measure of air pollution control in and around Ariyalur. *Journal of Industrial Pollution Control* 22 (2): 273-276.
- Santosh, K. P., and Tripathi, B. D. (2008). Seasonal Variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. *Journal of Environmental Quality* 37 (3): 865-870.
- SaralaThambavani, D. and Saravanakumar, R. (2011). Effect of Cement dust on Photosynthetic pigments of selected plant species *Asian J. Environmental Science* 6(2):161-167.

- Shradhanjali, S., Samarendra, N. M. and Pramila, P. (2016). Effect of industrial dust deposition on photosynthetic pigment chlorophyll and growth of selected plant species in Kalunga Industrial areas, Sundargarh, Odisha. *International Journal of Botany Studies* 1 (5): 1-5
- Singh, R.B. and Shrivastava, A.K. (2002). Cytotoxic effects and biological damages in *Clitoria ternatie* by cement dust. *Nat. Environmental Pollution Research* 1:457-461.
- Thambani, D. S. and Kumar, R. S. (2011). Effects of Cement dust on Photosynthetic pigments of selected plant species. *Asian Journal of Environmental Science* 6 (2):161-167.
- Tijani, A. A., Ajoba, O. and Akinola, A. A. (2005). Cement production externalities and profitability of crop enterprises in two Local Government Areas of Ogun State. *Journal of Social Science* 11 (1): 43-48.