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RESEARCH ARTICLE

EFFECTS OF CEMENT DUST ON PLANT PHYSIOLOGY OF TREES AROUND EWEKORO AND OBAJANA CEMENT FACTORIES

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ABSTRACT

Plants are frequently exposed to different biotic and abiotic environmental stress factors which exert detrimental effects on plant ecosystems. This study was carried out at the West African Portland Cement Co PLC (Lafarge) in Ogun state and Obajana Cement in Kogi state. A 500 x 500m plot was established in a forest at 50m and 3km distance to the cement factories. The parts of plant (bark and leaf) samples of the most abundant species from both locations were collected for chemical (Ca, Fe, K, Mg, N, C, P and Mn) composition examination using an atomic absorption spectrophotometer (AAS) Buck Scientific 210 VGP. Bark samples were taken at the height of 1.5m on the side of the trunk exposed to the cement factory, three samples from each tree. Analytical assessment of the parts of plants (bark and leaf) revealed that the analyzed elemental nutrients in both research locations are higher in concentration when compared with the reference locations (3km away from the research sites) with the exception of manganese in contrast presentation.

INTRODUCTION

It is impossible to envisage a modern life without cement. Cement is an extremely important construction material used for housing and infrastructure development and a key to economic growth. Cement demand is directly associated to economic growth and many growing economies are striving for rapid infrastructure development which underlines the tremendous growth in cement production (Shraddha and Siddiqui, 2014). The fast industrial growth is causing enormous environmental pollution problems and affecting distribution of plants and soil characteristics of the area. Industrial pollution is caused by the discharges of varieties of industrial pollutants in the forms of gases, liquids and solids which affect the physical, chemical and biological conditions of the environment and are detrimental to human health, fauna, flora and soil properties (Abu-Romman*et al*., 2012; Mittler, 2002).These dust particulates get deposited on various parts of plants especially on leaf surfaces as well as on ground soil and affect growth and yield of crop plants through biological changes (Lerman, 1972; Stern, 1976). The dust escaping from cement factories is often transported by wind and deposited in areas close and far away from the factory. These include agricultural lands, natural vegetation, towns and villages, such depositions of particulate matter and other pollutants interfere with normal metabolic activities of plants, causing direct injury and impairment of growth and quality and may ultimately lead to decrease in plant yield (Ediagbonya *et al*., 2013;Schutzki and Cregg, 2007). Dust deposition affects photosynthesis, stomatal functioning and productivity (Santosh and Tripathi, 2008). Besides causing suppression of plant growth, cement dust induces the change in the physico-chemical properties of soil, which are generally unfavorable to plant growth (Abu-Romman *et al*., 2012; Mittler, 2002; Singh and Rao, 1978). Accumulation of different metals has been observed in different plant parts as aluminum has been observed in leaves, however copper is found in the seeds (Clark, 1995; Kabirand Madugu, 2010; Naidoo *et al*., 2004). In some cases, plant growth was also found to be reduced due to metal-metal interaction which reduces the availability of certain minerals to the plants. Alkalization and high amount of calciumion content of the cement pollutes soil environment which inhibits the assimilation of magnesium, manganese and iron by plants (Mandre and Tuulmets, 1997). Heavy metal pollutants are stable in the environment but highly toxic to biological organisms (Kumar *et al*., 2008; Levent *et al*., 2009; Ritambhara *et al*., 2010; Yahaya *et al*., 2012; Zou *et al*., 2006). Dusts with pH values of ≥ 9, cause direct injury to leaf tissues on which they are deposited (Vardak *et al*., 1995) or indirectly through alteration of soil pH (Auerbach *et al*., 1997). Dust accumulating on leaf surfaces interferes with gas diffusion between the leaf and air. Sedimentation of coarse particles affects the upper surfaces of leaves more (Kim *et al*., 2000)

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while finer particles affects lower surfaces (Beckett *et al*. 2000; Fowler *et al*., 1989). Owing to the fact that comparatively, not many studies have been performed to investigate the influence of cement dust pollution on forest ecosystem in Nigeria and due to essential role of vegetation in both natural and managed ecosystems, the changes caused by the atmospheric pollution are not restricted to the vegetation only, but also extend to the detrimental effects on biodiversity, ecosystem dynamics and human welfare, the present study intends to examine the cement dust effects on plant chemical composition specifically bark and leaf.

METHODOLOGY

The study was carried out at the two most prominent cement factories in Nigeria namely: West African Portland Cement Co PLC (Lafarge) in Ogun state and Obajana Cement (Dangote) in Kogi state. Lafarge Cement Factory lies in the South-western Nigeria in the rainforest vegetation zone. Lafarge is one of the cement factories blessed with large deposits of limestone, the major raw material in the production of cement. Ewekoro Lafarge plant is located in Ewekoro local government area of Ogun State. The local government area is bounded in the North by Abeokuta, in the East by Obafemi - Owode, in the West by Yewa South and in the South by Ado-Odo Ota. The map of Lafarge Cement plant in Ewekoro local government areas, Ogun State is shown in figure 1a. Lafarge cement factory is on latitude 06.90080ºN and longitude 003.20534ºE with elevation of 41m. Also, it is approximately 64 kilometers north of Lagos and 42 kilometers south of Abeokuta. Dangote Cement has three fully integrated cement plants of 29.3Mta located in Obajana, Ibese and Gboko. 4.0Mta plant at Gboko in Beneu State, is the oldest factory in Nigeria, having been commissioned in 2007. Obajana in Kogi State, is the flagship plant and the largest of the three factories in Nigeria at 13.25Mta capacity across four lines, opened in 2008 with two lines totalling 5Mta, it was even then the largest cement factory in Sub-Sahara Africa. Obajana cement factory lies in the Northern Nigeria in the savanna vegetation zone. The Obajana plant is located in Obajana local government area of Kogi State and is on latitude 07.92635ºN and longitude 006.41450ºE with elevation of 210m. Obajana cement plant was extended in its capacity to 10.25Mta in 2012 with the opening of Line 3 and 3.0Mta line was further added in late 2014. Obajana was initially designed to run on natural gas, with LPFO as a back-up and even a primary fuel. Obajana has limestone reserves of 647 million tonnes, expected to last for about 45 years. The map of Obajana Cement plant in Kabba local government areas, Kogi State is shown in figure 1b. The graph image extract for sampling points for the research locations are shown in fig. 2a and fig. 2b respectively.

Foliar and bark chemical composition of selected species determination: The bark and leaf samples of the most abundant species from both locations were collected for chemical composition examination. Bark sample was taken at the height of 1.5m on the side of the trunk exposed to the cement factory, three samples from each tree. The composite samples were oven-dried at 70°C for 12 hours, blended with milling machine and stored in dustproof paper bags. The samples were extracted with HNO_3. The concentrations of Ca, Fe, K, Mg, Na, C, P and Mn, which are important components of cement dust were analyzed. The elements were determined with chemical titrations, flame photometry, atomic absorption spectrophotometer and other standard analytical methods appropriately. The result was given as mean values of two replicates (Tel and Hagarty, 1984; Tervahattu*et al*., 2001). For Fe and Mn determination, five(5g) of material was weighed into a 100ml plastic, 50ml of 0.1M HCl was added and shaken for 30minutes. The suspension was filtered and diluted in ratio 1:100. Fe and Mn were determined from the aliquot using Atomic Absorption Spectrophotometry (AAS) Buck Scientific 210 VGP. The ranges of standard solution of 5.0ppm, 4.0ppm, 3.0ppm, 2.0ppm, 1.0ppm, 0.5ppm were prepared and the appropriate one was selected as the spectrophotometer was set up and allowed to stabilize. The instrument was calibrated using standard solutions. Emission against concentration was recorded both in standard and sample solution. The concentration for each element was calculated following the described procedure for flame emission(AOAC, 1999; Barker, 2001; Cater, M. R. 1992).

RESULTS

The samples of the most common species as listed in Table 1 and 2 in the forest closest to the cement plants for both research locations were taken for research analysis and reference plant samples were taken at a distance of about 2km to the cement plant. Plant samples were taken from the nearest vicinity of the cement plant (50m) to farthest distance covered (230m) mapped out for the research. The result of major chemical parameters of the plant (bark and leaf) samples from the two locations is presented in Table 3. The result of summary of the major chemical parameters of the plant (bark and leaf) samples from the two locations is presented in Table 4

DISCUSSION

Dust pollution exerts detrimental effects on plant ecosystem and caused many problems relating to the environment, health, hygiene, economy and aestethics (Saeid *et al*., 2015; Schuhmacher *et al*., 2002). A thick dust layer covers the surfaces of the plants in the surroundings of the cement plant to a distance of more than 2km from the cement factories. The plants growth were seriously impaired. Table 3 revealed that elemental nutrients in the vegetations for both research locations are higher in concentration when compare with the reference locations at 3km away from the cement factory,this is similar to the reportof Anda, 1986. These values also vary with distances away from cement factories and it conforms to the report of Oluduye and Ogunyebi, 2017. Sodium (Na) concentration values of the leaf samples ranged from 20.10-33.28ppm and 20.38- 33.03ppm in both locations (Obajana and Ewekoro). The sample at 3km away from Obajana cement plant has 31.59ppmand the same distance to Ewekorocement plant has 24.54ppm respectively. The values for bark samples ranged from 14.33 - 34.95ppm and 20.10 - 49.47ppm in both locations (Obajana and Ewekoro). The sample at 3km away from Obajana cement planthas 30.38ppm and the same distance to Ewekorocement plant has 26.24ppm respectively. The mean chemical properties of the plant (bark and leaf) samples from the two locations as summarized in table 4 revealed that the mean Na concentration values ranged from 22.78±2.7ppm to 30.94±4.23ppm and 23.10±5.2ppm to 40.03±11.1ppm for leaf and bark respectively, implying that Na concentrations in most of the leaf samples from research site are not significantly different compared with the reference sample (3km away from the cement factory) of 28.57±7.7ppm while bark samples from research site are significantly different compared with the reference sample of 28.61±7.19ppm respectively.

Table 1. Selected tree species around Lafrage cement factory for analysis

Sample Points	Transect A Species	Transect B Species
1	*Lonchocarpus sericeus*	*Albizia lebbeck*
2	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
3	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
4	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
5	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
6	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
7	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
8	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
9	*Albizia lebbeck*	*Lonchocarpus sericeus*
10	*Lonchocarpus sericeus*	*Lonchocarpus sericeus*
Adjoining forest	*Anthocleista vogelii*	
Adjoining forest	*Ficus sur*	
Adjoining forest	*Lonchocarpus sericeus*	

Table 2. Selected tree species around Obajana cement factory for analysis

Sample Points	Transect A Species	Transect B Species
1	*Vitellaria paradoxa*	*Daniellia oliveri*
2	*Daniellia oliveri*	*Daniellia oliveri*
3	*Daniellia oliveri*	*Lonchocarpus sericeus*
4	*Vitellaria paradoxa*	*Daniellia oliveri*
5	*Anogeissus leicarpus*	*Daniellia oliveri*
6	*Terminalia avecenoide*	*Vapaca leudeudaci*
7	*Anogeissus leicarpus*	*Terminalia avecenoide*
8	*Daniellia oliveri*	*Daniellia oliveri*
9	*Anogeissus leicarpus*	*Vitellaria paradoxa*
10	*Stereospermum bignonaceae*	*Daniellia oliveri*
Adjoining forest	*Daniellia oliveri*	
Adjoining forest	*Parinari maranthes*	
Adjoining forest	*Terminalia avecenoide*	
Adjoining forest	*Albezia spp*	

Table 3. Major chemical parameters of the tree part from the two locations according to distances away from the cement factory

Location	Species	Elements	50m	70m	90m	110m	130m	150m	170m	190m	210m	230m	3km
Obajana	Leaf	Na (ppm)	24.60	32.18	27.58	24.80	30.57	31.93	20.10	33.28	26.52	20.23	31.59
		K (ppm)	23.23	43.82	36.17	31.10	33.55	34.43	29.75	30.55	27.75	32.98	42.11
		Mg(cMol/Kg)	0.73	0.67	0.62	0.60	0.52	0.70	0.44	0.28	0.38	0.80	0.67
		Ca (ppm)	0.83	0.62	0.76	0.38	0.70	0.92	0.42	0.76	0.46	0.36	0.50
		P (ppm)	73.70	85.20	46.90	46.50	80.70	51.90	50.10	71.30	71.40	46.80	48.25
		Mn (%)	0.48	0.18	0.47	0.57	0.21	0.43	0.27	0.35	0.23	0.23	0.25
		C (%)	7.83	3.00	18.83	3.00	26.33	5.83	5.00	3.50	1.00	6.00	3.00
		Fe (%)	1.29	1.23	0.51	1.13	1.03	0.93	1.18	0.96	1.64	1.21	0.85
	Bark	Na (ppm)	26.10	20.03	30.58	20.75	29.32	24.28	34.95	14.33	18.17	26.52	30.38
		K (ppm)	45.10	35.83	68.97	79.35	47.00	65.23	83.87	52.67	39.30	43.52	51.05
		Mg(cMol/Kg)	0.46	0.38	0.80	0.60	0.62	0.70	0.28	0.58	0.66	1.02	0.36
		Ca(cMol/Kg)	2.20	2.58	2.88	1.04	2.08	1.48	1.20	1.22	0.42	2.06	2.24
		P (ppm)	25.30	35.40	42.10	36.90	35.80	39.90	31.90	28.50	22.50	36.20	96.75
		Mn (%)	0.11	0.26	0.14	0.21	0.13	0.17	0.13	0.52	0.25	0.09	0.15
		C (%)	3.00	3.00	3.00	5.50	1.00	1.00	3.00	1.50	5.50	1.50	9.75
		Fe (%)	1.32	1.04	1.12	1.78	1.22	1.34	0.91	1.38	1.44	0.68	1.02
Ewekoro	Leaf	Na (ppm)	21.18	29.70	20.38	27.60	25.35	23.43	33.03	22.52	31.13	25.32	24.54
		K (ppm)	31.38	36.98	35.60	33.83	29.25	54.00	31.65	28.07	25.48	34.08	46.13
		Mg(cMol/Kg)	0.56	0.60	0.86	1.04	0.92	0.98	0.77	0.74	1.22	0.54	0.60
		Ca (ppm)	1.24	1.06	0.86	0.34	0.96	0.86	0.78	0.80	1.40	1.52	1.01
		P (ppm)	71.20	80.60	84.90	88.40	88.55	81.45	98.50	62.40	79.70	53.10	64.73
		Mn (%)	0.36	0.14	0.34	0.43	0.52	0.56	0.26	0.20	0.27	0.44	0.21
		C(%)	2.00	3.00	3.50	2.50	3.00	2.50	2.00	24.50	4.00	4.50	4.33
		Fe (%)	1.07	1.44	1.69	1.01	1.57	1.40	1.33	0.70	1.42	0.93	1.34
	Bark	Na (ppm)	20.10	44.95	49.47	26.72	42.67	42.47	28.85	24.73	30.72	27.93	26.24
		K (ppm)	34.00	40.05	32.75	36.17	37.57	40.20	41.22	29.60	37.82	44.58	44.31
		Mg(cMol/Kg)	0.62	0.62	0.68	0.60	0.60	0.74	0.88	0.98	0.56	0.66	0.63
		Ca(cMol/Kg)	2.22	2.10	1.96	2.24	2.04	2.10	2.10	2.29	2.52	2.14	1.79
		P (ppm)	55.60	52.40	62.90	56.50	59.55	66.80	66.20	55.80	48.50	43.30	69.40
		Mn (%)	0.05	0.19	0.22	0.28	0.17	0.55	0.34	0.31	0.33	0.29	0.08
		C (%)	4.50	4.00	3.50	5.00	5.00	4.00	4.00	7.00	5.50	3.00	5.670
		Fe (%)	0.95	1.29	0.52	1.02	1.10	0.47	1.72	0.93	1.02	1.63	1.00

Table 4. Summary of the major chemical parameters of the tree samples from the two locations

Species	Elements	50m	70m	90m	110m	130m	150m	170m	190m	210m	230m	3km
Leaf	Na (ppm)	22.89 ± 7.2^{a}	30.94 ± 4.23^{b}	23.98 ± 5.44^{a}	26.20 ± 2.18^{ab}	27.96 ± 4.7^{ab}	27.68 ± 5.8^{ab}	26.57 ± 7.1^{ab}	27.9 ± 8.8^{ab}	28.83 ± 10.4^{ab}	22.78 ± 2.7^{a}	28.57 ± 7.7^{ab}
	K (ppm)	27.31 ± 9.2^{a}	40.40 ± 4.1^{cd}	35.88 ± 12.8^{bc}	32.47 ± 6.8^{ab}	31.40 ± 8.7^{ab}	44.22 ± 10.3^{d}	30.70 ± 6.6^{ab}	29.31 ± 2.8^{ab}	26.62 ± 2.8^{a}	33.53 ± 7.8^{abc}	43.83 ± 13.2^{d}
	Mg (cMol/kg)	0.65 ± 0.10^{abc}	0.64 ± 0.11^{abc}	0.74 ± 0.13^{bc}	0.82 ± 0.38^{bc}	0.72 ± 0.22^{abc}	0.81 ± 0.25^{c}	0.60 ± 0.19^{ab}	0.51 ± 0.32^{a}	0.80 ± 0.45^{bc}	0.67 ± 0.19^{abc}	0.64 ± 0.18^{abc}
	Ca (ppm)	1.03 ± 0.57^{c}	0.84 ± 0.52^{bc}	0.81 ± 0.37^{bc}	0.36 ± 0.14^{a}	0.83 ± 0.42^{bc}	0.89 ± 0.35^{bc}	0.60 ± 0.43^{ab}	0.78 ± 0.11^{bc}	0.93 ± 0.49^{bc}	1.00 ± 0.72^{bc}	0.72 ± 0.44^{abc}
	P (ppm)	72.45 ± 18.09^{abc}	82.90 ± 16.95^{c}	65.90 ± 20.73^{abc}	67.45 ± 22.83^{abc}	84.63 ± 17.82^{c}	66.68 ± 18.34^{abc}	74.30 ± 32.73^{bc}	66.85 ± 19.11^{abc}	75.55 ± 12.90^{bc}	49.95 ± 21.23^{a}	55.31 ± 44.45^{ab}
	C (%)	4.92 ± 5.93^{ab}	3.00 ± 0.95^{a}	11.17 ± 14.24^{bc}	2.75 ± 1.14^{a}	14.67 ± 22.34^{c}	4.17 ± 2.86^{ab}	3.50 ± 1.88^{ab}	14.00 ± 11.62^{c}	2.50 ± 2.23^{a}	5.25 ± 2.13^{ab}	2.00 ± 2.61^{ab}
	Mn (%)	0.42 ± 0.08^{de}	0.16 ± 0.08^{a}	0.41 ± 0.18^{de}	0.50 ± 0.09^{e}	0.37 ± 0.31^{cde}	0.50 ± 0.12^{e}	0.26 ± 0.11^{abc}	0.28 ± 0.09^{abc}	0.25 ± 0.16^{abc}	0.33 ± 0.18^{bcd}	3.45 ± 0.09^{ab}
	Fe (%)	1.18 ± 0.41^{abc}	1.33 ± 0.15^{bc}	1.10 ± 0.69^{ab}	1.07 ± 0.36^{ab}	1.30 ± 0.30^{bc}	1.17 ± 0.26^{abc}	1.25 ± 0.43^{bc}	0.83 ± 0.35^{a}	1.53 ± 0.21^{c}	1.07 ± 0.54^{ab}	1.06 ± 0.45^{ab}
Bark	Na (ppm)	23.10 ± 5.2^{ab}	32.49 ± 17.8^{cdef}	40.03 ± 11.1^{f}	23.73 ± 7.9^{abc}	35.99 ± 12.5^{ef}	33.38 ± 12.6^{def}	31.90 ± 7.0^{bcdef}	19.53 ± 5.9^{a}	24.44 ± 12.6^{abcd}	27.23 ± 1.7^{abcde}	28.61 ± 7.19^{bcde}
	K (ppm)	39.55 ± 16.33^{a}	37.94 ± 6.21^{a}	50.86 ± 22.98^{abc}	57.76 ± 26.70^{bc}	42.28 ± 6.68^{ab}	52.72 ± 18.53^{abc}	62.54 ± 23.61^{c}	41.13 ± 30.61^{ab}	38.56 ± 15.64^{a}	44.05 ± 9.30^{ab}	48.16 ± 11.98^{abc}
	Mg (cMol/kg)	0.54 ± 0.27^{abc}	0.50 ± 0.17^{ab}	0.74 ± 0.23^{bcd}	0.60 ± 0.04^{abcd}	0.61 ± 0.37^{abcd}	0.72 ± 0.31^{abcd}	0.58 ± 0.35^{abcd}	0.78 ± 0.45^{cd}	0.61 ± 0.21^{abcd}	0.84 ± 0.20^{d}	0.47 ± 0.30^{a}
	Ca (ppm)	2.21 ± 0.77^{ab}	2.34 ± 10.65^{b}	2.42 ± 10.51^{b}	1.64 ± 10.68^{ab}	2.06 ± 1.04^{ab}	1.79 ± 0.49^{ab}	1.65 ± 0.70^{ab}	1.76 ± 0.57^{ab}	3.50 ± 1.13^{a}	2.10 ± 1.13^{ab}	2.04 ± 1.33^{ab}
	P (ppm)	40.45 ± 21.85^{a}	43.90 ± 10.62^{a}	52.50 ± 14.36^{a}	46.70 ± 20.06^{a}	47.68 ± 16.24^{a}	53.35 ± 17.81^{a}	49.05 ± 18.52^{a}	42.15 ± 16.48^{a}	35.50 ± 13.99^{a}	39.75 ± 9.15^{a}	85.03 ± 43.01^{b}
	C (%)	3.75 ± 1.87^{a}	3.50 ± 1.45^{a}	3.25 ± 0.97^{a}	5.25 ± 3.42^{ab}	3.00 ± 2.63^{a}	2.50 ± 1.68^{a}	3.50 ± 1.88^{a}	4.25 ± 3.33^{a}	5.50 ± 3.43^{ab}	2.25 ± 1.36^{a}	8.00 ± 7.87^{b}
	Mn (%)	0.08 ± 0.04^{a}	0.23 ± 0.11^{bc}	0.18 ± 0.07^{abc}	0.24 ± 0.18^{bc}	0.15 ± 0.04^{ab}	0.36 ± 0.28^{de}	0.23 ± 0.16^{bc}	0.42 ± 0.14^{e}	0.29 ± 0.11^{cd}	0.19 ± 0.17^{abc}	0.12 ± 0.06^{ab}
	Fe (%)	1.13 ± 0.32^{abcd}	1.16 ± 0.45^{abcd}	0.82 ± 0.41^{a}	1.40 ± 0.41^{d}	1.16 ± 0.11^{abcd}	0.91 ± 0.53^{ab}	1.32 ± 0.60^{cd}	1.15 ± 0.34^{abcd}	1.23 ± 0.31^{bcd}	1.15 ± 0.54^{abcd}	1.01 ± 0.24^{abc}

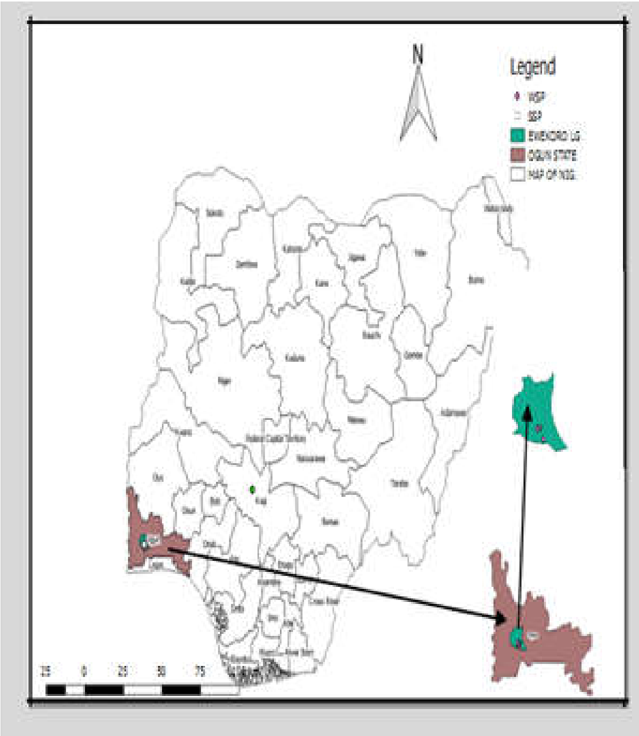

Fig. 1a: Map showing research locations in Kogi state

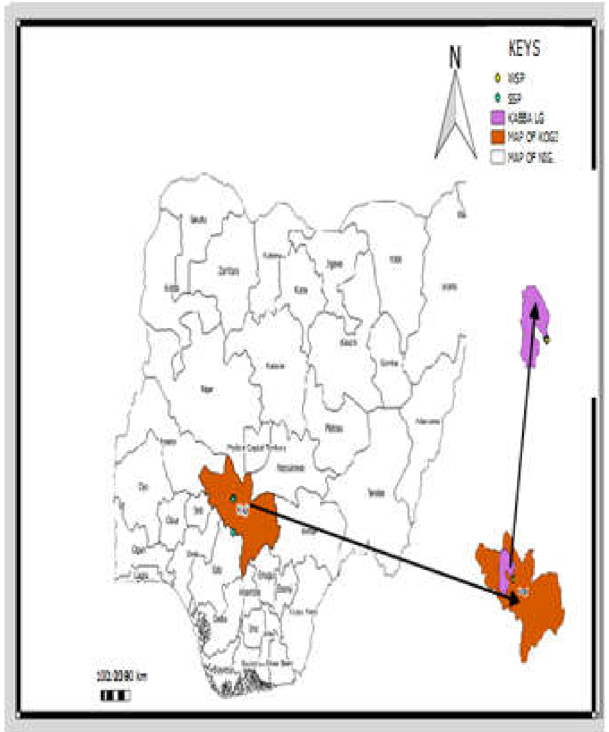

Fig. 1b: Map showing research locations in Ogun state

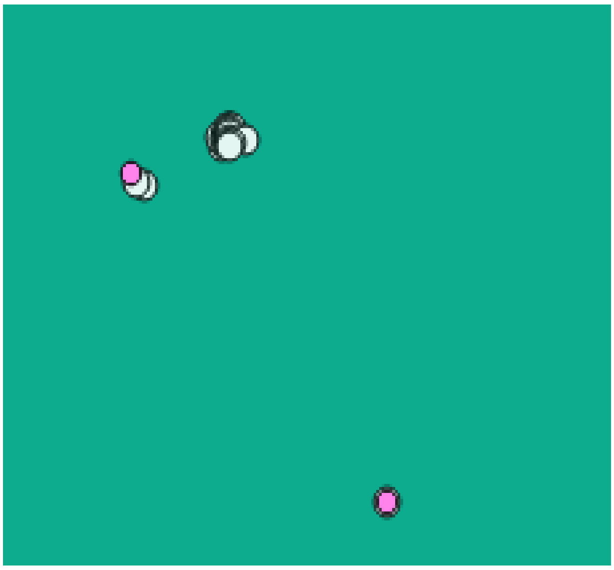

Fig. 2a. Soil and water sampling points in Ogun state

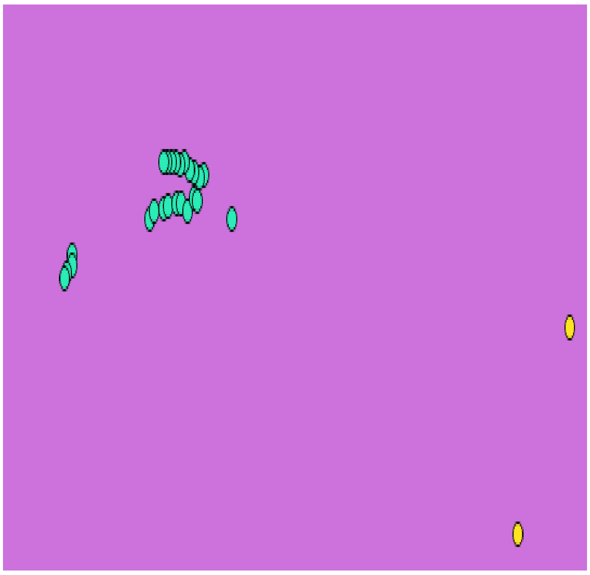

Fig. 2b. Soil and water sampling points in Kogi state

different compared with the reference sample of 28.61±7.19ppm respectively. The recorded Potassium (K) concentration values of the leaf samples ranged from 23.23- 43.82ppm and 25.48- 55.00ppm in both locations (Obajana and Ewekoro) respectively. The sample at 3km away from Obajana cement plant has 42.11ppmand the same distance to Ewekorocement plant has 46.13ppm respectively. The values for bark samples ranged from 35.83- 83.87ppm and 29.60 - 44.58ppm in both locations (Obajana and Ewekoro) respectively. Samples at 3km away from the cement factory inObajana has 51.05ppmand Ewekoro has 44.31ppm respectively. The mean values of K concentrations ranged from 26.62±2.8ppm - 44.22±10.3ppm and 37.94±6.21ppm to 62.54±23.61ppm for leaf and bark respectively, the values which are mostly significantly different compared with that of 3km away from the cement factory inObajana and Ewekoro with mean concentration values of 43.83±13.2ppm and 48.16±11.98ppm. Magnesium (Mg) concentration values of the leaf samples ranged from 0.28- 0.80 (cMol/kg) and 0.54 - 1.22 (cMol/kg) in both locations (Obajana and Ewekoro) respectively. The sample at 3km away from Obajana cement plant has 0.67ppmand the same distance to Ewekorocement plant has0.60ppm respectively. The values for bark samples ranged from 0.28- 1.02ppm and 0.56 - 0.98ppm in both locations (Obajana and Ewekoro) respectively. The sample at 3km away from Obajana cement plant has 0.36ppmand the same distance to Ewekorocement plant has 0.63ppm respectively. The mean values for magnesium (Mg) concentration ranged from 0.51±0.32cMol/kg - 0.82±0.38cMol/kg and 0.50±0.17cMol/kg - 0.84±0.20cMol/kg for leaf and bark respectively, showing variability among the leaf samples when compared with the leaf reference sampleat 3km away of mean concentration 0.64±0.18cMol/kg and bark samples that are significantly different from the reference sample at 3km away of mean concentration 0.47±0.30cMol/kg. Calcium (Ca) concentration values of the leaf samples ranged from 0.38- 0.92 (cMol/kg) and 0.34 - 1.52 (cMol/kg) in both locations (Obajana and Ewekoro) respectively. The sample at 3km away from Obajana cement plant has 0.50ppmand the same distance to Ewekorocement plant has 1.01ppm respectively. The values for bark samples ranged from 0.42- 2.88(cMol/kg) and 1.96- 2.52(cMol/kg) in both locations (Obajana and Ewekoro) respectively. The sample at 3km away from Obajana cement plant has 2.24ppmand the same distance to Ewekorocement plant has 1.79ppm respectively. The mean concentrations values of Ca ranged from 0.36±0.14cMol/Kg- 1.03±0.57cMol/Kg and 1.64±10.68cMol/Kg- 3.50±1.13cMol/Kg for leaf and bark respectively, showing that Ca concentrations in the leaf samples from research sites are significantly different from the reference sample at 3km away of 0.72±0.44cMol/Kg while bark samples from research sites are mostly not significantly different from the reference sample at 3km away of 2.04±1.33cMol/Kg.

The recorded Phosphorus (P) concentration values of the leaf samples ranged from 46.50 - 85.20ppm and 53.10 - 98.50ppm in both locations (Obajana and Ewekoro) respectively. Obajanarefrence sample (3km) has 48.25ppmand Ewekororefrence sample (3km) has 64.73ppm respectively. The values for bark samples ranged from 22.50 - 42.10ppm and 43.3 - 66.80ppm in both locations (Obajana and Ewekoro) respectively. Obajanareference sample (3km) has 96.75ppmand Ewekororefrence sample (3km) has 69.40ppm respectively. The mean concentration values of phosphorus ranged from 49.95±21.23ppm - 84.63±17.82ppm and 35.50±13.99ppm - 53.35±17.81ppm for leaf and bark respectively, indicating that P concentrations are higher in most of the leaf samples from the research sites than the reference sample at 3km away with mean concentration value of 55.31±44.45ppm and lower in bark samples from the research sites than the reference sample at 3km away with mean concentration value of 85.03±43.01ppm respectively. The recorded Manganese (Mn) concentration values of the leaf samples ranged from 0.18–0.57% and 0.14 - 0.56% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample has 0.25ppmand Ewekoro reference sample has 0.21ppm respectively. The values for bark samples ranged from 0.09 - 0.52% and 0.05 - 0.55% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample at 3km away has 0.15ppmand Ewekoro reference sample at 3km away has 0.08ppm respectively. The recorded mean Manganese (Mn) concentration values ranged from 0.16±0.08% – 0.50±0.09% and 0.08±0.04% - 0.42±0.14% for leaf and bark respectively, denoting that Mn concentrations are lower in the leafsamples from the research sites than the reference sample at 3km with mean concentration value of 3.45±0.09% and significant variability among the bark samples with the leaf reference sample at 3km with mean concentration of 0.12±0.06%. Carbon (C) concentration values of the leaf samples ranged from 1.00 – 26.33% and 2.00 - 24.50% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample at 3km away has 3.00ppmand Ewekoro reference sample at 3km away has 4.33ppm respectively. The values for bark samples ranged from 1.00 - 5.50% and 3.00 – 7.00% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample at 3km away has 9.75ppmand Ewekoro reference sample at 3km away has 5.67ppm respectively. The mean concentrations values of carbon (C) ranged from 2.50±2.23% - 14.67±22.3% and 2.25±1.36% - 5.50±3.43% for leaf and bark respectively, inferring that C concentrations are higher in the leafsamples from the research sites than the reference sample at 3km with mean concentration value of 2.00±2.61% and lower in bark samples from the research site than the reference sample at 3km with mean concentration value of 8.00±7.87% respectively. High carbon content in the samples reflects the storing abilities of trees as sinks for air pollutants emitted from the cement factories. Iron (Fe) concentration values of the leaf samples ranged from 0.51 – 1.64% and 0.70 - 1.69% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample at 3km away has 0.85ppmand Ewekoro reference sample at 3km away has 1.34ppm respectively. The values for bark samples ranged from 0.68 - 1.78% and 0.47 – 1.72% in both locations (Obajana and Ewekoro) respectively. Obajana reference sample at 3km away has 1.02ppmand Ewekoro reference sample at 3km away has 1.00ppm respectively. Iron (Fe) mean concentration values ranged from 0.83±0.35% – 1.53±0.21% and 0.82±0.41- 1.32±0.60% for leaf and bark respectively and also connoting significant variability among the leaf, bark and reference samples at 3km of mean concentration 1.06±0.45% and 1.01±0.24% for leaf and bark respectively.The maximum range of the vegetation elemental nutrients are higher in all the samples when compared with the reference samples at 3km away from the cement factory. This implies that cement dust has both direct and indirect effects on chemical compositions of trees and supported by Asadu and Agada, 2008 who reported that the concentration of metals such as Fe, Al, Zn, Cu, Pb, Cr and Cd were found relatively high in the soil nearby cement industries as compared to normal.

Statistical analysis: Systematic random sampling technique was adopted for plot demarcation and plants sampling. The experimental design used was Randomised Completely Block Design (RCBD). Data were analysed with one-way analyses of variance for comparison. Mean separation was carried out with the new duncan multiple range test ($p<0.05$). All data obtained were subjected to statistical analysis, the mean; standard deviation (SD) and coefficient of variation (CV) were calculated. All statistical calculations were performed using SPSS version 16 (SPSS Inc., Chicago, IL, USA) and Excel spread sheet.

Conclusion

The cement kiln dust, containing oxides of calcium, potassium and sodium is a common air pollutant affecting plants in various ways and leading to stunted growth. Air pollution has become a major threat to the survival of plants in the industrial areas. Injury to the plants ranges from visible markings on the foliage, reduced growth and yield to premature death of the plant. The pollutants cause a serious threat to the overall physiology of plants. Leaf is the most sensitive part to the air pollutants. Plants demonstrate a wide array of responses when exposed to pollutants in the form photosynthesis, respiration, enzymatic reactions, stomatal behavior, membrane disruption, senescence and ultimately death. This study revealed that cement production has effect on forest ecosystem around cement factories. The environmental adverse effect was cushion in a way with reforestation. The reforestation was not effective due to the fact that proper planning and planting scheme considering the magnitude and type of pollution, selection of pollution-tolerant and dust scavenging trees and shrubs was not appropriated.

Efficient and effective management of environmental pollutions from such activities has to put into consideration the facility lifespan of at least 40 to 50 years. The size of the plant is an important factor, as differences in production scale have a significant impact on production costs and, consequently, on investment costs for pollution abatement and control technologies. Pollution prevention and control techniques for particulate matter emissions associated with intermediate and final materials handling and storage (including crushing and grinding of raw materials), handling and storage of solid fuels, transportation of materials (e.g. by trucks or conveyor belts), and bagging activities should include, Proper handling of materials during operations, use of enclosed belt conveyors for materials transportation and emission controls at transfer points, cleaning of return belts in the conveyor belt systems, and storage of crushed and pre-blended raw materials in covered or closed bays.

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