Impact of Cement Production on soil Heavy Metals and Nutrients Uptake of Elephant Grass (Pennisetum Purpureum) Grown within 2km Radius of cement Factory in South West Nigeria

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Abstract— The study investigated the impact of cement production around cement factory at Ewekoro, South West Nigeria within two kilometer radius to the factory on nutrients uptake by Elephant grass. Elephant grass was sampled at 500, 1000, 1500 and 2000 m. Sampling was carried out in wet and dry seasons for two years (2015 and 2016). Samples were subjected to Laboratory analysis. The parameters determined in the plant samples were Ca, Mg, Na, K, total N, Cu, Zn, Fe, Mn, Pb, Ni, Cr, and Cd. Generally, there was a decrease in all the nutrients uptake by the grass as the distance from the factory increased during the dry season. Mg in the plant tissue initially decreased to a distance of 1500m and was later observed to increase 2000m from the factory. Calcium and Zn concentration was found to be highest in Pennisetum purpureum. Mean composition of micro-nutrients revealed higher concentration of Zinc ranged from 6.31±0.36 to 42.04±2.71 mg/kg and lower concentration from 6.42±0.78 to 10.44±3.39 mg/kg respectively. Results of heavy metal concentration revealed a range from 2.67±0.24 to 6.11±0.77 mg/kg for Lead while the mean values obtained ranged from 0.04±0.01 to 5.5mg/kg. Results obtained from analysis of Pennisetum purpureum showed Calcium to be the most abundant micronutrients with a mean concentration ranged from 2.99% to 5.13% while the mean value recorded at Ewekoro showed a range between 0.19% and 0.36%. Mean Nitrogen content ranged between 1.26 and 2.47% at Ewekoro.

Keyword— nutrient uptake, heavy metals, micronutrients, pollution.

I. INTRODUCTION

Pollution is the introduction of contaminants into a natural setting to cause instability, disorder, harm or discomfort to the ecosystem (Blacksmith Institute, 2007). Soil, water and air can be polluted by metals. Plants growing in a polluted environment are known to accumulate the toxic substances that can cause sicknesses to human body (Alloway, 1995). Plants normally absorb whatever soil nutrient that is available to them. Even the specks of dust that contaminate soils are absorbed by the plants and later hinder the normal functioning of the leaves, which ultimately results in crop low yield (Alloway, 1995). A reasonable amount of heavy metals are absorbed by the plants from the contaminated soil which are later absorbed by animals and man through the consumption of the plant products by livestock and man.

Accumulation of heavy metals by plant roots, stems and leaves grown in polluted soils have been reported by Okoronkwo et al. (2005). Elephant grass (Pennisetum purpureum Schumach), is a dominant tall tropical grass (CABI, 2014) with high yield and can tolerate a range of climatic conditions. It is also a valuable forage crop (CABI, 2014; FAO, 2015). Cattle and buffaloes cherish the plant. Elephant grass can be grazed, provided it is often kept at the lush vegetative stage. Meanwhile, livestock tend to feed only...
on the younger leaves (FAO, 2015). Elephant grass is a multipurpose plant. Apart from being animal feeds, its culms can also be used to build fences and thatches. Therefore, this study aims to assess the impact of cement particulate contamination on nutrient uptake and yield of Elephant grass (*Pennisetum purpureum*) within 2 km radius cement factory.

II. MATERIALS AND METHOD

Elephant grass was the pre-dominant plant that animal feeds on in the study area. It was randomly collected at 500, 1000, 1500 and 2000m interval. The four treatments were replicated three times i.e. from each location three plants were bulked in three places. Collection was carried out in wet and dry seasons for two years (2015 and 2016). Samples collected were subjected to Laboratory analysis using standard procedure. Determination of the composition of micronutrients such as Ca, Mg, Na, K, Cu, Zn, Fe, and Mn in the plant samples were carried out while the soil samples were analyzed to determine the level of the presence of heavy metals such as Pb, Ni, Cr, and Cd.

The soil samples were collected at different places, dried and 2mm sieved. The leaf samples were oven-dried and digested with Nitric/Perchloric acid mixture (2:1). The cations, (Ca, Mg, Na, K), were analyzed by Atomic Absorption Spectrophotometer (AAS) through flame ionization method (Chapman and Pratt, 1961), total Nitrogen in the plants was determined by Kjeldahl digestion and the Nitrogen determined colourimetrically (Bremner, 1996). Total P was determined colourimetrically by the Vanadomolybdenum yellow procedure (Murphy and Riley, 1962). Micro-nutrients (Cu, Zn, Fe and Mn) and heavy metals (Pb, Ni, Cr, and Cd) were also determined with AAS from the digest above.

**Statistical Analysis**

Statistical analysis of the data collected was carried out using the SAS software 2014 version. Parameters evaluated are mean values of data generated from the field using Duncan Multiple range Test at 5% significant level. The chemical composition of cement is shown in table 1 below.

Table 1: Chemical components of Cement.

| Components | Producer L (%) | Producer H (%) | Producer T (%) |
|------------|----------------|----------------|----------------|
| Na₂O       | 0.11           | 0.11           | 0.11           |
| MgO        | 1.60           | 2.10           | 3.82           |
| Al₂O₃      | 4.19           | 4.31           | 4.29           |
| SiO₂       | 18.59          | 19.84          | 19.31          |
| P₂O₅       | 0.58           | 0.09           | 0.09           |
| SO₃        | 3.31           | 2.96           | 3.26           |
| Cl         | 0.04           | 0.05           | 0.02           |
| K₂O        | 1.16           | 0.59           | 0.53           |
| CaO        | 55.62          | 62.05          | 56.62          |
| TiO₂       | 0.21           | 0.26           | 0.21           |
| MnO        | 0.03           | 0.17           | 0.38           |
| Fe₂O₃      | 2.66           | 3.01           | 3.30           |

Source: Lviv Polytechnic National University Institutional Repository [http://ena.lp.edu.ua](http://ena.lp.edu.ua)

Table 2 showed the level of Cr, Pb, Ni and Cd in the soil from 0 – 100m depth in Ewekoro North east. Compared with 0 – 20cm away from the cement factory at Ewekoro North East during dry and seasons, Cr and Pb contents in the soil were significantly reduced while there were no significance differences in the amount of Ni and Cd up to.
120cm depth. It was noticed that Cr, Pb, Ni and Cd decreased as the soil depth increased. In Ewekoro the major difference in heavy metals status was that the data recorded in the wet season were higher than the data obtained in the dry season.

Also, table 1 showed the effect of cement particulate on properties of heavy metals in Ewekoro north east direction during dry and wet seasons. Compare with 500cm distance away from the cement factory, the Cr content was significantly different from 1000, 1500 and 2000 m away from the factory while Pb, Ni and Cd were significantly reduced except 1000m away from the factory during the dry season. During the wet season, Cr, Pb and Ni were significantly increased except 2000m away from the factory. The Cd level was undetected. The Pb, Ni, Cr and Cd concentration in the oil did not follow the same pattern.

In Ewekoro south west, during the dry and wet seasons, there were no much significant differences between Cr and Pb from 0 – 20 cm to 100 -120 cm depth. During the dry season, Ni and Cd were not detected. Cadmium was not detected in Ewekoro south west during the wet season.

Compared with 500m distance away from the factory, there was increase in Cr content as the distance increased from 1000 to 2000m distance. Pb (except 500m), Ni and Cd were not detected during the dry season. During the wet season, compared with Cr, Pb and Ni at 500m distance away from the factory, the Cr, Pb and Ni increased as the distance increased except the Cr and Pb content at 1000m away from the factory. The Cr, Pb and Ni contents in wet season were higher than the Cr, Pb and Ni during the dry season. Cadmium content was not detected.

Table 2: Impact of Cement Production on Soil Chromium, Lead, Nickel and Cadmium at Ewekoro Cement Factory within 2km Radius

| EWEKORO NORTH-EAST(Dry) | EWEKORO NORTH-EAST(Wet) |
|-------------------------|-------------------------|
| Depth | Cr | Pb | Ni | Cd | Depth | Cr | Pb | Ni | Cd |
| 0-20 | 1.4275<sup>a</sup> | 1.74<sup>a</sup> | 0.15875<sup>a</sup> | 0.03<sup>a</sup> | 0-20 | 1.63125<sup>a</sup> | 1.07375<sup>a</sup> | 0.15625<sup>a</sup> | 0<sup>a</sup> |
| 20-40 | 1.335<sup>a</sup> | 1.4913<sup>ab</sup> | 0.12375<sup>a</sup> | 0.03125<sup>a</sup> | 20-40 | 1.58125<sup>b</sup> | 1.05<sup>a</sup> | 0.15625<sup>a</sup> | 0<sup>a</sup> |
| 40-60 | 1.20875<sup>b</sup> | 1.4238<sup>ab</sup> | 0.12375<sup>a</sup> | 0.025<sup>a</sup> | 40-60 | 1.54375<sup>bc</sup> | 1.01375<sup>b</sup> | 0.1425<sup>a</sup> | 0<sup>a</sup> |
| 60-80 | 1.2125<sup>b</sup> | 1.3263<sup>b</sup> | 0.11125<sup>a</sup> | 0.03625<sup>a</sup> | 60-80 | 1.55375<sup>bc</sup> | 0.94375<sup>c</sup> | 0.14125<sup>a</sup> | 0<sup>a</sup> |
| 80-100 | 1.11125<sup>b</sup> | 1.3063<sup>b</sup> | 0.11875<sup>a</sup> | 0.02125<sup>a</sup> | 80-100 | 1.57625<sup>b</sup> | 0.9225<sup>c</sup> | 0.11625<sup>b</sup> | 0<sup>a</sup> |
| 100-120 | 1.10125<sup>b</sup> | 1.1375<sup>b</sup> | 0.075<sup>a</sup> | 0.0175<sup>a</sup> | 100-120 | 1.525<sup>c</sup> | 0.87<sup>d</sup> | 0.05<sup>c</sup> | 0<sup>a</sup> |

| Distance | Cr | Pb | Ni | Cd | Distance | Cr | Pb | Ni | Cd |
|----------|---------|---------|---------|---------|----------|---------|---------|---------|---------|
| 500 | 1.33<sup>b</sup> | 2.2658<sup>a</sup> | 0.18<sup>a</sup> | 0.05417<sup>a</sup> | 500 | 1.44917<sup>c</sup> | 0.93333<sup>b</sup> | 0.105833<sup>c</sup> | 0<sup>a</sup> |
| 1000 | 1.6375<sup>a</sup> | 2.0608<sup>a</sup> | 0.24417<sup>a</sup> | 0.04833<sup>a</sup> | 1000 | 2.1<sup>c</sup> | 1.29917<sup>a</sup> | 0.124167<sup>b</sup> | 0<sup>a</sup> |
| 1500 | 0.84167<sup>d</sup> | 0.3125<sup>c</sup> | 0<sup>b</sup> | 0<sup>b</sup> | 1500 | 1.49167<sup>b</sup> | 0.78833<sup>c</sup> | 0.095<sup>c</sup> | 0<sup>a</sup> |
| 2000 | 1.12167<sup>c</sup> | 0.9775<sup>b</sup> | 0.05<sup>b</sup> | 0.0005<sup>b</sup> | 2000 | 1.23333<sup>d</sup> | 0.895<sup>b</sup> | 0.183333<sup>a</sup> | 0<sup>a</sup> |

| EWEKORO SOUTH-WEST(Dry) | EWEKORO SOUTH-WEST(Wet) |
|-------------------------|-------------------------|
| Depth | Cr | Pb | Ni | Cd | Depth | Cr | Pb | Ni | Cd |
| 0-20 | 0.19<sup>a</sup> | 0.01<sup>ab</sup> | 0<sup>a</sup> | 0<sup>a</sup> | 0-20 | 2.885<sup>a</sup> | 7.035<sup>a</sup> | 0.20375<sup>a</sup> | 0<sup>a</sup> |
| 20-40 | 0.2025<sup>a</sup> | 0.01<sup>ab</sup> | 0<sup>a</sup> | 0<sup>a</sup> | 20-40 | 2.6638<sup>ab</sup> | 6.065<sup>a</sup> | 0.16<sup>b</sup> | 0<sup>a</sup> |
| 40-60 | 0.1925<sup>a</sup> | 0.0125<sup>a</sup> | 0<sup>a</sup> | 0<sup>a</sup> | 40-60 | 2.3775<sup>b</sup> | 5.713<sup>a</sup> | 0.11375<sup>c</sup> | 0<sup>a</sup> |
| 60-80 | 0.18875<sup>a</sup> | 0.00375<sup>ab</sup> | 0<sup>a</sup> | 0<sup>a</sup> | 60-80 | 2.4788<sup>ab</sup> | 5.674<sup>a</sup> | 0.0925<sup>cd</sup> | 0<sup>a</sup> |
| 80-100 | 0.18<sup>a</sup> | 0.0025<sup>ab</sup> | 0<sup>a</sup> | 0<sup>a</sup> | 80-100 | 2.7088<sup>ab</sup> | 7.119<sup>a</sup> | 0.07<sup>d</sup> | 0<sup>a</sup> |
Effect of cement particulate on the nutrients status of the elephant grass (*Pennisetum purpureum*) at the vicinity of Ewekoro cement factory

Tables 3-6 showed the nutrients uptake of elephant grass (*Pennisetum purpureum*) in the vicinity of Ewekoro factory in the wet and dry seasons. The N, P, Ca, Mg, Na, Cu and Zn concentration in *Pennisetum purpureum* harvested at the south west direction of Ewekoro cement factory during the wet season is shown in Table 3. Generally, it was observed that all the nutrients were reduced in concentration as the distance from the factory increased. Phosphorus (P), K, Ca, Mg and Na (except 2000 m away) significantly increased as the distance from the factory reduced when compared with 2000 m away from the factory while there were no significant differences among N, Cu and Zn when the distances were compared. The nutrients were adequate for optimum growth of *Pennisetum purpureum*. The nutrients composition of *Pennisetum purpureum* in the dry season followed the same trend as that of the wet season except that the concentrations were much lower in the dry season than the wet season (Table 4).

### Table 3: Nutrients assessment of *Pennisetum purpureum* at the South-West direction of Ewekoro in the wet season

| Distance (Km) | N         | P         | K         | Ca          | Mg         | Na         | Cu         | Zn         |
|---------------|-----------|-----------|-----------|-------------|------------|------------|------------|------------|
| 500           | 2.47\(^a\) | 919.14\(^a\) | 16310.26\(^a\) | 45976.50\(^b\) | 6321.38\(^a\) | 1915.73\(^a\) | 24.50\(^a\) | 107.94\(^a\) |
| 1000          | 2.14\(^a\) | 781.85\(^b\) | 15391.23\(^a\) | 46265.70\(^a\) | 5880.14\(^b\) | 1816.27\(^b\) | 20.80\(^b\) | 105.04\(^a\) |
| 1500          | 1.92\(^a\) | 707.00\(^c\) | 14983.07\(^b\) | 42960.20\(^c\) | 5669.50\(^c\) | 1793.22\(^c\) | 20.15\(^a\) | 100.60\(^c\) |
| 2000          | 1.52\(^a\) | 673.79\(^d\) | 14085.72\(^c\) | 40526.70\(^d\) | 4524.00\(^c\) | 1757.62\(^c\) | 18.91\(^a\) | 94.28\(^a\) |

Means with the same letter in the same column are not significantly different at 5% level using Duncan multiple range test.

### Table 4: Nutrients assessment of *Pennisetum purpureum* at the South-West direction of Ewekoro in the dry season

| Distance | N         | P         | K         | Ca          | Mg         | Na         | Cu         | Zn         |
|----------|-----------|-----------|-----------|-------------|------------|------------|------------|------------|
| 500      | 2.6038\(^b\) | 5.529\(^a\) | 0.07625\(^d\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) |
| 1000     | 1.4\(^a\) | 4.0125\(^b\) | 0.20417\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) |
| 1500     | 5.13\(^a\) | 8.6892\(^a\) | 0.05417\(^c\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) |
| 2000     | 3.0058\(^b\) | 8.7042\(^a\) | 0.0575\(^c\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) | 0\(^a\) |

Means with the same letter in the same column are not significantly different at 5% level using Duncan multiple range test.

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Compared with 2000m away from the factory, the N, P, K, Ca and Mg contents of the leaves of Purpureum were significantly increased at 1500, 1000 and 500m distance away from the factory from the North east direction (Table 5). The N, P, K, Ca, Mg Na, Cu and Zn were reduced as the distance from the factory increased. The total N, K, Ca and Mg were adequate for proper growth of elephant grass up to 2000m away from the factory (Tables 5 and 6). The available P was very low at any distance from the factory. All the nutrients contents in the plants sampled during the dry season were generally higher than the plants analyzed during the wet season (Table 6). There were no significant differences in N content of the sampled elephant grass at any distance from the factory.

Table 5: Nutrients assessment of Pennisetum purpureum at the North-East of Ewekoro in the wet season

| Distance (m) | N% | P  | K  | Ca | Mg  | Na  | Cu  | Zn |
|-------------|----|----|----|----|-----|-----|-----|----|
| 500         | 1.91a | 561.48a | 14353.5a | 39947.6a | 4557.85a | 1677.9a | 17.63a | 85.08a |
| 1000        | 1.71a | 566.07a | 14180.4a | 38201.5b | 4093.5c | 1665.2a | 17.31a | 79.76a |
| 1500        | 1.40b | 519.39b | 13209.9b | 35537.6c | 3596.7b | 1517.7b | 12.77a | 70.45a |
| 2000        | 1.44c | 509.63c | 10128.0c | 29935.2d | 3898.97c | 1412.8c | 13.12a | 62.00a |

Means with the same letter in the same column are not significantly different at 5% level using Duncan multiple range test

Compared the nutrient contents of the sampled in the west direction to the east direction, the N, K, Ca and Mg contents of the plants in west direction was higher than the north east direction. The P, Na, Cu and Zn contents in the north east direction was higher than the west direction.
IV. DISCUSSION

The heavy metal Nickel (Ni) in the sampled soils was low, going by MAFF (1992) recommendation of 50 mg/kg for Ni as its critical level while Lead (Pb) concentration in the soil was above 0.01mg/L recommended by WHO (1984). At present, Ni might not pose negative effect on crops grown in the area while the concentration of Pb needs to be put in check. Alloway (1995) observed that the crop grown in polluted area can absorb heavy metals in excess that are likely to pose risk to human health. This work is in line with Adejumo et al., (1994); Schuhmacher et al., (2004); Al-Khashman and Shawabkeh, (2006); Isikli et al., (2006) who stated that cement production emits heavy metals such as Cd, Cr, Cu, Pb and Zn. Lepedus et al., (2003) emphasized that cement dust during cement processing can reduce chlorophyll and carotenoid content. Studies on the effect of cement dust on biosynthetic processes in the plant by Oyedele et al. (1995) also revealed a reduction in chlorophyll and carotenoid content, impair Carbon IV Oxide exchange and reduction in plant photosynthesis rate. Also, Oyedele et al., 1995; Schuhmacher et al., 2004; Al-Khashman and Shawabkeh, 2006; Isikli et al., 2006 buttressed that Cement production emits heavy metals such as Cd, Cr, Cu, Pb and Zn which are deposited into the soil and thereafter absorbed by plants. Achternbosch et al., (2003) reported that conventional cement raw materials contain 25 mg/kg of Cr, 21 mg/kg of Cu, 20 mg/kg of Pb and 53 mg/kg of Zn and about 50% of the total, Cd, Cu and Zn load in cement ranked highest. This might be the reason why the soils around the cement factory in Ewekoro are high in Fe, Zn, Pb and Cr. Josephine et al., (2017) were of the opinion that majority of the emitted heavy metals are known to be toxic to humans and plants, even at low concentrations. Murugesan et al., 2004 observed that cement kiln exhaust of the cement factory deposits on vegetables could be absorbed by plants and have adverse effect on human health when the plants are consumed. The Ca and Mg contents in the elephant grass were found to be high. This is in agreement with the assertion of Farmer (1993), that, the alkaline cement dust and their ash in the pollution complex lead to increase in soil alkalinity.

The high N content obtained in the elephant grass in this work in the dry season was higher than that reported for N in the dry season. This might be as a result of moisture that enhanced N nitrification. High rates of Ca is known to be inversely related to the phosphorus content in soil and it is even known to inhibit the absorption and utilization of P and other nutrient elements in the soil.

Also Cu and Zn in both locations and both seasons exceeded the World Health Organization (WHO) recommended value limit of 10 and 50 mgkg⁻¹ in plants. This is likely to have negative impact on animals that feed on them. There was no particular trend observed in the nutrient content of elephant grass with regard to the distance to the cement manufacturing factory for N, P, K, Ca, Mg, Na, Cu and Zn contents. Accumulation of heavy metals by plants’ roots, stems and leaves grown in polluted soils have been reported severally. Okoronkwo et al. (2005) said that it had been the interest of the public to know whether vegetables, fruits and other food crops cultivated in polluted soils are safe for human consumption especially now that the environmental quality of food production is of significant concern (Chiroma et al., 2003). The understanding of the behaviour of contaminants especially heavy metal in the soil-plant system seems to be particularly significant. For instance, consumption of Pb is believed to cause mental retardation in many children, while mild consumption causes anaemia (Bladwin and Marshall (1999)). Toxic elements are taken in through air, food and water. Out of these three, the air intake is the most readily assimilated into the body (Rai et al., 2010).

V. CONCLUSION

The study investigated the impact of cement production on physicochemical properties of soils and Elephant grass grown around Ewekoro cement factory, in Ogun state, SW Nigeria within two-kilometer radius to the factories between 2015 and 2016.

The research presented in this work revealed that the cement industry is one of the polluting industries. Controlling the spread of dust and other emissions should be given top priority to maintain the ecosystem around the vicinity of the factory.

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