



Research Article

Assessing the environmental risk of heavy metals in surrounding areas of Lafarge Cement Industry in Shagamu, Ogun State, Nigeria

Oketayo O. Oyedele¹✉, Dolapo S. Olaniyan¹, Justina A. Gabriel¹, Funmilayo H. Abejide², and Kolawole E. Adesina³

¹Department of Physics, Federal University of Oye-Ekiti, Oye-Ekiti, Ekiti State, Nigeria

²Department of Physics, Joseph Ayo Babalola University, Ikeji-Arakeji, Osun State, Nigeria

³Department of Medical Physics, Purdue University, West-Lafayette, Indiana, U.S.A

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✉ Corresponding Author: Oyebamiji.oketayo@fuoye.edu.ng.

Abstract

In this study, the levels of five heavy metals were determined in soil and vegetable samples (bitter leaf, African spinach, and Indian-Malabar spinach) samples around the Lafarge cement factory in Ogun State, Nigeria using Flame Atomic Absorption Spectrometer (FAAS). Identical samples were also collected at a place where no anthropogenic activity took place. Transfer factor (TF) and risk analysis of three heavy metals: manganese (Mn), zinc (Zn), and iron (Fe) were obtained. Cd and Pb were below the detection limits. The levels of Fe, Mn, and Zn in the vegetables were above the WHO limits. Zinc had the highest accumulation with the transfer factor (TF) of 0.01 – 0.32 while Manganese had the lowest accumulation with TF of 0.0055 to 0.06. African Spinach had the highest TF (0.32 for Zn). This shows a higher level of metals in the soil. Target Hazard Quotient (THQ) was used to determine the potential risk of human exposure as the THQ values in the two species ranged between 0.97 and 283.20 for adults, 3.39 and 991.21 for children respectively. Significant differences exist ($p < 0.05$) between the levels of Mn, Zn, and Fe in the site-specific vegetable samples and the control. The vegetable samples from the site were not all that enriched in Mn and Zn (E.F = 0.032 - 0.93) despite their elevated levels in soil samples. The results of this research showed that the vegetables from this location were to some degree contaminated and might not be suitable for consumption.

Keywords: Risk Assessment, Soil and Vegetable Samples, FAAS, Transfer, and Metals.

Introduction

Numerous industrial operations such as manufacturing, dredging, excavating, and mining, contribute to the deterioration of environmental ecosystems encompassing water, air, soil fauna, and flora. Scientific researchers, industrialists, environmentalists, and business policy makers are consistently confronted with the significant problem of environmental degradation daily (Murugesan et al., 2004).

It is unavoidable to encounter environmental pollution associated with urbanization and industrialization unless appropriate actions are implemented. The significant rise in the number of vehicles, cement, factories, steel and coal industries, and petrochemical industries, along with deforestation, has led to air pollution becoming a major issue in recent times. While gaseous pollutants' impact on air

quality receives considerable attention, there is relatively little focus on the influence of particulate pollutants on soil and vegetation characteristics (Iqbal & Shafiq, 2001; Princewill & Adanma, 2011).

According to the central pollution control board, cement industry is included among the seventeen industries recognized as major sources of pollution (Gbadebo & Bankole, 2006; Medina et al., 2009; Rahmani et al., 2018). The cement industry serves as a primary contributor to the emission of particulate matter, SO_x (Sulphur oxides), NO_x (nitrogen oxides), and CO₂. Cement dust itself contains detrimental heavy metals such as chromium, nickel, cobalt, lead, and mercury. These heavy metals pose a significant threat to the biotic environment, impacting vegetation, human health, animal health, and overall ecosystem wellbeing (Chidambaram et al., 2009).

Cement is a fine powder grey or white color, primarily consisting of Cement Kiln Dust (CKD), a by-product of the cement production process. Apart from gaseous and particulate pollutants, cement manufacturing also leads to elevated levels of toxic heavy metals such as cobalt, lead, chromium, nickel, and mercury in the surrounding environment, particularly in the vicinity of cement factories (Tripathi & Girjesh, 2010). These include 25 mg/kg of Cr, 21 mg/kg of Cu, 20 mg/kg of Pb, and 53 mg/kg of Zn. In addition to this elemental composition, it has been reported that around 0.07 kg of dust is released into the atmosphere during the manufacturing of 1 kg of cement (Chaurasia et al., 2014).

It has been reported that the soil tends to accumulate significant concentrations of hazardous metals because of human activities. Heavy metal contamination of soil can pose severe multiple challenges as these metals do not readily dissolve biologically, leading to various soil dysfunctions that increases environmental problems (Chen et al., 2015; Olawusi-Peters et al., 2017). Industries, including the Cement industry, release substantial quantity of heavy metals and other chemicals into the environment, therefore posing significant impact on environmental pollution levels (Yaşar et al., 2010).

The emission of cement dust into the environment in Nigeria is progressively increasing due to the growing number of cement plants established across the country to merge the domestic demand and reduce reliance on imports (Anudu & Faminu, n.d.). Cement factories are responsible for releasing highly dangerous heavy metals such as mercury (Hg), lead (Pb), nickel (Ni), and chromium (Cr) (Zou et al., 2006). These heavy metals can cause a range of detrimental biochemical changes. As a result, cement production facilities have the potential to contaminate the air, soil, water, and plants (Majolagbe et al., 2018).

The study of trace metals has been a subject of ongoing research and investigation in recent years (Aderonke et al., 2011; Awofolu et al., 2005). They play an important role in various domains of human activities, including Human and Animal Nutrition, Human Health and Disease (Davies, 1992), Geochemistry, and Environmental Pollution (Nriagu, 1986).

Cement dust has been associated with various health effects in humans and animals, including carcinogenesis, eye problems, cancer, genetic mutation, decreased antioxidant capacity, acute respiratory symptoms, and ventilatory effects (Ogunbileje & akinosun, 2011; Kumar et al., 2008). Moreover, heavy metals poisoning resulting from cement dust exposure can lead to plant withering, scorching of leaf edges, and reduced leaf growth (Gupta & Sharma, 2013).

Trace metals are present in various environmental components such as soil, water, biota, and sediment. However, their entry into the food chain poses potential risks to human health, leading to hazardous environmental effects (Ayodele & Oluyomi, 2001). While excessive concentrations of all trace elements are can be toxic to living organisms, some are essential for healthy growth and reproduction of both plants

and animals when presents within allowable concentrations (Anyakora et al., 2011).

To monitor the environmental impact of cement production at Lafarge cement factory in Ogun State, Nigeria, it is crucial to assess the heavy metal content of the surrounding soils. Since heavy metals are known for their persistent nature and toxic effects on living organisms. Therefore, this study aimed to investigate the potential sources and status of heavy metals in soil and vegetable samples (Bitter leaf, African Spinach, and Indian-Malabar Spinach) samples around the Lafarge cement factory in Ogun State, Nigeria.

Materials and methods

Study Area

The study was carried out in Lafarge cement factory situated in Sagamu, a cluster of thirteen towns located in Ogun state along the Ibu river and Eruwuru stream between Lagos and Ibadan. It was founded in the mid19th century by members of the Remo branch of the Yoruba people in South-Western Nigeria (6°50'7"00"N, 3°45'4"00"E) as shown in Fig. 1. The factory is located 67km northwest of Lagos, 63km Southeast of Abeokuta, 32km west of Ijebu-ode and 72 km Southeast of Ibadan. The Sagamu region is also a major producer of agricultural products, such as cocoa and kola nuts, and it is a national collection center for those nuts. Major deposits of limestone, which are used in the city's primary industry, the production of cement, are found beneath the Sagamu area. The production of baskets and rope, which are used to store kolanuts, is supported by the kola-nut industry along with other secondary businesses. The factory was founded, commissioned, and went into full operation in 1978, with a current production capacity of 900 000 tons annually (Lafarge et al., 2011). The area is characterized by high annual temperature, high rainfall, high transpiration, and relative humidity which classify it as humid tropical region (Fatoba et al., 2012).

Sample Collection

Twelve soil samples were collected using a hand soil auger from farms around WAPCO Lafarge Plc (Sagamu Plant) at the exact points where vegetables were uprooted. The soil was dug at a depth of 0.15 cm (top surface) and 15-30 cm (sub-surface depth). The samples were well-labeled in a different polythene bag and taken to the laboratory where they are analyzed. Three identical soil samples from an unpopulated non-industrial area in Shagamu, Ogun State were also collected into a different polythene bag as control. Twelve vegetable samples were collected in all three samples of each vegetable (i.e., of the different species; *Basella Alba*, *Amaranthus Hybridus*, *Veroniaamygdalina*.) around Lafarge Cement Industry, Sagamu, Ogun State with hand gloves worn to prevent contamination. Four identical samples of each of the vegetables were collected outside the vicinity as control.

Statistical Analysis

The results obtained gave the baseline level of those metals in the vegetables and soil samples from the cement factory. Using the T-test, the results showed that there is a significant difference between the levels of these heavy metals in the site and control ($p < 0.05$) in all of the vegetable samples. The analysis was carried out using Excel version 12 (2007) for windows.

Samples Pre-Treatment

The debris content of the soil was firstly removed followed by air drying it in a clean, well-ventilated laboratory under ambient temperature. The dried samples were homogenized by grinding and filtered by passing through a 2mm mesh size sieve to remove gravels larger than 2mm in diameter. The samples were then put in polythene bags and well labeled for Analysis. The vegetables were washed and rinsed with distilled water and stalks of each vegetable were removed with

gloves worn and cleaned properly. The vegetable was later weighed with XY200°C model electronic balance well labeled accordingly. Each of the samples was distributed into the freeze-drying machine, of which they were firstly freeze to 15°C and later dried to 25°C.

Freeze drying (lyophilizing)

According to (Ratti et al., 2001), it is a low temperature dehydration procedure that entails chilling the product, reducing pressure, and sublimating the ice. Because of the low processing temperature, the rehydrated product has outstanding quality and retains its original shape. The samples were freeze dried in the laboratory at the Department of Chemistry, Federal University Oye-Ekiti to avoid loss of volatile elements at 55°C to 0°C for 6 hours with a regular power supply and finally kept in different polyethylene bags to avoid contamination.



Fig. 1 Location map of the study area

Risk Assessment and Transfer Factor

Soil to plant transfer factor was calculated = Concentration in Soil/Concentration in plant Concentration of heavy metal in soil divided by Concentration of the same heavy metal in plant. This method was used to obtain transfer of trace elements (Ali et al., 2015).

Health Risk Assessment

To assess the potential health risk associated with prolonged consumption of vegetables intake with HM, Health risk in respect to non-carcinogen and carcinogenic effects was calculated based on the relationships shown in Table 1 below (Adeoye et al., 2019; WHO 1989).

For Vegetables:

$$EDIM = \frac{C_{metal} \times C_{factor} \times C_{foodintake} (DIM)}{Averagebodyweight}$$

C metal = Heavy metal concentration in vegetables (mg/kg); C factor= conversion factor (from fresh to dry weight 0.085); DIM = Daily vegetable intake, 65 g/day; WAB= average body weight, 70 kg and 20 kg for adult and children, respectively.

$$THQ = \frac{EF \times ED \times FIR \times C \times 10^{-3}}{RfD \times T \times WAB}$$

EF = 350 days/year; ED = 54 years; FIR = 65 g/person/day; C = metal concentration (m/kg); RfD = oral reference dose (Cd,

Cr, Pb, Mn, Fe and Zn were 0.001, 1.5, 0.0035, 0.4, 0.007 and 0.300 mg/kg/day, respectively) (Ashraf et al., 2015), WAB is the average WAB is the average body weight (70 kg and 20 kg for adults and children, respectively) and TA is the average exposure time for non-carcinogens (ED x 365days/year). If the THQ value is greater than 1, the exposure is likely to cause obvious adverse effects (Chauhan et al., 2014).

The Enrichment Factors of these elements (with Fe as a reference) were calculated using:

$$E.F = \frac{\frac{[X]}{CONCOFFE (Sample)}}{\frac{[Y]}{CONCOFFE (Reference)}}$$

Where, X is the concentration of the element in the sample, Y is the concentration of the element in the reference, and the reference used in this research is a non-contaminating site (i.e. control).

Table 1. Shows the calculated health risk parameters (Adeoye et al. 2019).

Risk exposure Factors	Symbols	Values	Units
Exposure frequency	EF	365	Days/year
Exposure duration	ED	30	Years
Fish ingestion rate	FIR	54.8	g/person/day
Average body weight adult	WABa	70	Kg
Average body weight child	WABc	20	Kg
Average time, carcinogens	ATc	25, 550days	Years
Carcinogenic potency slope	CPSo	µg ⁻¹ day ⁻¹	Mg/kg b w-day
HM concentration	CM	mg/kg	Days/year

Means, minimum, and maximum concentration of Heavy

Metal (HM) for the various metals were analyzed as indicated in Table 2 below.

Table 2. Heavy metal content (mg/kg) of the soil

Heavy metals	Soil 1		Soil 2		Soil 3	
	Site (mg/kg) Mean±S.D	Control (mg/kg) Mean ± S.D	Site (mg/kg) Mean ± S.D	Control (mg/kg) Mean ± S.D	Site (mg/kg) Mean ± S.D	Site (mg/kg) Mean ± S.D
Mn	19955±7.07	5690±14.14	29685±1.21	3555±14.14	50870±14.14	8510±14.14
Zn	20565±21.21	10475±7.070	19355±7.071	895±7.071	35885±21.21	9140±14.14
Cd	ND	ND	ND	ND	ND	ND
Fe	44765±7.071	17765±7.071	12665±21.21	3495±7.071	11838±42.43	7835±21.21
Pb	ND	ND	ND	ND	ND	ND

Table 3. Comparison of the concentration of heavy metals in vegetables samples with WHO/FEPA Limits ND = Below detection limit

Heavy metals	Bitter leaf (<i>veroniaamygdalina</i>) site (mg/kg)	Bitter leaf (<i>veroniaamygdalina</i>) control (mg/kg)	African Spinach (<i>Amaranthus Hybridus</i>) Site (mg/kg)	African Spinach (<i>Amaranthus Hybridus</i>) Control (mg/kg)	Indian-Malabar spinach (<i>BasellaAlber</i>) Site (mg/kg)	Indian-Malabar spinach (<i>BasellaAlber</i>) Control (mg/kg)	WHO/F EPA Limits (mg/kg) (2011, 2013)
Mn	152.35	91.36	292.33	221.91	258.24	224.46	6.640
Zn	624.06	242.88	480.42	286.44	362.64	216.12	60.00
Cd	ND	ND	ND	ND	ND	ND	-
Fe	1577.64	573.06	1824.66	459.66	2226.36	235.5	420.000
Pb	ND	ND	ND	ND	ND	ND	ND

Table 4. Transfer factors of vegetables samples relative to their soil source in Lafarge cement company Ogun State, Nigeria

Heavy metals	Bitter leaf (mg/kg) site	Bitter leaf (mg/kg) control	African Spinach (mg/kg) Site	African Spinach (mg/kg) control	Indian-Malabar spinach (mg/kg) Site	Indian-Malabar spinach (mg/kg) control
Mn	7.64×10^{-3}	0.02	9.85×10^{-3}	0.06	5.08×10^{-3}	0.03
Zn	0.03	0.02	0.03	0.32	0.01	0.02
Cd	ND	ND	ND	ND	ND	ND
Fe	0.04	0.03	0.14	0.04	0.19	0.03
Pb	ND	ND	ND	ND	ND	ND

Transfer Factor values > 1 (*) define the pollution range, while transfer factor values < 1 define the contamination range (is given as < 0.1: very slight contamination; 0.10–0.25: slight contamination; 0.26–0.5: moderate contamination; 0.51–0.75: severe contamination; 0.76–1.00: very severe contamination; 1.1–2.0: slight pollution; 2.1–4.0: moderate pollution; 4.1–8.0: severe pollution; 8.1– 16.0: very severe pollution; and > 16.0: excessive pollution (Ayanwu et al., 2018).

Results and discussion

The mean concentration (mg/kg) of HMs (Cd, Mn, Pb, Fe and Zn) in soil and vegetables collected from the Lafarge industrial area in Ogun state, Nigeria is shown in Tables 2 and 3 respectively.

The calculated bio-concentration factor (BCF) in soil (site) is presented with values ranging between 7.64×10^{-3} and 0.04, 9.85×10^{-3} and 0.14, 5.08×10^{-3} and 0.19 that Mn, Zn, Cd, Fe, and Pb respectively (Table 4). The total estimated intake rate for vegetables calculated for both Adults and children are shown in Table 4 and the accumulation factor for these metals are seen in Table 5.

The Daily dietary intake Mn, Zn and Fe through consumption of vegetables ranged from 12.03 to 67.09 mg/kg/day, 28.59 to 50.68 mg/kg/day, 36.28 to 144.02 mg/kg/day respectively, for adults, while that for children ranged from 42.09 to 80.76 mg/kg/day, 100.07 to 177.38 mg/kg/day and 126.98 to 504.07 mg/kg/day respectively.

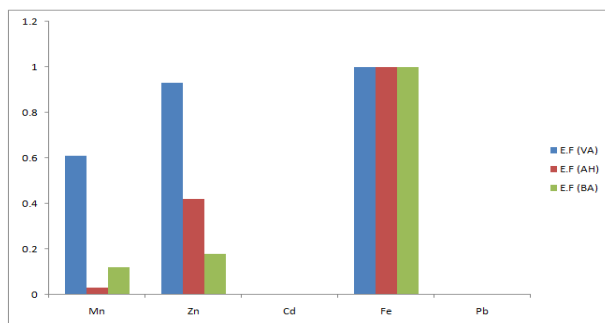


Fig. 2 The enrichment factors (E.F) of heavy metals in the vegetable samples

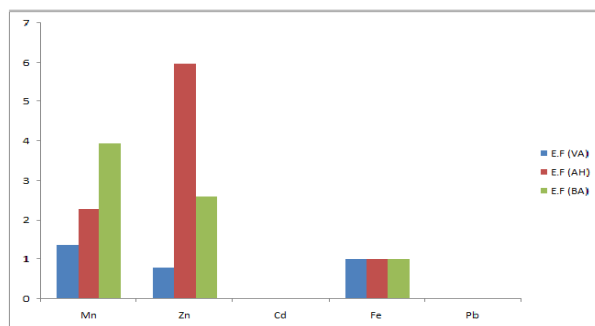


Fig. 3 The enrichment factors (E.F) of heavy metals in the soil samples

Fig. 2 & 3 shows the enriched factors (E.F) of heavy metals present in the vegetable and soil samples respectively.

Indicators: E.F < 1 is not enriched; E.F= 1-10 is slightly enriched; and E.F = 10 (Enriched).

Table 5. Accumulation factors of the heavy metals in each of the samples and their corresponding soil

Element	Accumulation Factor (VA)		Accumulation Factor (AH)		Accumulation Factor (BA)	
	Site	Control	Site	Control	Site	Control
Mn	0.00763	0.0161	0.00985	0.0624	0.0051	0.026
Zn	0.303	0.023	0.025	0.320	0.01	0.024
Cd	ND	ND	ND	ND	ND	ND
Fe	0.035	0.032	0.144	0.132	0.188	0.030
Pb	ND	ND	ND	ND	ND	ND

Table 6. Estimated Daily Intake (mg/kg day –1 Bw-1) and Target Hazard Quotient (THQ) of heavy metals from Consumption of Vegetables from industrial area (Sagamu) in Ogun State by Adult EDIM (70mg/kg/day)

Vegetables	Element	C(mg/kg/day)		Rfo	Adult EDIM (70)		THQ	
		Site	Control		Site	Control	Site	Control
Bitter leaf	Mn	152.35	91.36	0.14	12.03	7.21	0.97	0.58
	Zn	642.08	242.88	0.30	124.52	19.17	1.91	0.72
	Fe	1577.64	573.08	0.007	50.68	19.17	200.67	72.89
African Spanish	Mn	292.33	221.91	0.14	67.09	17.5	1.87	1.41
	Zn	480.42	286.44	0.30	37.92	22.61	1.43	0.85
	Fe	1824.66	459.66	0.007	144.02	36.28	232.11	58.47
Indian Malabar-Spinach	Mn	258.24	224.46	0.14	20.38	17.72	1.64	1.43
	Zn	362.24	216.12	0.30	28.59	17.06	1.08	0.64
	Fe	2226.36	235.5	0.007	36.28	18.59	283.20	29.96

Table 7. Estimated Daily Intake (mg/kg day –1 Bw-1) and Target Hazard Quotient (THQ) of heavy metals from Consumption of Vegetables from industrial area (Sagamu) in Ogun State by Children EDIM (20mg/kg/day)

Vegetables	Element	C(mg/kg/day)		Rfo	Children EDIM (20)		THQ	
		Site	Control		Site	Control	Site	Control
Bitter leaf	Mn	152.35	91.36	0.14	42.09	25.24	3.39	2.03
	Zn	642.08	242.88	0.30	177.38	67.09	6.67	2.52
	Fe	1577.64	573.08	0.007	435.82	67.09	702.36	255.13
African Spanish	Mn	292.33	221.91	0.14	80.76	61.30	6.51	4.94
	Zn	480.42	286.44	0.30	132.72	76.13	4.99	2.98
	Fe	1824.66	459.66	0.007	504.07	126.98	812.37	204.64
Indian Malabar-Spinach	Mn	258.24	224.46	0.14	71.34	62.00	5.75	4.99
	Zn	362.24	216.12	0.30	100.07	59.70	3.77	2.25
	Fe	2226.36	235.5	0.007	126.98	65.06	991.21	104.85

Adult and Children Similarly, THQ values of Mn, Zn and Fe were > 1 in *veroniaamygdalina*, *Basella Alber*, *Amaranthus Hybridus* except for Mn (*site*) (Table 6), while THQ values of Mn, Zn and Fe (Table 7) were >1.

This study assessed the levels of five heavy metals (Mn, Zn, Cd, Pb and Fe) in soil and three different kinds of edible vegetables from wastewater irrigated farms of Lafarge

Company area in Ogun State, Nigeria and also calculated risk assessment of the metals. The levels of Zn and Fe from Sagamu area in Kano State, Nigeria were above the permissible limits of 300 mg/kg, 200 mg/kg (for Zn in soil and plant, respectively); 5000 mg/kg, 425 mg/kg (for Fe in soil and plant, respectively) as set by FAO (Bjerregaard et al., 2000); EU (European, 2002; WHO/FAO 1993). The high levels of Zn and Fe may be due to industries close to the area,

which discharge their effluents into surrounding without proper treatment. Given the ongoing discharge, it is crucial to determine the levels in these media so that appropriate action can be taken regarding the consumption of local produce. This is because the vegetables are consumed continuously and accumulate over time. The long-term exposure to these vegetables may endanger both infants and adults. The recurrent use of untreated or inadequately treated wastewater from industrial establishments as well as the application of chemical fertilizers and pesticides could also be the primary source of the heavy metals in agricultural soils where farmers cultivate these vegetables (Asaduzzaman et al., 2013; Bhuiyan et al., 2011). Principally, the food chain (soil-plant-human) pathway is recognized as one of the major pathways for human exposure to HMs (McBride et al., 2009). Between plant species and among samples (soil and vegetables), accumulation factors varied considerably. These variations may be linked to soil nutrient management and soil properties (McBride et al., 2009). It was observed that the concentration of HMs decreased in vegetables with increasing concentration of metals in the soil as reported by (Chen et al., 2016). Nonetheless, agricultural activities (use of pesticides and fertilizers) have been identified as contributors to increasing toxic metal contamination in soil (Okieimen et al., 2011). Results from present and previous studies demonstrated that food grown on contaminated soils are more contaminated with HMs posing health concern (Fang et al., 2016; Okieimen et al., 2011; Bjerregaard et al. 2000) reported established provisional tolerable weekly intake set by FAO/WHO (FAO/WHO 1993) of 25µg lead/kg body weight for humans to obtain 1500µg lead/week for a 60 kg person.

Conclusion

The levels of five heavy metals (Mn, Zn, Cd, Fe, and Pb) in six vegetable samples and six soil samples from the site and control have been determined using a flame atomic absorption spectrometer (FAAS). The results obtained gave the baseline level of those metals in the vegetables and soil samples from the cement factory. Using the T-test, the results showed that there is a significant difference between the levels of these heavy metals in the site and control ($p < 0.05$) in all of the vegetable samples. While not all of the vegetable samples were enriched in Mn and Zn, they were all marginally enriched in Fe. The sediment samples had minor Mn, Zn, and Fe enrichments as well. For both the soil and vegetable samples, Cd and Pb seem to be below the detection threshold. The relative higher levels of these metals in this research compared to the WHO/FEPA limits were a sign of contamination. The mean concentration (mg/kg) of Mn, Zn, and Fe in the vegetable samples was higher than that of the maximum permissible limits set by WHO/FEPA Table 3, which suggest high health risk from the consumption of vegetables intake by inhabitants of Shagamu. Transfer Factor (TF) value of vegetables for toxic elements in this study is quite high, ranging between 7.64×10^{-3} and 0.04 , 9.85×10^{-3} and 0.14 , 5.08×10^{-3} and 0.19 that Mn, Zn, Cd, Fe, and Pb respectively (Table 4) in the various vegetables (African Spinach and Indian-Malabar spinach). This showed high

concentration of HMs in the soils in which vegetables were grown. The THQs showed that only Mn was less than 1 in all the vegetables samples (Site), while THQ in Fe and Mn were also above 1 in the control (Table 6). In children, the THQ of Fe was a hundred-fold above 1 and this may be considered potential risks for residents. Wastewater irrigation of vegetables and food crops by farmers around the industrial area of Shagamu should be discouraged. Researchers should provide feedback based on their findings to residents of Shagamu to educate them on the need to reduce their consumption of vegetables from that area and report industries that pollute/discharge waste to their environment to the government. Food and health agencies in developing countries like Nigeria should be proactive in making permissible limits for contaminants in food available to the public. Toxic HM concentrations in plants and vegetables must be continuously monitored because they may possibly enter the food chain and reach highly toxic levels in humans or animals without harming plants or vegetables.

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Conflict of Interest

The authors hereby declare no conflict of interest.

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References

- Adeoye Abiodun Oluwatosin, Nasir Abdul-Salam (2019). Assessment of impact of Industrial Discharge on the Quality of Water around Lafarge Cement WAPCO, Ewekoro, Nigeria. *Jewel Journal of Scientific research (JJSR)* 4(1&2): 45-44. ISSN: 2384-6267.
- Aderonke A. Okoya, Olabode I. Asubiojo, & Adeagbo A. Amusan. (2011). Trace element concentrations of soils of Ife-Ijesa area Southwestern Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 3(7), 173-179.
- Ali, M. P., Mustafizur, A. M. R., Rafiqul, I., Rowshon, A., Tasrina, R. C. (2015). Heavy metals contamination in vegetables and its growing soil, J. Environ. Anal. Chem. 2 3142 doi: 10.41722380-2391.1000142 (Page 6 of 6).
- Anudu, O. & Faminu, G. (2020). How cement makers turned Nigeria's big challenge into opportunity. *Bus. Day. Available Online at* <https://Businessday.Ng/Real-Sector/Article/329478.Assessed27.06>.
- Anyanwu, B. O., Ezejiofor, A. N., Igweze, Z. N., Orisakwe, O. E. (2018). Heavy metal mixture exposure and effects in developing nations: an update, *Toxics* 6(4)65 PMID: 30400192, doi:10.3390/toxics6040065.
- Asaduzzaman, M., Naidu, R. and Rahman, M. M. (2013). Consumption of arsenic and other elements from vegetables and drinking water from an arsenic-contaminated area of Bangladesh, *J. Hazard Mater.* 262 1056-1063.
- Awofolu, O., Mbolekwa, Z., Mtshemla, V., & Fatoki, O. (2005). Levels of trace metals in water and sediment from Tyume River and its effects on an irrigated farmland. *Water SA*, 31(1). <https://doi.org/10.4314/wsa.v31i1.5124>
- Ayodele, J. T. & Oluyomi. C. D. (2001). Grass contamination by trace metals from road traffic. *Journal of Environmental Chemistry and Ecotoxicology*, 3(3), 60-67.

- Bhuiyan, M. A. H., Dampare, S. B. and Suruvi, N. I. (2011). Investigation of the possible sources of heavy metal contamination in lagoon and canal water in the tannery industrial area in Dhaka, Bangladesh, *Environ. Monit. Assess* 175, pp633–649.
- Bjerregaard, P., Johansen, P., Pars, T. (2000). Lead, cadmium, mercury, and selenium intake by Greenlanders from local marine food, *Sci. Total Environ.* 245, 187–194.23.
- Chauhan, G. and Chauhan, U. K. (2014). Human health risk assessment of heavy metals viadietary intake of vegetables grown in wastewater irrigated area of Rewa, India, *Int. J. Sci. Res. Publ.* 4(9), 2250-3153.
- Chaurasia, S., Ahmad, I., Gupta, A. D. & Kumar, S. (2014). Assessment of air pollution emission from Cement Industries in Nimbahera, Rajasthan, India. *International Journal of Current Microbiology and Applied Sciences*, 3, 133-139.
- Chen, Y. H., Lin, F. F., Luo, D. and Su, M. Y. G. (2006). Wang, Transfer characteristics of cadmium and lead from soil to the edible parts of six vegetable species in southeastern China, *Environ. Pollut.* 144 (1). 127–135.
- Chen, Z., Zhu, B.-K., Jia, W.-F., Liang, J.-H., & Sun, G.-X. (2015). Can electrokinetic removal of metals from contaminated paddy soils be powered by microbial fuel cells? *Environmental Technology & Innovation*, 3, 63–67. <https://doi.org/10.1016/j.eti.2015.02.003>.
- Chidambaram, A., Sundaramoorthy, P., Murugan, A., Sankar Ganesh, K. & Baskaran, L. (2009). Chromium Induced Cytotoxicity In Blackgram (Vigna Mungo L.). *Iran. J. Environ. Health. Sci. Eng*, 6(1), 17–22.
- Chimezie, A., Kenneth, N., Olufunsho, A., Chinwe, N., Mohsen, A. & Herbert, Coker. (2011). Concentrations of heavy metals in some pharmaceutical effluents in Lagos, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 3(2), 25–31.
- Davies, B. E. (1992). Trace metals in the environment: Retrospect and prospect. *Biogeochemistry of Trace Metals*.
- Edogbo, B., Okolocha, E. and Maikai, B. (2020). *Scientific African* 7 (2020) e00281 9
- European Union (EU) (2002). Heavy Metals in Wastes, European Commission on Environment (<http://ec.europa.eu/environment/waste/studies/pdf/heavymetals.report.pdf>).
- Food and Agriculture Organization/World Health Organization. (1993). Joint FAO/WHO Expert Committee on Food Additives. Evaluation of certain additives and contaminants, 1993 Forty-first report of the Joint FAO/WHO Expert Committee on Food Additives, WHO Technical Report Series No. 837.
- Gbadebo, A. M. & Bankole, O. D. (2006). Analysis of Potentially Toxic Metals in Airborne Cement Dust Around Sagamu, Southwestern Nigeria. *Journal of Applied Sciences*, 7(1), 35–40. <https://doi.org/10.3923/jas.2007.35.40>
- Gupta, S., & Sharma, S. (2013). Effect of Heavy Metal Present in Cement Dust on Soil and Plants of Nokha (Bikaner). *Current World Environment Journal*, 8(2), 299–303. <https://doi.org/10.12944/CWE.8.2.16>
- Iqbal, M. Z., & Shafiq, M. (2001). Periodical Effect of Cement Dust Pollution on the Growth of Some Plant Species. *Turkish Journal of Botany*, 25(3), 1.
- 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 *Environment Engineering and Management Journal*, 7(1), 31-35.
- Li, N., Lia, M. B., McBrideb, H. and Xiaa, P. Zhuanga, (2009). Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China, *Sci. Total Environ.* 407(5). 1551–1561.
- Majolagbe, A. O., Yusuf, K. A., Agunbiade, S. E., & Oguntan, V. T. (2018). Trace Metals Charaterisation of Environmental Media (Soils, Water and Tree Barks) Around Cement Manufacturing Area, Nigeria. *Journal of Environmental Science and Pollution Research*, 4(2), 271–274. <https://doi.org/10.30799/jespr.123.18040203>
- Medina, S., Le Tertre, A., & Saklad, M. (2009). The Apheis project: Air Pollution and Health—A European Information System. *Air Quality, Atmosphere & Health*, 2(4), 185–198. <https://doi.org/10.1007/s11869-009-0050-2>.
- Murugesan, M., Sivakumar, A., Jayanthi, N. & Manonmani, K. (2004). Effect of cement dust pollution of physiological and biochemical activities of certain plants, *Pollut. Res. Pollution Research*, 23(2), 375-378.
- Nriagu, J. O. (1986). Chemistry of the river Niger, I: Major ions, II: Trace metals. *Sci. Tot. Environ.*, 58, 81–92.
- Ogunbileje, J. O., & akinosun, O. M. (2011). Biochemical and Haematological Profile in Nigerian Cement Factory Workers. *Research Journal of Environmental Toxicology*, 5(2), 133–140. <https://doi.org/10.3923/rjet.2011.133.140>.
- Okieimen, F. E. & Wuana, R. A. (2011). Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks Best Available Strategies for Remediation. Volume 2, (pp 20). doi:10.5402/2011/402647.
- Olawusi-Peters, O., Akinola, J. O. & Jelili, A. O. (2017). Assessment of Heavy Metal Pollution in Water, Shrimps and Sediments of Some Selected Water Bodies in Ondo State. *Journal of Researches in Agricultural Sciences*, 5(2), 55–66.
- Princwill, C. O., & Adanma, N. N. (2011). Metal concentration in soil and plants in abandoned cement factory. Int Conference on Biotechnology and Environment Management. *IPCBE*, 18.
- Rahmani, A. H., Almatroudi, A., Babiker, A. Y., Khan, A. A., & Alsahly, M. A. (2018). Effect of Exposure to Cement Dust among the Workers: An Evaluation of Health Related Complications. *Open Access Macedonian Journal of Medical Sciences*, 6(6), 1159–1162. <https://doi.org/10.3889/oamjms.2018.233>.
- Ratti, C. (2001) Hot Air and Freeze-Drying of High-Value Foods: A Review. *Food Engineering*, 49, 311-319. [https://doi.org/10.1016/S0260-8774\(00\)00228-4](https://doi.org/10.1016/S0260-8774(00)00228-4).
- Tripathi, R., & Girjesh, K. (2010). Genetic loss through heavy metal induced chromosomal stickiness in Grass pea. *Caryologia*, 63(3), 223–228. <https://doi.org/10.1080/00087114.2010.10589731>.
- World Health Organization (WHO) (1989). Evaluation of Certain Food Additives and Contaminants. Thirty third Report of the joint FAO/WHO expert committee on food additives. WHO technical report series (Geneva), 776, 26–27.
- Yaşar, U., Ozyiğit II, & Serin M. (2010). Judas tree (*Cercis siliquastrum* L. subsp. *siliquastrum*) as a possible bio monitor for Cr, Fe and Ni in Istanbul (Turkey). *Rom Biotechnol Lett.*, 15(1), 4979–4989.
- Zou, J. H., Wang, M., Jiang, W. S. & Liu, D. H. (2006). Effects Of Hexavalent Chromium (Vi) On Root Growth And Cell Division In Root Tip Cells Of *Amaranthus Viridis* L. *Pak. J. Bot.*, 38(3), 673–681.

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