Journal of Agriculture and Crops
ISSN(e): 2412-6381, ISSN(p): 2413-886X
Vol. 9, Issue. 1, pp: 1-8, 2023
URL: https://arpgweb.com/journal/journal/14
DOI: https://doi.org/10.32861/jac.91.1.8

Academic Research Publishing Group

Original Research | Open Access

Heavy Metal Contamination Assessment of Agricultural Farm Land Around Dimension Stone Areas in South West and North Central, Nigeria

Jimoh B. O. (Corresponding Author)
Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria
Department of Mineral and Petroleum Resources Engineering Tech. Federal Polytechnic, Ado-Ekiti, Nigeria
Email: jimohbomre@gmail.com

Ogunmodede T. O.
Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria

Adewole E.
Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria

Onasanya A.
Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria.

Ojo A.
Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria

Boluwade E. A.
Department of Mineral and Petroleum Resources Engineering Tech. Federal Polytechnic, Ado-Ekiti, Nigeria

Article History
Received: 21 June, 2022
Revised: 19 August, 2022
Accepted: 3 October, 2022
Published: 15 October, 2022

Abstract

Heavy metals have been discovered to have a variety of negative effects on the food chain, the environment, and humans. Farmers in Nigeria cultivate the land for the production of indigenous food crops for human use. Various farmlands are encircled by a plethora of three-dimensional stones. Supare Akoko in Ondo State and Lokoja in Kogi State were chosen as case studies to look into the possibility of soil pollution as a result of dimension stone mining. Metals; Mn, Fe, As, Cd, Cr, Cu, Pb, Ni, Co, and Zn were analyzed in the soil samples collected over three seasons using an Atomic Absorption Spectrophotometer (AAS). The results obtained were analyzed using analysis of variance (ANOVA). The examination revealed that the range of Mn and Fe readings were 0.94-3.86mg/kg and 631.54-898.06mg/kg, respectively, and were below the allowed limits. As was having values ranging from 0.01-0.08 mg/kg. Cd had a value of 0.01-0.09mg/kg, whereas Cr was below the limit, however acceptable limits vary by nation. Cu, Pb, and Ni concentrations were 1.21-9.15 mg/kg, 0.18-0.74 mg/kg, and 0.28-1.31 mg/kg, respectively, all below the indicated limit. Season one (S1) and season two (S2) samples had Co levels above the limit for Lokoja. Heavy metal concentrations appeared to rise as the year progresses, implying pollution impacts, a drop in agricultural yields. To avoid environmental issues, continuous monitoring and assessment of the Environmental Impact Assessment (EIA) should be implemented.

Keywords: Contamination; Dimension stone; Effluents; Environmental problems; Heavy metals; EIA.

How to Cite: Jimoh B. O., Ogunmodede T. O., Adewole E., Onasanya A., Ojo A., Boluwade E. A., 2022. "Heavy Metal Contamination Assessment of Agricultural Farm Land Around Dimension Stone Areas in South West and North Central, Nigeria." *Journal of Agriculture and Crops*, vol. 9, pp. 1-8.

1. Introduction

Until recently, the dimension stone business was not recognized as a player in the extractive industry by the mainstream mining industry [1]. Dimension stone is a broad phrase that encompasses a wide range of natural stones used for structural, monumental, and aesthetic purposes in the construction industry [2]. According to Ashmole and Motloung [1], dimension stone has a distinguishing feature. Unlike other mineral commodities, which are valued primarily based on their physical properties, dimension stone has a distinguishing feature. Physical properties are the minimum requirement for determining whether a rock is suitable for use as dimension stone. Floors and paving, external and interior wall cladding, steps, memorial arts, structural works, and unique works, according to him, are all applications for dimension stone. However, the production of dimension stone, from excavation/extraction (quarry) to processing, releases effluents that have the potential to damage soil structure and nature, lowering yield. Any running water or rain could wash the effluents away from the soil surface. It could even trickle down through the soil to the subsoil, causing soil damage. Heavy metals could be present in the effluent constituents, which could be harmful to plants if ingested/absorbed, and have a knock-on effect on animals. Water is used in the manufacture of blocks of stone from the mine face at the sites visited. Diamond wire or diamond cutting saw/blade were used to cut the stones, which were then cooled by flowing water. The resultant/effective grains are discharged to a specified pond. Many academics have worked on dimension stone exploitation in order to reveal its full potential in terms of earning cash for those who seek to enter the business, as well as the government [3-6]. The consequences of its exploitation in terms of degradation as a result of heavy metal generation have not been thoroughly investigated, particularly in the area under inquiry. Heavy metals and metalloids can accumulate in soil due to emissions from rapidly expanding industrial areas, mine tailings, high metal waste disposal, leaded gasoline and paints, fertilizer application, animal manures, sewage sludge, pesticides, waste water irrigation, coal combustion residues, petrochemical spillages, and atmospheric deposition [7]. Pb, Cr, As, Zn, Cd, Cu, Hg, and Ni are the most typically discovered heavy metals in contaminated sites, and they form an ill-defined group of inorganic chemical hazards [8].Unlike organic contaminants, which are usually oxidized to CO2 by microbial actions, most heavy metals do not undergo microbial or chemical degradation, and their available concentration persists long after their introduction. [9] found that heavy metals released to the environment by anthropogenic activities are usually accommodated by soil [10].

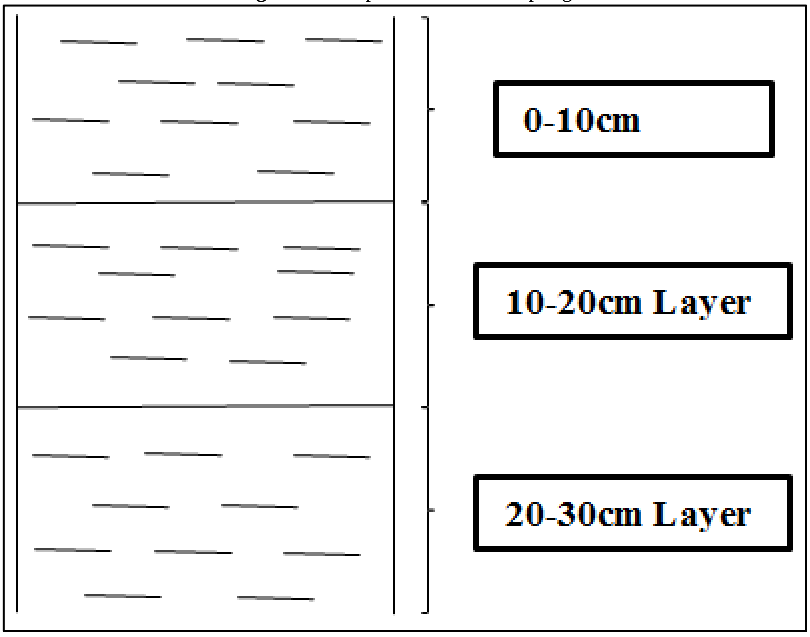
2. Materials and Methods

2.1. Collection and Preservation of Soil Samples

Bulk soil samples were collected from two regions in Nigeria. The locations were North Central in Lokoja, Kogi State and South West in Supare, Ondo state as shown in Fig 2, 3 and 4.

The samples were collected from two areas in Supare Akoko, Ondo State and Lokoja in Kogi State in three seasons (September, 2020; February, 2021 and June, 2021). The samples were collected at depth 0-30cm from three points within the areas at a distance of 0, 20m and 40m away from the original source. The control sample for this was taken at about 2000m along Emure-Supare road. Global positioning system (GPS) of each sample point was taken with phone (Galaxy 90A 5G model SM-A908B with installed GPS Camera of version 1.6). The soil samples were air-dried by spreading them in polythene sheets in alumina trays for 3-4 days at 25^0C and any debris like plants, stem, dead weed, leaves and stone were removed. Five grams of soil samples each was oven dried at 105^0C for 6 hours and crushed in a mortal into a fine powder, passed through a 2mm nylon sieve and kept in small-well-labeled polythene bags until they were digested as described by Ogunmodede, *et al.* [11].

Figure-1. Soil profile for soil sampling



2.2. Sample Preparation for Metal/Mineral Analysis (Soil/Sediment)

In a 100ml conical flask, one gram of pulverized sample was weighed. It was soaked in distilled water to keep it wet. 10 mL HNO_3: HCl (3:1) aqua regia was added. It was cooked over a low heat for over an hour, until it was virtually dry. It was chilled before being leached with 5ml of 6M H_2SO_4 for 5 minutes. 5 mL distilled water was added, and the mixture was allowed to boil for 10 minutes. After then, it was chilled and filtered. Mineral analysis was performed on the filtrate, which was made up to 100ml.

2.3. Metal/Mineral Analysis Using Atomic Absorption Spectrophotometer (AAS)

The analytical method for determining metal concentration was spectrometry, with the equipment being a Buck Scientific model 211 VGP Atomic Absorption Spectrophotometer (AAS) using the calibration plot method. Standard preparation, equipment calibration, and sample analysis were all included. The instrument was auto-zeroed for each element using distilled water as a blank, then the standards were inhaled into the flame from highest to lowest concentration. The equipment calculated the corresponding absorbance and plotted the absorbance vs. concentration graph. After extrapolating from the standard curve, the concentrations of the metals contained in the samples were shown in parts per million (ppm).

2.4. Statistical Analysis of Data

The data obtained from the experimental process was analyzed using analysis of variance (ANOVA). The two-way form of this analysis of variance is used. Because the two-way type is an extension of the one-way type, it was chosen. This is due to the fact that there are three seasonal factors in the study that are all independent of one another. The two-way analysis of variance will be used to investigate the interaction between the seasonal gathered samples once more.

2.5. Location of the Study Areas

Supare Akoko is a town in Ondo State, Nigeria, located in the Akoko South West Local Government Area.

Supare is around 100 kilometers from the state capital, Akure, Nigeria. It is mostly covered with rain forest, with high undulating rocky and hilly structures. It is located between the longitude and latitudes of 5.69357 and 7.45245.Lokoja is the capital of Kogi state, with a population of 195,261 people according to the 2006 census. It is located between the coordinates 6.74048 and 7.79688.

Figure-2. Area map of Supare Akoko, Ondo State showing Sample points

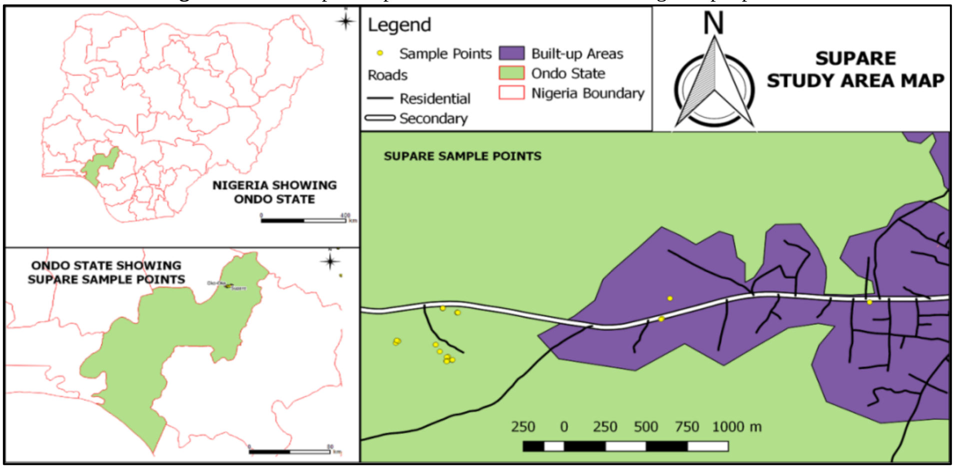


Figure-3. Area map of Ajaokuta road Lokoja, Kogi State showing Sample points

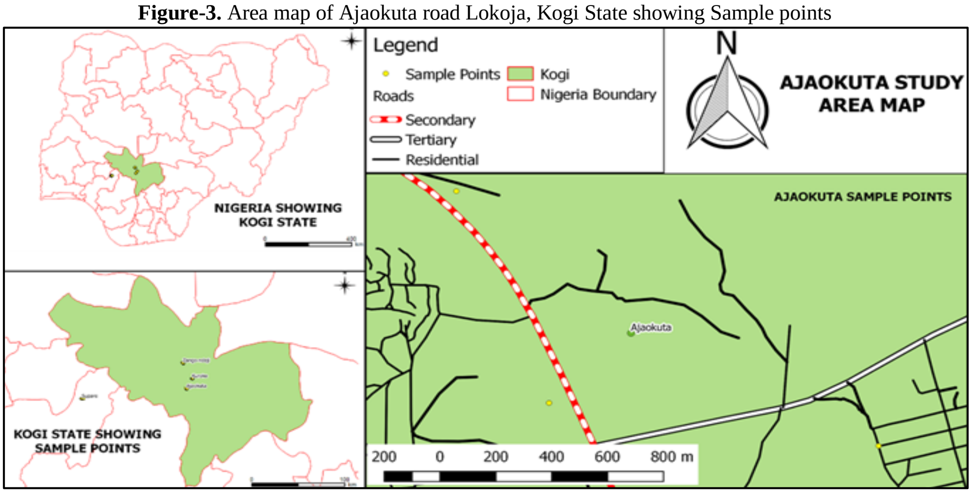
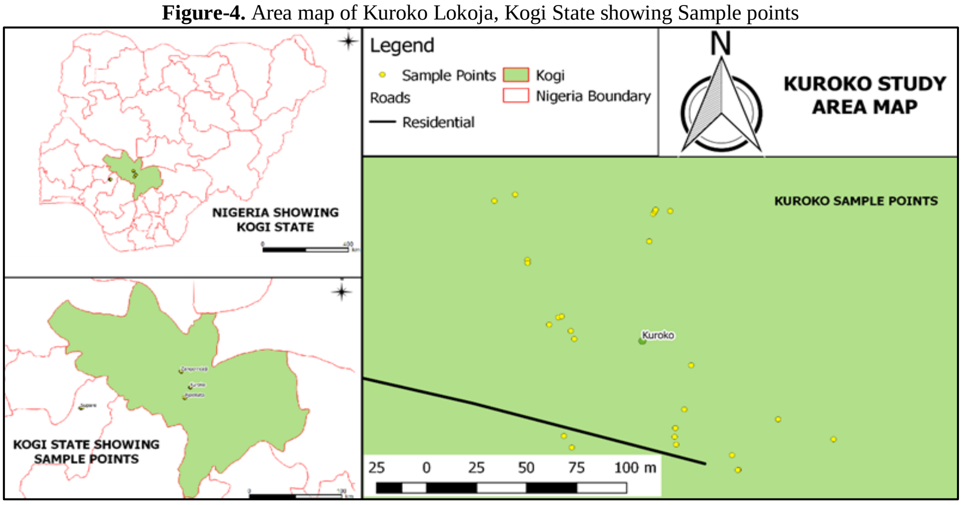


Figure-4. Area map of Kuroko Lokoja, Kogi State showing Sample points



3. Results and Discussion

Table-1. Analysis of variance for replicate (R), soil sample depth (SN1), sample point (SN_2) and point interaction (SN1xSN2) for season one

PARAMETERS (mg/kg)	F-RATIO			
	R	SN1	SN_2	SN1*SN_2
Mn	0.0001 ns	12405***	46.27***	404.52***
Fe	0.0001 ns	74448***	153.2***	448.02***
As	0.0001 ns	2827.9***	471.56***	827.9***
Cd	0.0001 ns	746.02***	48.21***	746.02***
Cr	0.0001 ns	426.39***	13.14***	426.39***
Cu	0.0001 ns	86989***	113.54***	988.77***
Pb	0.0001 ns	3315.5***	23.02***	315.5***
Ni	0.0001 ns	3114.5***	50.64***	114.48***
Co	0.0001 ns	699.45***	97.48***	699.45***
Zn	0.0001 ns	-	76.72***	-

*=0.05;**=0.001; ***= 0.0001; ns= not significant.

Table-2. Analysis of variance for replicate (R), soil sample depth (SN_1), sample point (SN_2) and point interaction (SN_1xSN_2) for season two

VARIATE (mg/kg)	F-RATIO			
	R	SN_2	SN_1	SN_2*SN_1
Mn	0.02 ns	300.24***	822.76***	822.76***
Fe	0.0001 ns	111.03***	6226.25***	6226.25***
As	0.22 ns	42.48***	134.11***	134.11***
Cd	0.08 ns	79.9***	211.19***	211.19***
Cr	0.07 ns	293.86***	804.97***	804.97***
Cu	0.0001 ns	2575.7***	2084.5***	2084.5***
Pb	0.43 ns	173.19***	140.67***	140.67***
Ni	0.25 ns	297.76***	232.88***	232.88***
Co	0.16 ns	76.61***	160.2***	160.2***
Zn	0.0001 ns	45.05***	3209.6***	3209.6***

*=0.05; **=0.001; ***= 0.0001; ns= not significant.

Table-3. Analysis of variance for replicate (R), sample point (SN_2), Sample number (SN_3) and interaction between sample point and number (SN_3xSN_2) for season three

VARIATE (mg/kg)	F-RATIO			
	R	SN_2	SN_3	SN_3*SN_2
Mn	0.01 ns	63.67***	768.95***	768.95***
Fe	0.0001 ns	93.43***	-	-
As	0.0001 ns	24.95***	106.62***	106.62***
Cd	0.03 ns	23.14***	226.95***	226.95***
Cr	0.0001 ns	94.45***	11989.52***	11989.52***
Cu	0.0001 ns	226.64***	30324.69***	30324.69***
Pb	0.0001 ns	439.21***	2695.68***	2695.68***
Ni	0.0001 ns	157.58***	2470.85***	2470.85***
Co	0.02 ns	43.3***	391.13***	391.13***
Zn	0.0001 ns	58.89***	23774.06***	23774.06***

*=0.05; **=0.001; ***= 0.0001; ns= not significant.

3.1. Heavy Metal Analysis of Soil Collected in Season One

The analysis of variance (ANOVA) of different sample depths, sample point and their interaction in terms of collected parameters such as Mn, Fe, As, Cd, Cr, Cu, Pb, Ni, Co, Zn gave significant differences at different significant level of probability (p) ($p \geq 0.0001$) (Table 1). Replications of parameters in terms of collected samples were not significant across season one indication of parameters well determined. The interaction between sample depth and sample point is a greater factor in evaluating the stability of the parameters across different sample point and depth. Means effect for samples point (SN2) in terms of different samples point in season one were significant at $p \geq 0.05$ for As, Cd, Co (Table 4.4a; Table 4.4b). While means effect for samples point (SN2) in terms of different samples point in season one were not significant for other parameters such as Mn, Fe, Cr, Cu, Pb, Ni and Zn (Table 4; 5; 6 and 7).

3.2. Heavy Metal Analysis of Soil Samples for Season Two

The Analysis of variance of soil sample depth (SN_1), sample point (SN_2) and sample depth and point interaction (SN_1xSN_2) for season two at $p \geq 0.0001$gave significant difference for all collected parameters such as Mn, Fe, As, Cd, Cr, Cu, Pb, Ni, Co, Zn (Table 2). The replication of parameters were not significantly different across season two which indicates that the parameters were well determined. Observation of the interaction that exists between the sample depth and sample point gave an indication of stability of the parameters. Means effect for samples point (SN2) in terms of different samples point length in season two were significant at p≥0.05 for As, Cd, Pb, Ni, Co (Table 4; 5; 6 and 7). while Means effect for samples point (SN2) in terms of different samples point length in season two were not significant for other parameters such as Mn, Mg, Fe, Cr, Cu and Zn (Table 4; 5; 6 and 7)

3.3. Heavy Metal Analysis of Soil Samples Collected in Season Three

The analysis of variance for sample number (SN_3), Sample point (SN_2) and interaction between sample point and number (SN_3xSN_2) for season three was conducted on the parameters such as Mn, Fe, As, Cd, Cr, Cu, Pb, Ni, Co, Zn obtained from the Physicochemical properties and metal analysis of soil and effluent samples collected in season three. The result indicated that they were all significantly different at different significant levels p≥0.0001. The replication gave no significant difference which is an indication of well determined parameters. The interaction is a measure of the stability of the parameters at different sample points and sample numbers across season three (Table 3). The means effect of sample points (SN_2) in terms of different samples points across season three were significant at p≥0.05 for As, Cd, Pb, Ni and Co (Table 4; 5; 6 and 7), while the means effect of sample points (SN2) in terms of different samples points across season three were not significantly different for other parameters such as Mn, Fe, Cr, Cu, Pb and Zn (Table 4; 5; 6 and 7).

3.4. Characteristics of Heavy Metals of the Soil Samples

Studies have shown that urban soils receive loads of contaminants that are usually greater than in the surrounding sub-urban or rural areas due to the concentration of anthropogenic activities of urban settlements [12].

Table-4. Means effect of Mn, Fe and As(mg/kg) for samples point across three seasons

SN_2	Mn S1	Mn S2	Mn S3	Fe S1	Fe S2	Fe S3	As S1	As S2	As S3
CRL_1	3.72	1.86	2.14	747.88	876.98	898.06	0.01	0.07	0.10
CRL_2	2.61	2.24	2.52	753.88	772.81	782.41	0.02	0.02	0.06
CRL_3	2.24	0.94	1.64	683.57	695.11	747.70	0.02	0.03	0.04
CRCS	3.30	1.77	2.23	808.08	676.87	719.62	0.02	0.02	0.03
$LKJL_1$	3.86	2.55	2.95	680.19	622.39	681.04	0.02	0.02	0.05
$LKJL_2$	3.03	3.07	2.43	631.54	800.37	739.92	0.02	0.01	0.08
$LKJL_3$	3.52	2.11	1.84	774.58	702.50	618.36	0.02	0.04	0.05
LKJCS	2.67	2.52	2.50	759.72	803.21	794.49	0.03	0.04	0.04
5%LSD	0.77	0.13	0.15	114.77	27.07	25.20	0.01	0.01	0.01

CR= sample from Crush Rock Supare; LKJ= samples from OFL Winstone Lokoja; L_1, L_2 and L_3= sample points; S1, S2 and S3 = seasons (1,2 and 3); LSD= least significant diffence.

3.4.1. Manganese (Mn) in Soil

In the current study, Manganese (Mn) has mean values which ranged from 2.24 – 3.72mg/kg for Crush Rock and 3.03-3.86mg/kg for Lokoja across season one, 0.94-2.24mg/kg (Crush Rock) and 2.11-3.07mg/kg Lokoja for season two while season three ranged from 1.64-2.52mg/kg (Crush Rock) and 1.84-2.95mg/kg (Lokoja); all with corresponding control values of 3.30 and 2.67, 1.77 and 2.52 and 2.23 and 2.50mg/kg (Crush Rock and Lokoja) respectively. All these values are below the acceptable limit of Mn according to World Health Organization WHO [13] which is 12mg/kg. The values obtained were not significantly different from one location to the other. Murtaza, *et al.* [14], reported concentration of 5.4-560mg/kg while they worked on accumulation and bioavailability of heavy metals in soils and vegetables irrigated with city effluent.

3.4.2. Iron (Fe) in Soil

The mean values of Iron (Fe) in the earlier presented table indicates that it ranges from 683.57-753.88mg/kg (Crush Rock) and 631.54-774.58mg/kg (Lokoja) compared to the control sample having 808.08 and 759.72mg/kg respectively across season one. Season two had concentration values of Fe which ranged from 695.11-876.98mg/kg (Crush Rock) and 622.39-800.37mg/kg with control sample value of 676.87 and 803.21mg/kg respectively while season three recorded a range of values 747.70-898.06mg/kg (Crush Rock) and 618.36-739.92mg/kg (Lokoja) against control sample of 719.62 and 794.49mg/kg respectively. It was observed that Fe reduces as distance increases during season two and three at Crush Rock. The concentrations of Fe in these two seasons were higher than their respective control samples. Fe acceptable limit ranges between 20,000- 550,000mg/kg as reported by Bodek, *et al.* [15]. Adefemi and Awokunmi [16], Confirmed that natural soil contains significant levels of iron. It was suggested that the pollution of environment by iron cannot be conclusively linked to waste materials alone but other natural sources must be considered as well [17].

3.4.3. Arsenic (As) in Soil

The levels of arsenic (As) in season one varies between 0.01 and 0.02mg/kg but the control sample at Lokoja had 0.03mg/kg. Though very slight, these values increase with seasons. The value ranges between 0.01-0.07mg/kg with control sample having 0.02 and 0.04mg/kg respectively for Crush Rock and Lokoja in season two, while season three was observed to have values that ranged from 0.04-0.1mg/kg with control samples of 0.03 and 0.04mg/kg respectively. Tripathi, *et al.* [18], reported that the level of As acceptable in plants is 0.01mg/kg.

Table-5. Means effect of Cd, Cr and Cu (mg/kg) for samples point across three seasons

SN2	Cd S1	Cd S2	Cd S3	Cr S1	Cr S2	Cr S3	Cu S1	Cu S2	Cu S3
CRL_1	0.01	0.04	0.07	1.08	0.77	0.80	5.67	5.26	5.93
CRL_2	0.07	0.01	0.04	0.95	1.45	1.66	6.80	3.10	4.67
CRL_3	0.01	0.01	0.02	0.84	0.26	0.66	5.73	1.21	3.62
CRCS	0.02	0.06	0.08	0.73	0.48	0.63	3.09	5.28	5.05
$LKJL_1$	0.10	0.01	0.02	1.31	1.11	1.28	8.99	7.24	6.98
$LKJL_2$	0.09	0.02	0.07	1.09	0.77	1.20	9.15	3.85	5.38
$LKJL_3$	0.07	0.07	0.06	0.97	0.90	0.57	7.94	4.66	6.83
LKJCS	0.02	0.05	0.03	0.86	0.87	0.91	4.82	4.81	4.96
5%LSD	0.02	0.01	0.01	0.20	0.06	0.11	0.99	0.13	0.21

3.4.4. Cadmium in Soil

Cadmium (Cd) was observed that the concentration values of soil sample parameter recorded as having range between 0.01-0.09mg/kg in season one with control sample having 0.02mg/kg for both locations. In season two, 0.01-0.07mg/kg with control sample of 0.06 and 0.05mg/kg, while season three ranged from 0.02-0.07mg/kg having control value of 0.08 and 0.03mg/kg respectively. The permissible limit is 0.31mg/kg. All the values presented fell below this limit as stated by MacLean et al, (1987) though this value vary from one country to another [19].

3.4.5. Chromium (Cr) in Soil

The concentration of chromium (Cr) in soil ranged from 0.84-1.31mg/kg which were all higher than the control sample of 0.73mg/kg from Crush Rock; Lokoja had concentration of 0.86mg/kg in the control sample in season one. Season two in this study presents concentration values of Cr with range of values of 0.26-1.45mg/kg in which the concentration values of the control samples were 0.48 and 0.87mg/kg respectively for Crush Rock and Lokoja. Season three had range of concentration values that ranged from 0.66-1.66mg/kg (Crush Rock) and 0.57-1.28mg/kg (Lokoja) with their control samples which had values of Cr as 0.63 and 0.91mg/kg respectively. Adelekan and Abegunde [20], observed in their study that chromium is one of the heavy metals whose concentration increases steadily in the environment as a result of industrial growth. Reyes . Gutierrez, *et al.* [21], stated that other sources of pollution may include water erosion of rocks**,** liquid fuels and industrial and municipal waste. The acceptable limit of Cr varies from country to country. In Austria, it is 100mg/kg, in Germany, 60mg/kg France, 150mg/kg, United Kingdom, 400mg/kg, Sweden, 40mg/kg, (ECDGE, 2010 as cited by Adelekan and Abegunde [20]. The permissible limit by World Health Organization WHO [13] is 100mg/kg. In this study, the derived concentration values fell below this limit.

3.4.6. Copper (Cu) in Soil

Copper (Cu) has WHO permissible limit of 36mg/kg [13]. The range of concentration values of Cu in season one is 5.67-9.15mg/kg which is higher than the control sample of 3.09 and 4.82mg/kg. Season two had 1.21-7.24mg/kg of which the control samples from the two locations fell within the range. Third season fell within the range of values of 3.62-6.98mg/kg and had control samples value that fell within the range. However, the control sample from Lokoja was lower than the samples from the investigated points. All the values in this study fell below the acceptable limit. Adelekan and Abegunde [20], stated that Cu is one of the essential plants nutrient but needed in low concentration. This study recorded values of copper that was in the range recorded by [20] across all seasons.

Table-6. Means effect of Pb and Ni (mg/kg) for samples point across three seasons

SN2	Pb S1	Pb S2	Pb S3	Ni S1	Ni S2	Ni S3
CRL_1	0.35	0.39	0.41	0.93	0.66	0.72
CRL_2	0.43	0.55	0.49	0.55	0.42	0.51
CRL_3	0.29	0.21	0.30	0.74	0.28	0.31
CRCS	0.42	0.50	0.52	0.56	0.53	0.47
$LKJL_1$	0.72	0.18	0.24	0.81	0.52	0.59
$LKJL_2$	0.68	0.43	0.44	1.31	0.61	0.94
$LKJL_3$	0.74	0.42	0.73	1.05	0.85	0.94
LKJCs	0.40	0.42	0.41	0.96	0.73	0.81
5%LSD	0.21	0.03	0.02	0.18	0.03	0.05

3.4.7. Lead (Pb) in Soil

Pb concentration in the soil samples ranged from 0.29-0.74mg/kg of which the control samples value fell within this range in season one. 0.18-0.55mg/kg was recorded with the control samples having 0.50 and 0.42mg/kg respectively in season two. While season three concentration values ranged from 0.30-0.49mg/kg (Crush Rock) and 0.24-0.73mg/kg (Lokoja) with their corresponding control concentration values as 0.52 and 0.41mg/kg in this season. All the values were lower than the permissible value of 85mg/kg as stated by World Health Organization WHO [13].

3.4.8. Nickel (Ni) in Soil

Nickel (Ni) is an element required by plants in low quantity as confirmed by previous studies and easily absorbed by plants [22]. Its permissible limit in soil is 35mg/kg. This study presented concentration values that ranged from 0.55-1.31mg/kg, 0.28-0.85mg/kg and 0.31-0.94mg/kg against their control samples of 0.56 and 0.96mg/kg, 0.53 and 0.73mg/kg and 0.47 and 0.81mg/kg across season one two and three respectively. It is equally observed that Ni decreases in value as the sample distance increases in crush rock for all the seasons while the reverse is the case with Lokoja across all seasons.

Table 7. Means effect of Co and Zn (mg/kg) for samples point across three seasons

SN2	Co S1	Co S2	Co S3	Zn S1	Zn S2	Zn S3
CRL_1	0.02	0.08	0.10	29.47	43.57	48.03
CRL_2	0.02	0.03	0.06	27.66	24.15	33.04
CRL_3	0.02	0.02	0.03	27.64	20.93	28.18
CRCS	0.03	0.07	0.10	25.04	37.20	44.56
$LKJL_1$	0.06	0.03	0.06	24.27	25.46	30.67
$LKJL_2$	0.08	0.03	0.09	50.40	21.11	24.93
$LKJL_3$	0.08	0.08	0.14	40.61	19.80	53.38
LKJCS	0.06	0.08	0.07	32.62	30.17	30.51
5%LSD	0.02	0.01	0.02	7.10	3.76	3.78

3.4.9. Cobalt (Co) in Soil

Cobalt in the samples ranged from 0.02-0.08mg/kg in season one with control sample from Crush Rock having higher concentration value than the investigated points while that of Lokoja was with same vale as that of the first point investigated. Season two ranged from 0.02-0.08mg/kg for both locations having their control samples concentration values within the range while season three 0.03-0.14mg/kg for both locations with their control samples concentration values within the range. There is yet to be acceptable standard set for Cobalt concentration by WHO. A permissible limit given as reported by Murtaza, *et al.* [14] is 0.05mg/kg. All the soil samples in season one for Crush Rock fell below the limit stated while Lokoja had were higher; season two presents concentration values that were lower than the limit except Crush Rock point L_1 (CRL_1); Lokoja points L_1 and L_2 ($LKJL_1$ and $LKJL_2$) were below this limit. All the samples in season three were slightly above this limit except Crush Rock point L_3 (CRL_3). It was discovered that cobalt concentration value in the soil in most cases increases as the hole depth increases which was in tandem with what [14] discovered during his report.

3.4.10. Zinc (Zn) in Soil

Zinc concentration in this present study ranged from 24.27-50.40mg/kg with the control sample concentration values that fell within the range of values in season one. 19.80-43.57mg/kg was the range of value with control sample of 37.20 and 30.17mg/kg respectively for Crush Rock and Lokoja in season two. While season three had values of range 24.93-53.32mg/kg with control samples of 44.56 and 30.51mg/kg. The acceptable limit of zinc is 50mg/kg [13],the samples collected at the second point ($LKJL_2$) at Lokoja in season one and the third point ($LKJL_3$) in season three were slightly higher (50.04 and 53.32mg/kg respectively) than the recommended WHO value. All the values from Crush Rock fell below the acceptable limits.

4. Conclusion and Recommendation

Most of the samples collected for analysis had concentration values of these heavy metals below the acceptable limits. Concentration of heavy metals investigated in the soil samples increase with seasons which is suggestive that there could be future contamination problems if nothing is urgently done or preventive measure is not taken. Dust is not a problem in the companies investigated because of water flushing medium put in place in the process of quarrying and processing.

Speciation of the metals should be carried out by further researcher in order to properly determine the valence of the elements that causes pollution. The Environmental Impact Assessment (EIA) done by the company before the ministry of mines and steel development gives the certificate of operation should be reviewed from time to time to prevent or ameliorate the effect of heavy metal discharge to the soil.

Conflict of Interest: The Authors have Declared no Conflict of Interest.

References

[1] Ashmole, I. and Motloung, M., 2008. "Dimension stone: The latest trends in exploration and production technology", the Southern African institute of mining and metallurgy; surface mining." vol. 2008, pp. 35-70. Available: https://www.saimm.co.za/Conferences/SurfaceMining2008/035-070_Ashmole.pdf

[2] Merke, G., 2000. "Sustainable development in the natural stone industry." *Roc Maquina,* vol. 2000, pp. 56-58.

[3] Egesi, N. and Tse, C. A., 2011. "Dimension Stone: Exploration, evaluation and Exploitation in Southwest parts of Oban Massif South-eastern Nigeria." *Journal of Geology and Mining Research,* vol. 3, pp. 115-122. Available: http://www.academicjournals.org/jgmr

[4] Egesi, N. and Ukaegbu, V. U., 2013. "Dimension stone exploration and development in boki Area Southeastern Nigeria." *J. Appl. Sci. Environ. Manage,* vol. 17, pp. 343-354.

[5] Joyce, A. R., Mamuda, I., and John, P. C., 2017. "The dimension-stone potentials of the rocks in Mahanga, North Central Nigeria." *International Journal of Scientific and Research Publications,* vol. 7, pp. 435-439. Available: https://www.ijsrp.org/research-paper-0617.php?rp=P666511

[6] Taiwo, A. I. and Zephaniah, F. A., 2017. "Determination of supare granite suitability for dimension stone production. Akoko-Edo, Ondo-State, Nigeria." *International Journal of Sciences: Basic and Applied Research (IJSBAR),* vol. 34, pp. 158-167. Available: https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/7647

[7] Raymond, A. W. and Felix, E. O., 2011. "Heavy metals in contaminated soils: A review of sources, chemistry, risks and best available strategies for remediation." *International Scholarly Research Network (ISRN) Ecology,* pp. 1-20. Available: 10.5402/2011/402647

[8] GWRTAC, 1997. "Remediation of metals-contaminated soils and groundwater:, Tech. Rep. TE-97-01, GWRTAC, Pittsburgh, Pa, USA, GWRTAC-E Series." Available: https://www.scirp.org/(S(czeh2tfqyw2orz553k1w0r45))/reference/ReferencesPapers.aspx?ReferenceID=878401

[9] Kirpichtchikova, T. A., Manceau, A., Spadini, L., Panfili, F., Marcus, M. A., and Jacquet, T., 2006. "Speciation and solubility of heavy metals in contaminated soil using X-ray microfluorescence", ." *Exafs Spectroscopy, Chemical Extraction, and Thermodynamic Modeling Geochimica et Cosmochimica Acta,* vol. 70, pp. 2163–2190. Available: https://doi.org/10.1016/j.gca.2006.02.006

[10] Vareda, J. P., Valente, A. J. M., and Durães, L., 2019. "Assessment of heavy metal pollution from anthropogenic activities and remediation strategies: A review." *J. Environ Manage,* vol. 15, pp. 101-118.

[11] Ogunmodede, O. T., Ajayi, O. O., Amoo, I. A., and Adewole, E., 2013. "Characterization of dumpsite soil: A case study of Ado-Ekiti and Ijero Ekiti, Nigeria." *IOSR Journal of Environmental Science, Toxicology and food technology (IOSR JESTFT),* vol. 3, pp. 43-50.

[12] Komarnicki, G. J. K., 2005. "Lead and cadmium in indoor air and the urban environment." *Environmental Pollution,* vol. 136, pp. 47-61.

[13] World Health Organization WHO, 1996. "Guidelines for drinking water quality. Health criteria and other supporting information". 94/9960-Mastercom/Wiener Verlag-800, Australia." pp. 74-219.

[14] Murtaza, G., Ghafoor, A., Qadir, M., and Rashid, M. K., 2003. "Accumulation and bioavailability of Cd, Co and Mn in soils and vegetables irrigated with city effluent." *Pak. J. Agri. Sci.,* vol. 40, pp. 18-24. Available: https://www.researchgate.net/publication/284410934

[15] Bodek, I., Lyman, W. J., Reehl, W. F., and Rosenblatt, D. H., 1988. *Environmental inorganic chemistry: Properties, processes, and estimation methods, Setac special publication series, B.T. Walton and R.A. Conway, editors*. New York: Pergamon Press.

[16] Adefemi, S. O. and Awokunmi, E. E., 2009. "The impact of Municipal solid waste disposal in Ado-Ekiti Metropolis, Ekiti – State, Nigeria." *Africa Journal of Environmental Science and Technology,* vol. 3, pp. 186-189.

[17] Eddy, N. O., Ndibuke, M. O., and Ndibuke, E. O., 2004. "Heavy metals in sediment from cross river at Oron." *African Journal of Environmental Pollution and Health,* vol. 5, pp. 281-290. Available: https://www.semanticscholar.org/paper/Heavy-Metals-In-The-Sediment-of-The-Cross-River-At-Eddy-Udo/90aaba5f1c51d5da3d218d5be55795d59e55edc3.

[18] Tripathi, R. D., Srivastava, S., Mishra, S., Singh, N., Tuli, R., Gupta, D. K., and Maathuis, F. J. M., 2007. "Arsenic hazards: Strategies for tolerance and remediation by plants." *Trends Biotech,* vol. 25, pp. 158-165. Available: https://doi.org/10.1016/j.tibtech.2007.02.003

[19] Adelekan, B. A. and Alawode, A. O., 2011. "Contributions of municipal refuse dumps to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria." *Journal of Applied Biosciences,* vol. 40, pp. 2727–2737.

[20] Adelekan, B. A. and Abegunde, K. D., 2011 "Heavy metals contamination of soil and groundwater at Automobile mechanic villages in Ibadan Nigeria." *International Journal of the Physical Sciences,* vol. 6, pp. 1045-1058.

[21] Reyes . Gutierrez, L. R., Romero – Guzman, E. T., Cabral, -. P., A., and Rodriquez – Castillo, R., 2007. "Characterization of chromium in contaminated soil studied by SEM, EDS, XRD and Mossbauer Spectroscopy." *Journal of Minerals and materials characterization and Engineering,* vol. 7, pp. 59–70.

[22] Ogundele, D. T., Adio, A. A., and Oludele, O. E., 2015. "Heavy metal concentrations in plants and soil along heavy traffic roads in North Central Nigeria " *Journal of Environmental and Analytical Toxicology,* vol. 5, pp. 1-5.