



# Effect of quarry activities on selected biological resources around quarry site within Onigambari forest plantation, Oyo State, Nigeria

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**Abstract** Quarry activities are creating diverse stress on biological resources in the rural areas where most of them are located globally. In this study, the effect of quarry activities on elephant grass (*Pennisetum purpureum*) leaves and soils around Onigambari Forest Reserve, Oyo State, Nigeria, were investigated. Soil and samples of elephant grass (*Pennisetum purpureum*) leaves were collected from two different distances from the quarry plant. Samples used as control were collected within the boundary of Cocoa Research Institute of Nigeria (CRIN), Oyo State, Nigeria estate. Samples were analysed using proton-induced X-ray emission, to determine the elements. The physiochemical parameters were also analysed in both soil and leaves samples. The mean concentration of the elements in the soil sample from Site 1 was higher in Mg, Cl, Ca, Ti, Cr, Mn, Fe, Zn and Zr than Site 2 and the control site. While in leaves, similar trend was observed. Cd and Ag were highly enriched.

**Keywords** Bioaccumulation · Biodiversity · Forest · *Pennisetum purpureum* · Quarry activities

## Introduction

Quarrying is a matter of interest everywhere in the world, including the developed countries (Lameed and Ayodele 2010). Quarrying is a process of acquiring resources such as rock, dimension stone, construction aggregate, gravel, from the surface of the ground (Vincent et al. 2012). These resources provide materials used in house flooring, such as granite, marble, sandstone and slate. Limestone is also used for cement and clay to make ceramic tiles (Lameed and Ayodele 2010). Extraction process depends on both explosives and heavy machines, and these processes result in noise and air pollution, destruction of habitat, dislocation of fertile soil and damage to biodiversity, this also poses threat to wildlife, livestock and people living around. One of the major impacts of quarrying is damage to biodiversity which affect plant photosynthetic activities (Sayara et al. 2016). Furthermore, pits are abandoned after excavation, creating large gaping landscape (Sayara et al. 2016).

However, like many other human activities, impact of quarrying activities on the environment is significant (Okafor 2006). The air pollution from the quarry site causes problems for humans especially those with respiratory problems and for plants in terms of settling

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on the leave surfaces and can also have physical effects on the plants such as forming obstacle and ravaging their internal structures, abrasion of cuticles and leaves, also chemical effects which may affect survival (Lameed and Ayodele 2010).

The dust released from the quarry site does not only settle on the plant and soil but contains heavy metals which are toxic to the environment. Heavy metals are regarded as the elements having density greater than  $5 \text{ g/cm}^3$  (Adriano 2001). It was mentioned that heavy metals pollution is dangerous to our environment as some of these elements are toxic for microorganisms, essential, nonessential, pose risk to animal's and man (Zamiur Rahman et al. 2015). World Health Organization (WHO) mentioned that air pollution is an increase in any of the constituents of the atmosphere which is harmful to the living beings and their environment (Kavana 2006). Air pollution from quarry site contains heavy metals that can be toxic, they are stable and cannot be degraded or destroyed, and therefore, they tend to accumulate in the plant and forest soil. Metallic elements have effect on plant physiology, growth, fruit yield and seed germination (Ambika et al. 2016).

For example, accumulation of heavy metals in plant results in reduction in root growth, malformation of root, reduces the germination, chlorophyll and photosynthesis (Ambika et al. 2016). *Pennisetum purpureum* was mentioned as the common forage available to cane rat in Oyo State (Ogunjobi et al. 2007). A study on heavy metal in bush meat recommended studies on pathway(s) in which heavy metal contaminant the affected animals displayed as bush meat (Ogunjobi and Ediaqbonya 2017). The objectives of this study are to: determination of the elemental concentration in the elephant grass (*Pennisetum purpureum*) and the soil around quarry site; compare the elemental concentration from quarry sites with the control site and available standard; determine the physiochemical parameters and the bioaccumulation factor.

## Materials and methods

Onigambari forest reserve is situated in the south-western part of Nigeria Oyo state. Its geographical co-ordinates are latitude  $7^\circ 08' 29'' \text{ N}$  and longitude  $3^\circ 50' 42'' \text{ E}$  within the low land semi-deciduous forest belt

of Nigeria. The control for this experiment was obtained at Cocoa Research Institute of Nigeria (CRIN) located on latitude  $7^\circ 13' 31'' \text{ N}$  and longitude  $3^\circ 52' 03'' \text{ E}$ .

The name of the quarry site is Kunlun Construction Company Limited located around Onigambari forest reserve Oyo state, Nigeria. Quarry activities were started in this area about 13 years ago (Table 1).

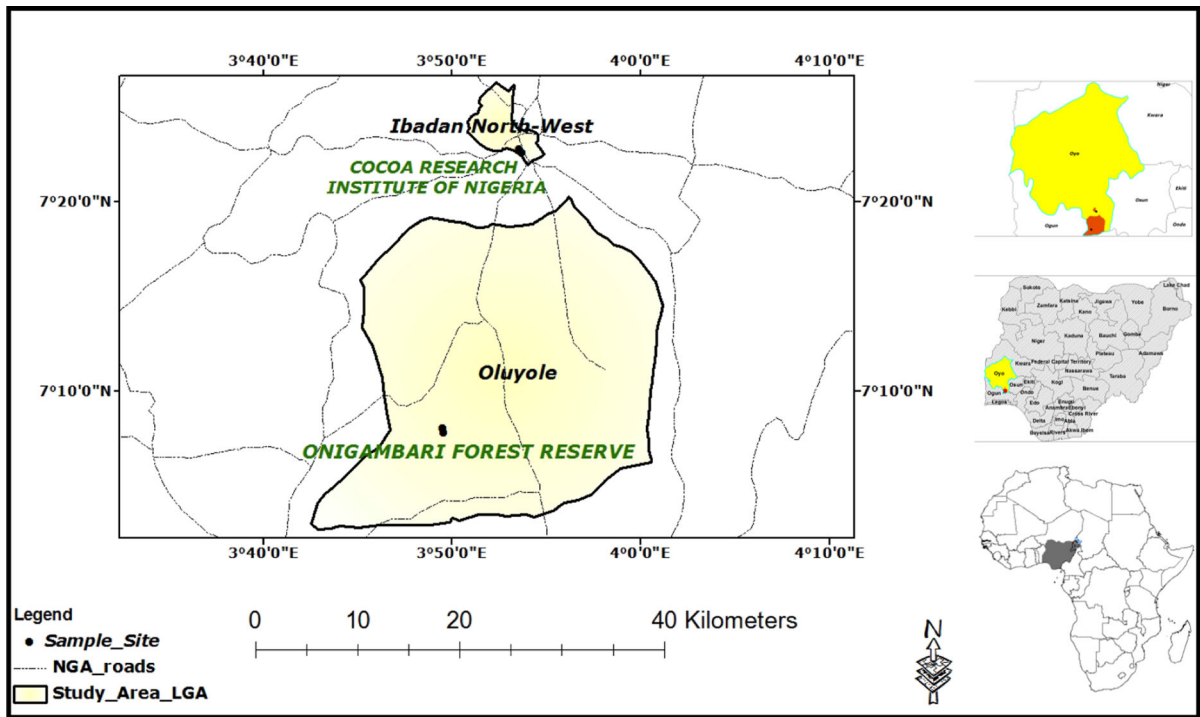
## Sampling

Two sites were mapped out for the sampling and a control site, and the distance between the two sites is 0.028 km (Fig. 1). For the first site, elephant grass leaves were collected, while the soil samples were taken at 10 cm depth. These samples were labelled leaves sample A1 and soil samples A1. For the second site, same steps were taken and these were labelled leaves sample A2 and soil sample A2; for the control site, samples were labelled leaves sample B and soil sample B. The leaves samples were oven-dried at  $70^\circ \text{ C}$  for 4 h and then crushed into small particles (in powdery form). The soil samples were also air-dried for 3 days.

Analysis of concentrations of metals in the samples was done using a 1.7 MeV SSDH Pelletron Accelerator. From each sample, 13 mm diameter and 1-mm-thick pellets were made with Spec-caps by applying 12 Ton pressure with hydraulic pelletizing machine to be used for PIXE analysis. Pellets of the samples were placed on a ladder that can carry eleven 13-mm-diameter pellets made from the samples. The detection limit of the technique is between 0.1 and 10 mg/kg. The elemental concentrations determined were the bioavailable metals. IAEA reference standards were used for the determination of the  $H$ -value which was subsequently used for analysing the samples and assures the accuracy of the experimental procedure. The pH and electrical conductivity of the extracts were

**Table 1** Co-ordinates of sample locations

Locations	Latitude	Longitude
Onigambari forest reserve	$7^\circ 08' 29'' \text{ N}$	$3^\circ 50' 42'' \text{ E}$
Site 1	$7^\circ 08' 27'' \text{ N}$	$3^\circ 50' 39'' \text{ E}$
Site 2	$7^\circ 08' 24'' \text{ N}$	$3^\circ 50' 36'' \text{ E}$
Control site	$7^\circ 13' 31'' \text{ N}$	$3^\circ 52' 03'' \text{ E}$



**Fig. 1** Map showing the various sampling sites

determined using portable pH and conductivity (Hanna 991,300) m. The nitrate and chloride were also determined using standard procedures (Ademoroti 1996). 2 g of each of the soil samples was weighed and shaken with 25 ml of distilled water in a stoppered conical flask. The shaking was done with mechanical flask shaker for 10 min at 350 rpm. The shaken sample was then allowed to equilibrate for 30 min and filtered using filter papers Whatman no. 42. Bioaccumulation factor was calculated using the formula:

$$BAF = C_{shoot}/C_{soil}$$

$C_{shoot}$  and  $C_{soil}$  are the metals concentration in the plant shoot (mg/kg) and soil (mg/kg), respectively. BAF was categorized further as hyper accumulators, accumulator and excluder to those samples which accumulated metals > 1 mg/kg, and < 1, respectively (Ma et al. 2001; Cluis 2004).

**Geo-Accumulation Index ( $I_{geo}$ )**

The geo-accumulation ( $I_{geo}$ ) index is to evaluate contamination level in sediment as given by Muller (1969) and Loska et al. (1997). It had been used by

Ediagbonya and Ayedun (2018), Al-kuziea (2015), Ayedun et al. (2019).  $C_n$  is the measured concentration of metal ‘n’ in sediments, and  $B_n$  is the background concentration of the same metal.

$$I_{geo} = \ln \left[ \frac{C_n}{1.5B_n} \right]$$

**Enrichment factor (EF)**

Enrichment factor (EF) is used to evaluate the contamination level in sediment to identify abnormal metal concentration in sediment. In this study, Al and Fe were used as reference elements. Few authors had used these elements reference element (Schiff and Weisberg 1999; Al-Khuzie et al. 2017; Al-Kuziea 2015). According to Ergin et al. (1991), the metal EF is defined as follows:

$$EF = \frac{\left( \frac{X}{Al} \right)_{sediment}}{\left( \frac{X}{Al} \right)_{crust}}$$

where  $X/Al$  is the ratio of the concentration heavy metal (X) to the Al concentration.

The reference crustal ratio of the shale value or the lithology was taken from Wedephol (1968).

### Statistical data analysis

IBM Statistical Package for Social Sciences (SPSS) version 24.0 was used for the statistical analyses in this study. Descriptive statistics such as range, mean, standard deviation for the physicochemical parameters as well as the heavy metals at the different sampling locations. One-way Analysis of Variance was used to perform the spatial variation of means of the heavy metals at the different sampling sites, where significant difference was observed. Duncan multiple range test (DMRT) was used to separate significant means. The physicochemical parameters were also correlated with the toxic elements using the Pearson correlation. Principal component analysis was the multivariate analysis performed for source identification of heavy metals. The level of significance was set at  $p < 0.05$ .

## Results and discussion

Table 2 shows the descriptive statistics of physicochemical parameters of soil samples in the different locations. The highest mean pH was recorded at Site 1,  $11.53 \pm 0.35$  (11.20–11.90) and the lowest recorded at CRIN  $9.23 \pm 0.15$  (9.10–9.40). The highest mean electrical conductivity (EC) was recorded at Site 1,  $2411.30 \pm 0.50$  (2410.80–2411.80)  $\mu\text{S}/\text{cm}$  and lowest recorded at CRIN  $1770.47 \pm 1.50$  (1768.90–1771.90)  $\mu\text{S}/\text{cm}$ . The highest mean temperature was recorded at

CRIN  $37.43 \pm 0.21$  (37.20–37.60), and lowest mean value reported at Site 1  $34.97 \pm 0.40$  (34.60–35.40), highest mean chloride was recorded at CRIN  $12.62 \pm 0.01$  (12.61–12.63), and lowest value reported at Site 2,  $9.02 \pm 0.01$  (9.01–9.03), while the highest nitrate was recorded at Site 2  $5.60 \pm 0.00$  (5.60–5.61), and the lowest mean value reported at CRI  $4.87 \pm 0.00$  (4.87–4.88).

Table 3 shows the descriptive statistics of physicochemical parameters of leaves samples in the different locations. The highest mean pH was recorded at Site 2,  $9.47 \pm 0.15$  (9.30–9.60) and the lowest recorded at Site 1,  $8.47 \pm 0.40$  (8.10–8.90). The highest mean EC was recorded at Site 2,  $219.53 \pm 0.35$  (219.20–219.90)  $\mu\text{S}/\text{cm}$  and lowest recorded at CRIN,  $200.43 \pm 0.21$  (200.20–200.60)  $\mu\text{S}/\text{cm}$ . The highest mean temperature was recorded at CRIN  $31.53 \pm 0.32$  (31.30–31.90) and lowest mean value reported at Site 1,  $30.40 \pm 0.26$  (30.10–30.60), highest mean chloride was recorded at CRIN  $8.81 \pm 0.00$  (8.81–8.82) and lowest value reported at Site 1  $5.75 \pm 0.01$  (5.74–5.76), while the highest nitrate was recorded at Site 1  $3.44 \pm 0.00$  (3.44–3.45) and the lowest mean value reported at CRIN  $2.82 \pm 0.00$  (2.81–2.82).

Table 4 shows the mean comparison of heavy metals in the different soil samples locations. The result shows that for all the heavy metals in the soil, there is significant spatial difference ( $p < 0.05$ ). The Site 1 has significantly higher Mg, Cl, Ca, Ti, Cr, Mn, Fe, Zn and Zr level than Site 2 and the control site. This can be as a result of quarry activities carried out at the quarry site. The Site 2 has significantly higher K, Cu and Rb level than Site 1 and control site. This is due to the quarry activities carried out daily. The control

**Table 2** Descriptive statistics of physicochemical parameters of soil samples at the various locations

	Site 1				Site 2				CRIN			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
pH	11.53	0.35	11.20	11.90	10.63	0.31	10.30	10.90	9.23	0.15	9.10	9.40
EC	2411.30	0.50	2410.80	2411.80	2402.07	0.47	2401.70	2402.60	1770.47	1.50	1768.90	1771.90
Temperature	34.97	0.40	34.60	35.40	36.70	0.46	36.20	37.10	37.43	0.21	37.20	37.60
Cl	9.11	0.00	9.11	9.12	9.02	0.01	9.01	9.03	12.62	0.01	12.61	12.63
Nitrate	5.12	0.00	5.11	5.12	5.60	0.00	5.60	5.61	4.87	0.00	4.87	4.88

Site 1 = Onigambari forest reserve, Site 2 = Onigambari forest reserve, CRIN = Cocoa Research Institute of Nigeria (control site)

**Table 3** Descriptive statistics of physiochemical parameters of *Pennisetum purpureum* at the various locations

	Site 1				Site 2				CRIN			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
pH	8.47	0.40	8.10	8.90	9.47	0.15	9.30	9.60	8.53	0.25	8.30	8.80
EC	205.40	0.36	205.10	205.80	219.53	0.35	219.20	219.90	200.43	0.21	200.20	200.60
Temperature	30.40	0.26	30.10	30.60	28.60	0.26	28.40	28.90	31.53	0.32	31.30	31.90
Cl-	5.75	0.01	5.74	5.76	8.15	0.00	8.14	8.15	8.81	0.00	8.81	8.82
Nitrate	3.44	0.00	3.44	3.45	3.02	0.00	3.02	3.03	2.82	0.00	2.81	2.82

Site 1 = Onigambari forest reserve, Site 2 = Onigambari forest reserve, CRIN = Cocoa Research Institute of Nigeria (control site)

**Table 4** Spatial variation of heavy metals in the different soil samples locations (mg/kg). *Limit source: IAEA Soil-7, 2000 = International Atomic Energy Agency Soil-7*

Elements	Site 1	Site 2	CRIN (control)	<i>p</i>	IAEA soil-7	Zamiur Rahman et al. (2015)
Na	2625.43 ± 8.69 <sup>a</sup>	2001.43 ± 0.57 <sup>b</sup>	2817.20 ± 2.00 <sup>c</sup>	0.000	24,000	NA
Mg	3367.03 ± 0.49 <sup>a</sup>	1530.63 ± 0.74 <sup>b</sup>	1066.50 ± 0.26 <sup>c</sup>	0.000	11,300	NA
Al	34,325.83 ± 2.36 <sup>a</sup>	62,443.63 ± 0.93 <sup>b</sup>	84,159.33 ± 6.49 <sup>c</sup>	0.000	47,000	NA
Si	468,052.17 ± 10.75 <sup>a</sup>	418,138.23 ± 0.45 <sup>b</sup>	488,288.60 ± 0.26 <sup>c</sup>	0.000	180,000	NA
P	378.40 ± 0.53 <sup>a</sup>	529.03 ± 1.05 <sup>b</sup>	530.40 ± 0.30 <sup>b</sup>	0.000	460	NA
Cl	402.17 ± 0.51 <sup>a</sup>	281.07 ± 0.32 <sup>b</sup>	239.57 ± 0.35 <sup>c</sup>	0.000	NA	NA
K	2345.60 ± 0.26 <sup>a</sup>	3190.67 ± 0.58 <sup>b</sup>	2523.30 ± 0.10 <sup>c</sup>	0.000	12,100	9706
Ca	8784.47 ± 0.12 <sup>a</sup>	7123.50 ± 0.26 <sup>b</sup>	1346.47 ± 0.31 <sup>c</sup>	0.000	163,000	68,270
Ti	28,042.67 ± 0.12 <sup>a</sup>	27,096.60 ± 0.17 <sup>b</sup>	12,421.37 ± 0.25 <sup>c</sup>	0.000	3000	28,000
Cr	898.43 ± 0.42 <sup>a</sup>	838.53 ± 0.32 <sup>b</sup>	288.57 ± 0.31 <sup>c</sup>	0.000	60	874
Mn	4717.43 ± 0.35 <sup>a</sup>	1548.50 ± 0.36 <sup>b</sup>	674.57 ± 0.31 <sup>c</sup>	0.000	631	12,236
Fe	311,231.33 ± 0.21 <sup>a</sup>	111,320.47 ± 0.40 <sup>b</sup>	215,955.47 ± 0.31 <sup>c</sup>	0.000	25,700	957,533
Cu	1011.75 ± 0.12 <sup>a</sup>	1280.47 ± 0.35 <sup>b</sup>	206.33 ± 0.23 <sup>c</sup>	0.000	11	NA
Zn	213.53 ± 0.32 <sup>a</sup>	87.63 ± 0.21 <sup>b</sup>	85.57 ± 0.31 <sup>c</sup>	0.000	104	11,640
Sr	61.67 ± 0.40 <sup>a</sup>	ND	159.43 ± 0.42 <sup>b</sup>	0.000	NA	NA
Rb	ND	35.53 ± 0.25	ND		NA	NA
Zr	3710.40 ± 0.10 <sup>a</sup>	1611.50 ± 0.36 <sup>b</sup>	128.53 ± 0.35 <sup>c</sup>	0.000	108	NA
Pb	ND	20.50 ± 0.10 <sup>a</sup>	21.73 ± 0.21 <sup>b</sup>	0.001	NA	NA
Ag	24.60 ± 0.20 <sup>a</sup>	17.47 ± 0.50 <sup>b</sup>	88.57 ± 0.31 <sup>c</sup>	0.000	NA	NA
Cd	44.63 ± 0.31 <sup>a</sup>	31.53 ± 0.31 <sup>b</sup>	191.40 ± 0.26 <sup>c</sup>	0.000	1.3	NA
Sn	118.57 ± 0.06 <sup>a</sup>	217.47 ± 0.31 <sup>b</sup>	429.50 ± 0.26 <sup>c</sup>	0.000	NA	NA
Pb	9.37 ± 0.21 <sup>a</sup>	8.33 ± 1.15 <sup>a</sup>	11.40 ± 0.30 <sup>b</sup>	0.005	60	NA

ND not detection, NA not available

Means with different superscripts are statistically significant at *p* < 0.05

site has significantly higher Pb, Sn, Cd, Na, Al, Si, Sr, Ag, Pd, level than Site 1 and Site 2. This may be as a result of agricultural activities, agricultural wastes and eroded debris. Also, some of these elements present in

the control site may be in their natural state on the earth crust.

Table 4 shows that the mean concentration of silicon and iron in the soils of Onigambari forest

reserve locations ranged from 418,138.23 to 468,052.17 mg/kg and 111,320.47 to 311,231.33 mg/kg, respectively, with the mean values of 443,095.2 mg/kg and 211,275.9 mg/kg, respectively. The mean value of silicon and iron was higher than the IAEA Soil-7 value 180,000 mg/kg and 25,700 mg/kg, respectively. However, the higher value of iron was reported in Zamiur Rahman et al. (2015). The concentration of aluminium, titanium, calcium, manganese, zirconium in the soils ranged from 34,325.83 to 62,443.63 mg/kg, 27,096.60 to 28,042.67 mg/kg, 7123.50 to 8784.47 mg/kg, 1548.50 to 4717.43 mg/kg and 1611.50 to 3710.40 mg/kg, respectively, with the mean values 48,384.73 mg/kg, 27,569.635 mg/kg, 7953.985 mg/kg, 3132.965 mg/kg and 2660.95 mg/kg, respectively. The mean value of aluminium, titanium, manganese and zirconium was higher than the IAEA Soil-7 value 47000 mg/kg, 3000 mg/kg, 631 mg/kg and 185 mg/kg, respectively, except from calcium which has lower value than the IAEA Soil-7 value 163000 mg/kg. However, higher value of titanium, calcium, manganese was reported in Zamiur Rahman et al. (2015). The concentration of potassium, sodium, magnesium, copper, chromium, phosphorus, zinc, cadmium and lead in the soils ranged from 2345.60 to 3190.67 mg/kg, 2001.43 to 2625.43 mg/kg, 1530.63 to 3367.03 mg/kg, 1011.75 to 1280.47 mg/kg, 838.53 to 898.43 mg/kg, 529.03 to 378.40 mg/kg, 87.63 to 213.53 mg/kg, 31.53 to 44.63 mg/kg and 8.33 to 9.37 mg/kg, respectively, with the mean values, 2768.135 mg/kg, 2313.43 mg/kg, 2448.83 mg/kg, 1146.11 mg/kg, 868.48 mg/kg, 453.715 mg/kg, 150.58 mg/kg, 38.08 mg/kg and 8.85 mg/kg, respectively. The mean values of potassium, sodium, magnesium, phosphorus and lead were lower than the IAEA Soil-7 value 12100 mg/kg, 24000 mg/kg, 11300 mg/kg, 460 mg/kg and 60 mg/kg, respectively. While the mean values of copper, chromium, zinc and cadmium were higher than the IAEA Soil-7 value 11 mg/kg, 60 mg/kg and 104 mg/kg and 1.3 mg/kg, respectively. However, the higher value of chromium, zinc and potassium were reported in Zamiur Rahman et al. (2015). There was no IAEA Soil-7 value for the following elements: chlorine, silver and tin, so they cannot be compared. This present study can also be compared with WHO/FAO limits as reported in Fosu-Mensah et al. (2017). The order of elemental concentration in the soil sample of Site 1 is: Pb < Ag < Cd < Sr < Sn < Zn < P < Cl < Cr

< Cu < K < Na < Mg < Zr < Mn < Ca < Ti < Al < Fe < Si. The order of elemental concentration in the soil sample of Site 2 is: Pb < Ag < Pd < Cd < Rb < Zn < Sn < Cl < P < Cr < Cu < Mg < Mn < Zr < Na < K < Ca < Ti < Al < Fe < Si. High concentration of these elements in soil affects animals, insects and microorganisms that live on the soil, and it also results in reduction in root growth, which may also affect photosynthesis. Table 4 shows the mean comparison of heavy metals in the different leaves samples locations. The result shows that for all the heavy metals in the leaves, there is significant spatial difference ( $p < 0.05$ ). The Site 1 has significantly higher Mg, Al, Si, P, Cl, Ca, Ti, Cr, Mn, Fe, Zn, Ag, Sn, Pb level than Site 2 and the control site. The Site 2 has significantly higher Na, K, Cu, Rb, Pd, Cd level than Site 1 and control sites. This is due to the movement of metals from soil to root, metal absorption and translocation, settlement of dust particles on the leaves.

Table 5 shows that the mean concentration of chromium in the leaves sample of Onigambari forest reserve locations ranged from 120.53 to 550.50 mg/kg with the mean value of 111.565 mg/kg. The mean value of chromium is higher than the WHO value 1.30 mg/kg. The concentration of copper in the leaves sample ranged from 776.50 to 803.53 mg/kg with the mean value of 790.015 mg/kg. The mean value of copper is higher than the WHO value 10 mg/kg. The concentration of lead in the leaves sample ranged from 4.13 to 3.67 mg/kg with the mean value of 3.9 mg/kg. The mean value of lead is lower than the WHO value 10 mg/kg. The concentration of cadmium in the leaves sample ranged from 18.47 to 21.80 mg/kg with the mean value of 20.135 mg/kg. The mean value of cadmium is higher than the WHO value 0.02 mg/kg. The concentration of zinc in the leaves sample ranged from 23.43 to 88.33 mg/kg with the mean value of 55.88 mg/kg. The mean value of zinc is higher than the WHO value 0.60 mg/kg. There were no WHO limits for the following elements: palladium, chlorine, silver, tin, potassium, sodium, magnesium, copper, phosphorus, aluminium, titanium, calcium, manganese, zirconium, silicon, iron and strontium, so they cannot be compared. The order of elemental concentration in the leaves sample of Site 1 is given as: Pb < Sr < Cd < Sn < Zn < Ag < Cr < P < Zr < Al < Cl < Cu < Mn < Mg < Na < K < Si < Ca < Ti < Fe. The order of elemental concentration in the leaves sample of Site

**Table 5** Spatial variation of elements in the *Pennisetum purpureum* leaves samples at different sampled locations (mg/kg). *Limit source: WHO (1997)*

Elements	Site 1	Site 2	CRIN (control)	<i>p</i>	Present study range (mean)	WHO limits
Na	1077.30 ± 0.50 <sup>a</sup>	1102.33 ± 0.21 <sup>b</sup>	900.72 ± 0.31 <sup>c</sup>	0.000	1077.30–1102.33 (1089.815)	NA
Mg	934.33 ± 0.21 <sup>a</sup>	778.43 ± 0.35 <sup>b</sup>	451.37 ± 0.38 <sup>c</sup>	0.000	778.43–934.33 (856.38)	NA
Al	155.07 ± 0.15 <sup>a</sup>	132.70 ± 0.53 <sup>b</sup>	100.20 ± 0.10 <sup>c</sup>	0.000	132.70–155.07 (143.885)	NA
Si	3871.40 ± 0.26 <sup>a</sup>	2110.80 ± 0.46 <sup>b</sup>	1771.40 ± 0.30 <sup>c</sup>	0.000	2110.80–3871.40 (2991.1) 1108.50–1331.63 (1220.065)	NA
P	133.57 ± 0.42 <sup>a</sup>	88.63 ± 0.25 <sup>b</sup>	38.40 ± 0.26 <sup>c</sup>	0.000	88.63–133.57 (111.1)	NA
Cl	254.43 ± 0.35 <sup>a</sup>	150.47 ± 0.51 <sup>b</sup>	100.67 ± 0.68 <sup>c</sup>	0.000	1108.50–1331.63 (1220.065)	NA
K	1108.50 ± 0.40 <sup>a</sup>	1331.63 ± 0.15 <sup>b</sup>	1211.53 ± 0.38 <sup>c</sup>	0.000	1108.50–1331.63 (1220.065)	NA
Ca	6617.50 ± 0.30 <sup>a</sup>	5958.40 ± 0.30 <sup>b</sup>	3319.57 ± 0.35 <sup>c</sup>	0.000	5958.40–6617.50 (6287.95)	NA
Ti	10,331.53 ± 0.11 <sup>a</sup>	9031.57 ± 0.31 <sup>b</sup>	6658.50 ± 0.36 <sup>c</sup>	0.000	9031.57–10,331.53 (9681.55)	NA
Cr	120.53 ± 0.35 <sup>a</sup>	102.60 ± 0.10 <sup>b</sup>	71.57 ± 0.31 <sup>c</sup>	0.000	102.60–120.53 (111.565)	1.30
Mn	871.53 ± 0.31 <sup>a</sup>	550.50 ± 0.36 <sup>b</sup>	283.43 ± 0.31 <sup>c</sup>	0.000	550.50–871.53 (711.015)	NA
Fe	29,817.67 ± 0.15 <sup>a</sup>	25,881.40 ± 0.36 <sup>b</sup>	21,004.50 ± 0.26 <sup>c</sup>	0.000	25,881.40–29,817.67 (27,849.535)	NA
Cu	776.50 ± 0.26 <sup>a</sup>	803.53 ± 0.25 <sup>b</sup>	558.40 ± 0.17 <sup>c</sup>	0.000	803.53–776.50 (790.015)	10
Zn	88.33 ± 0.21 <sup>a</sup>	23.43 ± 0.35 <sup>b</sup>	9.47 ± 0.15 <sup>c</sup>	0.000	23.43–88.33 (55.88)	0.60
Sr	14.23 ± 0.15 <sup>a</sup>	ND	88.53 ± 0.35 <sup>c</sup>	0.000	NA	NA
Rb	ND	11.63 ± 0.25 <sup>b</sup>	ND			NA
Zr	138.50 ± 0.40 <sup>a</sup>	11.53 ± 0.03 <sup>b</sup>	7.67 ± 0.25 <sup>c</sup>	0.000	11.53–14.23 (75.015)	NA
Pd	ND	8.23 ± 0.15 <sup>b</sup>	7.50 ± 0.10 <sup>c</sup>	0.002	NA	NA
Ag	104.50 ± 0.36 <sup>a</sup>	7.57 ± 0.25 <sup>b</sup>	5.27 ± 0.21 <sup>c</sup>	0.000	7.57–104.50 (56.035)	NA
Cd	18.47 ± 0.35 <sup>a</sup>	21.80 ± 0.30 <sup>b</sup>	15.63 ± 0.25 <sup>c</sup>	0.000	18.47–21.80 (20.135)	0.02
Sn	20.53 ± 0.25 <sup>a</sup>	10.47 ± 0.40 <sup>b</sup>	10.60 ± 0.26 <sup>c</sup>	0.000	10.47–20.53 (15.5)	NA
Pb	4.13 ± 0.03 <sup>a</sup>	3.67 ± 0.21 <sup>b</sup>	2.50 ± 0.30 <sup>c</sup>	0.000	3.67–4.13 (3.9)	10

ND not detection, NA not available

Means with different superscripts are statistically significant at *p* < 0.05

The superscripts are to the mean separation based on Duncan multiple range test (DMRT), which is a post hoc test after ANOVA revealed a significant difference

2 is given as: Pb < Ag < P < Sn < Rb < Zr < Cd < Zn < P < Cr < Al < Cl < Mn < Mg < Cu < Na < K < Si < Ca < Ti < Fe. High concentration of these elements has physical effects on the leaves such as forming obstacle and ravaging their internal structures, abrasion of leaves. The metallic elements also have effect on plant physiology, growth and yield.

Table 6 shows the plant bioaccumulation in Site 1, Site 2 and control site from the result. Bioaccumulation in the control site is lower compared to the Site 1 and Site 2. The order of bio accumulation in site 1 is as follows: Al < Si < Zr < Fe < Cr < Sn < Mn < Sr < Mg < P < Ti < Na = Zn = Cd < Pb < K < Cl < Ca < Cu < Ag. Silver has the highest bioaccumulation, and aluminium has the lowest in Site 2; the order of bio

accumulation is as follows: Al < Si = Zr < Sn < Cr < P < Fe < Zn < Ti = Rb < Mn < Pd < K < Ag < Pb < Mg < Cl < Na < Cu < Cd < Ca. Calcium has highest bioaccumulation, and aluminium had the lowest. In the control site, the order of bioaccumulation is as follows: Al < Si < Sn < Zr < Ag < P < Cd < Fe < Zn < Pb < Cr < Na < Pd < Mg = Cl = Mn < K < Ti < Sr < Ca < Cu. In the overall, silver has the highest bioaccumulation with the value 4.25 and aluminium had the lowest bioaccumulation with the value 0.00. The values of all the elements obtained were higher than WHO/EU 0.01 mg/kg except aluminium and silicon which fell within the purview of the limit. However, the values in this study can be compared with the values of other study (Opaluwa et al. 2012).

**Table 6** *Pennisetum purpureum* leaves bioaccumulation factor at various locations

	Site 1	Site 2	(Control)
Na	0.41	0.55	0.32
Mg	0.28	0.51	0.42
Al	0.00	0.00	0.00
Si	0.01	0.01	0.00
P	0.35	0.17	0.07
Cl	0.63	0.54	0.42
K	0.47	0.42	0.48
Ca	0.75	0.84	2.47
Ti	0.37	0.33	0.54
Cr	0.13	0.12	0.25
Mn	0.18	0.36	0.42
Fe	0.10	0.23	0.10
Cu	0.77	0.63	2.71
Zn	0.41	0.27	0.11
Sr	0.23	ND	0.56
Rb	ND	0.33	ND
Zr	0.04	0.01	0.06
Pd	BDL	0.40	0.35
Ag	4.25	0.43	0.06
Cd	0.41	0.69	0.08
Sn	0.17	0.05	0.02
Pb	0.44	0.44	0.22

ND not detection

Table 7 shows the correlation coefficients of physiochemical and the elements in the leaves samples. EC and nitrate have a significant negative relationship with Na, while  $\text{Cl}^-$  has a significant positive relationship with Na. pH is positively related with Mg, while temperature is negatively related with Mg. pH and EC are negatively related with Al, while temperature and  $\text{Cl}^-$  are positively related with Al. EC is significantly negatively related with P, while temperature is significantly positively related with P. pH, EC showed significant relationship with Cl, while temperature and  $\text{Cl}^-$  showed significant negative relationship with Cl. Nitrate showed a significant positive relationship with K. pH and EC showed positive significant relationship with C, while temperature and  $\text{Cl}^-$  showed significant negative relationship with Ca. pH, EC and nitrate showed significant positive relationship with Ti, while  $\text{Cl}^-$  and temperature showed significant negative

relationship with Ti. pH, EC and nitrate showed significant positive relationship with Cr, while temperature and  $\text{Cl}^-$  showed significant negative relationship with Cr. pH and EC showed significant positive relationship with Mn, while temperature showed significant negative relationship with Mn. Nitrate is significantly negatively related with Fe. pH, EC and nitrate showed significant positive relationship with Cu, while  $\text{Cl}^-$  showed significant negative relationship with Cu. pH showed significant positive relationship with Zn, while temperature showed significant negative relationship with Zn. pH, EC and nitrate showed a significant negative relationship with Sr, while temperature and  $\text{Cl}^-$  showed significant positive relationship with Sr. Temperature showed a significant negative relationship with Rb. pH, EC showed significant positive relationship with Zr, while temperature and  $\text{Cl}^-$  showed significant negative relationship with Zr. pH, temperature and nitrate showed significant negative relationship with Pd, while  $\text{Cl}^-$  showed positive relationship with Pd. pH, EC and nitrate showed significant negative relationship with Ag, while  $\text{Cl}^-$  showed positive relationship with Ag. pH, EC and nitrate showed significant negative relationship with Cd, while  $\text{Cl}^-$  showed positive relationship with Cd. pH, EC showed significant negative relationship with Ag, while temperature and  $\text{Cl}^-$  showed positive relationship with Sn. pH, EC and nitrate showed significant negative relationship with Pb, while  $\text{Cl}^-$  showed positive relationship with Pb.

Table 8 shows the correlation coefficients of physiochemical and the elements in the soil samples. EC and nitrate have a significant positive relationship with Na, while temperature has a significant negative relationship with Na. Nitrate is positively related with Mg, while  $\text{Cl}^-$  is negatively related with Mg. Nitrate is positively related with Al, while  $\text{Cl}^-$  is negatively related with Al. Nitrate is positively related with Si, while  $\text{Cl}^-$  is negatively related with Si. Nitrate is positively related with P, while  $\text{Cl}^-$  is negatively related with P. Nitrate is positively related with Cl, while  $\text{Cl}^-$  is negatively related with Cl. pH, EC and  $\text{Cl}^-$  are positively related with K. Nitrate is positively related with Ca, while  $\text{Cl}^-$  is negatively related with Ca. Nitrate is positively related with Ti, while  $\text{Cl}^-$  is negatively related with Ti. Nitrate is positively related with Cr, while  $\text{Cl}^-$  is negatively related with Cr. Nitrate is positively related with Mn, while  $\text{Cl}^-$  is



**Table 7** Correlation of the physiochemical parameters with the mean concentration of elements in the elephant grass leaves

Elements	pH	EC	Temperature	Cl <sup>-</sup>	Nitrate
Na	- 0.335	- 0.673*	- 0.003	0.698*	- 0.995**
Mg	0.872**	0.665	- 0.954**	- 0.639	- 0.001
Al	- 0.952**	- 0.834**	0.948**	0.814**	- 0.254
Si	- 0.386	- 0.714*	0.052	0.738*	- 0.999**
P	- 0.778*	- 0.518	0.920**	0.487	0.184
Cl	0.895**	0.706*	- 0.959**	- 0.681*	0.055
K	- 0.074	0.305	0.400	- 0.338	0.862**
Ca	0.955**	0.980**	- 0.823**	- 0.972**	0.597
Ti	0.914**	0.999**	- 0.734*	- 0.997**	0.717*
Cr	0.925**	0.997**	- 0.755*	- 0.994**	0.692*
Mn	0.878**	0.677*	- 0.956**	- 0.650	0.014
Fe	0.353	- 0.014	- 0.637	0.049	- 0.677*
Cu	0.778*	0.968**	- 0.521	- 0.976**	0.890**
Zn	0.783*	0.523	- 0.922**	- 0.493	- 0.178
Sr	- 0.983**	- 1.000**	0.977**	1.000**	- 1.000**
Rb	0.564	- 0.911	- 0.997*	- 0.434	- 0.475
Zr	0.947**	0.820**	- 0.951**	- 0.799**	0.230
Pd	- 0.942**	- 0.978**	0.792	0.977**	- 0.978**
Ag	- 0.857**	- 0.995**	0.638	0.998**	- 0.811**
Cd	- 0.865**	- 0.996**	0.649	0.999**	- 0.800**
Sn	- 0.968**	- 0.954**	0.869**	0.943**	- 0.512
Pb	- 0.686*	- 0.857**	0.391	0.866**	- 0.850**

\*\*Correlation is significant at the 0.01 level (2-tailed)  
\*Correlation is significant at the 0.05 level (2-tailed)

negatively related with Mn. Nitrate is positively related with Fe, while Cl<sup>-</sup> is negatively related with Fe. EC and nitrate are positively related with Cu, while temperature is negatively related with Cu. Nitrate is positively related with Zn, while Cl<sup>-</sup> is negatively related with Zn. Temperature and Cl<sup>-</sup> showed significant positive relationship with Sr, while EC and nitrate showed significant negative relationship with Sr. Nitrate is positively related with Zr, while Cl<sup>-</sup> is negatively related with Zr. pH, EC and nitrate showed significant positive relationship with Pd, while Cl<sup>-</sup> showed significant negative relationship with Pd. Nitrate is positively related with Ag, while Cl<sup>-</sup> is negatively related with Ag. pH and EC showed a significant positive relationship with Cd, while temperature showed a significant negative relationship with Cd. Nitrate is positively related with Sn, while Cl<sup>-</sup> is negatively related with Sn. Nitrate is positively related with Pb, while Cl<sup>-</sup> is negatively related with Pb.

Geo-accumulation index is based on a qualitative pollution intensity scale, whereby sediments can be classified as: uncontaminated/unpolluted (class 0, for

$I_{geo} < 0$ ); unpolluted to moderately polluted (class 1, for  $0 \leq I_{geo} < 1$ ); moderately polluted (class 2, for  $1 \leq I_{geo} < 2$ ); moderately to highly polluted (class 3, for  $2 \leq I_{geo} < 3$ ); highly polluted (class 4, for  $3 \leq I_{geo} < 4$ ); highly to extremely polluted (class 5, for  $4 \leq I_{geo} < 5$ ); and extremely polluted (class 6, for  $I_{geo} \geq 5$ ) according to Mediolla et al. (2008). From Table 9, the elements Na, Mg, Al, Si, K, Ca, Ti, Fe were uncontaminated in FR1, FR2 and the control. P, Cl, Cr, Mn, Cu, Zn, Sr, Sn, Pb were uncontaminated to moderately contaminated in FR1, FR2 and the control, while Ag and Cd were extremely contaminated in FR1, FR2 and the control. The values obtained in this study are in agreement with previous studies (Sakan et al. 2015; Ediagbonya and Ayedun 2018; Abdul-Kawi and Alhudify 2016) except in Ayedun et al. (2019).

The Enrichment Factor values were explained as interpreted by Acevedo-Figueroa et al. (2006), where: EF < 1 indicates no enrichment; < 3 is minor; 3–5 is moderate; 5–10 is moderately severe; 10–25 is severe; 25–50 is very severe; and > 50 is extremely severe (Table 10). When Fe was used as reference element, Na, Mg, Al, K, Ca, Cl, P, Mn, Zn, Sr, Rb and Pb indicated no

**Table 8** Correlation of the physiochemical parameters with the mean concentration of elements in the soil

Elements	pH	EC	Temperature	Cl <sup>-</sup>	Nitrate
Na	0.486	0.777*	- 0.842**	- 0.579	0.675*
Mg	0.126	0.439	- 0.550	- 0.869**	0.924**
Al	0.044	0.352	- 0.471	- 0.912**	0.956**
Si	- 0.372	- 0.119	- 0.020	- 0.998**	0.984**
P	- 0.026	0.282	- 0.406	- 0.940**	0.975**
Cl	- 0.229	0.052	- 0.189	- 0.993**	1.000**
K	0.812**	0.743*	- 0.631	0.714*	- 0.622
Ca	0.240	0.554	- 0.652	- 0.797*	0.865**
Ti	0.095	0.408	- 0.522	- 0.886**	0.936**
Cr	0.087	0.395	- 0.510	- 0.892**	0.941**
Mn	- 0.100	0.199	- 0.328	- 0.966**	0.990**
Fe	0.002	0.310	- 0.431	- 0.930**	0.968**
Cu	0.475	0.769*	- 0.835**	- 0.590	0.685*
Zn	- 0.360	- 0.103	- 0.036	- 0.999**	0.986**
Sr	0.124	- 0.995**	0.920**	1.000**	- 1.000**
Rb	- 0.217	- 0.471	- 0.300	0.013	- 0.676
Zr	- 0.469	- 0.242	0.102	- 0.983**	0.954**
Pd	0.968**	0.962**	- 0.984**	- 0.961**	0.963**
Ag	- 0.475	- 0.247	0.108	- 0.982**	0.952**
Cd	0.786*	0.971**	- 0.973**	- 0.160	0.280
Sn	- 0.508	- 0.278	0.137	- 0.975**	0.940**
Pb	0.154	0.463	- 0.577	- 0.822**	0.879**

\*\*Correlation is significant at the 0.01 level (2-tailed)

\*Correlation is significant at the 0.05 level (2-tailed)

enrichment. Cd was very severe in FR2 and extremely severe in control but was severe in FRI. Ag was extremely severe in FRI; FR2 and control. Sn was moderate in FR1 and severe in FR2 and control. Zr was moderate in both FR1 and FR2 but control indicated no enrichment. Cu was moderate in FR1, while FR2 was severe, but control was minor enrichment; Cr was minor in FR1, while FR2 was moderate, but control indicated no enrichment. Ti and Si were minor in FR2 but in FR1 indicated no enrichment, while in control Si was minor enrichment, but Ti indicated no enrichment. When Al was used as reference element, Na, Mg, K, Ca, Sr and Rb indicated no enrichment. Cd was extremely severe in FR1, FR2 and control. Ag was extremely severe in FRI, FR2 and control. Sn was very severe in FR1, FR2 and control was extremely severe. Zr was extremely severe in FR1, while FR2 was severe but control indicated no enrichment. Cu was extremely severe in FR1, while FR2 was very severe, but control was moderate enrichment. Cr was severe in FR1 and FR2 but was moderate control. Ti and Si were severe in FR1 but in FR2 moderately

severe while in control Si was moderate enrichment but Ti was minor. Cl was moderately severe in FR1 and minor in both FR2 and control. P was minor in FR1 and indicated no enrichment in both FR2 and control. Zn was moderately severe in FR1 and minor FR2 while control indicated no enrichment. Fe was severe in FR1 and moderate in both FR2 and control. Mn was severe in FR1, FR2 was minor, while control indicated no enrichment. Pb was minor in FR1 and indicated no enrichment in both FR2 and control. The values obtained in this study are in agreement with previous studies (Sakan et al. 2015; Ediagbonya and Ayedun 2018; Abdul-Kawi and Alhudify 2016) except in Ayedun et al. (2019).

## Conclusion

The present study shows that the mean concentration of silicon and iron in the soil samples of Onigambari forest reserve were found to be remarkably high,

**Table 9** Geo-accumulation index ( $I_{geo}$ ) at different sampling stations in soil

	$I_{geo}$ (FR1)	$I_{geo}$ (FR2)	$I_{geo}$ (Control)
Na	0.00	0.00	0.00
Mg	0.00	0.00	0.00
Al	0.00	0.00	0.00
Si	0.00	0.00	0.00
P	0.01	0.01	0.01
Cl	0.03	0.03	0.03
K	0.00	0.00	0.00
Ca	0.00	0.00	0.00
Ti	0.00	0.00	0.00
Cr	0.07	0.07	0.06
Mn	0.01	0.01	0.01
Fe	0.00	0.00	0.00
Cu	0.15	0.15	0.11
Zn	0.05	0.05	0.05
Sr	0.01	0.02	0.02
Rb	ND	ND	ND
Zr	0.05	0.04	0.03
Ag	44.01	39.30	61.61
Cd	12.18	11.06	16.85
Sn	0.77	0.86	0.97
Pb	0.11	0.10	0.12

ND not detection

among all the chemical elements while the mean concentration of silver and lead was very low. The mean concentration of iron and titanium in the *Pennisetum purpureum* leaves samples of Onigambari forest reserve were also found to be remarkably high, among all the chemical elements, while the mean concentration of lead was very low. This study reveals that the elemental concentrations of biological resources of Onigambari forest reserve are higher in both soil and leaves samples than the control site, while some elements (Na, Cd, Si, Ag, Sn) were found to be lower in the soil samples than the control area. Some elemental concentrations were found to be higher than the IAEA Soil-7 standard value and WHO standard limits. The mean concentration of the physiochemical parameters correlated positively and negatively with some elements in soil and leaves samples. Cd and Ag were extremely severe in this study. It is possible that elements that are high concentration are

**Table 10** Enrichment Factor using Iron and Aluminium as reference elements

	Fe			Al		
	FR1	FR2	Control	FR1	FR2	Control
Na	0.04	0.09	0.06	0.64	0.27	0.28
Mg	0.03	0.04	0.02	0.52	0.13	0.07
Al	0.07	0.33	0.23	1.00	1.00	1.00
Si	0.97	2.43	1.46	14.94	7.34	6.36
P	0.08	0.32	0.17	1.26	0.97	0.72
Cl	0.34	0.66	0.29	5.21	2.00	1.27
K	0.01	0.05	0.02	0.21	0.15	0.09
Ca	0.06	0.14	0.01	0.93	0.41	0.06
Ti	0.92	2.50	0.59	14.21	7.55	2.57
Cr	1.51	3.95	0.70	23.27	11.94	3.05
Mn	0.84	0.77	0.17	12.93	2.33	0.75
Fe	1.00	1.00	1.00	15.37	3.02	4.35
Cu	3.41	12.06	1.00	52.40	36.46	4.36
Zn	0.34	0.39	0.20	5.24	1.18	0.86
Sr	0.03	0.00	0.12	0.48	0.00	0.51
Rb	0.00	0.11	0.00	0.00	0.33	0.00
Zr	3.52	4.27	0.18	54.05	12.90	0.76
Ag	53.30	105.80	276.53	819.04	319.68	1202.71
Cd	22.56	44.57	139.44	346.74	134.66	606.47
Sn	3.00	15.37	15.65	46.06	46.43	68.05
Pb	0.07	0.18	0.12	1.09	0.53	0.54

geochemically very stable and, therefore, without obvious danger of contamination.

**Recommendation**

For the purpose of food safety, it is necessary for facilities to be put in place in order to reduce the emission of heavy metals from the quarry site as some bush meat resources are getting into the market from this forest. Phytoremediation can also be employed in removing the heavy metals from the soil.

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## References

- Abdul-Kawi, A. A. A., & Alhudify, N. S. (2016). Assessment of heavy metals contamination and its ecological risk in the surface sediments of Al-Mukalla coast, Yemen. *Journal of Scientific and Engineering Research*, 3(3), 13–23.
- Acevedo-Figueroa, D., Jiménez, B. D., & Rodríguez-Sierra, C. J. (2006). Trace metals in sediments of two estuarine lagoons from Puerto Rico. *Environmental Pollution*, 141, 336–342.
- Ademoroti, C. M. O. (1996). *Standard methods for water and effluents analysis* (pp. 29–118). Ibadan: Foludex Press Ltd.
- Adriano, D. C. (2001). *Trace elements in terrestrial environments: biogeochemistry, bioavailability and risks of metals* (2nd ed., p. 867). New York: Springer.
- Agency for Toxic Substances and Disease Registry. Public Health Statement Aluminium. (2008). ATSDR Publication CAS#7429-90-5.
- Al-Khuzie, D. K. K., Hassan, W. F., Al-Hatem, Z., Abdunabi, Z. A., AdilMizhir, A., & Shabar, H. A. (2017). Use Geo Accumulation Index and enrichment factor in assessing pollution in Iraqi tidal flats of some heavy metals. *Indian Journal of Natural Sciences*, 7(40), 11995–12005.
- Al-kuziea, D. K. K. (2015). Assessment of quality collected from Shatt Al-Arab river, Basrah, southern Iraq. *Journal of International Academic Research for Multidisciplinary*, 3(6), 235–246.
- Ambika, A., Mohnish, P., & Kumar, N. (2016). Effect of heavy metals on plants: An overview. *International Journal of Application or Innovation in Engineering & Management (IJAIEEM)*, 5(3), 56–66.
- Ayedun, H., Arowolo, T. A., Gbadebo, A. M., & Idowu, O. A. (2019). Elemental enrichment of sediments in an unprotected shallow groundwater of Lagos and Ogun States, Nigeria. *Environmental Geochemistry and Health*, 41(2), 951–966.
- Cluis, C. (2004). Junk-greedy greens: phytoremediation as a new option for soil decontamination. *BioTeach Journal*, 2, 60–67.
- Ediagbonya, T. F., & Ayedun, H. (2018). Geochemistry of terrigenous sediments in surface water from ore and Okitipupa southwest, Nigeria. *Bangladesh Journal of Science and Industrial Research*, 53(2), 145–154.
- Ergin, M., Saydam, C. Ö., Baştürk, Ö., Erdem, E., & Yörük, R. (1991). Heavy metal concentration in surface sediments from 2 inlets (Golden Horn Estuary and İzmit Bay) of the north eastern Sea of Marmara. *Chemical Geology*, 91, 269–285.
- Fosu-Mensah, B. Y., Emmanuel, A., Dzidzo, Y. T., & Frank, N. (2017). Heavy metals concentration and distribution in soils and vegetation at Korle Lagoon area in Accra. *Cogent Environmental Science*, 3, 58–69.
- International Atomic Energy Agency. (2000). *Analytical quality control services, trace elements in soil*. Vienna: International Atomic Energy Agency.
- Kavana, K. (2006). Water-consequence and remedial measure. Student X Standard Vikasa High School Alkola. Shimoga - 577204.
- Lameed, G. A., & Ayodele, A. E. (2010). Effect of quarry activity on biodiversity: Case study of Ogere Site, Ogun State Nigeria. *African Journal of Science and Technology*, 4(11), 740–750.
- Loska, K., Cebula, J., Pelczer, J., Wiechula, D., & Kwapuliński, J. (1997). Use of enrichment and contamination factors together with Geoaccumulation Indexes to evaluate the content of Cd, Cu, and Ni in the Rybnik Water Reservoir in Poland. *Water, Air, and Soil pollution*, 93, 347–365.
- Ma, L. Q., Komar, K. M., Tu, C., Zhang, W., Cai, Y., & Kenelly, E. D. (2001). A fern that hyper accumulates arsenic. *Nature*, 409, 579–582.
- Mediolla, L. L., Domingues, M. C. D., & Sandoval, M. R. G. (2008). Environmental assessment of and active tailings pile in the State of Mexico (Central Mexico). *Research Journal of Environmental and Earth Sciences*, 2, 197–208.
- Muller, G. (1969). Index of geoaccumulation in sediments of the Rhine River. *Geology Journal*, 2, 109–118.
- Ogunjobi, J. A., & Ediagbonya, T. F. (2017). Deposition of environmental contaminant in processed bushmeat along highways in South-western Nigeria. *Working and Living Environmental Protection*, 14(3), 243–251.
- Ogunjobi, J. A., Meduna, A. J., Inah, E. I., Oyeleke, O. O., & Ogunjinmi, A. A. (2007). Assessment of the common forages and feedstuff available to cane rats (*Thryonomys swinderianus* Temminck, 1827) on farms in Oyo State, Nigeria. *Tropical Animal Science Journal*, 10(1–2), 161–165.
- Okafor, F. C. (2006). “Rural development and the environmental degradation versus protection” in Lameed and Ayodele (2010): effect of quarrying activity on biodiversity. *African Journal of Environmental Science and Technology*, 4(2), 45–56.
- Opaluwa, O. D., Aremu, M. O., Ogbo, L. O., Abiola, K. A., Odiba, I. E., Abubakar, M. M., et al. (2012). *Heavy metal concentration in soils, leaves sample and crops grown around dump sites in Iafia Metropolis*. Nigeria: Nassarawa State.
- Sakan, S., Devic, G., Relic, D., And-elkovic, I., Sakan, N., & Dord-ovic, D. (2015). Evaluation of sediment contamination with heavy metals: the importance of determining appropriate background content and suitable element for normalization. *Environmental Geochemistry and Health*, 37, 97–113.
- Sayara, T., Hamdan, Y., & Basheer-Salimia, R. (2016). Impact of air pollution from quarrying and stone cutting industries on agriculture and plant biodiversity. *Resources and Environment*, 6(6), 122–126.
- Schiff, K. C., & Weisberg, S. B. (1999). Iron as a reference element for determining trace metal enrichment in southern California coastal shelf sediments. *Marine Environmental Research*, 48, 161–176.

- Vincent, K. N., Joseph, N. N., & Raphael, K. K. (2012). Effects of quarry activities on some selected communities in the lower Manya Krobo District of the Eastern Region of Ghana. *Atmospheric and Climate Sciences*, 2(3), 1–11.
- Wedephol, K. H. (1968). *Origin and distribution of the elements* (p. 99). London: Pergimon Press.
- WHO. (1997). *Environmental Health Criteria 194*. Geneva: World Health Organization, International Programme on Chemical Safety.
- Zamiur Rahman, Md., Arif, M., & Moshiur, R. (2015). Elemental analysis of soil samples by ion beam analysis (IBA) technique. *International Journal of Scientific & Engineering Research*, 6, 57–63.

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