Effects of Quarry Soil on Growth, Biomass and Nutritional Composition of Amaranths (*Amaranthus cruentus*)

ABSTRACT

This research work assessed the effects of quarry soil on morphology and nutritional composition of Amaranths (*Amaranthus* *cruentus* L*.*). Soil samples was collected from Sutol Crushed Rock Industries, Supare-Akoko, Ondo State, at a distance of 100m, 200m, 300m and 400m from the quarry site. The amaranths seed was sown into a perforated plastic bucket and replicated four times. Data collected were plant height, total number of green leaves, stem girth, leaf area and number of senescence leaves at 2, 4, 6 and 8 weeks after planting and root length, total number of roots, fresh shoot weight, fresh root weight, dry root weight and root length at 8 weeks after planting. Proximate composition and total chlorophyll content of *Amaranthus* *cruentus* were also evaluated. The result showed soil collected at a distance of 400m has the highest plant height and fresh shoot weight at 8 weeks, 100m gave the highest number of green leaves, higher root length and total number of roots at 8 weeks. The result also revealed that soil collected at a distance of 300m has the highest number of leaf area and stem girth at 8 weeks. While Soil collected at a distance of 200m has higher fresh root weight at 8 weeks. Also, quarry soil had significant (P < 0.05) effect on the proximate composition of the *Amaranthus cruentus* adversely. Chlorophyll content was also depleted in 200-meter soil, though restored as the distance further increased. However, the leaf was able to mitigate the adverse effect of the quarry soil more, in comparison to stem. Conclusively, the planting of *Amaranthus cruentus* L. on quarry soil adversely affect the nutritional composition performance.as measured by the proximate and chlorophyll composition.

**Key words**: Quarry soil, *Amaranthus* *cruentus*, chlorophyll, proximate.

**INTRODUCTION**

*Amaranthus cruentus L.* which is popularly called Amaranths belongs to the family of Amaranthaceae. It is a popular leafy vegetable which is commonly cultivated in Nigeria, other African countries and all over the world (Adewole and Dedeke, 2012). “It is an ephemeral crop and has a growing period of 5 to 6 weeks hence it can be cultivated by the rural and peri-urban farmers in Nigeria several times (at least five times) on the same piece of land in a year” (Adewole and Igberaese, 2011). “Amaranthus has diverse health advantages such as therapeutic value on cardiovascular diseases” (Martirosyan *et al*., 2007), “rich in phytosterols which reduce the cholesterol levels and also prevent cancer” (Su *et al*., 2002). “It is an important vegetable in human diet; it contains important nutrients such as protein, minerals, vitamins, sugar, water, and fibre needed for healthy body growth and development” (Bailey, 1992). Its fresh/young leaves and stems are boiled as greens (Akparobi, 2009). They are used as soup vegetables or for boiled salad greens (Adeyemi *et al.*, 1987; Akparobi, 2009). The nutrient values of amaranths per 100% edible portion (leaves) was estimated by (Tindall, 1975), to be: protein 5 g, fat 0.7 g, carbohydrates 5 g, water 85 ml, calorie 48, fibre 1.5 g, calcium 250 mg, iron 4 mg, B-carotene equivalent 1 800 mg, riboflavin 0.3 mg, thiamine 0.1 mg, niacine 1.5 mg and ascorbic acid 100 mg (Akparobi, 2009).

Quarry can be defined as an act of exploring, exploiting and using rocks in order to obtain minerals (Keeperman, 2000; Eta *et al.,* 2019). It involves the extraction of minerals (non-metal) and non-fuel materials from rocks for man’s use (Nwachukwu *et al.,* 2018; Eta *et al.,* 2019). Examples of products gotten from quarry activities are limestone, sandstones, marble, perlite, ironstone, granite, slate, rock salt and phosphate rock. Some of these products are used as raw materials for construction of rail, road, building, other industrial and civil constructions and others are used for other purposes. These purposes can be; making traditional hard floors and ceramic tiles (Lameed and Ayodele, 2010; Eta *et al.,* 2019).

Quarrying like many other man-made activities causes a significant impact on the environment. In particular, it is often necessary to blast rocks with explosives in order to extract material for processing but this method of extraction gives rise to noise pollution, air pollution, damage to biodiversity and habitat destruction. Quarry mining is one of the major causes of environmental pollution in Africa especially in Nigeria. It has negative effect on plants. The mechanical processes of crushing rocks into smaller sizes generate pollutants that are largely particulate in nature. These particulate contaminants have been known to adversely affect human health, soil and air quality, and vegetation.

The present study is therefore, aimed at assessing the impact of quarry soil on morphological and nutritional composition of amaranths grown in Akungba, Southwestern Nigeria.

**MATERIALS AND METHODS**

 **Study Area**

The study was conducted in the screen house of Faculty of Agriculture, Adekunle Ajasin University Akungba-Akoko, Ondo State which lies between Latitude 7023’N and Longitude 5000’E. it is located South western part of Nigeria. The quarrying site is located at Supare Community (Latitude 7048’N and Longitude 5075’E).

**Soil Sample Collection**

Soil samples were collected at distances of 100m, 200m, 300m and 400m away from the quarry site at Sutol Crushed Rock Industries, Supare-Akoko, Ondo State. Soil samples were taken at a ploughing depth of 0 - 15cm using a calibrated soil auger while the Seed of *Amaranthus cruentus* L. was acquired from the National Horticulture Research Institute Ibadan, Nigeria.

**Soil Preparation**

The quarry soil from each distance were bucked together to obtain a composite sample. The samples were packed in polyethylene bags, labeled appropriately and transported to the screen house of Faculty of Agriculture. Ten kilograms (10kg) each was weighed into a perforated plastic bucket and replicated four times.

**Planting Procedure**

Amaranth seed was broadcasted into perforated plastic bucket filled with 10kg of quarry soil. Thinning was performed 7 days after emergence, removing seedlings to 5 stands. Irrigation was performed daily to retain soil moisture. The plants were allowed to establish for 14 days before data on the following agronomic parameters and at 8 weeks before they were subjected to laboratory analysis.

**Plant Data Collected**

The parameters considered were plant height (cm), number of green leaves, leaf area (cm2), stem girth (cm), number of senescence leaves, fresh shoot weight(g), fresh root weight(g), dry root weight(g), root length(cm), and total number of roots.

**Laboratory Analysis**

**Determination of chlorophyll content**

5g each of the Amaranth leaves were grounded in 20ml of 80% (%) acetone using a mortar and pestle. The brew was filtered through a whatman’s No 1 fiter paper. The pigment quantities in the acetone extract were determine on a CE 373(visible) linear readout spectrophotometer at wavelength of 66nm and 647nm, chlorophyll ‘a’ and ‘b’ and the total chlorophyll quantities were determined using the formula. Chlorophyll ‘a’ (µm) =13.19A664-2.37A64

Chlorophyll ‘b’ (µM) =22.10a647-5.26A664 Total chlorophyll (µM) =7.93A664+19.53A67 A664 is the absorbance at 664nm A647 is the absorbance at 667nm (coombs *et al*., 1993)

**Nutritional content Analysis**

Determination of vitamin C

The vitamin C content was determined using the ascorbic acid as the reference compound. 200ml of the extract was pipette and mixed with 300ml 0f 13.3% of TCA and 75microliter of DNPH. The mixture was incubated at 37oC for 3hours and 500ml of 65% H2SO4 was added and the absorbance was read at 520nm (Benderitter *et al*., 1998). Conc.(mg/g) =Abs. of sample Slope standard.

Determination of vitamin A

A weighed quantity of sample was mixed, contain not more than 1g fat and at least 240 unit of vitamin A with 30ml of 5% potassium hydroxide. Gently boil under reflux for 30 minute in a stream of oxygen. Cool rapidly add 30ml water, transfer to separator, wash in with 3x50ml ether and extract the vitamin A by shaking for 1min. after complete separation the lower layer was discarded and the extract was washed in with 3x50ml water, mixing especially and continuously during the first two washes to avoid emulsion formation. Evaporate the washed extract down to about 5ml and the remaining ether in a stream of nitrogen at the room temperature was removed. The residue was then dissolve in sufficient isopropyl alcohol to give a solution on containing units per ml and measure the extinctions at 300,310,325 and 334nm and the wavelength of maximum absorption. Pearson D. (1976).

**Proximate Analysis**

**Crude fiber determination**

2g of defatted sample was weighed into 250 ml beaker containing 200 ml of 0.125M tetraoxosulphate (iv) acid (Sulphuric acid). The mixture was heated in a steam bath at 700c for hours, and then allowed to cool. The cooled mixture was filtered using a muslin cloth over a Buckner funnel. The residue was washed three times with hot water to remove the acid and then put in a beaker containing 200 ml of potassium hydroxide. The Mixture was heated as before over a steam bath for 2 hours. The solution was filtered and the residue washed three times with hot water. The final residue obtained was put in clean pre-weighed crucible and dried at 1200C to a constant weight. The crucible with the dry sample was put in a muffle furnace and ash at 5500C for 30 minutes such that the sample became ash white. Percentage fiber was calculated as followed: % Fibre = after oven dried, change in weight after ashing **/** sample weight

**Protein Content**

This method was divided into three namely, digestion, distillation and titration.

Digestion: Approximately 0.1g of ground sample was weighed into clean dried Kjeldahl flask for digestion, and 0.1g copper tetraoxo-sulphate (iv) crystals, 0.5g sodium tetraoxosulphate (iv) crystal and 25ml of concentrated H2SO4 acid was added into the flask and some glass beads was added into the flask content as anti-bumping agents. The Kjeldahl flask and its content was transferred to the digesting chamber in a fume cupboard and digested. Digestion continued with constant rotation of the digestion flask until the sample changed colour (that is from black to light blue). The digestion flask was removed from the digesting chamber and allow cooling. The digest was made up to 100ml using distilled water and shaken vigorously to a homogenous solution.

Distillation: Out of the homogenous solution of the digest, 20ml was transferred into a distillation flask using a pipette. Then 20ml of 40% sodium hydroxide solution was added carefully down the side of the flask through a funnel. Then 50ml of 2% boric acid solution was pipette into a receiving flask and two drops of methyl red indicator added. The distillation unit was fitted such that the condenser is connected to the receiving flask with a glass tube, and the condenser cooled with constant supply of cold water from tap. Also, the tip of the glass tube was immersed in the boric acid. The distillation unit is heated on a heating mantle for 35 minutes until the pink solution of the boric acid turned blue and the volume increased to about 100ml by the distillate.

Titration: Ten milliliters of the distillate was titrated against 0.1N hydrochloric acid to a colourless end point. A blank solution will also be titrated to get any trace of nitrogen in the blank. All the titre volumes were recorded. The percentage crude protein was calculated as follows: %Crude protein = % Nitrogen X 6.25

**Ash content determination**

Clean dried crucibles were weighed on an electronic balance and 5g of sample weighed into the crucibles. The samples were dried in the oven until constant weights are obtained. Then, the samples were transferred into the muffle furnace with a pair of tongs and ash at 550oC for 4 hours until ash was obtained. The sample was removed from the furnace and cooled in desiccators, and reweighed. The percentage ash was calculated as followed: % Ash = Ash weight **/** Sample weight

**Carbohydrate content determination**

The carbohydrate content of the sample was obtained by difference, that is, as the difference between the total summations of percentage moisture, fat, fiber, protein, ash and 100%. Carbohydrate= 100 – (% moisture + % fat + % protein + % fiber + % ash Determination of mineral content The mineral contents of the test samples was determined by the dry ash extraction method following each specific mineral element as described by AOAC. Twenty (20) grams of the samples was burnt to ash (as in ash determination and the resulting ash was dissolved in 100ml of dilute hydrochloric acid (1MHCL) and then diluted to 100ml volumetric flask using distilled water. The solution was used for the various analysis of mineral AOAC. Official method of Analysis. 18th Edition, Association of Officiating Analytical Chemists, Washington DC, Method 935.14 and 992.24; 2005.

**Data Analysis**

Data collected were subjected to Analysis of Variance using Minitab Version 17. The means were separated using Least Significant Design (LSD).

**RESULTS**

Growth of Amaranths

The growth of amaranths grown on soil samples collected from the quarry site under study are presented. Fig 1a shows that, the soil taken from 400m distance from the quarry site gave the highest plant height in week 2, 4, and 8 respectively. It was observed that there were significant differences in all number of green leaves. Week 2, 4 and 8 shows higher number of green leaves at a distance of 100m. Soil collected at a distance of 300m shows the highest number of green leaves in week 6 as shown in fig 1b. As shown in fig 1c, it was observed that there were significant differences in all leaf area of the plants. Soil collected at a distance of 300m gave the highest leaf area in 2, 6 and 8 weeks while Soil collected at a distance of 200m gave the highest leaf area in week 4. Moreover, the stem girth of amaranths was significant. Week 2 ad 6 shows the highest number of stem girth at a distance of 300m. fig. 1d.

Figure 1a: Plant Height of Amaranths at Different Distances from the Quarry Site.

Figure 1b: Number of Green Leaves of Amaranths at Different Distances from the Quarry Site.

 Figure 1c; Leaf Area of Amaranths at Different Distance from the Quarry Site.

Figure 1d: Stem Girth of Amaranths at Different Distances from the Quarry Site.

**Biomass of Amaranths**

The effects of quarry soil on biomass accumulation of amaranths plant. Figure 2a, shows the effects of quarry soil on Number of Senescence Leaves at 2, 4, 6 and 8 weeks after planting. It was observed that at 4,6 and 8 weeks, the plants had a significantly (P<0.05) higher of number of Senescence Leaves. Also, the root length (cm) of Amaranths at 8 weeks after shows the lowest root length at a distance of 200m (fig 2b). Fig 2c shows the total number of roots where plants at 100m had a significant higher numbers of root. The fresh root weight of *Amaranthus cruentus* L. shows to have a higher fresh root weight at a distance of 200m as show in fig. 2d. The dry root weight and fresh shoot weight of the plant at a distance 200m were lower compared to other distances as shown in fig 2e and 2f.

Figure 2a: Number of Senescence Leaves at Different Distances from the Quarry Site.

fig 2b: Root Length of Amaranths at Different Distances from the Quarry Site.

Figure 2c: Total Number of Roots of Amaranths at Different Distances from the Quarry Site.

Figure 2d: Fresh Root Weight of Amaranths at Different Distances from the Quarry site.

Figure 2e: Dry root weight of Amaranths at Different Distances from the Quarry Site.

Figure 2f: Fresh Shoot Weight of Amaranths at Different Distances from the Quarry Site**.**

Proximate composition of *Amaranthus cruentus* Plant Part

The effects of quarry soil on the proximate compositions of *Amaranthus cruentus* are presented in Table 1a. The moisture content on the leaf of *Amaranthus cruentus* (69.05g/ 100g) was observed to be significantly (P < 0.05) higher than that observed in the stem (61.98g/ 100g). The ash contents of the Amaranthus cruentus on the leaf and stem are 2.57g/100g and 1.98g/100g respectively. Inferentially, the ash content of the Amaranthus cruentus leaf was observed to be significantly higher than that of the stem. Also, result showed that the fat content of the Amaranthus cruentus leaf (2.43) was significantly (P < 0.05) higher when compared with the fat content obtained for the stem (0.63). However, the fibre content of the plant was significantly (P < 0.05) higher in the stem (16.67) compared to the leaf (9.46). Furthermore, the obtained protein content of the *Amaranthus cruentus* plant were observed to be significantly (P < 0.05) higher in the leaf in comparison to the stem. However, the stem of the Amaranthus cruentus plant was observed to have significantly (P < 0.05) higher carbohydrate content (15.18), when compared to the leaf (8.73)

The effects of soil distance from quarry soil on the proximate compositions of *Amaranthus cruentus* is presented in Table 1b. Interestingly, this study was observed that there is a significantly (P<0.05) increase in moisture content of Amaranthus cruentus plant as the distance of obtained soil increases. Also, result showed that the fat content of the Amaranthus cruentus plant was observed to increase significantly (P<0.05) with increase in soil distance to quarry site. Meanwhile, the fibre content was highest in the Amaranthus cruentus planted on the soil obtained at 100m from the quarry site. Furthermore, the obtained protein content of the Amaranthus cruentus plant were observed to significantly (P<0.05) decrease as the distance to quarry site increased. Likewise, the Amaranthus cruentus plant was observed to increase significantly (P<0.05) in carbohydrate content as the distance to quarry site increased.

Table 1a. Proximate Composition of *Amaranthus cruentus* on Plant Part

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Plant part | Moisture | Ash | Fat | Fibre | Protein | CHO |
| Leaf | 69.05a | 2.57a | 2.43a | 9.46b | 7.75a | 8.73b |
| Stem | 61.98b | 1.98b | 0.63b | 16.67a | 3.56b | 15.18a |

Table 1b. Proximate Composition of *Amaranthus cruentus* at Different Distances from the Quarry Site

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Distance** | **Moisture** | **Ash** | **Fat** | **Fibre** | **Protein** | **CHO** |
| **100m** | 67.27a | 1.63c | 0.84b | 14.19a | 5.83a | 10.24b |
| **200m** | 65.93ab | 2.47ab | 2.14a | 12.38b | 6.63a | 10.45b |
| **300m** | 64.51b | 2.37b | 2.06a | 12.63b | 5.50ab | 12.93a |
| **400m** | 64.36b | 2.63a | 1.08b | 13.06ab | 4.68b | 14.19a |

**Nutrient Composition of *Amaranthus cruentus on* Plant Part**

The leaf of the *Amaranthus cruentus* plant elicited significantly (P < 0.05) higher Vitamin C (65.13) and Vitamin A (1552.58) contents in comparison to the stem’s Vitamin C (56.86) and A (1252.85) contents. Also, the calcium content was significantly (P < 0.05) higher in the leaf (2.98) in comparison to that obtain for the stem (2.48), while the iron content was significantly (P < 0.05) higher in the stem (2.74) in comparison to that obtain for the leaf (2.51) as shown I Table 2a.

**Nutrient Composition of *Amaranthus cruentus* at different Distances**

Table 2b shows the effects of soil distance to quarry site on the proximate compositions of *Amaranthus cruentus*. The vitamin C and potassium content on the *Amaranthus cruentus* plant was observed to increase according at a distance of 300 m from quarry site. Also, this study observed a significant (P<0.05) decrease in vitamin A content of *Amaranthus cruentus* plant as the distance of obtained soil increases. However, the vitamin A content was significantly (P<0.05) elevated at 400m. Furthermore, the obtained iron content of the *Amaranthus cruentus* plant were observed to significantly (P<0.05) increase as the distance of 100 m.

**Table 2a. Nutrient Composition of *Amaranthus cruentus* Plant Part**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Plant part | Vit. C | Vit. A | K | Ca | Fe |
| leaf | 65.13a | 1552.58a | 4.46a |  2.98a | 2.51b |
| stem | 56.86b | 1252.85b | 4.46a | 2.48b | 2.74a |

**Ta**b**le 2b. Nutrient Composition of *Amaranthus cruentus* at different Distances**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Distance | Vit. C | Vit. A | K |  Ca | Fe |
| 100m | 46.03c |  1310.52b |  4.55ab |  2.73a | 2.98a |
| 200m | 67.26b | 997.88d |  4.19c |  2.71a | 2.60b |
| 300m | 89.33a | 1166.39c |  4.57a |  2.87a | 2.46d |
| 400m | 41.37d | 2136.07a |  4.53b |  2.61a | 2.48c |

## Interaction effect between proximate composition and plant parts

## The interaction effects of quarry soil on the proximate compositions of *Amaranthus cruentus* leaf

## and stem is presented in Table 3a. Interestingly, the interaction between the plant parts and distance

## on proximate composition increase in the moisture content of the leaf. However, the ash content

## was altered in the leaf and stem of *Amaranthus cruentus,* but the alteration was not consistently

## proportional to the distance of the quarry site. Also, the interaction between the plant parts and

## different distance was significantly (P<0.05) higher on fat content of the leaf in comparison to the

## stem. More so, the fibre content of the *Amaranthus cruentus* leaf and stem was altered, but the

## alteration was not proportional to the distancing to quarry site. Likewise, the protein was significantly

## lower in the stem of the plant at a distance of 300 m.

## Interaction effect of Nutrient Compositions between Plant Parts and Distances

## The interaction effects of quarry site on the nutrient compositions of *Amaranthus cruentus* leaf and

## stem is presented in Table 3b. Interestingly, the Vitamin C and Calcium content of the vegetable was

## observed to be relatively high in the leaf of *Amaranthus cruentus* at a distanceof 300mleaf. However,

## the vitamin A and Potassium content was highest in the leaf of *Amaranthus cruentus* at a distance of

## 400m*.* Also, the interaction between the plant parts and different distance was observed to result in

## significant (P<0.05) higher Iron content in the stem in comparison to the leaf.

## Table 3a. Interaction of Proximate Composition between Plant Parts and Distances

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Distance (m) | Plant part | Moisture | Ash | Fat | Fibre | Protein |
| 100 | Leaf | 62.35d | 0.96c | 0.41c | 20.72a | 3.66cd |
| Stem | 72.10a | 2.31b | 1.27c | 7.66d | 8.00a |
| 200 | Leaf | 69.71ab | 2.82a | 3.22ab | 8.52d | 8.61a |
| Stem | 62.15d | 2.11b | 1.06c | 16.24b | 4.64bc |
| 300 | Leaf | 68.01bc | 2.24b | 3.45a | 9.68d | 8.71a |
| Stem | 61.01d | 2.51ab | 0.66c | 15.58b | 2.30d |
| 400 | Leaf | 66.32c | 2.93a | 1.78bc | 11.99c | 5.70b |
| Stem | 62.41d | 2.33b | 0.38c | 14.13bc | 3.66cd |

## Table 3b. Interaction of Nutrient Compositions between Plant Parts and Distances

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Distance (m) | Plant part | Vit. C | Vit. A | K | Ca | Fe |
|  100 | Leaf | 56.98d | 1275.70d | 4.52d | 2.48cd | 2.45e |
| Stem | 35.08f | 1345.34d | 4.59c | 2.98abc | 3.50a |
|  200 | Leaf | 83.73c | 1093.94d | 4.05f | 2.62bcd | 1.95g |
| Stem | 50.79e | 901.82e | 4.32e | 2.79abc | 3.25b |
|  300 | Leaf | 91.22a | 1511.81c | 4.49d | 3.23a | 2.75d |
| Stem | 87.44b | 820.97f | 4.66b | 2.52cd | 2.17f |
|  400 | Leaf | 50.51e | 2259.23a | 4.72a | 3.10ab | 1.85h |
| Stem | 32.24g | 2012.92b | 4.33e | 2.13d | 3.11c |

**Discussion**

A large range of industrial processes can produce particulate emission which could affect the growth and development of plants. “Dust from quarry sites is a major source of air pollution, although the severity will depend on factors like the local microclimate conditions, the concentration of dust particles in the ambient air, the size of the dust particles and their chemistry, for example limestone quarries produce highly alkaline (and reactive) dusts, whereas coal mines produce acidic dust. The air pollution is not only a nuisance (in terms of deposition on surfaces) and possible effects on health, in particular for those with respiratory problems but dust can also have physical effects on the surrounding plants, such as blocking and damaging their internal structures and abrasion of leaves and cuticles, as well as chemical effects which may affect long-term survival” (Nduka *et al.,* 2022). Amaranths cultivated in soil collected from Quarry site showed significant differences in various physiochemical parameters with respect to differences in distances from the quarry site. Plant height generally ranges from 100m to 400m as *Amaranthus cruentus L.* had the highest height at 400m from the site. The high plant height in all distances was in agreement with the results of (Bouma *et al.,* 2010) that plants growing in a high concentration of dust pollution respond to nutrient stress by devoting more of their available carbon to shoot growth resulting in elongated stems. (Reynolds *et al.* 2016) postulated that these changes in plant habit can be attributed to daily photosynthetic changes and nutrient assimilation rate. The survival of the plants under quarry dust infested environment depends on the efficacy with which plants utilize the available nutrients.

 Interestingly, the moisture contents of the *Amaranthus cruentus* leaf and stem (Table1a) was significantly (P < 0.05) higher than that recommended (< 10 g/100 g) for food samples (NIS, 2004). This is an indication that the plant leaf and stem will lack adequate shelf life and therefore cannot be stored for a long period of time without experiencing nutritional quality deterioration or spoilage (Oluwajuyitan *et al.,* 2021). Typically, food samples with high moisture contents make nutrients hard to access and promote the activities and growth of microorganisms, thereby resulting in speedy food-samples’ spoilages (Adeoti and Osundahunsi, 2017; Oluwajuyitan *et al.,* 2021). However, the high moisture content of the leaf and stem may be an employed mechanism by the *Amaranthus cruentus* to survive, as quarry dusts have been proven to significantly deplete atmospheric moisture, thus forcing the plant to elevate its water uptake by the roots (Nduka *et al.,* 2022). Inferentially, the plant leaf has significantly (p<0.05) higher moisture content compared to the stem, as the leaf are more in contact with the atmospheric condition of the quarry site than the stem.

The crude ash content of a plant is the indication of mineral content of the plant and quality parameter for contamination (Owheruo *et al.,* 2021). Interestingly, the ash and fibre contents (Table 1b) of the quarry site exposed *Amaranthus cruentus* plant was within acceptable levels in comparison to the 2.6% and 3.1% observed by Mburu *et al.* (2012). An indication that the *Amaranthus cruentus* plant has developed strategies to mitigate against the possible bio toxicological effect expected as a result of exposure to quarry. However, the disparity in the crude ash and fibre contents between the leaf and stem could be attributed to their rate of exposure to the quarry condition, thus the necessitation of adaptation against the possible effects. More so, the maintenance of ash and fibre content could be as a result of increased metal accumulation and increased synthesis of lignin leading to woody texture in the vegetables that are associated with quarry site plants (Osuocha *et al.,* 2016a). Thus, the significantly (p<0.05) higher ash and fibre content observed with the *Amaranthus cruentus* leaf in comparison with stem may further commemorate the adaptivity of the plant as a result of its survival mechanism. However, the ash and fat contents of the *Amaranthus cruentus* plant were observed to increase as the distance of the soil obtained from the quarry site increases. Interestingly, the same pattern was observed for the leaf and stem analysis of the *Amaranthus cruentus.*

Energy is a function of the protein, fat and carbohydrate composition of any food product which could be the reason for variation in the energy values of the products (Ojinnaka *et al*., 2018). However, the fat contents of the *Amaranthus cruentus* leaf (2.43g/ 100g) and stem (0.63g/ 100g) (Table 1b) observed in the present study are significantly (p<0.05) low in comparison to the 7.0g/ 100g observed by Mburu *et al.* (2012). The low-fat content recorded in the present study might result in low energy value, which is unbeneficial as it would not be sufficient to supply adequate calories required for daily activities (Hasan *et al*., 2020; Simanjuntak *et al.,* 2020). Although, high fat content is nutritionally advantageous because it could increase the energy level of a diet, however, it could reduce the shelf life and stability of the food product during storage (Adeoti and Osundahunsi, 2017), which would compensate for the high moisture content of the plant parts. However, increase in the fat content of the *Amaranthus cruentus* plant was observed in proportion of the distance of the soil obtained was increasingly farther from the quarry site. Which may be indicative of reduction in the shelf life of the plant. Notably, this may be beneficial nutritionally, as the energy level would have been improved (Ojinnaka *et al*., 2018).

Comparative analysis also showeda significant (p<0.05) decrease in protein content of *Amaranthus cruentus* leaf (7.75g/ 100g) and stem (3.56g/ 100g) in comparison to the 17.2g/ 100g reported by Mburu *et al.* (2012). In addition to the nutritional potentials of high protein content diet foods, proteins are essential for biochemical activities as well as in the building and repair of new body tissues (Oluwajuyitan *et al.,* 2021). In humans, vitamins play a vital role in cellular defense against oxidative stress (Osuocha *et al.,* 2016b). Findings of this study revealed a significant increase in vitamin A and C composition of Amaranthus *cruentus.*

Also, the comparatively higher potassium content of the *Amaranthus cruentus* plant leaf (4.46 mg) and stem (4.46 mg) in comparison to the 508 mg/100 g reported by Wolosik and Markowska (2019) may be indicative of the adverse effect of the quarry condition on the mineral components of the plant. Furthermore, the comparatively lower calcium and iron contents of the *Amaranthus cruentus* plant’s leaf (2.98 and 2.51) and stem (2.48 and 2.74) respectively in comparison to the calcium (159 mg) and iron (7.61 mg) reported by Wolosik and Markowska (2019).

 **Conclusion**

Findings from this study revealed that amaranths plants at all distances accumulated and translocated variable amount of dust particles from the soil into the plant tissues. The Findings from the study also suggest negative impact on nutritional composition of vegetable grown on rock quarry soils. This implies that rock mining has a negative impact on different environmental media including plants.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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