http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS Pakistan Journal of Biological Sciences

ISSN 1028-8880
DOI: 10.3923/pjbs.2020.795.803

CrossMark

Research Article

Impacts of Quarry Mining Activities on Herbaceous Plant *Ageratum conyzoides* L. in Ugwuele-Uturu, Abia State, Nigeria

[1]Ogbonna Chidi Enyinnaya, [2]Ikpeazu Victor Okezie, [2]Emmanuel Okezie, [2]Uzor Uzoma Evangeline and [2]Ugbogu Eziuche Amadike

[1]Department of Environmental Resource Management, Abia State University, PMB 2000, Uturu, Nigeria
[2]Department of Biochemistry, Abia State University, PMB 2000, Uturu, Abia State, Nigeria

Abstract

Background and Objective: *Ageratum conyzoides* L. (Asteraceae) is nutrient compliant weed used as forage for grazing animals. It is used in the treatment of various ailments such as wounds, diabetes, pneumonia, asthma and stomach upset. This present study investigated the influence of quarrying on the nutritional composition, heavy metals and oxidative stress indices of the leaves, stem and root of *Ageratum conyzoides*. **Materials and Methods:** The various parts of *Ageratum conyzoides* harvested from a quarry site were compared with those harvested from a non-quarry (control) environment. Phytochemicals, proximate, mineral compositions as well as heavy metals, oxidative stress and air pollution tolerance index were investigated using standard analytical methods. **Results:** The results from this study revealed greater amount of alkaloid, saponins and flavonoids in the leaf, stem and root from the quarry site when compared to the control site. The micromorphological foliar revealed constricted venial and stomatal deformed guard cells on the quarry site when compared to the control. There were increased levels ($p<0.05$) in ascorbic acid, air pollution tolerance index (APTI) and pH in the samples collected from the quarry site, while percentage relative water and chlorophyll contents significantly decreased ($p<0.05$) in the quarry site when compared to the control. **Conclusion:** The results show that quarry mining activities induced biochemical stress and increased health promoting phytochemicals in *Ageratum conyzoides*.

Key words: Heavy metals, phytochemicals, proximate composition, air pollution tolerance, quarry mining, oxidative stress

Citation: Ogbonna Chidi Enyinnaya, Ikpeazu Victor Okezie, Emmanuel Okezie, Uzor Uzoma Evangeline and Ugbogu Eziuche Amadike, 2020. Impacts of quarry mining activities on herbaceous plant *Ageratum conyzoides* L. in Ugwuele-Uturu, Abia State, Nigeria. Pak. J. Biol. Sci., 23: 795-803.

Corresponding Author: Eziuche Amadike Ugbogu, Department of Biochemistry, Abia State University, PMB 2000, Uturu, Abia State, Nigeria
Tel: +2348167550663

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Environmental pollution is one of the greatest challenges the world is facing today with an annual irreparable damages on nutritional compositions of plants, edaphic factors and animals[1]. Plants are crucial environmental resources. They have much relevance on socio-economic aspects of life which include: run-off control, prevention of soil erosion, air purification, air pollution monitoring, stabilizing natural system, carbon sink, microclimatic modification and provision of habitats[2]. The trees and leaves of plants are in constant exchange of gases with the atmosphere and provide canopy for trapping particulate matter[3]. In addition, they serve as source of food and medicine.

In the quest to attain modern civilization, anthropogenic activity has not been neglected. Quarrying as an anthropogenic activity involves the processes of digging or excavating natural stones from quarry sites. It also involves the act of exploring and exploiting stone from rocks usually accompanied by crushing and grading of stones into smaller pieces[4]. Reports have revealed that industrial and economic development such as quarrying has significant detrimental impacts on human health as well as the environment[5].

In quarry vicinity, inhabitant plants often trap particulate matters leading to the accumulation of heavy metals and other toxic substances which are mainly caused by emissions from the quarry sites. Pollution from metal has become one of the most deleterious environmental problems today[6] and metals cannot be biodegraded by microorganisms unlike organic compounds. However, these emissions when inhaled or ingested can deteriorate and distort the metabolic activity, thereby predisposing individuals to serious health deviations like cardiovascular and vascular diseases including nodular fibrosis, asthma, hypoxia and chest congestion, diabetes, haematological disorders, hearing loss, carcinoma and portal fibrosis[7,8].

Reports have revealed that environmental stress alters both the physiological and biochemical parameters of plants. These include stunted growth, foliar structure distortion, abrading of leaves and cuticle, necrosis, oxidative stress, inhibition of photosynthesis and stomata conductance inhibition[9].

Over the past few decades, plants have been reportedly used as bio-monitors of environmental pollution[3]. One of such plants that have been reported in the pharmacopeia for its medicinal utilities and examined for its phytoremediation capacity is *Ageratum conyzoides*. It is an annual herbaceous plant with white flowers commonly eaten by goats in rural areas. *A. conyzoides* serves as fodder for grazing animals. It is found in various parts of the tropical and subtropical regions of the world and has been known to have originated from tropical part of America[10]. Many bioactive compounds including flavonoids, alkaloids, saponins, coumarins, essential oil, tannins, cardiac glycosides, anthraquinones, chromenes, benzofurans and terpenoids have been reported to be present in this plant[11]. The mineral compositions of the resource plant have shown to be rich in Na^+, K^+, Ca^{2+}, Mg^{2+}, P, Zn^{2+}, Mn^{2+} and Fe^{2+}, while vitamins like riboflavin, pyridoxine, ascorbic acid, α-tocopherol, thiamine and niacin are also present. The presence of these compounds and elements contribute to its medicinal potential[12].

Moura *et al.*[13] reported the anti-inflammatory activity of *Ageratum conyzoides* leaves with no hepatotoxicity. The plant has also been known to possess wound healing potentials[14]. It is also used in the treatment of boils, skin diseases, eye inflammation, burns, diabetes, headaches, pneumonia, asthma, spasmodic, stomach ailment and gynecological diseases[11]. It also has bactericidal and fungicidal, analgesic and antipyretic properties[15]. Dayie *et al.*[16] has reported that methanolic extract of *A. conyzoides* inhibited the activity of *Staphylococcus aureus* and *Escherichia coli*. However, various pharmacological examinations have validated *A. conyzoides* as hepatoprotective agent[17], haematological parameter enhancer[18], antioxidant agent[19] and antiulcerogenic potentials against gastric lesions[20].

In pastoral farming, *Ageratum conyzoides* is nutritionally sound for grazing animals. To increase profitability from this agricultural practice, farmers have resorted and relied on forages, grazing and pastures. It is also Rioba and Stevenson[21] revealed that *Ageratum conyzoides* has high insecticidal activity against various fields and storage crop pests including *Callosobruchus chinensis*, *Sitophilus oryzae*, *Chilo partellus*, *Panonychus citri*, *Sitophilus zeamais* and *Brevicoryne brassicae*. Given the various significant roles of *Ageratum conyzoides*, it is pertinent to understand how they respond to the quarry mining pollution. It is against these backbones, that the present study investigated for documentation the influence of quarry mining on nutritional composition, heavy metals and oxidative stress indices of *Ageratum conyzoides*.

MATERIALS AND METHODS

Study area: The study was carried out at Department of Biochemistry laboratory, Abia State University, Quality June-September, 2018. The plant (*Ageratum conyzoides*) was collected from two locations. The one collected from the quarry mining site located at Ugwuele, Abia state, Nigeria served as the test sample. Ugwuele lies between latitude

5°35' N and 5°55'N and longitudes 7°22'E and 7°30'E. Samples from the second location were collected around the environs of Abia State University, Uturu, Abia State, Nigeria where there are no quarrying activities and this served as the control sample.

Sample preparation: *Ageratum conyzoides* collected from both the quarry and control sites were destalked, sorted and thoroughly washed to remove dirt and other impurities. The various parts (leaf, stem and root) were sundried differently for 8 consecutive days. After this process, the samples were respectively milled using a mechanical homogenizer.

Determination of nutritional parameters of *Ageratum conyzoides*

Phytochemical analysis : Alkaloids, saponins, flavonoids and phenols were estimated by the methods described by Harborne[22], while tannin was quantified using the Folin-Denis spectrophotometric procedures as reported by Shabbir *et al.*[23].

Determination of proximate analysis: The assessment of the proximate constituents of *Ageratum conyzoides* were determined by methods described by the Association of Official Analytical Chemists (AOAC[24]).

Mineral and heavy metal compositions: The estimated mineral compositions of *Ageratum conyzoides*, calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), iron (Fe^{2+}), zinc (Zn^{2+}) were determined using a flame photometer as reported by Association of Official Analytical Chemists (AOAC[24]). The method described by AOAC[24] was also adopted for the heavy metal estimation. Different concentrations of the evaluated heavy metals were determined using atomic absorption spectrophotometer (AAS).

Determination of biochemical parameters of *Ageratum conyzoides*

Determination of ascorbic acid content: It was determined by the methods described Bajaj and Kaur[25]. Exactly 1 g of *A. conyzoides* leaf was treated and extracted with 4 mL of oxalate ethylenediaminetetraacetic acid (EDTA) solution in a test tube. Then, 1 mL of orthophosphoric acid, 1 mL of 5% tetraoxosulphate (vi) acid (H_2SO_4), 2 mL of ammonium molybdate and 3 mL of water were sequentially added. The resultant mixtures were allowed standing for 15 min. Then, the absorbance of the solution was read at wavelength of 760 nm.

Determination of chlorophyll content: The method described by Arnon[26] was employed. Exactly 3 g of blended *A. conyzoides* leaf was soaked in 10 mL 80% acetone and allowed standing for 15 min. The heterogeneous mixture was spun at 25000 rpm for 3 min in a centrifuge. The supernatant was read at wavelength of 663 nm using a spectrophotometer.

Determination of pH level: The leaf extract was soaked in deionized water and filtered using a filter paper. Exactly 10 mL of the filtrate was dipped into the electrode of pre-calibrated pH meter.

Determination of relative water content (%): It was estimated as described by Singh[27]. Freshly harvested *A. conyzoides* leaf was weighed and the weight was labeled as fresh mass. The leaf was floated in distilled water in an enclosed petridish and allowed for 24 h at room temperature. Post 24 h incubation periods, the leaf was blot-dried using filter paper and re-weighed. This weight was labeled turgid mass. Furthermore, the sample was placed in a hot air oven at temperature of 80°C for 48 h. After this, the sample was reweighed and recorded as dry mass:

$$\text{Relative water content (\%)} = \frac{\text{Fresh mass-Dry mass}}{\text{Turgid mass-Dry mass}} \times \frac{100}{1}$$

Determination of air pollution tolerance index (APTI): APTI is calculated mathematically using the formula below:

$$\text{APTI} = \frac{A\,(T+P)+R}{10} \tag{1}$$

Where:

A = Ascorbic acid content (mg g^{-1})
T = Total chlorophyll content (mg g^{-1})
P = pH of leaf sample
R = Relative water content (%)

The significance of APTI is based on the reference numbers below:

- APTI 30>100 is given as tolerant plant species
- APTI 17>29 is considered intermediate plant species
- APTI 1>16 is considered sensitive plant species
- APTI <1 is considered very sensitive plant species[28]

Micromorphological investigation of the foliar epidermis: The upper and lower surfaces of the leaves representing adaxial and abaxial respectively were prepared by Clearing method. The leaf samples were soaked for 18 h in a commercially prepared 3.5% sodium hypochlorite in a petridish. The epidermis was further scraped, stained with safranin and examined under light microscope at X400 magnification from Olympus Tokyo (Japan No.271961). The pictorial sections were taken using Motic Camera of version 2.0.

Statistical analysis: Triplicate determinations of the analyzed data and graphs were calculated using Microsoft Excel package 2010. The results were tested for statistical difference at 95% level of confidence using GraphPad Statistical Prism of version 7.03.

RESULTS

Phytochemical and proximate composition of *Ageratum conyzoides*: Table 1 shows the phytochemical analysis of *Ageratum conyzoides* from a control and quarry mining site. From the result, there was a significant elevation in the percentage phyto-constituents of leaf, stem and root extract of *Ageratum conyzoides* obtained from the quarry sites when compared to the control sites. More so, HCN were greater in amount on the leaf and root from the control site, while HCN and tannin were not detected on the stem and root samples obtained from the quarry site.

Proximate analysis of *Ageratum conyzoides* from a control and quarry mining site is presented in Table 2. The trend of the results obtained from the leaf, stem and root extract of the plant showed slight percentage increase in all proximate parameters in the sample obtained from the quarry site except crude lipid (leaf and root) and carbohydrate content (stem and root) were in significant amount more than those obtained from the quarry site.

Mineral and heavy metal composition of *Ageratum conyzoides*: Table 3 shows the mineral constituents of *Ageratum conyzoides* from control and quarry mining site. With the exception of Ca^{2+} and Na^{+} (leaf), Na^{+} (root), the various quantified minerals, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Fe^{2+} and Zn^{2+} were significantly more in the different parts of *A. conyzoides* obtained from the quarry site than the control site. However, K was not detected in the leaf and stem samples from the quarry sites.

Table 4 is the result obtained from heavy metal composition. *Ageratum conyzoides* from a control and quarry mining site. The following heavy metals, Cr^{2+}, Cd^{2+} and Ni^{2+} (leaf and stem) and Pb^{2+}, Cr^{2+} and Cd^{2+} (root) were below the detectable limit of the sample obtained from the quarry site. However, Mn^{2+}, Pb^{2+}, Co^{2+} (leaf), Pb^{2+} (stem) and Mn^{2+}, Ni^{2+} and Co^{2+} (root) were greater in amount (%) on the samples obtained from the control site than the quarry site.

Photomicrograph and air pollution tolerance index of *Ageratum conyzoides*: Figure 1 shows the result of the photomicrograph of *Ageratum conyzoides* obtained from

Table 1: Percentage phytochemical compositions of leaf, stem and root extract of *Ageratum conyzoides*

	Leaf		Stem		Root	
Phytochemicals	Control site	Quarry site	Control site	Quarry site	Control site	Quarry site
Alkaloids	1.14±0.02[a]	1.41±0.03[a]	0.94±0.02[a]	5.98±0.01[b]	0.65±0.03[a]	12.13±0.08[c]
Saponins	0.87±0.04[a]	3.13±0.06[c]	0.44±0.02[a]	2.80±0.07[d]	0.36±0.02[a]	2.10±0.17[b]
Flavonoids	0.49±0.03[a]	1.80±0.02[b]	0.26±0.02[a]	6.18±0.13[c]	0.50±0.03[a]	8.90±0.08[d]
Phenols	1.33±0.03[a]	0.83±0.08[a]	0.64±0.02[a]	0.94±0.05[a]	0.93±0.01[a]	0.50±0.17[a]
Tannins	0.66±0.02[a]	2.36±0.08[b]	0.36±0.02[a]	ND	0.25±0.01[a]	ND
HCN	17.36±0.86[a]	4.84±0.11[b]	9.31±0.44[c]	ND	14.67±0.12[d]	1.86±0.11[a]

Values are Mean±SD for triplicate determination, ND: Not detected, values in the same row bearing the same alphabets are not statistically significant at $p<0.05$, HCN: Hydrogen cyanide

Table 2: Percentage proximate composition of leaf, stem and root extract of *Ageratum conyzoides*

	Leaf		Stem		Root	
Parameters	Control site	Quarry site	Control site	Quarry site	Control site	Quarry site
Moisture content	10.67±0.02[b]	10.82±0.01[b]	8.56±0.07[a]	12.57±0.01[c]	8.21±0.05[a]	13.53±0.01[c]
Crude protein	13.77±0.10[b]	13.97±0.01[b]	8.59±0.01[a]	11.69±0.01[b]	8.69±0.10[a]	9.87±0.01[a]
Crude lipid	2.67±0.02[c]	2.47±0.01[c]	1.37±0.02[a]	2.05±0.01[b]	1.09±0.02[a]	1.99±0.01[b]
Crude fibre	18.54±0.10[b]	22.96±0.02[c]	19.84±0.07[b]	24.52±0.02[d]	21.65±0.33[c]	9.87±0.01[a]
Ash	8.69±0.09[b]	12.87±0.01[c]	5.87±0.09[a]	15.40±0.02[d]	9.41±0.13[b]	16.88±0.01[d]
Carbohydrate	45.66±0.09[b]	36.91±0.01[a]	55.79±0.09[c]	33.82±0.01[a]	50.94±0.09[c]	30.98±0.01[a]

Values are Mean±SD for triplicate determination, values in the same row bearing the same alphabets are not statistically significant at $p<0.05$

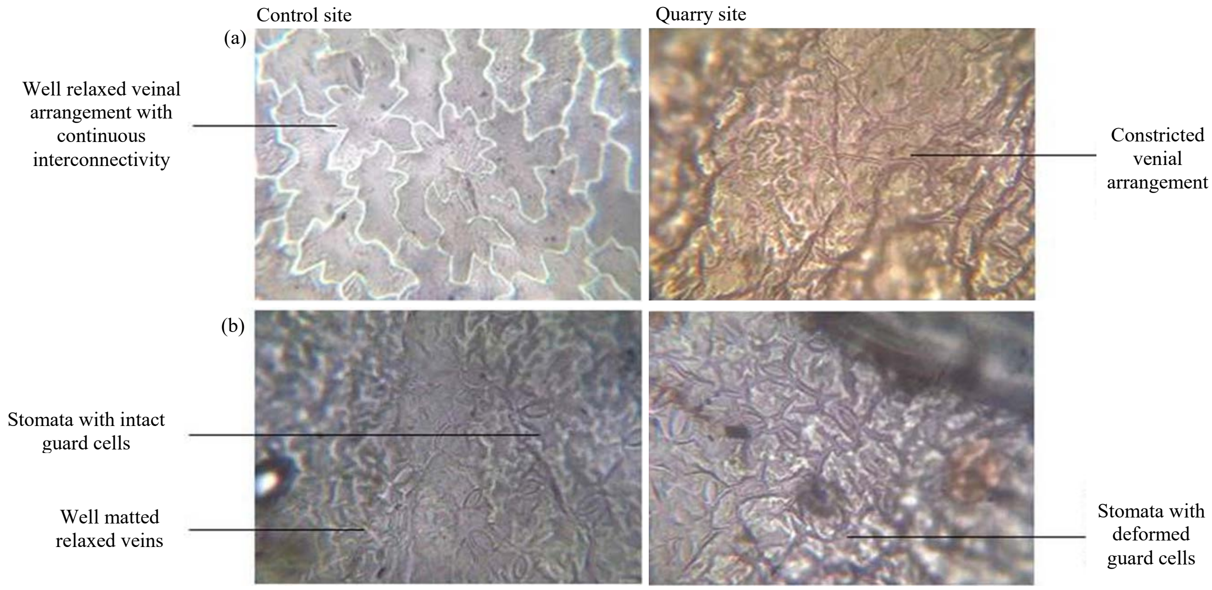

Fig. 1(a-b): Micromorphological investigation of the foliar epidermis of *Ageratum conyzoide*, (a) Adaxial and (b) Abaxial

Table 3: Mineral compositions of leaf, stem and root extract of *Ageratum conyzoides*

	Leaf		Stem		Root	
Parameters	Control site	Quarry site	Control site	Quarry site	Control site	Quarry site
Ca^{2+}	47.51 ± 0.63^{c}	45.86 ± 0.10^{bc}	30.05 ± 0.90^{a}	34.55 ± 0.09^{a}	66.36 ± 0.07^{d}	40.14 ± 0.07^{b}
Mg^{2+}	11.30 ± 0.43^{a}	380.04 ± 0.06^{e}	8.63 ± 0.02^{a}	206.05 ± 0.09^{d}	19.80 ± 0.07^{b}	125.04 ± 0.07^{c}
K^{+}	70.40 ± 1.97^{c}	ND	41.20 ± 0.21^{b}	ND	84.57 ± 0.06^{d}	0.07 ± 0.03^{a}
Na^{+}	104.20 ± 0.72^{c}	56.03 ± 0.05^{a}	88.67 ± 0.12^{b}	58.04 ± 0.06^{a}	146.37 ± 0.06^{d}	100.04 ± 0.08^{c}
Fe^{2+}	0.14 ± 0.02^{a}	29.76 ± 0.11^{b}	0.06 ± 0.01^{a}	65.67 ± 0.12	0.27 ± 0.01^{a}	45.33 ± 0.05^{c}
Zn^{2+}	0.37 ± 0.01^{a}	0.68 ± 0.10^{a}	0.10 ± 0.02^{a}	0.88 ± 0.09^{a}	0.65 ± 0.01^{a}	1.18 ± 0.08^{a}

Values are Mean±SD for triplicate determination, ND: Not detected, values in the same row bearing the same alphabets are not statistically significant at $p<0.05$

Table 4: Heavy metal composition of leaf, stem and root extract of *Ageratum conyzoides*

	Leaf		Stem		Root	
Parameters	Control site	Quarry site	Control site	Quarry site	Control site	Quarry site
Zn^{2+}	0.37±0.01	0.68±0.10	0.10±0.02	0.88±0.09	0.65±0.01	1.18±0.08
Mn^{2+}	0.47±0.05	0.43±0.06	0.05±0.01	0.15±0.08	0.70±0.02	0.27±0.08
Pb^{2+}	0.25±0.01	0.04±0.01	0.07±0.01	0.03±0.01	0.40±0.02	ND
Cr^{2+}	0.13±0.01	ND	0.05±0.01	ND	0.13±0.01	ND
Cd^{2+}	0.08±0.02	ND	0.00±0.00	ND	0.04±0.00	ND
Ni^{2+}	0.47±0.01	ND	0.17±0.01	ND	0.23±0.01	0.09±0.03
Cu^{2+}	0.36±0.02	0.56±0.11	0.21±0.01	0.54±0.07	0.33±0.01	0.45±0.09
Co^{2+}	0.11±0.01	0.03±0.01	0.07±0.01	0.03±0.01	0.22±0.00	0.04±0.02

Values represent the Mean±SD, ND: Not detected

both control and quarry sites. The result revealed constricted venial and stomatal deformed guard cells on the adaxial and abaxial respectively on the samples from quarry site when compared to the control.

Figure 2 shows the result of oxidative stress and air pollution tolerance index of *Ageratum conyzoides*. There were increased levels ($p<0.05$) in ascorbic acid, air pollution tolerance index (APTI) and pH in the samples collected from the quarry site, while percentage relative water and chlorophyll contents significantly decreased ($p<0.05$) in the quarry sample when compared to the control.

DISCUSSION

Physiological and biochemical changes in plants are indicators used for monitoring cellular activity of plant prior

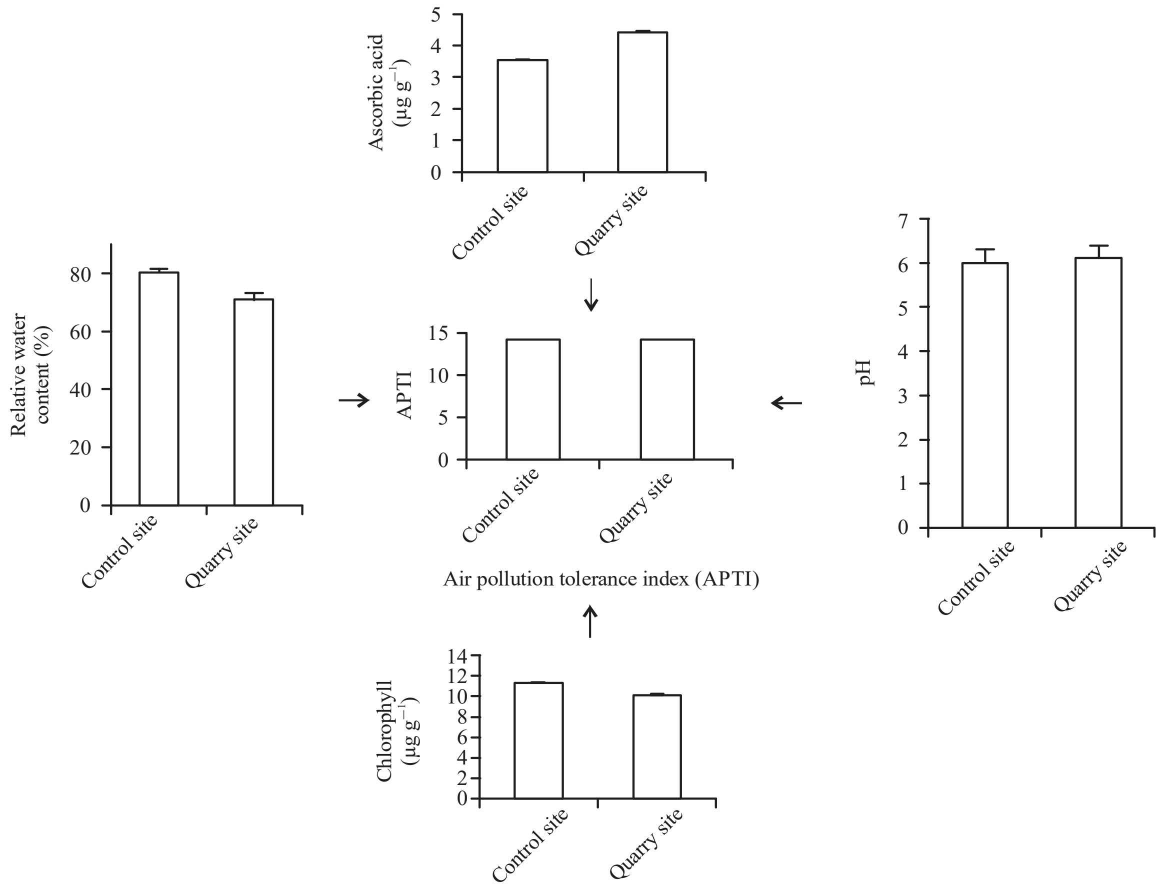

Fig. 2: Oxidative stress and air pollution tolerance index of *Ageratum conyzoide*

and post exposure to harsh environment[9]. In view of the foregoing, the present study investigated the influence of quarry mining on nutritional composition, heavy metals and oxidative stress indices of leaf, stem and root of *Ageratum conyzoides*. In the nutritional assessment of the present resource plant, comparative phytochemical, proximate and mineral compositions were analyzed in the various plant parts obtained from quarry site (test sample) and non-quarry site (control site). Phytochemicals, plant natural products or secondary metabolites are products synthesized by plants for defensive purposes and these secondary metabolites account for their medicinal values[29]. The present findings revealed a significant elevation ($p<0.05$) in the percentage phyto-constituents of leaf, stem and root extract of *Ageratum conyzoides* obtained from the quarry sites when compared to the control sites. More so, HCN were greater in amount on the leaf and root from the control site, while HCN and tannin were not detected at the stem and root samples obtained from the quarry site. These observed elevations in the various parts of *Ageratum conyzoides* obtained from the quarry site indicated physiological stress on the plant. In the bid to survive this condition triggered more biosynthesis of these protective and defensive metabolites are triggered. Reddy *et al.*[9] asserted that the acclimatization of plants to changes in environment results in the production of defensive and protective metabolites which are essential for their growth and survival. The result of this study agrees with the research carried out by Oh *et al.*[30], who reported that environmental stresses increased the health-promoting and antioxidants phytochemicals in lettuce.

Proximate analysis is carried out to determine the major food constituents[31]. The result obtained from the proximate analysis of leaf, stem and root extract of *Ageratum conyzoides* (%) from a control and quarry mining site showed slight percentage increase in all the proximate parameters obtained from the quarry site except crude lipid (leaf and root) and carbohydrate content (stem and root) which were in significant amount in the control more than those obtained from the quarry site. This suggests that the various parts of *A. conyzoides* were compliant nutritionally even against environmental stress. Although, the carbohydrate content recorded in the quarry site was lower when compared to the control. The decreased value of carbohydrate may be attributed to the metabolic distortion of photosynthesis. It has been reported that stomatal impairment or limitation is a characterized and determinant factor of reduced photosynthesis under plant's stress[32]. Therefore, the varying results obtained from the present study may be as a result of spatial differences including habitat and environmental influences which concomitantly shunts and distorts the nutrient availability[33].

The result obtained from the mineral estimation (Table 3) revealed the following minerals, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Fe^{2+} and Zn^{2+} in different parts of *A. conyzoides* obtained from the quarry sites and the control site. With the exception of Ca^{2+} and Na^{+} (leaf), Na^{+} (root), the various quantified minerals were significantly more in the various parts of *A. conyzoides* obtained from the quarry sites when compared to the control site. However, K^{+} was not detected in the leaf and stem samples from the quarry sites. The absence of K^{+} in the leaf and stem may be attributed to the insufficiency of this mineral for utilization by the plant due to duress environmental exposure. Research has shown that the exposure of plant to marginal environmental conditions leads to absorption of much sunlight by the plant and triggering the activation of molecular oxygen available in the chloroplast to reactive oxygen species (ROS). When these ROS are not adequately mopped up or scavenged, it results in chlorophyll damage, lipid peroxidation and in most cases, leads to cell death. Therefore, the adequate supply of mineral nutrients will help in striking balance in photosynthetic electron transport as inadequate supply of mineral can limit plant performance through exacerbating the photooxidative damage[34]. The increased mineral nutrients found in the sample from quarry site indicated that the plant was able to develop adaptive mechanisms to tolerate the stress accompanied with impairment of photosystems.

The result of the heavy metal composition of leaf, stem and root extract of *Ageratum conyzoides* (Table 4) showed that Mn^{2+}, Pb^{2+}, Co^{2+} (leaf), Pb^{2+} (stem) and Mn^{2+}, Ni^{2+} and Co^{2+} (root) were greater in amount (%) on the samples obtained from the control site than the quarry site. Heavy metals are regarded as trace elements due to their low concentrations in different environmental matrices. Reports have shown that metals such as zinc (Zn^{2+}), manganese (Mn^{2+}), chromium (Cr^{2+}), nickel (Ni^{2+}), copper (Cu^{2+}), cobalt (Co^{2+}) are essential nutrients that are needed for various biochemical and physiological roles[35]. Inadequate supply of these metals can result in variety of deficiency diseases or syndromes[35]. The result of the micromorphological foliar epidermis (plate 1) revealed constricted venial and stomatal deformed guard cells on the quarry obtained samples when compared with the control. This result agrees with the report of Reddy *et al.*[9] who reported that physiological, biochemical and metabolic changes in plants occurs post exposure of plant to harsh environment.

Biochemical analysis of leaf extract revealed significant increase ($p<0.05$) in ascorbic acid, air pollution tolerance index (APTI) and pH in the samples collected from the quarry site, while percentage relative water and chlorophyll contents significantly decreased ($p<0.05$) in the quarry sample when compared to the control. Ascorbic acid has antioxidant property and its increase in plant indicates defensive attack against oxidative stress[36]. Plants that show tolerable range to air pollution could be used as biomitigants for air pollution, while those sensitive could act as bioindicators of air pollution. From the study, APTI slightly increased in the sample from the quarry site than the control. This implies that *A. conyzoides* tolerated the air pollution from quarry site. Relative water and chlorophyll contents decreased in the quarry site sample and Sayed[37] reported that suspended dust particles decreases the rate of gaseous exchange in plant by clogging at the opening of stomata.

CONCLUSION

The study showed that *Ageratum conyzoides* responded to the stress induced by the quarrying activities and in the bid for survival and growth increased its defensive mechanism including the elevation of phytochemicals. Also, the increased mineral contents justify the survival mechanisms of *A. conyzoides* to ameliorate the photooxidative damages often caused by reactive oxygen species. The present study also showed that *A. conyzoides* from the quarry site may be recommended for use as bioindicator of air pollution due to its increased APTI values. However, further studies should be carried out to investigate the influence of dust accumulation on the surface of *Ageratum conyzoides*.

SIGNIFICANCE STATEMENT

In this present study, it was shown that quarrying and stone crushing activities induced biochemical stress in the studied herbaceous plant- *Ageratum conyzoides* and increased health promoting phytochemicals in the plant. The observed increase is likely due to the adaptive mechanisms from the plant to tolerate the stress that will cause impairment of its photosystems or photooxidative damages. This study also revealed that *A. conyzoides* from the quarry site may be used as bioindicator of air pollution due to the observed increase in the air pollution tolerance index (APTI) values.

ACKNOWLEDGMENT

The authors are grateful to the dynamic and research-loving Vice Chancellor of Abia State University, Professor E.U. Ikonne and his management team for providing conducive environment to carry out this study.

REFERENCES

1. Meagher, R.B., 2000. Phytoremediation of toxic elemental and organic pollutants. Curr. Opin. Plant Biol., 3: 153-162.
2. Zuazo, V.H.D. and C.R.R. Pleguezuelo, 2008. Soil-erosion and runoff prevention by plant covers. A review. Agron. Sustain. Dev., 28: 65-86.
3. Zhang, T., Y. Bai, X. Hong, L. Sun and Y. Liu, 2017. Particulate matter and heavy metal deposition on the leaves of *Euonymus japonicus* during the East Asian monsoon in Beijing, China. PLoS ONE, Vol. 12, No. 6. 10.1371/journal.pone.0179840.
4. Ololade, I.A., A.O Ashoghon and O. Adeyemi, 2007. Plants level of chromium and nickel at a refuse site, any positive impact? J. Applied Sci., 7: 1768-1773.
5. Emmanuel, A.Y., C.S. Jerry and D.A. Dzigbodi, 2018. Review of environmental and health impacts of mining in Ghana. J. Health Pollut., 8: 43-52.
6. Tchounwou, P.B., C.G. Yedjou, A.K. Patlolla and D.J. Sutton, 2012. Heavy metal toxicity and the environment. Exp. Suppl., 101: 133-164.
7. Tchounwou, P.B., J.A. Centeno and A.K. Patlolla, 2004. Arsenic toxicity, mutagenesis and carcinogenesis-a health risk assessment and management approach. Mol. Cell. Biochem., 255: 47-55.
8. Centeno, J.A., P.B. Tchounwou, A.K. Patlolla, F.G. Mullick and L. Murakat *et al*., 2005. Environmental Pathology and Health Effects of Arsenic Poisoning: A Critical Review. In: Managing Arsenic in the Environment: From Soil to Human Health, Naidu, R., E. Smith, J. Smith and P. Bhattacharya (Eds.). Chapter 17, CSIRO, Adelaide, Australia, ISBN-13: 9780643099234, pp: 311-328.
9. Reddy, A.R., K.V. Chaitanya and M. Vivekanandan, 2004. Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Plant Physiol., 161: 1189-1202.
10. Nogueira, J.H., E. Goncalez, S.R. Galleti, R. Facanali, M.O. Marques and J.D. Felicio, 2010. Ageratum conyzoides essential oil as aflatoxin suppressor of *Aspergillus flavus*. Int. J. Food Microbiol., 137: 55-60.
11. Kamboj, A. and A.K. Saluja, 2008. *Ageratum conyzoides* L.: A review on its phytochemical and pharmacological profile. Int. J. Green Pharmacy, 2: 59-68.
12. Nwankpa, M.E., R.B. Agbor, B.A. Amadi and E.V. Ikpeme, 2015. Vitamin and mineral content of *Ageratum conyzoides* (goat weed). Nat. Sci., 13: 1-5.
13. Moura, A.C.A., E.L.F. Silva, M.C.A.Fraga, A.G. Wanderley, P. Afiatpour and M.B.S. Maia, 2005. Antiinflammatory and chronic toxicity study of the leaves of *Ageratum conyzoides* L. in rats. Phytomedicine, 12: 138-142.
14. Arulprakash, K., R. Murugan, T. Ponrasu, K. Iyappan, V.S. Gayathri and L. Suguna, 2012. Efficacy of *Ageratum conyzoides* on tissue repair and collagen formation in rats. Clin. Exp. Dermatol., 37: 418-424.
15. Okunade, A.L., 2002. *Ageratum conyzoides* L. (Asteraceae). Fitoterapia, 73: 1-16.
16. Dayie, N.T., M.S. Newmen, A.E. Smith and F.S.K. Tayman, 2008. Screening for antimicrobial activity of *Ageratum conyzoides* L.: A pharmaco-microbiological approach. Internet J. Pharmacol., Vol. 5, No. 2.
17. Ita, S.O., E.O. Akpanyung, B.I. Umoh, E.E. Ben and S.O. Ukafia, 2009. Acetaminophen induced hepatic toxicity: Protective role of *Ageratum conyzoides*. Pak. J. Nutr., 8: 928-932.
18. Ita, S.O., O.E. Etim, E.E. Ben and O.F. Ekpo, 2007. Haematopoietic properties of ethanolic leaf extract of *Ageratum conyzoides* (Goat weed) in albino rats. Niger. J. Physiol. Sci., 22: 83-87.
19. Nasrin, F., 2013. Antioxidant and cytotoxic activities of *Ageratum conyzoides* stems. Int. Curr. Pharmaceut. J., 2: 33-37.
20. Aladdin, A., E. Yarar, T. Batool, H.I.M. Al-Astal, M. AlMatar and E.A. Makky, 2017. Antiulcerogenic activity of *Ageratum conyzoides*: A review. J. Biotechnol. Sci. Res., 4: 204-213.
21. Rioba, N.B. and P.C. Stevenson, 2017. *Ageratum conyzoides* L. for the management of pests and diseases by small holder farmers. Ind. Crops Prod., 110: 22-29.
22. Harborne, J.B., 1973. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. 1st Edn., Chapman and Hall, London, UK., ISBN: 978-94-009-5921-7, Pages: 271.
23. Shabbir, M., M.R. Khan and N. Saeed, 2013. Assessment of phytochemicals, antioxidant, anti-lipid peroxidation and anti-hemolytic activity of extract and various fractions of *Maytenus royleanus* leaves. BMC Complement. Altern. Med., Vol. 13. 10.1186/1472-6882-13-143.
24. AOAC., 1970. Official Methods of Analysis. 11th Edn., Association of Official Analytical Chemists, USA., Pages: 1015.
25. Bajaj, K.L. and G. Kaur, 1981. Spectrophotometric determination of L-ascorbic acid in vegetables and fruits. Analyst, 106: 117-119.
26. Arnon, D.I., 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. Plant Physiol., 24: 1-15.
27. Singh, A., 1977. Practical Plant Physiology. Kalyari Publishers, New Delhi.

28. Lalitha, J., S. Dhanam and K.S. Ganesh, 2013. Air pollution tolerance index of certain plants around SIPCOT industrial area Cuddalore, Tamilnadu, India. Int. J. Environ. Bioenergy, 5: 149-155.
29. Parivuguna, V., R. Gnanaprabhal, R. Dhanabalan and A. Doss, 2008. Antimicrobial properties and phytochemical constituents of *Rheo discolor* hance. Ethnobot. Leafl., 12: 841-845.
30. Oh, M.M., E.E. Carey and C.B. Rajashekar, 2009. Environmental stresses induce health-promoting phytochemicals in lettuce. Plant Physiol. Biochem., 47: 578-583.
31. Adamma, E.P., S.M. Sani, O.K. Israel and Z.S. Yusuf, 2014. Proximate and anti-nutritional constituents of *Abelmoschus esculentus* grown in Fadaman Kubanni, Zaria, Kaduna State, Nigeria. J. Scient. Res. Rep., 3: 2015-2027.
32. Cornic, G., 2000. Drought stress inhibits photosynthesis by decreasing stomatal aperture-not by affecting ATP synthesis. Trends. Plant Sci., 5: 187-188.
33. Bernas, E., G. Jaworska and Z. Lisiewska, 2006. Edible mushrooms as a source of valuable nutritive constituents. Acta Sci. Pol. Technol. Aliment., 5: 5-20.
34. Cakmak, I., 2006. Role of mineral nutrients in tolerance of crop plants to environmental stress factors. Proceedings of the International Symposium on Fertigation, September 20-24, 2005, Beijing, China, pp: 35-48.
35. WHO., 1996. Trace Elements in Human Nutrition and Health. World Health Organization, Geneva, Switzerland, ISBN-13: 9789241561730, Pages: 343.
36. Dietz, K.J., U. Kramer and M. Baier, 1999. Free Radicals and Reactive Oxygen Species as Mediators of Heavy Metal Toxicity. In: Heavy Metal Stress in Plants: From Molecules to Ecosystems, Prasad, M.N.V. and J. Hagemeyer (Eds.). Springer-Verlag, Berlin, pp: 73-97.
37. Sayed, S.A., 1997. Effect of cadmium and kinetin on transpiration rate, stomatal opening and leaf relative water content in safflower plants. J. Islamic Acad. Sci., 10: 73-80.