Asian Journal of Environment & Ecology

14(2): 12-20, 2021; Article no.AJEE.65780
ISSN: 2456-690X

Evaluation of some Medicinal Plants for Green Belt Development in Rock Quarrying Locations at Lokpaukwu, Abia State, Nigeria

C. E. Ogbonna[1], F. I. Nwafor[2,3*] and O. O. Ogbonnaya[1]

[1]Department of Environmental Resource Management, Abia State University, Uturu, Nigeria.
[2]Department of Pharmacognosy and Environmental Medicines, University of Nigeria, Nsukka, Nigeria.
[3]Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author CEO designed the study and wrote the protocol. Author FIN performed that laboratory tests and statistical analysis, and wrote the first draft of the manuscript. Author OOO managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2021/v14i230200
Editor(s):
(1) Dr. Ravi Kant Chaturvedi, Chinese Academy of Sciences, P.R. China.
Reviewers:
(1) Nguyen Thanh Lam, Vietnam National University of Agriculture, Vietnam.
(2) Deepti Tomar, Rani Durgawati Vishwavidyalaya, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/65780

Original Research Article

Received 14 December 2020
Accepted 19 February 2021
Published 04 March 2021

ABSTRACT

This study evaluated air pollution tolerance plants as well as anticipated performance indices of some medicinal plants growing in the Lokpaukwu rock quarrying area in order ascertain their suitability for green belt development. Two quarry locations A which is older and has a higher level of activity, and B were used for the study with a control location at Abia State University, Uturu. Out of the sixteen dominant plant species identified, five species; *Alchornea cordifolia, Baphia pubescens, Napoleona imperialis, Nauclea latifolia* and *Vitex doniana.* were randomly selected for the study. Leaf samples were randomly collected in triplicate from the lowest branch of each selected plants with similar characteristics. Relative water content of plants was significantly higher ($p<0.05$) at the study area suggesting stomatal occlusion by dust while chlorophyll content was significantly lower at the quarry sites, a clear indication of pollution stress. Chlorophyll content was also lower in all plants at site B, being significant in *N. imperialis* and *V. doniana. N. imperialis* had the highest APTI of 19.15 at the quarry site suggesting suitability for green belt development at the quarry site. Based on API, *V. doniana* is the most suitable for green belt development among the five plant species.

**Corresponding author: E-mail: felix.nwafor@unn.edu.ng;*

Keywords: Air pollution; greenbelt; medicinal plants; rock quarrying; Lokpaukwu.

1. INTRODUCTION

Air pollution, especially dust from quarry sites is known to be responsible for vegetation injury and crop yield loss and has become a threat to the survival of plants in industrial areas [1]. Plants growing in and around the quarry site are in direct contact with air pollutants, and have possible biomonitoring potentials (Sharma et al., 2007). Biomonitoring of plants is an important tool to evaluate the impact of air pollution [2].

The resistance and susceptibility of plants to air pollution can be determined by evaluating their physiological and biochemical parameters [3]. Classification plants sensitive or tolerant to different pollutants is very important for identifying those plants that can be used in air pollution monitoring and mitigation as well as those that are suitable for green belt development [4,5]. Sensitive species are early indicators of pollution and tolerant species help in reducing the overall pollution load (Nrusimha et al, 2005).

Air pollution tolerance index of plant species is evaluated by analyzing important biochemical parameters [6]. It is a species dependent attribute of plants which indicates the inherent capacity of plants to withstand stress from air pollutants (Rao, 2006). The anticipated performance index of these plant species can be calculated by considering their APTI value together with other socio-economic and biological parameters [7] assessed anticipated performance index of five road side plant species by considering their APTI values together with biological parameters such as plant height, canopy structure, plant size, texture, hardness.

In the study area, morphological alterations were observed in plants suggesting the likelihood of pollution stress, and possible biochemical changes. It has been reported that biochemical alterations following exposure to pollutants happen before morphological changes are observed [8]. Observed morphological alterations in plants within the quarrying environment include abrasion of leaves and cuticles, necrosis and stunted growth.

The assessment of biochemical properties and anticipated performance indices of plants in the study area would help identify those plants that are tolerant of air pollution from rock quarrying as well as their suitability for green belt development. Identified suitable plants would be useful in the mitigation of air pollution from the quarry site and possibly other quarrying environments. Physiochemical assessment and air pollution tolerance of *Psidium guajava, Dialium guineense* and *Pterocarpus soyauxii* in a different quarry site in Lokpaukwu was assessed by Ogbonna et al. [9]. This study however focuses air pollution tolerance plants as well as anticipated performance indices of some medicinal plants in the study area in order evaluate their suitability for green belt development.

2. METHODOLOGY

2.1 Study Site

Lokpa-ukwu is situated in Umunneochi Local Government of Abia State, between latitudes 05°55'00''N and 06°03'00''N and longitudes 07°21'05''E and 07°31'33''E (Fig. 1). The study area falls within the southern tropical climatic belt with mean annual rainfall of 2250 mm. The study area is in the tropical rain forest region of Nigeria and falls within the South Eastern part of the lower Benue trough. The area is underlined by two main geologic formations, the Asu River Group and Nkporo formation. Study site A is located in (Eluama community) while study site B (Aguokeakpu- Amaubiri community). Site A is older, larger and has a higher level of quarrying activity than Site B.

2.2 Sample Collection and Identification

A 50 m by 50 m transect was used as sampling plots on each side of the perimeter of both quarry sites. Frequency of occurrence of plant species in each transect was used to determine the most dominant tree species. Out of the sixteen dominant plant species identified, five species were randomly selected. The selected plants were *Alchornea cordifolia, Baphia pubescens, Napoleona imperialis, Nauclea latifolia* and *Vitex doniana.*

Leaf samples were randomly collected in triplicate from the lowest branch of each selected plants with similar characteristics, particularly in age, from the study sites. Control samples were collected within the premises of Abia State University, Uturu. Physical measurement of plant breadth was used to estimate the age bracket of the sampled trees in the study area and at the control site. Plant breadth was measured using a meter tape.

2.3 Laboratory Analysis

This consisted of the analysis of ascorbic acid content, total chlorophyll content, leaf pH and relative water content of plant leaves.

2.3.1 Determination of ascorbic acid content

This was done according to the method of Iqbal et al. [10]. One gram of the leaf sample was extracted with 4 ml of oxalic acid – EDTA solution. To a test tube containing the extract, 1 ml of 5% H_2SO_4, 2 ml of ammonium molybdate and 3 ml of water were added successively and allowed to settle for 15 minutes. The absorbance was measured at 760 nm and the concentration of ascorbic acid was calculated from a standard curve.

2.3.2 Determination of chlorophyll content

This was done according to Singh et al. [11]. Three (3) grams of the leaf sample was macerated with 10 ml of 80% acetone and the liquid portion was decanted after allowing to settle for 15 minutes, then centrifuged at 2,500 rpm for 3 minutes as absorbance of the supernatant was measured at 663 nm using UV-Vis spectrophotometer.

2.3.3 Determination of leaf pH

Few quantity of the leaf sample was macerated with de-ionized water and filter through an ash less filter paper. The filtrate was read for pH with the aid of a digital pH meter [12].

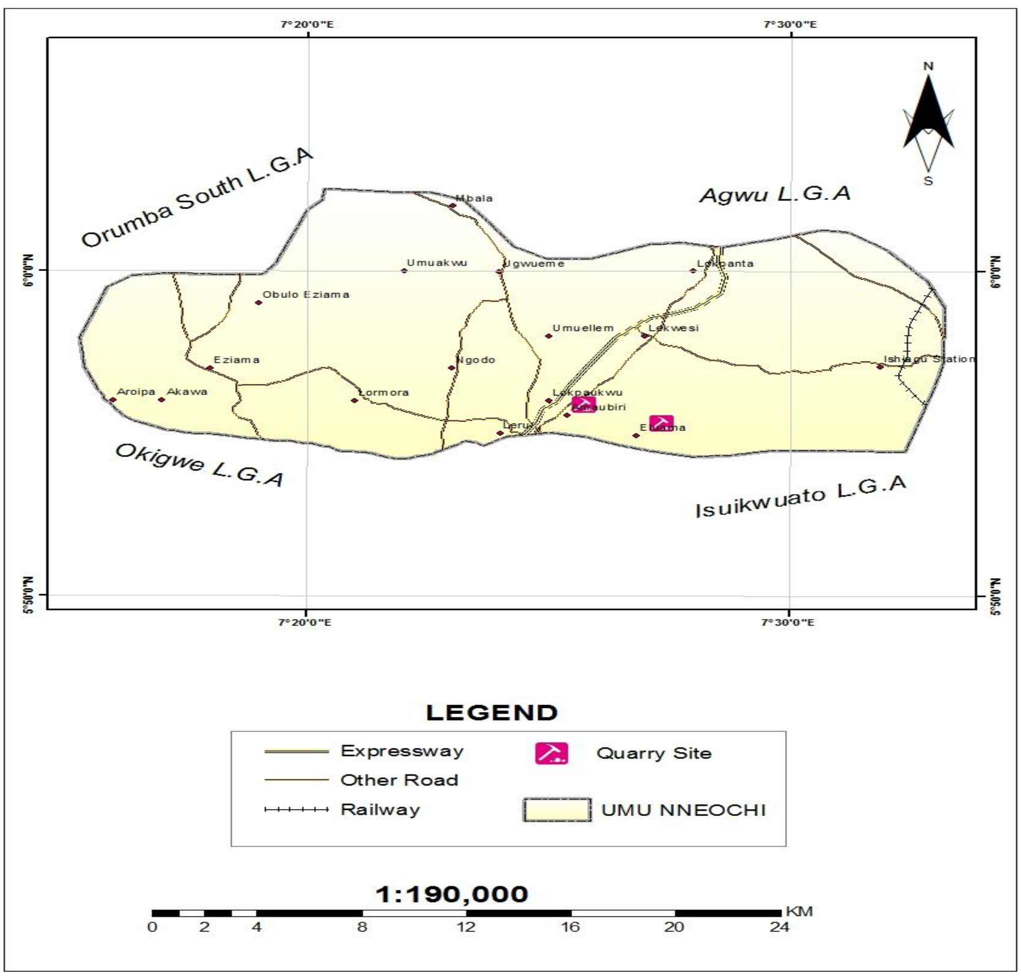

Fig. 1. Study area

Source: Ogbonna et al. [9]

2.3.4 Determination of relative water content (RWC)

Fresh leaf sample was weighed and the fresh mass (FM) was recorded. The same sample was floated in distilled water inside a closed petri dish at room temperature for 24 hours. At the end of the incubation period, the leaf sample was wiped dry gently with blotted paper and re weighed to obtain the turgid mass (TM). It was then placed in a pre-heated oven at 80ºC for 48 hours. Thereafter the leaf was weighed to obtain the Dry Mass.

Relative water content was calculated using the formula:

$$RWC = (\frac{FM - DM)}{(TM - DM)} X \frac{100}{1} \dots\dots\dots\dots\dots.(1)$$

Where,

RWC = Relative water content (%)
FM = Fresh mass of leaf sample (g)
DM = Dry mass of leaf sample (g)
TM = Turgid mass of leaf sample (g)

2.4 Determination of Air Pollution Tolerance Index (APTI)

Air pollution tolerance index was computed following Assad et al. [5]; Lalitha et al. [13] using the equation:

$$APTI = \frac{[A(T + P)] + R}{10} \dots\dots\dots\dots\dots\dots..(2)$$

Where,

A = Ascorbic acid (mg/g) of leaf sample.
T = Total chlorophyll (mg/g) of leaf sample.
P = Leaf extract PH of leaf sample.
R = Relative water content (%) of leaf sample.

On the basis of APTI values, selected plants will be rated as follows:

APTI 30 – 100 is considered 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

2.5 Assessment of Anticipated Performance Index (API)

Anticipated performance indices of the species were determined following Mondal et al. [14] with little modifications. This was assessed by factoring in the APTI in combination with some biological and ecological features such as plant habit and size, canopy structure, leaf size and texture, and economic uses (in ethnomedicine, food, construction, as fodder etc.). Anticipated performance indices were scored as in Table 1 below and expressed in percentage.

Table 1. Anticipated performance indices

Grading character	Category	Pattern of assessment	Grade allotment
Tolerance	APTI	1 - 16	+
		17 - 30	++
		30 - Above	+++
Biological and Socio-economic importance	Plant habit	Small	-
		Medium	+
		Large	++
	Canopy structure	Sparse/irregular/globular	-
		Spreading crown/open/semi-dense	+
		Spreading dense	++
	Type of Plant	Deciduous	-
		Evergreen	+
Laminar Structure	Size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Rough/coriaceous	+
	Economic value		
	Food, Medicinal, Timber, Fuel, Cash crop, Ornamental, Fodder	Less than 3	-
		3 or 4	+
		5 or more	++

2.6 Statistical Analysis

Data was analyzed using statistical package for social science (SPSS) version 20. Analysis of variance was used to test for differences in physiochemical properties and heavy metal content among selected plants at $p \leq 0.05$. Post hoc analysis and Duncan multiple test range was used for separation of means. Values were expressed as mean ± standard deviation.

3. RESULTS AND DISCUSSION

3.1 Biochemical Parameters

Significant differences were observed in relative water content RWC, pH, total chlorophyll, ascorbic acid and air pollution tolerance index (APTI) among the plants and across the study locations. For Site A, the values for RWC and APTI were statistically the same among the plants but varied in other parameters. pH was highest in *B. pubescens* (8.05 ± 0.05) and *V. doniana* (8.30 ± 0.10) and lowest in *A. cordifolia* (6.65 ± 0.05) and *N. latifolia* (6.60 ± 0.10) (Table 2). At Site A, total chlorophyll ranged from 0.42 mg/g in *N. latifolia* to 1.99 mg/g in *A. cordifolia*. Ascorbic acid was observed to be significantly lower in *N. imperialis* (7.03 ± 0.18) while *A. cordifolia, B. pubescens, N. latifolia* and *V. doniana* did not show significant differences in their ascorbic acid content. Site A recorded significant higher RWC in *A. cordifolia* and *B. pubescens* compared to site B and C. RWC was statistically similar across locations in *N. imperialis* plant while site A and B had significantly higher RWC in *N. latifolia* and *V. doniana* compared to site C (Table 2).

pH significantly reduced in *A. cordifolia* and *N. imperialis* in site A and B compared to the control. The pH values were not significantly different for *N. latifolia* and *V. doniana* across the different locations evaluated. A similar trend was also observed in total chlorophyll content with the control having significantly higher values in all plants assessed, At the study sites A and B, chlorophyll content was not significantly different in *A. cordifolia, B. pubescens* and *N. latifolia* while in *N. imperialis* and *V. doniana*, site B recorded significantly higher total chlorophyll content (5.14 ± 0.18 and 2.95 ± 0.14) compared to site A (Table 2).

Ascorbic acid content was highest (12.99 mg/g) in *B. pubescens* at the control site and lowest in the same plant at site B (6.66 mg/g). Ascorbic acid concentration was generally higher in plants collected from control site than those at site A and B except for *N. imperialis* and *N. latifolia* whose value was not significantly different between study (site A) and control locations (Table 2).

Relative water content has been connected to managing the survival of plants in hostile environments (Krishnaveni, 2013) and is related to several leaf physiological variables, such as leaf turgor, growth, stomatal conductance, transpiration, photosynthesis and respiration [15]. The higher relative water content of the plants at the quarry sites suggests that they were not experiencing water stress. This could be as a result of higher dust deposition on leaves which will eventually clog the stomatal opening and severely affects the transpiration rate. Rai and Panda [16] suggested that dust may also absorb water through non-cutinized plant surface such as leaves thereby contributing to decreased water content. Reduced relative water content of plant species is due to the effect of pollutants on transpiration rate in leaves [17] such that plants lose their ability to pull water and minerals from roots for biosynthesis. Therefore, maintenance of relative water content by the plant may decide the relative tolerance of plants towards air pollution [18]. Tree species with higher water content under polluted condition may be tolerant to pollutants [19]. This is supported by the higher relative water content and APTI of *N. imperialis*, *N. latifolia* and *V. doniana* at site B.

It has been reported that plants with low pH are less tolerant of air pollution [20]. This was indicated by this study for all plants with the exception of *V. doniana* although the pH values were not statistically different for the plant, Leaf pH is reduced in the presence of acidic pollutants and the reducing rate is more in sensitive plants [21,22]. The slightly acidic condition observed in *A. cordifolia* and *N. latifolia* at both study sites agrees with the findings of Rai and Panda [16] who attributed the acidic condition to the presence of acidic pollutants which shifts the cell sap pH towards the acidic side. As suggested by our findings, low leaf pH had been reported by Yan and Hui [23] to be connected to air pollution and reduced photosynthetic process in plants. Dust accumulation had been alternatively reported to cause alkalinity in leaves by dissolution of chemicals present in dust particles such as metals and polycyclic hydrocarbons in the cell sap thus increasing the pH [21].

Chlorophyll content of plants indicates photosynthetic activity as well as the growth and development of biomass [24]. The significant reduction in chlorophyll at both study sites in comparison with the control sitethe quarry site is therefore a clear sign of air pollution at the quarry sites. This is in line with the findings of Walia et al. [25]; Pandit et al., 2017; Iqbal et al. [26] and Ninavenave et al. [27] who reported a reduction in chlorophyll content of plants from polluted sites. The observed lower chlorophyll content in plants at study site A relative to B could be attributed to the higher level of activity and longer length of operation there. Dust particles carry many polycyclic hydrocarbon and metals with them which inhibits the production of enzymes required for chlorophyll synthesis leading to a reduction of chlorophyll content [6]. Therefore the reduction in chlorophyll content observed in the quarry sites could be attributed to the degradation of photosynthetic pigment of plants by pollutants.

Ascorbic acidic a stress reducing factor present in tolerant plant species generally in elevated levels. Ascorbic acid is vital in cell wall synthesis, defense and cell division which is crucial for photosynthetic carbon fixation [18]. It has therefore been given top priority and used as a multiplication factor in the Air Pollution Tolerance Index equation [28]. Increased level of ascorbic acid content enhances pollution tolerance which is a response of defense mechanism of plant [29]. Plant species having high ascorbic acid content under polluted conditions are considered to be tolerant to air pollution stress [30,31].

Randhi and Reddy [32] noted that lower ascorbic acid content in plants suggests sensitivity to air pollutants, implying that higher ascorbic acid content is associated with the adaptive capacity of plants to overcome stress. This position is supported by the findings of this study. The reduction observed in ascorbic acid content of plants at the polluted sites could possibly be as a result of impaired ascorbic acid biosynthesis pathway by pollutants. Thus plants having lower ascorbic acid values could be ranked among the air pollution sensitive plants category [33]. The ascorbic acid content of plants at the study site was generally lower in comparison with plants at the control. This is contrary to reports by ([16]; Pandit et al., 2017; [25]).

3.2 Air Pollution Tolerance Indices and Anticipated Performance Indices of Plants

APTI also varied across locations and among plants, with *V. doniana* at the control having the highest APTI of 25.68 ± 0.28. *N. Imperialis* at site B had the highest APTI of 19.15 for both study sites. APTI was significantly higher at the control (Table 2). The result of the anticipated performance indices of the plant species at the pollution sites showed that *B. pubescens* was the least with API value of less than 30%. This was considered to be poor. *V. doniana,* on the other hand recorded the highest value for API and graded very good for greenbelt development. Other species are intermediate (Table 3).

Table 2. Comparative biochemical parameters and APTI of plants across the three study locations

Sample	Site	RWC (%)	pH	Total chlorophyll (mg/g)	Ascorbic acid (mg/g)	APTI (%)
AC	Site A	79.15 ± 0.96^a	6.65 ± 0.05^b	1.99 ± 0.00^b	8.58 ± 0.16^b	15.33 ± 0.27^b
	Site B	61.95 ± 2.98^b	6.75 ± 0.05^b	2.11 ± 0.12^b	9.04 ± 0.30^b	14.21 ± 0.12^b
	Control	52.97 ± 0.31^b	8.55 ± 0.05^a	6.67 ± 0.34^a	10.82 ± 0.05^a	21.76 ± 0.54^a
BP	Site A	63.39 ± 15.56^a	8.05 ± 0.05^{ab}	0.46 ± 0.07^b	9.13 ± 0.20^b	14.11 ± 1.61^b
	Site B	37.65 ± 0.81^b	7.78 ± 0.03^b	1.06 ± 0.15^b	6.66 ± 0.32^c	9.65 ± 0.28^b
	Control	33.25 ± 1.98^b	9.00 ± 0.20^a	5.89 ± 0.13^a	12.99 ± 0.22^a	22.66 ± 0.44^a
NI	Site A	53.24 ± 2.92^a	7.15 ± 0.05^b	1.18 ± 0.14^c	7.03 ± 0.18^b	11.19 ± 0.57^b
	Site B	62.17 ± 6.40^a	7.30 ± 0.10^b	5.14 ± 0.18^b	10.39 ± 0.39^a	19.15 ± 1.20^{ab}
	Control	51.36 ± 6.48^a	8.35 ± 0.05^a	8.46 ± 0.21^a	11.24 ± 0.52^a	24.01 ± 1.33^a
NL	Site A	81.10 ± 3.85^a	6.60 ± 0.10^a	0.42 ± 0.10^b	9.04 ± 0.28^b	14.46 ± 0.01^c
	Site B	86.23 ± 1.69^a	6.85 ± 0.15^a	0.77 ± 0.16^b	11.58 ± 0.45^{ab}	17.44 ± 0.19^b
	Control	50.53 ± 2.00^b	7.05 ± 0.05^a	7.82 ± 0.00^a	12.93 ± 0.28^a	24.29 ± 0.28^a
VD	Site A	65.96 ± 1.01^a	8.30 ± 0.10^a	1.21 ± 0.02^c	8.65 ± 0.31^b	14.82 ± 0.33^b
	Site B	73.62 ± 1.56^a	8.50 ± 0.10^a	2.95 ± 0.14^b	8.54 ± 0.45^b	17.15 ± 0.88^b
	Control	42.52 ± 0.99^b	8.35 ± 0.15^a	10.84 ± 0.18^a	11.17 ± 0.18^a	25.68 ± 0.28^a

Means with different letters as superscripts along the column for each species are significantly different at $P \leq 0.05$

Table 3. APTI and API of the plants at the two dust pollution sites

Sample	Site	APTI	APTI Grade	API (%)	API Grade
AC	Site A	15.33 ± 0.27	Sensitive	38.5	Good
	Site B	14.21 ± 0.12	Sensitive	38.5	Good
BP	Site A	14.11 ± 1.61	Sensitive	23.1	Poor
	Site B	9.65 ± 0.28	Sensitive	23.1	Poor
NI	Site A	11.19 ± 0.57	Sensitive	38.5	Good
	Site B	19.15 ± 1.20	Intermediate	46.2	Good
NL	Site A	14.46 ± 0.01	Sensitive	38.5	Good
	Site B	17.44 ± 0.19	Intermediate	46.2	Good
VD	Site A	14.82 ± 0.33	Sensitive	61.5	Very Good
	Site B	17.15 ± 0.88	Intermediate	69.2	Very Good

Air pollution tolerant index (APTI) was also observed to reduce in the plants at both quarry sites. Based on APTI classification, all plants at site A were sensitive to air pollution, while at quarry site B, *V. doniana*, *N. Latifolia* and *N. imperialis* had intermediate tolerance to air pollution suggesting that the could be used as biomitigators of air pollution. It could be suggested that the sensitive nature of all plants at study site A is as a result of the higher level of activity and longer length of operation at the site, However, *N. Imperialis* with the highest APTI value of 19.15 among the three plants would have greater applicability with respect to biomitigation especially given that the plant also had the highest value of total chlorophyll content among plants at both quarry sites.

The variation in APTI across the study sites be attributed to variations in the biochemical properties which are synthesized in computing the index. APTI is also a specie dependent attribute of plants Rao, 2006). All other plants at both sites with APTI values less than 17 are sensitive to air pollution and are not recommended for green belt development.

Anticipated performance index (API) indicates the ability of certain plants dominant in the environment to improve air quality and promote green belt development [14]. API is calculated by combining air pollution tolerance indices of plants (APTI) and their morphological and socio-economic attributes in order to provide a better predictive method for selecting plants suitable for environmental monitoring. API of plants at the polluted were rated poor for *Baphia pubescens,* good for *A. cordifolia, N. imperialis* and *N. laevis* while *V. doniana* was rated very good. Therefore, based on API, *V. doniana* is the most suitable for green belt development among the five plant species [34]. This might have been influenced by its numerous economic uses. From our field study experience, *V. doniana* is used for food, fuel wood, medicine, and timber in the community.

4. CONCLUSION

This study evaluated the effect of dust pollution at two different quarry sites on heavy metals accumulation and stomata micromorphology of selected medicinal plants. Dust load was higher at the quarry sites when compared with control site. The amount of dust was not influence by the size of the leaf rather other factors like surface texture and hairiness could be responsible for the accumulation. Heavy metals were also found to occur in the samples, most probably as a result of the quarrying activities and fuel combustion by machineries and automobiles within the industries. These also negatively affected the stomatal features of the plants, evidenced by plamolysed cells, distorted epidermal cell walls and change in stomata sizes, pore sizes and other relevant indices. We recommend that inhabitants of the study area should be educated on the health issues of consuming or ingesting plants growing in the study area due to the potential health risk. Furthermore, quarry companies should be required to take positive steps to suppress dust at the emission points. This can be done by using a water tanker browser to spray water on road surface and stockpiles at least once a day especially during dry season. Other systems like pipes could also be developed to suppress dust at the blasting and processing sites and also along the roads.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iqbal MZ, Shafig M, Periodic effect of cement dust pollution on the growth of

some plants. Turk. J. Batany. 2001;25:19-24.

2. Rai A, Kulshreshtha K, Srivastava PK, Mohanty CS. Leaf Surface Structure Alterations due to Particulate Pollution in Some Common Plants, Environmentalist. 2010;30:18–23.
3. Enete IC, Ogbonna CE. Evaluation of air pollution tolerance index of some selected ornamental shrubs in Enugu City, Nigeria. Journal of Environmental Science, Toxicology and Food Technology. 2012; 1(2):22–25.
4. Singare PU, Talpade MS. Physiological response of some plant species as a bio-indicator of roadside automobile pollution stress using the air pollution tolerance index approach. International Journal of Plant Research. 2013;3(2):9-16.
5. Asaad SMA, Ibrahim A, Najem AN. Evaluation of air pollution tolerance index of some plant species in Kerbala city, Iraq. Journal of Pharmaceutical Science and Research. 2018;10(6):1386-1390.
6. Prajapati SK, Tripathi BD. Anticipated performance index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city. Indian Journal of Environmental Management. 2008;88(4): 1343-1349.
7. Tsega YC, Deviprasad AG. Variation in air pollution tolerance index and anticipated performance index of roadside plants in Mysore. India Journal of Experimental Biology, 2014;35:185-190.
8. Liu YJ, Ding H. Variation in air pollution tolerance index of plants near a steel factory: implications for landscape plants species selection for industrial areas. WSEAS Transactions on Environment and Development. 2008;1(4):24-32.
9. Ogbonna CE, Ugbogu EA, Nwafor F. Physiochemical Properties and Anticipated Performance of Selected Plant Species in Lokpaukwu Quarry Site in Abia State, Nigeria. Journal of Environmental Pollution and Human Health. 2019;7(1):7-14.
10. Iqbal H, Lajber K, Khan MA, Khan FU, Sultan A. UV spectrophotometric analysis profile of ascorbic acid in medicinal plants of Pakistan. World Applied Science Journal. 2010;9(7):800-803.
11. Singh SK, Rao DN, Agrawal M, Pandey J, Naryan D. Air pollution tolerance index of plant. Journal of Environmental Management. 1991;32(2):45-55.
12. Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution. In Proceedings of Symposium on Air Pollution Control. 1983;1:218-224.
13. Lalitha J, Dhanam S, Sankar-Ganesh K. Air Pollution Tolerance Index of Certain Plants Around SIPCOT Industrial Area, Cuddalore, Tamilnadu, India, International Journal of Environmental and Bioenergy. 2013;5(3):149–155.
14. Mondal D, Gupta S, Kumar JD. Anticipated performance index of some tree species considered for green belt development in an urban area. International Research Journal of Plant Science. 2011;2(4):99-106.
15. Das S, Prasad I. Seasonal variation in air pollution tolerance indices and selection of plant species for industrial areas of Rourkela. Indian Journal of Environmental Protection. 2010;30(12):978–988.
16. Rai PK, Panda LS. Leaf dust deposition and its impact on biochemical aspect of some roadside plants of Aizawl, Mizoram. International Research Journal of Environment Science. 2014;3(11):14-19.
17. Samal AK, Santra SC. Air quality of Kalyani Township (Nadia, West Bengal) and its impact on surrounding vegetation. Indian Journal of Environmental Health. 2002;44(1):71-76.
18. Rai PK, Pandaa LLS, Chutia BM, Singh MM. Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rorkela) and non industrial area (Aizawal) of India. African Journal of Environmental Science and Technology. 2013;7(10):944-948.
19. Kumar SR, Arumugam T, Anandakumar CR, Balakrishnan S, Rajave DS. Use of plant species in controlling environmental pollution: A review. Bulletin of Environment, Pharmacology and Life Sciences. 2013;2(2):52-63.
20. Singh SN, Verma RD. Phytoremediation of air pollutants: A review in environmental bioremediation technology (Singh SN and Tripathi RD. eds). Springer, Berlin Heidelberg, 2007;1:293-314.
21. Gholami A, Mojiri A, Amini H. Investigation of the air pollution tolerance index using some plant species in Avhaz region. Journal of Animal and Plant Sciences. 2016;26(2):475-480.
22. Tiwari S, Agrawal M, Marshall FM. Evaluation of ambient air pollution impact on carrot plant at a sub-urban site using

open top chambers. Environ. Monit. Assess. 2006;119:15-30.

23. Yan-ju L, Hui D. Variation in air pollution tolerance index of plant near a steel factory: Implications for landscape plant species selection for industrial areas. Environmental Development. 2008;1:24-30.
24. Leghari SK, Zaid MA, Sarangzai AM, Faheem M, Shawani GR, Ali W. Effect of road side dust pollution on the growth and total chlorophyll contents in Vitis vinifera. African Journal of Biotechnology. 2014; 13(11):1237-1242.
25. Walia K, Aggarwal RK, Bhardwaj SK. Leaf dust accumulation and its relationship with biochemical parameters of different plant species growing along national highway-22, India. International Journal of Chemical Studies. 2019;7(1):1386-1390
26. Iqbal MZ, Shafig M, Qamar Zaidi S, Athar M. Effects of authomobile pollution on chlorophyll content of roadside urban trees. Global. J. Environ. Sci. Manage. 2015;1(4):283-296.
27. Ninave SY, chaudhari PR, Gajghate DG, Tarar JH, Foliar AD. Biochemical features of plants as indicators of air pollution. Bulletin of Environmental Contamination and Toxicology. 2001;67(1):133-140.
28. Yannawar VB, Bhosle AB. Air pollution tolerance index of various plant species around Nanded city, Maharashtra, India. Journal of Applied Phytotechnology in Environmental Sanitation. 2013;3(1):23-28.
29. Pandey AK, Pandey M, Mishra A, Tiwary SM, Tripathi BD. Air pollution tolerance index and anticipated performance index of some plant species for development of urban forest. Urban Forestry and Urban Greening. 2015;14:866-871.
30. Joshi N, Joshi A, Bist B. Air pollution tolerance index of some trees species from the industrial area of Tarapur. International Journal of Life Sciences. 2016;2(2):173-182.
31. Subramani S, Devaanandan S. Application of air pollution tolerance index in assessing air quality. International Journal of Pharmacy and Pharmaceutical Sciences. 2015;7(7):216-221.
32. Randhi UD, Reddy MA. Evaluation of tolerant plant species in urban environment: A case study from Hyderabad, India. Universal Journal of Environmental Research and Technology. 2012;2(4):300-304.
33. Varshney SRK, Varshney CK. Effects of sulphur dioxide on ascorbic acid in crop plants. Environment Pollution. 1984;35: 285-90.
34. Panda LRL, Rajeev KA, Bhardway DR. A review of air pollution tolerance index and anticipated performance index. Current World Environment. 2018;13(1): 55-65.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/65780