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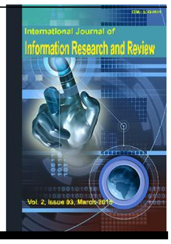

Research Article

QUARRY DUST EMISSION EFFECTS ON TREE SPECIES DIVERSITY IN CHONGONI FOREST RESERVE AND VEGETATION CHARACTERISTICS IN ADJACENT VILLAGES, DEDZA, MALAWI

***Edward Missanjo, Edina Ndalama, Dalirani Sikelo and Gift Kamanga-Thole**

Department of Forestry, Malawi College of Forestry and Wildlife, Private Bag 6, Dedza, Malawi

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ABSTRACT

Quarrying dust is one of the air pollutants and is reported to have adverse effects on human health and alters plant community structure. A study was conducted to investigate the effects of quarrying dust emission on the tree species diversity and vegetation characteristics in Chongoni Forest Reserve and adjacent villages in Dedza, Malawi. An inventory on tree species diversity was carried out within a ground distance of 0–1km from the quarrying site into the reserve at an increasing distance of 250m (0–250m; 250–500m; 500-750m; 750–1000m). Leaves of five common plant species in four adjacent villages, located at 0 to 4km from the quarrying site were collected and brought to the laboratory for analysis. The results show that tree species diversity and chlorophyll content increased at an increasing ground distance away from the quarrying site with high tree species diversity index and evenly distributed individual tree species at 750-1000m as 3.25 to 3.20 from 0-alpha to infinity. Low chlorophyll content of common plants species was observed at Jonathan village, which is 0 km away from the quarrying site, as (13.01±0.16), (17.08±0.15), (8.72±0.16), (14.21±0.15) and (9.86±0.15) mg/g/dry-weight for *Brachystegia spiciformis, Eucalyptus grandis, Mangifera indica, Prunus persica* and *Psidium guajava,* respectively. There were significant (P<0.001) differences on chlorophyll content and dust retaining capacity on common plant species growing in the adjacent villages to the quarrying site. *Eucalyptus grandis* had the highest chlorophyll content and also showed a high dust retaining capacity as (34.01±0.19) mg/g/dry-weight and (1.21±0.03) mg/cm^2 respectively.It is therefore, recommended that in the study area there is a need to develop green belt to restrict spreading of quarrying dust for the betterment of the environment and human being and *Eucalyptus grandis* may be very significant for using as green belt surroundings of the study quarrying site.

INTRODUCTION

Green belt is defined as mass plantation of pollutant-tolerant trees for mitigating the air pollution by intercepting, filtering and absorbing pollutants in a sustainable manner (Sharma and Roy, 1997; Saini *et al*., 2011). Quarrying dust is reported to have adverse effects on human health and alters plant community structure (Pandey *et al*., 2004; Srivastava *et al*., 2005). Dust falling on leaves of plants may cause foliar injuries and affect photosynthesis, respiration and transpiration, which leads to decreased yield (Raina *et al*., 2008; Saini *et al*., 2011). Forest disturbance due to quarrying dustand its consequences on tree species diversity have been widely studied, and most severe one have reported reduction in plant growth as well as loss of forest cover (Sharma and Roy, 1997; Pandey *et al*., 2004; Srivastava *et al*., 2005; Raina *et al*., 2008; Kumar *et al*., 2008; Lameed and Ayodele, 2010; Omosanya and Ajibade 2011; Saini *et al*., 2011; Nartey *et al*., 2012). The consequences of this loss not only affect the diversity but also ecosystem functions, including pest control, dispersal, and pollination and the regulation of water resources (Omoro and Luukkanen, 2011). Therefore, monitoring of the effects of dust particles on vegetation in essential. Despite the dangers of the dust emission resulting from quarrying, there has not been any study on the effects of this activity on the tree species diversity in Chongoni Forest Reserve and on vegetation characteristics in the nearby villages. Therefore, the objective of this study was to investigate the effects of quarrying dust emission on the tree species diversity and vegetation characteristics in Chongoni Forest Reserve and adjacent villages respectively.

****Corresponding author: Edward Missanjo,***
Department of Forestry, Malawi College of Forestry and Wildlife, Private Bag 6, Dedza, Malawi.

MATERIALS AND METHODS

Study site

The study was conducted in Malawi located in Southern Africa in the tropical savanna region at Chongoni Forest Reserve in Dedza. Chongoni is located between latitudes $14^0$10'S and $14^0$21'S and longitudes $34^0$09'E and $34^0$17'E (Figure 1). Itreceives 1200 mm to 1800 mm rainfall per annum, with annual temperature ranging from 7 ^{0}C to 25 ^{0}C. The altitude of the reserve varies from 1570 m to 1690 m above the sea level. It is situated about 85 km southeast of Lilongwe, the capital (Missanjo and Mwale, 2014). The quarrying activities are carried out on the edge of the reserve (Figure 1).

Table 1. Details of Villages Studied

No. of Site	Village Name	Direction with respect to Quarrying Site	Distance with respect to Quarrying site (km)
1	Jonathan	South	0
2	Chilamba	South-west	2
3	Kalinyeke	South	3
4	Chimpazi	South-west	4

Statistical analysis

Data obtained weretested for normality and homogeneity with Kolmogorov-Smirnov D and normal probability plot tests using Statistical Analysis of Systems software version 9.1.3 (SAS, 2004).

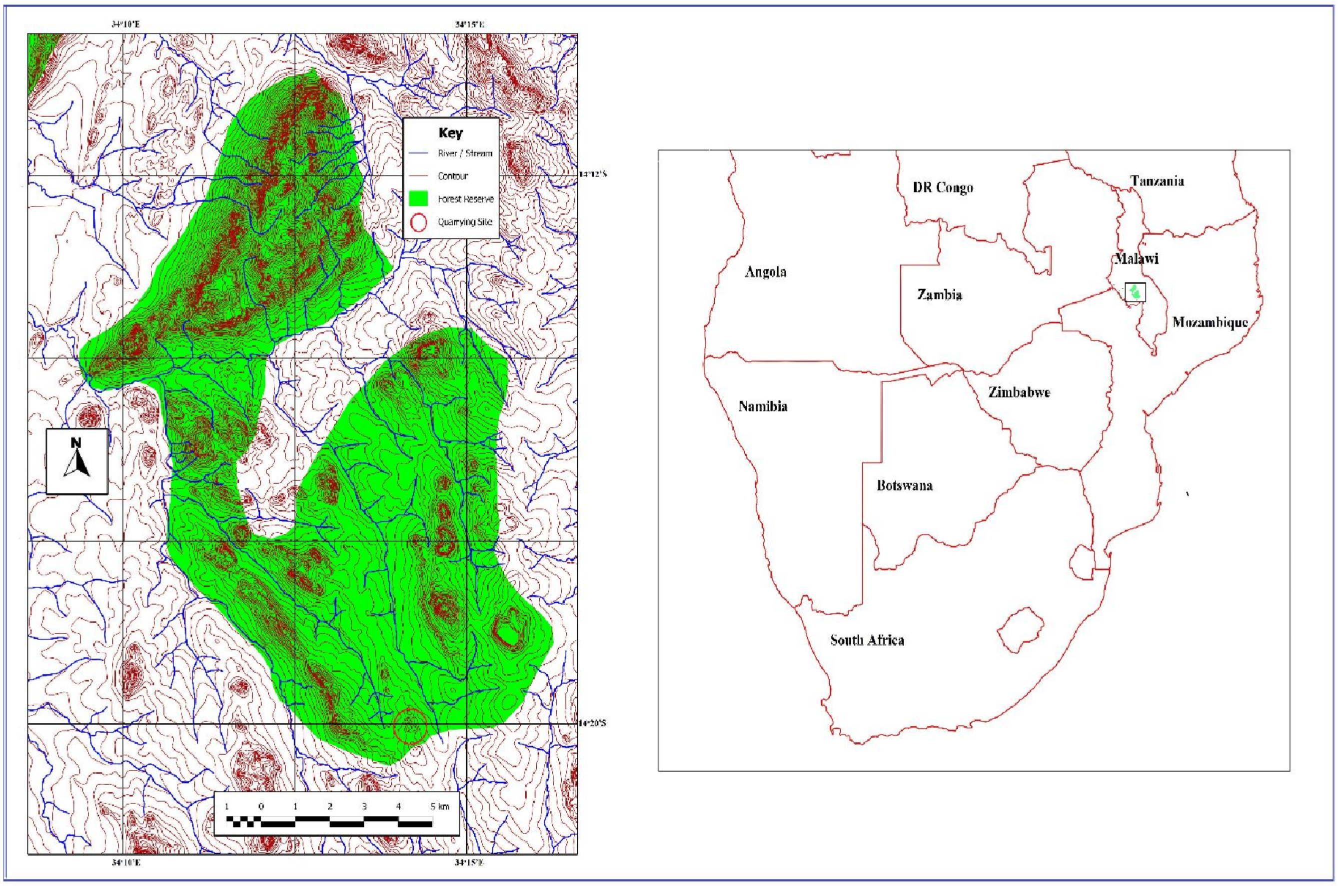

Figure 1. Location of Chongoni Forest Reserve in Southern Africa

Experimental design and data collection

An inventory on tree species diversity wascarried out within a ground distance of 0 – 1km from the quarrying site into the reserve at an increasing distance of 250 m. i.e. 0 – 250 m; 250 – 500m; 500 -750m; and 750 – 1000m. Five plots of 10m x 10m were laid out systematically in each of the treatment. Tree species stocking were enumerated and their species name were also recorded.Leaves of five common plant species in the adjacent villages were collected and brought to the laboratory for analysis. Dust load estimation and chlorophyll extraction were determined according to the methods of Kumar *et al*. (2008) and Coombs *et al*. (1985) respectively. The study was conducted in dry season, September 2013. Details of the studied villages are presented in Table 1.

After the two criteria were met, tree species diversity was determined by using Rẻnyi diversity profile in Biodiversity R. (Kindt and Coe, 2005). Biodiversity R. description has been well explained by Missanjo *et al*. (2014). Data on chlorophyll concentration and dust load were subjected to analysis of variance (ANOVA) using the Statistical Analysis of Systems software and means were separated with Fischer's least significant difference (LSD) at the 0.05 level.

RESULTS AND DISCUSSION

Tree species diversity

Rẻnyi diversity profiles for the four treatments at Chongoni Forest Reserve are presented in Figure 2. The results shows that the distance of 750-1000m had a higher profile than the other treatments, followed by 500-750 m and 250-500m. This means that tree species diversity increased at an increasing ground distance away from the quarrying site. Furthermore, the shape of the profiles shows that at the ground distance of 500-750 m and 750-1000m from the quarrying site, the individual tree species were evenly distributed. On the other hand, the ground distance of 0-250 m from the quarrying site showed the lowest profile and the shape of the profile was less horizontal. This means that the proportional of the individual species were not evenly distributed. This was attributed to the dominance of *Uapaca kirkiana* (Table 2).

This is in agreement with results in literature (Cunningham *et al*., 2005; Lameed and Ayodele, 2010). Cunningham *et al.* (2005) reported that there is a tendency of dominance of one species once the woodland has been disturbed. The dominance of *Uapaca kirkiana*in the ecosystem is an indicator of degraded or exploited community (Webster and Fittipaldi, 2007; Spinage, 2012). The results reported by Lameed and Ayodele (2010), which shows that biodiversity was disturbed by quarrying activity at Ogbere, Nigeria, also support the findings of the present study.

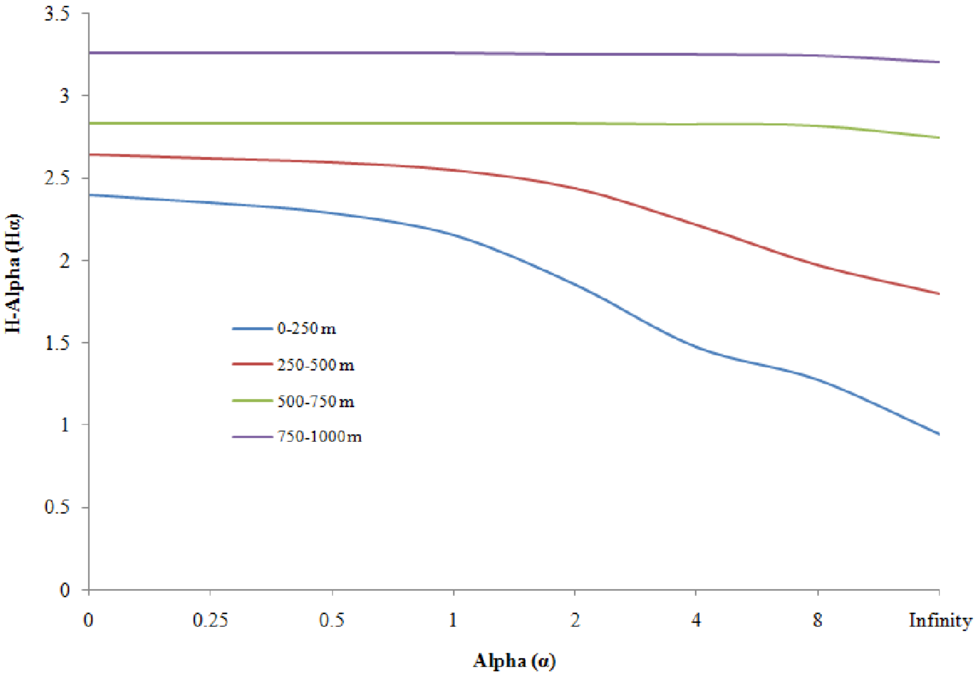

Figure 2. Rếnyi diversity profiles for four treatments at Chongoni Forest Reserve

Table 2. Tree species abundance (trees ha^{-}) for different treatments

Tree species	Abundance (trees ha^{-}) for each treatment			
	0-250m	250-500m	500-750m	750-1000m
Annona senegalensis	84	91	118	107
Azanza garckeana	72	87	116	115
Bauhinia thonningii	-	-	-	102
Brachystegia spiciformis	152	73	132	105
Brachystegia utilis	77	136	111	100
Bridelia micrantha	-	-	119	106
Combretum molle	-	-	-	98
Diospyros kirkii	134	123	121	116
Faurea saligna	68	113	118	112
Faurea speciosa	-	-	100	109
Flacourtia indica	-	-	-	118
Grewia bicolor	-	53	-	117
Hyperrhenia cymbarica	-	-	-	111
Julbernardia paniculata	122	75	113	98
Multidentia crassa	-	-	119	105
Panicum maximum	-	-	-	113
Parinari curatellifolia	118	117	124	115
Protea nitida	-	-	116	108
Pseudolachnostylis maprouneifolia	75	113	106	102
Rhus longipes	-	64	-	99
Steganotaenia araliacea	-	-	107	100
Themeda triandra	-	-	-	114
Trinichocladus crinitus	98	85	105	101
Uapaca kirkiana	489	258	111	98
Vitex payos	-	-	-	103
Ziziphus mucronata	-	62	114	102

Table 3. The mean of chlorophyll concentration of leaves of common plant species in the adjacent villages

Village Name	Distance and direction	Chlorophyll concentration (mg/g/dry weight) on the common plant species				
		Brachystegia spiciformis	*Eucalyptus grandis*	*Mangifera indica*	*Prunus persica*	*Psidium guajava*
Jonathan	0 km South	13.01±0.16c	17.08±0.15c	8.72±0.16c	14.21±0.15c	9.86±0.15c
Chilamba	2 km SW	21.46±0.14b	34.65±0.19b	13.07±0.18b	22.93±0.21b	14.31±0.19b
Kalinyeke	3 km South	29.87±0.16a	41.98±0.18a	18.83±0.18a	30.97±0.16a	19.78±0.16a
Chimpazi	4 km SW	30.12±0.15a	42.31±0.25a	19.02±0.19a	31.01±0.14a	20.01±0.18a
Mean		23.62±0.15y	34.01±0.19x	14.91±0.18z	24.78±0.17y	15.99±0.17z
CV%		9.1	5.6	6.4	9.8	6.0

Means with different letters (a,b,c) within a column differ (*P*<0.001); Means with different letters (x,y,z) within a row differ (*P*<0.001)

Table 4. Dust load on leaves of common plant species in the adjacent villages

Village Name	Distance and direction	Dust load(mg/cm^2) on the common plant species				
		Brachystegia spiciformis	*Eucalyptus grandis*	*Mangifera indica*	*Prunus persica*	*Psidium guajava*
Jonathan	0 km South	1.19±0.02c	2.51±0.05c	0.58±0.01c	1.21±0.03c	0.62±0.04c
Chilamba	2 km SW	0.42±0.01b	1.12±0.01b	0.12±0.06b	0.44±0.01b	0.14±0.01b
Kalinyeke	3 km South	0.17±0.03a	0.61±0.02a	0.05±0.02a	0.19±0.06a	0.08±0.03a
Chimpazi	4 km SW	0.15±0.04a	0.59±0.03a	0.03±0.01a	0.18±0.03a	0.05±0.02a
Mean		0.48±0.03y	1.21±0.03x	0.20±0.03z	0.51±0.03y	0.22±0.03z
CV%		7.3	8.1	4.9	5.4	6.8

Means with different letters (a,b,c) within a column differ (*P*<0.001); Means with different letters (x,y,z) within a row differ (*P*<0.001)

Chlorophyll concentration and dust load

The chlorophyll concentration and dust load for common plant species in the adjacent villages to the quarrying site are given in Tables 3 and 4 respectively. There were significant (*P*<0.001) differences among ground distances from the quarrying site on the chlorophyll concentration of plant leaves. Chlorophyll concentration increased with increasing ground distance away from the quarrying site. However, the chlorophyll concentration for Kalinyeke and Chimpazi, 3 km and 4 km away from the quarrying site, respectively, did not significantly (*P*>0.05) differ. The results have further revealed that *Eucalyptus grandis* had the highest chlorophyll content followed by *Prunus persica* and *Brachystegia spiciformis,* while *Psidium guajava* and *Mangifera indica* showed a low chlorophyll content. This means that *Eucalyptus grandis* is more tolerant to pollutants. The present results are inline to those of Singh (2000), who reported a decrease in pigment concentration in plants growing near the stone crashers. The reduction in chlorophyll concentration is due to degradation of chlorophyll into phaeophytin by the loss of magnesium ions (Saini *et al*., 2011). Saini *et al*. (2011) also argued that chlorophyll concentration may differ in different period of time under different conditions of pollution stress and meteorological conditions. Therefore, high chlorophyll concentration in plants might favour tolerance to pollutants. The present study has revealed a decline in chlorophyll concentration in trees growing in the villages adjacent to quarrying sites. It is therefore, recommended that in the study area there is a need to develop green belt to restrict spreading of quarrying dust for the betterment of the environment and human being.

The results also shows that there were significant (*P*<0.001) differences on the dust load on the common plant species growing in the villages adjacent to the quarrying site. *Eucalyptus grandis* showed a high dust retaining capacity than the other tree species. The present results are similar to those reported elsewhere (Kumar *et al*., 2008). Leaf surface and size of the leaf are one of the most important factors that determine the dust retaining capacity (Prajapati and Tripathi, 2008). Nowark (1994) also reported that dust retaining capacity of plants depends on their surface geometry, phyllotaxy, leaf external characteristics, height and canopy of the trees. If the leaf surface is smooth there is less dust retaining capacity, while leaves having rough surface retain high dust (Saini *et al*., 2011).Since *Eucalyptus grandis* showed a high dust retaining capacity. Therefore, it is recommended that these species may be very significant for using as green belt surroundings of the study quarrying site.

Conclusion

The present study has revealed that the deposition of quarrying dust has an effect on tree species diversity and vegetation characteristics in the villages adjacent to the quarrying site. Tree species diversity and chlorophyll content increased with an increasing ground distance away from the vicinity of the quarrying site, while dust load decreased with increasing ground distance away from the quarrying site. *Eucalyptus grandis* had the highest chlorophyll content and also showed a high dust retaining capacity than the other tree species growing in the villages adjacent to the quarrying site. It is therefore, recommended that in the study area there is a need to develop green belt to restrict spreading of quarrying dust for the betterment of the environment and human being.*Eucalyptus grandis* may be very significant for using as green belt surroundings of the study quarrying site.

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