EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 Volume 2 Number 3 (March-2015) pp. 1-6

www.ijcrbp.com

Original Research Article

Saw Dust Emission Effects on Vegetation Characteristics in the Vicinity of Sawmilling Plants

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Abstract

Survival of plants in the vicinity of industrial areas is being threatened by particulates. A study was conducted to investigate the effects of sawmilling dust on vegetation characteristics in Dedza, Malawi. Four sawmills were randomly selected. An inventory on natural seedling regeneration was carried out within a ground distance of 0–1km around the sawmill sites at an increasing distance of 250m (0–250m; 250–500m; 500-750m; 750–1000m). Leaves of dominant plant species in these treatments were also collected and brought to the laboratory for analysis. The results show that the distance of 750-1000m had higher natural seedling regeneration both in rainy (4800 stocking ha^{-}) and dry season (1500 stocking ha^{-1}) followed by 500-750m (4200 stocking ha^{-1}, 1400 stocking ha^{-1}) and 250-500m (3100 stocking ha^{-1}, 890 stocking ha^{-1}), while 0-250m had a low natural seedling regeneration both in rainy (1700 stocking ha^{-1}) and dry season (450 stocking ha^{-1}) respectively. Chlorophyll concentration, leaf area and stomata number of leaves showed the same trend, while dust load in leaves decreased with increasing ground distance away from the sawmills. The study also revealed that *Eucalyptus camaldulensis* was affected least from chlorosis and necrosis (had high chlorophyll concentration) in both rain (19.75 mg/g/dry weight) and dry seasons(25.25 mg/g/dry weight) and also showed a high saw dust holding capacity in both rain (1.01 mg/cm^2) and dry seasons (1.32 mg/cm^2). Therefore, it is recommended that adequate green belt should be developed in the sawmilling industry area in order to restrict spreading of saw dust and *Eucalyptus camaldulensis* may be very significant for using as green belt surroundings of sawmilling industry.

Keywords

Chlorophyll
Green belt
Leaf area
Natural regeneration
Saw dust
Stomata

Introduction

Air pollution is described as the introduction of particulates, biological molecules or other harmful materials into the Earth's atmosphere, causing diseases, death to humans, and damage to other living organisms such as food crops, or the natural or built environment (Farmer, 1993). These particulates may originate from many sources, but mainly from industrial processes (Oke and Oyedare, 2006). The survival of plants in the industrial areas is being threatened by these particulates. (Addo et al., 2013).Generally, air pollution through the particulates reduces chlorophyll content in leafs which lead to stunted growth in plants (Isichei and Sanford, 1976; Odu, 1994; Oke and Oyedare, 2006).

The effect of different types of dust on plants has been investigated by many authors. However, most studies have concentrated on effect of cement dust on vegetation characteristics (Gostin, 2009; Lepedus et al., 2003 and Mandre et al., 2000). Enespa and Dwivedi (2013) reported that cement dust displayed both inhibitory and promontory effects on different growth parameters of the *Solanum melongena*. Cement dust had a significant effect on the growth and structure of some plant species compared withnon-polluted plants (Joshi and Swami, 2009; Rao and Narayanan, 1998). According to Liu et al. (1997), Pandey and Kumar (1996), and Satao et al. (1993) cement dust decrease the growth, productivity and concentration of chlorophyll in a number of annual non-leguminous crops. It has been reported that sawmilling activities also plays a major role in environmental pollution and destroy the beauty of the area and this is area specific (Oke and Oyedare, 2006). However, very little information is available in the literature on the effect of sawmilling dust on plant characteristics. Besides that no attempt has been made to investigate the impact of sawmilling dust emission on vegetation attributes in the vicinity of Sawmilling Plants in Malawi. Therefore, the present study was undertaken to investigate the effect of sawmilling dust on vegetation characteristics in Dedza district, Malawi.

Materials and methods

Study site and sawmill selection

The study was conducted in Malawi located in Southern Africa in the tropical savanna region in Dedza. Dedza lies on latitude 13^{0}52'S and 14^{0}38'S and longitude 33^{0}39'E and 34^{0}44'E. It receives 1200 mm to 1800 mm rainfall per annum, with annual temperature ranging from 7 ^{0}C to 25 ^{0}C. The altitude of the district varies from 500 m to 1600 m above the sea level. Dedza is situated about 85 km southeast of Lilongwe, the capital. The district has a lot of *Pinus* plantations which are the major source of raw material for sawmilling in Malawi. Four sawmills were randomly selected for this study.

Experimental design and data collection

An inventory on natural seedling regeneration was carried out within a ground distance of 0 – 1km around the sawmill sites at an increasing distance of 250 m. i.e. 0 – 250 m; 250 – 500m; 500 -750m; and 750 – 1000m for each sawmill. Five plots of 10m x 10m were laid out systematically in each of the treatment. All regenerants from seedlings up to 1.9 cm diameter at stump height (DSH) were enumerated and their species names were also recorded. Leaves of dominant plant species in these treatments were collected and brought to the laboratory for analysis. Dust load estimation, Leaf area determination, Chlorophyll extraction and Stomata count were determined according to the methods of Kumar et al. (2008), Osei-Yeboah et al. (1983), Coombs et al. (1985), and the technique of Metcalf (1960) respectively. This was done both during the dry season (September – October 2013) and the rainy season (January – February 2014).

Statistical analysis

Data obtained were subjected to Kolmogorov-Smirnov D and normal probability plot tests using Statistical Analysis of Systems software version 9.1.3 (SAS, 2004). This was done in order to check the normality of the data. After that the data was subjected to analysis of variance (ANOVA) using the same Statistical Analysis of Systems software version 9.1.3. Differences between treatment means were separated using Fischer's least significant difference (LSD) at the 0.05 level.

Results and discussion

The dominant plant species and natural regeneration

The following are the dominant and common plant species around the four sawmills: *Brachystegia spiciformis*, *Bridelia micrantha*, *Combretum molle*, *Eucalyptus camaldulensis*, *Faurea speciosa*, *Parinari curatellifolia*, *Protea nitida*,*Pseudolachnostylis maprouneifolia*, *Rhus longipes*, *Steganotaenia araliacea*,*Trinichocladus crinitus*, *Uapaca kirkiana*, *Ziziphus mucronata*. However, the following plant species were found in all the four sawmills in both rainy and dry seasons and in all the distances:

Brachystegia spiciformis, *Bridelia micrantha*, *Eucalyptus camaldulensis* and *Parinari curatellifolia*.

Natural regeneration rate between different ground distances from sawmills in both rainy and dry seasons are presented in Table 1. The results indicates that there were significant (p<0.001) differences on the natural regeneration of plants among different ground distances from sawmills. The natural regeneration increased with increasing ground distance away from sawmills. However, beyond 500 m from sawmills the natural regeneration showed no significant (p>0.05) differences. The trend was the same for both rainy and dry seasons.

The present results are in agreement with the results reported by Lameed and Ayodele (2010), Mudd and Kozlowski (1975), Oke and Oyedare (2006) and Rocky and Mligo (2012). Lameed and Ayodele (2010) reported that dust which accumulates on the surfaces of leaves, penetrates into the leaves, block and damage the stomata which in turn affect the processes of photosynthesis and respiration. These affects the physiological activities of the plants most especially those around the sawmill sites.

The consequence of these is that some of the plants may have stunted growth while others may be eliminated (Oke and Oyedare, 2006).As the distance increases away from the sawmills the effects of dust, gaseous emissions and air-borne particulates are less felt by the plants, hence high rate of natural seedling regeneration and abundance of plant species (Lameed and Ayodele, 2010).

Table 1. Mean stocking of natural regeneration of plant species around the sawmills in rainy and dry seasons.

Ground distance (m)	Mean stocking of natural regeneration of plant species (stocking ha^{-})	
	Rainy season	Dry season
0 – 250	1700±109c	450±49c
250 – 500	3100±105b	890±52b
500 – 750	4200±124a	1400±141a
750 – 1000	4800±148a	1500±114a
CV%	7.5	8.3
Means with different letters within a column differ (p<0.001)		

Chlorophyll concentration, leaf area and stomata number

The chlorophyll concentration and leaf area for common plant species around the sawmills both in rainy and dry seasons are presented in Tables 2 and 3 respectively, while the results for stomata number for both adaxial and abaxial surfaces of the leaves are presented in Table 4. The results indicate that there were significant (P<0.001) differences on chlorophyll concentration, leaf area and stomata number among different ground distances from sawmills with highest values being observed at 1 km away from sawmills and lowest values at 0 m away from sawmills. This means that chlorophyll concentration, leaf area and stomata number increases with increasing ground distance. The results also show that *Parinari curatellifolia* was highly affected from chlorosis and necrosis, while *Eucalyptus camaldulensis* was affected least.

The present results are in line with those reported by Oke and Oyedare (2006) in the study of sawmill dust on plant characteristics in Nigeria. The study on *Amaranthus viridis* and *Abelomoscus esculentus* (Odu, 1994) also supports the results of the present results. This is also supported by Enespa and Dwivedi (2013) who reported that impurities can cause reductions in leaf area.

Therefore, the decrease in leaf area and the number of stomata for the plants located in the vicinity of sawmills could be due to synergic effect of impurities on metabolic process which hinders many enzyme systems of plants (Singh and Verma, 2007). As a result, this could reduce the amount of radiations to be absorbed by the leaf. Hence reduction in photosynthetic rate and subsequently reduced growth (Tiwari et al., 2006).However, the present results are in contrast to the study of *Beta vulgaris* (Czaja, 1961) who reported no reduction in chlorophyll concentration in response to presence of limestone dust. Oke and Oyedare (2006) suggested that the reason behind this is that plant species may be differently immuned to the effect of pollutants from the sawmill activities.

The present study has revealed that saw dust emission has produced an adverse effect on the growth of plant species around sawmills. It is therefore, recommended that adequate green belt should be developed in the sawmill industry areas in order to restrict spreading of saw dust.

Table 2. The mean of chlorophyll concentration of leaves of common plant species around the sawmills.

Ground distance (m)	Common species chlorophyll concentration (mg/g/dry weight)							
	Rain season				Dry season			
	Brachystegia spiciformis	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*	*Brachystegia spiciformis*	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*
0 – 250	7.04±0.05d	6.47±0.08d	8.25±0.04d	15.12±0.05d	11.08±0.05d	11.76±0.03d	12.04±0.07d	16.95±0.04d
250 – 500	9.92±0.09c	8.96±0.05c	10.04±0.08c	18.49±0.02c	13.56±0.09c	13.92±0.09c	14.87±0.02c	24.63±0.05c
500 – 750	11.34±0.01b	10.69±0.04b	13.01±0.01b	20.31±0.06b	16.67±0.02b	15.29±0.05b	17.78±0.08b	26.92±0.09b
750 – 1000	14.05±0.05a	11.54±0.07a	15.72±0.06a	25.06±0.01a	20.05±0.03a	16.02±0.03a	21.45±0.05a	32.51±0.06a
CV%	6.2	6.9	7.8	9.2	7.2	6.3	6.8	7.1
Means with different letters within a column differ (*p*<0.001)								

Table 3. The mean of leaf area of leaves of common plant species around the sawmills.

Ground distance (m)	Common species leaf area (cm^2)							
	Rain season				Dry season			
	Brachystegia spiciformis	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*	*Brachystegia spiciformis*	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*
0 – 250	69.94±0.05d	112.69±0.01d	95.04±0.01d	104.87±0.04d	47.07±0.05d	65.23±0.04d	52.19±0.01d	78.01±0.05d
250 – 500	72.06±0.08c	115.61±0.06c	102.23±0.04c	110.03±0.08c	56.09±0.02c	76.03±0.02c	64.02±0.01c	87.01±0.03c
500 – 750	89.04±0.06b	119.12±0.04b	109.76±0.05b	117.18±0.05b	63.98±0.07b	87.12±0.08b	70.28±0.05b	93.14±0.05b
750 –1000	97.43±0.09a	125.39±0.02a	115.89±0.04a	129.03±0.01a	67.05±0.01a	91.04±0.04a	77.97±0.08a	99.94±0.06a
CV%	9.2	8.7	5.0	8.9	8.3	9.8	7.6	8.5
Means with different letters within a column differ (*p*<0.001).								

Table 4. The mean of stomata of leaves of common plant species on adaxial and abaxial surfaces around the sawmills.

Ground distance (m)	Common species stomata per mm^2 of leaf							
	Adaxial surface				Abaxial surface			
	Brachystegia spiciformis	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*	*Brachystegia spiciformis*	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*
0 – 250	23.76±0.03d	25.07±0.03d	16.83±0.04d	13.07±0.09d	54.98±0.02d	50.04±0.04d	45.08±0.02d	59.21±0.04d
250 – 500	29.51±0.04c	30.03±0.08c	21.05±0.07c	21.03±0.07c	61.34±0.09c	56.76±0.01c	57.27±0.07c	68.02±0.02c
500 – 750	35.06±0.01b	36.07±0.09b	26.05±0.01b	32.01±0.02b	67.91±0.02b	65.03±0.05b	64.44±0.01b	75.34±0.01b
750 – 1000	39.01±0.06a	43.05±0.01a	33.33±0.05a	45.21±0.04a	70.23±0.04a	68.71±0.04a	71.12±0.05a	88.73±0.07a
CV%	7.1	7.9	7.5	6.9	7.9	6.7	7.1	8.4
Means with different letters within a column differ (*p*<0.001).								

Dust load on plant species

Summary of the results on the dust load on plant species are presented in Table 5. The results show that there were significant (*p*<0.001) differences on the dust load on plant species among the ground distances from sawmills. Dust load decreased with increasing ground distance away from sawmills. *Eucalyptus camaldulensis* showed a high saw dust holding capacity followed by *Brachystegia spiciformis*, while *Parinari curatellifolia* and *Bridelia micrantha* showed a small saw dust holding capacity. The present results are similar to those reported elsewhere (Kumar et al., 2008). Since *Eucalyptus camaldulensis* showed a high saw dust holding capacity. Therefore, it is recommended that these species may be very significant for using as green belt surroundings of sawmilling industry.

Conclusion

The present study has shown that the deposition of sawdust has an effect on vegetation characteristics on natural communities and this may alter the competitive balance between plant species. The rate of natural regeneration, chlorophyll concentration, leaf area and stomata number increased with an increasing ground distance away from the vicinity of the sawmill plants, while dust load decreased with increasing ground distance away from sawmills. Therefore, it is recommended that adequate green belt should be developed in the sawmilling industry area in order to restrict spreading of saw dust. Since *Eucalyptus camaldulensis* was affected least from chlorosis and necrosis and also showed a high saw dust holding capacity, therefore, these species may be very significant for using as green belt surroundings of sawmilling industry.

Table 5. Dust load on leaves of common plant species around the sawmills.

Ground distance (m)	Common species dust load (mg/cm^2)							
	Rain season				Dry season			
	Brachystegia spiciformis	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*	*Brachystegia spiciformis*	*Parinari curatellifolia*	*Bridelia micrantha*	*Eucalyptus camaldulensis*
0 – 250	0.89±0.01a	0.65±0.03a	0.41±0.01a	1.98±0.02a	1.13±0.03a	0.74±0.01a	0.48±0.01a	2.46±0.01a
250 – 500	0.52±0.01b	0.43±0.01b	0.32±0.03b	1.03±0.01b	0.91±0.01b	0.51±0.03b	0.39±0.02b	1.25±0.03b
500 – 750	0.18±0.02c	0.17±0.01c	0.15±0.02c	0.63±0.03c	0.46±0.03c	0.26±0.02c	0.21±0.02c	0.94±0.02c
750 –1000	0.12±0.01d	0.11±0.02d	0.11±0.01d	0.39±0.02d	0.29±0.01d	0.15±0.03d	0.14±0.01d	0.61±0.03d
CV%	6.1	9.8	5.6	8.8	6.7	6.4	9.2	5.9

Means with different letters within a column differ (p<0.001).

Acknowledgement

The authors thank the staff of the four sawmills for allowing the study to be conducted within the vicinity of sawmills.

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