Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

Special Issue

MORPHOLOGICAL LEAF CHARACTERISTICS OF SELECTED TREES AND ITS ADSORBENT CAPACITY AT PARTICULATE MATTER (PM_{10}) IN CAGAYAN DE ORO CITY, PHILIPPINES

B. M. T. Estoque, D. J. G. Saberon, S. R. B. Sac, G. L. Lacang, C. P. Ascaño*

Department of Environmental Science and Technology, College of Science and Mathematics, University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines.

Published online: 24 February 2018

ABSTRACT

The study aimed to give information about the use of trees in helping the environment particularly to the quality of air. Leaves of selected tree species planted along the busy streets in Cagayan de Oro City, Philippines were analyzed in terms of its surface area and its ability to adsorb PM_{10}. Results revealed that *G. arborea* Roxb. exhibits the greatest leaf surface area based from the method UTHSCA software. Further, results of the study showed that among the four plant species sampled and analyzed along the road of Brgy. Kauswagan , the leaves of *G. arborea* Roxb., adsorbed the highest amount of PM_{10} while in Masterson Avenue, *M. calabura* Linn. showed the highest rate of adsorption capacity compared to other three species sampled and analyzed. Two- way ANOVA revealed that there are no significant differences between the two busiest streets and among the four species sampled and analyzed.

Keywords: $PM_{10,}$ Surface leaf area, Adsorption, Air quality

1. INTRODUCTION

Air pollution is considered to be a global problem. It has various sources like natural volcano, forest fires and sandstorms to anthropogenic vehicle exhausts and processing industries, for instance cement or fertilizers production (Farmer, 2002).

Author Correspondence, e-mail: author@gmail.com

doi: http://dx.doi.org/10.4314/jfas.v10i3s.58

Ambient air pollution is one of the worldwide leading causes for increased mortality and morbidity in the population (Beelen et al., 2014; Yang et al., 2013). Previous studies suggest that air pollution may induce adverse health effects through multiple biological pathways, among which activation of oxidative stress has received incresing attention in recent years (Ghio et al., 2011; Valavanidis et al., 2008).

Dust particles or particulate matter (PM) in a traffic emission contributes a major source of air pollution in urban areas. The combustion process of fossil fuels and road dust suspension particulates deteriorate air quality and can cause adverse effect on human health. It is widely recognized as one of the most harmful pollutants for human health (WHO, 2005; Pope and Dockery, 2006). Road traffic emissions include not only gases and particulate matter released from motor exhausts, but also ‘‘non-exhaust’’ particles derived from the wear and tear of vehicles (Schauer et al., 2006) and road surface, as well as from re-suspension due to the turbulence generated by vehicle wheels.

Non-exhaust emissions in urban environments currently represent a PM source comparable to, or even greater than exhaust emissions (Amato et al., 2009a; Kousoulidou et al., 2008;Kristensson et al., 2004; Abu-Allaban et al., 2003; Jaecker-Voirol and Pelt, 2000] mostly for PM_{10} (particles with aerodynamic diameter <10 mm). Particles with aerodynamic diameters <10μm (PM10) are of concern for environmental problems (Seinfeld and Pandis, 2006). PM is described as particles of a diameter range between 0.001 and 100mm. Depending on their size, it can penetrate different levels of the human respiratory system. PM in the atmosphere is usually monitored as PM_{10} with a size smaller than 10mm and $PM_{2.5}$ with a size smaller than 2.5 mm. Increasing urbanization also implies an increase in the number of people exposed to high levels of air pollution, such as PM. In the Philippines, based from the 2006 National Emission Inventory, the transport sector is the major source of air pollution in the country wherein 65% of air pollutants come from them. Public transport comprises 71% of the total number of vehicles registered in the country. Cagayan de Oro City is located along the central coast of northern Mindanao islands. It is a first class highly urbanized and capital city of the province of Misamis Oriental, southern part of the Philippines. According to the 2010 Census of Population, the city has a population of 602,088, making it the 10th most populous city and one of the major cities in the Philippines with significant numbers of motor vehicles.

Vegetation alongside major highways and interstate has the potential to provide many benefits to society and for conservation efforts. Numerous studies have identified as abundance of very real and tangible benefits that trees, plants and natural areas provide to us each and every day, benefits such as energy conservation, improved air and water quality, increased property values and economic vitality, improved health and well- being, habitat improvement, etc. City streets are not simply through fares for motor vehicles, but must also as public spaces where people walk, shop, meet, and generally participate in the social and recreational activities that make urban living enjoyable. Urban foresters, designers, and planners in Cagayan de Oro City encourage streetscape tree planting to enhance the livability of urban streets. Yet transportation professionals often discourage the placement of inflexible features near travel lanes due to safety concerns. Discussions about trees are largely framed in terms of aesthetic values, and many not be viewed as justification for trees when weighed against long held assumptions about safety. This paper gives information to the people about the beneficial use of the trees not only for aesthetic purposes but also for helping the environment particularly to the quality of air.

2. METHODOLOGY

2.1 Research Settings

The figure 1 shows the map of Cagayan de Oro City highlighting the two busy streets as recommended by Roads and Traffic Administration (RTA) where the sampling areas were established.

Fig.1. Map of Cagayan de Oro City, showing the two sampling sites

2.2 Collection of samples

The samples were collected during dry season, from 8 o'clock in the morning to 12 o'clock in the afternoon. The number of leaves per tree species collected were 15 pieces. Leaves were collected at the lower canopy, ranging between 0 to 20 meters from traffic roads using the portable ladder. Upon getting the leaves from the tree, the samples were immediately placed inside the zip-lock plastic bags to avoid contamination. Each zip-lock bag was properly labeled using a marker. Plastic gloves were used by the researchers instead of rubber gloves in order to prevent the dust particles from sticking on the hands.

2.3 Refrigeration and removal of dust particles

The samples in the zip-lock bags were stored inside freezer. Temperature was regulated to avoid contamination and to preserve the dust particles adsorbed. The samples were only removed from the refrigerator during analyses. After storage in the freezer, the leaves of the selected species of leaf samples were washed first with the deionized water. Each trial containing 15 leaves was soaked together for ten minutes and shaken for one minute in a plastic ware with 300 ml deionized water in order to remove the eventual presence of PM from the leaf surface. The zip-lock bags were also washed with deionized water by using the wash bottle in order to remove the remaining dust that was left in the plastic bags. The leaves were put back inside the zip-lock bags for the next step which was the identification of its morphological characteristics.

2.4 Pre weighing and constant mass

Each filter paper (Edirol type 91) involved in the filtration procedure was placed in a petri dish and pre-weighed using analytical balance with a calibration displaying "0.0000 g". Weighed filter paper supported with a petri dish to avoid contamination is placed in the drying oven set at 105^{0}c. The process of heating in the oven, desiccating and weighing is repeated until constant mass is obtained. Empty zip-lock bags and zip-lock bags with leaf samples were also pre-weighed.

2.5 Filtration and re-weighing

Each jar equal to one trial containing 300ml deionized water with dust particles was passed through a clean Edirol type 91 filter paper (pores 10 mm) in a glass funnel until the water samples were drained. All filters containing the PM were dried in HASUC drying oven at 100°C for one hour and were stabilized in a desiccator that was placed in a closed room, with controlled humidity and temperature for 30 minutes. All filters were re-weighed through analytical weighing balance after 30 minutes of storage in the desiccators. The filter papers with dust particles were re-weighed for several times after every heating until the constant mass was obtained. The difference between the constant mass of filter with dust particle and constant mass of empty filter paper (expressed in grams) represents the PM accumulated on the sampled leaves.

2.6 Identification of morphological characteristics of the leaf

Surface leaf Area (SLA).

The surface leaf area was calculated based from the mathematical principle of UTHSCA (Fig. 2).

Surface Leaf Area formula.

Surface Leaf Area= Leaf 1+ Leaf 2+ Leaf 3+ ….. Leaf 15/ 15.

Sum of the Surface Leaf Area= W1 + W2 + W3/ 3. Where, W= the sum of the surface leaf area per trial.

Amount of PM10.

Calculation of the amount of the PM: = y-z

Where: z= the constant mass of the filter paper;

y= the constant mass of the filter paper with PM10

Dust analysis.

Dust Collected = x/S

Where: x= the mass of the dust particles per trial;

S= the average surface leaf area per trial.

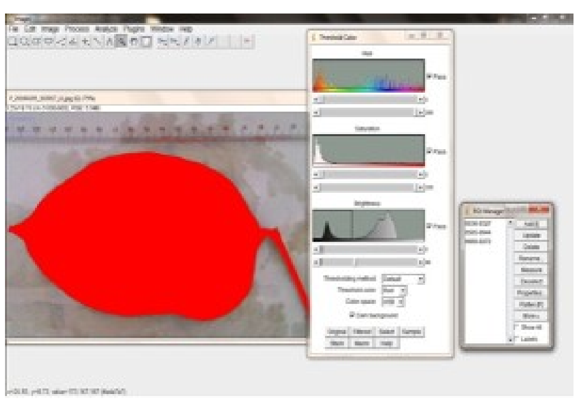

Fig.2. The surface leaf area calculation using the UTHSCA software.

2.7 Data analysis

Two Way ANOVA was used to determine whether there are any significant differences between two selected streets and leaves of different tree species. The analysis were applied to analyze PM deposition variability versus the factors such as the time (dry season), space (distance from traffic roads), canopy location (lower canopy), and the leaf morphology (trichomes).

3. RESULTS AND DISCUSSION

The leaves of four species of trees that were collected from the busy streets in Cagayan de Oro City includes; *Muntingia calabura* Linn.(Aratiles Leaf), *Psidium guajava* L.(Guava Leaf), *Gmelina arborea* Roxb. (Gmelina Leaf), *Sandoricum koetjape* Merr. (Santol Leaf) (Fig. 3).

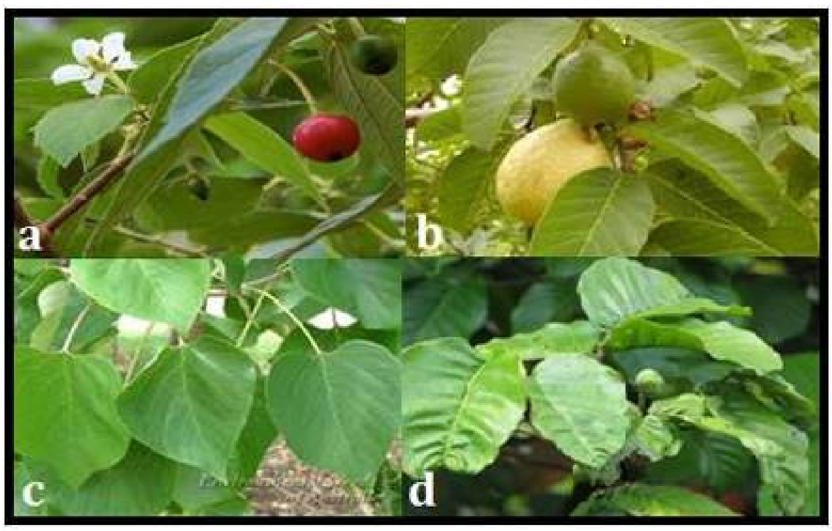

Fig.3. Tree species observed and analyzed from the busy streets in Cagayan de Oro City (legend: a. *M. calabura* Linn., b. *Psidium guajava L.*, c. *G. arborea* Roxb., d. *Sandoricum koetjape* Merr.)

The figure 4 shows the average surface leaf area (SLA) of each tree leaf species along Brgy. Kauswagan Street and Masterson Avenue. In Kauswagan Street, the *G. arborea* Roxb has the greatest leaf surface area among the four with an average of 216.7235 cm2. This may be attributed to its morphological traits of having broader leaves and wider canopy cover. The leaf species that has the least leaf surface area was the *M. calabura* Linn with an average of 32.0422 cm2. In Masterson Avenue, the *G. arborea* Roxb. has the greatest leaf surface area among the four leaf species having an average of 209.9121 cm2. The leaf species that has the least surface area was the *M. calabura* Linn. with an average of 21.0534 cm2 because of its lesser surface area. These two species have varied size and structure. Leaves with complex shapes and large circumference/area ratios collect particles most efficiently than smooth leaf. Generally, greater leaf surface and roughness increases particle capture efficiency (Gupta, V. K. and Kapoor, R. K. 1990).

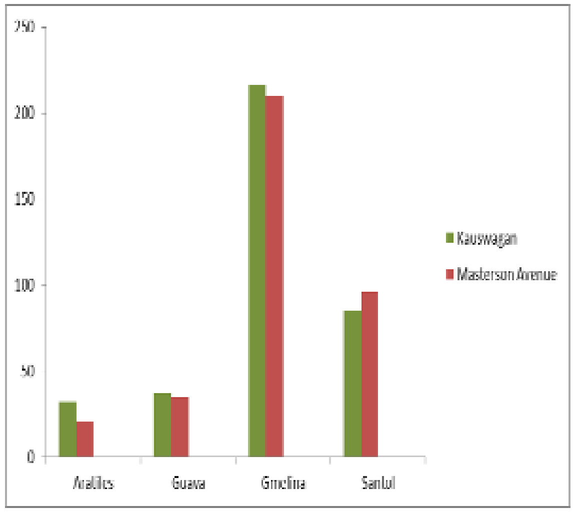

Fig.4. The surface area (cm2) of leaves collected along Brgy. Kauswagan Street and Masterson Avenue.

Figure 5 shows the graph of the PM_{10} (mg) adsorbed by each tree leaf species along Brgy. Kauswagan Street and Masterson Avenue. In Brgy. Kauswagan Street, the *G. arborea* Roxb has greater adsorption capacity of particulate matter among the four leaf species with an amount of 8.1889 mg. Its leaf size and trichomes have greatly influenced its adsorptive capacity other than wider canopy cover. The leaf species that adsorbed the least amount of PM_{10} among the four species was the *P. guajava* L. with an amount of 1.7711 mg. In Masterson Avenue, the *M. calabura* Linn has greater adsorption capacity of particulate matter among the four leaf species with an amount of 8.6356 mg. The leaf species that adsorbed the least amount of PM_{10} among the four was the *P. guajava* L. with an average amount of 5.7289 mg. Leaves with hairy, resinous, scaly, and coarse surfaces could capture more particles than smooth leaf (Beckett et al. 1998; Beckett et al. 2000a and Beckett et al. 2000b). The capacity of plants to reduce air pollution is well known and has been reported in the literature (Sharma and Roy, 1997; Nowak, 1994 and Nowak et al. 1996).

Figure 6 shows the graph of the dust particles collected (mg/cm2) by each tree leaf species collected along the Brgy. Kauswagan Street and Masterson Avenue. In Brgy. Kauswagan

Street, the *M. calabura* Linn. has the highest amount among the four leaf species with the value of 0.1254 mg/cm2. The leaf species which has the lowest amount adsorbed was the *G. arborea* Roxb with the value of 0.0381 mg/cm2. These two species have varied leaf size and structure (rough and hairy type). In Masterson Avenue, the *M. calabura* Linn has the highest amount of dust collected among the four leaf species with the value of 0.4689mg/cm2. The leaf species that has the lowest value was *G. arborea* Roxb with the value of 0.0339mg/cm2. Leaf with abundant trichomes (leaf hairs) are found to be particulate accumulator (Abbasi and Khan, 2000).

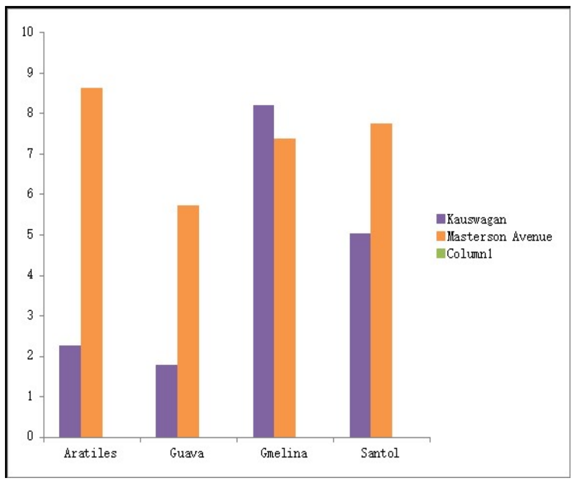

Fig.5. PM_{10} collected along Brgy. Kauswagan street and Masterson Avenue

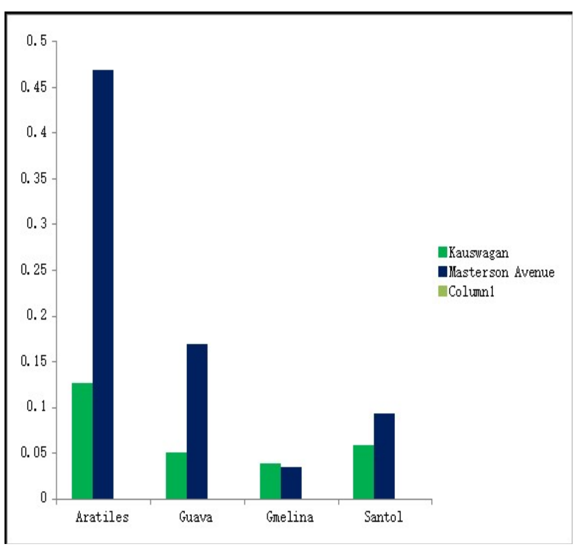

Fig.6. Dust collected along Brgy. Kauswagan and Masterson Avenue

Table 1. ANOVA result of the dust collected of the Barangay Kauswagan Street and Masterson Avenue.

Source ofVariation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Tree Species	0.080393	3	0.026798	2.215004	0.265267	9.276628
Two Busy Streets	0.03048	1	0.03048	2.51936	0.210654	10.12796
Error	0.036295	3	0.012098			
Total	0.147167	7				

Significant at 0.05 level

The result presented in table 1 revealed that there is no significant difference between the two streets because it varies to the surface leaf area. Moreover the broader or wider surface leaf area or morphologically hairy, the greater is capacity to adsorb particulate matter particularly PM_{10} between the two sites and among the four species.

4. CONCLUSIONS

This study revealed that the four leaves from different tree species collected from the busy streets in Cagayan de Oro exhibited variable leaf surface area where *G. arborea* Roxb. was considered having the widest area. In terms of dust adsorption capacity, *M. calabura* Linn. showed the highest degree of filtering PM_{10}. Leaves' morphological structure – hairy leaf, resinous, scaly, and coarse surfaces greatly influenced its ability to capture more particles.

REFERENCES

Abbasi SA and Khan FI (2000). Greenbelts for pollution abatement: concepts, design, an application. 34

Abu-Allaban M, Gillies JA, Gertler AW, Clayto R, Proffitt D (2003). Tailpipe, resuspended road dust, and brake-wear emission factors from on-road vehicles Atmospheric Environment 37) 5283–5293.

Amato F, Pandolfi M, Escrig A, Quero, X, Alastuey, A, Pey J, et al. (2009a). Quantifying road dust resuspension in urban environment by multilinear engine: a comparison with PMF2. Atmos. Environ. 43, 2770–2780.

Beckett KP, Freer Smith P and Taylor G (1998). Urban woodlands their role in reducing the effects of particulate pollution. Environmental Poll. 99: 347-360.

Beckett KP, Freer Smith, P. and Gail, T. (2000a). Effective tree species for local air quality management. Journal of Arboriculture. 26 : 12-18.

Beckett KP, Freer Smith P and Gail T (2000b). The capture of particulate pollution b trees at five contrasting urban sites. Arboricultural Jr. 24: 209-230.

Beelen R, Raaschou-Nielsen O, Stafoggia M, Andersen ZJ et al. (2014). Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. Lancet 383, 785-795.

Farmer A (2002). "Effects of particulates". In: Bell J.N.B., Treshow M., eds. Air Pollution and Plant Life. Hoboken: Wiley: 187–199.

Gupta VK and Kapoor RK (1990). Attenuation of air pollution by greenbelt- optimization of density of tree plantation. Report, Operating, Plant Safety Dividion, Atomic Energy Regulatory Board, Bhaba Atomic Research Centre, Bombay.

Ghio AJ, Carraway MS, Madden MC (2011). Composition of air pollution particles and oxidative stress in cells, tissues, and living systems. J. Toxicology. Environ. Health Part B Crit. Rev. 15, 1-21.

Jaecker-Voirol A and Pelt P (2000). PM10 emission inventory in Ile de France for transport and industrial sources: PM10 re-suspension, a key factor for air quality. Environmental Modelling& Software, 575–581.

Kousoulidou M, Ntziachristos L, Mellios G, and Samaras Z (2008). Road-transport emission projections to 2020 in European urban environments, Atmos. Environ., 42, 7465–7475.

Kristensson A, Johansson C, Westerholm R, Swietlicki E, Gidhagen, L., Wideqvist, U., et al. (2004). Real-world traffic emission factors of gases and particles measured in a road tunnel in Stockholm, Sweden. Atmos. Environ. 38, 657–673.

Nowak DJ (1994). Air pollution removal by Chicago's urban forest. In: McPherson, E.G., Nowak, D.J., Rowntree, R.A. (Eds.), Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186, Radnor, PA, pp. 63-81.

Nowak DJ, Rowntree RA, McPherson EG, Sisinni SM, Kerkmann E, Stevens JC (1996). Measuring and analyzing urban tree cover. Landscape and Urban Planning 36,49-57.

Nowak DJ (1994). Air pollution removal by Chicago's urban forest. In: McPherson, E.G., Nowak, D.J., Rowntree, R.A. (Eds.), Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186, Radnor, PA, pp. 63-81.

Nowak DJ, Rowntree RA, McPherson EG, Sisinni SM, Kerkmann E, Stevens JC (1996). Measuring and analyzing urban tree cover. Landscape and Urban Planning 36,49-57.

Sharma SC and Roy RK (1997). Green belt—aneffective means of mitigating industrial pollution. Indian Journal of Environmental Protection Vol. 17, pp. 724–727.

Schauer JJ, Lough GC, Shafer MM, Christensen WF, Arndt MF, DeMinter JT, Park JS (2006). Characterization of Metals Emitted from Motor Vehicles.Health Effects Institute 1-98.

Seinfeld JH and Pandis SN (2006). Atmospheric chemistry and physics: From air pollution to climate change. 2nd edition, John Wiley & Sons, New York, 1255 pp. ISBN: 9780-471-72018-8, E-ISBN: 978-1–60119-595-1, online version available at: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2126&VerticalID=01-21.

Pope III, C.A. and Dockery, D.W. (2006). Health Effects of Fine Particulate Air Pollution: Lines that Connect. J. Air Waste Manage. Assoc. 56: 709–742.

Valavanidis A, Fiotakis K, Vlachogianni T (2008). Airborne particulate matter and human health: toxicological assessment and importance of size and composition of particles for oxidative damage and carcinogenic mechanisms. J. Environ. Sci. Health C Environ. Carcinog.Ecotoxicol. Rev. 26, 339-362.

WHO (2005).Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: global update 2005. Summary of risk assessment. Geneva, World Health Organization, 2006. Retrieved from (http://www.who.int/phe/air/aqg2006execsum.pdf)

Yang G, Wang Y, Zeng Y, Gao GF, Liang X, Zhou M, Wan X, Yu S, Jiang Y, Naghavi M, Vos T, Wang H, Lopez AD, Murray CJ (2013). Rapid health transition in China, 1990-2010: findings from the Global Burden of Disease Study 2010.Lancet. 2013 Jun 8; 381(9882):1987-2015.

How to cite this article:
Estoque B M T, Saberon D J G, Sac S R B, Lacang G L, Ascaño C P. Morphological leaf characteristics of selected trees and its adsorbent capacity at particulate matter (pm_{10}) in cagayan de oro city, philippines. J. Fundam. Appl. Sci., 2018, *10(3S), 680-690.*