International Journal of Biology Research
ISSN: 2455-6548
Impact Factor: RJIF 5.22
www.biologyjournal.in
Volume 3; Issue 1; January 2018; Page No. 287-291

Effects of air pollution on chlorophyll content of urban trees leaves

[*1] Aminullah Yousafzai, [2] Asmatullah Durani, [3] Atal Hameedi, [4] Muhammad Hassan Mohammadi, [5] Hashmatullah Durrani, [6] Khuwaja Safiullah

[1] Environmental Science Program, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand
[2, 5, 6] Department of Soil Science and Agricultural Chemistry, NMCA, Agricultural University, Navsari, Gujarat, India
[3] Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh, India
[4] Agribusiness Program School of Business Study, Punjab Agriculture University, Ludhiana, Punjab, India

Abstract
Air pollution is one of the serious problems the world is facing today. It deteriorates ecological condition and can be defined as the fluctuation in any atmosphere constituent from the value that pollutants responsible for flora injury and crop yield losses, are causing increased concern. In the present investigation comparative studies have been done to find the effect of air pollutants generated from the exhaust of automobiles on the chlorophyll a, chlorophyll b and total chlorophyll of leaves. The leaves samples of *Mangifera indica* L., *Ficus religiosa* L., *Plumeria rubra* L., *Lagestroemia speciosa* (L.) pers., *Alstonia scholaris* (L.)R. Br., *Butea monosperma* (Lam.) Taub, and *Polyalthia longifolia* sonn., were collected in two different season with potentially higher and lower levels of air pollution. Photosynthetic pigments chlorophyll a, chlorophyll b and total chlorophyll content were quantified. A reduction in the photosynthetic pigments of leave sample collected in the dry and higher polluted season as compared to rainy or less polluted season were observed in all studied tree species except *Plumeria rubra* which showed slightly increasing trend of photosynthetic pigments in dry season compare to rainy season.

Keywords: air pollution, chlorophyll a, chlorophyll b, total chlorophyll, dry and rainy season

Introduction
Industrialization, urbanization, rapid economic growth and associated increase in energy demands have resulted in a profound deterioration of air quality in developing countries like Thailand. Oxides of nitrogen and sulphur and particulate matters constitute as the major proportions for the gaseous and particulate emissions from industries and automobile. Chlorophyll is the key photoreceptor in photosynthesis, the light-driven process through which carbon dioxide is fixed to yield carbohydrates and oxygen. When plants are exposed to the environmental pollution above the normal physiologically acceptable range, photosynthesis gets inactivated or adversely affected. Air pollutants especially, sulfur dioxide, ozone, particulate matter and oxides of nitrogen can alter the whole physiological processes of plants, thus affecting patterns of growth (Agbaire and Esiefarienrhe, 2009) [1]. Pollutants adverse effects on plant have long been known, air pollutants cause damage to leaf cuticles and affect stomata conductance, and they can also have direct effects on photosynthetic systems, leaf longevity, and patterns of carbon allocation within plants (Wolfenden and Mansfield, 1990) [9]. Chlorophyll is the fundamental activating particle of green plants and its amount is unavoidable while surveying resistance of plant against stress. Furthermore, it is the main essential part of energy production in green plant and the amount of chlorophyll in plants are significantly affected by environmental condition (Verma, 2003). Yousafzai *et al*, (2017) [11] reported that the impact of air pollution in terms of changes from the rainy to the dry and polluted season were not significantly differences in two groups of chlorophyll contents.

Description of study area: This study was carried out in Chiang Mai city, a part of Chiang Mai province, which is considered as a second largest province after Bangkok, located in the north of Thailand, lies between 17.242º and 20.148º North latitude and 98.010º to 99.513º East longitude at an elevation about 310 meter above sea level (Janta and Chantara, 2017) [2]. Chiang Mai province covers an area around 20,110 km^2 from which 83 % of the area is forest. The province has a population around 1,640,479 people, whereas population density is 81.6 people per km^2 (Janta and Chantara, 2017) [2]. Chiang Mai has grown rapidly in the recent past decades with an associated increasing level in air pollution and respiratory health problems (Sriyaraj *et al.*, 2008) [6]. Road traffic, industry expansion, burning of domestic wastes, forest fire, and agricultural residues burning are key area sources and influence factors of the air pollution in Chiang Mai city (Sriyaraj *et al*., 2004) [6]. Geographically, Chiang Mai city, situated in a natural basin and is surrounded by high mountainous ranges is another important influencing factor (Wiriya *et al*., 2013) [8].

Leaf sample collection procedure: With respect to Chiang Mai city air quality situation, the sample collection were made in the month of October, 2016, the highest peak of rainfall,

and in the hot summer and dry season of the region in March, 2017. Seven common urban trees species of Chiang Mai city, i.e., *Mangifera indica* L., *Ficus religiosa* L., *Plumeria rubra* L., *Lagestroemia speciosa* (L.) pers., *Alstonia scholaris* (L.) R. Br., *Butea monosperma* (Lam.) Taub., and *Polyalthia longifolia* sonn., were chosen, because of their presence as very common in the urban surrounding areas of Chiang Mai city. For investigation, 100-200 grams of leaves from four (North, South, East, and West) directions of each of the trees were collected in marked polythen bags. The samples were quickly transferred to laboratory for further chemical analysis.

Analysis of chlorophyll content

Chlorophyll content was estimated using the method of (Kanawapee *et al.*, 2012) [3]. Briefly, 30 milligrams of leaf sample was sliced and placed in a test tube containing 5 mL of 80% acetone. The test tube was covered by aluminum foil and placed in a dark room at 25 ºC for one day. The absorbance of the extracted solution was measured with visible spectrophotometer (Thermo model Genesis 20, USA) at 645 and 663 nm, and the solution of 80 % acetone was used as a blank. Chlorophyll content was expressed as mg g^{-1} tissue fresh weight and calculated using the following equations as:

$$\text{Chlorophyll a } (mgg^{-1}) = [2.7\ (OD\ 663nm) - 2.69 * (OD\ 645nm)] * \left(\frac{V}{1000 * W}\right)$$

$$\text{Chlorophyll b } (mgg^{-1}) = [22.9\ (OD\ 645nm) - (4.68) * (OD\ 663nm)] * \left(\frac{V}{1000 * W}\right)$$

$$\text{Total Chlorophyll } (mgg^{-1}) = [20.2\ (OD\ 645nm) + 8.02\ (OD\ 663nm)] * \left(\frac{V}{1000 * W}\right)$$

The level of change in total chlorophyll contents due to air pollution was expressed as the ratio between total chlorophyll content during in the dry and polluted season and that during the least polluted and rainy season.

Results and Discussion

Temperature and Relative Humidity

Chiang Mai has three distinct seasons, the hot (summer) season from March through May, the rainy season from June to October, and the cool (winter) season from November to February. The average annual temperature is a pleasant 25ºC. During the hot (summer) season, day-time high temperatures can reach 42 ºC, but the cool (winter) season, night-time lows can drop below 10 ºC in the city and 4 ºC in mountainous areas (World Weather Online, 2017). During the study period the relative humidity varied from 9% to 100%. The maximum relative humidity (100%) was observed during June, 2016 and January, 2017. The minimum relative humidity (9.0 %) occurred in January 2016, and 2017. However the average highest humidity (81.51 ± 1.98%), was observed in September 2016, followed by July and August, about 80.57 ± 2.96% and 80.43 ± 3.01% respectively. The average lowest relative humidity was recorded in March, 2017, about 43.66 ± 5.84%, followed by April (43.79 ± 3.17%), and March (45.09 ± 5.12%) in 2016.

Ambient air quality monitoring

The air quality in Chiang Mai is primarily affected by road traffic, biomass open burning, and industrial discharge in concentrated industrialized areas. The biomass open burning and vehicular exhausts contribute a significant amount to the air pollution in the city. In order to estimate the maximum and minimum air pollutant concentrations during the study period, ambient air quality monitored data of Pollution Control Department (PCD) during study period (January 2016; March 2017) at two locations from two main air quality monitoring stations including Chiang Mai city main hall air quality monitoring station and Yupparaj Wittayali School air quality monitoring station were assessed and analyzed. The pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and particulate matters $PM_{2.5}$, and PM_{10} assessments were done and their average concentration are shown in Table 1.

Table 1: Average air pollutants concentration during period from January, 2016-March, 2017(PCD, 2017) [4]

Month	CO (ppm/3m)	NO_X (ppb/3m)	SO_2 (ppb/3m)	NO_2 (ppb/m^3)	$PM_{2.5}$ (ug/m^3)	PM_{10} (ug/m^3)
October 2016	0.89±0.26	22.63±15.22	1.03±0.16	13.12±7.72	15.47±7.64	28.71±12.65
March 2017	0.97±0.39	28.98±23.99	1.40±0.54	19.41±15.06	51.04±23.02	69.32±25.80

Chlorophyll a content: The result revealed that the chlorophyll a (mg/g) was found maximum in *Polyalthia longifolia* during the rainy season (3.22±0.58), and the dry season (3.16±0.56). Identically trend was found in case of *Mangifera indica* during the rainy season (3.17±0.16) and the dry season (3.11±0.13),*Ficus religiosa* during the rainy season(2.43±0.15) and the dry season (2.32±0.31) and *Butea monosperma* (2.02±0.34) and (1.99±0.32) during the rainy and the dry season respectively. However, chlorophyll a content was recorded minimum by *Plumeria rubra* during in the rainy season (1.28±0.17), while during the dry season observation (1.41±0.42). The result indicated that in case of *Lagestroemia speciosa* the chlorophyll a in the dry season with respect to the rainy season was found to be decrease by 0.19%. While, in case of *Ficus religiosa* a reduction by 0.11% was observed. For *Alstonia scholaris*, a reduction in chlorophyll a content during the dry season with respect to the rainy season was observed by 0.07%. Whereas the least decreasing change was recorded by *Butea monosperma* about 0.03%, nevertheless in case of *Plumeria rubra* the concentration of chlorophyll a content during the dry season with respect to the rainy season was more by 0.13 % (Figure1).

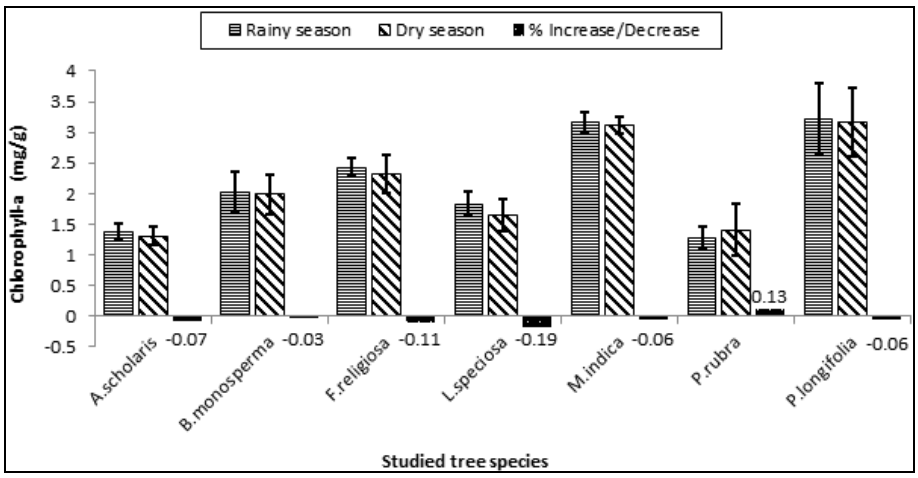

Fig 1: Seasonal variation in the chlorophyll a content of the studied tree species

As shown in Figure 2 the chlorophyll b content (mg/g) was found maximum in *Polyalthia longifolia* during the rainy season (11.91±1.18), and the dry season (11.03±1.12). Identically trend was found in case of *Mangifera indica* during the rainy season (10.54±0.66) and the dry season (10.30±0.53) , *Ficus religiosa* during the rainy season (7.52± 0.89) and the dry season (7.46±1.39) and *Butea monosperma* (7.29±1.04) and (7.19±1.01) during rainy and dry season, *Lagestroemia speciosa* (7.03±0.64) and (6.11±1.29) during the rainy and the dry season respectively. On the other hand, chlorophyll b was recorded minimum by *Plumeria rubra* during in the rainy season (4.49±0.62), while during and the dry season observation (4.72±1.40). The result indicated that in case of *Lagestroemia speciosa* the chlorophyll b in the dry season with respect to the rainy season was found to be decrease by 0.92%. While, in case of *Polyalthia longifolia* a reduction by 0.88% was observed. For *Alstonia scholaris*, a reduction in chlorophyll b content during the dry season with respect to the rainy season was observed by 0.65%, while the least decreasing change was recorded by *Ficus religiosa* about (0.06%), however in case of *Plumeria rubra* the concentration of chlorophyll b content during the dry season with respect to the rainy season was more by 0.23 %. (Figure 2).

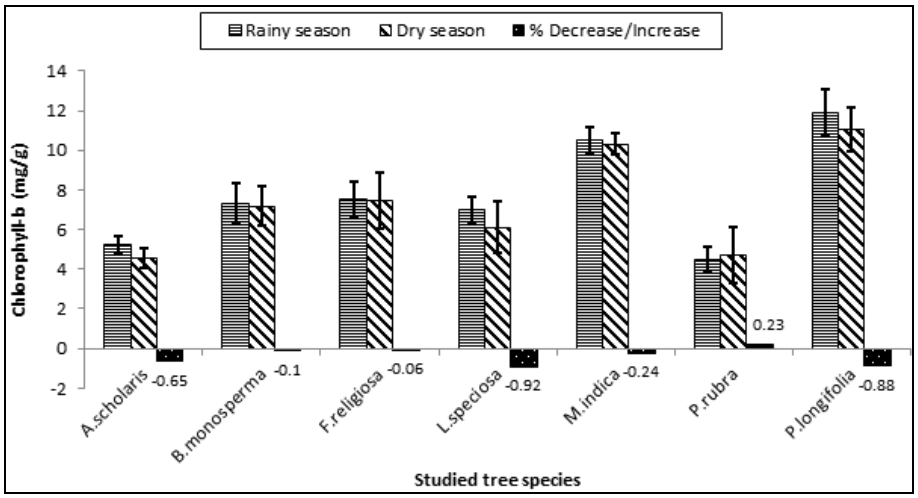

Fig 2: Seasonal variation in chlorophyll b content of the studied tree species

Present investigation revealed that the highest total chlorophyll content (mg/g) was found in *Polyalthia longifolia* during the rainy season (10.53±1.03), and dry season (9.75±0.99), followed by *Mangifera indica* during the rainy season (9.32±0.58) and the dry season (9.11±0.46). Another trees species with high total chlorophyll content was *Ficus religiosa* during the rainy season (6.65±0.78) and the dry season (6.59±1.23). However, total chlorophyll content was recorded minimum by *Plumeria rubra* during in the rainy season (3.97±0.54), while during and the dry season observation the total chlorophyll content was (4.17±1.23), another tree species with the minimum total chlorophyll content was *Alstonia scholaris* (4.60±0.38) during the rainy season and (4.03±0.45) during the dry season observation. The result showed that in case of *Lagestroemia speciosa* the total chlorophyll content in the dry season with respect to the rainy season was found to decrease by 0.81%,while, in case of *Polyalthia longifolia* a reduction by 0.78% was observed. For *Alstonia scholaris*, a reduction in total chlorophyll content during the dry season with respect to the rainy season was observed by 0.57 %. Identically trend was recorded by *Mangifera indica* a reduction about (0.21%), whereas the least

decreasing change was recorded by *Ficus religiosa* about (0.06%). On the other hand for *Plumeria rubra* the concentration of total chlorophyll content during the dry season with respect to the rainy season was more by 0.2% (Figure 3).

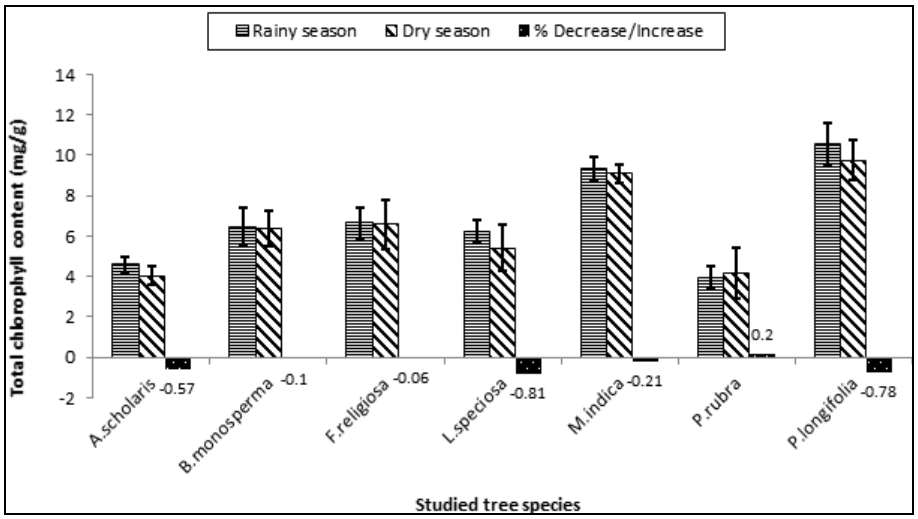

Fig 3: Seasonal variation in total chlorophyll content of the studied tree species

Statistical Analysis

The Pearson's correlation among chlorophyll a, chlorophyll b and total chlorophyll, and air pollutants including CO, NO_2, SO_2, NOx, $PM_{2.5}$, PM_{10} were determined. The results of the correlation analysis among photosynthetic pigments and pollutants are presented in Table 2. There were high significant correlations among chlorophyll a, chlorophyll b and total chlorophyll contents; however there were high significant correlation among CO, $PM_{2.5}$ and PM_{10}. Identical trend were recorded in case of NOx and NO_2, $PM_{2.5}$ and PM_{10}. On the same hand correlation were high significant among NO_2 and $PM_{2.5}$,PM_{10}, and $PM_{2.5}$ and PM_{10}. On other hand the correlation recorded significant among CO and NO_x and NO_2. (Table2). The correlation was recorded negative among photosynthetic pigments and studied air pollutants, which indicated that the chlorophylls contents are highly degradable by air pollution (Table2).

Table 2: Correlation among chlorophylls pigments and air pollutants investigated during the study period

Parameter	Chl-a	Chl-b	Total-Chl	CO	NO_x	SO_2	NO_2	$PM_{2.5}$	PM_{10}
Chl-a	-	0.98**	0.98**	- 0.076	0.032	-0.15	-0.038	-0.037	-0.042
Chl-b	0.98**	-	1.00**	-0.3	-0.011	-0.12	-0.074	-0.074	-0.082
Total-Chl	0.98**	1.00**	-	-0.3	-0.011	-0.12	-0.074	-0.075	-0.082
CO	-0.076	-0.3	-0.3	-	0.88*	0.22	0.88*	0.93**	0.92**
NO_x	0.032	-0.011	-0.011	0.88*	-	0.16	0.95**	0.96**	0.95**
SO_2	-0.15	-0.12	-0.12	0.22	0.16	-	0.25	0.26	0.25
NO_2	-0.038	-0.074	-0.074	0.88*	0.95**	0.25	-	1.00**	1.00**
$PM_{2.5}$	-0.037	-0.074	-0.075	0.93**	0.96**	0.26	1.00**	-	1.00**
PM_{10}	-0.042	-0.082	-0.082	0.92**	0.95**	0.25	1.00**	1.00**	-

** Correlation is high significant at the p<0.01 level.

* Correlation is significant at the p=0.05 level.

Conclusion

From the results it can be concluded that chlorophyll a, chlorophyll b and total chlorophyll contents of the studied trees species were comparatively found higher during the rainy and least polluted season, and lower during the dry and polluted season, this might be due to the highly destruction of chlorophyll pigments, hence the chlorophyll content are the most likely to be damaged by air pollution.

References

1. Agbaire P O, Esiefarienrhe E. Air Pollution tolerance indices (apti) of some plants around Otorogun Gas Plant in Delta State, Nigeria. Journal of Applied Sciences and Environmental Management 2009; 13(1):11-14.
2. Janta R, Chantara S. Tree bark as bioindicator of metal accumulation from road traffic and air quality map: A case study of Chiang Mai, Thailand. Atmospheric Pollution Research 2017; 1-12.
3. Kanawapee N, Sanitchon J, Lontom W, Threerakulpisut P. Evaluation of salt tolerance at the seedling stage in rice genotypes by growth performance, ion accumulation, proline and chlorophyll content. Plant and Soil 2012; 1-2(358):235-249.
4. Pollution Control Department, Bangkok, Thailand. Retrieved July 16, 2017, from http://www.pcd.go.th/en_ab_about.cfm.
5. Sriyaraj K, Priest N, Shutes B, Wiwatanadate P, Trakultivakorn M, Crabbe H, … Ouiyanukoon, P. Air

quality modelling in Chiang Mai City, Thailand. Proceedings of the 13th World Clean Air and Environmental Protection Congress and Exhibition. 2004.
6. Sriyaraj K, Kanyawat, Priest N, Shutes, B. Environmental factors influencing the prevalence of respiratory diseases and allergies among school children in Chiang Mai, Thailand. International Journal of Environmental Health Research. 2008; 18(2):129-148.
7. Verma A. Attenuation of automobile generated air pollution by higher plants. University of Lucknow, Lucknow, India. 2003.
8. Wiriya W, Prapamontol T, Chantara S. PM10-bound polycyclic aromatic hydrocarbons in Chiang Mai (Thailand) Seasonal variations, source identification, health risk assessment and their relationship to air-mass movement. Atmospheric Research. 2013; (124):109-122.
9. Wolfenden J, Mansfield T. A. Physiological disturbances in plants caused by air pollutants. Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences. 1990; 97:117-138.
10. World Weather Online. Weather in Chiang Mai, Chiang Mai, Thailand | Weather Forecast Chiang Mai, Chiang Mai. Retrieved June 2, 2017, from https://www.worldweatheronline.com/chiang-mai weather/ chiang-mai/ th.aspx.
11. Yousafzai A, Wangpakapattanawong P, Saengnil K, Saipunkaew W. An assessment of air pollution tolerance capability of common tree in Chiang Mai city Thailand. International Journal of Advances in Science Engineering and Technology.2017; 5(4):2321-9009.