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PHYSIOLOGICAL RESPONSES OF SOME TREE SPECIES UNDER ROADSIDE POLLUTION IN KALUPUR AREA OF AHMEDABAD, GUJARAT

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ABSTRACT

Plants can be used to mitigate increasing air pollution from vehicular exhaust by planting them along roadside. The present study focuses on the changes on physiological parameters selected tree species growing along road passing through Kalupur fruit market and Vimal Park society, Ahmedabad, Gujarat. The leaf samples of four trees were collected observe some physiological and biochemical parameters including pH of the leaf extract, Relative Water Content, Stomatal index, and Total Chlorophyll. Result of study showed that Ficus religiosa has the highest pH of leaf extract at polluted site, Azadirachta indica has highest total chlorophyll compared to non-polluted and Polyalthia longifolia has highest Stomatal index and RWC.

Keyword: Air pollution, stomatal index, RWC, pH, Total Chlorophyll, Azadirachta indica, Polyalthia longifolia, Alstonia scholaris, Ficus religiosa

1. INTRODUCTION

Air Pollution is the major problem of developed cities because of increasing urbanization and industrialization which have major impact on living world including plants and animals. The gaseous pollutants and smoke released by the vehicular exhaust have significant impact on the physiology of plant (Rai, 2013). Air pollution is the major direct cause for the change in the plant physiology while soil acidification does not directly affect the plant (Liu and Ding, 2008). The morphology of the plants is also get affected resulting into chlorosis, epinasty and necrosis (Prashad and Choudhary, 1992). The increasing air pollution have also affected the leaf area and the size of petiole on the street plants growing on the continuous exposure of smoke and dust observed on its surface (Tanee and Albert, 2013; Dineva, 2004). Number of plants have been studied to have lesser chlorophyll content in the plants growing along the roadside (Tiwari, Agrawal and Marshall, 2006; Joshi and Swami, 2007) and in few plants the chlorophyll content has been found to increase (Agbaire and Esiefarienrhe, 2009). The dust particles and particulate matter covers the leaf surface clog the stomatal pores and decrease the light penetration inside the leaf, affecting gaseous exchange, photosynthetic property of the leaf at the polluted areas (Joshi and Swami, 2007).

Plants can tolerate and have scavenging property by absorbing and accumulating few pollutants there by changing the physiology of leaf (Joshi and Swami, 2007). Quality of climatic condition prevailing in the urban area can be improved by planting the pollutant resistant tress along the street side and in orchard of every house (Bamniya et al., 2012). Wind- blown sir pollutants and dust get settle down by gravity on the leaf surface (Pugh et al., 2012). This dust deposition and accumulation was observed to be higher on plants than on build up structures (Varshney and Mitra, 1993). Vegetation traffic barriers is one of the ways to control air pollution (Barwise and Kumar, 2020). Urban heat land effect can be reduced through urban vegetation (Bowler et al., 2010). Thus vegetation with proper design of plants can be used to improve the air quality of city areas which was accepted in many developed countries (Singh et al., 2019). However not all plants give benefits to reduce air pollutant some of the plants may act as pollutant itself by producing volatile organic compounds in the air (Curtis et al., 2014). Therefore the plants are carefully selected for vegetation traffic barrier (Shrestha et al., 2021). Biomonitoring of plants referred as the impact of air pollutant on the plants. This impact on plants can be studied by air pollution tolerance indices. The higher value of APTI shows plant tolerance level to pollutant (Jyothi and Jaya, 2010). Plants with APTI index of <11,12-16, and >17 is considered as sensitive, intermediate tolerance and tolerant to air pollution (Manjunath and Reddy, 2019).Certain physiochemical parameters such as RWS, pH of leaf extractives, stomatal index, total chlorophyll content and ascorbic acid in the leaf extractives have been calculated to examine the effect of air pollution on selected plants by following the methods of Manjunath and Reddy (2019) to access impact of air pollution on plants. Although some other parameters with conflicting result have also been used to studied on plants by Han et al., (1995). In the present study, an attempt is made to evaluate physiological responses of some selected tree species under roadside pollution in Kalupur area of Ahmedabad, Gujarat.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

Kalupur is always known for its great crowd of vehicles and its vehicular jam for hours. The street passing through the Kalupur fruit market have wanderer on the sides of road. Kalupur lies between 23°C 01'N latitude to 72°C36'E longitude of Ahmedabad district of Gujarat. The area selected for study is Kalupur Fruit Market and Vimal Park Society, Naroda, Ahmedabad (as shown in Fig. 1 and 2) for polluted and non-polluted sites, respectively having common growing plants. The other area which is selected to understand the difference in the physiology of selected common plants is Vimal Park Society which is 17 kilometers away from the Kalupur Fruit Market and selected as non-polluted.

Fig 1 Kalupur Fruit Market

Fig 2 Vimal Park Society

2.2 Collection of samples

The trees selected for the study are Azadirachta indica A. Juss, Alstonia scholaris L.R.Br., Polyalthia longifolia Sonn. and Ficus religiosa L. and Forsek. The study was conducted in month January – February, 2023. The Fresh leaves were collected from the tress of approximately same height of about 1-2 meters. The collected samples of polluted sites and non-polluted sites are placed in polythene bags and immediately taken to the laboratory for the analysis of following physiological parameters.

2.3 Physiological parameters

Relative Water content: The fresh five leaves were taken into the laboratory and weighed the leaf after washing it with tap water as a Fresh Weight (FW). Than soaked overnight in distilled water and weight of leaves were recorded after blotting it on filter paper referred as Turgor Weight (TW). Leaves were then dried at 70°C in Hot Air Oven and reweighted and referred as Dry Weight (DW). Relative Water Content (RWS) is calculated using the following formula given by Singh and Rao 1983.

RWC = Fresh Weight (FW) – Dry Weight (DW) * 100 / Turgor Weight (TW) – Dry Weight (DW)

pH

pH is calculated based on the method given by Manjunath and Reddy (2019). Leaves were chop into pieces and weighed about 100 mg leaves pieces. The leaves were dried in oven, homogenized in 20 ml of distilled water and then pH of the filtrate of the leaf extract was examined by calibrated pH meter (pH 4 and pH 9).

Stomatal Index

The modified methodology by Ileperuma and Abeyratne (2006) was used in the present study. Freshly collected leaves were washed with distilled water and blotted on filter paper. Firstly transparent nail varnish is painted to the leaf surface and allowed it to dry for 5 minutes. Sticky transparent cellophane tap is attached on the painted area, pressed to get the imprints on cellophane tap and removed it. The cellophane tap with imprints on nail varnish is tapped on the slide and observed under 45x and 100x of magnification. Fevicol was also applied in few samples instead of nail varnish. Stomatal index can be calculated using the following formula:

Stomata index = $\{S/(S+E)\}*100$

Total Chlorophyll

500 mg fresh leaves were grounded using 80% acetone in mortar-pestle, volume was made upto 10 ml with 80% acetone and then centrifuged at 2500 rpm for 15 minutes. The supernatant was collected, and the spectrophotometer is used to measured absorbance at 645 nm and 663 nm for chlorophyll a and chlorophyll b. Chlorophyll content is measured using the following formula:

Total Chlorophyll = {20.2(O. D at 645 nm) + 8.02(O. D at 663 nm)} (Arnon, 1949: Shrestha et al., 2021)

X [V/1000 x W]

where, OD at 645 = absorbance at 645 nm, OD at 663 = absorbance at 663 nm, V = total volume of the extract (ml), and W = weight of the sample (gm) .

3. RESULTS AND DISCUSSION

3.1 Relative Water Content

Relative Water Content of non-polluted and polluted site has been summarized in the Figure3 (a and b). In the plants selected for studies have Relative water content ranging from 50.56% to 92.70% as given in the Table 1. The polluted sites with higher RWC were observed in Ficus religiosa (92.70%) followed by Alstonia scholaris (90.27%), Polyalthia longifolia (90.14%) and Azadirachta indica (76.00%), While the Non polluted have RWC higher in Ficus religiosa (91.08%) which was 2% reduced in non-polluted sites. Polyalthia longifolia shows 1% reduction in the Non polluted sites (have 90.14% RWC in Non-polluted plants), thus Ficus and Polyalthia shows lesser reduction the RWC value of leaves. In Azadirachta, RWC value in non-polluted site was 50.56% which shows 33% reduction from polluted sites (Fig 3a). Fig 3b shows that the plant sources from polluted sites shows higher RWC as compared to non-polluted. Similar kinds of results were reported by Kanwar, Dhamala and Maskey-Byanju (2016); Tak and Kakde, (2017) and Shrestha et al., (2021), stating relative water content was considerably higher in the Polluted than that of non-polluted plants. The higher value of RWC suggest higher air pollution tolerance capacity (Manjunath and Reddy, 2019). An exposure to air pollution under stress condition increases the transpiration rate and the RWC value of the leaves which gives plants potential to tolerate pollution (Singh et al., 1991; Shrestha et al., 2021). Soil salinity, temperature, humidity also play role in increase or decrease of RWC (Volkov et al., 2020; Shrestha et al., 2021). Stomatal conductance and CO_2 assimilation get reduced with decrease in the RWC. At very small RWC value upto less than 40%, the net CO_2 assimilation, CO_2 exchange, and photosynthetic rate becomes zero (Lawlor, 2002; Shrestha et al., 2021). Depending upon the plant species the relative water content can be as low as 30% to 40% in drying leaves while it can be as high as 98% in fully turgid leaves based on the environmental condition (Zhang et al., 2015; Shrestha et al., 2021).

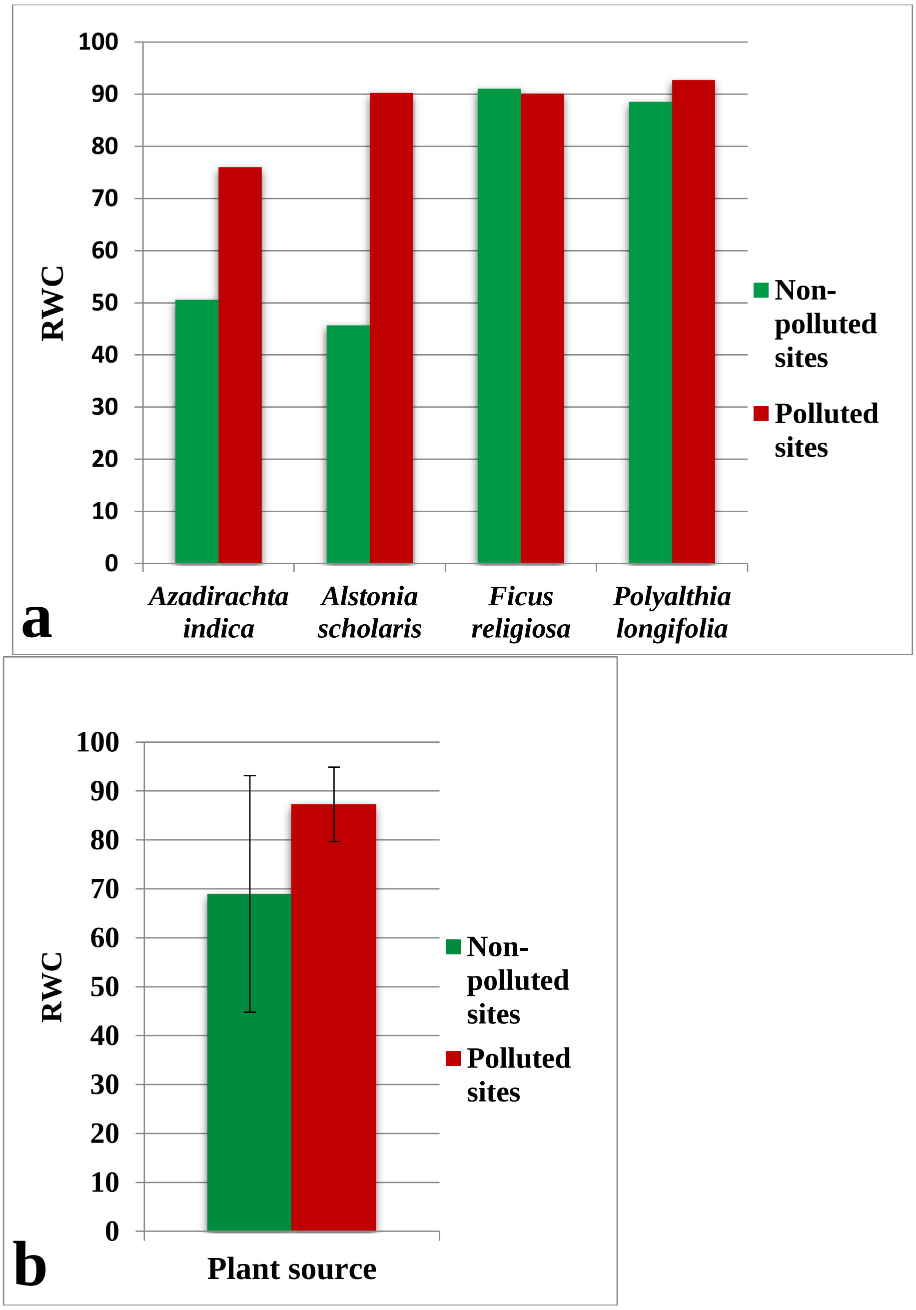


Fig 3 (a and b) RWC of selected trees of non-polluted and polluted sites

3.2 Leaf extract pH

pH of the leaf extract of polluted and non-polluted sites has been summarized in the Figure 4 (a and b). The pH of the polluted and non-polluted plant ranges from 7.316 to 7.444 and 7.339 to 7.484, respectively as shown in Table 1. The pH in F. religiosa and P. longifolia was almost same in both polluted and non-polluted sites. The pH in A. indica was 0.1 unit higher in non-polluted site compared to polluted site. The pH value in A. scholaris was 0.04 unit higher in polluted than non-polluted site. pH of the leaf extract was more than 7 in all the plants of both polluted and non-polluted sites as shown in Fig 4a. There was no major variation in pH observed in polluted and non-polluted sites, however pH of non-polluted site was slightly higher than that of Polluted plant sources (Fig 4b). The leaf exposure to the air pollutant like SO_2, NO_2 and CO_2 causes lowering of pH of leaf (Karmakar, Deb and Padhy, 2021). pH reduces the activity of the ascorbic acid and other enzymes involved in the CO_2 fixation thus the leaf with higher pH shows more tolerance to air pollution than lower pH (Liu and Ding, 2008). Acidic pH also reduces the chlorophyll content of the leaf as it inactivates the enzymes involved in chlorophyll content (Singh et al., 1991).

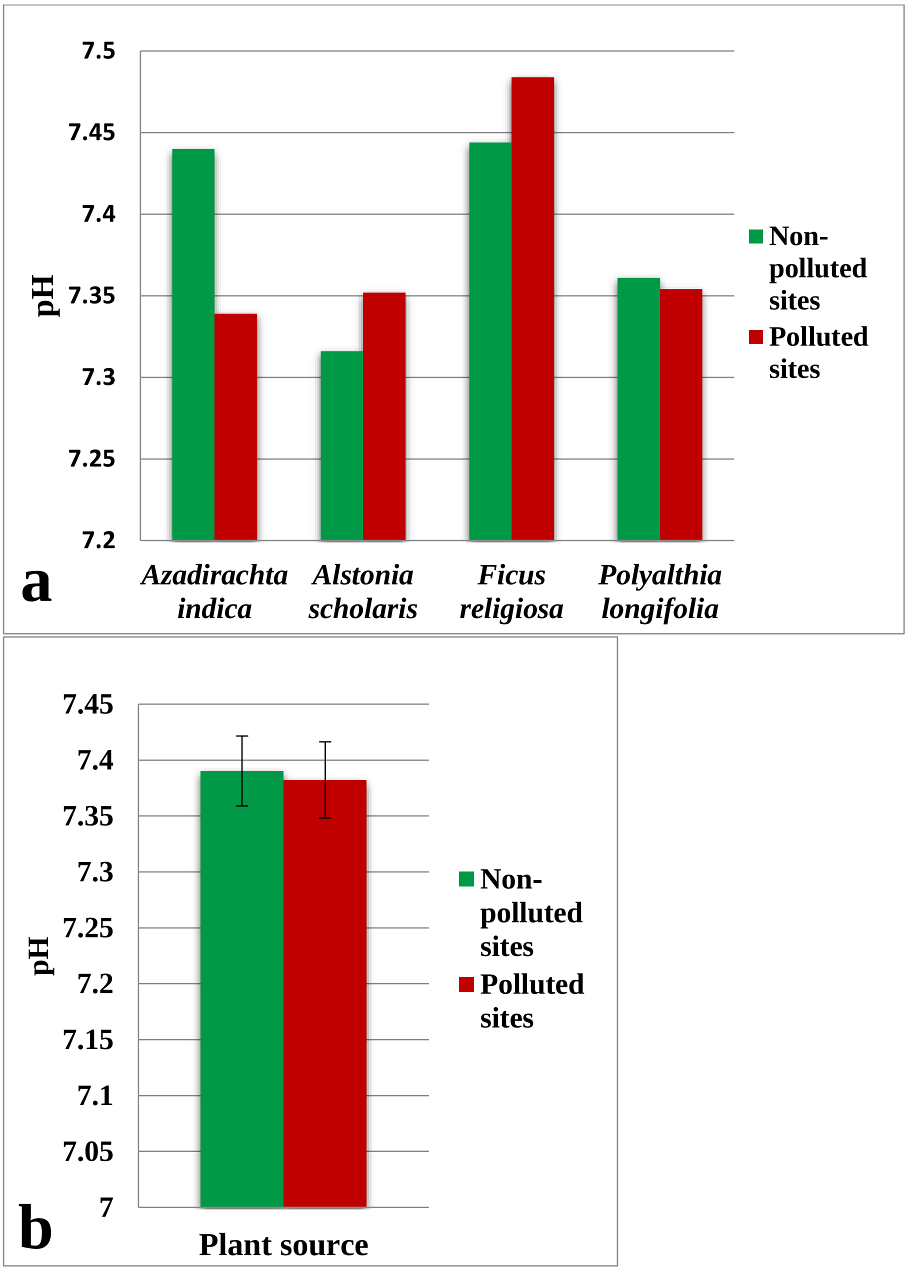


Fig 4 (a and b) pH of selected trees of non-polluted and polluted sites

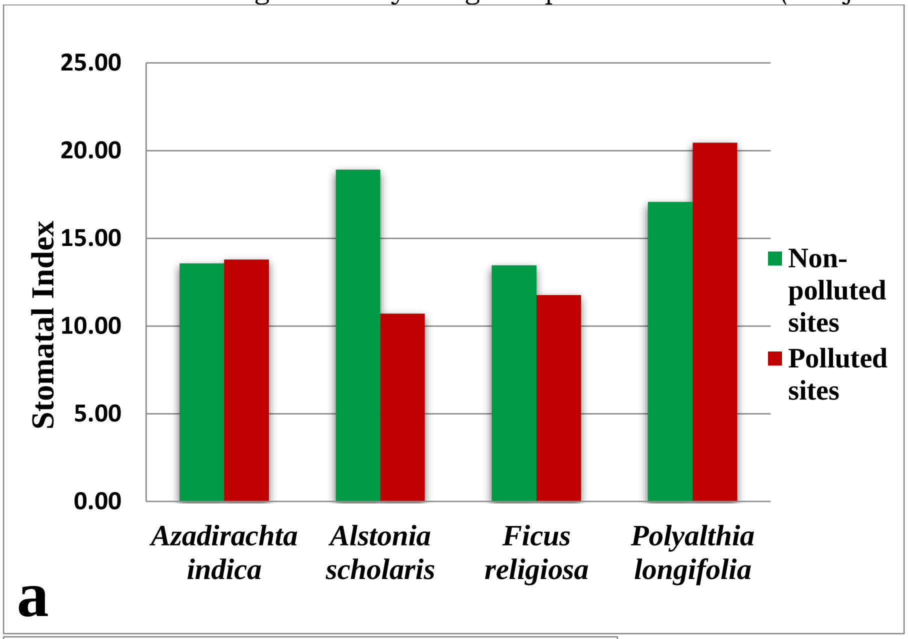
Table 1: Physiological parameters of selected tress from polluted and non-polluted sites

Plant	RWC	pH	Total Chlorophyll (mg/g)	Stomatal Index
Azadirachta indica (NP)	50.56	7.44	0.73388	13.58
Alstonia scholaris (NP)	45.66	7.316	0.48828	18.92
Ficus religiosa (NP)	88.53	7.444	0.90238	13.46
Polyalthia longifolia (NP)	91.08	7.361	0.55258	17.07
Azadirachta indica (P)	76	7.339	0.92604	13.79
Alstonia scholaris (P)	90.27	7.352	0.6299	10.71
Ficus religiosa (P)	90.14	7.354	0.47566	11.76
Polyalthia longifolia (P)	92.7	7.484	0.44924	20.45

* NP: Non-polluted, P: Polluted, RWC: Relative Water Content

3.3 Stomatal Index

The stomatal index of polluted and non-polluted has been summarized in the Table 1. The stomatal index of lower epidermis was observed. The stomatal index was comparatively higher at plants of non-polluted sites than the plants at polluted sites except in Polyalthia longifolia where the stomatal index is higher in polluted sites as observed in the figure 5a. The stomatal index ranges from 18.92 to 13.46 and 20.45 to 10.71 at non polluted and polluted sites (Table 1). The highest stomatal index at non polluted site was found in A. scholaris (18.92), followed by P. longifolia (17.07), A. indica (13.58) and F. religiosa (13.46). Stomatal index was found to be decreased in the leaves of plant sources from polluted site (Fig 5b). Similar reduction in stomatal index was also observed in all the plant species growing in polluted area by Rai (2016). The reason might be that the plants get adapted to the polluted environment to eliminate the damage cause by the gases present in the air (Manjunath and Reddy, 2019).



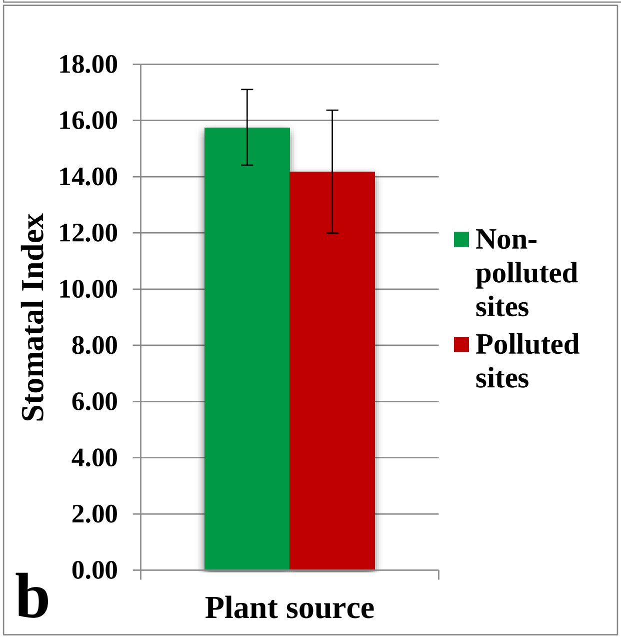
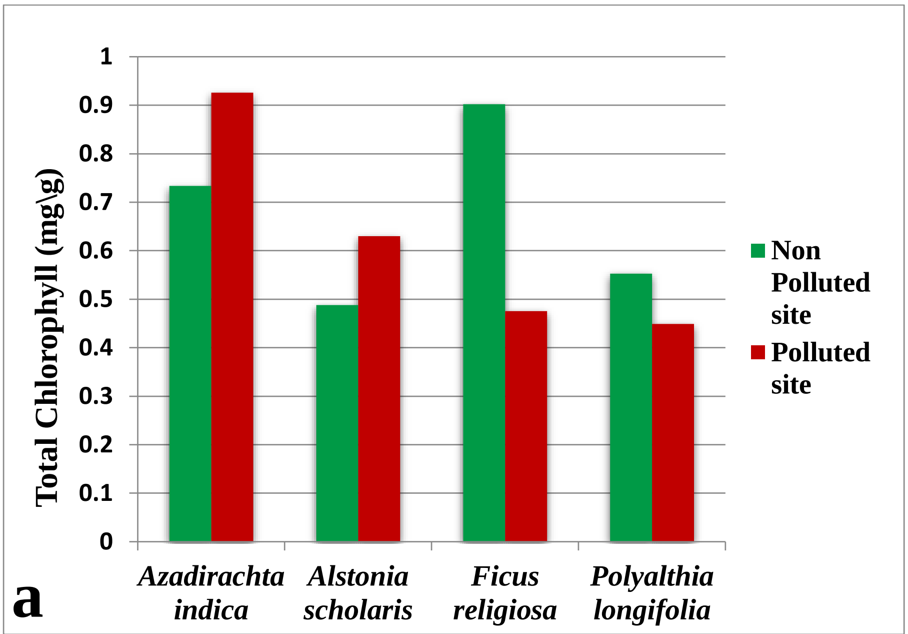


Fig 5 (a and b) Stomatal Index of selected trees of non-polluted and polluted sites

3.4 Total Chlorophyll content

The Total chlorophyll content is summarized in the given Table 1. The chlorophyll content ranges from 0.488mg/g to 0.902mg/g and 0.449mg/g to 0.926mg/g in non-polluted site and polluted sites, respectively. The highest chlorophyll content of 0.902mg/g and lowest chlorophyll content of 0.488mg/g was found in F. religiosa and A. scholaris in non-polluted sites. While in polluted site the highest chlorophyll content (0.926mg/g) and lowest chlorophyll content (0.449mg/g) was found in A. indica and P. longifolia. Chlorophyll content of 0.552mg/g was observed in P. longifolia of non-polluted site and 0.449mg/g was observed in polluted site P. longifolia. Therefore 19% reduction was recorded in P. longifolia of polluted site compared to non-polluted site. Similarly, chlorophyll content of 0.902 was observed in F. religiosa in non-polluted site while in polluted site chlorophyll content was observed to be 0.475. Thus 47% reduction was recorded in the F. religiosa of polluted site compared to non-polluted site. In these two plants the chlorophyll content was found to be lesser in polluted site compared to non-polluted site shown in Fig 6a. The mean Total chlorophyll was found be higher in non-polluted sites as compared to polluted (Fig 6b). The reduction in Total chlorophyll in Polluted sites was also reported by Manjunath and Reddy (2019). Chlorophyll is considered to be an important parameter to determine the impact of air pollutants on plants and it also determines the photosynthetic activity of plants (Singh et al., 1991). The reduction in the stomatal index when exposed to certain gases impact the chlorophyll content (Leghari and Zaidi, 2013; Manjunath and Reddy, 2019).



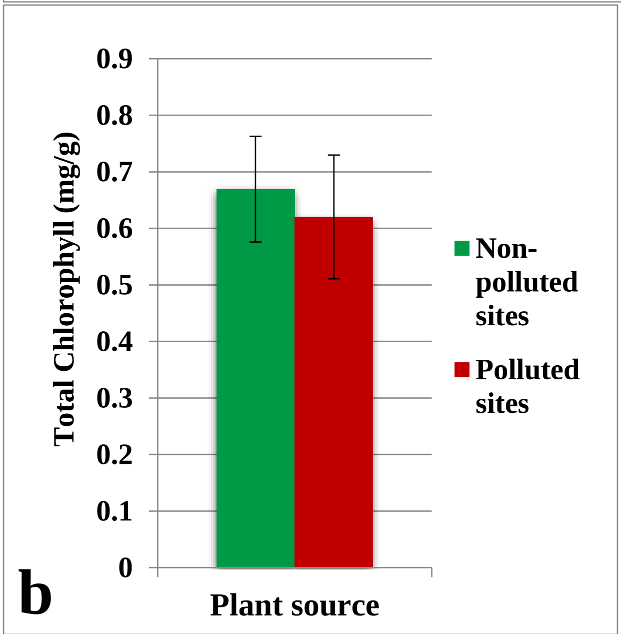


Fig 6 (a and b) Total chlorophyll of selected trees of non-polluted and polluted sites

4. Conclusion

The study finding reveals that pollution has adversely affected the physiological parameters of plants in polluted sites. However, despite of these changes, some plant species were thriving well in polluted sites. Highest pH levels in polluted sites were reported in Ficus religiosa showing more tolerance to the pollution. Alstonia scholaris showed the highest Total chlorophyll followed by Azadirachta indica in polluted site as compared to non-polluted. Polyalthia longifolia showed more RWC as well as more stomatal index in polluted sites as compared to non-polluted. Though, further efforts to evaluate the APTI (Air Pollution Tolerance Index) of these plant species would be beneficial for the restoration of green urban ecosystems.

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