International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 03 Issue: 12 | Dec -2019 ISSN: 2582-3930

Impact of industrial air pollution on the leaf macromorphology of some plants growing in Tarapur Industrial Area. (MIDC), Maharashtra

MANOHAR RATHINAM[1] and SWARANJIT KAUR CHEEMA[2]
[1,2]Department of Botany, G.N.Khalsa College, Matunga, Mumbai 400019. India

---***---

Abstract
The industrial air pollution is a major environmental issue particularly in the developing countries like India. The increase in the number of industries continuously adds to toxic gases and particulate matter into the atmosphere. In urban surroundings trees play an important role in improving air quality by absorbing gases and particulate matter. They are also effective indicators of air pollution. The present study was carried out to assess the impact of industrial air pollution on the leaf macromorphology of some plants growing in Tarapur Industrial Area of ten plant species viz. *Acacia auriculiformis, Artocarpus heterophyllous, Azadirachta indica, Cassia siamea, Ficus benghalensis, Ficus religiosa, Mangifera indica, Polyalthia longifolia, Terminalia catappa and Thevatia nerifolia* growing along Navapur road in the MIDC industrial area, Tarapur, Maharastra, India and Tarapur Atomic Power Station Colony (TAPS) during the year 2015 to 2016 in different seasons. The parameters examined were leaf length, breadth, petiole length, leaf area, stomatal index, length and breadth of stomata. The results revealed that all the plant species in polluted site (MIDC) exhibited reduction in the leaf length, breadth, petiole length and leaf area, as compared with the control site (TAPS). Thus present findings show that this could be mainly due to the exposure of plants to air pollutants coming from various industries as the dust particulates remain in the atmosphere for varying length of period and get deposited especially in the leaf surface and thus affect the foliar morphology.

Key words: Air pollution, Tarapur, macromorphology, micromorphology ,stomatal index.

Introduction

Today there is overwhelming evidence that various pollutants do and will continue to affect the life on this world. With the commencement of the 20th century, the range of the atmospheric pollutants has widened drastically. Air pollution is a lot complicated than most alternative environmental challenges. The main reason for air pollution in India is the increase in industrialization, vehicles and domestic sources. According to Central Pollution Control Board (CPCB) guidelines of Ambient air quality monitoring, the reason for high air pollution in India are poor quality of fuel, uncontrolled expansion of vehicle pollution and poor design, wrong location and old process technology in industries, no pollution prevention steps in early stage of industrialization and poor compliance of standard in small and medium sized industries

All combustion produces gases and particles in the air which incorporates Sulphur, NO_x, CO, and soot particles. Smaller quantities of noxious metals, organic molecules and radioactive isotopes (Agbaire and Esiefarienrhe, 2009) are also released. A major cause of pollution is industrialization (Odilara *et al.*, 2006). Exposure to pollution endangers these trees. Air pollution may result in changes in foliar anatomy and morphology and may cause visible injury (Ghouse et al. 1980; Jahan and Iqbal 1992; Pandey and Agrawal 1994; Verma et al. 2006; Joshi and Swami 2007; Joshi and Abhishek 2007). Of all other parts leaf is the most sensitive part to be affected by air pollutants. The leaves from trees near air pollution sources can even be 'coated' with particulates (Ricks and Williams 1974; Lerman and Darley 1975). This leads to reduced photosynthesis due to stomatal occlusion (Williams et al. 1971). The various pollutants either adhere to the plant surface or enter the leaf through the cuticle or stomata, where physiological and structural responses are induced. Stomata are believed to represent a major site of pollutant penetration in some plants. Stomatal structure, frequency and distribution have been assumed to be significant variables affecting plant sensitivity and overall leaf resistance. Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants. They reduce the pollutants level in the environment to a various extent (Lui and Ding, 2008; Escobedo et al, 2008) Plants act as the scavengers for many air borne particulates in the atmosphere (Joshi and Swami, 2007). Air pollution in Tarapur industrial area is rising to an alarming state since last decades due to bulk drug manufacturing units, chemical manufacturing units, steel plants and some textile plants. Therefore the present study was mainly designed to analyze impact of industrial air pollution on the leaf macromorphology and

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 03 Issue: 12 | Dec -2019 ISSN: 2582-3930

micromorphology of some plants growing in Tarapur Industrial Area (MIDC),

Material and Methods

Study area

Tarapur is a census town in Palghar district (earlier Palghar was taluka and has recently notified as district) of Maharashtra State, India. Located at 17.7º N, 75.47º E at an elevation of 456 meters (1496 feet). Tarapur MIDC in-house major Industrial Estate of Maharashtra Industrial Development Corporation which includes bulk drug manufacturing unit's especially chemical manufacturing units, steel plants and some textile plants.

Sample Collection

Leaf samples were collected from MIDC Tarapur for polluted site (PS). A site nearby with similar ecological conditions, Tarapur atomic power station colony (TAPS) was selected as the control site (CS). Fresh leaves were collected in the morning hours from identified trees. They were brought to the laboratory in polythene bags. Samples are preserved in refrigerator for other analysis.

Plants: Plant species studied were *Acacia auriculiformis, Artocarpus heterophyllous, Azadirachta indica, Cassia siamea, Ficus benghalensis, Ficus religiosa, Mangifera indica, Polyalthia longifolia, Terminalia catappa* and *Thevatia nerifolia*.

Methods

The effect of air pollution induced changes on the leaf morphology which was analysed based on:

A) Morphological characters of the leaf:

1) Leaf area in cm^2 (graph paper method) Leaf / leaflets area measurements were worked out by using graph paper. Leaf outline was drawn. Then the leaf area was calculated by counting the number of bigger and the smaller squares Agarwal S K, 2005).
2) Leaf length in cm (thread method).
3) Leaf breadth in cm by taking the average measure of upper, middle and lower part and
4) Petiole length in cm (using scale).

Result and discussion:

Results pertaining to the study of different morphological and anatomical attributes of the ten plant species are described and discussed as under:-

Table 4.6.1.2: Seasonal variation for second year in leaf leaf length (cm)

Sr. No	Plant names	Polluted site			Control site		
		Rainy	Winter	Summer	Rainy	Winter	Summer
1	*Acacia auriculiformis*	19.61±1.61 (8.01%)	15.75±1.31 (35.48%)	16.25±1.50 (28.00%)	18.04±2.13	24.41±2.45	22.57±1.48
2	*Artocarpus heterophyllus*	14.50±0.83 (19.35)	14.43±0.60 (23.73%)	15.82±0.94 (8.55%)	17.89±2.06	18.92±1.37	17.30±1.89
3	*Azadirachta indica*	18.54±0.88 (4.78)	19.17±1.25 (3.47%)	18.84±1.28 (2.74%)	19.47±0.78	19.86±1.04	19.37±1.09
4	*Cassia siamea*	26.65±0.88 (6.06)	27.02±0.67 (2.60%)	26.49±0.72 (1.52%)	28.37±0.80	27.47±0.85	26.90±0.64
5	*Ficus benghalensis*	14.18±0.97 21.09)	15.50±0.93 (19.06%)	16.28±1.15 (10.40%)	17.97±3.12	19.15±1.65	18.17±1.74
6	*Ficus religiosa*	26.86±2.17 (12.65%)	24.24±1.13 (9.01%)	19.89±2.34 (10.54%)	30.75±1.60	26.64±1.33	22.23±2.52
7	*Mangifera indica*	19.40±2.40 (10.68%)	18.24±1.84 (18.23%)	20.27±1.96 (23.02%)	21.72±3.22	22.54±4.06	26.33±3.06
8	*Polyalthia longifolia*	19.84±1.82 10.27%)	18.44±1.90 (23.90%)	21.14±1.68 (6.34%)	22.11±1.71	24.23±1.44	22.57±1.08
9	*Terminalia catappa*	23.33±1.95 (18.54%0	23.67±3.46 (9.48%)	25.35±3.06 (24.31%)	28.64±2.80	26.15±3.91	33.49±3.49
10	*Thevatia nerifolia*	11.48±1.35 (27.25%)	13.99±1.15 (8.44%)	11.60±0.95 (23.28%)	15.78±0.80	15.28±1.04	15.12±0.96

Table 2: Seasonal variation in leaf breadth (cm)

Sr. No	Plant names	Polluted site			Control site		
		Rainy	Winter	Summer	Rainy	Winter	Summer
1	*Acacia auriculiformis*	1.67±0.14 (10.35%)	1.77±0.20 (12.52%)	2.04±0.20 (1.78%)	1.86±022	2.02±0.28	2.07±0.30
2	*Artocarpus heterophyllus*	6.11±0.56 (13.33%)	5.90±0.55 (20.15%)	6.52±0.59 (6.23%)	7.05±0.61	7.39±0.44	6.95±0.61
3	*Azadirachta indica*	11.72±0.53 (3.93%)	12.27±1.12 (12.04%)	11.80±0.66 (5.75%)	12.20±0.86	13.95±0.75	12.52±0.50
4	*Cassia siamea*	11.98±1.26 (1.64%)	10.73±1.33 (19.20%)	11.36±1.54 (0.79%)	12.18±1.05	13.28±1.39	11.45±0.79
5	*Ficus benghalensis*	7.68±0.48 (23.36%)	9.11±0.34 (5.93%)	9.14±0.47 (0.65%)	10.02±1.01	9.69±0.84	9.20±0.72
6	*Ficus religiosa*	9.35±1.00 (27.27%)	9.04±0.89 (12.35%)	7.61±0.31 (22.57%)	12.85±1.00	10.31±0.98	9.82±1.06
7	*Mangifera indica*	3.46±0.43 (11.37%)	3.47±0.32 (2.34%)	3.92±0.34 (6.15%)	3.91±0.79	3.55±0.63	4.18±0.39
8	*Polyalthia longifolia*	2.85±0.43 (34.85%)	2.96±0.43 (26.78%)	3.25±0.37 (13.96%)	4.37±0.37	4.04±0.32	3.78±0.39
9	*Terminalia catappa*	10.56±1.11 (8.39%)	11.41±1.13 (10.94%)	11.98±0.77 (0.97%)	11.52±1.77	12.81±1.71	12.10±0.66
10	*Thevatia nerifolia*	0.92±0.40 (25.92%)	0.86±0.06 (16.44%)	0.75±0.08 (24.03%)	1.25±0.46	1.03±0.10	0.98±0.07

Table 3: Seasonal variation in leaf petiole length (cm)

Sr. No	Plant names	Polluted site			Control site		
		Rainy	Winter	Summer	Rainy	Winter	Summer
1	*Acacia auriculiformis*	--	--	--	--	--	--
2	*Artocarpus heterophyllus*	1.37±0.16 43.39%)	1.43±0.09 (40.42%)	1.63±0.21 (25.23%)	2.42±0.37	2.40±0.21	2.18±0.33
3	*Azadirachta indica*	5.61±0.37 2.60%)	5.95±0.63 (10.39%)	5.97±0.38 (1.32%)	5.76±0.44	6.64±0.66	6.05±0.38
4	*Cassia siamea*	6.65±0.31 0.60%)	6.80±0.47 (2.58%)	7.01±0.46 (3.18%)	6.69±0.5	6.89±0.49	7.24±0.56
5	*Ficus benghalensis*	2.56±0.32 20.74%)	2.65±0.20 (14.52%)	3.13±0.49 (12.57%)	3.23±0.24	3.10±0.45	3.58±0.72
6	*Ficus religiosa*	9.46±0.47 2.37%)	8.29±1.22 (5.04%)	4.17±0.70 (25.40%)	9.69±1.08	8.73±0.92	5.59±0.70
7	*Mangifera indica*	2.44±0.18 5.79%)	1.84±0.46 (23.97%)	1.72±0.27 (33.85%)	2.59±0.62	2.42±0.61	2.60±1.00
8	*Polyalthia longifolia*	0.55±0.08 9.84%)	0.56±0.07 (16.42%)	0.60±0.00 (6.25%)	0.61±0.12	0.67±0.11	0.64±0.15
9	*Terminalia catappa*	1.30±0.19 27.37%)	1.55±0.34 (1.27%)	1.33±0.17 (10.14%)	1.79±0.39	1.57±0.50	1.48±0.50
10	*Thevatia nerifolia*	0.20±0.00 33.33%)	0.20±0.00 (33.3%)	0.20±0.00 (0.00%)	0.30±0.00	0.30±0.00	0.20±0.00

Table 4: Seasonal variation in leaf area (cm^2)

Sr. No	Plant names	Polluted site			Control site		
		Rainy	Winter	Summer	Rainy	Winter	Summer
1	*Acacia auriculiformis*	22.30±3.99 (18.17%)	26.15±5.21 (29.04%)	26.85±8.10 (28.40%)	27.25±3.08	36.85±4.80	37.50±6.29
2	*Artocarpus heterophyllus*	68.05±10.62 (22.41%)	62.15±6.21 (37.03%)	79.35±10.09 (8.79%)	87.70±16.77	98.70±6.83	87.00±16.67
3	*Azadirachta indica*	112.60±21.58 (51.88%)	93.75±18.79 (8.09%)	109.50±14.66 (7.01%)	234.00±26.65	102.00±11.29	117.75±14.16
4	*Cassia siamea*	174.80±33.44 (0.40%)	138.78±28.76 (34.94%)	125.10±25.61 (6.71%)	175.50±22.15	213.30±44.10	134.10±14.36
5	*Ficus benghalensis*	81.00±9.09 (34.91%)	102.85±12.29 (23.65%)	108.25±13.43 (8.57%)	124.45±11.24	134.70±21.76	118.40±16.10
6	*Ficus religiosa*	123.50±34.17 (40.02%)	109.45±16.77 (14.46%)	71.60±10.19 (39.04%)	205.90±19.42	127.95±18.91	117.45±28.10
7	*Mangifera indica*	44.30±9.92 (28.43%)	46.70±9.54 (22.49%)	66.70±10.11 (12.29%)	61.90±21.89	60.25±25.46	76.05±14.22
8	*Polyalthia longifolia*	44.40±8.66 (49.37%)	44.50±6.75 (39.08%)	57.40±6.40 (15.84%)	87.70±19.66	73.05±8.12	68.20±7.33
9	*Terminalia catappa*	208.70±43.62 (10.47%)	206.85±45.76 (18.75%)	237.45±38.73 (22.41%)	233.10±27.67	254.60±68.47	306.05±48.86
10	*Thevatia nerifolia*	8.05±2.05 (45.61%)	10.90±1.20 (25.60%)	6.25±0.49 (61.89%)	14.80±2.82	14.65±2.07	16.40±2.39

Rainy season

The leaf length showed minimum percentage reduction in *Azadirachta indica* (4.78%) and maximum percentage reduction in *Thevatia nerifolia* (27.25%) with respect to control site than the polluted site. Leaf breadth showed minimum percentage reduction in *Cassia siamea* (1.64%) and maximum percentage reduction in *Polyalthia longifolia* (34.85%) with respect to control site than the polluted site. The leaf petiole length showed minimum percentage reduction in *Cassia siamea* (0.60%) and maximum percentage reduction in *Artocarpus heterophyllous* (43.39%) with respect to control site than the polluted site. The leaf area showed minimum percentage reduction in *Cassia siamea* (0.40%) and maximum percentage reduction in *Azadirachta indica* (51.88%) with respect to control site than the polluted site.

Winter season

The leaf length showed minimum percentage reduction in *Cassia siamea* (2.60%) and maximum percentage reduction in *Acacia auriculiformis* (35.48%) with respect to control site than the polluted site. Leaf breadth showed minimum percentage reduction in *Mangifera indica* (2.34%) and maximum percentage reduction in *Polyalthia longifolia* (26.79%) with respect to control site than the polluted site. The leaf petiole length showed minimum percentage reduction in *Terminalia catappa* (1.27%) and maximum percentage reduction in *Artocarpus heterophyllous* (40.42%) with respect to control site than the polluted site. The leaf area showed minimum percentage reduction in *Azadirachta indica* (8.09%) and maximum percentage reduction in *Polyalthia longifolia* (39.08%) with respect to control site than the polluted site.

Summer season

The leaf length showed minimum percentage reduction in *Cassia siamea* (0.36%) and maximum percentage reduction in *Mangifera indica* (18.97%) with respect to control site than the polluted site. Leaf breadth showed minimum percentage reduction in *Ficus benghalensis* (0.65%) and maximum percentage reduction in *Thevatia nerifolia* (24.03%) with respect to control site than the polluted site. The leaf petiole length showed minimum percentage reduction in *Azadirachta indica* (1.32%) and maximum percentage reduction in *Mangifera indica* (33.85%) with respect to control site than the polluted site. The leaf area showed minimum percentage reduction in *Cassia siamea* (6.71%) and maximum percentage reduction in *Thevatia nerifolia* (61.89%) with respect to control site than the polluted site.

The atmospheric pollutants after making their entry through stomata of leaf causes reduction in leaf size of plants due to damage of photosynthetic tissues. (Iqbal and Shafiq, 1999, Shafiq and Iqbal, 2003, 2005) Therefore it has been proved from the above result that leaf surfaces were badly affected by air pollutant as leaf area remains small at pollutant site with respect to non-polluted site (Qadir and Iqbal, 1991). Similarly reduction in leaf area growing in vicinity of heavy pollutants was also observed in many other plant species by Bhatti and Iqbal (1998). Seasonally maximum reduction in all the parameter in all the plant species at the polluted site was observed during rainy season followed by winter season and summer season. Similar results was reported by Jahan and Iqbal., 1992; Dineva., 2004 and Tiwari et al., 2006.

Conclusion

Plants naturally cleanse the atmosphere. They absorb the pollutants through their leaves as they have a large surface area and they function as an efficient device to trap the pollutants. Results obtained from the present study provide evidence that. The pollutants affect the macromorphology of the plants with respect to leaf length, leaf breadth, petiole length and leaf area. To mitigate and reduce air pollution in the industrial area, further planning of the landscape can be undertaken.

References

1. Agarwal,S,K. Environmental monitoring. A P H Publishing Corporation. 2005; 204-205
2. Bhatia, S.C. 2006. Environmental Chemistry. CBS Publishers and Distributors.
3. Bhatti, G.H., M.Z. Iqbal. 1988. Investigations into the effect of automobile exhausts on the phenology, periodicity and productivity of some roadside trees. Acta Societatis Botanicorum Poloniae., pp: 57.
4. Escobedo, F.J., Wagner, J.E., Nowak, D.J., Dele Maza, C.L., Rodriguez, M., Crane, D.E., 2008. Analyzing the cost effectiveness of Santiago, Chiles policy of using urban forests to improve air quality. Journal of Environment Management. (86), 148–157.
5. Dineva, S.B., 2004, "Comparative studies of the leaf morphology and structure of white ash *Fraxinusamericana* L. and London plane tree Platanusacerifolia Wild growing in polluted area,". Dendrobiology, 52, pp.3-8.
6. Ghouse AKM, Iqbal M, Khan, S, Khan, A.H. 1980. Comparative study on the structure of vascular cambium in some Verbenaceae. Phytomorphology, 30: 32-40.
7. Gupta A K, Mishra R M; Effect of lime kilnos air pollution on some plant species. Air Pollution Research. 1994; 13(1):1-9.
8. Rao, C.S. 2006. Environmental Pollution Control Engineering. New Age International Publication. Revised Second Edition.
9. Lui, Y.J., Ding, H., 2008. Variation in air pollution tolerance index of plants near a steel factory, Implication for landscape plants species selection for industrial areas, WSEAS Transaction on Environment and Development, 4, 24-32.
10. Jahan, S, Iqbal, M.Z, 1992 Morphological and anatomical studies of leaves of different plants affected by motor vehicles exhaust. Journal of Islamic Academic Science. 5:21–23
11. Joshi, P., Swami, A., 2007. Physiological responses of some tree species. Under road sides automobile pollution stress around city of Haridwar, India, The Environmentalist, 27, 365-374.

11) Joshi, P. C., and Abhishek, S, 2007, "Physiological responses of some tree species under roadside automobile pollution stress around city of Haridwar, India," Environmentalist, 27, pp. 365–374.
12) Iqbal, M.Z., Shafiq, M, 1999. Impact of vehicular emission on germination and growth of Neem (*Azadirachta indica*) tree. Hamdard Medicus., XLII: 65-69.
13) Pandey,J ., Agrawal,M.,1994 Evaluation of air pollution phytotoxicity in seasonally dry tropical urban environment using three woody perennials New Phytologist, 126, pp. 53–61
14) Qadir, S.A., Iqbal, M.Z. 1991. Growth of some plants raised from polluted and unpolluted seeds. International Journal of Environmental Studies. 39: 95-99.
15) Ricks, G.R, Williams, R.J.H, 1974. Effects of atmospheric pollution on deciduous woodland part 2: effects of particulate matter upon stomatal diffusion resistance in leaves of *Quercus petraea* (Mattuschka) Leibl. Environmental Pollution. 6:87–109.
16) Salisbury, E.J. 1927 On the causes and ecological significance of stomatal frequency with special reference to the woodland floor. Philosophical Transaction of the Royal Society B., 216, 1-65.

17) Salisbury, E.J. 1932. The interrelations of soil climate and organisms and the use of stomatal frequency as an integrating index of relation of the plant. Bech. Bot. Zbl.**99**, 402-420.
18) Shafiq, M., Iqbal, M.Z, 2003. Effects of automobile pollution on the phenology and periodicity of some roadside plants. Pakistan Journal. Botany, 35: 931-938.
19) Shafiq, M., Iqbal, M.Z. 2005. The impact of auto emission on the biomass production of some roadside plants. International Journal of Biology and Biotechnology, 2: 93-97.
20) Stevovic, S., Mikovilovic, V.S, Calic-Dragosavac, D, 2010. Environmental impact on morphological and anatomical structure of Tansy. African. Journal of Biotechnology. 9(16): 2413-2421.
21) Tiwari, S., Syed, K., Sikka, J., Joshi, O.P, 2008. Air pollution induced changes in foliar morphology of two species of Cassia at Indore city (India). Journal of Environmental Research and Development. Vol.2 No.3:406-412.
22) Tiwari, S., M., Agrawal and Marshall, F.M., 2006, "Evaluation of ambient air pollution impact on carrot plants at a sub urban site using open top chambers," Environmental Monitoring and Assessment, 119:pp. 15-30.
23) Verma, R. B., Mahmooduzzafar, T. O. Siddiqi and M. Iqbal (2006). Foliar Response of *Ipomea pes-tigridis* L. to Coal-Smoke Pollution, Turkish Journal of Botany. 30(5):413-417.
24) Williams RJH, Lloyd MM, Ricks GR. Effects of atmospheric pollution on deciduous woodland I: Some effects on leaves of *Quercus petraea* (Mattuschka) Leibl. Environmental Pollution. 1971; 2:57–68.