International Journal of Ecology and Environmental Sciences 51: 275-280, 2025
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2025.0532

Short communication

Morphological Variation in Plants Growing in Polluted and Non-polluted Environment

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ABSTRACT

Plants growing in industrial areas can absorb pollutants, detoxify them, and tolerate high pollution levels. The degree of tolerance is indirectly correlated with the intensity of changes in many characteristics of plants. In the present study, analysis of morphological changes in plants induced by the water and soil pollutants leaching from the Carbo and TATA Metalics factory of Kharagapur was considered. Four water and soil pollution-tolerating plant species - *Pistia stratiotes, Nelambo nucifera*, *Eichhornia crassipes*, and *Trapa natans* - were selected for the study. Quantitative analysis of some major morphological parameters of these selected plants growing in said polluted areas revealed drastic changes in morphological features observed with respect to the plants growing in non-polluted areas. Thus, in the future, the analysis of the morphological features of these plant species will play an important role in the study of phytoremediation and green development in urban areas.

Key words: Water pollution, plant morphology

INTRODUCTION

A living organism cannot be alive but interacts among itself and its habitat. Hence, all organisms, such as plants, animals, and human beings, as well as the physical surroundings with whom we interact, form a part of our environment (Gillette 1984). All these constituents of the environment are dependent upon each other. Thus, they maintain a balance in nature. The environment is being modified and imbalanced daily to fulfill various human needs. Pollution stress can change plant growth, and the effects are often widespread (Sagar et al. 1982). Darley (1966) reported that after falling on the soil, industrial dust caused a pH shift, which was unfavorable to the growth of oats trees. Darley et al. (1966) also reported that the number of leaves was less in plants growing in heavily dusted fields near the cement industry in different corners of the world. There were significant changes in the structure and composition of the seedlings, shrubs, saplings, and tree strata near limestone quarries and processing plants compared to non-dusted forest communities (Brandt and Rhoades 1972). The deterioration of air quality around an industry influenced by the area's meteorological conditions cause plant growth changes (Turtos et al. 2009, Yadav and Pandey 2020). Air pollutants were responsible for vegetation injury and crop yield losses reported by Fuji (1973). Rapid industrialization causes the addition of toxic substances to the environment that are responsible for altering the ecosystem were studied by various authors from different corners of the world (Mudd and Kozlowski 1975, Stern 1976, Clayton and Clayton 1982, Niragau and Davidson 1986, Kaur and Nagpal 2017).

Plants growing in polluted environments often show symptoms of various injuries and premature aging. Various pollutants like SO_2, CO_2, N_2O, NO, HF, chlorine, and particulate matter are discharged into the atmosphere from automobiles, industries, and power stations, which cause serious injuries internally as well as externally to plants and plant cells (Jacobson and Hill 1970). A perusal of the literature reveals little information on the effect of industrial pollutants on the morphology of aquatic plants. Hence, the present study is undertaken to record the effects of pollutants on various morphological characteristics of some selected aquatic plants like - *Nelumbo nucifera, Eichhornia* *crassipes, Trapa natans, and Pistia stratiotes*.

Kharagpur is one of India's most important industrialized subdivisions, suffering from different pollutants from nearby Carbo and TATA-Metalics industries. The pollutants become deposited in the aquatic as well as terrestrial habitats, producing a significant effect on local plants. Therefore, in the present study, the morphological changes in some selected plants were taken into account, which were severely affected by the water and soil pollutants leaching from the Carbo and TATA Metallics factory of Kharagpur.

MATERIAL AND METHODS

Materials

Four aquatic plants - *Nelumbo nucifera, Eichhornia crassipes, Trapa natans, and Pistia stratiotes* were selected for the study.

Nelumbo nucifera is an aquatic, herbaceous plant species under the family Nelumbonaceae, with its large round leaves held as much as 2 m above the water surface instead of floating on it. Flowers are usually found on thick rhizomatous stems rising several centimetres above the leaves. They are showy and grow up to 35 cm in diameter. Nutlike fruits contain extremely hard covered seeds. The plant seeds are rich in proteins, carbohydrates, lipids, vitamins, minerals, and other bioactive components. They are a good source of albumin, globulin, zinc, iron, calcium, and phosphorus and are also used to treat hypertension (Mukherjee et al. 2010, Lim 2016).

Eichhornia crassipes is a perennial, aquatic, free floating herb under the family Pontederiaceae with prostrate and densely branched stems and leaves are of ovate to circular, 10-20 cm in diameter. The flowers are held on a spike above the water and foliage and open in the morning, usually lasting for a day. After pollination, the inflorescence curves downwards, allowing the fruits to mature below the water surface. It produces masses of seeds in thin-walled capsule fruits. The plant has anti-inflammatory, antibacterial, antifungal, antiviral, and antitumor properties. The plant is traditionally used to treat diarrhoea, intestinal worms, digestive disorders, and flatulence (Villamagna and Murphy 2010, Coetzee and Hill 2012).

Trapa natans is a floating annual, aquatic herb species under the family Trapaceae, growing in slow-moving freshwater up to 5 m depth with the water caltrop's submerged stem that reaches 3.7 to 4.6 m in length, anchored into the mud by very fine roots. Leaves are of two types- finely divided, feather-like submerged leaves borne along the length of the stem and undivided floating leaves borne in a rosette at the water's surface. The floating leaves have saw-tooth edges and are ovoid or triangular with water chestnut fruit. The fruits are edible, raw, or cooked (Karg 2006).

Pistia stratiotes is a perennial, aquatic monocotyledonous herb under the family Araceae with thick, soft leaves that form a rosette. It floats on the water's surface, its roots hanging submersed beneath floating leaves. The leaves can measure 2-15 cm long and are light green, with parallel venations and wavy margins. The surface of the leaves is covered in short, white hairs, which form basket-like structures that can trap air bubbles and increase the plant's buoyancy. The flowers in spadix inflorescence are dioecious and lack petals. They are hidden in the middle of the plant amongst the leaves: pistillate flowers with one ovary and staminate flowers with two stamens. Fruits are oval, green berries with ovoid seeds.

Extractions of the leaves of *P. stratiotes* reduce mast infiltration and degranulation in allergic reactions and present anti-inflammatory properties (Koffuor et al. 2014). The ethanolic extracts have also been positively correlated with reduced inflammatory disorders, such as arthritis and fevers (Koffuor and Boampong 2012). It is also used as a traditional ringworm treatment; researchers have tested *P. stratiotes* methanolic extracts on dermatophyte fungi (Shyamsundar and Premkumar 2005).

Methods

Study area

Two industrial zones under the Kharagpur subdivision, i.e., Carbo and TATA Metallics factory and their adjoining area, were selected for the study, which was extended from latitude 22° 22' 46.5" to 22°23'10.1" N and longitude 87°16'53.5'' to 87°17'13.0" E

Collection of samples

Some healthy seedlings of each selected species, i.e., *N. nucifera*, *E. crassipes*, *T. natans*, *and P. stratiotes,* were collected from their native habitat in the year

2023 and transferred to pots with 4 ft in diameter and 7 ft in depth residing at an experimental site located at latitude 22° 36'90.4" N and longitude 87°55'44.2'' E. The experimental site was the Debra College Campus under the Kharagpur subdivision. Two sets of pots for each species were prepared. One set bears the water and soils collected from the selected industrial zones treated as (P), and another set bears the water and soil collected from non-polluted zones of Kharagpur treated as control (NP). Mature plants at their flowering and fruiting stage were collected from the polluted (P) demarcated pots and some control (NP) demarcated pots. The morphological characters, such as the length of the root, shoot, leaf, and petiole, as well as the width and number of leaves, were taken into account and measured by scales. A student's T-test is used to test the significance of the test.

RESULTS AND DISCUSSION

Variation in morphology

In the present study, there were significant variations in shoot length, leaf number, leaf length, and breadth, as well as petiole length, noted in all of the selected plants growing in the pots (P) containing polluted soil and water in respect to control.

In *N. nucifera,* the length of root, shoot, and petiole in the plants grown in the polluted area reduced to 13 cm from 16 cm and 16.46 cm from 20.63 cm and 147 cm from 163 cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth also reduced to 3 from 3.6, 11.1 cm from 12.6 cm, and 8.3 cm from 8.7 cm, respectively, in the plants grown in polluted areas (Table 1).

In *N. nucifera*, the statistical analysis showed that the variation in root length and shoot length were significant only at the 1% level and leaf number only at the 5% level (Table 1). The leaf breadth and petiole length variations between the control and the polluted samples remained statistically insignificant.

In *E. crassipes,* the length of root, shoot, and petiole in the plants grown in the polluted area reduced to 6.0 cm from 6.23 cm and 9.06 cm from 9.6 cm and 3.1cm from 3.3 cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth also reduced to 5 cm from 5.6 cm, 4.5 cm from 5.1 cm, and 3.7 cm from 3.8 cm, respectively, in the plants grown in polluted areas (Table 2).

Table 1. Variation of morphological characters of *N. nucifera* growing at polluted and non-polluted sites

Morphological parameters	Control (NP) Mean ± SD	Polluted (P) Mean ± SD	t-test
Root length (cm)	16± 1.00	13 ± 1.00 *	3.9438
Shoot length (cm)	20.63±2.15	16.46±1.20*	3.7870
Leaf length (cm)	12.60±1.56	11.10±0.72	2.9522
Leaf breadth (cm)	8.70±0.25	8.30±0.25 NS	0.0358
Leaf number	3.60±0.57	3.0 ±1.00 **	2.6733
Petiole length (cm)	163.0±8.0	147.0±7.5 NS	4.2626

* Significant at 1%, ** Significant at 5%, NS-Non significant

Table 2. Variation of morphological characters of *E.crassipes* growing at polluted and non-polluted sites

Morphological parameters	Control (NP) Mean ± SD	Polluted (P) Mean ± SD	t-test
Root length (cm)	6.23±1.00	6.0± 0.30**	2.7412
Shoot length (cm)	9.60± 0.91	9.06 ±1.45NS	1.8942
Leaf length (cm)	5.1±0.7	4.5±0.64	2.9361
Leaf breadth (cm)	5.1±0.7	3.7±0.1**	2.6723
Leaf number	5.6±0.57	5.0±1.00	2.9729
Petiole length (cm)	3.3±0.70	3.1±0.4**	2.6636

* Significant at 1%, ** Significant at 5%, NS-Non significant

The statistical analysis in *E. crassipes* showed that the variation in root length, leaf breadth, and petiole length were significant only at the 5% level (Table 2). In contrast, the variations in shoot length between the control and the polluted samples remained statistically insignificant.

In *T. natans,* the length of root, shoot, and petiole in the plants grown in polluted areas reduced to 5.6 cm from 6.7 cm and 7.3 cm from 8.3 cm and 2.9 cm from 3.1 cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth also reduced to 6.6 cm from 7.6 cm, 4.1 cm from 4.9 cm, and 3.4 cm from 3.7 cm, respectively, in the plants grown in polluted areas (Table 3).

In *T. natans,* the statistical analysis showed that the variation in shoot length was significant only at the 1% level and leaf breadth only at the 5% level (Table 3). The leaf number and root length variation between the control and the polluted samples

Table 3. Variation of morphological characters of *T. natans* growing at polluted and non-polluted sites

Morphological parameters	Control (NP) Mean ± SD	Polluted (P) Mean ± SD	t-test
Root length (cm)	6.7 ±1.10	5.6 ± 0.96^{NS}	1.9712
Shoot length (cm)	8.3 ±0.88	7.3 ±0.96*	4.0155
Leaf length (cm)	4.9 ±0.1	4.1 ±0.40	2.9304
Leaf breadth (cm)	3.7±0.25	3.4±0.52**	2.6061
Leaf number	7.6±0.57	6.6±0.57^{NS}	2.1224
Petiole length (cm)	3.1 ±0.37	2.9 ±0.15	2.8802

* Significant at 1%, ** Significant at 5%, NS-Non significant

Table 4. Variation of morphological characters of *P. stratiotes* growing at polluted and non-polluted sites

Morphological parameters	Control (NP) Mean ± SD	Polluted (P) Mean ± SD	t-test
Root length (cm)	3.7 ±0.40	3.5 ±0.55	2.8629
Shoot length (cm)	3.4 ±0.52	3.3 ±0.35**	2.7357
Leaf length (cm)	2.4 ±0.20	2.2 ±0.25^{NS}	1.9872
Leaf breadth (cm)	1.7±0.15	1.4±0.15^{NS}	2.2017
Leaf number	6.3±0.57	6.0±0.1*	3.9097
Petiole length (cm)	0.6 ±0.15	0.5 ±0.2**	2.6713

* Significant at 1%, ** Significant at 5%, NS-Non significant

remained statistically insignificant.

In *P. stratiotes*, the length of root, shoot, and petiole in the plants grown in polluted areas reduced to 3.5 cm from 3.7 cm and 3.3 cm from 3.4 cm and 0.5 cm from 0.6 cm, respectively, with respect to the non-polluted area. Similarly, leaf number, length, and breadth were also reduced to 6 from 6.3 and 2.2 cm from 2.4 cm and 1.4 cm from 1.7 cm, respectively, in the plants grown in polluted areas (Table 4).

The statistical analysis in the species *P. stratiotes* showed that the variation in leaf number was significant only at the 1% level, whereas shoot length and petiole length only at the 5% level (Table 4). The leaf length and breadth variations between the control and the polluted samples remained statistically insignificant.

The changes in morphological characteristics of selected aquatic plants growing in polluted industrial areas in our study were reasonable and consistent with many earlier reports from different corners of the world regarding the changes of leaf morphology with respect to accumulation of dust particles depending on internodal distances, petiole length, leaf area, orientation, margin, folding and arrangement, hair density, hair type and length (Varshney and Mitra 1993, Dipu and Salom 2014, Dubey et al. 2023). Warrah et al. (2021) also reported similar morphological changes in plants growing around Sokoto Cement Company in Nigeria.

Darley et al. (1966) also noted that plants showed stunted growth, with few leaves growing in California's heavily cement-dusted portions of alfalfa fields. Brandt and Rhoades (1972) observed significant changes in the structure and composition of the seedling, shrub, sapling, and tree strata when they compared dusted and non-dusted forest communities near limestone quarries and processing plants.

Therefore, in the study, it was seen that plants' morphological characters were affected by soil and water containing industrial dust from the Kharagpur industry, which might be due to the presence of different toxic pollutants. It is clear that industrial pollutants were an operative ecological factor causing deterioration in the quality of our environment (Shah et al. 1989, Rai and Mishra 2013).

CONCLUSION

The observations recorded in the present study indicated that pollutants emitted from the industry and automobile exhaust exercised a decisive influence on plant morphology. From the present data, it was apparent that the length of root, shoot, petiole, leaf, and leaf number and breadth were affected. It showed the important changes in the plants growing in the polluted area, especially the industrial belt. Estimating the effects of pollutants is difficult because the organisms are exposed to a wide range of uncontrolled variables (parasites, weather conditions, complex mixture of pollutants). However, despite these changes, plants survived well in the polluted environment of the selected industrial area, i.e., Kharagpur TATA-Metalics and Cargo. These results showed the importance of morphological data for precocious diagnosis injury and for determining the sensitivity of different plant species to the action of air pollutants. After this study, there was still a severe lack of knowledge of the impact of pollution quality on vegetation in urban areas. Overall, the study reveals that all the plant species growing in the city's polluted environment are badly affected by auto-emission. There was a need to limit how much of a pollutant is allowed in the pollution. Our goal must be to have clean air for flora and fauna. We should take the necessary steps to get rid of the ever-increasing pollution.

ACKNOWLEDGEMENTS

The authors are grateful to the Principal of Egra S.S.B. College, Egra, India for giving us the laboratory facilities and special thanks go to the local people for their kind co-operation during sample collection.

Authors' contributions: All authors contributed equally.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

Brandt, C.J. and Rhoades, R.W. 1972. Effects of limestone dust accumulation on composition of a forest community. Environmental Pollution, 3, 217-225. https://doi.org/10.1016/0013-9327(72)90005-5

Clayton, G.D. and Clayton, F.E. 1982. Pattys Industrial Hygiene and Technology. Wiley Interscience, New York. 5045 pages. https://doi.org/10.1002/0471435139

Coetzee, J.A. and Hill, M.P. 2012. The role of eutrophication in the biological control of water hyacinth, *Eichhornia crassipes*, in South Africa. BioControl, 57, 247-261. https://doi.org/10.1007/s10526-011-9426-y

Darley, E.F. 1966. Studies on the effect of cement kiln dust on vegetation. Journal of the Air Pollution Control Association, 16(3), 145-150. https://doi.org/10.1080/00022470.1966.10468456

Darley, E.F., Drugger W.M., Mudd J.B., Ordin L., Taylor O.C. and Stephe E.R. 1966. Plant damage by pollution derived from auto mobiles. Arch Environment Health, 6, 700-761. https://doi.org/10.1080/00039896.1963.10663475

Dipu, S. and Salom, G.T.V. 2014. Heavy metal uptake, its effects on plant biochemistry of wetland (constructed) macrophytes and potential application of the used biomass. International Journal of Environmental Engineering, 6, 43-54. https://doi.org/10.1504/IJEE.2014.057831

Dubey, R., Choudhary, A., Singh, S., Ajay, A., Kumar, S., Kumar, R., Mondal, S. and Singh, V.K. 2023. Assessing the impact of air pollution on trees and crops in the Eastern Gangetic Plains of India. Current Science, 124, 956-963. https://doi.org/10.18520/cs/v124/i8/956-963

Fuji, S. 1973. The current state of plant damage by air pollution in Okayama Perfecture. Shokbutsu Boeki, 27, 249-252. (in Japanese)

Gillette, D.G. 1984. Concern about atmospheric pollution. Pp. 7-13, In: Bell, J.N.B. and Treshow, M. (Eds.) Air Pollution and Plant Life. John Wiley and Sons, New York.

Jacobson, J.S and Hill, A.C. 1970. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Air Pollution Control Association Pittsburgh, Pennsylvania. 106 pages.

Karg, S. 2006. The water chestnut (Trapa natans L.) as a food resource during the 4th to 1st millennia BC at Lake Federsee, Bad Buchau (southern Germany). Environmental Archaeology, 11, 125-130. https://doi.org/10.1179/174963106x97106

Kaur, M. and Nagpal, A.K. 2017. Evaluation of air pollution tolerance index and anticipated performance index of plants and their application in development of green space along the urban areas. Environmental science and pollution research international, 24, 18881-18895. https://doi.org/10.1007/s11356-017-9500-9

Koffuor, G. and Boampong, K. 2012. Antiarthritic effect of aqueous and ethanolic leaf extracts of *Pistia stratiotes* in adjuvant-induced arthritis in Sprague-Dawley rats. Journal of Experimental Pharmacology, 4, 41-51. https://doi.org/10.2147/jep.s29792

Koffuor, G., Samuel, A.K., Emmanuel, A.A., Nsobire, C. A., Agnes, A. and Samuel, A. 2014. Antiallergic effect of an aqueous leaf extract of Pistia stratiotes in murine model of ovalbumin-induced allergic conjunctivitis. Pharmacognosy Research, 6, 274-279. https://doi.org/10.4103/0974-8490.138243

Lim, T. K. 2016. Nelumbo nucifera. Edible Medicinal and Non-Medicinal Plants. Springer, Cham. pp. 55-109. https://doi.org/10.1007/978-3-319-26062-45.

Mudd, J.B. and Kozlowski, T.T. 1975. Response of plants to air pollution. Academic Press, New York. 383 pages.

Mukherjee, P.K., Mukherjee, D., Maji, A.K., Rai, S. and Heinrich, M. 2010. The sacred lotus (*Nelumbo nucifera*) – phytochemical and therapeutic profile. Journal of Pharmacy and Pharmacology, 61, 407-422. https://doi.org/10.1211/jpp.61.04.0001

Niragau, J.O. and Davidson, C.I. 1986. Toxic Metals in the Atmosphere. Jon Wiley and Sons, New York. 664 pages.

Rai, P. and Mishra, R.M. 2013. Effect of urban air pollution on epidermal traits of road side tree species, *Pongamia pinnata* (L.) Merr. Journal of Environmental Science, Toxicology and Food Technology, 2, 4-7. https://doi.org/10.9790/2402-0260407.

Sagar, V.K., Gregory, C.P. and Paul, S.J. 1982. Air Pollution-an important issue in plant health. Plant Disease, 66, 429-434. 224 pages.

Shah, F.H., Ilahi, I. and Rashid, A. 1989. Effect of cement dust on the chlorophyll contents, stomatal clogging and biomass of some selected plants. Pakistan Journal of Scientific and Industrial Research, 32, 542-545. https://pjsir.org/multidisciplinary-archive/Volume%2032%201989/Issue%208/Article%2011%20Vol%2032%20Issue%208%201989.pdf

Shyamsundar, D. and Premkumar, V.G. 2005. Antidermatophytic activity of *Pistia stratiotes*. Indian Journal of Pharmacology, 37, 127. https://doi.org/10.4103/0253-7613.15116

Stern, A.C. 1976. Air Pollution. Measurement, Monitoring and Surveillance of Air Pollution, 3rd ed., Academic Press, New York. 799 pages.

Turtos, L., Sanchez, M., Meneses, E., Rivero J., Pire, S. Diaz N. and Paz, E. 2009. The air quality modelling to support operational atmospheric pollution mitigation in generator sets. Environmental Capacity Enhancement Project (ECEPC) Final Workshop, Havana.

Varshney, C.K. and Mitra, I. 1993. Importance of hedges in improving urban air quality. Landscape and Urban Planning, 25, 85-93. https://doi.org/10.1016/0169-2046(93)90124-V

Villamagna, A.M. and Murphy, B.R. 2010. Ecological and socio-economic impacts of invasive water hyacinth (*Eichhornia crassipes*): a review. Freshwater Biology, 55, 282-298

Warrah, M.M., Senchi D.S, Fakai, I.M. and Daboh, U.M. 2021. Effects of cement dust on vegetation around Sokoto Cement Company. International Journal of Environment Agriculture and Biotechnology, 6, 017-024. https://doi.org/10.22161/ijeab.61.3

Yadav, R. and Pandey, P. 2020. Assessment of air pollution tolerance index (APTI) and anticipated performance index (API) of roadside plants for the development of greenbelt in urban area of Bathinda City, Punjab, India. Bulletin of Environmental Contamination and Toxicology, 105, 906-914. https://doi.org/10.1007/s00128-020-03027-0

Received:26th September 2024
Accepted:15th February 2025