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The Analytical Study of Biomathematics to Relate Pollution Indicator Species

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ABSTRACT

The present study conducted in and around the Durgapur Industrial region, West Bengal, India aims to characterize the air pollution indicator parameters and identify the pollution tolerant species by detailed analysis of 21 morphological and biochemical parameters under the air pollution stress.

It was noted that the Air Pollution Index (API) became higher (266.88) around the clusters of the industrial sectors in Durgapur city while the atmosphere of the per urban area are comparatively less polluted. The different deposition patterns in the forms of granules, crust, flakes, immurations and the surface architectural patterns of epicuticular wax of both plant species were analyzed and compared using the Scanning Electron Microscopy (SEM) study. Thirteen major variables could be screened to be the most influenced ones under the air pollution stress from the Principal Component Analysis (PCA). This study can serve as a guide for the forest managers to analyze pollution induced variables of model tree species and develop an effective Green belt to combat air pollution in urban industrial regions.

Keywords. Biochemical, Parameters, Morphological, Pollution

Air pollution is among the greatest scourges of the present civilized world imposing severe long term toxicological effects on the climate change, human health and biodiversity (Song et al., 2016; Wu et al., 2018). The ever-increasing global urbanization and industrialization has accelerated the air pollution mediated adversity to become more tangible and consequently invited researchers to identify the control measures as a priority area of research in various disciplines.

It is well known that the changing environmental conditions have resulted in genetic and non-genetic adaptations in several organisms during the process of evolution. Plants are no exceptions to resist such adaptations. During their ontogeny period, plants get exposed to abiotic factors such as high temperature, water deficit and overload, frost or cold conditions, drought, hypersalinity, radiation effects etc., while the biotic ones include plant herbivore, plant pathogen interactions etc. (Duveiller et al., 2007; McDonald et al., 2009; Peters et al., 2014). The morphological and

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biochemical characteristics of vegetation are influenced considerably due to air pollution. However, plants continue to function by developing physiological, biochemical, micro and macro-morphological adaptations is response to these inexperienced factors. The internal and external characteristic response to the adverse environmental changes is observed in some plants only, regarded as a tolerant which develops the adaptive modification of morphological features on epithelial layer of leaves and biochemical variability (Banerjee et al., 2016).

India, being a developing economy has witnessed rapid industrialization and urbanization leading to severe degradation of the urban atmospheric quality as a result of the industrial and vehicular emissions. The major air pollutants include fine suspended particles such as PM_{10}, $PM_{2.5}$, gases such as NH_3, CO_2, SO_2, NO_x, O_3, CO, VOCs (Haakman et al., 2020), and heavy metals such as Pb, Cr, Ni, Fe, Cd etc. These atmospheric pollutants create multiple symptomatic adversities on biochemical (Legge and Krupa, 2002), cellular (Li et al., 2007) and morphological level (Baldacchini et al., 2017) of floral community.[1]

As a control measure to combat the air quality deterioration, no artificial devices have yet been developed to the best of knowledge. Alternatively, the natural heterogeneous vegetation layer capable of cleaning the air is employed as the most effective mechanism in the urban sectors to reduce air pollution effects (Zhang et al., 2020).

Leaves adsorb, congregate, absorb, metabolize and detoxify several air pollutants (Shannigrahi et al., 2004; Agbaire and Esiefarienrhe, 2009) through different morphological and biochemical variables such as leaf size, stomatal frequency, trichomes, ascorbic acid, pH etc. and therefore behave as the sensitive parts of the plant body. It is worth mentioning that the plant variables which are significantly influenced by the air pollutants can be of potent research interest for the conservation and restoration of indigenous plant species.

The present study provides a deep insight regarding the applicability of biochemical and morphological attributes that can be used as bioindicator to assess the level of air pollution load over a particular region at a particular time. Most of the previous studies have attempted to calculate atmospheric air pollution load or characterize the vegetation as tolerant, sensitive etc. on the basis of air pollution tolerance index and anticipated performance index values. Therefore, the present study is different from the previous studies in terms of identifying specific biochemical and morphological parameter to be used as indicator for air pollution assessment that would be a new scientific finding in the field of pollution biology.

The species which adapts maximum fitness under adverse environmental conditions show maximum capacity to ameliorate air pollution. The role of plant variables under air pollution stress

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cannot be justified merely through statistical interpretations; rather the detailed individual leaf ultramicroscopic observation is required to assess the capability of the pollution tolerance by the plant species under natural conditions.[2]

Air pollutants influence the floral community structure in the urban sectors by affecting their variable characteristics. The pollution responsive plant variables are considered as ecosystem drivers and are not only responsible for forest dynamism of a region but also have the capability to mitigate the surrounding air pollution problems.

The present study conducted in the Durgapur industrial region is a location specific approach aiming to extract some air pollution responsive plant variables and the investigation will be of value to the urban planners and managers to successfully implement the environmental management programmes to combat the air pollution stress.

As the plantation of properly scrutinized air pollution tolerant indigenous tree species is cost effective, eco-friendly and biodiversity enhancer and may bring extra socio-economic benefit for the society. Urban planners and managers can effectively utilize such screened vegetation for improving the air quality with net reduction of Green House Gases (GHGs) from the ambient environment.[3] The total management programmes i.e. the technology of screening species and their site specific plantation can be implemented with minimum cost, therefore, the findings can be applied considering the national and provincial political influence in new ways of combating environmental issues.

This study is divided into six sections. The first one is the air pollution monitoring, in which the regional variability of the air pollutants SO_2, NO_x and SPM are analyzed. The intensity of air pollution was determined from the Air Pollution Index (API) calculation. The subsequent sections include cuticular evaluation, morphological evaluation and biochemical evaluation. The degree of tolerance and sensitivity level of each plant species was determined from the Air Pollution Tolerance Index (APTI) (Banerjee et al., 2019a). Finally, the statistical evaluation comprehends the study in terms of Fisher's F- test, Student 't'- test, Principal Component Analysis (PCA) and Correlation coefficient matrix of Pearson to detect the variability, impacts and correlation of multiple plant variables under natural air pollution stress.

Study sites

Durgapur city is situated in the industrial belt of West Bengal housing several factories such as Durgapur Steel Plant (DSP), Alloy Steel Plant (ASP); power sectors such as Durgapur Project

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Limited (DPL), National Thermal Power Plant (NTPC), Damodar Valley Corporation (DVC) etc., and is consequently exposed to various air pollutants including the criteria air pollutants which significantly affect the plant species.[4]

Statistical methods

Statistical methods were used to detect the variability, impacts and correlation of multiple plant variables under natural air pollution stress. The values of all parameters were calculated as mean ± SD and are represented as the bar chart. The spatial variability was determined by Fisher's F- test and Student 't'- test (at $P < 0.05$) depending on all the investigated morphological and biochemical parameters of the two studied plant species. The Principal Component Analysis (PCA) of both plants

Results and discussion

In a large industrial area, the spatial variation of air pollutants has been noticed and this differentiation also keeps an imprint on the morphological and biochemical characteristics of the floral community.[5] In this study the morphology of leaf lamina of *F. benghalensis* (*FIBE*) and *T. arjuna* (*TEAR*) was divided into two sets; one was the macromorphology which includes leaf length (LL), leaf breadth (LB), size of leaf (LS), petiole length (PL), mid rib width (MRW) and the other one was

Fisher's F- test and Student 't'- test

The variability and significant difference of the concerned morphological and biochemical parameters (significance level at $P < 0.05$) of *FIBE* and *TEAR* between S1 and S2 were assessed from the Fisher's F- test and Student 't'- test (see Table 1). F- test (ANOVA) and T-test are the statistical procedure for comparison of variances and means of the two groups respectively. The comparison of group means by 't'- test are not sufficient to demonstrate an experiment properly, rather it would be better

Conclusions

In the present study, the floral characteristics influenced by atmospheric air pollution have been identified, which can serve as the ecosystem drivers for pollution mitigation and floral dynamism of a region. The parameters LL, LB, LS, SL/SB, APTI, Prot., PL, SF, AA, pH, RWC, TSS and 'aa' were prone to be affected more by air pollution.

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