Studies on Lichen Diversity in relation with Air Pollution Monitoring around some selected Thermal Power Plants of Uttar Pradesh, India

THESIS

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The research work initiated with survey and collection of lichens from localities around all the three thermal power plants of Uttar Pradesh during the year **2013-2017**. A total of more than 500 lichen samples were collected and were dried and labelled with locality, date of collection and other ecological notes. The specimens were identified based on the morphological characters, anatomy and chemistry.

Morphological characters were studied under LABOMED dissecting microscope while LEICA ATC 2000 compound microscope was used for microscopic anatomical details. The chemical compounds present were identified by using colour spot tests and Thin Layer Chromatography (TLC) techniques. Complete identification of the all the samples revealed the occurrence of 21 species belonging to 14 genera and 11 families with maximum representation of lichen family Ramalinaceae followed by Physciaceae, Caliciaceae and Lecanoraceae from all the sites explored around selected thermal power plants of Uttar Pradesh. One specimen of each species was deposited in the National Repository CSIR-National Botanical Research Institute, Herbarium (LWG). Among of all the thermal power plants, Unchahar thermal power plant has the highest representation of 18 species of lichens, followed by Tanda thermal power plant and Panki Thermal Power plant with 11 and 8 species of lichens respectively.

Out of the 21 species recorded, only *Pyxine sorediata* reported as new addition to the lichen flora of Uttar Pradesh. Lichen genus, *Bacidia* emerges as the dominant genus with 4 species. The crust forming lichens exhibit their dominance with 14 species followed by foliose and squamulose represented by 4 and 2 species respectively. A follicolous lichen, *Strigula elegans* is the only lichen taxa reported from the single locality on the leaves of *Mangifera indica* at Salon near Bhawanipur,

Unchahar thermal power plant. *Mangifera indica* trees cultivated in orchards in all the sites bears the maximum growth of lichen species on their bark, twig, trunks and branches followed by *Artocarpous heterophyllus, Azadirachta indica, Litchi chinensis* and *Pongamia pinnata* respectively. Among, all 21 lichen species, only 3 species are commonly reported from selected thermal power plant of Uttar Pradesh i.e. *Bacidia incongruens, Pyxine cocoes* and *Rinodina sophodes.*

On comparison of lichen data for all the three selected thermal power plant (156 sampling sites or localities), *Pyxine cocoes* is widely distributed around all the selected thermal power plants while other species of lichens have narrow range of distribution.

In the present study, maximum evenness are recorded for crustose and foliose growth forms whereas minimum evenness is recorded for squamulose and follicolous lichen. Distribution of lichens has also been observed to be affected by abiotic, biotic and other environmental factors. Field observation have revealed that rapid expansion of agriculture land, destruction of forest, execution of developmental activities such as construction of paths through breaking of rocks and other anthropogenic factors have resulted in deteriorating the lichen habitat thus posing serious threat to diversity of lichens around thermal power plants.

It is clear from the observation that lichen diversity and dominance of lichens exhibit increasing trend as the distance increases towards the outskirts from the source of pollution i.e. thermal power plant. The localities Rajesultanpur road, Mubarakpur has the highest number of species followed by Rajesultanpur road, Rampur benepur; Faizabad-Tanda road, Mehbubganj, Bhitaura from Tanda thermal power plant; whereas Umaran area of Unchahar thermal power plant has the maximum number of species followed by area Nababganj, Sanhoo kuwan;

Raghunathpur Paterwa; Allipurbahera. The Panki thermal power plant has poor diversity of lichens as only 8 species are recorded from the area, but the area Airport road, Kataraghan Shyam near Sachendi; Aligarh- Kanpur road, bagdudi bazar, Amiliha near Choubeypur Kalan near Tatiyaganj of the thermal power plant have more diversity of lichens can be termed as **"Lichen Rich Areas"**. It is clear from the study that air pollution is not equally spread around the thermal power plant. The areas near thermal power plant have higher vehicular activity, urbanization, industrial activity and lack of vegetation leads to more pollution than the outskirts areas of the thermal power plants. The east direction of Panki thermal power plant can be termed as **"Lichen Desert Area"** as it showed complete absence of lichen species.

Epiphytic lichens are more sensitive than rock and soil inhabiting lichens, therefore they are generally considered as good indicators of air quality. The majority of air pollution sites have open dry spaces with heavy anthropogenic activities resulted into complete absence of sensitive lichens. The distribution data of lichen collected from all the study area provides an idea about the overall picture of the lichen distribution around thermal power plants.

Out of all the lichen species encountered in the study area, the species can be categorized into tolerant (2 species), moderate sensitive (2 species) and sensitive species (17 species) with reference to air pollution. The species mostly found growing in polluted areas *Pyxine cocoes* and *Rinodina sophodes* are well known toxitolerant taxa of lichens. The genus *Anisomeridium, Arthothelium, Caloplaca, Dirinaria, Lecanora, Peltula* and *Strigula* collected from more or less pollution free or moderately polluted areas are the pollution sensitive species of lichens recorded from the study area.

Lichen species differs in morphology and anatomy but bioaccumulates more or less similar concentration of metal through adsorption and absorption, as validated by SEM and FTIR respectively. FTIR spectra showed structural peculiarities of metabolites in the lichens as well as variation in the functional groups which indicating the role of metabolites in sequestration of metals (absorption phenomenon), while SEM analysis showed adsorption of particulate bonded matter on the surface of lichen thallus which is responsible for bioaccumulation. The variation in the functional group bands in IR region shows the effect of pollutant on the functional group chemistry of the particular lichen species. This phenomenon is principally involved in metal absorption by formation of chelates or bond dissociation due to the presence of phytotoxic gases mainly SO_2.

Changes both in Chlorophyll and carotenoid content may be used as a tool to monitor changes in area due to air pollution. Carotenoids are considered to be relatively more tolerant to metal toxicity than the chlorophyll. The lichens in polluted area exhibit decrease in chlorophyll content but when the pollution increases some lichen species can adapt to that increasing level of pollution.

The level of concentration of different metal present in the lichens helped in assessment of risk to the population living in the vicinity of the power plant together with long-term hazard due to metal accumulation. The study provided an understanding about the mechanisms adopted by different growth form of lichens for bioaccumulation of metals emitted by thermal power plant and indicates that the particulate bound adsorption is the major factor responsible for bioaccumulation in lichens irrespective of their growth form.

Out of the three sites, the species showed more or less similar sequence of metal accumulation around thermal power plants. *P. cocoes* had metal selectivity sequence

as Fe> Mn> Zn> Pb> Cr> Cu> Ni> As> Co> Se> Cd while *R. sophodes* had metal selectivity sequence as Fe> Mn> Pb> Zn> Cr> Cu> Ni> As> Co> Se> Cd around Panki thermal power plant. Accumulation of most of the metals at different directions exhibited least similar sequence of accumulation. The east direction had complete absence of lichens because of construction of roads, buildings and residential area. Among the different metals, Fe showed higher accumulation while Cd accumulated in lower concentration in both the species. Since the area is close to Panki thermal power plant, therefore, the probable source of metals in species may be attributed to the emission of thermal power plant. Total metal concentration in *Pyxine cocoes* was recorded higher in west direction (33681.28 $\mu g g^{-1}$) while *Rinodina sophodes* exhibit higher accumulation of metals (36850.07 $\mu g g^{-1}$) in north direction from Panki thermal power plant.

In samples from Tanda thermal power plant, *P. cocoes* showed more or less similar selectivity sequence of metals as Zn> Al> Cu> Fe> Pb> Cr> Cd in all the four directions, while *B. incongruens* exhibited a different sequence of metals as Fe> Zn> Cu> Al> Pb> Cr> Cd. Out of the four directions, *P. cocoes* showed minimum concentration of 116.17 $\mu g g^{-1}$ were recorded from north direction whereas maximum accumulation was recorded from south direction (1810.43$\mu g g^{-1}$), while total metal concentration in *B. incongruens* was recorded higher from north (488.39 $\mu g g^{-1}$) and lower in south direction (336.27 $\mu g g^{-1}$). Both *P. cocoes* and *B. incongruens* showed higher accumulation of Zn, Al, Fe, Cu and lower accumulation of Pb, Cr and Cd in all directions around Tanda thermal power plant. The total metal bioaccumulation are having different source as evident from the Pb in *B. incongruens* showed negative correlation with almost all metal while in *P. cocoes* it is positively correlated.

All the three lichen species such as *B. incongruens, P. cocoes* and *R. sophodes* exhibit similar type of metal selectivity sequence of Fe> Mn> Zn> Cr> Ni> Cu> Co> As> Se around Feroze Gandhi Unchahar Thermal Power Plant. In *P. cocoes*, the total metal concentration was highest in east (23628.32 $\mu g g^{-1}$) and lowest in west (18637.68 $\mu g g^{-1}$) direction of the study area. Among nine metals, Fe> Mn> Zn> Cr> Ni was accumulated in maximum concentration followed by Cu> Co> As> Se. Among the nine metals accumulated, Fe showed higher accumulation while Se accumulated in lower concentration in all the three species. Highest Fe accumulation of 50383.04±1.24 $\mu g g^{-1}$ was recorded in west (in *B. incongruens*) and minimum accumulation of 15053.04±0.90 $\mu g g^{-1}$ in north direction (in *R. sophodes*); while Se was recorded higher accumulation of 8.99±0.13 $\mu g g^{-1}$ in east (in *R. sophodes*) and lower accumulation of 0.69±0.12 $\mu g g^{-1}$ in north direction (in *P. cocoes* around Feroze Gandhi Unchahar Thermal Power Plant.

The present study illustrates the pattern of lichen diversity and metal accumulation may influence of prolonged exposure to emission of coal-based thermal power plant in all three lichen species i.e. *B. incongruens*, *P. cocoes* and *R. sophodes* in different directions. The study also indicates that the concentration of metal increases with decreasing distance from thermal power plant and provide direct evidence about the air quality status. The utility of lichen species as an environmental sensor is clearly displayed as metal accumulation in between the species exhibit more or less similar concentration of metal. Assessment of immediate risk to the population living in the vicinity of the power plant, long-term hazard due to metal accumulation should be seriously considered around thermal power plant. Higher concentration of Fe, Mn, Zn, Cr and Ni around the thermal power plant may be due to the high vehicular activity and other source of pollution involved in the disposal of coal waste.

Vehicular activity along with wind pattern also may be a cause for the dumping of all metal from outside the source.

Present study provides useful information to some selected thermal power plants in the state of Uttar Pradesh for the use of lichen as biomonitors of environmental pollution. The available account of lichens from the study area not only contributes a clear picture of lichen diversity around thermal power plants of Uttar Pradesh, but also provides a platform for studying lichens as biomonitors which are well known from their unique secondary metabolites or developments of green biomolecules for treatment of various disease of mankind. Thus, the result showed that the vehicular and anthropogenic activities are the major cause of metal load in the study area.

The sufficient past distribution data of the lichen taxa from the study area were not available; therefore it was not possible to draw any conclusion about the changes in the distribution pattern of lichen communities at present. However, the present available distribution pattern can be used as a record for carrying out future biomonitoring studies in the area.