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Heavy Metal Accumulation in *Pyxine cocoes* (Sw.) Nyl. Transplanted at Kolkata City, West Bengal, India

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ABSTRACT

A foliose lichen *Pyxine cocoes* (Sw.) Nyl., was transplanted at ten biomonitoring sites in Kolkata city of West Bengal for 30 days. Concentration of heavy metals Zn, Cu, Cd, Ni, Fe and Pb accumulated in lichen were determined. The result indicates an enhanced concentration of most of the metals in the transplanted samples than the control. Two heavy metals Cd and Pb were not detected in the samples, while Cr accumulated in lower (3.3±0.3 to 15.9±0.2 µg g^{-1}) and Fe in higher concentrations (2958.2±0.9 to 4690.4±0.7 µg g^{-1}). The concentration of Zn ranged from 47.1±0.6 to 114.0±0.5 µg g^{-1}, Cu 3.4±0.3 to 38.7±0.6 µg g^{-1} and Ni 31.2±0.3 to 81.3±0.8 µg g^{-1}. The lichen transplanted in the inner zone of the city with congested roads and heavy vehicular movements accumulated comparatively higher levels of most of the metals than at the sites situated in outer zone of the city. According to the concentration of heavy metals accumulated in lichen, it can be concluded that Jadabpur and Esplanade area are highly polluted, while BBD Bagh and Dum Dum Airport areas are less polluted.

1) INTRODUCTION

Lichens are being utilized as indicators of air pollution worldwide since Nylander [1] first noticed their disappearance in Paris city. Wolterbeek *et al.* [2] presented a world review of air pollution monitoring studies using lichens while Shukla and Upreti [3] and Bajpai *et. al.* [4] updated similar studies from India. The lichens show sensitivity towards low levels of pollutants such as sulphur dioxide and NOx gases. However, not all lichens are sensitive; several crustose and some foliose lichens are pollution tolerant. The pollution tolerant species have an ability to accumulate heavy metals in large amount beyond their physiological needs [5]. Such lichens have applications in biomonitoring studies. In Europe the lichen species *Lecanora conizaeoides* Nyl. is recognized as a common pollution tolerant species for air pollution studies, whereas in tropical Asia *Pyxine cocoes* (Sw.) Nyl. turned out to be effective pollution accumulator and monitors [6]. *P. cocoes* is a foliose lichen belonging to family Physciaceae with corticolous or saxicolous habitat and has a broad distributional range up to foot hills of Himalaya. In India Mishra *et al.* [7] and Bajpai *et. al* [8] for the first time utilized *P. cocoes* to estimate the heavy metal contents in commercial, industrial and residential areas of Lucknow city with transplant technique. Bajpai *et al.* [9,10] studied the physiological effect of arsenate and Cr in transplanted thalli of *P. cocoes* through periodic exposure to gradual increased concentration of pollutants. In our earlier studies it is observed that naturally occurring thallus of *P. cocoes* growing close to the Feroz Gandhi Unchahar National Thermal Power Plant accumulated high amount of heavy metals in comparison to the distant ones [11]. The lichen *P. cocoes* also exhibited its ability to accumulate arsenic and fluoride [12]. Similarly, naturally growing *P. cocoes* accumulated high amount of heavy metals (Al, As, Cu, Fe and Zn) in polluted sites of Sitapur district of Uttar Pradesh [13]. It is also observed that the heavy metals significantly altered the photosynthesis of lichen by chlorophyll degradation and other physiology process [11, 12, 13]. In another study carried out in Chinsura, a highly arsenic contaminated area of West Bengal *P. cocoes* samples collected from road side accumulated significant amount of Al, Cr, Fe, Pb, Zn, Cd and Cu, while samples near paddy field accumulated high concentration (48.1±2.1 µg g^{-1}) of As [14]. Keeping in view of potential of lichen *P. cocoes* and advantage of lichen transplant technique air quality of Kolkata city is analyzed in the present study.

Kolkata is the capital city of West Bengal situated at latitude of 22° 32" N long. 88° 20" E lat. Kolkata is one of the most populated, polluted and fast growing metropolitan cities of India. Increased urbanization, industrialization and heavy vehicular traffic activity have resulted in deterioration of air quality in the city. Upreti *et al.* [15] noticed that lichen biota of Indian Botanic Garden, Howrah has drastically changed in 140 years with replacement of sensitive species with tolerant ones. In Kolkata city one of the prominent lichen species *Parmelia caperata* (L.) Ach. (now *Flavoparmelia caperata*

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(L.) Hale) recorded by Das *et al.* [16] is thought to be extinct due to air pollution [17]. However, Majumder *et al.* [18] recollected this species from surroundings of Kolkata city and carried out metal accumulation and physiological studies. This study indicates that *F. caperata* is a pollution tolerant species. In Kolkata city has few pollution tolerant species dominated mostly by crustose forms. The pollution tolerant foliose species *F. caperata* and *P. cocoes* are scarce and not uniformly distributed in Kolkata city. Therefore the major objective of the current study is to study the level of air pollution in different part of the Kolkata city using *P. cocoes* and transplant technique.

2) MATERIALS AND METHODS

The samples of *Pyxine cocoes* growing on trunks of mango trees (*Mangifera indica*) in Malihabad area of Lucknow were collected along with the bark. The samples were fixed on a 20×20 cm card board with glue and transplanted at 10 biomonitoring sites of Kolkata City (**Table 1, Figure 1**) at a height of 1 to 3 m from ground level. Part of collected samples were preserved in pollution free environment of the laboratory and utilized as control. The biomonitoring sites are distributed in city centre (Inner zone) and little outskirts areas (Outer zone). After 30 days of exposure all the transplanted samples were brought to the laboratory for analysis. The lichen thalli were carefully removed from the bark using snapper blade and 100 mg of it was used for heavy metal estimation. The samples wer analyzed in triplicate for all the sites. The lichen material was digested in 5 ml HNO_3 followed by 1 ml of $HClO_4$ and placing it at 120^{o}C in digester. The temperature was further raised by 180^{o}C till the material got digested and become transparent. The digest aliquot was filtered through

Table 1. Biomonitoring sites of *P. cocoes* transplantation in Kolkata

S.No.	Locality	Site description
Inner zone		
1	**BBD Bagh**, BSNL Head Quarter Campus	15-meters away from main road, Garden area, narrow roads with heavy, slow moving traffic
2	**Esplanade**, Chowrangi Lane, above KC Das sweet house	5 meters away from road crossing, heavy, slow moving traffic
3	**Howrah Bridge**	5 meter away from road, narrow streets, high vehicular activity, slow moving traffic
4	**Shyam Bazaar**, 5 point circle	5 meter away from road, market area, narrow crowded street, high vehicular activity, slow moving traffic
5	**Gariahat**, crossing facing main road	15 meter away from road, market area, near bus and taxi stand, narrow crowded streets, high vehicular activity, slow moving traffic
6	**Park Circus**, main road	10 meter away from 8 roads crossing open wide roads, moderately fast moving traffic
7	**Ras Bihari Avenue**, Shyam Prasad Mukherjee crossing	Inner circle of city, 10 meter away from crossing, moderately wide roads, fast moving traffic
8	**Jadabpur**, 8-B bus stand	15 meter away from main road, narrow crowded streets, heavy traffic activities, slow moving traffic
Outer zone		
9	**Dum Dum Airport**, Chiria More, B.T. Road	Outer circle of city, 15 meter away from highway, 25 trams per minute, wide roads, open area, traffic
10	**Salt Lake**	15 meter away from main road, open areas, wide road, traffic moves fast

Table 2. Metal Content μg g^{-1} in lichens of Kolkata City

Locality	Heavy metal						
	Zn	**Fe**	**Cu**	**Cd**	**Cr**	**Pb**	**Ni**
Inner zone							
BBD Bagh	49.2±0.8	2958.2±0.9	15.6±0.7	ND	3.3±0.3	ND	81.3±0.8
Esplanade	114.0±0.5	4020.5±0.8	38.7±0.6	ND	3.6±0.4	ND	66.0±0.3
Howrah Bridge	75.0±0.4	3330.7±0.5	3.4±0.3	ND	10.8±0.5	ND	34.8±0.8
Shyam Bazaar	81.3±0.2	2925.8±0.7	7.8±0.5	ND	10.8±0.3	ND	34.8±0.3
Giriahat	55.8±0.4	3030.2±0.8	16.8±0.3	ND	10.8±0.2	ND	62.4±0.4
Park Circus	80.7±0.3	3060.3±0.5	4.5±0.2	ND	3.6±0.5	ND	66.0±0.2
Ras Bihari Avenue	55.5±0.3	4530.1±0.6	7.8±0.3	ND	13.5±0.3	ND	54.9±0.3
Jadabpur	84.0±0.3	4690.4±0.7	22.8±0.2	ND	15.9±0.2	ND	66.9±0.4
Outer zone							
Dum Dum Airport	47.1±0.6	4020.0±0.9	3.6±0.3	ND	5.1±0.3	ND	31.2±0.3
Salt Lake	72.3±0.5	4080.5±0.8	6.3±0.5	ND	10.5±0.3	ND	39.6±0.2
Control, Lucknow	25.2±0.2	3030.2±0.9	11.7±0.7	ND	1.2±0.2	ND	12.9±0.2

ND = not detected

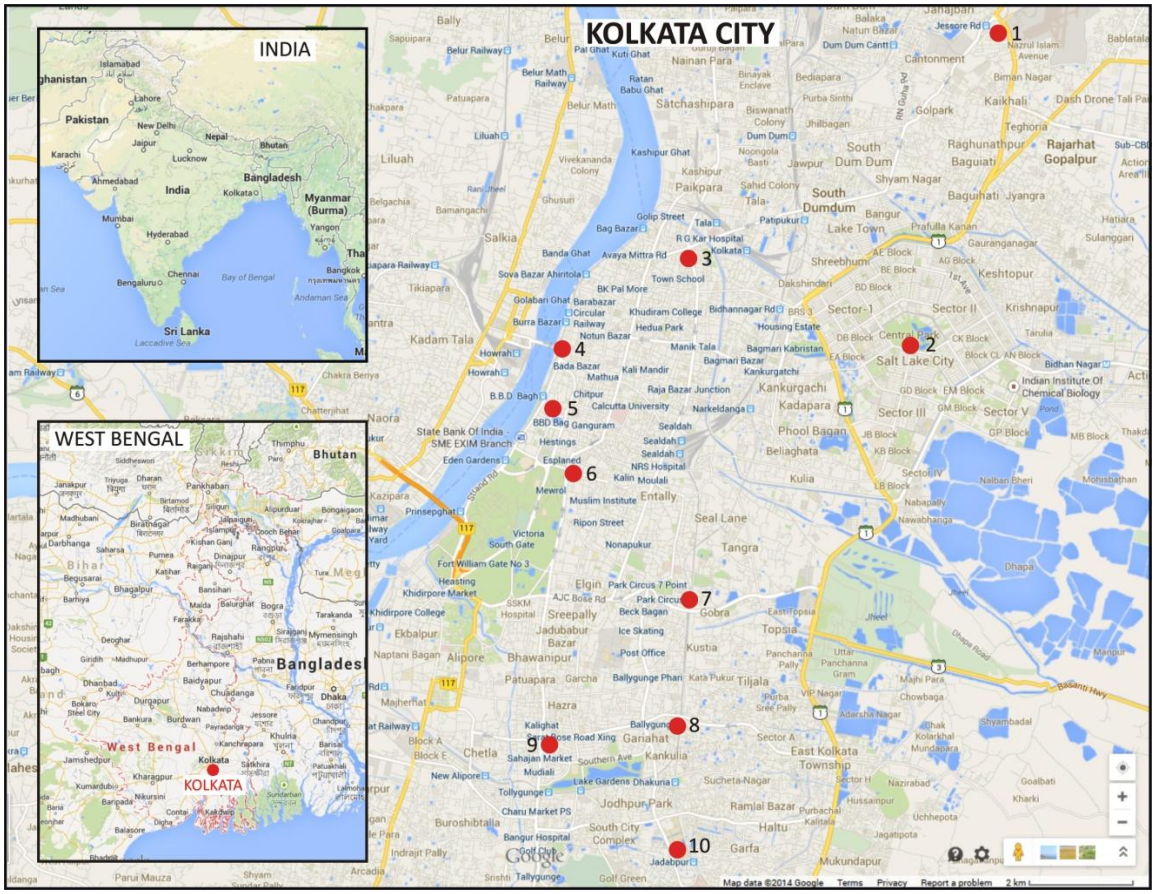

Figure 1. Map showing biomonitoring sites in Kolkata City. 1. Dum Dum Airport 2. Salt Lake, 3. Shyam Bazaar, 4. Howrah Bridge, 5. BBD Bagh, 6. Esplanade, 7. Park Circus, 8. Gariahat, 9. Ras Bihari Avenue, and 10. Jadabpur.

Whatman filter paper no.1. and the filtrate was diluted to desired volume 30 ml with double distilled water. The concentrations of the heavy metals (Zn, Fe, Cu, Cd, Cr. Pb, Ni) in the solution were determined by Perkin Elmer Atomic Absorption Spectrophotometer.

3) RESULTS

The accumulation of heavy metals in transplanted *P. cocoes* samples are presented in **Table 2** and their concentration ranged from 3.3±0.3 to 4690.4±0.7 µg g^{-1}. Most of the transplanted samples exhibited enhanced levels of metal accumulation than the control one. Two metals Cd and Pb were not detected in the samples, while Cr accumulated in lower (3.3±0.3 to 15.9±0.2 µg g^{-1}) and Fe in higher concentrations (2958.2±0.9 to 4690.4±0.7 µg g^{-1}). The concentration of Zn ranged from 47.1±0.6 to 114.0±0.5 µg g-1, Cu 3.4±0.3 to 38.7±0.6 µg g^{-1} and Ni 31.2±0.3 to 81.3±0.8 µg g^{-1}. Accordingly the heavy metal accumulation potential of transplanted lichen *P. cocoes* in Kolkata city followed the sequence of Fe > Ni > Zn > Cu > Cr > Cd ≥ Pb. The mean concentration of metals did not vary considerably between samples transplanted in outer zone and within inner zone, which indicates wide spread pollution effect in the area. It can be noted that except for the site BBD Bagh, all the samples transplanted at the inner zone of the city accumulated all the heavy metals in higher quantity in comparison to those of outer zone. Accordingly, it can be concluded that Jadabpur and Esplanade area are highly polluted, while BBD Bagh and Dum Dum Airport areas are least polluted.

4) DISCUSSION

It is observed that the outer zone of the Kolkata city (Dum Dum and Salt Lake) has much open areas and broader roads as highway. Whereas the inner zone of the city (Park Circus, Gariahat, Ras Behari Avenue, Jadabpur, Howrah, Esplande, BBD Bagh and Shyambazar) is congested, has narrow roads and more vehicular movements. Therefore the inner zone experiences more emission by vehicles as the traffic moves slow with frequent halting at 'signals'. Apart from the automobiles Kolkata city also has a number of other sources of air pollution including large and small scale industries of rubber, dyeing, bleaching, plywood, pharmaceutical and paper-board manufacturing units. Earlier coal fired boilers were used to produce steam for the operation of press vulcanizer, heating and drying but now they are replaced by oil boilers or thermic fluid heater.

The concentration of different heavy metals in *P. cocoes* can be attributed to their specific origin. The reason for high Cr concentration in the inner zone of the city may be due to fact that the area has a number of industrial units together with higher traffic activity and narrow streets. The Cr concentration was lowest in sites situated on the boundary of the city having wide open area. In all the ten biomonitoring sites the transplanted lichen exhibited exceptionally high concentration of Fe than the other metals. It has been learnt in earlier studies that lichens have special affinity for Fe [19]. The laboratory experiments have shown the great efficiency with which Fe is bound to lichens. The levels of Fe are more or less similar in both inner and outer zones of the Kolkata city. In case of Zn

the automobile tyres and industries are the major source in urban area [20. 21]. According to Ward and Brooks [22] lubricating oils and brake pads also produce Zn. In the present study except the sample at Esplande (114±0.5 µg g^{-1}) almost all the sites exhibited more or less similar concentration of Zn between 47.1 to 84.0 µg g^{-1}. The exceptionally high concentration of Zn at Esplande may be due to the fact that the samples were transplanted near the road, facing a four side road crossing and at the vertical height of 1 m, where the vehicular activity was high and the traffic moves very slowly. The presence of Cu in the samples may be due to the vehicular activity as it is present in fuel as particulate matter. Cu content exhibit a more or less similar level in both zones of the city. The sample at Jadabpur bus stand site has the maximum concentration of Cu (22.8±0.2 µg g^{-1}) as the area experienced heavy traffic activity. The main anthropogenic emission of Ni to the atmosphere is coal and oil combustion [23]. Also the rubber dyeing, bleaching and chemical industries are the major source of atmospheric Ni in Kolkata city. Therefore most of the transplanted lichen exhibit presence of Ni in them. The sample at BBD Bagh site showed significant accumulation of Ni (81.3±0.8 µgg^{-1}) as it is transplanted near the bus terminal and taxi stand with narrow, congested streets and higher traffic activity where traffic moves very slowly.

It is interesting to note that the Pb and Cd were not detected in the transplanted samples. The short term transplantation is probably the reason for the absence of Pb and Cd in the samples. Also usage of unleaded petrol in vehicles in recent times may also be a reason for absence of Pb in atmosphere and transplanted lichens. The site BBD Bagh though, located in inner zone of the city with narrow roads and heavy vehicular movements the lichen accumulated lesser concentrations of heavy metals, which may be due to presence of more number of tree in gardens of that area acting as sink and reducing the load of pollution.

5) CONCLUSION

The heavy metal accumulation in transplanted *P. cocoes* clearly indicates high level of pollution in Kolkata city. Undoubtedly such a level of pollution is responsible for disappearance of sensitive lichen species as discussed earlier. The effect can be extrapolated to other living organism in the city. The increased level pollution is also health hazardous that can range from nausea and difficulty in breathing or skin irritation, to cancer. The problem also includes birth defects, serious developmental delays in children, and reduced activity of the immune system, leading to a number of diseases. However, studies indicate that primarily affected systems are the cardiovascular and the respiratory system [24]. Therefore, it has become necessary to check the air pollution in the city by rigorous regulatory action by the state government. In the present study lichen *P. cocoes* also proves to be successful model for air pollution studies. The lichen transplant technique serves as cheap and cost effective method for air pollution monitoring. The technique is more useful in places where naturally growing suitable biomonitoring species are absent. Such studies have to be implemented in other cities of India.

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