Analysis of Heavy Metals Concentration in Soil and Lichens from Various Localities of Hosur Road, Bangalore, India

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Abstract: Assessment of heavy metal content in lichens and soil samples from various localities of Hosur Road, Bangalore south was undertaken. Topsoil samples (0-10 cm) were taken at various locations, the metals analysed were Cr, Pb, Fe, Zn, Ni and Cu. The geoaccumulation index of these metals in the soils under study residential areas indicated that they are uncontaminated with Ni, Zn, and Fe and moderately contaminated with Cr and Pb. In Industrial areas and traffic junctions the concentration of Fe, Pb and Ni was maximum. Heavy metal accumulation in few prominent lichens of some localities was analysed. Cr and Pb were maximum in *Chrysothrix candelaris* (L.) Laundon, at the gardens of Madiwala and Silk Board junction with 95.29 and 623.95 $\mu\text{g g}^{-1}$ dry weight respectively. Fe and Cu were maximum in *Bulbothrix isidiza* (Nyl.). Hale and *Pyxine petricola* Nyl at Central Prison campus and Kendriya Sadan campus with 22721 and 338.12 $\mu\text{g g}^{-1}$ dry weight respectively, *Lecanora perplexa* Brodo at Infos and Wipro Campus, electronic city have 531.5 and 634 $\mu\text{g g}^{-1}$ dry weight of Zn. While Ni and Fe were maximum in Arthopyreniaceae at Shanti Niketan of MICO Limited with 1100 and 23200 $\mu\text{g g}^{-1}$ dry weight respectively.

Keywords: Heavy metals, Soils, Lichen species, Hosur road, Bangalore south.

Introduction

Bangalore, a fast growing metropolis, the garden city is the capital of the Southern Indian State of Karnataka situated at about 1000 meters above sea level, it is known for its

salubrious climate where temperatures remain moderate through out the year. The maximum temperature in July is around 32⁰C and the minimum around 22⁰C. It is connected by air, rail and road to all major cities of the country and has direct international connections to many cities worldwide. Hosur Road is the part of National Highway which connects the city of Bangalore and the Tamil Nadu border town of Hosur. It is a four-lane highway which also has service lanes on either side at the busier parts. Apart from being a part of the National Highway, the road is also significant because it houses many industrial and IT business houses. The famous IT industrial park Electronics City is also located in Hosur Road. Owing to the large number of offices and its use as major truck route, the road is chocked during most part of the day. In recent years, the main highway connecting Electronics City with Bangalore has seen a large increase in vehicular traffic, causing traffic jams at several road junctions. Currently, major infrastructure improvements are taking place including widening of the road and the building of a 9 kilometer elevated highway. It promises to reduce and redistribute the traffic for a smoother flow. The highway, Hosur road also has some buildings of some major IT players like BOSCH, Sasken, Convergys *etc.*, along with showrooms of major auto manufacturers like Toyota *etc.* Air pollution in Bangalore city is undoubtedly the exhaust emission from vehicular traffic¹. Inadequate public transport system has led to an increase in the use of personalized vehicles, Congested traffic, poor road conditions and outdated automotive technology add to the increase in vehicular emissions. Large quantities of pollutants have continuously been introduced into ecosystems as a consequence of urbanization and industrial processes. Metals are persistent pollutants that can be biomagnified in the food chains, becoming increasingly dangerous to human and wildlife. This has led to the development of monitoring schemes aimed at directly measuring levels of contaminants in various organisms, and biomonitoring schemes that use indicator species to estimate the levels in other parts of the ecosystem². Therefore, assessing pollutants in different components of the ecosystem has become an important task in preventing risk to natural life and public health. Heavy metals enter into the environment mainly via three routes: (i) deposition of atmospheric particulate, (ii) disposal of metal enriched sewage sludges and sewage effluents and (iii) by-products from metal mining process. Soil is one of the repositories for anthropogenic wastes. Biochemical processes can mobilize them to pollute water supplies and impact food chains. Trace heavy metal contamination in the soils is a major concern because of their toxicity and threat to human life and the environment³. Heavy metals such as Cu, Cr, Cd, Ni, and Pb are potential soil and water pollutants. Heavy metals studies have been conducted in soils with differing levels of anthropogenic influences such as in highly populated and industrialized cities. Most heavy metal concentration in urban cities has insufficient drainage system leading to contamination of immediate surroundings and the ground water with trace heavy metals. Heavy metal studies are necessary to evaluate both soil/sediment and groundwater contamination. Also most of the municipal water supplies come from boreholes, most of which are shallow wells. Urban food security in India is a matter of growing concern. The problem of environmental pollution due to toxic metals has begun to cause concern now in most major metropolitan cities. The toxic heavy metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnifications. Heavy metals like Fe, Cu, Zn, Ni and other trace elements are important for proper functioning of biological systems and their deficiency or excess could lead to a number of disorders. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and air⁴.

Lichens are a group of symbiotic organisms exploiting variety of habitats throughout the world. Lichens have long been recognized as sensitive indicators of environmental conditions. Lichens show their sensitivity to air pollution in various ways such as decline in diversity, absence of sensitive species, and morphological, anatomical and physiological

changes. They are also proved to be good accumulators of many elements, particularly heavy metals. Various heavy metals such as Pb, Zn, Ni, Cu, Hg and Cr, considered as toxic for many other living organisms. The purpose of the present study is to provide information regarding lichen flora of certain localities of Hosur Road. Together with the accumulation of six heavy metals in some commonly growing lichen species of the area. The major cause is the emission from industrial establishment, traffic snarls, biodegradation and uncontrolled burning of garbage accumulated in dumping yards contribute to urban air pollution. The impact of pollution in the vicinity of overcrowded cities and from industrial effluents and automobile exhausts has reached a disturbing magnitude and is arousing public awareness^{7,8}.

Data collection and analysis

15 Soil samples (three replicates) were collected at surface level (0–10 cm in depth) were collected from various locations to cover industrial, commercial and residential areas. The collected soil samples were air-dried and sieved into coarse and fine fractions. Well-mixed samples of 2 g each were taken in 250 mL glass beakers and digested with 8 mL of aqua regia on a sand bath for 2 hours⁵. After evaporation to near dryness, the samples were dissolved with 10 mL of 2% nitric acid, filtered and then diluted to 50 mL with distilled water. Heavy metal concentrations of each fraction was analysed by Atomic Absorption Spectrophotometry using GBC Avanta version 1.31 by flame Atomization⁶. Quality assurance was guaranteed through double determinations and use of blanks for correction of background and other sources of error. EC of the soil samples were determined from saturation extract by conductivity meter. Measurement of pH of the water and soil samples were done (soil and water ratio 1:25) were done with help of a glass electrode pH meter^{5,6}.

Lichens from all the available tree species were collected from 15 localities in Hosur Road (Table 1) during September and October 2007. The lichens were carefully removed from the bark snapper blade and were oven-dried to a constant weight^{7,8} at 80°C. The dried lichen samples (three replicates) were then powdered (0.5 g) for further metal analysis. Lichen samples were extracted and analysed with (aqua regia) a mixture of concentrated HCl and HNO₃ (3:1) and digested to 80°C, few drops of perchloric acid is added. The mixture was filtered through Whatman filter paper No. 42. The filtrate was diluted to the desired volume with deionised water. The total concentrations of Cr, Pb, Fe, Zn, Ni and Cu in the filtrate were determined by atomic adsorption spectrometer. Different concentrations of the air-dried Soil Samples dissolved in distilled water were analyzed for pH, alkalinity, CO₂ and dissolved oxygen.

Results and Discussion

The heavy metal analysis of (Table 2) various species of lichens collected, analysed and identified (Botonically from the department of Botony SJR Women's Degree College Rajajinagar, Bangalore.) in the 12 localities of Hosur Road is reported. Cr concentration ranged between 2.50-95.29 µg g⁻¹ dry weights of lichens species. Maximum concentration was in Chennakeshavanagar Main Road 95.29 Bomannahalli traffic junction 34.57 Begur Road 36.43 µg g⁻¹ dry weight. Pb concentration ranged between 31.92-623.95 µg g⁻¹ dry weight of lichens species. Maximum concentration was in Bomannahalli traffic junction 623.95. Mangamanapalya Road 484.69 and Agara Lake 203.10 µg g⁻¹ dry weight. Fe concentration ranged between 55.47-9795 µg g⁻¹ dry weights of lichens species. Maximum concentration was in Madiwala Market 9795 µg g⁻¹ dry weight. Chennakeshavanagar Main 9202 µg g⁻¹ dry weight Zn concentration ranged between 79.86-831.01 µg g⁻¹ dry weights of

litchens species. Maximum concentration was in Begur Road 831.01 $\mu\text{g g}^{-1}$ dry weight, Bomannahalli traffic junction 553.92 $\mu\text{g g}^{-1}$ dry weight. Agara Lake 384.55 $\mu\text{g g}^{-1}$ dry weight. Cu concentration ranged between 5.02-338.12 $\mu\text{g g}^{-1}$ dry weights of litchens species. Maximum concentration was in Shanthi Niketan gardens MICO Naganathapura plant 338.12 $\mu\text{g g}^{-1}$ dry weight, Bomannahalli traffic junction 158.32 $\mu\text{g g}^{-1}$ dry weight. Chennakeshavanagar Main Road 115.19 $\mu\text{g g}^{-1}$ dry weight. Ni concentration ranged between 343-1409.34 $\mu\text{g g}^{-1}$ dry weights of litchens species. Maximum concentration was in Shanthi Niketan gardens MICO Naganathapura plant 1409.34, Central prison Road 843.10 and Chennakeshavanagar Main Road 800.7 $\mu\text{g g}^{-1}$ dry weight. Respectively (Table 2) It is observed that maximum heavy metal pollution near the industrial, traffic junction where traffic jams and the legendary 'go-slow' of automobiles is the order of the day and in localities of large population concentration and relatively small areas under poor conditions of sanitation¹⁰⁻¹².

Table 1. Some physicochemical parameters of the soil samples.

Sample Stations	pH	EC ds/cm	Dissolved Oxygen mg/L	Carbon dioxide mg/L	Alkalinity mg/L
Kendriya Sadan Koramangala	7.46	7.56	7.36	5.62	19.36
Agara Lake	6.20	4.88	7.60	5.79	19.22
Madiwala Market	7.30	7.05	6.60	5.86	19.18
Ayappa Swamy Temple Road	6.67	5.75	6.78	5.32	19.45
Madiwala Police Station Junction	7.55	29.74	6.99	5.60	19.45
Bomannahalli Ttraffic Junction	6.25	22.23	7.27	5.01	19.33
Begur Road	6.55	28.90	5.29	5.01	17.43
Mangamanapalya Road	6.55	10.83	5.36	5.62	19.55
B.D.A Complex H.S.R Layout	7.94	5.80	7.12	5.88	19.21
Chennakeshavanagar Main Road	7.48	9.66	7.12	5.79	19.78
Shanthi Niketan gardens MICO	7.30	7.05	7.386	5.81	19.24
Central prison Road	7.54	4.85	7.56	5.62	19.56
Infosys garden Electronic City	7.65	7.65	6.68	5.62	19.43
Wipro Garden Electronic City	7.35	5.75	6.68	5.45	17.68
Electronic city Phase 1 Junction.	6.89	9.37	6.79	5.34	17.48

Figure 1. Study stations of Hosur Road

Figure 2. Heavy metal concentration $\mu\text{g g}^{-1}$ dry weight in lichens species at various localities* in Hosur Road.

*(Kendriya Sadan Koramangala, Agara Lake , Madiwala Market , Madiwala Market , Ayappa Swamy Temple Road, Madiwala Police Station Junction, Bomannahalli Junction Begur Road , Mangamanapalya Road, B.D.A Complex H.S.R Layout, Chennakeshavanagar Main Road, Shanthi Niketan gardens MICO Naganathapura plant, Central prison Road , Infosys garden Electronic City , wipro Garden Electronic City, Electronic city Phase 1 Junction.)

Figure 3. Heavy metal concentration $\mu\text{g g}^{-1}$ dry weight in soils of Hosur Road, Bangalore south.

Table 2. Lichen species found in various localities of Hosur Road, Bangalore south.

S. No.	Lichen Species	Growth form	Stations
1	<i>C. candelaris</i> (L.) Laundon	C	Kendriya Sadan Koramangala
	<i>L. perplexa</i> Brodo	F	
	<i>D. aegialita</i> (Afz. in Ach.) Moore	C	
	<i>D. consimilis</i> (Stirton) Awasthi	F	
	<i>L. perplexa</i> Brodo	F	
2	<i>G. scripta</i> (L.) Ach.	F	Agara Lake
	<i>L. perplexa</i> Brodo	F	
	<i>D. aegialita</i> (Afz. in Ach.) Moore	C	
3	<i>leucosorodes</i> Nyl.	F	Madiwala market
4	<i>P. cocoas</i> (Swartz) Nyl.	C	Ayappa Swamy Temple Road
5	<i>D. aegialita</i> (Afz. in Ach.) Moore	C	Madiwala Police Station Junction
6	<i>L. perplexa</i> Brodo	F	Bomannahalli Junction
7	<i>P. austrosinensis</i> (Zahlbr.) Hale	C	Begur Road
8	<i>P. nanospora</i> (A. Singh) Upreti	F	Mangamanapalya Road
9	<i>C. candelaris</i> (L.) Laundon	C	B.D.A Complex H.S.R Layout
	<i>L. perplexa</i> Brodo	F	
10	<i>D. aegialita</i> (Afz. in Ach.) Moore	C	Chennakeshavanagar Main Road
	<i>L. perplexa</i> Brodo	F	
11	<i>P. petricola</i> Nyl. in Crombie	C	Shanthi Niketan gardens
	<i>L. perplexa</i> Brodo	F	MICO Naganathapura plant
	<i>D. aegialita</i> (Afz. in Ach.) Moore	C	
12	<i>C. candelaris</i> (L.) Laundon	C	Central Prison Road
13	<i>C. candelaris</i> (L.)	C	Infosys Garden Electronic City
	<i>Laundon</i>	F	
	<i>L. perplexa</i> Brodo	F	
14	<i>P. praesorediosa</i> (Nyl.) Hale	F	Wipro Garden Electronic City
	<i>L. perplexa</i> Brodo	F	
15	<i>P. concinna</i> Erichsen	C	Electronic City Phase 1 Junction.
	<i>P. petricola</i> Nyl. in Crombie	C	

C: Crustose; F: Foliose.

Table 3&4 shows the results of heavy metal analysis in soils. Metal concentrations in soils were minimum during August to October 2007 and maximum during January-March 2007. Low values may be explained due to leaching effect, and degree of flushing during heavy rains. Heavy metal concentrations were minimum in stations 1, 9, 11 (Ni concentration was maximum), 13 and 14 as these localities are well maintained with all amenities. Maximum concentration of all analysed heavy metals was observed in all traffic junction particularly in Bomanahalli traffic junction which is serious and matter of concern. Maximum heavy metal concentration was found in Agara lake and also thickly populated industrial areas like Begur Road and Mangamanapalya Road where sanitation and sewage maintenance facility is very poor.

Table 3. Heavy metal concentration / $\mu\text{g g}^{-1}$ dry weight in selected lichens species.

S. No.	Stations and Lichen Species	Cr	Pb	Fe	Zn	Cu	Ni
1	Kendriya Sadan Koramangala <i>C. candelaris</i> (L.) Laundon <i>D. consimilis</i> (Stirton) Awasthi	5.18 ND	ND 31.92	7556 7081	95.76 198.14	23.72 22.22	420.90 453.70
2	Agara Lake <i>G. scripta</i> (L.) Ach. <i>leucosorodes</i> Nyl.	35.59 3.04	203.10 149.15	863 570	384.55 79.86	10.06 5.84	600.76 460.01
3	Madiwala Market <i>P. cocoes</i> (Swartz) Nyl.	10.31	101.4	9795	224.6	19.32	600.54
4	Ayappa Swamy Temple Road <i>D. aegialita</i> (Afz. in Ach.) Moore	ND	ND	7358	322.39	16.06	720.34
5	Madiwala Police Station Junction <i>L. perplexa</i> Brodo	7.96	199.32	265	531.5	7.37	644.10
6	Bomannahalli traffic junction * <i>P. austrosinensis</i> (Zahlbr.) Hale	34.57	623.95	4530	553.92	158.32	703.12
7	Begur Road** <i>P. nanospora</i> (A. Singh) Upreti	36.43	175.9	1506	831.01	18.28	698.13
8	Mangamanapalya Road <i>C. candelaris</i> (L.) Laundon	13.79	484.69	748	103.82	19.66	650.23
9	B.D.A Complex H.S.R Layout <i>D. aegialita</i> (Afz. in Ach.) Moore	ND	46.4	6887	98.6	8.99	351.67
10	Chennakeshavanagar Main Road *** <i>P. petricola</i> Nyl. In Crombie	95.29	183.33	9202	133.05	115.19	800.73
11	Shanthi Niketan gardens MICO Naganathapura plant**** <i>P. petricola</i> Nyl. in Crombie	18.47	ND	5538	105.38	338.12	1409.34
12	Central prison Road <i>C. candelaris</i> (L.) Laundon	13.79	84.69	748	103.82	19.66	843.10
13	Infosys garden Electronic City <i>C. candelaris</i> (L.) Laundon	19.00	ND	6926	157.496	19.75	343
14	wipro Garden Electronic City <i>P. praesorediosa</i> (Nyl.) Hale	28.23	164.35	2040	126.85	15.65	390
15	Electronic city Phase 1 traffic junction. <i>P. concinna</i> Erichsen	2.50	ND	55.47	351.68	5.02	690.01

Table 4. Heavy metal concentrations / $\mu\text{g g}^{-1}$ dry weight in soils of Hosur Road, Bangalore South.

Stations	Name of the Sample locations in Hosur Road	Cr		Pb		Fe		Zn		Cu		Ni	
		Jan-March	Sept-Nov	Jan-March	Sept-Nov	Jan-March	Sept-Nov	Jan-March	Sept-Nov	Jan-March	Sept-Nov	Jan-March	Sept-Nov
1	Kendriya Sadan Koramangala	ND	ND	ND	ND	748	235	49.34	24.34	17.34	9.43	420.90	350
2	Agara Lake	88.56	56.33	234.56	146.35	7242	6899	235.16	163.78	42.17	23.49	453.70	345.67
3	Madiwala Market	54.34	49.43	226.43	178.23	4533	3456	435.34	345.15	13.54	9.45	600.76	454.25
4	Ayappa Swamy Temple Road	52.23	44.67	124.34	56.43	2530	1229	234.19	167.44	12.30	10.34	460.01	346.60
5	Madiwala Police Station Junction	66.31	49.45	127.41	98.24	12400	6784	275.14	201.54	134.28	98.34	600.54	543.50
6	Bomannahalli traffic junction	145.45	79.45	298.34	94.24	11400	7432	423.66	198.57	25.43	20.66	720.34	600
7	Begur Road	123.67	65.87	279.54	200.46	976	654	435.15	345.44	11.37	9.23	644.10	544.65
8	Mangamanapalya Road	56.62	50.23	623.95	423.87	4630	3324	534.19	450.23	162.85	98.43	703.12	573.25
9	B.D.A Complex H.S.R Layout	ND	ND	134.52	56.23	576	560	111.23	78.45	15.67	13.34	698.13	432.34
10	Chennakeshavanagar Main Road	72.56	56.71	484.69	305.60	16234	12965	234.51	164.23	23.45	12.46	650.23	540.28
11	Shanthi Niketan Gardens MICO Naganathapura plant	ND	ND	41.39	23.56	4847	3671	59.34	44.11	198.23	145.34	1409.34	663.50
12	Central Prison Road	33.34	13.63	183.33	126.73	6820	4569	156.56	68.65	115.19	67.45	800.73	604.51
13	Infosys garden Electronic City	67.45	47.98	ND	ND	4984	3421	93.23	58.26	5.34	1.29	351.67	20.45
14	wipro Garden Electronic City	58.89	43.21	ND	ND	655	355	127.12	59.23	6.89	3.46	843.10	450.00
15	Electronic city Phase 1 Junction.	134.67	79.45	345.56	244.63	7234	6234	393.28	198.58	22.51	18.45	343	20.45

Conclusions

Monitoring of heavy metals through lichen species provides efficient way to assess the qualitative and quantitative differences in metal concentrations at distinct locations and on local and landscape scales. Under the present ecological conditions the heavy metal load is significant in Hosur Road, Bangalore.

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