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Bioaccumulation of Lead Content in Mushroom and Soil in Delhi-NCR Region of India

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Abstract: *In this study, bioaccumulation of lead in wildly growing edible mushroom and its underlying soil near the industrial drainage and heavy traffic area was investigated during monsoon. These accumulations were compared with the cultivated and remote residential area. Commercial samples were also collected during monsoon. Four different varieties of mushroom Button mushroom (Agaricusbisporus), Oyster mushroom (Pleurotussajor-caju), Milky mushroom (Calocybeindica)and Shiitake (Lentinusedodes) along with and its top soil samples were collected and the levels of Pb was analyzed using Flame Atomic Absorption Spectrometry. From the two way ANOVA, it was found there was significant variation in Lead concentrations at different locations and from correlation analysis Lead concentration in soil and mushroom samples were positively correlated.*

Keywords: *Lead, Bioaccumulation, Heavy Metals, Mushroom, Soil, Flame Atomic Absorption Spectrometry*

1. INTRODUCTION

The accumulation of trace metals in agricultural soils disposal, waste incineration, urban effluent, traffic is of increasing concern due to the food safety issues and potential health risks as well as its detrimental effects on soil ecosystems. Heavy metals are considered to be one of the main sources of pollution in the environment, since they have a significant effect on its ecological quality. Human activity leads to increasing levels of heavy metal contamination in the environment [1]. Heavy metals owing to atmospheric and industrial pollution accumulate in the soil and influence the ecosystem nearby [2]. The determination of heavy metal in soils is very important in monitoring environmental pollution [3]**.** Lead has no beneficial role in human metabolism, producing progressive toxicity.

2. MATERIALS AND METHODS

2.1. Sample Collection

Samples of soils and four different species of wildly growing edible mushrooms: Button mushroom (*V1*), Oyster mushroom (*V2*), Milky mushroom *(V3)* and Shiitake (*V4*) were collected from North Delhi Border and Sonepat region, India during monsoon. The area studied was divided into area of industrial activity (L1), road side area (L2) with heavy vehicular traffic on NH-1 national highway and state highway criss crossing NH1 and connecting Sonepat and UP, residential area as (L3), Commercial samples named (L4) were collected from APMC Market Azadpur Delhi and Cultivated samples (L5) taken from HAIC, Murthal, Sonepat . Soil samples were taken at measurement points at a depth of approximately 0-15cm. The samples were dried at 105^0 C and ground to pass through 200 mesh sieve and transferred to polyethylene bottles until analysis. Mushroom samples were not washed and they were dried as such at 105^0 C for 24h. The dried samples were ground, then homogenized using an agate pestle and stored in polyethylene bottles until analysis. Sub samples were analyzed for moisture content at 103^0 C using tray dehydrator.

2.2. Sample Preparation

For soil analysis one gram of dried soil sample was taken in a 100ml conical flask with 10ml of concentrated nitric acid and kept overnight. The flask was placed on a hot plate inside a fume hood for digestion, heated at a temperature of 70^0 C for 1h, and then kept it for cooling for 30min and 5ml of aquaregia, a mixture of conc. nitric acid (HNO_3) and perchloric acid ($HClO_4$) (AR 70%, Merck) in a ratio of 4:1, was added and again the flask was placed on hot plate, heated at a temperature of 80^oC for 2h. After that it was cooled for 1h and transferred to 50ml volumetric flask through filtration (Whatmann 42) and the final volume was made up to the mark with double distilled water, mixed well by shaking, and let settle for at 15h. The resultant supernatant was analyzed. For mushroom analysis, 1g of ground-dried mushroom sample was placed in a small beaker.10 ml of concentrated HNO_3 was added & allowed it to stand overnight. It was heated on a hot plate carefully until the production of red NO_2 fumes has been ceased and then kept for cooling and a small amount (2-4ml) of 70% $HClO_4$ was added. Heated again and allowed to operate a small volume. Transferred the sample to a 50ml flask and diluted to volume with double distilled water. Then the quantification of metallic content of digested samples was carried out with the FAAS.

2.3. Analytical Method of Soil and Mushroom

Lead in samples was analyzed using Flame Atomic Absorption Spectrophotometer (Perkin-Elmer, ANALYST 100) equipped with flame and graphite furnace. Air-acetylene flame was used for determination of metal content. Statistical methods like **two way ANOVA and Correlation analysis** were used to determine the lead accumulation in wildly growing edible mushroom and its underlying soil.

3. RESULTS AND DISCUSSION

3.1. Concentration of Lead in Mushroom Samples

Results showed that location had significant variation in lead concentration in mushroom. Highest mean lead concentration was recorded in industrial drainage i.e. 9.71mg/kg dw in the first year and 10.38 mg/kg dw in the second year as shown in table 1 and table 2 while minimum mean lead concentration was found in the cultivated samples i.e. 0.89 mg/kg dw and 0.9 mg/kg dw in the first year and second year respectively as shown in table 1 and table 2. In both the year industrial drainage area recorded the highest mean lead accumulation followed by roadside area, commercial area and remote residential area. All these samples except cultivated samples were above the safe limits of most stringent **PFA/FSSA** maximum allowed concentration i.e. 1.0 mg/ kg of dry matter [4]. Significant differences ($p<0.01$) was there in samples collected from different locations. Mean concentration of remote residential area and cultivated area was lower than Czech (10mg/kg dry matter) safe and EU (2mg/kg dry matter) permissible limit for lead whereas maximum concentration was above the limits [5]**.**Though lead bioaccumulation was highest in case of Button mushroom but at some locations mean differences in lead concentrations among different varieties was not statistically significant ($P>0.05$). Lead contents of mushroom samples in the literature have been reported to be in the ranges: 0.40–2.80 mg/kg[6], 1.43–4.17 mg/kg[7], 0.1- 27.5mg/kg[8], 0.9–2.6 mg/kg[9]and 0.67 to 12.9 mg/kg[10]. Mushrooms accumulate remarkably high concentrations of lead, especially in the vicinity of industrial drainage and highways. Our results agree with the data of other authors and within the literature values.

When compared in different species, highest lead accumulation was in Button mushroom (*V1*). Similar observation had earlier been reported by Falandysz[11] and Yilmaz[12]. Another consideration from the view health risk, from mushroom consumption is the FAO/WHO provisional tolerable weekly intake. There is limit of 25 microgram per kg of bodyweight for lead[13]. For intake calculations, usually a 300 g portion of fresh mushrooms per meal is assumed, which contains 30 g of dry matter. A tolerable weekly intake for a person with a bodyweight of 60 kg is thus reached by a single portion of 300 g of fresh mushrooms containing 50 mg/kg dry matter of lead. Current Czech statutory limit for the lead content in wild-growing

edible mushrooms is 10.0 mg/ kg dry matter. In the EU, the limit is 3.0 mg/ kg dry matter lead is valid for cultivated mushroom 14**(EEC Directive 2001/22/EC).** Lead concentrations in our cultivated samples were below these values. However, the mushrooms are not the only source of dietary heavy metals, and moreover, wild-growing mushrooms are usually consumed repeatedly during the relatively short growing periods.

Table 1. *Mean Lead Concentration (mg/kg dw) in different varieties of mushroom in the year 2009*

	Agaricus bisporus	*Pleurotus sajor caju*	*Vovraiella vovacea*	*Lentinula edodes*	Mean
Industrial Drainage Area (L1)	13.88	6.31	8.53	10.12	9.71
Roadside Area (L2)	5.20	6.17	7.09	6.21	6.17
Remote Residential Area (L3)	1.89	1.26	1.73	1.13	1.50
Commercial Area (L4)	7.55	6.73	3.40	3.60	5.32
Cultivated Area (L5)	0.79	0.72	1.16	0.00	0.89
Mean	5.86	4.24	4.38	5.26	
		Location	Species	Location x Species	
	S.E.(m)A	0.40	0.35	0.79	
	LSD (0.05 P)	1.11	0.99	2.22	

Table 2. *Mean Lead Concentration (mg/kg dw) in different varieties of mushroom in the year 2010*

	Agaricus bisporus	*Pleurotus sajor caju*	*Vovraiella vovacea*	*Lentinula edodes*	Mean
Industrial Drainage Area (L1)	13.92	6.18	9.88	11.53	10.38
Roadside Area (L2)	5.68	5.83	4.99	5.18	5.42
Remote Residential Area (L3)	1.93	1.24	1.76	1.13	1.52
Commercial Area (L4)	7.31	5.96	3.52	3.59	5.10
Cultivated Area (L5)	0.82	0.72	1.17	0.00	0.90
Mean	5.93	3.99	4.26	5.36	
		Location	Species	Location x Species	
	S.E.(m)A	0.26	0.24	0.53	
	LSD (0.05 P)	0.74	0.66	1.48	

3.2. Concentration of Lead in Soil Samples

Location had significant variation in lead concentration in soil as shown in table 3 and 4. Highest mean lead concentration was recorded in industrial drainage soil i.e. 11.89 mg/kg dw and 13.27 mg/kg dw while minimum in the samples collected from HAIC (cultivated samples) i.e. 1.72 mg/kg dw and 1.89 mg/kg dw in the first year and second year respectively. All these samples were found below 50 mg/kg set by VBBo [14] and was lower than EU upper limit of 300 mg/kg [15]**.**The Pb obtained in the present study substantially not exceeds reported background values of 25 mg/kg Pb in most of the soil samples [16] **(Canadian Environmental Quality, 1992).**Result showed that soil samples of different mushroom varieties had significant variation ($P<0.01$) in lead concentration. Maximum mean lead concentration in the both years was found in *Lentinulaedodes* followed by *Calocybeindica* and *Agaricusbisporus* and the minimum mean concentration was in *Pleurotussajor-caju*as.In the both years, lead concentration of the soil of Shiitake (*Lentinulaedodes*), Milky mushroom (*Calocybeindica*), Button mushroom (*Agaricusbisporus*) and Oyster mushroom (*Pleurotussajor-caju*) was found in the range of 1.69 to

19.5 mg/kg dw, 1.74 to 18.95 mg/kg dw, 1.18 to 19.2 mg/kg dw and 1.08 to 15.44 mg/kg dw. But the differences between the soil of varieties i.e. Button and Milky was not statistically significant (P>0.05).

Table 3. *Mean Lead Concentration (mg/kg dw) in Soil in the year 2009*

	Agaricus bisporus	*Pleurotus sajor caju*	*Vovraiella vovacea*	*Lentinula edodes*	Mean
Industrial Drainage Area (L1)	15.02	8.17	10.37	14.02	11.89
Roadside Area (L2)	8.41	11.09	14.84	12.08	11.60
Remote Residential Area (L3)	3.71	2.42	3.28	2.15	2.89
Commercial Area (L4)	0.00	0.00	0.00	0.00	0.00
Cultivated Area (L5)	1.50	1.50	2.16	0.00	1.72
Mean	7.16	5.79	7.66	9.42	
		Location	Species	Location x Species	
	S.E.(m)A	0.38	0.34	0.77	
	LSD (0.05 P)	1.08	0.96	2.15	

Table 4. *Mean Lead Concentration (mg/kg dw) in Soil in the year 2010*

	Agaricus bisporus	*Pleurotus sajor caju*	*Vovraiella vovacea*	*Lentinula edodes*	Mean
Industrial Drainage Area (L1)	15.27	9.08	13.14	15.58	13.27
Roadside Area (L2)	9.65	11.68	11.02	10.59	10.73
Remote Residential Area (L3)	4.10	2.67	3.43	2.18	3.09
Commercial Area (L4)	0.00	0.00	0.00	0.00	0.00
Cultivated Area (L5)	1.61	1.59	2.48	0.00	1.89
Mean	7.66	6.26	7.52	9.45	
		Location	Species	Location x Species	
	S.E.(m)A	0.36	0.33	0.73	
	LSD (0.05 P)	1.02	N.S.	2.05	

3.3. Relationship between Mushroom Metal Concentration and Underlying Soil Metal Concentration

Comparing the concentration in the fruiting body and the concentration in the substratum that the mushrooms grew on, we obtain the bioaccumulation factor, for each studied heavy metal. For a plant or mushroom to be efficient tool in the polluted soil bioremediation, the bioaccumulation factor have to be higher than 1 [17]**.** The significant relationships between concentration of heavy metals in mushrooms and soil were further substantiated by performing correlation analysis. Statistically significant correlation coefficients (r >0.515 at 0.05 probability level) were established between metal concentrations in mushroom and soil with different varieties. The values of correlation coefficients between metal concentrations are given in fig 1.

Regression analysis showed that the lead content in soil and mushroom showed increasing trend during both the years. The relationship between soil and mushroom has been found to be significant. It is clear that lead concentration in mushrooms were significantly positively correlated with lead concentration in soil. Mushroom collected from industrial area and roadside area have significant higher lead concentrations than in cultivated and remote residential area. This could be attributed to higher lead concentrations in soil of respective locations. The bioaccumulation factor of lead in the fruiting body of analyzed species has sub unitary values, because the level of lead in the fruiting body of these species is lower than the concentrations in substratum (BCF ranging from 0.7 to 0.99). No case of bio concentration as was observed[17]. There was not significant difference in the accumulation of lead in different varieties of

mushrooms because BCF have been found almost similar in all the species. Lead concentrations in mushrooms are low compared to levels in surface soil [18].

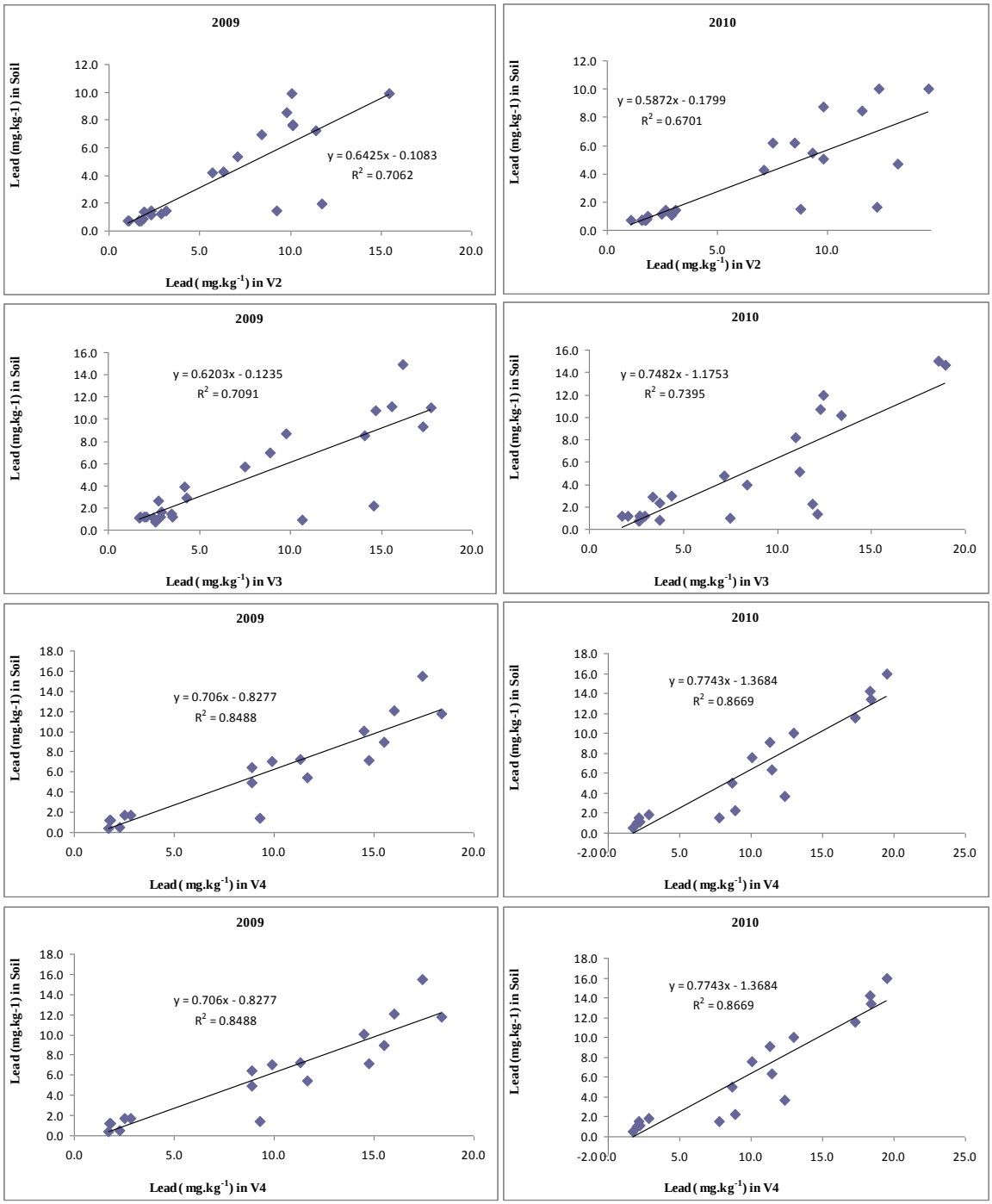

Fig 1. *Relationship between Lead Concentration in various mushroom varieties and their underlying soil*

4. CONCLUSION

In Present study on the basis of data evaluation it has been that location has significant role in concentration of lead. Samples collected near industrial drainage and highway were highly contaminated and showed higher lead concentration. Remote residential area and cultivated samples on the contrary don't have lead concentration higher than permitted limits.

Analysis showed positive correlation between concentration of lead in mushroom and soil. This infers that mushroom can be used as bio indicators of lead pollution. Also they can be used for phytoremediation. Frequent analysis of lead accumulation in both soil and mushroom should be done in this area to avoid possible risk to human health due to this.

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