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Estimation of Accumulation of Zinc content in mushroom and Soil by Atomic Absorption Spectroscopy

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Abstract
The current study was undertaken to determine Level of Zinc in four wildly growing edible mushroom varieties Button mushroom (Agaricus bisporus), Oyster mushroom (Pleurotus sajor-caju), Milky mushroom (Calocybe indica) and Shiitake (Lentinus edodes) and its soil collected in near the industrial drainage and heavy traffic neighboring area of Delhi-NCR, India. It was determined by Flame Atomic Absorption Spectrometry. The concentration was determined on dry weight basis. The range of elemental concentration was mg/kg. In general, levels of Zinc were higher than PFA and WHO permissible limits in case of industrial area, roadside area. Whereas level of the metal at remote residential area and cultivated area was within permissible limits. Two Way ANOVA was used to found significant variation in trace metal concentrations at different locations and in different varieties.

Keywords: *Zinc, Heavy Metal, Mushroom, Atomic Absorption Spectroscopy.*

1. Introduction

Various environmental and toxicological studies have lead to interest in the determination of toxic elements in food. Though mushroom does not constitute significant portion of human diet, still the consumption of both wildly grown and cultivated mushrooms have been sought after in recent times. There are several reasons why mushroom poisoning can occur among people, and the high heavy metal concentrations in some edible fungi is a known source as chronic poisoning **(Tuzen et al., 1998)**. Many species of mushrooms possess the ability to effectively take up and accumulate heavy metals (**Kojo and Lodenius 1989; Kalacˇ *et al.* 1991; Falandysz *et al.* 1993, 1995; Lodenius 1994; Melgar *et al.* 1998; Garcia *et al.* 1998; Alonso *et al.* 2000; Kalacˇ and Svoboda 2000).**

The accumulation of trace metals in agricultural soils disposal, waste incineration, urban effluent, traffic is of increasing concern due to the food safety issues 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. Heavy metals owing to atmospheric and industrial pollution accumulate in the soil and influence the ecosystem nearby **(Al-Radady et al., 1994)**. The determination of heavy metal in soils is very important in monitoring environmental pollution **(Zhou et al., 1997).**

In the present paper the accumulation of zinc was studied in four wildly grown mushroom at four different locations in an around Delhi- NCR region for two consecutive years.

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2 MATERIALS AND METHODS

2.1 Sample Collection

Samples of soils and four different species of wildly growing edible mushrooms: Button mushroom (*Agaricus bisporus*) (V1), Oyster mushroom (*Pleurotus sajor-caju*) (V2), Milky mushroom *(Calocybe indica)* (V3) and Shiitake (*Lentinus edodes*) (V4) were collected from North Delhi Border and Sonipat 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 Sonipat and UP. Residential area (L3), Commercial samples (L4) was studied from APMC Market Azadpur, Delhi. Cultivated samples (L5) were collected from HAIC, Murthal, Sonipat, Haryana.

2.2 Analytical method of soil and Mushroom

Flame Atomic Absorption Spectrophotometer (Perkin-Elmer, ANALYST 100) equipped with flame and graphite furnace was used to determine level of Zinc content.

3. RESULTS AND DISCUSSION

3.1 CONCENTRATION OF ZINC IN THE MUSHROOM SAMPLES

A perusal of Table No. 1 and 2 and Figure 1 shows that mushroom varieties had significant variation ($P<0.01$) in zinc concentration. Zinc Concentration was found to be maximum in Milky (*Calocybe indica)* followed by Button mushroom (*Agaricus bisporus*). Thereafter was Oyster (*Pleurotus sajor-caju)* and the minimum value was in Shiitake (*Lentinula edodes).*

The maximum zinc accumulation was in roadside samples followed by industrial drainage samples . Sporocarps collected from HAIC (cultivated samples) have minimum zinc accumulation ranged from 31.0 to 54.0 mg/kg dry matter. Cultivated samples have minimum zinc accumulation.

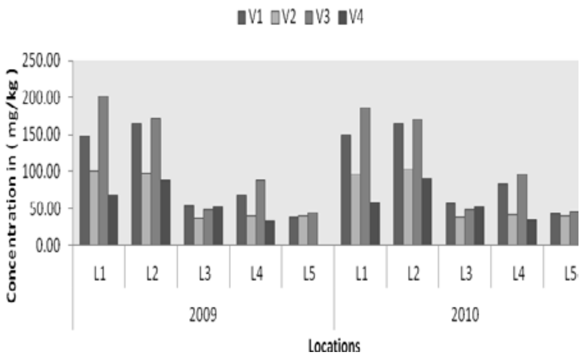

Fig 1. Zinc Concentrations (as mg/kg) of different Mushroom Species at various locations

In the study if was observed that location had significant variation in zinc concentration in mushroom at different locations ($p<0.01$). All the samples of roadside area and Industrial drainage above the safe limits WHO limits (60 mg/kg dw) and most stringent PFA/FSSAI maximum allowed concentration i.e. 50.0 mg/ kg of dry matter. In case of Commercial sample, remote residential area sample and cultivated samples only some sample were above the safe limits of WHO and PFA. The FAO/WHO has set a limit for heavy metal intakes based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intake for zinc is 60 mg/kg dw **(FAO/WHO 1999).**

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

Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	148.44	100.98	201.58	67.61	129.65
L2	165.50	97.64	172.10	87.31	130.64
L3	54.75	37.39	48.95	52.60	48.43
L4	67.62	40.25	88.21	33.35	57.35
L5	39.01	40.51	44.23	-	41.25
Mean	95.07	63.35	111.01	60.22	
		Location	Variety	Location x Variety	
	S.E.(m)	4.34	3.88	8.67	
	LSD (0.05 P)	12.18	10.89	24.35	

Mushrooms are known as zinc accumulators and the sporophore: substrate ratio for Zn ranges from 1 to 10 mg/kg **(Isıloglu et al., 2001).** Zinc concentrations of mushroom samples in the literature have been reported to be in the ranges: 30-150 mg/kg **(Kalac & Svoboda, 2000),** 29.3–158 mg/kg) **(Isıloglu et al., 2001)**, 33.5–89.5 mg/kg **(Tüzen, 2003)**, 40.3–64.4 mg/kg **(Mendil et al., 2004)**, 45.2–173.8 mg/kg **(Soylak et al., 2005),** 30.1-137.4 **(Ita, Essien and Ebong, 2006),** 43.5–205 mg/kg **(Sesli et al., 2008)** and 42.9-94.3mg/kg **(Fangkun Zhu et al., 2011)** respectively. Hence, zinc content in mushrooms of the present study is in agreement with the previous studies.

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

Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	149.93	95.70	186.64	58.74	122.75
L2	164.79	103.19	171.47	91.02	132.62
L3	56.63	39.08	48.82	52.66	49.30
L4	83.59	41.67	96.92	34.94	64.28
L5	42.97	39.79	45.22	-	42.66
Mean	99.58	63.89	109.82	59.34	
		Location	Variety	Location x Variety	
	S.E.(m)	3.98	3.56	7.95	
	LSD (0.05 P)	11.17	9.99	22.33	

3.2 CONCENTRATION OF ZINC IN THE SOIL OF MUSHROOM SAMPLES

Soil of mushroom varieties had significant variation ($P<0.01$) in zinc concentration as shown in Figure 2 and Table No. 3 and 4. Among the soil of different varieties of mushrooms, in the first year the maximum zinc concentration was found in soil of Milky (*Calocybe indica)* followed by Button mushroom (*Agaricus bisporus*) . This was followed by Oyster (*Pleurotus sajor-caju)* and the minimum value was in Shiitake (*Lentinula edodes)* i.e. 50.13 mg/kg dw. Whereas in the second year, minimum zinc concentration was found in sample of Oyster (*Pleurotus sajor-caju).*

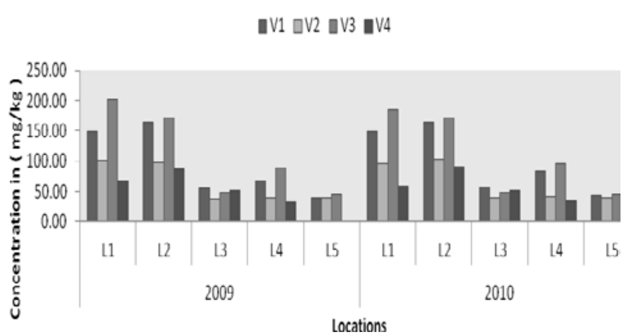

Fig 2. Zinc Concentrations (as mg/kg dw) in Soil at different locations

Locations had significant variation in zinc concentration in the soil at different locations ($p<0.01$). There is significant variation in trace metal concentration with location. **(Jain et al 2013, Chauhan 2014 and Chauhan et al 2015)**. Highest zinc concentration was recorded in roadside area i.e. 99.31 mg/kg dw in the first year and 97.79 mg/kg dw in the second year while minimum in the samples collected from HAIC (cultivated

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samples) i.e. 31.25 mg/kg dw in the first year and 30.20 mg/kg dw in the second year. All the samples of soil were within the safe limits of WHO (7500 mg/kg dw).

Table 3
Mean Zinc Concentration (mg/kg dw) in Soil in the year 2009

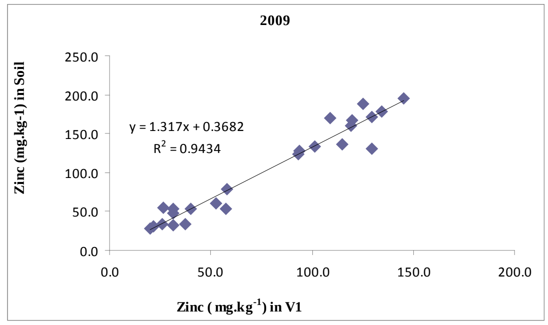
Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	112.35	71.66	139.87	43.93	91.95
L2	123.42	77.20	128.49	68.13	99.31
L3	41.22	28.45	35.50	38.32	35.87
L5	31.47	29.14	33.15	-	31.25
Mean	77.11	51.61	84.25	50.13	
		Location	Variety	Location x Variety	
	S.E.(m)	2.09	1.87	4.19	
	LSD (0.05 P)	5.88	5.26	11.75	

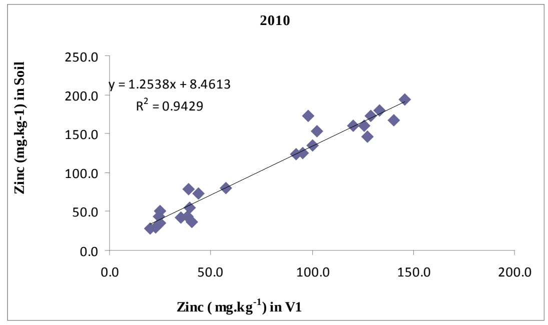
Table 4
Mean Zinc Concentration (mg/kg dw) in Soil in the year 2010

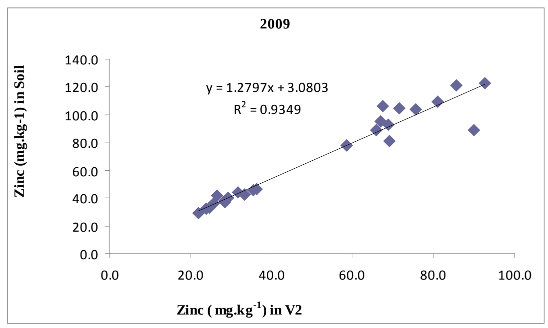
Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	111.21	75.62	151.10	50.63	97.14
L2	123.87	73.05	128.95	65.29	97.79
L3	39.82	27.19	35.60	38.24	35.21
L5	28.56	29.63	32.41	-	30.20
Mean	75.86	51.37	87.02	51.39	
		Location	Variety	Location x Variety	
	S.E.(m)	2.29	2.05	4.59	
	LSD(0.05 P)	6.44	5.76	12.88	

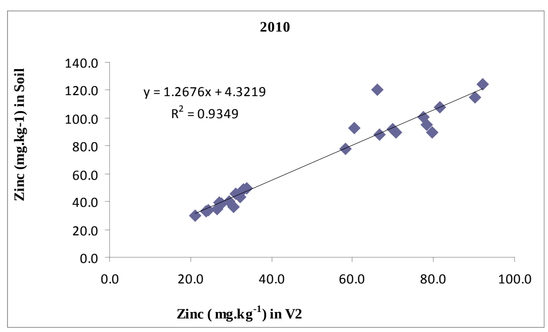
3.3 Relationship between Zinc Concentration in various mushroom varieties and their underlying soil.

The zinc shows a higher mobility in the analyzed species of mushrooms because of the highest concentration of this element in the cap of fruiting body for the analyzed wild growing edible species of mushrooms. All tested fungi revealed ability for zinc accumulation being higher concentration of zinc in mushroom than in soil. **Rudawska and Leski, 2005** also reported similar findings. During our investigation, we did not found much difference in zinc accumulation in relation to sites and different varieties of mushrooms due to similar BCF values. Zinc is an essential element and fungi have high requirements for Zn conveying this element to their metabolism by means of well-operating mechanisms of absorption and translocation **(Carlyle and Watkinson, 1994)**. However, **Carmen Cristinia, 2010** did not find the significant influence of soil characteristics on zinc accumulation in the fruiting body of mushrooms. He also found negative correlation between soil and mushroom zinc levels i.e. for an increase of zinc content in the soil with 20-25 mg/kg, the zinc concentration in the fruiting body decreased with 10-15 mg/kg. But he also reported higher level of concentration for this metal in the in cap comparing with the stalk of mushroom.









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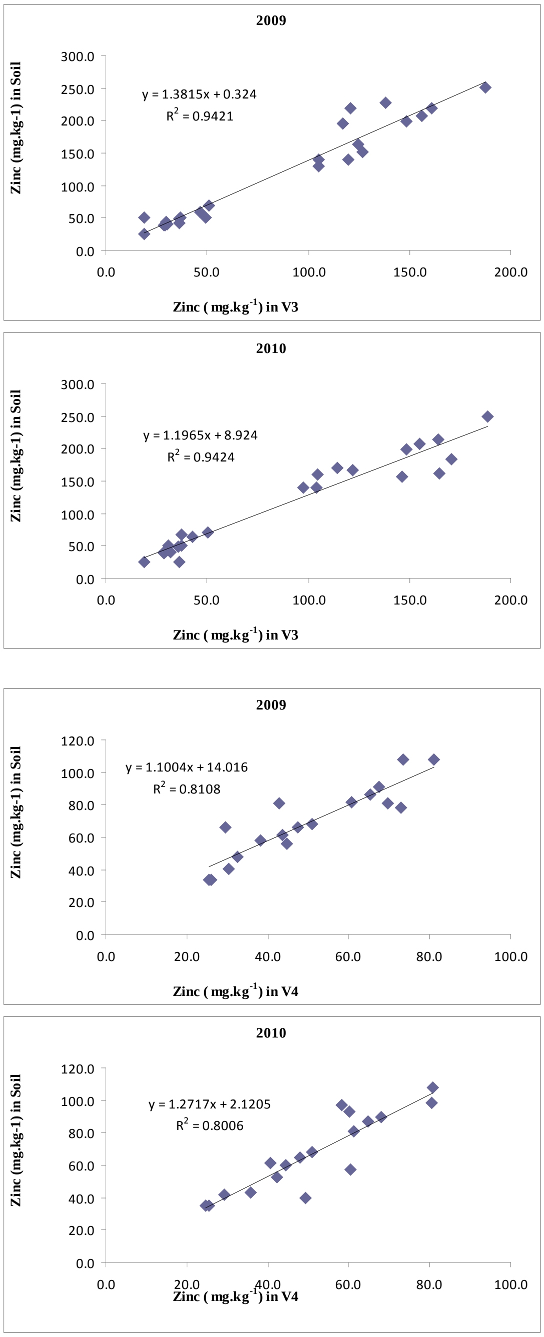

Fig 3: Relationship between Zinc Concentration in various mushroom varieties and their underlying soil.

4. CONCLUSION

Among all the four varieties of mushrooms the mean zinc concentration was in the descending order as *Calocybe indica*, *Agaricus bisporus*, *Pleurotus sajor-caju* and *Lentinula edodes*. Mean zinc concentration in soil samples were found to be maximum in roadside followed by industrial drainage and the least was in cultivated soil samples. In the present study, the detected levels of zinc in the samples from industrial drainage and roadside area were found to be 34.0-251.6.

The order of the levels of heavy metals in the mushroom samples were generally in agreement with previously reported but higher than maximum permissible standards of WHO, PFA, Czech and EU. Observed concentrations of Zn in the vegetables were compared with Prevention of Food adulteration (PFA) act 50 mg/kg, standards of food contamination. Even the loosely available commercial mushroom samples during monsoon have shown higher metal contents. This may be due their collection might be done from wildly growing places. Roadside soils have been shown to have considerable contamination due to both depositions on vehicle – derived metal and to relocation of metals deposited on the road surface **(Ball et al., 1991)**. Because of the severe adverse environmental and/or ecological and health effects of these heavy metals, there have been many studies on heavy metal contamination in soils along major roads **(Turer, 2005)**. The fruit bodies of mushrooms accumulate remarkably high concentrations of trace metal content, especially in the vicinity of highways. Our results agree with the data of other authors **(Laaksovirta & Alakuijaka, 1978)**. Mushrooms can be used as bioindicators for soil pollution **(Lodenius et al., 1981; Quinche, 1987)**.

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