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STUDY ON ACCUMULATION OF NICKEL CONTENT IN MUSHROOM IN DELHI-NCR REGION OF INDIA BY ATOMIC ABSORPTION SPECTROSCOPY

Dr Monika Chauhan [1], Dinesh Chauhan[2], Dr Vinod Gupta[3] and Dr Ashok Kumar[4]
[1]Adama Science and Technology University, Adama, Ethiopia
[2]Wollega University, Nekempte, Ethiopia
[3]Principal, NITM, Gwalior, India
[4] Ex HOD (Dep't. Of Chemistry), St John's College, Agra University, Agra, India

Email: jmoni30@gmail.com

Abstract:
The study was carried out in order to estimate the distribution and accumulation of nickel in wildly grown edible mushroom and its underlying soil from surrounding areas of Delhi-NCR. Samples were collected from regions polluted with industrial drainage and heavy traffic. Nickel accumulations in these were compared with that of wildly grown mushroom collected from non polluted cultivated and remote residential areas of Delhi. Commercial samples of mushroom were also collected and analyzed. All these study was conducted on four different varieties of mushroom Button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus sajor-caju*), Milky mushroom *(Calocybe indica)* and Shiitake (*Lentinus edodes*). The levels of nickel were analyzed using Flame Atomic Absorption Spectrometry. The results from the two way ANOVA showed that there was significant variation in trace metal concentrations at different locations. It was found from correlation analysis that nickel concentration in soil and mushroom samples were positively correlated.

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

1. Introduction

Nickel is one of many trace metals widely distributed in the environment, being released from both natural sources and anthropogenic activity, with input from both stationary and mobile sources. It is present in the air, water, soil and biological material. Natural sources of atmospheric nickel levels include wind-blown dust, derived from the weathering of rocks and soils, volcanic emissions, forest fires and vegetation. Nickel finds its way into the ambient air as a result of the combustion of coal, diesel oil and fuel oil, the incineration of waste and sewage, and miscellaneous sources (Cempel, M. and Nikel, G. 2006)

Nickel is a highly toxic metal with a natural occurrence in soil and also spreads in environment due to human activities. Nickel is known as a principal toxic metal. It was reported that nickel is accumulated mainly in kidneys, spleen, and liver, and its blood serum level increases considerably following mushroom consumption (Kalac and Svoboda 2000). Thus, nickel seems to be the most deleterious among heavy metals in mushrooms. It can be taken up directly from water, and to some extent from air and it has a tendency to accumulate in both plants and animals. Mushrooms, in particular, can be very rich in nickel. Nickel is a byproduct in the production of zinc and lead. Other major sources are fossil fuel combustion and waste incineration. Nickel accumulation has been demonstrated by Kojo & Lodenius, 1989;Stijve & Besson, 1976; Vetter, 1987.

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 Sonepat region, India during monsoon. The area studied was divided into area of industrial activity (Location 1), road side area on National Highway NH 1 with heavy vehicular traffic and state highway crossing NH1 (Location 2) and remote residential area (Location 3). Commercial samples obtained from Azadpur Market, Delhi (Location 4) whereas cultivated samples (Location 5) were collected from Mushroom research centre, Sonepat (NCR). Soil samples were taken at measurement points at a depth of approximately 0-15cm.

2.2 Analytical method of soil and Mushroom

Nickel content in samples was analyzed using Flame Atomic Absorption Spectrophotometer (Perkin-Elmer, ANALYST 100). Air-acetylene flame was used for determination of metal content.

3. Results and Discussion

3.1 Concentration of nickel in mushroom samples

Table No.1 and 2 clearly shows that mushroom varieties had significant variation ($P<0.01$) in nickel concentration. In First year Maximum nickel concentration was found in Shiitake (*Lentinula edodes)* i.e. 6.85 mg/kg dw followed by Button mushroom (*Agaricus bisporus*) i.e. 5.93 mg/kg dw and Oyster (*Pleurotus sajor-caju)* i.e. 4.47 mg/kg dw. The minimum content was in Milky (*Calocybe indica)* i.e. 3.42 mg/kg dw. In next year, the maximum nickel concentration was found in Button mushroom (*Agaricus bisporus*) i.e. 7.32 mg/kg dw followed by Shiitake (*Lentinula edodes)* i.e. 6.84 mg/kg dw. Thereafter were Oyster (*Pleurotus sajor-caju)* i.e. 5.15 mg/kg dw and minimum in Milky (*Calocybe indica)* of 3.67 mg/kg dw.

It was shown that location had significant variation in nickel concentration in mushroom ($p<0.01$).With Highest recorded in roadside area i.e. 8.84 mg/kg dw and 10.59 mg/kg dw in year first and second respectively. Cultivated area reported minimum with 1.46 mg/kg dw in the first year and 1.38 mg/kg dw in the second year. All the samples of roadside area and Industrial drainage were found to be above the safe limits of WHO (60 mg/kg dw) In case of Commercial sample, remote residential area sample and cultivated samples only some sample were found to be above the safe limits of WHO and PFA. The FAO/WHO has set a limit for heavy metal intakes based on body weight. Mean nickel concentrations in different varieties of mushroom are shown in Table 1 and Table 2 and Figure 1.

Table 1Mean Nickel 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	8.97	5.04	6.20	8.72	7.23
L2	11.55	6.71	7.14	9.94	8.84
L3	2.60	2.58	1.17	2.27	2.16
L4	5.41	5.66	1.71	6.49	4.82
L5	1.10	2.36	0.91	-	1.46
Mean	5.93	4.47	3.42	6.85	
		Location	Variety	Location x Variety	
	S.E.(m)	0.44	0.40	0.89	
	LSD (0.05 P)	1.25	1.12	2.49	

Table 2 Mean Nickel 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	12.07	6.56	6.26	8.54	8.36
L2	15.55	8.50	8.21	10.10	10.59
L3	2.24	2.88	1.27	1.97	2.09
L4	5.32	5.94	1.70	6.74	4.93
L5	1.41	1.84	0.89	-	1.38
Mean	7.32	5.15	3.67	6.84	
		Location	Variety	Location x Variety	
	S.E.(m)	0.47	0.42	0.95	
	LSD (0.05 P)	1.33	1.19	2.66	

All the samples analyzed were within the WHO safe limit of nickel i.e. between 100 and 300 mg/kg dw (WHO 1994). Nickel values have been reported in the ranges: 2.73–19.4 mg/kg (Isıloglu et al., 2001), 1.18– 5.14 mg/kg (Tüzen, 2003), 8.2–21.6 mg/kg (Mendil et al., 2004), 0.4–15.9 mg/kg (Isildak et al. 2004), 1.22–58.60 mg/kg (Yamac et al. 2007) and 0.76-5.08 (Fangkun Zhu et al., 2011) respectively. Hence, nickel content in mushrooms of the present study is in agreement with the previous studies.

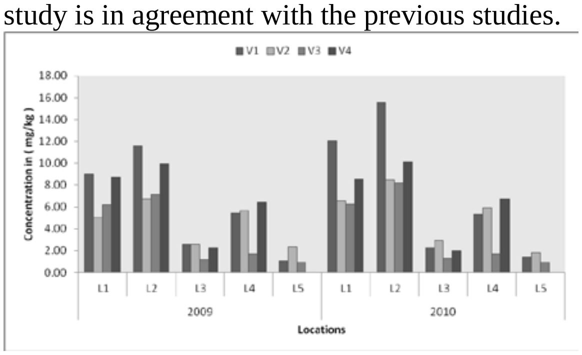


Fig 1. Nickel Concentrations (as mg/kg) of different Mushroom Species at various locations

3.2 Concentration of nickel in soil samples

Results revealed from Table No. 3 and 4 that soil of different mushroom varieties had significant variation (P<0.01) in nickel concentration. During first year, the maximum nickel concentration was found in the soil of Button mushroom (*Agaricus bisporus*) i.e. 5.69 mg/kg dw followed by Shiitake (*Lentinula edodes)* i.e. 5.02 mg/kg dw. This was followed by Oyster (*Pleurotus sajor-caju)* i.e. 3.59 mg/kg dw and the minimum value was in Milky (*Calocybe indica)* i.e. 3.0 mg/kg dw. However there was not statistically significant difference in the soil of Shiitake and Button mushroom (P>0.05).

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

Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	8.75	4.79	4.51	6.18	6.06
L2	11.38	6.13	5.93	7.45	7.72
L3	1.62	2.10	0.93	1.44	1.52
L5	1.02	1.34	0.64	-	1.00
Mean	5.69	3.59	3.00	5.02	
		Location	Variety	Location x Variety	
	S.E.(m)	0.35	0.31	0.70	
	LSD (0.05 P)	0.98	0.87	1.96	

In the second year, maximum nickel concentration was found in Shiitake (*Lentinula edodes)* i.e. 5.06 mg/kg dw followed by Button mushroom (*Agaricus bisporus*) i.e. 4.39 mg/kg dw and Oyster (*Pleurotus sajor-caju)* i.e. 3.05 mg/kg dw. The minimum concentration was in Milky (*Calocybe indica)* i.e. 2.80 mg/kg dw. However there was not statistically significant difference in the soil of Milky and Oyster varieties (P>0.05)

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

Sampling sites	*Agaricus bisporus*	*Pleurotus sajor-caju*	*Calocybe indica*	*Lentinula edodes*	Mean
L1	6.50	3.67	4.53	6.35	5.26
L2	8.40	4.96	5.19	7.20	6.44
L3	1.88	1.85	0.83	1.63	1.55
L5	0.78	1.71	0.66	-	1.05
Mean	4.39	3.05	2.80	5.06	
		Location	Variety	Location x Variety	
	S.E.(m)	0.33	0.29	0.66	
	LSD (0.05 P)	0.92	0.82	1.84	

As shown in mushroom, location had significant variation in nickel concentration in the soil at different locations ($p<0.01$). Location had significant variation in accumulation of trace elements like lead and Cadmium etc in soil (M. Chauhan, 2014); M. Jain, 2013). Highest nickel concentration was recorded in roadside area i.e. 7.72 mg/kg dw in the first year and 6.44 mg/kg dw in the second year while minimum in the samples collected from HAIC (cultivated samples) i.e. 1.00 mg/kg dw in the first year and 1.05 mg/kg dw in the second year.

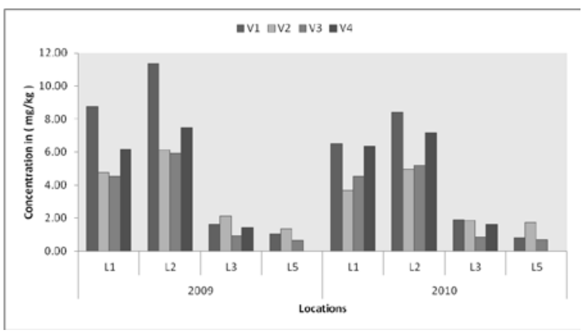
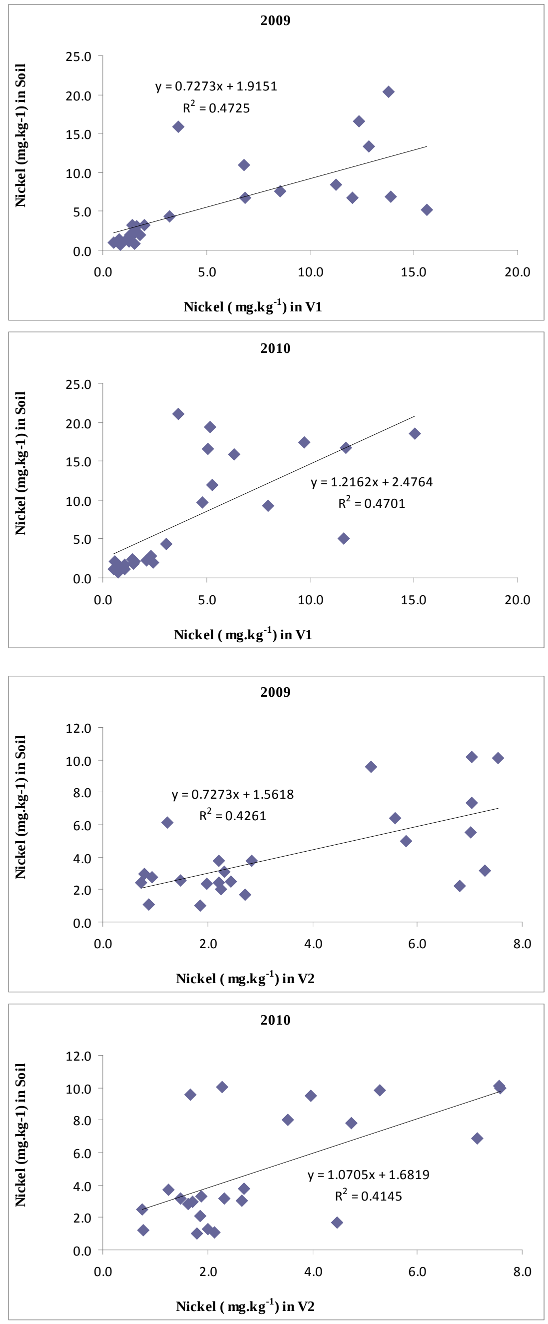


Fig 2. Nickel Concentrations (as mg/kg dw) in Soil at different locations

All the samples of roadside area and Industrial drainage above the safe limits WHO limits (75 mg/kg dw)

3.3: Relationship between Mushroom Metal concentration and Underlying Soil Metal concentration

Comparing the concentration of nickel in the fruiting body and the concentration in the substratum that the mushrooms grew on, we obtain the bioaccumulation factor. The bioaccumulation factor represents the pollutant concentration in mushrooms comparing with the environment concentration (in soil) **(Scragg, A., 2005).** For a plant or mushroom to



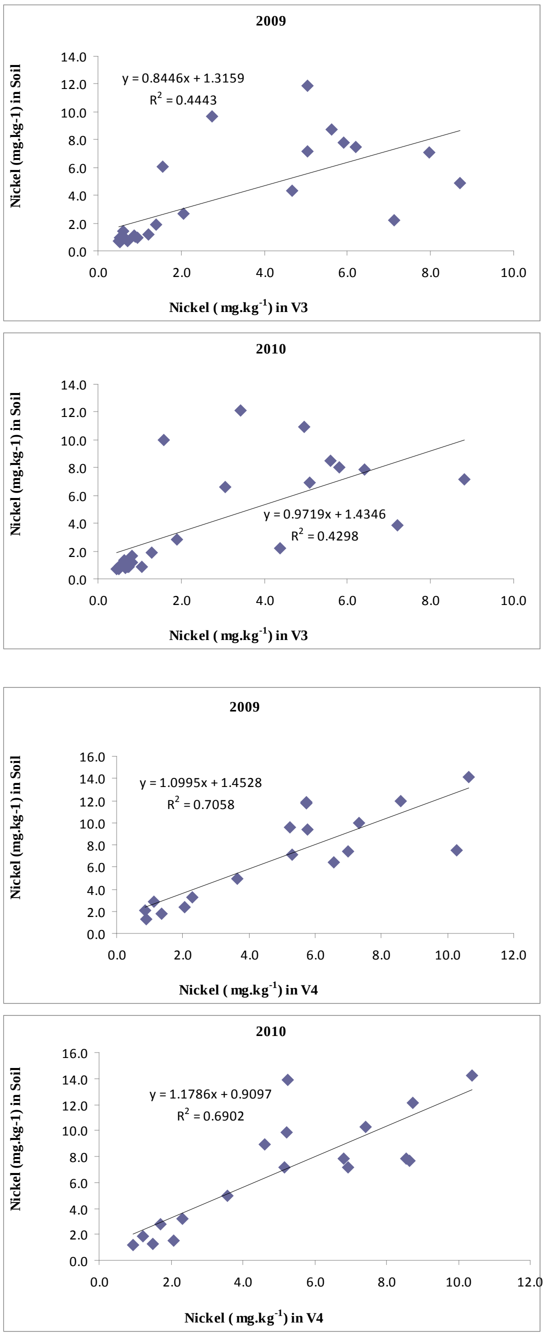


Fig.3: Relationship between Nickel Concentration in various mushroom varieties and their underlying soil.

be efficient tool in the polluted soil bioremediation, the bioaccumulation factor have to be higher than 1 **(Tyler (1980).** 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 3 with their respective graphs.

The levels of nickel have been found higher in mushroom than in underlying soil showing its higher mobility in the analyzed species. It was also observed cap has higher nickel concentrations than stalk. Ni is considered as essential for animals. However Ni is as integral part of the enzyme urease. **Poulik Zdenek (1999)**, reported increasing levels of nickel, below the toxic level did not affect growth, development and yields of lettuce. However at higher concentrations, in case of tomatoes the dry matter weight of the fruit decreased significantly.

4. Conclusion

In present study, on the basis of data evaluation it has been found that location has significant role in concentration of nickel. Samples collected near industrial drainage and highway were highly contaminated and showed higher nickel concentration. Remote residential area and cultivated samples on the contrary didn't had nickel concentration higher than permissible limits.

Analysis showed positive correlation between concentration of nickel in mushroom and soil. This infers that mushroom can be used as bio indicators of nickel pollution. Also they can be used for phytoremediation. Frequent analysis of nickel 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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Dr Monika Chauhan, PhD, MSc Food Technology, Area of interest is Food Chemistry, Heavy Metals in Food, Food Quality and Food Safety. She has been into academics since last 14 years and currently working as Associate Professor, Department of Chemical Engineering, Adama Science and Technology University, Ethiopia.

Dinesh Chauhan, PhD (Management) pursuing, MBA Agribusiness Management, MSc Food Technology. Area of interest is Food Safety, Effect of various Economic activities on food Quality and its composition. He is Lecturer, Department of Agriculture Economics and Value Chain Management, Wollega University, Nekempte, Ethiopia. Has more than 15 years of experience in Agribusiness, Food Production, Quality, Supply Chain Management, Warehousing, Commodity Care and Food Retail

Dr Vinod K Gupta, PhD (Chemistry) (IIT, Roorkee) is currently Principal, NITM, Gwalior, India. Earlier he was Head of Department, Department of Chemistry, PG College, Ambah, Gwalior, India.

Dr Ashok Kumar PhD (Chemistry) was Head of Department, St John's College, Agra University, Agra. He has active interest in subjects related to Trace Metals accumulation.