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Heavy Metals Accumulation in Human Fingernails

N. S. Sisodia [a,*], H. Kulshreshtha [a], S. Sharma [b], S. K. Khanna [c]
[a] Department of Chemistry, School of Chemical Sciences, St John's College, Agra, Upper Pradesh, India
[b] Department of Chemistry, JMIT, Radaur, Yamuna Nagar, Haryana, India
[c] Department of Development of Research & Consultancy, TMU, Moradabad, Upper Pradesh, India

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Abstract

Metal determination in human tissues is the most common application of biological monitoring for screening, diagnosis and assessment of metal exposures and their risks. Humans and other living organisms are exposed to a variety of chemical pollutants that are released into the environment as a consequence of anthropogenic activities. Environmental pollutants are incorporated into the organism by different routes and can then be stored and distributed in different tissues, which leads to an internal concentration that can induce different alterations, adverse effects and/or diseases. Control measures should be taken to avoid these effects and human biomonitoring is very useful tool that can contribute to this aim. This paper deals with the quantitative determination of Fe, Pb, Ni, and Zn concentrations in fingernails of male subjects from various locations i.e., from industrial, commercial, urban, and rural areas. The levels of these metals were assayed by AAS. Studied metal concentrations in fingernails were in the order Fe > Zn ≥ Ni > Pb. This study proved that human fingernails could be used as a biological indicator for the assessment of heavy metal pollution.

1. Introduction

Industrialization, urbanization, mining operations, increased vehicular traffic and use of fertilizers and pesticides in agriculture have resulted in increased metal contamination in our environment. Not only the occupationally exposed workers (high-risk population group) but the community at large (low-risk population group) may suffer due to increased metal pollutants in the environment. Though certain essential trace elements are required in trace amounts for various physiological processes; but, at higher concentrations, these micronutrients tend to be toxic and derange various physiological processes, leading thereby to diseases. Therefore, it is important to determine the metal concentrations in humans to monitor and assess their impact on human health (Florence 1990; Oluwole et al 1994; Ather and Vohora 1995; Satake et al 1997; Nath 2000).

Metal poisoning as a health issue has been described as a "silent epidemic" (Mielke et al., 1999). Many authors are in agreement that unless the level of toxic metal is high enough the symptoms of poisoning are not apparent and might slow late in adulthood, making the number of undiagnosed cases very high (Nevin, 2000; Needleman et al., 2002; Brito et al., 2005). It has been established that toxicity and absorption of these metals is elevated in children under the age of six years compared to adults due to their not having fully developed nervous system and other organs, more hand to mouth activities, untimely outdoor activities, not fully developed hygienic habits and active metabolism (Mielke et al., 1999; Granero and Domingo, 2002). Lead and cadmium exposure has also been negatively associated with neurotoxic, osteroporosis and osteomalacia in children (Berglund et al., 2000; Lanphear et al., 2005).

Nails are metabolic end products that incorpate metals into their structure during the growth process. Therefore, the determination of heavy metals content in nail is understood to play as important role for monitoring the impact of environmental pollution on inhabitants of a community (Ashraf et al, 1994; Pereira et al, 2004).

As a continuation of our earlier studies (Mehra and Juneja 2003a,b,c,2004), here we report the nail trace

Corresponding Author,
E-mail address: shashank.enviro@gmail.com

metal levels (Pb, Cd, Ar,) in different age groups of subjects with varying personal habits and prone to the hazards of trace metals in their occupational environment.

2. Materials And Methods

2.1 Sample Collection

Samples are collected from male and female subjects from different industrial and residential locations. For sample collections subjects are asked to wash their hands thoroughly with double distilled water and medicated soap to avoid metal contamination, followed by drying with a clean towel or tissue paper to remove external contamination. Nails were cut with sterilized stainless steel scissors. All nail samples were also sealed in plastic bags prior to analysis.

2.2 Procurement of requisite details of subjects

The personal and medical history, along with relevant details of the subjects taken for study was obtained through a questionnaire based on recommendation of WHO. The information was included sex, age, smoking and drinking habits, food habits, disease, place of residence, occupation.

2.3 Laboratory procedure and quality control

Preparations of samples for analysis were carried out using the standard methods (Samantha et al., 2004; Mehra and Juneja, 2005, Sukumar and Subramanian, 2007).

2.4 Sample pre-treatment

The fingernails samples in the plastic containers were soaked in non-ionic liquid soap for 2h in a labeled glass beaker and washed free from metallic debris. They were subsequently soaked in acetone for 1h before rinsing them five times with distilled – deionised water. The samples were kept in labeled vials, oven dried at 60^0C to a constant weight.

2.5 Acid digestion

For acid digestion, the dried nail samples were digested with 10 ml of 6:1 mixture of conc HNO_3 and $HClO_4$ kept overnight at room temperature to prevent excessive foaming. The digestion tubes were covered with aluminum foil. The samples were digested slowly for about 1h until all the nails dissolved, leaving a clear solution.

2.6 AAS Analysis

The meatals concentrations were analysed by using Perkin Elmer AAS ANALYT 100 with air acetylene flame. A series of standerds wer prepared in deionized water for instrumental calibration by diluting commercial standerds containing 1000 ppm of the meatals. All reagent used were of analytical grade (MERCK).

3. Results And Discussion

S. No.	Sample ID	SEX	AGE	VEG/NON VEG	TOB.	Alc/Non Alc	Smoker/Non Smoker	Source of Water	Site Status
1	N1	M	20-30	Veg	Y	Y	N	Ground	Urban
2	N2	M	50-60	Veg	N	N	Y	Ground	Industrial
3	N3	M	11-20	Veg	N	N	N	Ground	Rural
4	N4	M	40-50	Veg	N	N	Y	Ground	Commercial
5	N5	M	21-30	Non Veg	N	N	N	Ground	Rural
6	N6	M	30-40	Veg	Y	N	Y	Ground	Commercial
7	N7	M	21-30	Veg	N	N	N	Ground	Rural
8	N8	M	30-40	Non Veg	Y	Y	Y	Ground	Industrial
9	N9	M	50-60	Veg	N	N	Y	Ground	Rural
10	N10	M	20-30	Non Veg	Y	Y	Y	Ground	Industrial

Table: 1. Categorization of subjects according to their personal habits

Site	No of samples	Fe(µg/g)	Ni(µg/g)	Pb(µg/g)	Zn(µg/g)
N1	3	388.6±31.3 (365.4 – 424.3)	109.3±18.8 (91.1-128.8)	41.0±20.0 (25.4-63.6)	227.0±47.1 (112.0-289.9)
N2	3	1646.7±164.0 (1099 – 1425.3)	261.5±41.1 (165.8-246)	107.6±34.8 (81.2-147.0)	209.7±91.5 (147.2-314.8)
N3	3	454.5±92.2 (368.3-534.2)	115.2±27.7 (97.2-147.1)	52.4±36.7 (26.5-94.4)	167.0±44.9 (139.3-142.8)
N4	3	1554.3±132.8 (1156.3-1411.8)	263.7±61.9 (233.4-345.5)	37.3±28.4 (19.7-70.1)	204.3±70.2 (158.3-285.1)
N5	3	465±23.5 (358.7-405.2)	127.2±18.8 (111.9-148.2)	7.3±6.2 (3.1-14.5)	130.6±17.8 (119.4-151.2)
N6	3	581.4±146.4 (417.6-689.2)	136.6±36.8 (95.0-165.0)	18.6±11.0 (11.0-31.3)	148.2±24.4 (122-170.2)
N7	3	1027.1±19.2 (881.4-918.2)	151±43.7 (129.7-208.7)	5.8±6.1 (2.1-13.0)	167.3±40.9 (139.4-214.3)
N8	3	1700±67.6 (1398.9-1534.2)	172.5±59.2 (127.4-238.7)	37.1±24.0 (21.3-64.8)	162.1±35.0 (157.8-199.1)
N9	3	1565±194.4 (1109-1498)	234.6±62.9 (151-275.4)	35.0±15.5 (23.4-52.7)	199.6±81.5 (142.4-293.0)
N10	3	685.9±55.9 (645-749.7)	154.2±29.5 (134.4-189.7)	8.0±7.1 (3.4-16.3)	160.9±34.6 (139.5-200.0)

Table: 2. Mean±SD (µg/g) values of trace metals in nails with respect to different parameters

Mean ± SD

(Range)

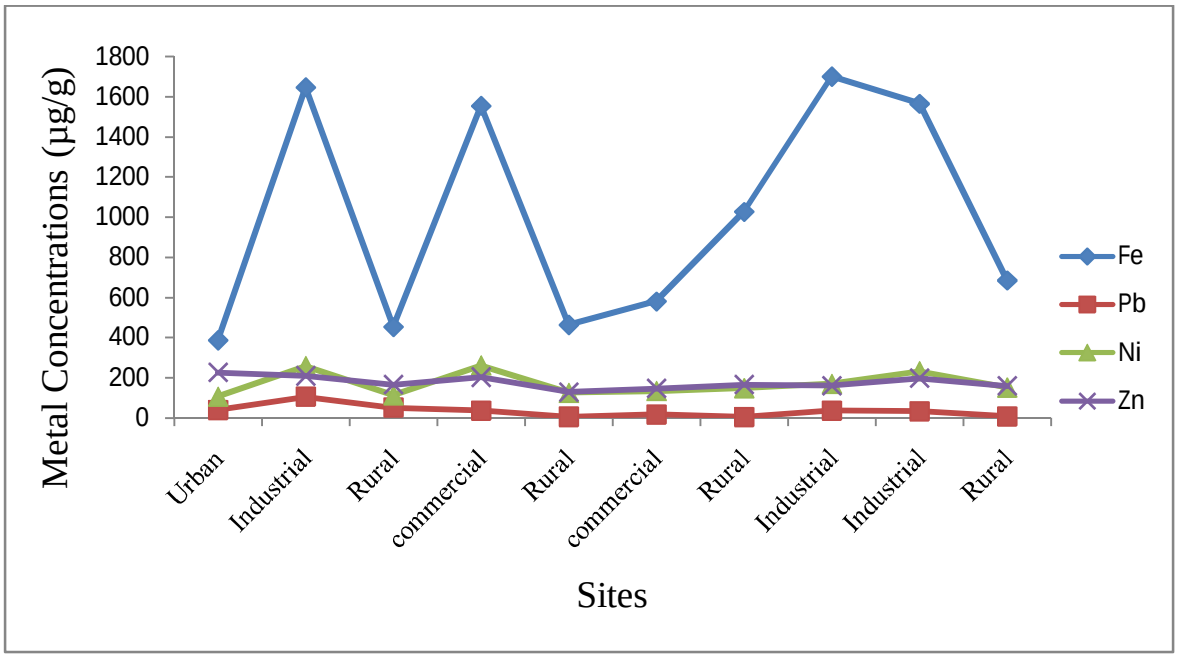

Fig: 1. Metals concentrations in fingernails of male subjects from various sites

The personal habits (smoking, drinking and food) of male subjects of various locations in Agra district are described in Table 1. The results of the quantitative analyses of fingernails for Fe, Ni, Pb and Zn are given in Table 2. The concentrations of Fe were found to be highest among all four metals at every site. The concentration range for Fe was 388.6 – 1700.0 µg/g .The order of metals concentrations at various locations was as follows: Industrial > Commercial > Urban > Rural. This study shows that the concentrations of metals were found to be in the order of Fe > Ni ≥ Zn > Pb .High level of iron observed is probably due to the presence of iron oxide fumes in the environment of workplace as various processes involved emanate oxides of iron. Nickel level may be due the inhalation of vapors of nickel carbonyl from the work type (welding, fitting, etc.). An overall view of the results obtained for trace/toxic metals and its correlation ship with different diseases although establish the use of nails as a diagnostic tool but still more number of studies on a larger portion of the population will enhance the merit of such investigation and their applications in medical and forensic sciences.

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