International Journal of Chemical and Biochemical Sciences

Journal Home page: www.iscientific.org/Journal.html

Heavy metals in human scalp hair and nail samples from Pakistan: influence of working and smoking habits

Um-e-Ammara Shan* and Naheed Ikram

Department of Chemistry, Bahauddin Zakariya University, Multan, Pakistan.

Abstract

Scalp hair and nail samples from 100 volunteers of varied age groups from Multan region (Pakistan) were analyzed for Cu, Cd, and Pb by FAAS. The P-value and t-test was done to find out the significance of mean values between different age groups. Highly significant ($p < 0.01$) Cu, Cd and Pb raised levels were seen in hairs and nails sample of jewelry, automobile and industrial workers in comparison to those controls which do not work in metal contaminated environment. Amount of Cu, Cd and Pb found in hairs and nail samples was found to be correlated with age and working environment of volunteers. Striking differences appeared when smokers were compared with non-smokers in amount of Cd in their hairs and nails samples. Consideration of a large number of biological and behavioral factors minimizes bias inherent in unmatched sample composition. Results obtained clearly indicate that hairs/nails concentrations of heavy metals can be used as an indication of heavy metal exposure in human.

Key words: Human hair, nail, heavy metal pollution, industrial workers, smokers

Full length article Received: 01-11-2011 Revised: 01-12-2011 Accepted: 18-12-2011 Available online: 15-01-2012

**Corresponding Author*, e-mail: ammarajawad@gmail.com

1. Introduction

Environmental pollution affecting air, land and water is due to modern ever-increasing industrialization which in turn affects the people interacting with them. The main health hazard is associated with exposure to lead, cadmium, arsenic and mercury [1]. When ingested and inhaled in excessive amount, heavy metals can affect liver, brain, bone and lungs, although each metal causes its own characteristic symptoms [2]. Prolonged exposure to low doses can cause chronic lung disease, cancer, nervous impairment, bone abnormalities and sterility [3]. All the workers especially adults working in industries like metal and mining are severely exposed to many toxic metals when inhaled in polluted air. Non-occupationally exposed persons and children are also suffering from heavy metal pollution by inhaling airborne particulates and ingesting dissolved metals in contaminated food and water [4]. Elemental copper may be a source of toxicity when leached from copper piping into water supplies or inhaled occupationally as dust or fumes. Short term copper exposure can cause gastrointestinal distress while long term exposure can damage liver or kidney [5]. Cadmium is a cumulative toxic agent having half life in blood 2-3 months. Cadmium also causes a rise of Cu kidney concentration; the content of latter in liver as well as activity of some copper dependant undergoes transient changes. The effect of cadmium greatly depends on its dose and exposure time as well as dietary content of iron, zinc and copper [6]. Occupational exposure to cadmium can lead to glomerular and bone damage with increased risk of cancer [7]. The presence of lead in fuels has contributed a lot for current human exposure. In most developed countries, the fuel content has been controlled but it is still an issue in countries like Pakistan. Early symptoms of lead poisoning in adults are commonly nonspecific and include depression, loss of appetite, intermittent abdominal pain, nausea, diarrhea, constipation, and muscle pain. The main symptoms in adults are headache, abdominal pain, memory loss, kidney failure, male reproductive problems, and weakness, pain, or tingling in the extremities [8].

During the past three decades, the determination of trace element levels in hair and nail has been the subject of continual interest in the biomedical and environmental sciences. The significance of such measurements as indices for assessing nutritional status, diagnosing diseases, identifying systemic intoxication, and/or monitoring environmental exposures, however, remains controversial.

On the one hand, hair and nail can be considered to be an excretory product, the trace element contents of which reflect mineral metabolism in the body. On the other hand, their concentrations bear little relation to the levels in other tissues [9-10].

Thus, the aim of the present study was to measure the heavy metals: Cu, Cd and Pb in the hair and nail sample of people living in Multan, Pakistan. In the present work, element concentrations in the hair and nail samples of volunteers dealing with metal operations and not dealing with metal operations were determined with flame atomic absorption spectrometry (FAAS). The high selectivity and sensitivity coupled with simplicity and low cost make FAAS the most widely used technique for the determination of trace elements in hair and nail samples. Purpose of this study was to find out base line information about levels of Cu, Cd and Pb in hairs and nails in our population as previously no reported data is available in this regard in our area. Significant result may lead to develop a better and easy diagnostic measure about metal toxicity particularly as screening program.

2. Methods and Materials

2.1. Sample collection

Fingernails and scalp hairs were collected from workers of different occupations and living in different areas of Multan region, Pakistan. The volunteer for the present study belong to be involved in following industries or operations: jewelry, automobile workshops, agricultural fields, industrial operations and tanneries. Before sample collection the hands of workers were washed with metal free medicated soap followed by drying with sterile tissue paper to remove any external contamination. Using sterilized scissors and nail clippers samples were collected from 15-50 year old males. Samples of about 100 mg of hair and nail were collected from each volunteer. A questionnaire given to all participants provided the following information: age, home address, nutritional habits, smoking and occupational exposure to heavy metals.

2.2. Sample preparation

These samples were scrapped and cleaned with Triton X-100, a non-ionic detergent to remove attached dust particles and washed according to washing procedure by Gammelgaard et al. [11]. Samples of were placed in beakers and stirred for 10 min periods successively with acetone, three portions of water and again with acetone; in each wash, 100 ml of solvent was used and decanted. Finally sample were dried in oven at 50˚C for 24h and stored in a desiccator. For FAAS analyses samples were wet using 10 ml of 6:1 mixture of concentrated nitric and perchloric acid by heating at 160˚C for 1h. After cooling each sample was quantitatively diluted up to 50mL using 0.1 N nitric acid [11].

2.3. Determination of toxic metals

The metal ion concentration in samples was determined using Flame Atomic Absorption Spectrophotometry (FAAS) (Model: A1800 Hitachi Japan). Standard solutions were prepared from single-element stock solutions of 1000 ppm from Merck (Darmstadt, Germany). All chemical materials used in this work were of analytical grade and blank samples were prepared to avoid any contamination. The main instrumental parameters were band width, lamp current and wavelength.

2.4. Statistical analysis

Data were analyzed statistically using the arithmetic mean, standard deviation and Student t-test.

3. Results and Discussion

Metal absorption or depletion of in human tissues including hair and nail may occur due to environmental and/or occupational exposure, illness, poor diet, and ingestion of drugs or specific treatments. The relationship between concentration of trace elements in human tissues (hair and nail) and environmental exposure to metals is very complex, but still these tissues may reflect general community exposure in dustfall, household and soil. All volunteer worker involved in metal operation had mean age 32.65 ± 9.59 years. Twenty controls (no direct metal exposure) were also sampled for Cu, Cd and Pb concentrations in hairs and nails. Fifty six subjects were smokers with mean smoking period 8.5 years. Cu, Pb and Cd concentration in hair and nail samples obtained from control group was significantly lower than workers involved in some type of metal operation (Tables 1-3).

In this study different occupations have been selected to evaluate the effect of generalized and work area specific heavy metal pollution. Hair and finger nail samples were collected from 20 jewelers, 20 automobile worker and 60 industrial (paints/dyes, fertilizer and tanneries) workers. All the subjects showed various signs and symptoms. Only 17 out of 100 volunteers did not show any symptoms related with heavy metal exposure. Blood pressure noted during present was 118.67±1.45/82.97±7. Heavy metal exposure produced joints/bone pain, headache, anemia, muscle cramp, chest distress and Weakness among individual participated in the present study. Similar type of health affect shown by Cu, Cd and Pb noted in literature [18- 21]. Metals are toxic because these bind with ligand of biological structure [13]. One of the major ever-increasing problems is the influence of pollution especially heavy metals contaminants. When such toxic metals accumulate & become threat to the human health then determination of their level become important in terms of easy & effective diagnosis. Hairs and nails act as an indicator of body stores of heavy metals [12]. Average amount of Cd detected in hair and nail samples was 143.57 ± 52.01 and 104.71 ± 49.54 µg/gm, respectively. The detected amount of Cd in worker group was significantly different from control group. High stand deviation values were obtain in case of Cd. Amount of Cd detected in hair and nail sample of 19 workers was between 100-200 µg/gm and other 46 workers was 84-99 µg/gm. Such group fluctuation was not observed in case of Cu. One obvious reason for raised cadmium level in subjects is presence of 56 smokers out of 80 subjects [14]. Cause of raised copper and cadmium levels in hairs may be environmental pollution. Metal cleaning operations, leather tanneries, copper pipe, electronic instrument, jewelry and copper welding are source of copper and cadmium pollution. Considerable level of copper may be present in municipal sewage, bulk of this originates from industrial discharge [15]. Excessive Cd exposure has been occurred in general population through ingestion of contaminated food and water [16].

Table 1: Determination of heavy metals (µg/g) in forty fingernails and hairs samples of Jewelers

Age	Experience	Jewelry workers					
		Cu		Cd		Pb	
		Nails	Hairs	Nails	Nails	Hairs	Nails
20-30	10	38.62±5.73*	23.25±6.42*	45.31±12.28*	25.43±15.34*	10.5±4.87	4.2±0.63
30-40	20	63.70±7.71*	56.65±7.23*	74.10±18.21*	58.21±17.82*	14.5±6.21	9.7±5.10
40-50	30	94.43±13.24*	77.21±9.14*	98.39±26.82*	80.11±27.23*	18.2±7.11	13.1±6.79
50-60	40	119.34±17.81*	89.21±13.10*	129.31± 39.27*	93.21±31.20*	23.5±7.84	15.4±7.52
60-70	50	130.79±26.01*	99.34±19.24*	143.57±52.01*	104.71±49.54	27.9±8.01	20.9±7.89

Table 2: Determination of heavy metals (µg/g) in forty fingernails and hairs samples of Automobile workers

Age	Experience	Automobile mechanics/workers					
		Cu		Cd		Pb	
		Nails	Hairs	Nails	Nails	Hairs	Nails
20-30	10	43.62±6.73*	38.25±7.42*	7.83±3.54*	4.62±1.31	24.54±6.87*	19.35±4.76*
30-40	20	69.70±7.71*	65.55±13.23*	12.15±5.63*	9.75±4.56*	39.5±7.67*	27.32±5.60*
40-50	30	98.43±13.24*	89.21±17.14*	18.95±6.90*	13.87±5.92*	46.29±8.98*	41.18±6.07*
50-60	40	139.34±17.81*	109.61±23.10*	29.25±7.84*	19.21±7.11*	61.25±11.51*	52.89±7.89*
60-70	50	157.67±32.11*	121.56±29.24*	38.60±9.53*	25.87±7.65*	85.79±12.54*	72.45±11.56*

Table 3: Determination of heavy metals (µg/g) in sixty fingernails and hairs samples of Industrial workers

Age	Experience	Industrial workers					
		Cu		Cd		Pb	
		Hairs	Nails	Hairs	Nails	Hairs	Nails
20-30	10	60.25±14.53*	43.25±8.40*	0.27±0.15	0.21±0.13	38.14±9.83*	29.31±4.56*
30-40	20	73.70±17.71*	65.50±13.21*	0.35±0.17	0.28±0.16	48.5±13.62*	35.67±9.41*
40-50	30	85.24±21.20*	74.26±17.46*	0.38±0.22	0.34±0.21	69.29±18.91*	56.71±12.47*
50-60	40	97.60±24.57*	84.62±21.18*	0.47±0.25	0.42±0.24	87.25±21.56*	74.89±17.83*
60-70	50	106.34±32.12*	93.80±29.25*	0.58±0.29	0.49±0.27	103.79±26.34*	89.5±11.56*

Note: For tables 1-3, all the values in Mean (µg g^{-1} ± SD), * Values are significant at $p<0.01$

Lead contamination was higher in automobile and industrial workers in comparison to control subjects. The main symptoms in all the subjects observed from the questionnaire were headache, abdominal pain, kidney failure, male reproductive problems, and weakness which are according to the symptoms observed by Pearce [8]. All heavy metals cause Mees' lines on the nails. These usually begin a few months after significant exposure starts and may be useful in identifying the source of exposure. All the subjects with prolonged exposure (15-30 years of experience) exhibit the Meees lines. In this study we found tht subjects suffering from these lines have a hevy body burden of cadmium and lead metals in their body in addition to other symptoms observed. Contaminated water from water tankers may be a source of high levels of lead. The concentration of all the heavy metals in hairs may be affected by dust attached to hair, while nails samples are more strongly related to the concentration absorbed by the body. The higher levels of lead and cadmium are also related with the traffic and industrial exhaust [17]. In addition open burning of plastics and bricks and other activities are contributing to higher levels of heavy metals.

WHO guidelines show that maximum venerable Cu, Cd and Pb amount in hair/nail (μg/gm) is 20, 10 and 0.2 μg/gm. The results of the present study, clearly demonstrate that individual participated in the present study were exposed to increased heavy metal concentration [22].

Acknowledgments

Authors would like to thank Prof. T.M. Ansari for his useful suggestions and help in FAAS analysis.

References

[1] L. Jarup. (2003). Hazard of heavy metal concentration. British Medical Bulletin. 68: 167-182.

[2] J. M. Besser, C. A. Mebane, D. R. Mount, C. D. Ivey, J. L. Kunz, I. E. Greer, T. W. May and C. G. Ingersoll. (2007) Sensitivity of mottled sculpins (Cottus bairdi) and rainbow trout (Onchorhynchus mykiss) to acute and chronic toxicity of cadmium, copper, and zinc. Environmental Toxicology and Chemistry. 26(8):1657-65.

[3] M.A. Khan and S.A. Khan. (1989). Environmental pollution; A Menace to Public health: Science International. 1(6) 400-408.

[4] R. Nath. (2000). Health and Disease: Role of Micronutrients and Trace Elements. APH Publishing Corporation, New Delhi. pp: 650.

[5] M. Mathrani and Z. Khwaj. (2001). Content of metals in drinking water of Hyderabad. Pakistan Journal of Chemistry. 29: 34-38.

[6] J. Witkowska, D. Czerwińska, A. Kiepurski, and W. Roszkowski. (1991). Harmful elements versus iron, zinc and copper: their interactions in animals and humans. I. Mercury, tin, nickel, selenium, fluorine and aluminum. Rocz Panstw Zakl Hig. 42(1) 15-23.

[7] L. Jarup and A. Akesson. (2009). New Insights into the mechanisms of cadmium toxicity-advances in cadmium research. Toxicol. Applied Pharmacology. 238: 201-208.

[8] J.M. Pearce. (2007). "Burton's line in lead poisoning". European neurology. 57 (2) 118–119.

[9] M. Popovic, F.E. McNeill, D.R. Chettle C.E. Webber, C.Y. Lee and W.E. Kaye. (2005). Impact of occupational exposure on lead levels in women. Environ. Health Perspectives. 113: 478-484.

[10] M.N. Rashed and F. Hossam. (2007). Heavy metals in fingernails and scalp hair of children, adults and workers from environmentally exposed areas at Aswan, Egypt. Environ. Bioindicators. 2: 131-145.

[11] B. Gammelgaard, K. Peters and T. Menno. (1991). Reference values for the nickel concentration in human fingernails. Journal of Trace Element and Electrolytes inHealth Diseases. 5: 121-123.

[12] M.N. Chattergea, R. Shinda. 2004. Text book of medical biochemistry 2004, 6th edition. Metabolism of minerals and trace elements. pp: 547-554.

[13] P. Sanaulllah. (2000). Tobacco and cancer a case study. Journal of Science and Technology University of Peshawar. 24 (1-2) 53-57.

[14] M. Wolfsperger, G. Hauser, W. Gössler, C. Schlagenhaufen. (1994). Heavy metals in human hair samples from Austria and Italy: influence of sex and smoking habits. Science of Total Environment. 156(3) 235-42.

[15] T.C. Timmreck, and G.Shook. (1992). Environmental-Health and Occuptional-Health Implications of baritosis, A Pneumoconiosis. Journal of Environmental Health. 55: 22-26.

[16] T. Kjellstrain, K. Shiroishi and P. Evrin. (1997). Urinary z-microglobin Excretion among people exposed to cadmium in the general environment. And epidemiological study in cooperation between Japan and Sweden. Environmental Research. 13: 318-344.

[17] N. Hasan, D. Emery, S.I. Baithun and S. Dodd. (1995). Chronic copper intoxication due to ingestion of coins: a report of unusual case. Human Experimental Toxicology. 14: 500-502.

[18] B. Nowak and J. Chmielnicka. (2000). Relationship of lead and cadmium to essential elements in hair, teeth and nails of environmentally exposed people. Ecotoxicology and Environmental Safety. 46: 265-274.

[19] D.J. Weatherall, J.G.G. Lodingham and D.A. Warrel. (1996). Oxford Text Book of Medicine 3rd Ed. New York; Oxford University press inc.

[20] G. Bouley, A. Dubrevil, N. Despause and C. Boudene. (1977). Toxic effect of Cadmium microparticles on respiratory system. Scand. Journal of Work. Environment and Health. 3: 116-121.

[21] A. Bernard and R. Lauwerys. (1984). Cadmium in human population. Experentia. 40: 143.

[22] M.N. Rashed and F. Hossam. (2007). Heavy metals in fingernails and scalp hair of children, adults and workers from environmentally exposed areas at Aswan, Egypt. Environmental Bioindicators. 2: 131–145.