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Full Length Research Paper

Hairs as biomonitors of hazardous metals present in a work environment

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Human beings come across metal exposure not only through contaminated water and food, but through their metal body burden which increases by working in the environment that is contaminated and not safe. These hazardous metals present in the workplace increases the risk of both illness and injury. Illness tends to develop over time following repeated exposure to a hazard, whereas injury usually occurs instantly. Human biomonitoring is a popular method to cogitate the metal exposure of the work place. The present investigation was carried out to access the metal body burden of males belonging to different profession by using hairs analysis, which is one of inexpensive and useful biomonitors of occupational exposure of hazardous metals. Among the three groups under study (such as traffic constables, cloth dyers and office workers), lead and zinc concentrations were detected to be higher among traffic constables, while hairs analysis of cloth dyers show that copper, chromium, cadmium and manganese were present in greater amount as compared to other groups. Intra correlation of these metals among all categories was also carried out. Lead showed antagonistic relation with zinc, chromium, cadmium and manganese and synergistic relation with copper in the case of traffic constables. The present study reveals that metal toxicity in hair samples of office workers, dyers and traffic personnel, vary with their occupation. So there is instantaneous need for public awareness about the hazards of different occupations in order to enable these personnel take necessary precautionary measures.

Key words: Metals, occupational, toxicity, hair, traffic personnel, dyers, office workers.

INTRODUCTION

Biomonitoring of metal concentrations in the human body have great importance because their levels in biological samples (hairs, nails, blood, saliva and urine) can be employed as an index of metal contamination of their surrounding medium. Biological monitoring (BM) is the assessment of workplace agents or their metabolites either in tissues, secreta, excreta or any combination of these to evaluate exposure and health risks (Zielhuis and Henderson, 1986). The unit being measured is termed biomarkers. There are biomarkers of exposure, effect and susceptibility. Biomarkers of exposure identify and measure xenobiotics in tissues or body fluid. However, hair metal analysis is one of the popular biomarker of metal exposure (Guidotti et al., 2008).

Metals concentration in hairs reflects absorption from all sources, including occupational exposure, diet hobbies, medication, smoking and combustion of fuels. These contaminants are incorporated into the organism by different routes such as dermal, pulmonary and oral. The most important route on the basis of absorption is the pulmonary route, which offers least resistance to environmental contaminants. After being absorbed, these contaminants are distributed into the body, where they

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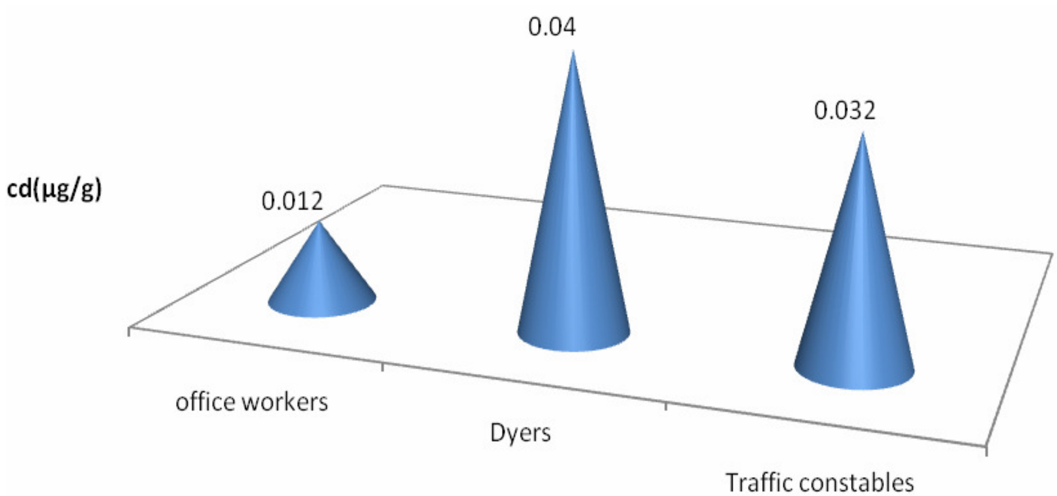

Figure 1. Comparison of cadmium concentration (ug/g) in hair samples of males from different working environments.

alter the internal concentrations and produce deleterious health effects that are eliminated or stored in different body organs and tissues (hairs, nails, blood and fat) (Marta and Argelia, 2008).

Hair, as compared to other biological samples, is considered as the best one not only because it is inexpensive, easy to collect and stored, but also because it reflects long term exposure to these contaminates. Elemental analysis of hair samples has been widely used to assess human exposure to different contaminates present in the environment (Schuhmacher et al., 1991; Wilhelm et al., 1994; Schuhmacher et al., 1996; Sen and Chaudhuri, 1996) or at workplace (Jamall and Jaffer, 1987; Ashraf et al., 1994).

Concentration of metals in hair reflects their mean level in the human body during a period of 2 - 5 months. Human nails indicate the level over a longer period of time, that is, 12 - 18 months (Nowak et al., 1991). Hair is also an excellent indicator of past changes in metabolism and environmental exposure of metals (Ashraf et al., 1995b; Ajayi et al., 2001).

The aim of the present investigation was to evaluate the relationship between occupational exposure and metal concentration in hair samples of those professionals working in that environment.

MATERIALS AND METHODS

Hair samples were collected from the residents of different areas of Sargodha District with their own consents. Samples were collected from traffic constables, dyers and office workers. Hairs were collected from different scalp areas of the head (1 to 2 cm) by using stainless steel scissors. There was an assurance that no dye or hair color had been used on hairs. Each sample was stored in a plastic bag after allocating specific codes to them. In order to remove external contamination such as dust particles, each sample was soaked in distilled water after cutting it to smaller pieces.

Each sample was finally washed with carbon tetrachloride, in order to remove a sufficient amount of oil and grease from it. The washing procedure was also necessary to ensure that salts of Na, K, Mg and Ca, which are normally accumulated by these tissues during growth, were quantitatively removed. This washing procedure is an agreement with the observations of Ndiokwere (1985) and Bate and Dyeer (1967). About 100 mg of each sample was taken in a properly washed and labeled Erlenmeyer flask. Acid digesting solution, 5:1 ratio (nitric acid and perchloric acid), was added to the sample and incubated overnight at room temperature. These samples were shifted to hot plate, and were finally removed when they became water clear. Samples were poured into volumetric cylinders. Double distilled water was added into the samples up to the mark of 25 ml. After filtration, the solution was transferred into marked Teflon bottles. Running through, wet acid digested samples were subjected to analysis through Atomic Absorption Spectrophotometer (AA 6600, Shimadzu) for determination of metal concentration.

RESULTS AND DISCUSSION

The workplace man may be exposed to the elevated levels of known and unknown chemicals, apart from environmental exposure. Almost two centuries ago, cancer of the scrotum and testicles in chimney-sweepers was the first recognized occupational cancer (Pott, 1975). Since then, other numerous hazardous occupational activities have been traced (Farmer et al., 1987). The analysis of professionals’ biological material was carried out to evaluate the group/types of trace metals responsible for toxicity in affected individuals.

Graphical data (Figures 1 to 6) depict the concentration of metals among different professionals. In accordance to

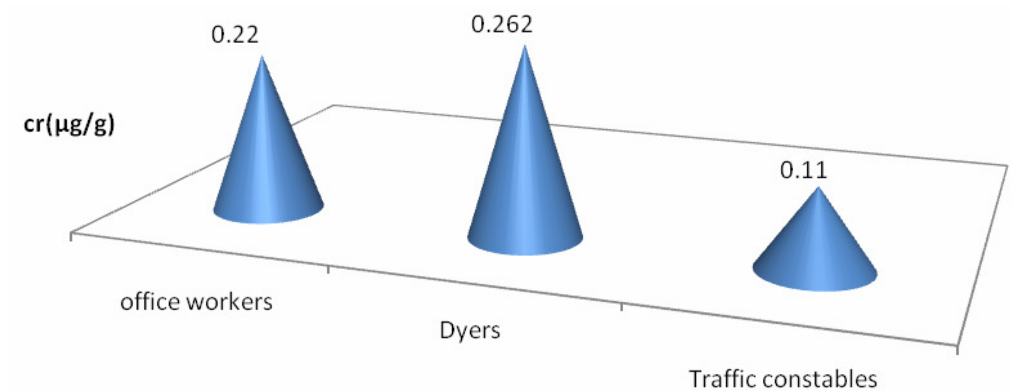

Figure 2. Comparison of chromium concentration (ug/g) in hair samples of males from different working environments.

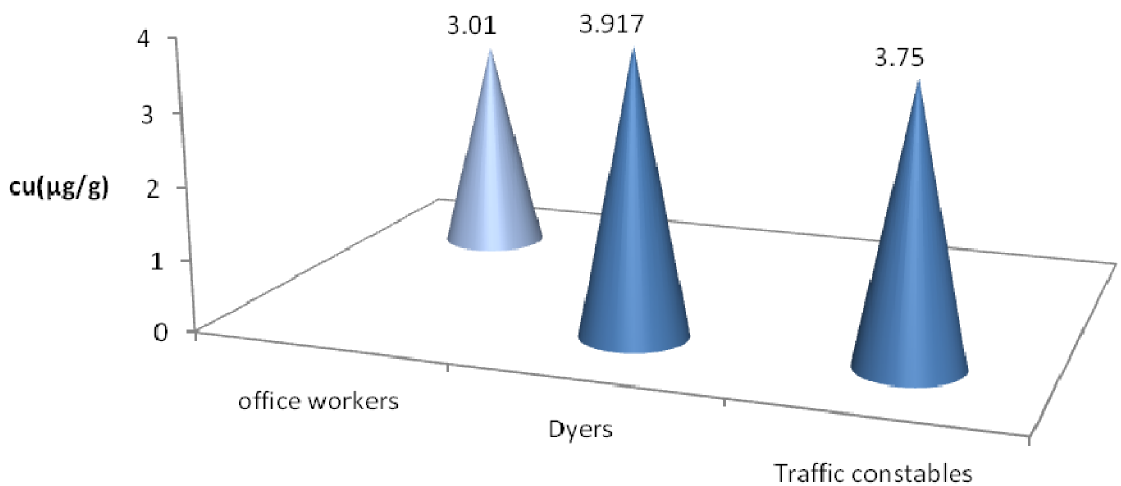

Figure 3. Comparison of copper concentration (ug/g) in hair samples of males from different working environments.

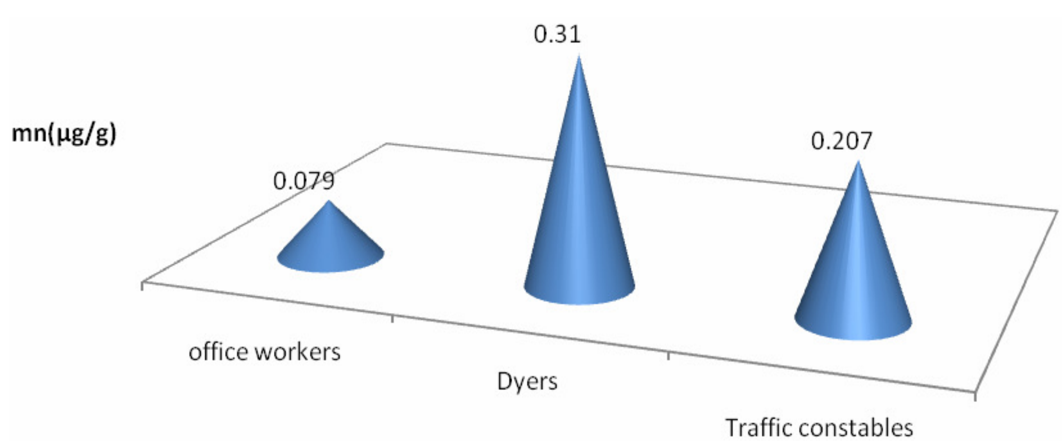

Figure 4. Comparison of manganese concentration (ug/g) in hair samples of males from different working environments.

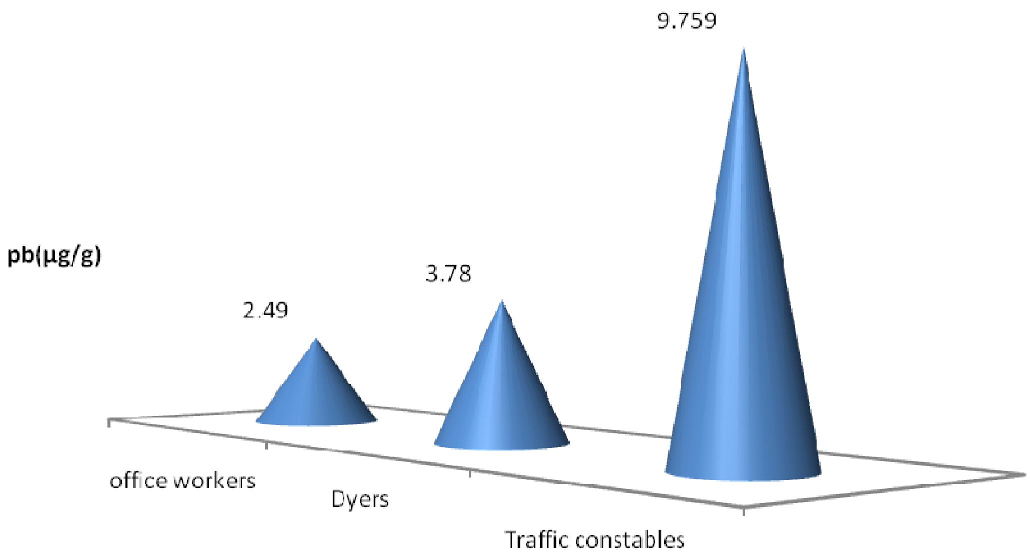

Figure 5. Comparison of lead concentration (ug/g) in hair samples of males from different working environments.

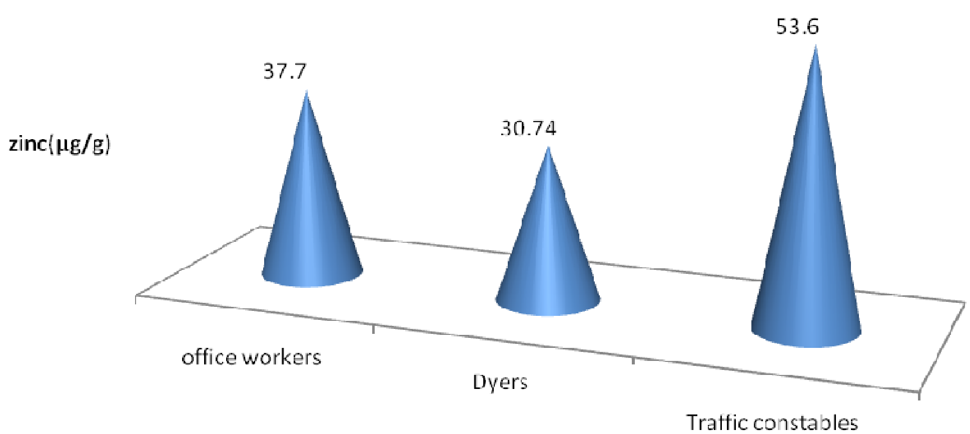

Figure 6. Comparison of zinc concentration (ug/g) in hair samples of males from different working environments.

the study's expectation, the lowest values of metals were found in the office because their workplace is the safest as compared to other workers. Among three categories, lead level was the most differentiating parameter. Concentration of lead was higher among the traffic constables who remain exposed to vehicle smoke throughout the day. Vehicle smoke is one of the major contributors to lead pollution.

Lead is one of those metals, which are highly toxic to human beings because it is known to easily dissolve in blood and can be transported to non-active tissues like hair, nails and bones for storage (Pozebon et al., 2000). Lead toxicity, especially chronic toxicity of lead, has been recognized as the major global health problem inclusive to Pakistan. In this scenario, traffic constables are at a high risk of diseases caused by lead toxicity. The results of this investigation study corroborate with the findings of Marlowe (1983) who reported that the concentration of lead and other heavy metals provide an accurate and permanent record of exposure. Zinc deficiency was found in the above studied groups. These values were lower than the ones described by Nnorom et al. (2005) and

Table 1. Correlation among metals in hair samples of traffic constables.

Heavy metal	Lead	Zinc	Cadmium	Chromium	Manganese	Copper
Lead	1					
Zinc	-0.01559	1				
Cadmium	-0.05395	-0.00829	1			
Chromium	-0.0844	-0.21305	-0.287122699	1		
Manganese	-0.17964	0.25521	-0.0282619	0.157952004	1	
Copper	0.542271	-0.01607	-0.099075367	-0.027704392	-0.251693155	1

Table 2. Correlation among metals in hair samples of cloth dyers.

Heavy metal	Lead	Zinc	Cadmium	Chromium	Manganese	Copper
Lead	1					
Zinc	0.183573	1				
Cadmium	-0.09976	-0.07097	1			
Chromium	-0.03286	-0.21785	0.163914	1		
Manganese	-0.16716	-0.27094	0.313055	0.219318	1	
Copper	0.060293	0.148183	-0.01963	0.114381	0.100777	1

Rosberg et al. (2003); they obtained zinc levels of 117.2 and 174 ug/g, respectively.

The consequences of zinc deficiency are several and are impacted on human health severely (Prasad, 1993). Millions of people throughout the world may have inadequate levels of zinc in their diet due to limited access to zinc-rich foods (animal products, oysters and shellfish) and the abundance of zinc inhibitors, such as phytates, which are common in plant-based diets (Sandstead, 1991). Zinc deficiency is largely related to inadequate intake or absorption of zinc from the diet, although excess losses of zinc during diarrhea may also contribute (Gibson, 1994; WHO, 1996). Besides nutritional deficiency of zinc, there are many other clinical conditions which may result in zinc deficiency. These include other mal-absorption syndromes, chronic alcoholic liver disease, chronic renal disease, sickle cell disease, and total parenteral nutrition, if zinc is not replaced adequately following the use of chelating agents such as penicillamine therapy in Wilson's disease, and various chronic debilitating illnesses. Higher concentration of manganese, copper, cadmium and chromium were detected in the hairs of cloth dyers as compared to the other two categories such as traffic constables and office workers. The concentration of these four metals in cloth dyers were found in this ranking order; copper > chromium > manganese > cadmium. Among humans, route of potential exposure to colorant is inhalation. Biologically, insoluble pigment would be removed from the airways by clearance mechanism. Chromates are technically important pigments which are well investigated. Biochemical and toxicological research on chromates has shown that the common toxicological principle of chromates, which penetrate the cell membrane and after intracellular transformation, exert genotoxic effects, is the chromate anion (Hermann, 2005). Statistically, significant difference was present among all categories of the studied metals.

Correlation studies

Correlation studies revealed that there was a synergistic relation between zinc and manganese, chromium and manganese and lead and copper in the case of traffic constables (Table 1), while antagonistic relationship was present between lead versus zinc, lead versus chromium, and lead versus manganese. In the case of cloth dyers and office workers, lead was positively correlated with zinc, while negative correlation was found between manganese versus lead, zinc versus cadmium and zinc versus chromium in these categories (Tables 2 and 3).

Conclusions

Concentration of metals elevated up to toxic levels in the workers who remain exposed to these substances for a longer period of their duty without any precautionary measure. Continuous exposure leads to the accumulation of toxicants that can produce adverse health effects in an exposed population.

Table 3. Correlation among metals in hair samples of office workers.

Heavy metal	Lead	Zinc	Cadmium	Chromium	Manganese	Copper
Lead	1					
Zinc	-0.20595	1				
Cadmium	0.030778	0.407021575	1			
Chromium	0.134006	-0.198288005	-0.29630459	1		
Manganese	-0.20215	-0.050073586	-0.123971415	-0.094415351	1	
Copper	-0.07154	0.39798756	0.325713758	0.247522248	-0.001934448	1

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