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# Biomonitoring of Metal Exposure of Humans in the Occupational Environment and Their Associated Hazards

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**Abstract:** The problem of exposure to toxic metals in work environment exists since long even when no proper management of workplace was done by industrialists. Until today effective management practices are lacking leading to metal pollution in the work environment of workers exposed to metals in their environment. Implementation of proper preventive measures necessitates assessment of metals in the environment in view of hazards of exposure to trace toxic metals. Biomonitoring helps in assessment of metals in the environment using human body tissues and fluids as biological materials. In the present study total 40 workers were included as subjects out of which, 20 were exposed to metals at workplace and 20 were taken as respective controls. Head hair samples were collected from all subjects, hair samples were pretreated for washing with Triton X-100, acetone and deionized water. All hair samples were digested using wet acid digestion method to get colourless solution prior to analysis for manganese, cobalt, copper, lead and cadmium with an Atomic Absorption Spectrophotometer (AAS), ECIL Model-AAS4129. Student t test was applied to compare the means and Spearman's rank correlation coefficient was calculated to study the correlation among trace and toxic metals. Results of the study help in identifying hazards of metals and sites of metal exposure leading to suggesting measures for better occupational environment for the exposed subjects.

**Keywords:** Biomonitoring, Atomic Absorption Spetrophotometer, Occupational Hazards

## 1. Introduction

The increased awareness of occupational health, hygiene and safety in past decades has resulted in improvement of working conditions in recent years and in reducing workers' exposure to many toxic substances. However, substantial hazards remain the same, the number of cases of occupational illness due to hazardous exposure is still high and new cases will continue to occur if there are no further improvements. Investigations in past years have revealed a number of examples of unreported health problems related to occupational exposure [1-4]. New problems have appeared with changes related to energy development, biotechnology, electronics, chemicals and other industrial activities [5-6]. There is an increasing tendency to develop essentially ambient, but also biological limits and to develop methods of ensuring their implementation, there by preventing health damage from exposure to toxic substances. Aspects of monitoring include providing information to help achieve compliance with standards, ensuring reliability of measurements and accumulating information for later revision of the standards [7].

In the present study concentration of manganese, cobalt, copper, lead and cadmium were determined in hair of workers and control subjects. Total 40 male subjects were included in the study, out of which 20 were controls who were not exposed to metals at their workplace and remaining 20 subjects were exposed to metals at their workplace. Hair samples were collected from all subjects under study and information relevant with subjects was obtained from a questionnaire recommended by World Health Organization (W.H.O.). Hair samples were washed and digested and analyzed using Atomic Absorption Spectrophotometer [8]. It was hypothesized that subjects under study are exposed to metal pollution at their workplace and these metals accumulate in their body. It was also goal of this study to determine the correlation, if any between manganese, cobalt, copper, lead and cadmium in hair. The main aim of this study was to identify the population at risk to exposure to metals in occupational environment.

## 2. Materials and Methods

Selection of site for possible metal exposure was carried out to identify the subjects and controls for the present study. Forty male subjects were included in this study, out of which 20 were controls, which are not exposed to metals at their workplace, 20 subjects were exposed to metals at their work place. Approximately 2 gm of head hair samples from nape region with 1 cm distance from scalp were collected using a stainless steel scissor and stored in airtight polythene. The scissor was prewashed with acetone and alcohol to remove contaminants. While sampling, other relevant in formation of subject like age, sex, occupation were also obtained from a questionnaire recommended by World Health Organization (W.H.O.).

Hair samples were washed to remove external contamination with non-ionic detergent (Triton X-100), acetone and deionised water and kept for drying at 110°C for one hour in oven [9-10]. Washed and dried samples were then digested using an acidic mixture of Nitric Acid and Perchloric Acid in 6:1 ratio in a fumehood chamber, until a colourless clear solution is obtained [11-12]. All chemicals used in washing and digestion of hair samples were of ARgrade. The acid is now evaporated and white residue is then dissolved in 0.1N Nitric Acid. The quantitative analysis of five metals under study viz. manganese, cobalt, copper, lead and cadmium was performed with an Atomic Absorption Spectrophotometer (AAS) using airacetylene flame. Separate cathode lamps were used for separate metals. The main instrumental parameters (like wavelength, bandwidth, lamp current) were set up separately for the estimation of specific metals by Atomic Absorption Spectrophotometer. The value of metal concentrations in hair was expressed as the mean value in μg/g with standard deviation. Student t test was applied to compare the means and Spearman’s rank correlation coefficient was calculated to study the correlation among trace and toxic metals.

## 3. Results and Discussion

Mean and standard deviation of manganese, cobalt, copper, lead and cadmium in hair samples have been calculated and presented in Table 1. Mean manganese concentration in hair of subjects occupationally exposed to metals was 5.83μg/g (±2.69μg/g) that was higher than 7.28μg/g (±6.58μg/g) of controls. Cobalt concentration in hair of subjects occupational exposed to metals 0.67μg/g (±0.25μg/g) and those of control were 0.51μg/g (±0.26μg/g). Mean copper concentration in hair of subjects occupationally exposed to metals was 10.82μg/g (±4.36μg/g) that was higher than 13.11μg/g (±8.02μg/g) of controls. Lead concentration in hair of subjects occupational exposed to metals 23.29μg/g (±20.76μg/g) and those of control were 16.76μg/g (±14.19μg/g). Mean cadmium concentration in hair of subjects occupationally exposed to toxic was 1.25μg/g (±1.36μg/g) that was lower than 0.62μg/g (±0.79μg/g) of controls.

***Table 1.*** *Range and mean of manganese, cobalt, copper, lead and cadmium concentration in hair of Exposed and Controls.*

| Metals | Exposed Subjects | | Controls | |
|---|---|---|---|---|
| | **Range (μg/g)** | **Mean ± SD (μg/g)** | **Range (μg/g)** | **Mean ± SD (μg/g)** |
| Manganese | 2.33-16.35 | 5.83(2.69)* | 1.86-48.72 | 7.28(6.58) |
| Cobalt | 0.05-0.99 | 0.67(0.25) | 0.02-0.97 | 0.51(0.26) |
| Copper | 4.08-23.28 | 10.82(4.36)* | 5.07-65.02 | 13.11(8.02) |
| Lead | 1.02-75.21 | 23.29(20.76)* | 2.31-56.02 | 16.76(14.19) |
| Cadmium | 0.01-4.39 | 1.25(1.36)* | 0.01-3.18 | 0.62(0.79) |

*P<0.05.

The concentration of manganese and copper in hair of exposed subjects was significantly lower as compared to controls. Concentration of lead and cadmium in hair of Exposed subjects was significantly higher as compared to controls. This result is supported by reported works [13-14]. Significant negative correlation at P<0.05 was observed between Pb/Mn, Pb/Cu, Cd/Mn and Cd/Cu concentration in hair of exposed subjects. Significant positive correlation at P<0.05 was observed between Pb/Cd in hair of exposed subjects. The negative correlation indicates that accumulation of lead and cadmium in hair affects the concentration of manganese and copper [15]. The positive correlation between Pb and Cd in hair supports the study done by Telisman et al. (2000) on trace metal level in blood and seminal fluid [16].

The significant difference of metal concentration in hair of workers with different work environment is also supported by our earlier works [15]. The results suggests that various toxic and trace metals can interact by influencing each other’s absorption retention distribution and bioavailability in the body this is in support to the reported work [17-18].

## 4. Conclusion

These result showed that workers are exposed to toxic metals and these toxic metals get accumulate in body tissues and affect the concentration of trace elements as well as trace metals at their workplace. This exposure has accumulated metals in the body, hair as one of the fastest growing tissues of body also accumulates these metals in them. Therefore hair is best suited for such type of study involving occupationally exposed workers. These metals alter the normal biochemical reactions of body and causes adverse health hazards. Important preventive measures are to be taken to protect workers from being exposed to metals at their workplace.

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