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Trace Cadmium Concentration in Scalp Hair of Workers in a Locomotive Workshop

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Abstract. Cadmium, a highly toxic non-essential metal, is one of the potential environmental hazard. Excess concentration of cadmium causes gastrointestinal disturbance, hypertension, kidney problems and anaemia. The present study was taken up to investigate the cadmium levels in the hair of workers of a locomotive workshop.
The cadmium content in the hair of 80 male subjects working in various sections of a locomotive workshop was assayed by means of Atomic Absorption Spectrometry, following the wet acid digestion procedure. The results of the study are given in this paper.

Introduction

Cadmium does not occur free in nature. It occurs in rocks and soils in inorganic forms principally as the sulphide greenockite. In addition to inorganic form, it is also bound to organic compounds in plants. In human body it is bound predominantly to a protein called metallothionein.[1-2]

Cadmium was recognised as an occupational hazard a century ago on the basis of its acute toxicity[3]. The chronic toxicity of cadmium was known in 1955 as bone decalcification in the victims of itai-itai disease. It was caused by ingestion of food and water contaminated with cadmium. Cd ingestion also resulted in damage to the kidneys and renal tubular dysfunction. The mechanism of Cd toxicity may involve inactivation of sulfhydryl containing enzymes competition with zinc and inhibition of copper absorption[4]

The present study was undertaken to estimate the cadmium body burden of the workers of locomotive workshop Ajmer in Rajasthan State, using hair as diagnostic tool. In locomotive workshop cadmium is used as a constituent of easily fusible alloys, soft solder, electroplating, deoxidizer in nickel plating, photoelectric cell and in nickel-cadmium storage batteries. In view of the different type of works viz., moulding, pouring of molten material, mixing of sand, removal of slag from cupla and furnace, melting of brass, aluminium and various ferrous and non-ferrous alloys, the workers are exposed to different metals. Few of these may become a potential hazard when they exceed an optimum value. The exposure of metals in the workshop may occur from inhalation of metal dust or fumes. Heated metal volatilizes and burns to form fumes of metal oxides (Cd0). It is reported that a concentration as low as 0.1 mg cd/m^3 in air may cause toxic manifestations and levels of 1mg cd/m^3 and above may be fatal[5]. The exposure to such workplace atmosphere is reflected by elevated concentrations of heavy metals in the workers hair.

In addition to airborne heavy metals the likelihood of ingesting them from contaminated food and water is also high. The heavy metal hazards are often discovered in ambient monitoring programmes by public health agencies but hair analysis has found frequent application in identifying such occupational exposures e.g. from food.

The present work is emphasized on studying the variation in cadmium levels in the workers of different age groups and its correlation if any, with smoking and food habits of the subjects taken for study.

Material and Method

In this study, hair, the smallest excretory unit for trace elements in the human body is used as biopsy material. As per literature at least 40 elements have been reported in human hair[6]. According to Hammer *et al*[7] hair can better reflect the total body pool of some elements than either blood or urine and can therefore be a practical dosimeter for monitoring elemental environmental pollutants. Lenihan, Smith and Harvey[8] have used hair analysis to monitor Hg hazards in the occupational environment of the dental profession and Chattopadhyay *et al*[9] have used scalp hair as a monitor of community exposure to lead. Strain *et al*[10] extended the use of hair as an indicator of elemental stores in the body to assessment of Zn nutritional status in Egyptian dwarfs.

Hair analysis for monitoring metal burden of the body is advantageous because it can be conveniently obtained easily stored, correctly analysed, easily transported and above all it can retain elements for longer time as compared to blood and urine[11]. The sulfhydryls or the disulfides of the hair protein have been proposed as the binding sites for heavy metals. the amino groups may also be involved. The binding of endogenous trace elements in the fully keratinized hair is assumed to be irreversible or at least quite firm.[12]

Prior to collection of hair samples, the subjects of various age groups were further grouped in accordance with their smoking and food habits. This was ascertained while sample collection, when the data regarding the personal history of the subjects was obtained by filling the questionnaire as per recommendation of WHO[13-14]. The collected hair samples were cut into pieces of about 1cm in length, washed with deionized water and then soaked in non-ionic detergent to remove exogenous deposition followed by rinsing thrice with deionized water and then dried at 110°C. The dried hair samples were digested using wet acid digestion method and a water clear solution is obtained[15-17]. The sample solutions was analysed for cadmium using Perkin Elmer USA. AAS Model-5000 with graphite furnace and air acetylene flame. The main instrumental parameters for the analysis by AAS were as follows:

Wavelength : 228.8nm, Bandwidth : 0.7nm and lamp current : 0.25mA

Results and Discussion

The mean level of cadmium in hair of controls were 0.181 (S.D. 0.146) $\mu g/g$ and in occupationally exposed subjects were 0.288 (S.D. 141) $\mu g/g$. On comparing the two it was found that exposed subjects had higher levels of cadmium. This can be attributed to the presence of Cd in the working environment. In occupational exposure the respiratory and gastrointestinal tracts constitute the major route of absorption of Cd. About 165 times and 140 times increase in hair Cd concentration of exposed workers relative to controls have been reported by Anke and Bruckner respectively. (18-19). The data of Cd levels in exposed and controls subjects was also subjected to statistical analysis. The results of statistical analysis show that although the hair cadmium levels are not very significant relative to controls but they do reflect cadmium exposure.

Annova Table 1

S.No.	Source of Variation	d.f.	Calculated T	Tabulated T	Signified level
1.	Between Age Groups	$n_1 = 3, n_2 = 3$	14.02	9.3	S
2.	Between Exposure	$n_1 = 1, n_2 = 3$	8.36	10.1	N.S.

The exposed subjects were further categorised on the basis of smoking habit and the cadmium levels in hair of smokers and non- smokers were estimated. The mean cadmium concentration in the smokers was found to be 0.441 (S.D. 0.339) $\mu g/g$ whereas in non-smokers it was 0.091 (S.D. 0.067) $\mu g/g$. From the resulting data there seems to be a significantly higher concentration of cadmium in smokers in contrast to non-smokers. This was initially attributed to usually higher cadmium levels due to smoking as well as Cd exposure at place of work. Chattopadhaya et al[20] found similar results in the hair of smokers residing in Calcutta but Sikorski et al[21] and Takagi et al[22] observed insignificant differences in hair element levels between non-smokers and smokers.

Smoking is a contributing factor to higher bioaccumulation of Cd in hair[23-24]. Besides occupational exposure, smokers are also exposed to cadmium that is absorbed by tobacco leaves from soil and irrigation water[25]. This cadmium is released into a smoke stream when a cigarette is burned. Heavy smokers have approximately double the Cd intake as compared to that ingested from all other sources by non-smokers. Smoking cigarettes signigicantly enhances the total body burden of cadmium with a proportionate increase in the risk of cancer[26]. Smoking habit may not be the sole etiological factor for the Cd levels in human hair, other factors also cntribute to the enhanced concentrations. When the observed data was subjected to statistical analysis the following results were obtained:

Annova Table 2

S.No.	Source of Variation	d.f.	Calculated T	Tabulated T	Signified level
1.	Between Age Groups	$n_1 = 3, n_2 = 3$	1.9	9.3	N.S.
2.	Between Smoking Habits	$n_1 = 1, n_2 = 3$	20.8	10.1	S.

The analysis of variance at P=0.05 between age groups and smoking habits clearly show (Annova-2) that the hair Cd levels are influenced by smoking habits. This can be infered because the variation in hair Cd concentration is significant between smoking habit (T calculated 20.8 is greater than T tabulated 10.2) and the same due to age (T calculated 1.9 is less than T tabulated 9.3) is non-significant. This shows that the cadmium accumulation is influenced by smoking and also that Cd exposure to workers is not significant in the workplace. (Annova Table 1). This once again implies that unlike other metals like Pb and Zn, cadmium cannot be directly categorised as an occupational hazard in a locomotive workshop but various other factors may influence its concentration and cause cadmium toxicity to subjects.

The exposed subjects were also categorised on the basis of food habit. The results of present study also reveal slightly higher Cd levels in vegetarians 0.311 (S.D. 0.385) μg/g as compared to non-vegetarians 0.237 (S.D. 0.205) μg/g. Results already reported[27] establish enhaced cadmium content of various food and food products like sugar, rice, breakfast cereals, canned tomatoes, carrots, orange juice etc.

Annova Table 3

S.No.	Source of Variation	d.f.	Calculated T	Tabulated T	Signified level
1.	Between Age Groups	$n_1 = 3, n_2 = 3$	8.5	9.3	N.S
2.	Between Food Habits	$n_1 = 1, n_2 = 3$	5.0	10.1	N.S.

The student's t-test between age groups and food habit (Annova Table 3) clearly show that there is no significant differences in the Cd levels with regard to type of food. Althoug hliterature reveals higher Cd concentration in vegetables and fruits in contrast to meat, fish etc., the non-significant results as per Annova Table-3 can be attributed to the fact that non-vegetarians workers must also be taking fruits and some vegetables occasionally, which is in agrrement with the data already reported by Carvalho et al[28].

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