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Assessment of Occupational Environment for Metal Exposure and Biomonitoring

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ABSTRACT*: The Role of Science is more confined to either the optimum use of scientific inventions and discoveries to save the environment from the adverse effects and from environmental pollution due to emanation of various kinds of pollutants. The second way, science can play its role to save the environment is by assessing the environment and explore the possibilities to reduce the pollution burden of the environment and improve the quality of the environment. From among these two ways this paper gives an insight on how to save the environment by assessing it for the various pollutants emitted in the environment. To be more specific, we shall emphasize the work environment and study the pollution of the environment with respect to metals emanated in the environment from various anthropogenic sources. The technique used in present work is Biomonitoring and it envisages use of biological tissues and fluids i.e. biological materials for determining metal levels in humans. The significance lies upon assessing the occupational environment. In the present study the assessment has been accomplished using human hair and human nails as biopsy materials. These tissues are sampled from the workers employed in sites having likely metal exposure lead and cadmium in present study and thereafter they were digested and converted to a clear solution using nitric and perchloric acid in the ratio of 6:1 by wet acid digestion method. The clear solutions contain the metal present in the work environment, one possible source of that metal found in human hair and nail. A questionnaire recommended by WHO was got filled by the subjects. The analysis for lead and cadmium was done using Atomic Absorption Spectrophotometer and subsequently data is subjected to statistical analysis followed by interpretation of results to lead to valid conclusions. Age and sex matched controls have also been taken .The results are provided in this paper.*

KEYWORDS - *Biopsy materials, Hair, Cadmium, Lead, AAS.*

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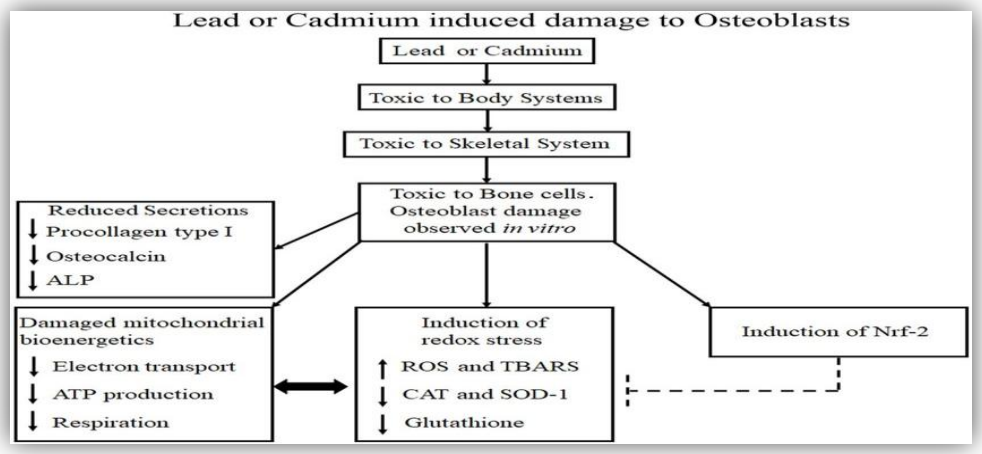
I. INTRODUCTION

Human biomonitoring (HBM) measures the levels of substances in body fluids and tissues and can be used to study time trends of these levels or to estimate the external and internal exposure of humans to substances. Therefore, HBM can be used to determine or evaluate exposure to these substances in humans. In addition, when internal concentration-effect relations are known, it is also possible to estimate whether adverse effects can be expected in a population. [1]

The main objective of this paper is to present the results of this study of lead and cadmium concentrations in hair of people suffering from various disorders in their workplace. A parametric test, the student's t test, was used to assess significant levels between the unhealthy and normal subjects at a significant level of $p < 0.05$.

According to the results of our analysis, there was a significant difference in lead and cadmium levels in subjects suffering from acidity, ophthalmic problems, hypertension, psycho logical problems, tuberculosis and their respective controls. No correlation with lead and cadmium was obtained with cardiac diseases, diabetes, hepatitis B, respiratory problems, dermatitis and hypotension. Lead exposure may cause neurotoxicity, cardiovascular effects and chronic kidney disease in humans. Nephrotoxicity is considered the primary effect of cadmium [2].

Unfortunately, humans are not only exposed to lead and cadmium via food, but also via other sources, such as smoking cigarettes, breathing air or swallowing dust. Therefore, the dietary exposure only partially contributes to the total body burden of these substances. In contrast to dietary exposure assessments, biomonitoring data take into account the absorption of a chemical by an individual through all routes of exposure(inhalation, ingestion,[3] absorption through the skin or a combination of these routes) and thus represents the individual's actual exposure level. Furthermore, estimations of the body burden obtained by biomonitoring can also be used to estimate the risk that certain adverse effects may occur.



II. MATERIAL AND METHOD

Selection of site for possible metal exposure in locomotive, roadways workshops and Pb-Cd battery units was carried out to identify the subjects and controls for the present study. This study includes 100 male subjects, the subjects were between the ages of 30 and 50, with an exposure time of 11 to 20 years. Using a stainless steel scissor, approximately 2 gm of head hair samples were collected from the nape region at a distance of 1 cm from the scalp and stored in airtight polythene bags. Other relevant details about the subject, such as age, sex, and occupation, were obtained via a questionnaire recommended by the World Health Organization (W.H.O.) throughout the sampling process. Hair samples were washed with non-ionic detergent (Triton X 100), acetone and deionised water to remove external contamination and dried in the oven for one hour at 110° C [4-5].

In a fumehood chamber, one gram of washed and dried samples were digested with an acidic mixture of Nitric Acid and Perchloric Acid in a 6:1 ratio, until a colourless clear solution is obtained [6-7]. All chemicals used in washing and digestion of hair samples were of AR grade.

The quantitative analysis of two metals under study viz. Pb and Cd, was performed with an Atomic Absorption Spectrophotometer (AAS) Model-4129 using air acetylene flame. For each metal, different cathode lamps were used. The main instrumental parameters for the estimation of cadmium by atomic absorption spectrophotometer were of the wave length: 228.8 nm, band width: 0.5 nm and lamp current: 3.5 mA. Instrumental parameter for lead, wave length: 217 nm, band width: 1.0nm and lamp current: 10 mA. Suitable statistical treatment was given to the obtained data to get mean, and test for significance was done using student‘t’ test.

III. RESULTS AND DISCUSSION

Table 1 shows the results of the quantitative analysis for cadmium levels (µg/g ± S.D.) in male human hair. The samples analysed were of subjects with health disorders and controls. Controls of the same age and sex were also selected from the same work place, i.e. sampling sites. Hypotension, hypertension, gastrointestinal problems, skin problems, diabetes, TB, hepatitis B, and mental stress were among the health issues observed. The mean Pb ans Cd concentrations, as well as their standard deviations, were treated to a parametric test, the student t-test, in order to determine the significant concentration differences between the study groups.

Table 1: Range and Mean (±SD) concentrations of Cadmium in scalp hair of subjects with health disorders and their respective controls.

Subjects	Range(µg/g)	Mean±S.D.(µg/g)
Controls	0.14-0.72	0.60±0.15
Diseased Subjects		
Skin diseas	0.30-1.89	0.64±0.31
Hypotension	0.34-1.83	0.63±0.31
Hypertension	0.22-0.99	0.91±0.17*
Mental stress	0.26-1.48	1.08±0.34*
Diabetes	0.36-0.82	0.54±0.15
Chest pain	0.60-1.21	0.84±0.18

Respiratory Trouble	0.44-0.92	0.64±0.14
Cardiovascular disease	0.47-1.79	0.76±0.28
Tuberculosis	0.32-0.64	0.43±0.08
Acidity	0.20-16.63	6.96±7.33*
Opthalmic disease	0.20-0.48	0.32±0.08
Hepatitis B	0.66-0.76	0.72±0.02

*Values Significant at P<0.05

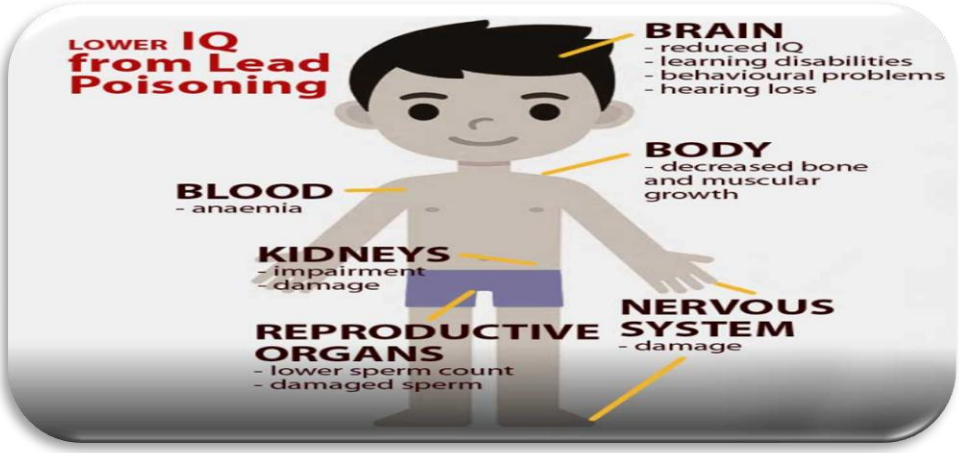
Table 2: Range and Mean (±SD) concentrations of Lead in scalp hair of subjects with health disorders and their respective controls.

Subjects	Range(µg/g)	Mean±S.D.(µg/g)
Controls	7.19-17.31	14.29-3.54
Diseased Subjects		
Skin diseas	7.63-17.19	14.22±3.28
Hypotension	8.25-19.27	14.86±3.51
Hypertension	6.81-16.17	13.42±3.39
Mental stress	10.19-26.26	23.54±3.87*
Diabetes	9.37-15.19	14.37±1.08
Chest pain	23.62-99.31	78.73±20.71*
Respiratory Trouble	9.41-15.69	14.36±1.48
Cardiovascular disease	8.19-14.39	11.16±1.86
Tuberculosis	13.29-22.94	17.30±2.63
Acidity	9.73-11.73	10.66±0.49
Opthalmic disease	10.56-12.32	11.74±0.47
Hepatitis B	8.35-9.41	8.82±0.23

*Values Significant at P<0.05

Our results indicate significant difference in cadmium levels in subjects suffering from acidity, hypertension and mental stress with their respective controls. Cd is present in hair because it has a strong affinity for hair protein. In our study group, mentally stressed people have higher Cd levels than controls, indicating a passive link between Cd levels and nervous tension. Thatcher et al [8] have done extensive research on the utilisation of hair as a diagnostic tool for evoked potentials related to hair Cd and Pb, as well as analysing the brain functions associated with these metals. Jenkins [9] observed a high level of toxic metals like Cd and Pb in hypertensive patients in his report on the presence of toxic metals in humans and mammalian tissues like hair and nail. Using hair as a biopsy material, Mederious and Pellum [10] investigated the relationship of Cd, Pb, Zn, and Cu with hypertension status, indicating that adult female hypertensives were able to absorb more of the elements than normotensives. Schroeder et al [11] has reported elevated kidney In a post mortem study of untreated hypertensive patients on male workers in cadmium exposed jobs for more than a year and their medical history, it was found that a longer period of employment was directly related to hypertension which can be interpreted in terns of environmental factors adding to cause of hypertension. The relationship between blood Cd levels, as well as hypertension, has been examined in various studies.

In a study on air pollution, Hickey et al [12] observed a correlation between the amount of Cd in the atmosphere and cardiovascular deaths. Because of the increased Cd body burden due to exposure to the metal in the workplace, our results suggested that hair could be used as an indicator for Cd toxicity. The presence of cadmium-related disorders and symptoms indicate cadmium exposure in the work environment of the subjects studied. In contrast, lower cadmium levels were obtained in hypotensive workers, which also lead to infer that cadmium is related to hypertension. In comparison to their respective controls, the mean values in our study are higher. A similar result was found in cardiovascular patients, where the mean levels were higher but the parametric test showed no significant results, despite the fact that the mean levels were higher. No statistically significant correlation could be found between the hair Cd correlations of persons with respiratory, skin, and diabetic problems.



The mean concentration of Pb in hair of subjects as a function of health disorders are shown in Table 2 alongwith that in controls. Our results indicate significant difference in Pb levels of subjects suffering from chest pain with respect to controls. From this it should not be interpreted that Pb levels that were not significantly different from the controls in subjects with respect to other diseases exhibit no metabolic defect. This may be ascribed to the fact that in determining hair Pb levels there may be possibly errors in washing procedure, collection of samples, choice of hair dyes, sprays and shampoos, which could possibly affect the results, but only to some extent. High levels of Pb in subjects with complaint of chest pain can be explained by the fact that Pb has been reported to cause heart ailments by raising the blood pressure through its attack on the specific sites and cellular elements of the nervous system [13]. Biochemical abnormalities of increased caproporphyrin concentration in urine and reduced haemoglobin levels have been observed with blood lead levels, which may lead to cardiovascular disorders causing heart ailments consequently [14-16]. High magnitude of mental retardness in children has also been reported by Shrestha and Carrera [17]. Studies carried out by Kostial and Momcilovic [18] suggest that particularly in children the mental retardation may be correlated with Pb levels in drinking water. Physiologically lead plays a role in the nervous system. A strong negative correlation between the WISC-RIQ test performance of public school children and their hair lead concentrations was found in university of Maryland, USA. They also examined the sensory evoked potentials from the same children in an attempt to delineate electrophysiological correlation of Pb and Cd. Thus it forms a diagnostic tool of evoked potentials in the assessment of brain functions related to body Pb [19].

IV. CONCLUSION

An overall view of the results obtained for Pb, Cd reveals their correlation with different diseases, thereby further strengthening the use of hair as diagnostic tool in the field of medical. However, future studies with a larger population will enhance the value of such investigations and their applications in medical and forensic sciences. Enhanced levels of lead and cadmium are well known to cause several health related abnormalities in humans affecting the central nervous system, kidney, liver and reproductive system, etc [20] Inorganic Pb and Cd were absorbed through the skin and was rapidly distributed through the body leading to abnormal blood lead levels. Being serious cumulative body poison, it can affect every [21] organ and system in the body.

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