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Trace metal status and the Impact of occupational exposure on the Serum metal content of the Laboratories staff

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Abstract

Exposure to trace metals through various sources is likely to be somewhat higher in the work place than in the external environment. Recently there has been growing interest in the problem of the health and occupational disease risks that associated with protecting workers from unsafe working conditions. However, the health risks of chemicals and exposure to the trace metals in Sulaimani city scientific laboratories has not received much attention from scientist. This study aimed to compare the trace metals (Pb, Cu, Ni, Fe, Zn, Cr, Mn) concentrations of the serum sample for the 25 exposed laboratory staff members of chemistry department, with 25 unexposed individuals consisted of healthy office employees and to assess the impact of occupational exposure on serum heavy and trace metal concentration. The serum samples were analyzed by Inductively Coupled Plasma spectroscopy (ICP-OES). The results revealed that all exposed participant had elevated level of some trace and heavy metals. The statistical analysis shows a significant difference between the mean of serum metal concentrations of exposed staff and non-exposed control. Serum lead, copper, Nickel, Iron and Zinc concentrations of exposed staff were significantly higher compared with unexposed controls ($P < 0.05$), while chromium concentrations were significantly lower ($P< 0.05$). Moreover, Manganese serum concentrations remained unaltered. Regression results of the Lead (Pb) concentration indicate that the elevation of (Pb) serum content according to other parameters show a statistically significant effect for exposing time and using PPE parameters.

Introduction

Trace metals found naturally in the environment and play an important role in human health and diseases due to their essential and toxic effects at concentrations beyond those necessary for their biological functions on human health[1]. In less developed countries where the combustion of raw fuels in the indoor environment remains a major health hazard the human trace metal exposure are continuous and is even increasing in some part of the world [2].

The widespread use of heavy metals at the workplace activities has enhanced the occupational exposure to metals as well as the health risks of metal hazards on the worker [3]. Most of the previous study findings reflect various distributions of different trace metals in the blood (plasma, serum) and another sample type like hair, nail, teeth and body fluid, which are the most common application of biological monitoring for screening, diagnosis, and assessment of such exposures and health risk.[4-10]

An earlier reported study described the methods for monitoring the degree of exposure and potential health hazards associated with worker exposed to the trace metal such as lead, Cadmium, nickel, and iron at the workplace [11]. Among 20 elements that were measured in the dust sample of the workplace and steel workers for exposing workers and compare with a control group significantly elevated levels of cadmium and lead in the whole blood sample were observed[12-14].

Deadly diseases like edema of eyelids, tumor, and congestion of the nasal membrane, muscular, reproductive, neurological, and genetic malfunction were caused by some of these trace and heavy metals [5]. Since there are a strong relationship between the chemical composition of body fluid and tissues with pathological conditions, analysis of the composition is highly significant to understand how they are correlated. Many analytical tools are available with high precision and lower detection limits, such as ICP-MS, ICP-OES, energy dispersive XRF [10,15,16].

Among people involved in electronic-waste recycling the results of serum and urine assay for heavy and trace metals showed significantly high levels of Co, Cr, Cu, Fe, Sr and Pb in the exposed worker compared to the non-exposed, this may be attributable to exposure in to the products of e-waste [17]. Others have found many correlations of essential trace metals to diseases, metabolic disorders, and nutritional status. [2,8-10]. Higher level of toxic and essential trace elements has been detected in hair sample of both petrochemical workers involved in different technological processes[18] and occupationally exposed workers from various workplace, were full-time workers of various auto workshops situated in the densely populated and industrialized city of Lahore[19]

The significant correlations have been found between skin disease and Cr, Mn, Fe, Cu; chest pain and Pb; hypertension and Cu, Mn; mental stress and Mn, Ni, Cu, Zn; liver problem and Ni; indigestion and Cr; Ni, diabetes and Cr, Mn, Ni; tuberculosis and Zn; breathing trouble and Cr, Mn, Fe, Ni, Zn by using hair as biopsy material for a workers group includes the male workers such as welders, foundry man, fitter, hammer man, machine man, cupola man exposed to metals at workplace besides office workers of locomotive workshop in Ajmer and surrounding areas exposed to different metals [20].

Trace metal concentrations in serum depend not only on external factors, including micronutrient status, but also on many internal factors; profiles are believed to be influenced by the host physiology, pathogen physiology, and host diet [4]. However, the availability of these trace elements for digestion, absorption, and utilization, in addition to their clinical impacts on patient outcomes, are still under investigation [21, 22].

Recent study was estimate the carcinogenic and non-carcinogenic health risk due to exposure toPM2-bound trace metals from an industrial area in Southwestern Nigeria[23], and more recently Human biomonitoring reference values are statistical estimates the upper margin of background exposure to a given chemicals ata given time. Nationally representative human bio-monitoring form data on 176chemicals, including several metals and trace elements, they derived RVs for 15 metals and trace elements through the Canadian Health Measures Survey(CHMS)[24].

The present study shows the quantitative determination of some heavy metal ions in the serum of the staff member worked in the laboratories at the chemistry department (University of Sulaimani, Kurdistan). The staff members have worked for almost more than 10 years at the hazardous conditions unsafe workplace. As a part of our evaluation process for risk assessment at workplaces, we thought it is necessary to focus on the hazards of exposure to trace and heavy metals, in which throughout different exposure routes their effects keep on rising. Directly or indirectly hazards are affecting the lab staff health which has been working in the old building that not designated for laboratories without fume cupboard, ventilation system, safety policy and even no safety data sheet.

Material and Method

The data of this research has been collected during the academic year of 2015-2016 after moving the chemistry department from the old campus in which we barely had lab safety requirements with a highly risky environment to the new campus in which we have all the essential safety lab inquiries and a safer work environment for all lab workers and staff members. In order to assess knowledge, perception, and practices in relation to safe work practices and potential for hazardous from chemicals during daily working in the laboratories the questionnaire was done and carried out over 2 days by two of trained department student concerning age, gender, use of PPE, duration of being in the lab (exposure time), smoking and alcoholism.

Sample Collection

Blood samples were collected from 25 Lab. staff member of chemistry department and 25 control unexposed participants during a morning visit: 10 mL of venous blood was collected into plastic tubes containing EDTA using stainless needles. After extracting serum samples from whole blood, 5 mL of serum was stored at –20 °C until the analysis.

Determination of elements:

All the glassware and plastic containers were soaked in 10% HNO overnight and rinsed thoroughly with distilled deionized water. All reagents used in the present study were of high purity and analytical grade for trace elements analysis. Standard solutions (1000 µg/mL) of each element were used with inductively coupled plasma-optical emission spectrometry (ICP-OES; Perkin ElmerSpectro Analytical Instruments), purchased from Merck. Deionized water was used throughout the study for serial dilution of standards. ICP-OES was used for the determination of elements (cobalt(Co), Chromium(Cr), Copper(Cu), iron(Fe), Manganese(Mn), nickel (Ni), Lead(Pb) and Zinc(Zn).

Statistical analysis

The statistical analyses were carried out using linear regression analysis, Studentt-test, F- test and correlation analysis were used.Personal information statistics were computed using SPSS software program (version 24) to compare and test the mean of each parameter according to exposed lab staff and unexposed (control) groups P-Values less than 0.05 were considered statistically significant.

Result and Discussion

The results -and output data analysis showed that there was a difference between the serum trace metal concentrationfor exposed lab.staff and unexposed control group (table-1). Throughout the years in which chemistry department lab.staff has spent working in a low-quality laboratories, they were exposed to a lot of dangerous chemicals through many different exposure routes; inhalation, skin absorption, ingestion.. etc. Health risk of workplace exposure to chemicals must be identified promptly, and individually exposed to them must be evaluated and manage without delay [15].

Table -1-Mean and (St.d) of trace metal level(µg/L) in theSerum sample of exposed Lab. staff andControl groups.

Trace Metal	**Mean(St.d) Trace Metal Conc. µg/L**	
	lab.staff Exposed group	**Control group**
Lead	93.00 (19.53)	38.98 (26.18)
Nickel	9.83 (6.21)	6.52 (2.09)
Copper	926.79 (544.48)	418.68 (69.27)
Iron	1668.16 (1147.32)	1073.68 (364.38)
Zinc	1061.74 (612.71)	702.70(207.57)
Chromium	24.15 (5.98)	29.33 (1.91)
Manganese	10.00 (11.21)	10.20 (9.155)

The figure below illustrates that all exposed laboratory staff participant had elevated level of serum lead, copper, Nickel, Iron and Zinc concentrations compared with unexposed controls group while surprisingly the chromium concentration was lower in the lab staff serum sample.. Moreover, Manganese serum concentrations remained unaltered fig-1.

Diseases that involve the presence of trace metals, both in low or high concentration, have taken on the spotlight for researchers because exposure to chemicals including trace metals creates much serious public health problems that affect wildlife, soils, water, and air and can have very harmful human health effects.Similar to our findings, the elevated level of metals that observed in the serum sample was corresponded to what was reported in previous studies concerning densely populated urban area with a higher heavy metal concentration in street dust and different workplace area in addition to the high level of heavy metals Pb and Cd ,also the rising of trace metal Zn, Cu, Fe, Cr concentration has been reported [8,13, 15, 25,26].

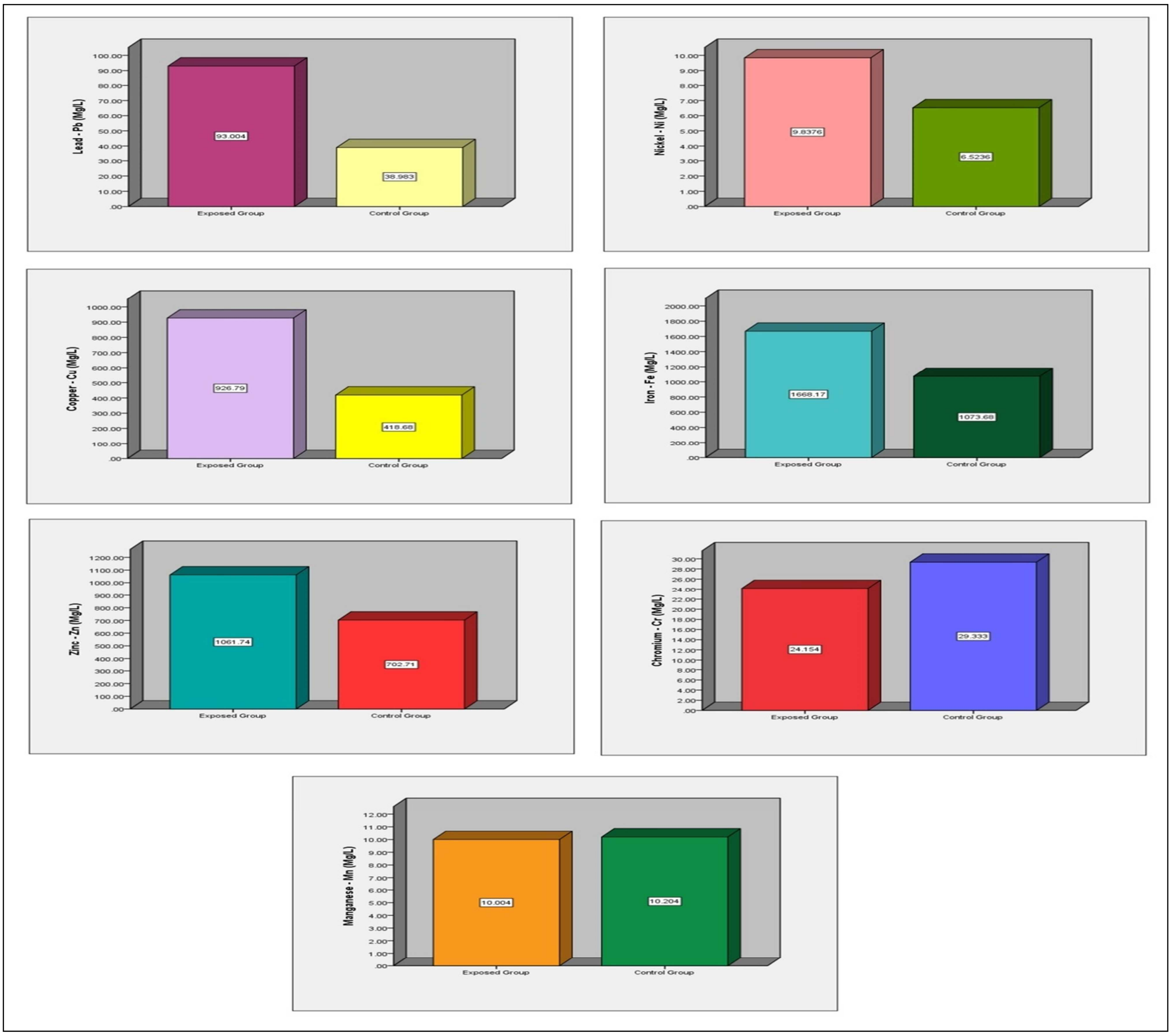

Fig -1- Mean and standard deviation (St.d) of all analyzed trace metal level for exposed lab. staff and unexposed control groups.

Descriptive statistics of the trace metal content in the Serum sample of exposed lab.staff and control group are tabulated in the table -2-, which compare each parameter for both groups from their mean scores, mean difference of their scores and the result was analyzed by t-test to represent the significance of the differences between the metal level.

The result of the test revealed that there is statistically significant difference between the means of trace metal serum concentration of exposed and control group except the manganese concentration at the level of ($\alpha = 0.05$) , from table (2) it is noted that the P-value (Sig.) for each metal concentration parameter are equal to (0.000, 0.000, 0.017, 0.015, 0.000, and 0.008) respectively which are smaller than the level of significant ($\alpha = 0.05$) that is mean, H0 can be rejected. (The H0 states that the mean score of parameters are not different according to exposed and control group)[27]. It says that two means are not equal and there is statistically difference between the means of trace metal level according to control and exposed group at the level of (0.05), but the result of the test showed that there isn't statistically significant difference between the means of Mn concentration according to exposed and control group at the level of($\alpha = 0.05$) , where P-value (Sig.) is equal to (0.945) which is greater than the level of significant ($\alpha = 0.05$) that is mean, H0 cannot be rejected. (The H0 states that there isn't different mean score of Mn level according to both group). It says that two means are equal and there is not statistically difference between the means of Mn-concentration .

The pattern of concentration of the heavy metals in the serum samples was in decreasing order of Pb> Cu > Ni> Fe >Zn >Mn when the analysis has been carried out for assessing metal body burden of lab. workers to ascertain the accumulation of trace metals .

Table (2): Descriptive statistics of the trace metal content in the Serum of exposed lab staff and control group.

Parameters	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Mn	-.069	48	.945	-.200	2.894	-6.020	5.620
Cr	-4.119	48	.000	-5.178	1.257	-7.706	-2.650
Cu	4.629	48	.000	508.11	109.774	287.396	728.827
Fe	2.469	48	.017	594.48	240.760	110.405	1078.569
Ni	2.526	48	.015	3.314	1.312	.675	5.952
Pb	8.269	48	.000	54.02	6.532	40.885	67.155
Zn	2.775	48	.008	359.04	129.384	98.889	619.181

The most interesting point in the study is the change in Serum lead (Pb) concentration according to other parameters in the study which are Exposing time , and use of PPE during working in hazardous condition . The results show that the Pb metal concentration gradually increased based on the years of working (exposing time) and there are statistically significant effect of both parameters, the measure of R – square of the regression model has very high value which is equal to 0.94, it means that the value of (0.94) of changes in Pb-concentration is due to the change in the level of the both exposing time and using PPE parameters, and the p-value of t-test and F-test are less than the statistically significant level ($p<0.05$) which indicates that the fit regression model and their parameters are significant (table -3-).

The F-statistic is used to test the effect of factors on response Lead(Pb) concentration as a whole in fitted above regression model. The results in the table show that F-value of the regression model is equal to (79.28) with a p-value (0.000), indicates the significance of the model.The results of the study showed that there was no significant contribution of other parameters (Age, Smoking, and alcoholism)on the Lead (Pb) concentration value.

Table (3): Regression results of lead (Pb) serum level response with other parameters

Parameter		t-test		F-test		R-square
	Beta	t-test	P-value	F-test	P-value	
Alcoholism	0.391	0.035	.972	79.276	0.000	0.94
Smoker	18.222	1.259	.222			
Exposing time	12.242	1.878	.074			
PPE	19.905	2.031	.049			

It is also possible to use t-test for estimating the effect of factors on the response of the lead(Pb) concentration individually, the t-value of the Exposing time parameter is equal to (1.878) with p-value (0.074), this indicates that the parameters has statistically significant effect on Pb-level by amount (12.24) at statistical level, ($\alpha = 0.10$), and the t-value of the PPE parameter is equal to (2.03) with p-value (0.049), this indicates that this parameter (PPE) has statistically significant effect on pb-parameter by amount (19.91) at statistical level ($\alpha = 0.05$).

The small fraction of lead in the plasma and serum is in equilibrium with soft tissue lead. Soft tissues that take up lead are liver and kidney, with smaller amounts taken up by the brain and muscle[28].The prime hazard of lead is its toxicity. For a long time, it is known that lead is toxic for brain, kidney and reproductive system and can also cause impairment in intellectual functioning, infertility, miscarriage and hypertension. Several studies have shown that lead exposures can significantly reduce IQ and has been associated with aggressive behavior, delinquency and attention disorders also[29]. The toxicity of metals, both heavy and trace metals is a topic of great interest to many biomedical scientists and an issue of great public health importance. An ever increasing literature has pointed to adverse effects of life exposure to metals on chronic disease health outcomes later in life.[10]

Conclusion

The study demonstrates that there are considerable differences between the concentration of some trace metals in the serum sample of exposed lab.staff at chemistry department and nonexposed staff in the ordinary office and its the first study to assess trace element concentrations in the serum of the scientific lab.staff in Kurdistan Universities. Our findings suggest that especially lead, copper, Nickel, iron, and zinc levels should be annually monitored in lab. worker serum sample in order to avoid extra exposing problems. Further study is required to find out the further aspect and reason for such alarming level of in metal in the chemistry lab. staff serum sample.

A correlation of serum trace metal content with parameters (time of exposing and using personal protective equipments) indicate that in order to assess the levels of trace metals in relation to hazardous conditions and unsafe workplace the best way seems to be the correct analysis of all three types of biological fluids and other biological samples like Hair and nail because the serum metal content does not give complete information about the exposing condition. The study results indicate the necessity of controlling all the hazards associated with working in the chemistry labs.and adjusting the pollution of metals in the workplace and encourage the analysis of speciation of elements to increase knowledge on the mode of action and understanding of health effects.

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