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Estimation of trace elements in workers at electrical substations and communication towers in Baghdad City

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***Abstract*---**The works on pollution in developing countries indicate a prevalence of trace elements in environment. Electrical stations and cellular communication towers are important sources of pollution that affects the quality of human health. While the electric power generating stations constructed away from cities, the substations are located near the consumers. Because of the lack in information on the effects of electric substations on human health and the abundance of cellular towers in Baghdad we aimed to evaluate the trace elements in the workers at these two facilities since they are on continuous exposure to the underlying pollution. Lead (Pb) and cadmium (Cd) were evaluated in the blood, while copper (Cu), zinc (Zn) and manganese (Mn) were evaluated in the serum of forty workers at electrical substations and forty workers at communication towers and compared with forty healthy people with no attachments to these two facilities. The effect of trace elements on renal and liver function was estimated. The levels of blood Pb, Cd, and Cu were significantly ($P<0.05$) higher in workers at electrical substations and communication towers compared to control. On the other hand, Zn level was significantly ($P<0.05$) reduced in electrical substation and communication towers workers compared to control. The workers at electrical substations have shown significant ($P<0.05$) higher levels of Pb, Cd and Cu compared to the workers at communication towers, while the differences of Zn levels were non-significant ($P>0.05$). The

levels of Mn were significantly (P<0.05) lower in the serum of electrical substations workers compared to control, but no-significant (P>0.05) differences were observed between communication towers workers neither with control nor with electrical substations workers. The levels of urea was significantly (P<0.05) elevated in communication towers and electrical substations workers compared to control, but non-significant (P>0.05) differences were obtained between the two groups of workers. Creatinine, ALT, AST and ALP were all shown non-significant (P>0.05) differences among the three groups. In conclusion, the results indicate a mild toxicity with trace elements under continuous exposure to electric substation and communication tower pollutions, but with no effect on the renal and liver function.

***Keywords*---**heavy metals, pollution, renal function, liver function.

Introduction

In developing country, the pollution augmented due to many factors that affect the quality of life [1-5]. Such environment can be found in industrial places of particular; factories [6-8]. People in industrial field are vulnerable to toxic effects such as gases [9], heavy metals [10], radiation [11], etc. depending on their fields. Electrical stations provides variety of pollutant agents. The abundance of heavy metals in electrical power stations has been documented in the literature [12]. The studies have indicated the presence of lead (Pb) and cadmium (Cd) in soil surface around electric power stations [13, 14]. Despite the awareness and extensive research on pollution in electrical power generating stations, the documents are rare in substations.

Communication towers are another important source of pollution in cities [15]. Because a cell device and its cell tower are two-way communicators, they produce radio frequency radiation as a way to connect, which can be harmful to persons in close proximity [16]. The researchers have reported that cellular towers exhibit serious risks on human health upon continuous exposure to radiation in approximate distance [17].

Pb is a very toxic heavy metal that poisons humans through air, water and/or food [18]. In human and animal models, Pb effects is related with behavioural disturbances, hearing deficits, neurological dysfunction, and reduced cognitive abilities [19]. Moreover, Pb is linked to developing renal dysfunction [20] and endocrine disorders [21]. Cd is another heavy metal with chronic toxic behavior [22]. Cd is known to induce renal toxicity at high doses [23, 24], and accumulated at liver at acute exposure [25].

In addition to these non-essential heavy metals, there are some essential metals required in many biological functions including zinc (Zn), copper (Cu) and manganese (Mn) [26]. They are essential in some enzymatic reactions (e.g. Cu/Zn-superoxide dismutase and Mn-superoxide dismutase) [27], and found in many protein arrangement [28]. At high levels, these trace elements turns from being beneficial to harmful, for example, Cu is a pro-oxidant that induces oxidative

stress [29]. The aim of the present study is to evaluate the serum level of Pb, Cd, Cu, Zn, and Mn in the workers at electrical substations and cellular communication towers and investigate their effect of renal and liver function.

Experimental

Subject collection and sample preparation

T The study was included 40 people who worked at electrical stations, and other 40 people who worked at communication towers. Additional 40 people were completely healthy and apart from these two sites were volunteered as control for the study. The subjects were all males and collected from November 2021 to January 2022. Vein blood was collected from each individual and divided into EDTA and gel tubes. The blood in gel tubes were centrifuged at 1500 xg for 10 minutes and the separated serum was stored in three Eppendorf tubes and stored at -20 °C until analysis. The blood in EDTA tubes were analyzed within 2 days from collection for Pb and Cd elements.

Methods

The levels of Cu, Zn and Pb were measured in atomic absorption spectroscopy (AAS) by using NovAA300 (Germany), while the levels of Cd and Mn were measured by using AAS Buck 210 VGP (USA). Urea, creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) were all evaluated by using commercial kits purchased from Linear (Spain).

Statistical analyses

Statistical Package for the Social Sciences (SPSS) version 26.0 was used for operating the statistical processes on the collected data. Results are expressed by mean and standard deviation (SD) and the comparisons were performed by using analysis of variances (ANOVA). The differences between each two groups were obtained by the highest significant differences (HSD) test. The correlation between variables was obtained by using Pearson's correlation coefficient in the serum of electrical substations workers and in cellular communication tower workers. Chi-square test was used for the comparisons of percentages.

Results

The demographic presentation of the study subjects are shown in Table 1. The age was non-significantly ($P>0.05$) different among control, electrical substation and communication towers workers. The value of body mass index (BMI) was non-significantly ($P>0.05$) variated among the three groups, although, the subjects were overweight ($25<BMI<30$ $kg.m^{-2}$). Less than half of the subjects were smokers in all of three groups. The trace element levels are shown in Table 2. Pb level was significantly ($P<0.05$) elevated in communication towers workers (21.45±2.68 µg/dL) and electrical substations workers (26.63±3.14 µg/dL) compared to control (14.60±2.21 µg/dL). Workers at electrical substations have

shown significant (P<0.05) higher levels of Pb compared to communication towers workers.

Cd level was significantly (P<0.05) elevated in communication towers workers (0.27±0.03 µg/dL) and electrical substations workers (0.32±0.04 µg/dL) compared to control (0.15±0.03 µg/dL). Workers at electrical substations have shown significant (P<0.05) higher levels of Cd compared to communication towers workers. Cu level was significantly (P<0.05) elevated in communication towers workers (147.77±8.63 µg/dL) and electrical substations workers (155.38±8.28 µg/dL) compared to control (118.83±11.96 µg/dL). Workers at electrical substations have shown significant (P<0.05) higher levels of Cu compared to communication towers workers.

Zn level was significantly (P<0.05) reduced in communication towers workers (74.08±7.08 µg/dL) and electrical substations workers (73.98±6.58 µg/dL) compared to control (99.13±11.44 µg/dL). Workers at electrical substations have shown non-significant (P>0.05) differences in the levels of Zn compared to communication towers workers. Mn level was significantly (P<0.05) reduced in electrical substations workers (0.11±0.03 µg/L) compared to control (0.12±0.02 µg/L), but the workers at electrical substations have shown non-significant (P>0.05) differences in the levels of Mn neither with communication towers workers (0.12±0.03 µg/L) nor with control.

Renal and liver function parameters are shown in Table 3. The concentration of urea was significantly (P<0.05) elevated in electrical station (25.07±9.89 mg/dL) and communication towers workers (25.58±5.84 mg/dL) compared to control (16.33±2.01 mg/dL). The differences of urea concentration between electrical and communication towers workers were non-significant. But regarding creatinine, ALT, AST and ALP, no significant (P>0.05) differences were observed among the three groups, Table 3.

Pearson's correlation coefficient (r) was used to analyze the correlation between trace elements and the other variables of the study in the blood of electrical station (Table 4) and cellular communication towers (Table 6) workers. In Table 4, the workers at electrical stations do not exhibit any significant association in the tested parameters, except for the negative weak correlation between copper and lead (r= -0.313, *P*=0.049). In Table 5, the workers at cellular communication towers have exhibited significant weak correlation between serum copper and the activity of AST (r= -0.325, *P*= 0.041) and between serum manganese and urea concentration (r= -0.319, *P*= 0.045).

Discussion

The literatures have shown the harmful effect of electrical power generating stations on the quality of human health, and due to these evidence these stations are constructed in locations distal from cities [30]. Moreover, the power grid constitute from subunits located in the middle between power generating stations and the consumers. One of the power grid parts is the electrical substation which located in the cities, near the consumers [31].

Baghdad city, as the other cities of developing countries, contains many electrical substations and abundant with cellular communication towers. The effect of these two important facilities on the human health is not fully clear, besides we did not find any previous work that investigated the trace elements in people with continuous exposure to the environment at electrical substations. Hence, we have studied the effect of electric substations and communication towers on the human health by measuring trace elements, renal and liver function in people whom under continuous exposure to the tested environment.

We have found a significant elevated levels of Pb, Cd and Cu levels, encountered by a significant reduction in Zn and Mn levels in the blood of electrical substation workers, and a reduction in Zn level in communication towers workers (Table 2). Workers at the electrical substations exhibited the worst trace elements values. Even though, electrical substations are for electricity distribution not generating, the grid itself contains parts that involved in toxic elements emission, which we were informed by the Occupational Safety Committee at the Iraqi Ministry of Electricity. The continuous exposure to these effects would results eventually in human poisoning.

Aksen et al. have exposed rats to mobile radiation and measured the levels of trace elements. The workers reported non-significant differences of Cu concentration with control rats, but the experimented rats have shown significant lower Zn levels and significant higher Mn levels [32]. The mechanism by which the levels of elements become unregulated is not clear. Lead and cadmium are very toxic and result in many health problems [33]. The literatures have indicated their role in cardiovascular diseases [34], renal toxicity [35], infertility [36, 37], and liver dysfunction [38, 39]. In this study, the liver and renal function parameters were all in normal range (Table 3), urea was slightly higher than that in control. This indicates that the increase of Pb, Cd and Cu did not affected the kidney and the liver in the examined subjects of the study.

Table 1
Demographic presentation of the study subjects

Parameter	Control	Electrical substation	Cellular towers	*p*-value
Age (year)	39.90±9.28	42.98±10.15	40.15±8.17	0.259
BMI (kg.m-2)	26.44±2.87	26.86±3.32	27.87±3.04	0.107
Smokers %	35%	40%	35%	0.866

Table 2
The levels of trace elements in control and tested subjects

Parameter	Control	Electrical substation	Cellular towers	*p*-value		
				A	B	C

Pb (µg/dL)	14.60±2.21	26.63±3.14	21.45±2.68	0.0001	0.0001	0.0001
Cd (µg/dL)	0.15±0.03	0.32±0.04	0.27±0.03	0.0001	0.0001	0.0001
Cu (µg/dL)	118.83±11.96	155.38±8.28	147.77±8.63	0.0001	0.0001	0.002
Zn (µg/dL)	99.13±11.44	73.98±6.58	74.08±7.08	0.0001	0.0001	0.999
Mn (µg/L)	0.12±0.02	0.11±0.03	0.12±0.03	0.383	0.043	0.512

A: *p*-value of comparison between control and electrical substations workers; B: *p*-value of comparison between control and communication towers workers; C: *p*-value of comparison between electrical substations and communication towers workers.

Table 3
Renal and liver function in control and tested subjects

Parameter	Control	Electrical substation	Cellular towers	p-value		
				A	B	C
Urea (mg/dL)	16.33±2.01	25.07±9.89	25.58±5.84	0.0001	0.0001	0.939
Creatinine (mg/dL)	0.81±0.06	0.74±0.25	0.74±0.11	0.144	0.171	0.996
ALT (IU/L)	17.68±3.21	19.34±8.89	19.98±11.16	0.652	0.443	0.939
AST (IU/L)	21.65±5.19	22.80±7.62	24.98±6.69	0.716	0.065	0.303
ALP (IU/L)	95.03±18.62	103.78±32.34	91.38±25.44	0.294	0.806	0.089

A: *p*-value of comparison between control and electrical substations workers; B: *p*-value of comparison between control and communication towers workers; C: *p*-value of comparison between electrical substations and communication towers workers.

Table 4
Correlation between trace elements and other variables in the serum of the workers at electrical stations

Variables	Pb		Cd		Cu		Zn		Mn	
	r	P	r	P	r	P	r	P	r	P
Cd	-0.024	0.886	-	-	-0.021	0.896	0.266	0.097	-0.231	0.152
Cu	-0.313*	0.049	-0.021	0.896	-	-	0.287	0.073	0.197	0.223
Zn	-0.309	0.053	0.266	0.097	0.287	0.073	-	-	0.191	0.239
Mn	-0.264	0.099	-0.231	0.152	0.197	0.223	0.191	0.239	-	-
ALT	0.025	0.879	-0.198	0.221	-0.041	0.802	-0.075	0.644	-0.147	0.365
AST	0.216	0.181	0.058	0.722	0.167	0.302	-0.014	0.930	0.032	0.843
ALP	0.239	0.137	-0.014	0.930	-0.269	0.093	-0.093	0.569	0.061	0.710
Urea	-0.110	0.498	0.161	0.320	-0.162	0.317	-0.275	0.086	-0.164	0.312
Creatinine	0.136	0.402	-0.070	0.668	0.157	0.334	-0.236	0.142	0.268	0.094

Table 5
Correlation between trace elements and other variables in the serum of the workers at communication towers

Variables	Pb		Cd		Cu		Zn		Mn	
	r	P	r	P	r	P	r	P	r	P

Cd	0.22	0.891	-	-	0.120	0.462	0.089	0.583	0.054	0.740
Cu	-0.200	0.216	0.120	0.462	-	-	0.270	0.092	-0.293	0.066
Zn	-0.012	0.943	0.089	0.583	0.270	0.092	-	-	0.012	0.942
Mn	0.197	0.22	0.054	0.740	-0.293	0.066	0.012	0.942	-	-
ALT	-0.284	0.076	-0.162	0.319	-0.080	0.625	-0.186	0.250	0.010	0.950
AST	0.021	0.898	-0.167	0.304	-0.325*	0.041	-0.109	0.505	0.004	0.978
ALP	0.049	0.762	-0.062	0.706	-0.004	0.982	-0.177	0.275	0.050	0.761
Urea	-0.217	0.178	-0.069	0.671	0.045	0.781	-0.059	0.716	-0.319*	0.045
Creatinine	0.126	0.439	-0.009	0.955	-0.185	0.253	-0.045	0.784	0.058	0.722

Conclusions

The results have shown significant elevation in the levels of Pb, Cd and Cu in the workers at electrical substations and cellular communication towers. This was encountered with a reduction in the level of Zn and Mn in the serum of electrical substations workers, and only Zn was reduced in the serum of communication towers workers. This reflects a serious health issues that can catch the workers at these two fields and extended to the residents near these locations. Nowadays, the electrical substations and communication towers are extended with the increase of population, hereby, further researches are required to evaluate their effect on people.

Conflicts of interest

There are no conflicts to declare.

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