



Original Research Article

Evaluation of heavy metal levels in blood of cable manufacturing factory workers in Nnewi

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ABSTRACT

Background of Study: Heavy metals are toxic and have adverse effects on human health depending on the intensity and duration of exposure.

Materials and Methods: This is a cross sectional study designed to assess the heavy metal levels in blood of cable manufacturing factory workers in Nnewi, Nigeria. A total of forty (40) apparently healthy individuals from the cable manufacturing factory (the exposed group) aged between 19 and 56 years and 79 control individuals (comprising of 39 control individuals from Nnewi (N) and 40 control individuals from Elele (E) respectively) aged between 18 and 44 years were recruited for the study. The body mass index (BMI) and length of service (LOS) of participating individuals were obtained using structured questionnaire and thereafter, 10ml of venous blood sample was collected from each individual for the evaluation of heavy metal levels (Pb, Ni, Cu, Zn, As and Se) using atomic absorption spectroscopy (AAS).

Results: There was no significant difference in Body mass index (BMI) of factory workers compared with control subjects ($P > 0.05$). There were significant increases in the mean levels of Ni, As and Pb and decreases in Cu, Zn and Se levels in cable manufacturing factory workers than in controls ($p < 0.05$) respectively. However, no significant statistical correlations were found between metal levels in factory workers and age as well as LOS ($p > 0.05$).

Conclusion: This study has shown a possible metal toxicity and deficiency of microelements in the subjects studied and these may impact negatively on human health.

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1. Introduction

Cables are classified into solid and stranded, power, installation, monitoring, mine cables, and control cables.¹ The process of cable manufacturing consists of several stages which include; drawing, cure, extruding, winding on a spool. The most energy-consuming is the cure. This physical-chemical process takes quite a long time (hundreds of seconds) and occurs at a low pulling rate and

high temperature heat insulating product is used.¹ It is also necessary to monitor the temperature of the surface of the insulating layer, which should not exceed the temperature in the beginning of the thermal decomposition of the material sheath.

Heavy metals such as copper, lead, arsenic etc. are used in cable making and such workers are prone to being exposed to such heavy metal toxicity. Heavy metals are generally referred to as those metals which possess a specific density of more than 5 g/cm³ and adversely affect the environment and living organisms.² Heavy metals

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occur in the environment naturally and are released during anthropogenic activities. Soil contamination with heavy metals results from human-related activities such as mining, smelting procedures and agriculture as well as earth-related activities.^{3,4} Chemical and metallurgical industries are the most important sources of heavy metals in the environment, sewage-treated sludge, known as biosolids and used as fertilizers on the soil can contribute to increased heavy metal levels in the soil.⁵ Exposure to heavy metals is higher in the workplace than in the external environment.⁶ The three main routes by which chemicals may enter the body are ingestion, skin absorption, and inhalation. Poor hygiene practices, contamination of food, and smoking in the workplace all contribute to the risk of ingestion of heavy metals or their compounds. Skin contact and absorption is probably of concern only with respect to those metals which are implicated in causing dermatitis. Inhalation is usually by far the most significant exposure risk. A number of physical factors determine the uptake of inhaled material. Gases and vapours readily enter the lungs, but the degree of absorption depends on the solubility of the particular material in blood, water, and body fats.⁶ Heavy metals are toxic and they have adverse and acute after effects on humans. These metals, although they have beneficial effect, their hazards are very pronounced. The target organs for toxicity of heavy metals vary according to the pollutant and effects depend on the intensity and duration of exposure. For example, low levels of Pb can over time damage the central nervous system and also the heart and kidneys.⁷ Level of heavy metals is increasing due to rapid industrialization and pollution and their toxicity causes diseases and health issues among people especially individuals who are occupationally exposed to them.⁸ So detection of these metals in blood is an important issue because even at low doses they can cause health problems among the exposed population. Blood is directly influenced by heavy metal toxicity when these metals are inhaled from environment where their concentration is high.⁸

Previously, a number of studies documented elevated levels of some of these metals in occupationally exposed workers than in control individuals.^{9–11} Therefore, this study was aimed at evaluating the heavy metal levels in blood of cable manufacturing factory workers in Nnewi, Anambra State South eastern Nigeria.

2. Materials and Methods

2.1. Study design and participant recruitment

This is a cross-sectional study designed to evaluate some heavy metal levels in blood of cable manufacturing factory workers in Nnewi, Anambra State South eastern Nigeria. A total of forty (40) apparently healthy individuals in the exposed group (Cable manufacturing factory workers) aged between 19 and 56 years were recruited for the

study. The exposed group comprised workers from cable manufacturing factory who were constantly being exposed to effluents from the factory. The control groups were made up of two (2) sets: The first set was made up of thirty-nine (39) staff and undergraduate students of the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus whose residential homes were at least 5–10 km from the factory sites, while the second set was made up of forty (40) staff and undergraduate students of the Faculty of Medicine, Madonna University, Elele. They were aged between 18 and 44 years. Informed consent was obtained from all individuals after being educated on the benefit of the study and completing of a structured questionnaire. Thereafter, 10ml of venous blood sample was collected from each individual for the evaluation of heavy metal levels. Blood samples for the determination of lead (5ml) were delivered into new EDTA containers, mixed and stored frozen at -4°C until analyzed. The rest of the blood sample was delivered into lithium heparin containers and then centrifuged for 3 minutes at 2000 rpm. The plasma were separated and put into clean dry sample containers and stored deep-frozen at -4°C until analyzed. The plasma was used for the estimation of heavy metals (Pb, Ni, Cu, Zn, As and Se) by atomic absorption spectroscopy (AAS) according to the method of Smith *et al.*¹² Determination of lead in whole blood was done using the method as described by Hessel.¹³

2.2. Inclusion criteria

Apparently healthy individuals aged between 19 and 56 years who are exposed to metal fabricating factory effluents and control individual (non-exposed groups) were included in this study.

2.3. Exclusion criteria

Individuals of any known kidney disease, liver disorder, alcoholics and smokers as well as those outside the age limits were excluded from the study.

2.4. Ethical consideration

Ethical approval for this study was sought and obtained from Ethical Committee, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

2.5. Statistical analysis

The data were presented as mean \pm SEM and the mean values of the control and test group were compared by Students t-test and Pearson's bivariate correlation coefficient using Statistical package for social sciences (SPSS) (Version 16) software. A $P < 0.05$ was considered as significant.

3. Results

Table 1 shows some demographic profiles of control subjects from Nnewi (control N) an industrial town and Elele (control E), a rural town and the workers of the cable manufacturing factory (X). The cable manufacturing factory workers had the length of service (LOS) of 3.45 ± 0.65 years. The body mass index (BMI) of control N subjects (24.75 ± 0.38) and E subjects (23.58 ± 0.67) were not statistically different ($p > 0.05$) from those of cable manufacturing (23.74 ± 0.48) factory workers.

The levels of Cu, Zn, As, Se and Pb levels from control E subjects were higher and statistically different ($p < 0.05$) from those of control N subjects, however, no significant difference ($p > 0.05$) was observed for Ni.

The Ni level of cable manufacturing (2.64 ± 0.04) factory workers were highly elevated and statistically different ($p < 0.05$) when compared to control N subjects (0.04 ± 0.00) and control E subjects (0.07 ± 0.00). The Cu level in the cable manufacturing factory workers (9.26 ± 0.07) was significantly reduced ($p < 0.05$) when compared with control N (16.69 ± 0.21) and control E (19.72 ± 0.21) subjects. Zn levels of the factory workers of 7.40 ± 0.10 , for cable manufacturing factory were statistically reduced ($p < 0.05$) when compared with the controls N (11.73 ± 0.19) and E (17.11 ± 0.46) subjects. While the As level (0.03 ± 0.00) in the cable manufacturing factory workers were significantly elevated whereas, Serum Se levels were reduced compared to both controls N and E subjects respectively ($p < 0.05$). Furthermore, the Pb level in the factory workers were significantly elevated ($p < 0.05$) when compared with control N (0.59 ± 0.01) and E (0.79 ± 0.10) subjects. See Table 2.

The effect of age and LOS on the metal levels of cable manufacturing factory workers are presented in Table 3 and Table 4 respectively, while Figures 1 and 2 show the regression analyses for age and LOS, respectively. Ni, As and Pb were all significantly increased ($p < 0.05$) while Cu, Zn and Se were significantly reduced ($p < 0.05$) in all the age groups compared to the control subjects of Nnewi (N) and Elele (E). While the highest levels of Ni, As and Pb were obtained in the 51-60yrs age group, the lowest Cu, Zn and Se levels were obtained in the 51-60, 31-40 and 41-50 yrs age groups, respectively. The result of the correlation analyses of the effect of age on the metal levels showed that Ni ($r = 0.065$; $p = 0.694$), As ($r = 0.077$; $p = 0.643$) and Pb ($r = 0.100$; $p = 0.545$) were positively correlated while Cu ($r = -0.170$; $p = 0.302$), Zn ($r = -0.143$; $p = 0.384$) and Se ($r = -0.063$; $p = 0.701$) were negatively correlated with age, though non-significantly ($p > 0.05$) in each case.

There was a significant increase in the levels of Ni, As and Pb in all the LOS groups while Cu, Zn and Se levels were significantly reduced ($p < 0.05$) when compared with both control subjects (N and E), however, while Ni, Cu, Se and Pb were positively correlated with LOS with r values of 0.057, 0.043, 0.156 and 0.188, respectively, Zn and As were

negatively correlated with r values of -0.128 and -0.022, respectively. The highest Ni and Pb levels were recorded at the 6-10yrs, and 16-20yrs LOS groups, respectively.

4. Discussion

In this study, the nickel (Ni) level of cable manufacturing factory workers was significantly elevated when compared to control subjects. This is in keeping with the report of Ibeto and Okoye who documented a high level of Ni in an urban population in Nigeria which they attributed to the prevalent environmental population in Nigeria.¹⁴ The present finding portends a great health implication for the public bearing in mind the hazardous effects caused by long term exposure to nickel. Nickel is an important cause of contact allergy.¹⁵ Also, Nickel-Sulphur fumes and dust are believed to be carcinogenic.¹⁶ Nickel induces a morphological transformation and chromosomal aberration in cells¹⁷ and can lead to cancer.¹⁸

The present study showed that the mean copper (Cu) level in the cable manufacturing factory workers was significantly reduced than in the control subjects. Copper is a beneficial heavy metal that aids in building of important enzymes in the human body including those involved in redox cycling, mitochondrial respiration, iron absorption and free radical scavenging.¹⁹ Acquired copper deficiency has been implicated in adult-onset progressive myeloneuropathy²⁰ and in the development of severe blood disorders including myelodysplastic syndrome.²¹ This finding is in consonance with the report of El Safty et al. who showed depleted level of Cu among galvanization workers in the iron and steel industry.²² However, the present result is in contrast with the study of Adejumo et al. who reported higher level of Cu in occupationally exposed automotive workers in Benin City, Nigeria than in control subjects.²³

Also, Zn levels of the factory workers under study were significantly reduced when compared with the control subjects. This may be due to the Zn-Pb interaction which tends to cause a reduction in the concentration of zinc in the blood. Previously, a lead-zinc interaction has been observed.²⁴ Zinc (Zn) is essential for cellular membrane integrity and metabolism²⁵ as a central part of over 300 enzymes and proteins.²⁶ This is in contrast with previous studies which reported elevated zinc levels in occupationally exposed persons than in controls.^{22,23} Expectedly, the mean serum levels of arsenic (As) as well as lead (Pb) were significantly elevated in the cable manufacturing factory workers than in control subjects respectively. This may be an indication of the serious environmental contamination prevailing in the area under study. These findings have great health consequences as these individuals are prone to suffering the effects of lead and arsenic toxicities in the long run if this situation is not addressed. Pb is a potent health hazard²⁷ that may cause

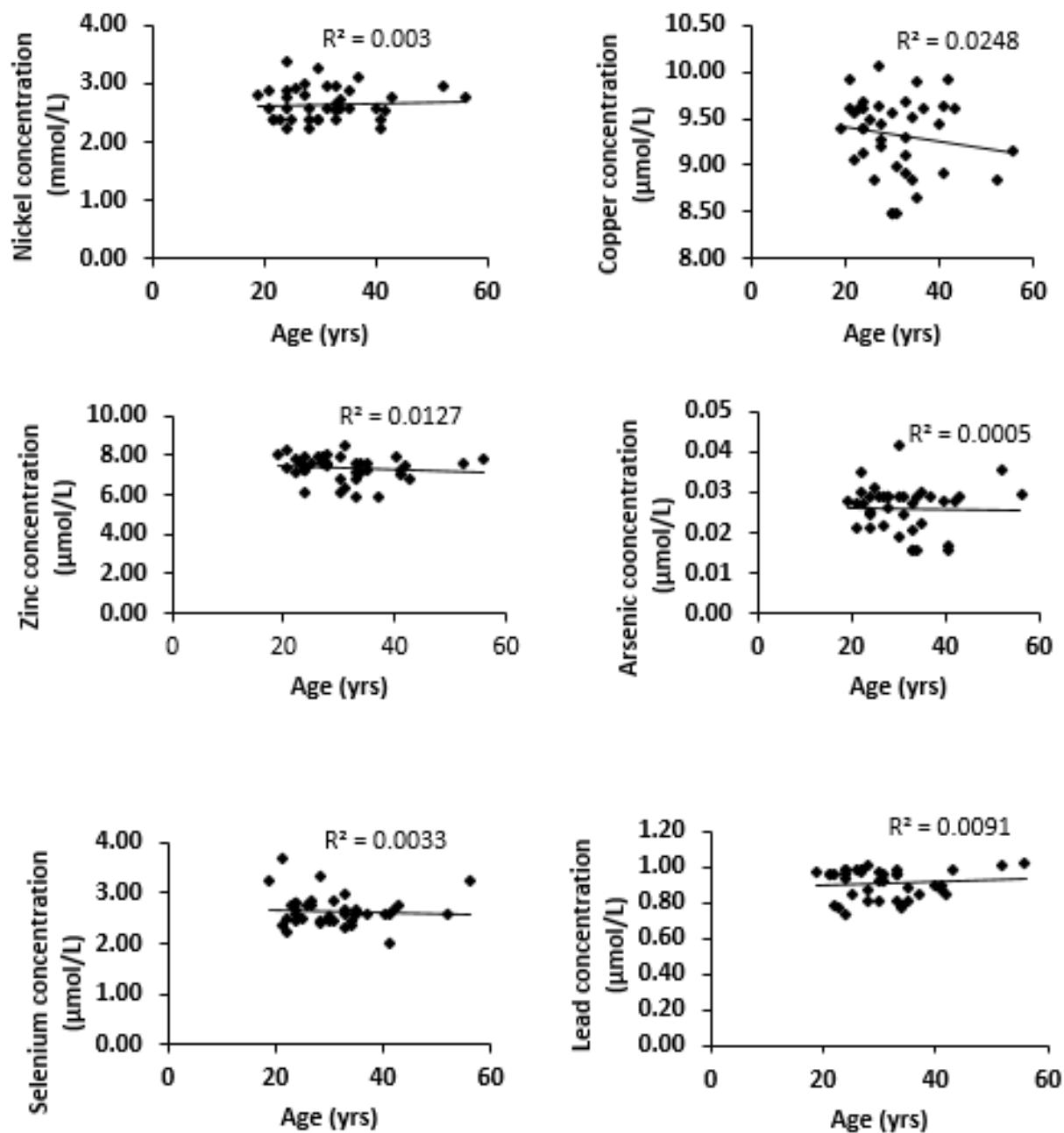


Fig. 1: Regression of metal levels of cable manufacturing factory workers with age

Table 1: Demographic profiles of cable manufacturing factory workers

Factory	Age (yrs)	LOS (yrs)	Weight (kg)	Height (m)	BMI (kg/m ²)
N (n=39)	23.28±0.91 ^{ab}		74.82±1.04 ^c	1.74±0.01 ^b	24.75±0.38 ^b
E (n=40)	21.68±0.33 ^a		66.10±10.91 ^b	1.68±0.01 ^a	23.58±0.67 ^b
X (n=39)	30.77±1.32 ^c	3.45±0.65 ^a	68.00±1.62 ^b	1.69±0.01 ^a	23.74±0.48 ^b

* Values are in mean (±SEM); within the column, means with different superscripts (a, b, ab, c) are statistically significant (p<0.05).

Key: N: Control subjects from Nnewi; E: Control subjects from Elele; X: Workers from cable manufacturing factory; BMI: Body mass index; LOS: Length of service

Table 2: Metal levels of cable manufacturing factory workers

Factory	Ni (μmol/L)	Cu (μmol/L)	Zn (μmol/L)	As (μmol/L)	Se (μmol/L)	Pb (μmol/L)
N (n=39)	0.04±0.00 ^a	16.69±0.21 ^c	11.73±0.19 ^d	0.01±0.00 ^a	5.11±0.08 ^c	0.59±0.07 ^a
E (n=40)	0.07±0.00 ^a	19.72±0.21 ^d	17.11±0.46 ^e	0.02±0.00 ^a	6.66±0.08 ^d	0.79±0.10 ^b
X (n=39)	2.64±0.04 ^b	9.26±0.07 ^a	7.40±0.10 ^b	0.03±0.00 ^b	2.71±0.05 ^a	0.91±0.08 ^d

Values are in mean ±SEM; within the column, means with different superscripts (a, b, c, d) are statistically significant (p<0.05).

Key: N: Control subjects from Nnewi; E: Control subjects from Elele; X: Workers from cable manufacturing factory

Table 3: Effect of age on metal levels of cable manufacturing factory workers

Age group	Ni (μmol/L)	Cu (μmol/L)	Zn (μmol/L)	As (μmol/L)	Se (μmol/L)	Pb (μmol/L)
N (n=38)	0.04±0.00 ^a	16.72±0.21 ^b	11.71±0.19 ^b	0.01±0.00 ^a	5.31±0.08 ^b	0.59±0.07 ^a
18-30yrs (n=22)	2.63±0.07 ^{bc}	9.33±0.09 ^a	7.53±0.12 ^a	0.03±0.01 ^b	2.76±0.08 ^a	0.91±0.02 ^b
31-40yrs (n=11)	2.70±0.07 ^b	9.14±0.13 ^a	7.13±0.25 ^a	0.02±0.00 ^b	2.66±0.06 ^a	0.88±0.02 ^b
41-50yrs (n=4)	2.47±0.11 ^b	9.47±0.21 ^a	7.17±0.15 ^a	0.03±0.01 ^c	2.58±0.17 ^a	0.90±0.03 ^b
51-60yrs (n=2)	2.85±0.07 ^c	8.96±0.16 ^a	7.80±0.07 ^a	0.04±0.01 ^b	2.99±0.32 ^a	1.02±0.01 ^c

Values are in mean (±SEM); within column, means with different superscripts (a, b, bc, c) are statistically significant (p<0.05).

Key: N: Control subjects

Table 4: Effect of LOS on heavy metal levels of cable manufacturing factory workers

LOS group	Ni (μmol/L)	Cu (μmol/L)	Zn (μmol/L)	As (μmol/L)	Se (μmol/L)	Pb (μmol/L)
N (n=39)	0.04±0.00 ^a	16.69±0.21 ^b	11.73±0.19 ^b	0.01±0.00 ^a	5.11±0.08 ^b	0.59±0.01 ^a
0-5yrs (n=30)	2.62±0.05 ^{bc}	9.25±0.08 ^a	7.45±0.11 ^a	0.03±0.00 ^b	2.71±0.06 ^a	0.90±0.01 ^b
6-10yrs (n=5)	2.82±0.11 ^c	9.23±0.24 ^a	7.03±0.39 ^a	0.03±0.00 ^b	2.73±0.8 ^a	0.91±0.04 ^{bc}
11-15yrs (n=2)	2.47±0.08 ^b	9.50±0.09 ^a	7.59±0.31 ^a	0.03±0.01 ^b	2.67±0.00 ^a	0.89±0.01 ^b
16-20yrs (n=2)	2.76±0.01 ^c	9.33±0.22 ^a	7.32±0.54 ^a	0.03±0.00 ^b	3.06±0.26 ^a	1.00±0.02 ^c

Values are in mean (±SEM); within column, means with different superscripts (a, b, bc, c) are statistically significant (p<0.05).

Key: N: Control subjects; LOS: Length of service

neurotoxicity, hypertension, anemia, renal impairment and interferes with sperm production.²⁸ Pb compounds may also be carcinogens.²⁸ Also, As can induce cancer, genotoxicity and affect the hematopoietic system, liver, kidneys, skin and brain.²⁹ The mean level of blood Pb recorded in this study is in line with the report of some previous studies.⁹ Furthermore, Damastuti *et al.* documented elevated levels of Pb and As from analysis of occupationally exposed workers than in the control subjects.¹⁰

In this study, serum Se levels were reduced compared to control subjects. This may be explained by the inverse relationship which tends to exist between blood Pb and Se levels. This is in agreement with the finding of Kasperczyk

et al. who showed significantly decreased level of Se in occupationally exposed workers.³⁰

Interestingly, the mean levels of Ni, As and Pb were all significantly elevated while Cu, Zn and Se were significantly reduced in all the age groups compared to the control subjects. Also, there was a significant increase in the mean levels of Ni, As and Pb in all the LOS groups while Cu, Zn and Se levels were significantly reduced when compared with control subjects. However, while Ni, Cu, Se and Pb were positively correlated with LOS, Zn and As was negatively correlated. This may imply that the accumulation of these metals in occupationally exposed subjects tend to increase with increasing LOS or duration of exposure.

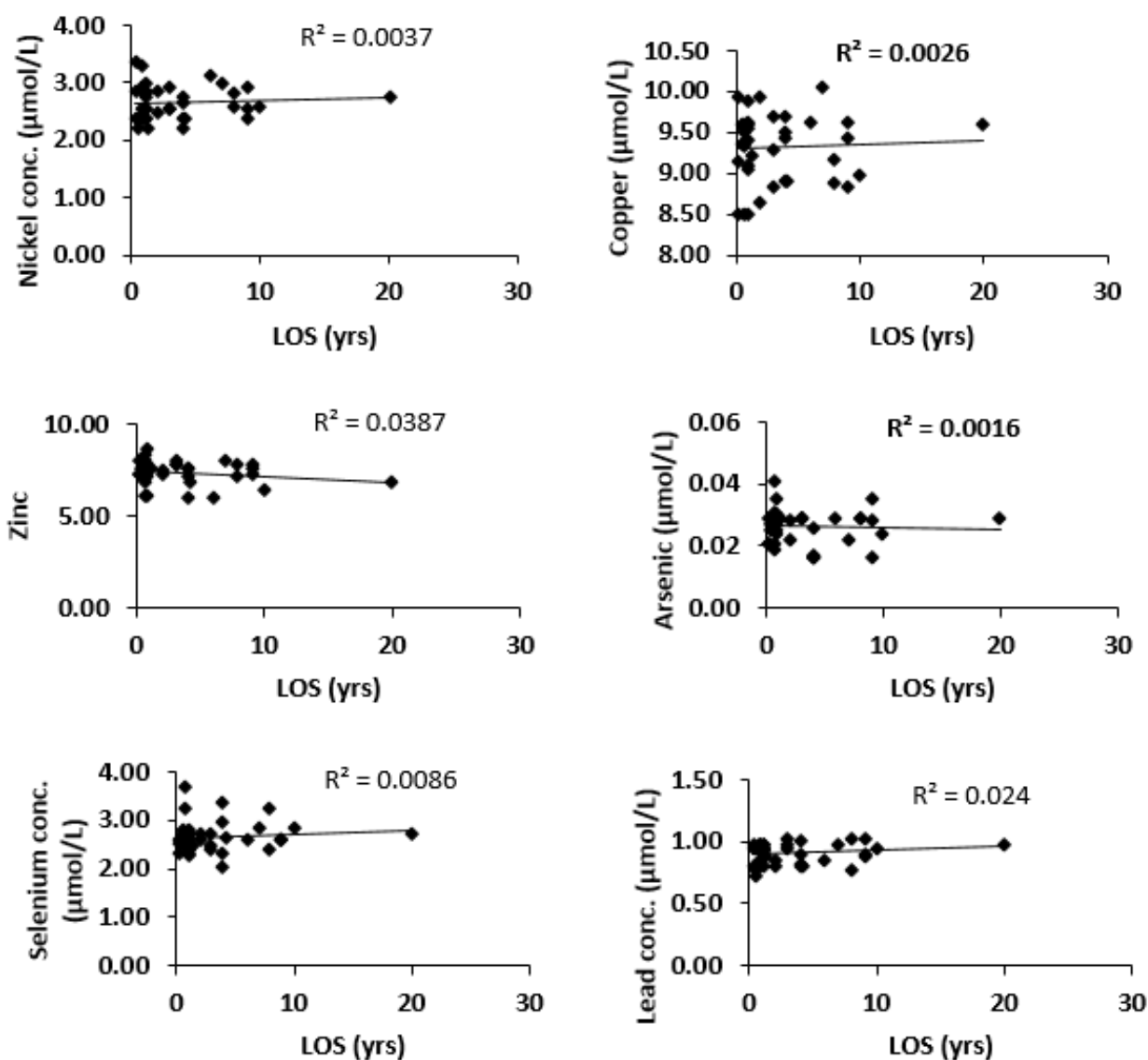


Fig. 2: Regression of metal levels of cable manufacturing factory workers with LOS

5. Conclusion

This study has shown that the exposed individuals may suffer the consequences of Ni, As and Pb toxicity as well as possible defects in functions mediated by the microelements such Cu, Zn and Se and this may have negative implications on human health.

6. Source of funding

None.

7. Conflict of interest

None.

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Author biography

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