Original Article

Evaluation of Trace Elements of Individuals Exposed to Cement Dusts in Ekpoma and Its Environs

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ARTICLE INFO

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Received: *19-10-2023*
Accepted: *06-12-2023*
Published: *13-12-2023*

Keywords. *Cement dust, Trace elements, Lead, Copper, Manganese.*

ABSTRACT

Background and aim. *Cement dust consists of toxic constituents, the heavy metals like nickel, cobalt, lead, chromium and pollutants hazardous to the biotic environment, with adverse impact for human, animal vegetation, health and ecosystem. This study was carried out to assess the Lead, Manganese and Copper levels of individuals exposed to cement dusts in Ekpoma and environs.* ***Methods.*** *A total of 100 samples were used in this study comprising fifty (50) cement factory workers and fifty (50) control subjects. Manganese, Copper and Lead concentrations were estimated using Atomic Absorption Spectrophotometer. Statistical analysis was done using one-way analysis of variance and the student's t-test.* ***Results.*** *The results obtained showed that Manganese and Lead were significantly higher ($p<0.05$), while Copper was significantly lower in individuals exposed to cement dust compared with control group ($p<0.05$). There was no significant difference ($p>0.05$) in Lead, Copper and Manganese of individuals exposed to cement dust according to age. Lead increased significantly ($p<0.05$) with duration of work, while Copper and Manganese did not show any statistically significant difference ($p>0.05$).* ***Conclusion.*** *The finding of this study showed that exposure to cement dust caused significant increase in Pb, Cu and Mn in individuals exposed to cement dust which indicates a possible metal toxicity in the subjects studied and these may have negative impact on their health. There was a progressive increase in trace elements concentration with duration of exposure. These observations emphasize the need for adequate safety and precautionary measures among cement factory workers and in individuals exposed to cement dust.*

Cite this article. *Airhomwanbor K, Omon E, Omolumen L, Asibor E, Omolumen B, Ighedo K. Evaluation of Trace Elements of Individuals Exposed to Cement Dusts in Ekpoma and Its Environs. Alq J Med App Sci. 2023;6(2):804-810.* https://doi.org/10.5281/zenodo.10372622

INTRODUCTION

Cement is a powdery composition (limestone, laterites, clay and gypsum) used in making and holding blocks or bricks in-place during construction. The major components of cement are derived from toxic heavy metals such as nickel, cobalt, lead, chromium and Silica [1]. Cement production is one of the major sources of environmental pollution associated with industrialization in developing countries. Cement dust emission has been described as the major source of heavy metal contamination of the environment [2]. Molecules of primary importance in cement dust in terms of content and potential health effects basically include 60–67% calcium oxide, 17–25 silicon oxide (SiO2), and 3–5% aluminium (Al) oxide, with some amount of iron oxide, chromium (Cr), potassium, sodium, sulphur, and magnesium oxide. Deleterious effects of exposure to constituents of cement dust on organ system in humans have been described [3].

The functions of trace elements are determined by their charges, mobilities and binding constants to biological ligands. Some of them are used as charge carriers to conduct electric impulses along nerves, while others form moderately stable complexes with enzymes, nucleic acids and other ligands [4]. They act as triggers/activators controlling biological functions. Trace elements and some of their compounds show antiviral activity by combining with cellular proteins and inactivating them. On the other hand, some trace elements enhance severity of various viral infections. Thus, trace elements may play an important role in several disease conditions [5]. Trace element deficiencies are often associated with alterations in many metabolic processes and cause various kinds of diseases. Deficiency of these trace elements causes severe economic loss due to increased susceptibility to oxidative stress, growth retardation, anaemia, decrease in feed efficiency and fertility, enhance the virulence of the infectious agent, and decrease immune system function [6].

Cement factory is considered as a major pollution problem on account of dust and particulate matter emitted at various steps of cement manufacture [7]. Cement dust consists of toxic constituents, heavy metals like nickel (Ni), cobalt (Co), lead (Pb), and chromium (Cr) pollutants which are hazardous to the biotic environment, with adverse impact on humans, animals, vegetations and ecosystem [8]. Unfortunately, some cement factory workers pay little to no attention to protecting themselves from the potential inhalation or ingestion of such toxic substances because they are unaware of the amount of these toxic metals to which they are exposed or the harmful effects they have on their health. Most disturbing is the lack of workplace regulations for environmental pollutant exposure in Nigeria and the utter disregard for workshop ethics and environmental protection laws by the cement factory workers. Furthermore, the use of recommended workshop garments and hand gloves to protect against direct contact with the toxic metals are utterly disregarded. The present study is therefore aimed at assessing the level of lead, manganese and copper of cement factory workers in our study area.

METHODS

Study area

This study was carried out in Ekpoma. Ekpoma is the administrative headquarters of Esan West Local Government Area in Edo state which falls within the rain forest/savannah transitional zone of south western Nigeria. The area lies between latitudes 60 43' and 60 45' North of the equator and longitudes 60 5' and 60 8' East of the Greenwich Median with a land area of 923 square kilometers.

Study design

The study is a comparative cross-sectional study involving male cement factory workers.

Ethical approval

Ethical approval for this study was obtained from the Ethics and Review Committee, Ambrose Alli University, Ekpoma. Informed consent was sought from each subject who participated in the study before the collection of samples.

Sample size

The number of samples studied was guided by the upper limit required, and gave 95% level of confidence at a prevalence of 5.6% pilot study, using the precise prevalence formula:

$$N = \frac{z2pq}{d2}$$

Where; N= the desired sample size (when population is greater than 10,000)

z = is a constant given as 1.96 (or more simply at 2.0) which corresponds to the 95% confidence level.

p = prevalence (5.6%)

q = 1.0 – p

d = acceptable error (5%)

$$N = \frac{(1.96)2 \times 0.056 \times (1 - 0.056)}{(0.05)2}$$

$$N = 81.23$$

A total of one hundred (100) subjects between the ages of 18-35 years were recruited for this study which comprised of fifty (50) subjects exposed to cement dust (cement factory workers) and fifty (50) control subjects (non-exposed individuals).

Inclusion criteria

Cement factory workers and those constantly exposed to cement dust who gave their consent were included in this study.

Exclusion criteria

Individuals with a history of cigarette smoking, tobacco use, liver disease or pulmonary disorders, chronic organ or systemic illness and long-term medication were excluded from the study.

Sample collection

For each participant, 4ml of blood sample was collected via veinpuncture under aseptic conditions into a labeled dry, clean plain sample container. The samples were allowed to clot and centrifuged at 3,500 revolutions per minute for 5 minutes. After centrifuging, the serum was separated with the aid of a Pasture pipette and dispensed into dry chemically clean serum container and stored at −200C until analysis.

Analytical methods

Manganese, Copper and Lead concentrations in serum were estimated using Atomic Absorption Spectrophotometer [9].

Principle

A hollow cathode lamp containing a coated cathode of the element that is to be analyzed is used as a light source. The light source emits a beam of a specific wavelength across the burner and into the monochromator. The sample is aspirated into the flame at the burner which converts the aerosol into energy at a specific wavelength and as the atoms increase the amount of light absorbed will also increase. The amount of light absorbed can be measured and used for a quantitative determination of the amount of analyte in a sample.

Statistical analysis

The results were presented using tables and charts. Data was presented as mean ± SD (standard deviation). Comparison was made between subjects and control groups using one-way analysis of variance (ANOVA) and the student's t-test. Significant difference was accepted at $p<0.05$.

RESULTS

Table 1 shows the mean values of BMI, Lead (Pb), Copper (Cu) and Manganese (Mn) of the test subjects and control group. The results obtained showed that the BMI (kg/m2), Pb (µg/ml), Cu (µg/ml) and Mn (µg/ml) of test subjects were 23.78±2.16, 0.21±0.12, 1.36±0.26 and 0.82±0.20 respectively. Similarly, the BMI, Pb, Cu and Mn of the control subjects were 22.35±4.09, 0.07±0.02, 0.87±0.25 and 0.05±0.13 respectively. Mn, Cu and Pb were significantly higher ($p<0.05$) in test subjects compared with control group ($p<0.05$).

Table 2 shows the mean values of BMI, Manganese, Copper and Lead of the test subjects according to age. The results obtained showed that the BMI (kg/m2) of the subjects in age group 20-25, 26-30 and 31-35 years were 23.86±1.77, 25.14±3.53 and 23.72±1.80, Pb (µg/ml) were 0.17±0.09, 0.22±0.08 and 0.49±0.08, Cu (µg/ml) were 0.76±0.25, 0.86±0.24 and 0.63±0.26, while Mn (µg/ml) were 0.08±0.12, 0.09±0.02 and 0.08±0.02 respectively. There was no significant difference ($p>0.05$) in BMI, Pb, Cu and Mn of the subjects according to age.

Table 3 shows the mean values of BMI, Manganese, Copper and Lead of the subjects with respect to duration of work. The results obtained showed that the BMI of the subjects with work duration of less than 1 year, 1–2 years and 3–5 years were 23.97±2.89, 24.53±2.51 and 26.19±3.03, Pb (µg/ml) were 0.11±0.01, 0.15±0.05 and 0.30±0.11, Cu (µg/ml) were 0.77±0.27, 0.80±0.18 and 0.91±0.26, while Mn (µg/ml) were 0.08±0.14, 0.08±0.02 and 0.09±0.02 respectively. Pb increased significantly ($p<0.05$) with duration of work, while BMI, Cu and Mn did not show any statistical significant difference with duration of work ($p>0.05$).

Figure 1, 2 and 3 shows the correlation between BMI and Lead, BMI and Copper and BMI and Manganese respectively in cement factory workers. The results obtained showed that there was an insignificant negative correlation between BMI and Lead ($r = -0.022$, $p=0.908$), insignificant negative correlation between BMI and Copper ($r = -0.127$, $p=0.502$) and significant positive correlation between BMI and Manganese ($r = 0.579$, $p=0.001$) respectively.

Table 1. Mean values of BMI, Manganese, Copper and Lead of the subjects and Control

Parameters	Subjects Mean ± SD (n = 50)	Controls Mean ± SD (n = 50)	t-value	p-value
BMI (kg/m2)	23.78±2.16	22.35±4.09	1.709	0.104
Pb (µg/ml)	0.21±0.12	0.07±0.02	5.098	0.000
Cu (µg/ml)	1.36±0.26	0.87±0.25	5.827	0.000
Mn (µg/ml)	0.82±0.20	0.05±0.13	6.148	0.000

*Keys: **BMI** – Body mass index; **Pb** – Lead; **Cu** – Copper; **Mn** – Manganese; **n** – Sample size*

Table 2. Mean values of BMI, Manganese, Copper and Lead of subjects according to age

Parameters	20–25 years Mean ± SD (n=15)	26–30 years Mean ± SD (n=21)	31–35 years Mean ± SD (n=14)	F-value	p-value
BMI (kg/m2)	23.86±1.77b	25.14±3.53b	23.72±1.80b	1.802	0.105
Pb (µg/ml)	0.17±0.09a	0.22±0.08a	0.29±0.08a	0.869	0.369
Cu (µg/ml)	0.76±0.25c	0.86±0.24c	0.63±0.26c	1.474	0.175
Mn (µg/ml)	0.08±0.12d	0.09±0.02d	0.08±0.02d	0.916	0.384

***Note:** *Values in a row with different superscript are significant at p<0.05. **Keys**: **BMI** – Body mass index; **Pb** – Lead; **Cu** – Copper; **Mn** – Manganese; **n** – Sample size*

Table 3. Mean values of BMI, Manganese, Copper and Lead of subjects with respect to duration of work

Parameters	<1 year Mean ± SD (n=17)	1–2 years Mean ± SD (n=18)	3–5 years Mean ± SD (n=15)	F-value	p-value
BMI (kg/m2)	23.97±2.89a	24.53±2.51a	26.19±3.03a	0.521	0.616
Pb (µg/l)	0.11±0.01a	0.15±0.05b	0.30±0.11c	5.801	0.000*
Cu (µg/ml)	0.77±0.27a	0.80±0.18a	0.91±0.26a	1.406	0.197
Mn (µg/ml)	0.08±0.14a	0.08±0.02a	0.09±0.02a	0.247	0.811

***Note:** *Values in a row with different superscript are significant at p<0.05. **Keys**: **BMI** – Body mass index; **Pb** – Lead; **Cu** – Copper; **Mn** – Manganese; **n** – Sample size*

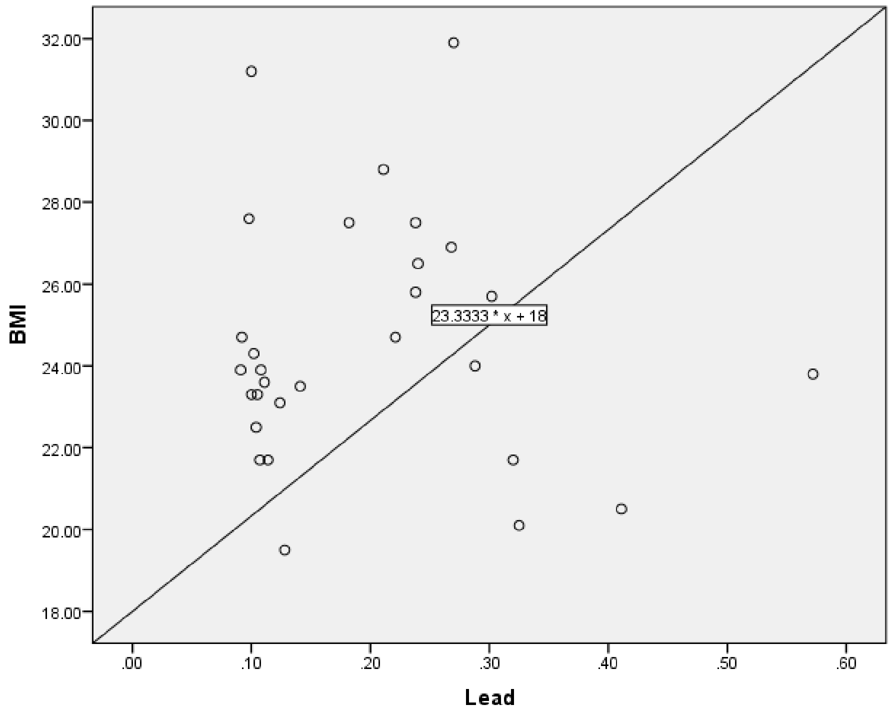

Figure 1. Scattered plot showing Pearson Correlation between BMI and Lead in cement factory workers

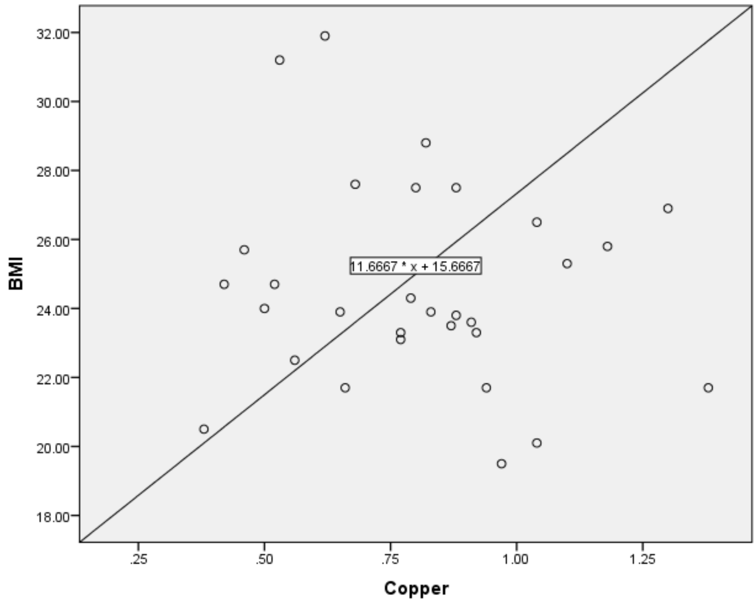

Figure 2. Scattered plot showing Pearson Correlation between BMI and Copper in cement factory workers

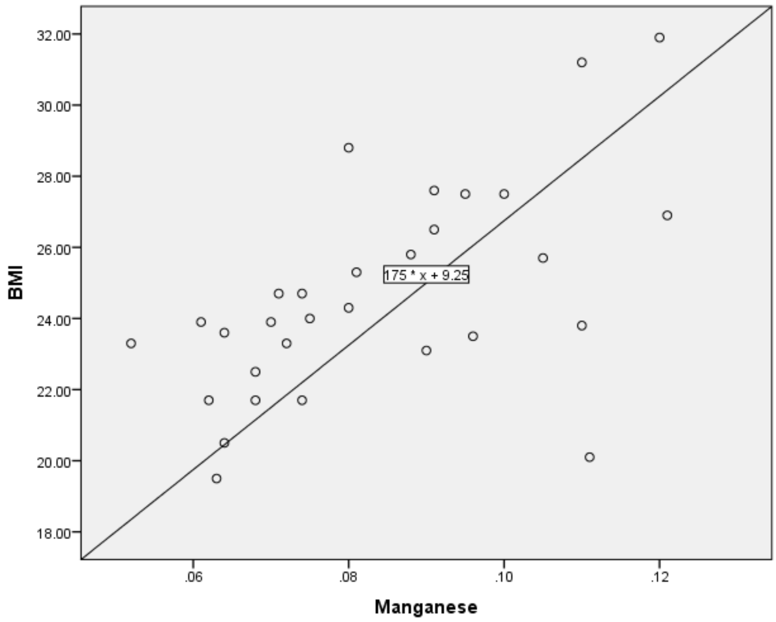

Figure 3. Scattered plot showing Pearson Correlation between BMI and Manganese in cement factory workers

DISCUSSION

Exposure to cement dust has been implicated as the major cause of silicosis and lung cancer. Exposure to cement dust has also been documented to cause various occupational and long-term health complications in humans [10]. Additionally, most of the trace elements are found in the human body in very minute quantities and any increase in some of them may have toxic effect [11]. This study was therefore aimed at assessing the levels of Pb, Mn and Cu of cement factory workers in Ekpoma and environs.

In this study, manganese was significantly higher in individuals exposed to cement dust compared with control subjects ($p<0.05$). Increased levels of manganese as seen in cement factory workers can be attributed to their exposure to cement dust. This finding is in agreement with previous authors [12-13]. The toxic effect of most elements depends principally on the absorption, concentration and persistence of the element at its site of action [14]. These elements react with the endogenous target molecule such as receptors, enzymes, DNA, proteins and lipids, and critically alter their biologic functions, producing structural and functional changes that result in toxic damage [14].

The result of this study shows that Cu was significantly higher in individuals exposed to cement dust compared with control subjects ($p<0.05$). This finding is in agreement with previous studies [15-16]. The increased demand on the antioxidant system to buffer the deleterious effects of heavy metal accumulation may account for high copper levels seen in cement factory workers. The body tends to retain copper to combat heavy antioxidant demands [17]. Copper is a component of ceruloplasmin which catalyzes the oxidation of iron to ferric forms for binding to its transport protein transferrin and subsequent storage in tissues and synthesis of hemoglobin. Therefore, increased copper implies increased conversion and removal of circulating iron and hence decreased serum levels seen in cement factory workers [18].

In this study, lead (Pb) was significantly higher in cement factory workers compared with control subjects ($p<0.05$). This finding is in agreement with previous authors [15-16,19]. Higher levels of Pb in cement workers may be attributed to the observation that some cement factory workers do not observe the laid down protective and safety precaution of the use of nose masks at factory site. Higher Pb levels in cement factory workers may also be attributed to duration of exposure which is also a determining factor in serum elements concentration [20]. The continuous inhalation or ingestion makes even the smallest concentration of such toxic elements a concern to their health. This is because the effects of exposure to any hazardous substance depend on the route of the exposure, concentration of substance, and duration of exposure. The level of toxicity found in short term exposure may be remedied, but the long-term toxicity is associated with undesirable health consequences [21].

There was no significant difference ($p>0.05$) in the Pb, Mn and Cu of subjects according to age, but there was significant increase ($p<0.05$) in the Pb of the subjects with respect to duration of work. This finding is consistent with previous studies [15-16,19]. Lead poisoning is known to have adverse effects on the nervous system, heme biosynthesis, kidneys, reproductive system, hepatic, hearing, endocrinal, gastrointestinal, blood pressure and cardiovascular system amongst occupationally exposed persons [22]. Exposure to lead at workplaces such as cement factory has been shown to be mainly through inhalation of lead laden particles, poor personal hygiene, water and food also contribute to the exposure [23].

CONCLUSION

The finding of this study showed that exposure to cement dust caused significant increase in Pb, Cu and Mn in individuals exposed to cement dust which indicates a possible metal toxicity in the subjects studied and these may have negative impact on their health. There was a progressive increase in trace elements concentration with duration of exposure. These observations emphasize the need for adequate safety and precautionary measures by cement factory workers and individuals exposed to cement dust to protect themselves from harmful effects of cement dust in the work environment.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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تقييم العناصر النزرة للأفراد المعرضين لغبار الأسمنت في إيكبوما وضواحيها

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المستخلص

الخلفية والهدف. يتكون غبار الأسمنت من مكونات سامة، ومعادن ثقيلة مثل النيكل والكوبالت والرصاص والكروم والملوثات الخطرة على البيئة الحيوية، ولها تأثير سلبي على الإنسان والنباتات الحيوانية والصحة والنظام البيئي. أجريت هذه الدراسة لتقييم مستويات الرصاص والمنغنيز والنحاس لدى الأفراد المعرضين لغبار الأسمنت في إكبوما والمناطق المحيطة بها. **طُرق الدراسة**. تم استخدام إجمالي 100 عينة في هذه الدراسة تضم خمسين (50) عاملاً في مصنع الأسمنت وخمسين (50) شخصًا ضابطًا. تم تقدير تراكيز المنغنيز والنحاس والرصاص باستخدام جهاز مطياف الامتصاص الذري. تم إجراء التحليل الإحصائي باستخدام تحليل التباين أحادي الاتجاه واختبار (ت) للطالب. **النتائج**. أظهرت النتائج التي تم الحصول عليها أن المنجنيز والرصاص كانا أعلى معنويا(P<0.05) ، بينما كان النحاس أقل معنويا في الأفراد المعرضين لغبار الأسمنت مقارنة بمجموعة السيطرة .(P<0.05) لم يكن هناك فرق معنوي (P>0.05) في الرصاص والنحاس والمنجنيز لدى الأفراد المعرضين لغبار الأسمنت باختلاف العمر. زاد الرصاص معنويا (P<0.05) مع مدة العمل، في حين لم يظهر النحاس والمنجنيز أي فروق ذات دلالة إحصائية .(P>0.05) **الخاتمة**. أظهرت نتائج هذه الدراسة أن التعرض لغبار الأسمنت تسبب في زيادة كبيرة في الرصاص والنحاس والمنغنيز لدى الأفراد الذين تعرضوا لغبار الأسمنت مما يشير إلى احتمال وجود سمية معدنية في الأشخاص الذين تمت دراستهم وقد يكون لها تأثير سلبي على صحتهم. كانت هناك زيادة تدريجية في تركيز العناصر النزرة مع مدة التعرض. تؤكد هذه الملاحظات على ضرورة اتخاذ تدابير السلامة والاحتراز الكافية بين عمال مصانع الأسمنت والأفراد المعرضين لغبار الأسمنت.

الكلمات الدالة. غبار الأسمنت، العناصر النادرة، الرصاص، النحاس، المنغنيز.