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Investigation of Hepatotoxic Effect of Cement-Dust in Occupationally Exposed Individuals in Malete, Kwara State, Nigeria, 2022

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Abstract

Background: *Cement is pivotal in advancing Nigeria's economic and infrastructural development amid rapid urbanization, where the demand for robust infrastructure underscores its integral contribution to meeting developmental requirements. While respiratory concerns have been extensively studied, the impact on the liver with the central role of detoxification remains a critical yet under explored dimension of occupational health.*

Objective: *Thus, this study investigated the hepatic effect of cement dust exposure among occupationally exposed individuals in North Central Nigeria.*

Methods: *A comparative cross-sectional study was conducted at Kwara State University Malete, Kwara State, North Central Nigeria, to compare the hepatic profiles of 60 individuals occupationally exposed to cement with 60 non-exposed who served as controls between June and October, 2022. Ethical approval was obtained from the Kwara State Ministry of Health, and informed consent was secured from each participant. Five (5) milliliters of blood were collected, and hepatic profiles were analyzed using standard spectrophotometric methods. Both descriptive and inferential statistics were used to investigate the comparison and correlation between the duration of exposure to cement dust and hepatic profiles among the study participants.*

Results: *The study revealed a significant increase in alanine aminotransaminase (ALT) and alkaline phosphatase (ALP) activities among individuals exposed to cement (ALT: 30.58 ± 11.54, ALP: 181.68 ± 26.25) compared to non-exposed controls (ALT: 19.90 ± 7.26; ALP: 163.68 ± 29.92) at a significance level of $p < 0.05$. Additionally, the duration of cement dust exposure demonstrated a significant positive correlation with gamma-glutamyl transferase (GGT) activity ($r = 0.363$; $p = 0.004$). Conversely, no significant positive correlation was observed between the duration of cement dust exposure and the activities of aspartate aminotransferase (AST) ($r = 0.190$; $p = 0.147$), ALT ($r = 0.016$; $p = 0.904$), ALP ($r = 0.178$; $p = 0.175$), and direct bilirubin ($r = 0.057$; $p = 0.664$). Furthermore, the duration of cement dust exposure showed a negative and non-significant correlation with total protein ($r = -0.098$; $p = 0.455$), albumin ($r = -0.097$; $p = 0.461$), and total bilirubin ($r = -0.156$; $p = 0.233$).*

Conclusion: *The study suggests that occupational exposure to cement dust may pose a risk of developing hepatotoxicity in the future.*

Introduction

Cement dust is mineral dust that contains chemical components such as silicon, calcium, aluminum, chromium, and iron [1]. This dust is formed in several parts of cement manufacturing and processing, including raw material extraction, crushers, rotary kilns, cranes, mills, storage silos, packing areas, and so on. According to Schenker *et al*. [2], cement is a crucial part of concrete that creates the foundation for buildings and roadways, and most of the professionals involved with the use of these materials include tillers, plaster of Paris (POP) installers, construction site workers, and so on. Cement dust contains 60–70% calcium oxide, 17–25% silicon oxide (SiO_2), and 3-5% aluminum oxide, along with iron oxide, chromium, potassium, sodium, sulphur, and magnesium oxide [3].

According to the Occupational Safety and Health Administration, nearly two million workers are exposed to cement dust every day [4]. This dust may enter the human body via the respiratory and gastrointestinal systems, causing harmful effects [5]. Cement dust inclusion particles, diffuse edema, hepatic sinusoidal lining cell proliferation, sarcoid granulomas, and perisinusoidal and portal fibrosis have all been observed in the hepatocytes of cement mill workers. These changes have been linked to liver lesions caused by breathed cement dust [6]. Other organs that might be damaged include the respiratory tract, which is characterized by diseases such as pulmonary embolism, osteo-pulmonary tuberculosis, silicosis, renal diseases, and skin problems that include palm keratinization [7]. The level of toxicity found in short-term exposure may be remedied, but the long-term toxicity is associated with undesirable health consequences [7].

The vast majority of cement workers in Nigeria and other developing nations are unaware of the importance of taking specific precautions to protect their health. Frequently, they are hired without the essential prerequisite training and sent to the job site with or without personal protective equipment [8]. Thus, industrial workers' knowledge and awareness of occupational hazards and how working in excessively dusty conditions affects health and safety is woefully inadequate [9].

A nonchalant attitude towards the use of personal protective devices by cement handlers leads to overly inhalation and ingestion of cement dust, thereby causing damages such as gastrointestinal and liver damage. Hence, this study evaluated the hepatic profile among cement occupationally exposed individuals to ascertain possible occupational hazards and proper management of already exposed individuals.

Material and Method

Study Area

This study was conducted at Kwara State University (KWASU) Malete, located in Moro Local Government Area of Kwara State, and lies within latitude 8.6563°N to 8.8136°N and longitudes 4.2359°E to 4.5410°E. KWASU has over 30,000 population including undergraduate and graduates students. It is located about 25 km north of Ilorin, the Kwara State capital. Though a relatively virgin area, it is highly vulnerable to unplanned expansions due to its proximity to the state capital and recently the siting of the KWASU campus, which facilitates continuous construction involving cement-occupation exposed individuals both in Malete and KWASU campus. The University provides Health facility accessible to both workers and students and the Medical Laboratory Science Department has standard equipment that aids sample processing, storage, and analysis [10]. The built up area gained an astronomical increase (180%) between 2005 and 2015 while forest lost significantly (34%) within the same periods, with most of the gains occurring in 2010 and 2015 after the establishment of KWASU. The climate of Kwara State exhibits both wet (rainy)and dry seasons in response to the South West Monsoon wind and the North East continental wind which are the major prevailing winds that blow across the state. The wet or rainy season begins towards the end of April and last till October. The dry season begins in November and end in April. The temperature of the state ranges from 33°C to 35°C from November to January and from 34°C to 37°C from February to April.The total annual rainfall ranges from 990.3mm to1318mm. The rainfall exhibits double maximal pattern.Relative humidity ranges from 75% to 88% from May to October and 35% to 80% during the dry season.

Study Design and period

A comparative cross-sectional study involving cement-exposed workers and unexposed individuals was conducted between June and October, 2022 in KWASU Malete, Kwara State.

The sample size was calculated using the formula for comparative survey

$$n = \frac{(Z_{a/2} + Z_{\beta})^2 \times P1\,(1\text{-}P1) + P2\,(1\text{-}P2)}{(p1\text{-}\,p2)^2} \quad [11]$$

Where;

P1= proportion of occupational cement exposure in Ekpoma, Nigeria = 4% [12].

P2 = proportion of non-exposed controls

$Z_{\alpha/2}$ = the standard normal deviation (1.96)

Z_{β} = power of the test

n = sample size

$n = (Za/2 + Z_{\beta})\ 2 \times P1\,(1\text{-}P1) + P2\,(1\text{-}P2) / (P1\text{-}P2)^2$

The sample size was calculated to be 59 and was increased to 60 to increase the power of the study.

Hence, a total of 120 subjects comprising 60 Cement occupationally exposed individuals and 60 healthy individuals were recruited for this study.

Study Population

The study population includes male and female cement occupationally exposed individuals aged 18 and 50 years and non-exposed age-matched individuals in Malete, Kwara state.

Ethical Approval

Approval for this research was obtained from the Ethical Review Committee of the Kwara State Ministry of Health, Ilorin, with reference number ERC/MOH/2022/05/034 in accordance with the 1975 Helsinki Declaration as revised in 2000. Informed consent was obtained from all participants included in the study.

Inclusion Criteria

Male and female human subjects aged 18–50 years.

Subjects whose duration of exposure to cement is 1 year and above [12].

Exclusion Criteria

Subjects whose exposure duration is less than a year.

Subjects at the extremes of age.

Pregnant women.

Sampling Technique

A convenient random sampling technique was used for the recruitment of study participants, while a detailed questionnaire was provided and given to each participant to fill out.

Data Collection and Sample Analysis

A 5 ml venous fasting blood sample was collected from the superficial vein of the antecubital fossa of each participant and dispensed into a plain bottle. The sample was allowed to clot and spun at 3000 rpm for 5 minutes to obtain serum. The serum was then separated into another sterile plain tube, which was then used to estimate the serum ALP, serum ALT, serum AST, serum GGT, total protein, bilirubin, and albumin using appropriate methods.

Laboratory Procedure

Serum Albumin Estimation by Dye Binding Method as described by Doumas *et al.* [13].

Principle

In the presence of bromocresol green at a slightly acidic pH, serum albumin produces a color change of the indicator from yellow-green to green-blue. The absorbance of the color produced is measured in a colorimeter at 630 nm, and the intensity of the blue-green color is proportional to the concentration of albumin in the sample.

Quantitative determination of serum total protein by direct biuret method as described by Tietz [14].

Principle

Protein in serum reacts with cupric ions in an alkaline medium to form a blue-colored complex. The intensity of the blue color is proportional to the protein concentration.

Quantitative Estimation of AspartateAminotransferase Activities by the Enzymatic Method as Described by Lorentz [15]**.**

Principle

Aspartate aminotransferase catalyzes the reversible transamination of L-aspartate and alpha-ketoglutarate to oxaloacetate and L-glutamate. The oxaloacetate is then reduced to malate in the presence of malate dehydrogenase with the concurrent oxidation of NADH to NAD.

Quantitative Estimation of Serum Alanine Aminotransaminase Activities as Described by Reitman and Frankel [16]**.**

Principle

ALT catalyzes the reversible transfer of an amino group from alanine to alpha-ketoglutarate, forming glutamate and pyruvate. The pyruvate produced is reduced to lactate by lactate dehydrogenase and NADH. The rate of decrease in NADH concentration measured photometrically is proportional to the catalytic concentration of ALT present in the sample.

Quantitative Estimation of Serum Alkaline Phosphatase as Described by King and Armstrong [17]**.**

Principle

ALP catalyzes the hydrolysis of the colorless organic phosphate ester substrate, p-Nitrophenyl phosphate, to the yellow-colored product p-Nitrophenol and phosphate in an alkaline medium of pH 10.3 and the presence of magnesium ions. The increase in the rate of absorbance is proportional to the activity of ALP in the sample.

Quantitative estimation of serum bilirubin as described by Jendrassik and Grof [18]**.**

Principle for Total Bilirubin

Sulfanlic acid reacts with sodium nitrate to form diazotized sulfanilic acid. Total bilirubin reacts with diazotized sulfanilic acid in the presence of TAB to form azobilirubin.

Principle for Direct Bilirubin

Sulfanlic acid reacts with sodium nitrate to form diazotized sulfanilic acid. Direct bilirubin reacts with diazotized sulfanilic acid to form azobilirubin.

Quantitative Estimation of Serum Gamma Glutammy Transferase Activities Using Szasz Methodology [19].

Principle

GGT catalyzes the transfer of a gamma-glutamyl group from the colorless substrate, gamma-glutamyl-p-nitroaniline, to the acceptor glycylglycine with a production of the colored product, p-nitroaniline.

Statistical Analysis

A statistical package for social science (version 20) was used for the statistical analysis. All measured data were presented as mean ± standard deviation. An independent t-test was used to compare the hepatic profile variables between cement-exposed workers and unexposed controls, and the level of significance was considered at P < 0.05.

Result

A total of 60 occupationally exposed and 60 unexposed individuals were recruited for this study (Table 1).The mean age was 27.27 ± 7.38 years, with most participants aged 19-30 (55.3%). Over half were single (67.5%), and the majority identified as Yoruba (73.3%). Half (50%) had a tertiary education with 95% employed full-time. A 50% of the participants had no cement dust exposure, 77.5% never smoked, and 85.8% never consumed alcohol.

Table 1: Socio-Demographic Characteristics of the Study Participants in Malete, Kwara State, Nigeria, 2022

Variables	Category	Frequency N=120	Percentage (%)
Age (Years)	19-30	67	55.8
	31-40	39	32.5
	41-50	12	10
	51-60	2	1.7
Mean ± SD		27.27±7.38	
Marital Status	Single	81	67.5
	Married	39	32.5
Ethnicity	Yoruba	88	73.4
	Hausa	25	20.8
	Others	7	5.8
Educational Status	Tertiary	60	50
	Secondary	26	21.7
	Primary	25	20.8
	None	9	7.5
Occupation	Students	53	44.2
	Bricklayer	31	25.8
	Cement Loader	19	15.8
	Others	17	14.2
Occupation Options	Full-Time	114	95.0
	Part-Time	6	5.0
Duration of Cement Dust Exposure (Years)	Nil	60	50
	1-4	24	20
	5-10	20	16.7
	11-20	9	7.5
	21-30	7	5.8
Cigarette Smoking	Never	93	77.5
	Daily	11	9.2
	Before	8	6.7
	Others	8	6.6
Alcohol Intake	Never	103	85.8
	Daily	7	5.8
	Others	10	8.3

There was a statistically significant difference when ALT (p=0.000) and ALP (p=0.002) were compared between cement occupationally exposed individuals and healthy non-exposed individuals at p < 0.05. There was no statistically significant difference when AST (p = 0.064), GGT (p = 0.838), total protein (p = 0.213), albumin (0.964), total bilirubin (p = 0.086), and direct bilirubin (p = 0.779) were compared between cement occupationally exposed individuals and healthy non-exposed individuals at p < 0.05 (Table 2).

Table 2: Comparison of Hepatic Profiles of Cement Occupationally Exposed and Non-Exposed Individuals in Malete, Kwara State, Nigeria, 2022

Parameters	Cement-expose individuals	Non-exposed individuals	T-value	P-value
AST (U/L)	27.72±11.85	24.02±7.91	1.888	0.064
ALT (U/L)	30.58±11.54	19.90±7.26	5.758	0.000*
ALP (U/L)	181.68±26.25	163.68±29.92	3.279	0.002*
GGT (U/L)	21.95±6.49	21.65±7.76	0.205	0.838
Total Protein (g/L)	67.87±8.51	69.73±6.86	-1.260	0.213
Albumin (g/L)	39.85±3.97	39.88±3.67	-0.046	0.964
Total Bilirubin (µmol/L)	3.72±2.09	3.18±1.40	1.727	0.089
Direct Bilirubin (µmol/L)	1.18±0.82	1.22±0.81	-0.282	0.779

(*) means significant at $p < 0.05$.

Table 3 showed that the duration of cement dust exposure showed a positive correlation with AST (r = 0.190; p = 0.147), ALT (r = 0.016; p = 0.904), ALP (r = 0.178; p = 0.175), GGT (r = 0.363; p = 0.004) and direct bilirubin (r = 0.057; p = 0.664). Duration of Cement Dust Exposure showed a negative correlation with Total Protein (r = -0.098; p = 0.455), Albumin (r = -0.097; p = 0.461), and Total Bilirubin (r = -0.156; p = 0.233).

Table 3: Relationship between Duration of Cement Dust Exposure and Hepatic Profile in Cement Occupationally Exposed Individuals in Malete, Kwara State, Nigeria, 2022

Duration of Cement Dust Exposure		
Variables	Correlation	P-value
AST (U/L)	0.190	0.147
ALT (U/L)	0.016	0.904
ALP (U/L)	0.178	0.175
GGT (U/L)	0.363	0.004*
Total Protein (g/L)	-0.098	0.455
Albumin (g/L)	-0.097	0.461
Total Bilirubin (µmol/L)	-0.156	0.233
Direct Bilirubin (µmol/L)	0.057	0.664

(*) means significant at $p < 0.05$

Discussion

The cement industry is regarded as a major polluter due to the dust and particle matter released during the various stages of cement manufacture. Workers are typically exposed to dust via dermal and respiratory pathways, as well as, to a lesser extent, ingestion [20]. Cement dust inclusion particles, diffuse swelling, proliferation of hepatic sinusoidal lining cells, sarcoid granulomas, and perisinusoidal and portal fibrosis have all been observed in the hepatocytes of cement mill workers [21]. These changes have been linked to hepatic lesions caused by inhaled cement dust [9].

In this study, we observed that ALT significantly increased at in cement occupationally exposed individuals compared to non-exposed individuals. This finding is consistent with the studies of Al Salhen *et al.* [22] and Richard *et al.* [1], who reported significant increases in ALT activities in cement handlers. ALT is of value as it indicates the existence of liver diseases, as this enzyme is present in large quantities in the liver. It increases in serum when cellular degeneration or destruction occurs in this organ [23]. Higher plasma ALT activities in cement handlers have also been reported by Malekirad *et al.* [24] and Owonikoko *et al*. [25]. However, this finding disagrees with the findings of Mojiminiyi *et al.* [26], who reported a decrease in ALT activity in cement handlers.

We also observed an insignificant increase in aspartate transaminase (AST) of cement occupationally exposed individuals compared to non-exposed individuals. This is consistent with previous studies by Festus *et al.* [12]. However, our findings disagree with Al Salhen *et al.* [22] and Richard *et al.* [1], who reported a significant increase in AST activities in cement handlers, and Mojiminiyi *et al.* [26], who reported a general decrease in AST activity in cement handlers. Also, Akhter *et al*. [27] reported non-significantly lower AST activities in the case group compared to the control group of cement factory workers.

Furthermore, our study demonstrated that alkaline phosphatase (ALP) significantly increased in cement occupationally exposed individuals compared to non-exposed individuals. The increase in alkaline phosphatases in plasma caused by exposure to cement dust agrees with the findings of Orman *et al.* [28], Al Salhen *et al.* [22], and Richard *et al.* [1]. Conversely, our study disagrees with Festus *et al.* [12], who reported no significant change in ALP, and Mojiminiyi *et al.* [26], who reported a decrease in ALP activity in cement handlers. Alkaline phosphatases comprise a group of enzymes that catalyze the hydrolysis of phosphate esters in an alkaline environment, generating an organic radical and inorganic phosphate [29]. In healthy adults, this enzyme is mainly derived from the liver, and its increased serum level is seen in liver disease associated with extra or intra-hepatic obstruction, obstructive jaundice, infectious mononucleosis, biliary cirrhosis, and cholestasis [30] [31].

In addition, there was no significant change observed in GGT between cement occupationally exposed individuals compared to non-exposed individuals. This is in contrast to the study of Zawilla *et al.* [32], who reported a significant increase in GGT in occupationally exposed individuals. The reason for variation in the studies could be due to the duration of exposure to cement dust on Gamma Glutamyl Transferase, which showed a significant positive correlation in the present study. This suggests that long-term or chronic exposure to cement dust could have deleterious effects on Gamma Glutamyl Transferase.

Total protein and albumin were observed to be insignificantly decreased in cement occupationally exposed individuals compared to non-exposed individuals at which agrees with Sameen [33] and Ogunbileje and Akinosun [34], who reported no significant difference in total protein and albumin levels in cement-exposed workers in Al-Ramadi city, Iraq, and Nigeria, respectively. However, our findings are in discordance with Oluwayemisi [35], who reported a significant decrease in total protein and albumin.

Moreso, no significant difference was observed in total and direct bilirubin of cement occupationally exposed individuals and non-exposed individuals. This agrees with the study of Ashwini *et al.* [36], Idris *et al*. [37], and Ogeniyi *et al*. [38], who reported no significant difference in total and conjugated bilirubin in cement handlers compared with non-cement handlers and with an insignificant perturbation in liver function. This observation is in discordance with the findings of Richard *et al.* [1], who reported an increase in the level of total and conjugated bilirubin in cement handlers. Similarly, Krishna *et al.* [39] reported a significant increase in plasma bilirubin levels of cement handlers; however, Mojiminiyi *et al.* [26] reported a general decrease in plasma total and conjugated bilirubin levels of cement factory workers compared with those of the control subjects.

The findings of this study have shown that occupational exposure to cement dust can be a potential for future development of hepatotoxicity, as ALT and ALP levels were significantly increased. Due to the high concentration of ALT in the liver, it is useful in detecting the presence of liver disease. It rises in serum levels when this organ experiences cellular degeneration or injury [40–50]. Increased Alanine aminotransaminases and alkaline phosphatase activities indicate toxicity and liver injury.

Conclusion

Cement-exposed individuals exhibited elevated levels of liver enzymes such as Alanine transaminase and alkaline phosphatase, suggesting potential liver impairment. Liver dysfunction typically manifests when 60% of hepatocytes are affected. This increase in enzyme levels may indicate potential hepatotoxic complications**.**

Recommendation

The observations from our study emphasize the need for adequate safety and precautionary measures among cement-exposed individuals.

Limitations

A limitation of this study is the relatively small sample size, which may limit the generalizability of the findings. Further research with a larger sample size is warranted to confirm these results.

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Conflict of interest

The authors of this work declare no conflict of interest.

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