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Impact of Cement Dust Exposure on Haematological, Immune, and Oxidative Status of Block Molders in Benin City, Nigeria: A Comparative Assessment

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<https://dx.doi.org/10.4314/sokjmls.v10i4.6>**Abstract**

Chronic exposure to cement dust is an occupational hazard associated with systemic inflammation, oxidative stress, and haematological dysfunction. Cement dust contains silica and heavy metals, which can trigger immune activation, oxidative damage, and alterations in trace element homeostasis, particularly among workers in developing countries. This study assessed the impact of chronic cement dust exposure on haematological indices, inflammatory response, oxidative balance, and trace element status among industrial and non-industrial block molders in Benin City, Nigeria. A cross-sectional study was conducted involving 205 participants: 80 industrial block molders, 80 non-industrial block molders, and 45 unexposed controls. Blood parameters measured included red blood cell count (RBC), haemoglobin, white blood cell count (WBC), erythrocyte sedimentation rate (ESR), interleukin-10 (IL-10), total antioxidant status (TAS), calcium, and zinc levels, using automated analyzers and immunoassays. Data were analyzed using ANOVA, with significance set at $p < 0.05$. Compared to controls, exposed workers exhibited significant reductions in RBC count and haemoglobin levels, indicating anaemia ($p = 0.001$). Inflammatory markers ESR and IL-10 were significantly elevated in both exposed groups ($p = 0.001$), suggesting persistent systemic inflammation. Total antioxidant status was reduced ($p = 0.001$), reflecting oxidative stress. Trace element analysis showed zinc depletion and calcium elevation ($p = 0.001$). The industrial block molders demonstrated more pronounced hematological and biochemical alterations than non-industrial molders. Chronic cement dust exposure impairs haematological

function through mechanisms involving inflammation and oxidative stress and disrupts trace element balance. These findings highlight the need for occupational health interventions, including dust control, consistent use of personal protective equipment, and routine health monitoring of exposed workers.

Keywords: Cement dust, inflammation, oxidative stress, anemia, IL-10, trace elements, occupational health

Introduction

Occupational exposure to cement dust is increasingly recognized as a significant health hazard due to its potential to induce oxidative stress, inflammation, and haematological disturbances (Ahmad *et al.*, 2024). Cement dust contains toxic components such as silica, hexavalent chromium, lead, and other heavy metals, which are known to generate reactive oxygen species (ROS) and trigger oxidative damage within biological systems (Ahmad *et al.*, 2021). These oxidative processes, in combination with inflammatory responses, can negatively affect red blood cell (RBC) production by impairing bone marrow function and inhibiting hemoglobin synthesis, ultimately contributing to anemia in exposed individuals (Capitão *et al.*, 2022). Chronic exposure to cement dust has been associated with decreases in RBC count, haemoglobin concentration, haematocrit, and mean corpuscular haemoglobin concentration (MCHC), suggesting compromised erythropoiesis and possible haemolytic effects (Wan *et al.*, 2021).

Workers involved in block molding are particularly susceptible due to their prolonged and repetitive exposure to dust-laden environments, often without sufficient protective equipment. Such exposure has been linked to persistent systemic inflammation, as evidenced by elevated inflammatory markers, including erythrocyte sedimentation rate (ESR) and interleukin-10 (IL-10) (LeVan *et al.*, 2018). Chronic inflammation may further modulate immune function and exacerbate haematological abnormalities, creating a cycle of immune and haematopoietic dysregulation. At the same time, reductions in total antioxidant status (TAS) and deficiencies in essential trace elements, particularly zinc, compromise the body's defense against oxidative damage, given zinc's role as a cofactor for critical antioxidant enzymes. Additionally, disruptions in mineral homeostasis, including elevated calcium levels, indicate metabolic imbalance arising from chronic inflammation and the toxic effects of cement dust (Dubey *et al.*, 2020).

Epidemiological studies from diverse industrial and geographic settings support these findings (Razzaque and Wimalawansa, 2025; Aaseth, 2022). Research conducted in Nigerian cement factories has documented significant alterations in hematologic indices, including anemia, leukocytosis, and platelet changes, among workers exposed to cement dust (Egbe *et al.*, 2016). Comparable observations have been reported internationally, including in Bangladesh and Turkey, where occupational exposure to cement dust was associated with oxidative stress, inflammatory responses, and haematological changes (Ahmad *et al.*, 2021). These studies collectively emphasize the widespread nature of these occupational hazards and highlight the need for localized investigations.

In this context, understanding the impact of cement dust on the haematological, immune, and oxidative status of block molders is critical, particularly in Benin City, Nigeria. Such assessments are essential for identifying at-risk populations, informing occupational safety measures, and guiding interventions to mitigate the adverse health effects of chronic cement dust exposure.

Methods and Materials

Study Design and Setting

A cross-sectional comparative analysis was conducted in various workshops across Benin City, Edo State, Nigeria. The setting included both formal industrial workshops and informal non-industrial block molding sites, representing typical exposure environments for cement dust inhalation among workers in the region.

Study Population

The study recruited a total of 205 participants divided into three groups: 80 industrial block molders with intense exposure to cement dust, 80 non-industrial block molders with comparatively lower exposure levels, and 45 unexposed control individuals drawn from surrounding communities with no occupational contact with cement dust.

Inclusion and Exclusion Criteria

Inclusion Criteria

Participants aged between 18 and 60 years who had been engaged in block molding work for at least one year and who provided informed consent were included to ensure adequate exposure duration and ethical participation.

Exclusion Criteria

Exclusion criteria were designed to reduce confounding factors and included a history of chronic systemic illnesses such as cardiovascular diseases, diabetes mellitus, and hypertension. Individuals with recent acute infections or those under medication that could influence haematological or biochemical markers were excluded. Participants with known exposure to other toxic substances were also excluded to isolate the effects of cement dust exposure.

Sample Size Determination

Sample size calculation employed Cochran's formula to achieve sufficient statistical power for detecting significant differences in haematological, inflammatory, and trace element parameters among groups. The calculation assumed 80% power and a 5% significance level, resulting in a minimum required sample of 205 participants.

Cochran's formula was employed to determine a total sample size of 205, powered at 80% with a 95% confidence level to detect statistically significant differences in hematological means between groups.

The sample size for occupational exposure to cement dust will be determined using Cochran's formula for estimating sample sizes in prevalence studies:

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{d^2}$$

Where: n = required sample size, Z = Z-score for a 95% confidence interval (1.96)

p = estimated prevalence of was 14 % according to Rahmani *et al.* (2018), d = margin of error (set at 0.05)

Based on previous studies, the prevalence of cement dust exposure was 14 % amongst subjects according to Rahmani *et al.* (2018).

Substituting these values:

$$N = \frac{(1.96)^2 \times 0.14 \times (1-0.14)}{(0.05)^2}$$

$$N = \frac{0.4626}{0.0025}$$

$$N = 185.01 = 186 \text{ Subjects}$$

Accounting for a 10% non-response rate, the sample size was adjusted to 205 subjects. The study included 80 industrial block molders, 80 non-industrial block molders, and 45 controls.

Sample Collection and Laboratory Analysis

Venous blood samples were collected aseptically from the antecubital fossa using sterile needles and tubes—EDTA tubes for haematological assays and plain tubes for serum separation. Automated haematology analyzers measured red blood cells (RBC), haemoglobin, haematocrit (HCT), white blood cells (WBC), platelets, and erythrocyte sedimentation rate (ESR). Serum was used to quantify total antioxidant status (TAS) and interleukin-10 (IL-10), a proinflammatory cytokine, through enzyme-linked immunosorbent assay (ELISA) using commercially validated kits. Trace elements calcium and zinc were quantified by atomic absorption spectrophotometry, ensuring sensitive and accurate detection relevant to dust exposure effects.

Data Management and Statistical Analysis

Data collected were entered into IBM SPSS Statistics version 26 for analysis. Initial data cleaning and validation were performed. Descriptive statistics summarized participant demographics and biochemical parameters. One-way analysis of variance (ANOVA) was conducted to compare mean values across the three groups. Where ANOVA indicated significant differences, Tukey's post hoc test determined intergroup significance. Statistical significance was predefined at $p < 0.05$.

Ethical Considerations

The study secured ethical approval from the Institutional Review Board of the Edo State Ministry of Education. Written informed consent was obtained from all participants after detailed explanation of study objectives, procedures, risks, and benefits. Participant confidentiality was strictly maintained, and all procedures complied with the Declaration of Helsinki on human research ethics.

Limitations

Despite its strengths, this cross-sectional study design restricts causal interpretation, as exposure and outcome were assessed simultaneously. The inability to track temporal changes or progression limits etiological conclusions. Reliance on self-reported occupational exposure duration introduces potential recall bias and misclassification. Environmental or personal dust concentration measurements were not incorporated, limiting precise exposure quantification. The sample size, though statistically adequate, may not represent all industrial and non-industrial block molders in Nigeria or other regions with varying exposure conditions. Future longitudinal, multi-center studies with objective exposure assessments and clinical outcome evaluation are necessary to validate and extend these findings.

Results

Table 1: Effect of cement Dust Exposure on Haematological, Immune, and Oxidative Parameters of Block Molders

Parameter	Control (Mean ± SD)	Industrial (Mean ± SD)	Non-Industrial (Mean ± SD)	Interpretation	p-value
RBC ($\times 10^{12}/L$)	5.12 ± 0.41	4.78 ± 0.38 ?	4.92 ± 0.39 ?	Reduced in exposed groups; anemia more severe in industrial	0.001
Haemoglobin (g/dL)	14.8 ± 1.1	13.2 ± 1.0 ?	13.8 ± 1.2 ?	Decreased, reflecting impaired erythropoiesis	0.001
WBC ($\times 10^3 /L$)	6.8 ± 1.2	8.1 ± 1.4 ?	7.6 ± 1.3 ?	Elevated, indicating immune activation/inflammation	0.001
ESR (mm/hr)	5.2 ± 1.1	8.7 ± 1.8 ?	7.4 ± 1.5 ?	Persistent systemic inflammation	0.001
IL-10 (pg/mL)	12.4 ± 2.1	15.8 ± 2.8 ?	14.2 ± 2.5 ?	Elevated anti-inflammatory cytokine response	0.001
TAS (mmol/L)	1.85 ± 0.22	1.42 ± 0.18 ?	1.58 ± 0.20 ?	Reduced antioxidant capacity; oxidative stress	0.001
Calcium ($\mu\text{g}/\text{dL}$)	95.2 ± 8.1	102.4 ± 9.2 ?	98.7 ± 8.5 ?	Mineral imbalance; higher in exposed workers	0.001
Zinc ($\mu\text{g}/\text{dL}$)	75.6 ± 6.3	68.3 ± 5.8 ?	71.2 ± 6.0 ?	Trace element depletion; antioxidant enzyme cofactor	0.001

Legend:

- = Significantly higher than control
- = Significantly lower than control

Notes:

- Industrial block molders exhibit the most pronounced alterations across all parameters, reflecting the intensity and duration of cement dust exposure.
- Non-industrial molders also show significant deviations from controls but less severe than industrial workers.

Discussion

This study demonstrates that chronic exposure to cement dust significantly affects haematological, inflammatory, oxidative, and trace element parameters among block molders in Benin City, Nigeria. Both industrial and non-industrial workers exhibited measurable alterations compared to controls, with industrial workers showing the most pronounced changes, highlighting a dose-response relationship associated with exposure intensity and duration.

Haematological assessment revealed significant reductions in red blood cell (RBC) counts (industrial: $4.78 \pm 0.38 \times 10^{12}/L$, non-industrial: $4.92 \pm 0.39 \times 10^{12}/L$ vs. control: $5.12 \pm 0.41 \times 10^{12}/L$, $p=0.001$) and haemoglobin levels (industrial: 13.2 ± 1.0 g/dL, non-industrial: 13.8 ± 1.2 g/dL vs. control: 14.8 ± 1.1 g/dL, $p=0.001$), indicating anaemia among exposed workers. These reductions are likely attributable to impaired erythropoiesis and increased red cell destruction induced by oxidative stress (Zhang *et al.*, 2022). Decreased total antioxidant status (TAS) in industrial (1.42 ± 0.18 mmol/L) and non-industrial workers (1.58 ± 0.20 mmol/L) compared to controls (1.85 ± 0.22 mmol/L, $p=0.001$) suggests that reactive oxygen species (ROS) generated from cement dust components such as silica, chromium, and heavy metals overwhelm endogenous antioxidant defenses, further contributing to red blood cell damage (Schaeffer *et al.*, 2018; Ahmad *et al.*, 2024).

Systemic inflammation was evident from elevated erythrocyte sedimentation rate (ESR) (industrial: 8.7 ± 1.8 mm/hr, non-industrial: 7.4 ± 1.5 mm/hr vs. control: 5.2 ± 1.1 mm/hr, $p=0.001$) and interleukin-10 (IL-10) levels (industrial: 15.8 ± 2.8 pg/mL, non-industrial: 14.2 ± 2.5 pg/mL vs. control: 12.4 ± 2.1 pg/mL, $p=0.001$). IL-10 elevation may reflect a regulatory anti-inflammatory response to persistent immune activation triggered by cement dust inhalation, while elevated white blood cell counts (industrial: $8.1 \pm 1.4 \times 10^9/L$, non-industrial: $7.6 \pm 1.3 \times 10^9/L$ vs. control: $6.8 \pm 1.2 \times 10^9/L$, $p=0.001$) indicate ongoing inflammatory processes. These findings align with previous studies showing chronic dust exposure activates systemic immune responses (Anderson *et al.*, 2020; Hedbrant *et al.*, 2023).

Trace element imbalance was also observed, with zinc significantly depleted in industrial (68.3 ± 5.8 µg/dL) and non-industrial workers (71.2 ± 6.0 µg/dL) compared to controls (75.6 ± 6.3 µg/dL, $p=0.001$), while calcium was elevated (industrial: 102.4 ± 9.2 µg/dL, non-industrial: 98.7 ± 8.5 µg/dL vs. control: 95.2 ± 8.1 µg/dL, $p=0.001$). Zinc deficiency may exacerbate oxidative stress and compromise antioxidant enzyme function, while elevated calcium suggests mineral dysregulation related to chronic inflammation or toxic exposure (López Alonso *et al.*, 2025; Aaseth *et al.*, 2025).

Overall, the findings highlight a pathogenic cascade initiated by cement dust exposure, in which oxidative stress and inflammation impair haematopoiesis and disrupt trace element balance, resulting in anemia and systemic dysfunction (Owonikoko *et al.*, 2022). Industrial block molders exhibited more severe derangements than non-industrial molders, confirming that exposure intensity and duration are critical determinants of health outcomes (Tavares *et al.*, 2022). These results underscore the urgent need for occupational health interventions, including dust control, personal protective equipment use, and regular monitoring of haematological, inflammatory, and oxidative biomarkers to prevent long-term morbidity among exposed workers.

Conclusion

Chronic occupational exposure to cement dust induces significant inflammation, oxidative stress, and haematological changes that elevate health risks among block molders. Cement dust contains irritant constituents such as silica, chromium, and other heavy metals which generate reactive oxygen species leading to oxidative damage. This oxidative stress reduces total antioxidant status and increases pro-inflammatory cytokines like IL-10, triggering a persistent inflammatory response evidenced by elevated ESR. Such inflammation and oxidative damage impair erythropoiesis and increase red blood cell destruction, culminating in anemia frequently observed in exposed workers. Furthermore, trace element imbalances, especially zinc depletion and calcium elevation, worsen immune function and disrupt metabolic

homeostasis. These findings align with studies globally demonstrating respiratory complications, systemic inflammation, and haematologic dysfunction in cement-exposed populations. The severity correlates with exposure intensity and duration, with industrial workers showing more pronounced effects. To mitigate these adverse health outcomes, strict occupational safety measures including dust control, personal protective equipment, routine health monitoring, and worker education are urgently needed to protect vulnerable laborers engaged in cement-related work. These strategies will reduce morbidity and improve workers' overall wellbeing.

Recommendations

Mandatory use of personal protective equipment and dust control systems, routine health assessments including inflammation and oxidative stress markers and worker education programs on exposure risks should be implemented.

Contribution to Knowledge

The study elucidates inflammatory and oxidative stress mechanisms underlying haematological impairments due to cement dust, informing targeted occupational health strategies.

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Declaration

No conflicts of interest declared; ethical approval and informed consent duly obtained.

Disclaimer

Author(s) hereby declare that generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

Aaseth, J. (2022). Toxic and essential metals in human health and disease 2021. *Biomolecules*; **12(10)**:1375.
Ahmad, F., Akhter, S., Haque, N. (2021).

Occupational cement dust exposure and inflammatory nemesis: Bangladesh relevance. *Journal of Inflammatory Research*; **14**:2425-2444.

Ahmad, F., Haq, I., Sinha, A., Mehta, R., Kumar, V., Haque, N., *et al.* (2024). Impact of occupational cement dust exposure on hematological health parameters: a cross-sectional study. *Cureus*; **16(10)**:e72673.

Anderson, S.E., Shane, H.L., Long, C.M., Marrocco, A.J., Lukomska, E., Roberts, J.R., *et al.* (2020). Biological effects of inhaled hydraulic fracturing sand dust. VIII. Immunotoxicity. *Toxicology and Applied Pharmacology*; **408**:115256.

Capitão, F., Martins, C., Santos, M., Bicho, M., Szigeti, T., Katsonouri, A., *et al.* (2022). Exposure to heavy metals and red blood cell parameters in children: a systematic review of observational studies. *Frontiers of Paediatrics*; **10**:921239.

Dubey, P., Thakur, V., Chattopadhyay, M. (2020). Role of minerals and trace elements in diabetes and insulin resistance. *Nutrients*; **12(6)**:1864.

Hedbrant, J., Engström, K., Andersson, J., Eklund, A., Westberg, H., Persson, B., *et al.* (2023). Occupational quartz and particle exposure affect systemic levels of inflammatory markers related to inflammasome activation and cardiovascular disease. *Environatal Health*; **22**: <https://doi.org/10.1186/s12940-023-00980-1>.

LeVan, T.D., Romberger, D.J., Siahpush, M., Grimm, B., Ramos, A.K., Johansson, P.I., *et al.* (2018). Relationship of systemic IL-10 levels with proinflammatory cytokine responsiveness and lung function in agriculture workers. *Respiratory Research*; **19**: <https://doi.org/10.1186/s12931-018-0875-z>.

López Alonso, M., Rivas, A., Miranda, M. (2025). Trace mineral imbalances in global health: challenges, biomarkers, and the role of serum analysis. *Nutrients*; **17(13)**:2241.

Owonikoko, K.M., Salami, S.O., Odukanmi, A.O., Emikpe, B.O., Olaleye, T.S. (2022). Hematopoietic toxicity in Wistar rats experimentally exposed to cement dust. *Comparative Clinical Pathology*; **13(2)**: 181-199.

Rahmani, A.H., Almatroudi, A., Babiker, A.Y.,

- Khan, A.A., Alsahly, M.A. (2018). Effect of exposure to cement dust among the workers: an evaluation of health related complications. *Open Access Macedonian Journal of Medical Science*; **6(6)**:1159–1162. doi:10.3889/oamjms.2018.233.
- Razzaque, M.S., Wimalawansa, S.J. (2025). Minerals and human health: from deficiency to toxicity. *Nutrients*; **17(3)**: 454.
- Richard, E.E., Augusta Chinyere, N.A., Jeremaiyah, O.S., Opara, U.C., Henrieta, E.M., Ifunanya, E.D. (2016). Cement Dust Exposure and Perturbations in Some Elements and Lung and Liver Functions of Cement Factory Workers. *Journal of Toxicology*; **2016**:6104719.
- Schaeffer, A., Kästner, M., Trapp, S. (2018). Improving the interpretation of Non-Extractable Residues (NER) in degradation assessment. *Research Portal Denmark*.
- Tavares, S., Aimonen, K., Ndaw, S., Fučić, A., Catalán, J., Duca, R., *et al.* HBM4EU Chromates Study—Genotoxicity and oxidative stress biomarkers in workers exposed to hexavalent chromium. *Toxics*; **10(8)**:483.
- Wan, Z., Medina, S., Zhang, J., Pan, Y., Zhou, T., Bolt, A.M., *et al.* (2021). Arsenite exposure inhibits the erythroid differentiation of human hematopoietic progenitor CD34+ cells and causes decreased levels of hemoglobin. *Science Report*; **11**: 22121.
- Zhang, L., Liu, Y., Guo, Q., Zhang, H., Zhang, X., Deng, M., *et al.* Hematological effects and benchmark doses of long-term co-exposure to benzene, toluene, and xylenes in a follow-up study on petrochemical workers. *Toxics*; **10(9)**:502.

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