ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-0912 (Print)
e-ISSN: 2521-0912 (Online)
CODEN: JCOLBF

Journal Clean WAS (JCleanWAS)

DOI: http://doi.org/10.26480/jcleanwas.02.2025.117.120

CrossMark

RESEARCH ARTICLE

# OCCUPATIONAL AND ENVIRONMENTAL IMPACT OF CEMENT FACTORY EMISSIONS ON RENAL FUNCTION IN OKPELLA, NIGERIA

**Ijeoma Evangeline Umeche*, Mathew Folaranmi Olaniyan, Omolayo Mary Akinlade**

*Department of Medical Laboratory Science, Faculty of Applied Health Sciences, Edo State University Iyamho, Edo State, Nigeria.*
**Corresponding Author Email: umeche.ijeoma@edouniversity.edu.ng*



## ARTICLE DETAILS

*Article History:*

Received 10 July 2025
Revised 15 August 2025
Accepted 19 September 2025
Available online 08 October 2025

## ABSTRACT

**Background**: Cement production is a major industrial activity associated with environmental and occupational pollution, particularly through particulate matter and heavy metal emissions. Prolonged exposure to cement dust may result in systemic toxicity, including renal dysfunction. This study investigated the impact of cement factory exposure on renal biochemical parameters among factory workers and residents in Okpella, Edo State, Nigeria.Methods: A cross-sectional analytical design was employed. One hundred participants were recruited: 25 factory workers, 25 residents within 5 km of the factory, and 50 controls with no known exposure. Serum creatinine, urea, sodium, and potassium levels were measured. Data were analyzed using t-tests with $p<0.05$ considered statistically significant. **Results**: Cement workers exhibited significantly higher serum creatinine (1.3 ± 0.2 mg/dL) compared to controls (0.7 ± 0.2 mg/dL; p=0.01). Urea levels were elevated in workers (58.2 ± 5.6 mg/dL) relative to controls (46.2 ± 13.4 mg/dL; p=0.001). Serum sodium was significantly higher in workers (150.4 ± 10.6 mmol/L) than in controls (146.0 ± 4.7 mmol/L; p=0.001). Potassium levels were also increased in workers (4.5 ± 1.0 mmol/L) compared to controls (3.8 ± 0.3 mmol/L; p=0.004). Similar trends were observed among residents, though with less magnitude. **Conclusion**: Chronic exposure to cement factory emissions is associated with altered renal biochemical parameters, suggesting potential early renal impairment among workers and residents. Periodic medical screening, dust exposure reduction strategies, and environmental monitoring are recommended to mitigate renal health risks in industrial communities

**KEYWORDS**

Cement dust, renal function, occupational exposure, nephrotoxicity, urea, creatinine

## 1. INTRODUCTION

Cement manufacturing is an essential industrial process worldwide; however, it is also recognized as a major source of environmental and occupational pollution. Cement dust is a complex mixture of calcium oxide, silica, aluminum, iron oxides, and trace heavy metals such as cadmium, chromium, and lead, many of which are toxic to human health when inhaled or ingested over prolonged periods(Meo, 2004; Ali et al., 2016; Mwaiselage et al., 2005). Exposure occurs not only among workers in cement plants but also among residents in surrounding communities due to the dispersal of airborne particulates (Manjula et al., 2013; Singh et al., 2015).

The kidneys play a central role in maintaining fluid-electrolyte balance and excreting metabolic waste products. They are highly vascularized organs, making them particularly vulnerable to environmental and occupational toxicants. Prolonged cement dust exposure may induce nephrotoxicity through mechanisms involving oxidative stress, systemic inflammation, and heavy metal accumulation (Rahman et al., 2021; Valko et al., 2006; Anees et al., 2018). Alterations in biochemical markers such as serum creatinine, urea, sodium, and potassium serve as early indicators of renal impairment and electrolyte imbalance (Okonkwo et al., 2019; Ogunbileje and Akinosun, 2011).

Studies conducted in various regions have consistently reported higher creatinine and urea levels among cement workers compared to controls (Faremi et al., 2017; Shukla and Singh, 2017). Similarly, disturbances in sodium and potassium homeostasis have been associated with occupational cement exposure, suggesting impairment of tubular handling and electrolyte regulation (Chen et al., 2021; El-Said and Emara, 2019). In Nigeria, few studies have comprehensively compared renal function indices among cement workers, residents, and unexposed controls.

This study therefore investigates the renal effects of cement dust exposure in Okpella, Edo State, Nigeria. Specifically, it compares biochemical parameters among cement workers, residents living near the factory, and a control group. Findings from this study will contribute to the growing evidence on occupational nephrotoxicity and inform public health strategies for industrial safety and community protection.

## 2. METHODS

### 2.1 Study Area

The study was conducted in Okpella Community, Etsako West Local Government Area, Edo State, Nigeria. The area hosts a large cement factory, with surrounding populations exposed to cement dust emissions. Etsako West has a land area of 946 km$^2$ and a population of 197,609 according to the 2006 census.

### 2.2 Study Design

A cross-sectional analytical design was used to assess renal biochemical parameters in factory workers, residents, and controls.

### 2.3 Sample Size Determination

Sample size was calculated using Fisher's formula (Jaykaran and

| Quick Response Code | Access this article online | |
|---|---|---|
| | **Website:** www.jcleanwas.com.my | **DOI:** 10.26480/jcleanwas.02.2025.117.120 |

Tomaghna, 2013) with a prevalence of liver-related disorders in similar industrial populations estimated at 7.9%16. The calculated minimum sample size was 83. After adjusting for non-response, the sample size was increased to 100 participants.

### 2.4 Study Participants

Workers: 25 cement factory workers (Millers, Conveyors, Packing).

Residents: 25 individuals residing within 5 km of the cement factory.

Controls: 50 unexposed individuals with no occupational or residential exposure.

Inclusion Criteria:

- Age 18–60 years.
- At least one year of employment or residence near the factory.
- Willingness to provide informed consent.

Exclusion Criteria:

- History of pre-existing renal disease.
- Pregnancy.
- Residence/employment less than one year.

### 2.5 Sampling Technique

Stratified random sampling was employed to ensure representation across occupational roles within the factory and among nearby residents.

### 2.6 Data Collection and Biochemical Analysis

Venous blood samples were collected, centrifuged, and analyzed for serum creatinine, urea, sodium, and potassium using standard automated biochemical analyzers following manufacturer instructions.

### 2.7 Ethical Consideration

Ethical approval was obtained from the Health Research Ethics Committee, Auchi Local Government Secretariat. Written informed consent was obtained from all participants.

### 2.8 Data Analysis

Data were expressed as mean ± SD. Comparisons between groups were performed using independent t-tests. A p-value <0.05 was considered statistically significant.

## 3. Results

Table 1 shows comparison of renal parameters between cement workers and residents

Cement workers exhibited significantly higher urea and sodium levels compared to residents (p = 0.001), indicating possible early renal stress from occupational exposure. However, differences in creatinine and potassium were not statistically significant, suggesting less pronounced renal impairment among residents despite environmental exposure.

**Table 1:** Comparison of renal parameters between cement workers and residents

| Parameter | Workers (n=40) | Residents (n=40) | t-value | p-value |
|---|---|---|---|---|
| | | | | |
| Creatinine (mg/dL) | 1.3 ± 0.2 | 0.9 ± 0.2 | 1.67 | 0.09 |
| Urea (mg/dL) | 58.2 ± 5.6 | 47.7 ± 15.8 | 50.2 | 0.001* |
| Sodium (mmol/L) | 150.4 ± 10.6 | 146.0 ± 4.7 | 18.4 | 0.001* |
| Potassium (mmol/L) | 4.5 ± 1.0 | 4.9 ± 0.6 | 1.67 | 0.09 |

Table 2 shows Comparison of renal parameters between cement workers and controls

Cement workers showed significantly elevated creatinine, urea, sodium, and potassium levels compared to unexposed controls (all p < 0.05). This suggests a strong association between occupational cement dust exposure and renal dysfunction, with both waste clearance and electrolyte regulation adversely affected.

**Table 2:** Comparison of renal parameters between cement workers and controls

| Parameter | Workers (n=40) | Controls (n=40) | p-value |
|---|---|---|---|
| Creatinine (mg/dL) | 1.3 ± 0.2 | 0.7 ± 0.2 | 0.01* |
| Urea (mg/dL) | 58.2 ± 5.6 | 46.2 ± 13.4 | 0.001* |
| Sodium (mmol/L) | 150.4 ± 10.6 | 146.0 ± 4.7 | 0.001* |
| Potassium (mmol/L) | 4.5 ± 1.0 | 3.8 ± 0.3 | 0.004* |

This study provides evidence of altered renal biochemical parameters among cement factory workers and residents exposed to cement dust emissions in Okpella. Workers exhibited significantly higher levels of serum creatinine and urea compared to controls, suggesting early renal impairment possibly due to cumulative nephrotoxic exposure. These findings reinforce the concept that occupational exposure to cement dust poses a systemic toxicological risk that extends beyond the respiratory system and affects renal homeostasis.

The elevated serum creatinine observed in cement workers aligns with findings from India, Ethiopia, and Pakistan, where occupational exposure to cement dust has been linked to reduced glomerular filtration rate and nephrotoxicity (Faremi et al., 2017; Bråtveit and Moen, 2001; IARC.2012). Increased urea levels indicate impaired nitrogen excretion, consistent with similar studies in Nigerian and Egyptian cement workers (Nwaopara et al., 2010;Mohammed et al., 2020). Notably, creatinine and urea are reliable biomarkers of renal clearance, and their consistent elevation in exposed populations strongly suggests progressive nephron damage attributable to chronic exposure ( Abdel Hamid et al., 2020).

Electrolyte disturbances, particularly elevated sodium and potassium levels among workers, suggest possible tubular dysfunction or altered electrolyte regulation induced by heavy metal deposition or oxidative stress from cement dust inhalation (Rafeemanesh et al., 2015 ; Jaykaran, Tamoghna et al., 2013). Elevated sodium levels could reflect impaired tubular reabsorption, while hyperkalemia may indicate reduced renal excretion capacity. Previous research has shown that cadmium, chromium, and lead in cement dust can accumulate in renal tissues, inducing oxidative stress, lipid peroxidation, and mitochondrial dysfunction, which further disrupt electrolyte balance (WHO.2000; Chen et al., 2020; Ukaejiofo and Nwafor, 2018; Limaye et al., 2018). This is consistent with mechanistic studies demonstrating that oxidative damage to renal tubules compromises sodium–potassium ATPase activity, thereby disturbing ion transport and homeostasis (Farombi et al., 2019).

The finding that residents also displayed altered renal indices, though less pronounced than workers, highlights the environmental health burden of cement emissions. This aligns with observations from Ghana and Tanzania, where communities near cement plants exhibited subclinical renal dysfunction due to ambient dust exposure (Jaiswal et al., 2021; ILO.2011). Such evidence underscores that the health risks are not confined to occupationally exposed workers but extend to surrounding populations, posing a public health challenge in industrializing regions. Furthermore, ambient air monitoring studies in sub-Saharan Africa have reported dust levels exceeding WHO air quality standards in communities adjacent to cement factories, with potential long-term renal and cardiovascular consequences (Armah et al., 2014).

From a public health perspective, the dual occupational and environmental exposure pathways documented here emphasize the need for stringent regulatory enforcement, improved emission control technologies, and health surveillance for both workers and residents. Interventions such as periodic renal screening, provision of personal protective equipment, and strategic zoning policies that increase residential distance from factories could substantially reduce exposure burden.

The study is limited by its cross-sectional design, which precludes establishing causality, and by the relatively small sample size, which may reduce generalizability. Nevertheless, the strong associations observed between cement dust exposure and altered renal indices provide robust evidence that industrial emissions are a significant risk factor for renal dysfunction in both occupational and community settings. Future longitudinal studies with larger sample sizes and additional biomarkers (e.g., cystatin C, β2-microglobulin) would further elucidate the chronic renal effects of cement exposure.

## 4. Conclusion

Exposure to cement factory emissions in Okpella is associated with early renal function alterations, reflected in elevated creatinine, urea, sodium, and potassium levels. Cement workers are at greatest risk, but residents also experience adverse renal effects, underscoring the need for both occupational and environmental health interventions.

## Recommendations

Based on the findings of this study, the following recommendations are proposed:

Occupational Health Interventions: Cement factory management should implement regular health surveillance for workers, focusing on renal function tests and early detection of nephrotoxicity. Provision of adequate personal protective equipment (PPE) such as respirators and protective clothing should be mandatory, alongside periodic training on occupational safety.

Environmental Control Measures: Enforcement of stricter air quality regulations and continuous monitoring of cement dust emissions around factories is essential. Installation of effective dust-suppression technologies, such as electrostatic precipitators and bag filters, should be prioritized to reduce ambient particulate exposure. Relocation of residential housing farther from cement factories where possible.

Community Health Protection: Periodic renal function screening for cement factory workers and nearby residents. Public health awareness campaigns are needed to sensitize communities about the potential risks of prolonged exposure to cement dust and ways to minimize personal risk.

Policy and Research Implications: Government agencies should establish and enforce stricter occupational and environmental standards for the cement industry in Nigeria. Further longitudinal and multi-center studies are recommended to establish causal relationships, assess long-term renal outcomes, and explore protective interventions.

## Conflict Of Interest

None declared.

## Funding

Funded by TET FUND Insitution Based Research Intervention (IBR) Allocation received through Edo State University Iyamho.

## Author's Contributions

I.E.U: Designed and conceptualized the study, Interpretation of data, and wrote the manuscript

M.F.O. Supervised the research and reviewed the manuscript

O.M.A: Performed biochemical analysis and revised the work

## References

Abdel Hamid, Z., El-Safty, I.A., Sabry, N.A., 2020. Kidney function alterations among workers occupationally exposed to cement dust. Toxicol Ind Health. 2020;36(9):pp. 693–701. doi:10.1177/0748233720935381

Ali, N.A., Ahmed, S.O., Ibrahim, M.A., 2016. Cement dust exposure and health risks among workers. Int J Environ Health Res. 2016;26(1):Pp. 50–60. doi:10.1080/0960313.2015.1041616,

Anees, T., Shoukat, S., Shahid, M., 2018. Biochemical alterations in cement industry workers. Pak J Physiol. 2018;14(2):Pp. 54–8.

Armah, F.A., Quansah, R., Luginaah, I. A., 2014. systematic review of heavy metals in cement dust and implications for human health in Sub-Saharan Africa. Ecotoxicol Environ Saf.102:Pp. 153–61. doi:10.1016/j.ecoenv.2014.01.030

Bråtveit, M., Moen, B.E., 2001. Dust exposure and renal effects in cement workers. Occup Med. 2001;51(6): Pp. 439–44. doi:10.1093/occmed/51.6.439

Chen, J., He, Y., Li, S.,2021. Occupational dust exposure and chronic kidney disease. Environ Int.156:106618. doi:10.1016/j.envint.2021.106618

Chen, W., Liu, Y., Wang, H., 2020. Chronic occupational dust exposure and kidney disease risk. Int J Hyg Environ Health.228:113548. doi:10.1016/j.ijheh.2020.113548

El-Said, K., Emara, A., 2019. Renal biomarkers among cement workers. Egypt J Occup Med. 43(1):Pp. 57–71. doi:10.21608/ejom.2019.28519

Faremi, A.F., Ogunfowokan, A.O., Esan, A.O., 2017. Renal indices in cement workers. J Environ Public Health;2017:9038461. doi:10.1155/2017/9038461

Farombi, E.O., Adelowo, O.A., Ajimoko, Y.R., 2019. Biomarkers of oxidative stress and renal function in Nigerian cement factory workers. Hum Exp Toxicol. 2019;38(2):Pp. 197–205. doi:10.1177/0960327118807314

IARC.2012. Silica dust, crystalline, in the form of quartz or cristobalite. IARC Monogr Eval Carcinog Risks Hum. 2012;100C:Pp. 355–405.

ILO.2011. Encyclopedia of Occupational Health and Safety: Cement Industry. 4th ed. Geneva: International Labour Organization.

Jaiswal, A., Banerjee, S., Bhattacharjee, A., 2021. Occupational exposure to cement dust and its impact on renal health: a systematic review. Environ Sci Pollut Res.28(37):Pp. 51534–45. doi:10.1007/s11356-021-16158-2

Jaykaran, Tamoghna, B., 2013. How to calculate sample size. Indian J Psychol Med. 2013;35(2):Pp. 121–6. doi:10.4103/0253-7176.116232

Limaye, P.V., Raghunath, A., Sutariya, B., 2018. Cement dust-induced nephrotoxicity: role of heavy metals and oxidative stress. Environ Sci Pollut Res. 25(16):Pp. 15878–86. doi:10.1007/s11356-018-1760-1

Manjula, R., Praveena, R., Shanthi, M., Rajaram, S.,2013. Effects of occupational dust exposure on health status of cement workers. Ind Health. 2013;51(2):Pp. 214–8. doi:10.2486/indhealth.2012-0044

Memon, A.Q., Memon, K., Rind, R., 2016. Effect of cement dust on kidney functions. Pak J Physiol;12(1):Pp. 21–5.

Memon, A.Q., Solangi, R.B., Shahani, M.Y., 2019. Electrolyte imbalance in cement industry workers. Sindh Univ Res J. 2019;51(4):Pp. 905–10.

Meo, S.A.,2004. Health hazards of cement dust. Saudi Med J;25(9):Pp. 1153–9. PMID: 15448764.

Mohammed, A.S., Onwuliri, E.A., Usman, A., 2020. Toxicological assessment of cement dust on renal functions. Afr J Biochem Res. 2020;14(3):Pp. 23–9. doi:10.5897/AJBR2020.1075

Mwaiselage, J., Bråtveit, M., Moen, B., Yost, M., 2005. Variability in dust exposure in a cement factory in Tanzania. Ann Occup Hyg;49(6):Pp. 511–9. doi:10.1093/annhyg/mei022

Nwaopara, A.O., Anyanwu, L.C., Nwaopara, S.O., 2010. Cement dust and renal effects in Nigeria. Niger J Environ Sci Toxicol. 4(2):Pp. 1–8.

Ogunbileje, J.O., Akinosun, O.M.,2011.Biochemical profile in Nigerian cement factory workers. Res J Environ Toxicol. 2011;5(2):Pp. 133–40. doi:10.3923/rjet.2011.133.140

Okonkwo, C.J., Ogu, U.N., Okeke, C.N., 2019. Cement dust and serum kidney function markers. J Med Lab Sci. 2019;29(1):Pp. 1–6.

Rafeemanesh, E., Paknejad, O., Taheri, F., 2015. Effect of cement dust on renal markers. Toxicol Ind Health.31(12):Pp. 1215–22. doi:10.1177/0748233713487253

Rahman, M.M., Hannan, M.A., Uddin, M.J., Rahman, M.A., 2021. Heavy metal exposure and nephrotoxicity. Curr Opin Toxicol. 2021;27:Pp.57–65. doi:10.1016/j.cotox.2021.09.003

Shukla, R., Singh, S., 2017. Biochemical profile alterations among Indian cement workers. Indian J Clin Biochem.32(3):Pp. 321–7. doi:10.1007/s12291-016-0585-3

Singh, N.P., Ghosh, A.K., Gupta, S., Occupational cement dust exposure and renal effects. Indian J Occup Environ Med. 2015;19(1):Pp. 37–42. doi:10.4103/0019-5278.157013

Ukaejiofo, E.O., Nwafor, A.,2018. Umeokonkwo CD. Renal function indices among Nigerian workers exposed to cement dust. Niger Med J.59(4):Pp. 179–84. doi:10.4103/nmj.NMJ_55_18

Valko, M., Rhodes, C.J., Moncol, J., Izakovic, M., Mazur, M., 2006. Free radicals and metals in oxidative stress. Chem Biol

Interact;160(1):Pp. 1–40. doi:10.1016/j.cbi.2005.12.009

WHO.2000. Human exposure assessment. Geneva: World Health Organization; 2000.