



Research Journal of
**Environmental
Toxicology**

ISSN 1819-3420



Academic
Journals Inc.

www.academicjournals.com

Biochemical and Haematological Profile in Nigerian Cement Factory Workers

^{1,2}John Olusegun Ogunbileje and ¹Olubayo Micheal Akinosun

¹Department of Chemical Pathology and Immunology, College of Medicine, University of Ibadan, Ibadan, Nigeria

²Department of Pathology, University of Texas Medical Branch, Galveston, Texas, USA

Corresponding Author: John Olusegun Ogunbileje, Department of Chemical Pathology and Immunology, College of Medicine, University of Ibadan, Ibadan, Nigeria

ABSTRACT

Cement dust exposures has been reported to result in various occupational health problems and long term complications. However, effects of cement dust exposures on biochemical, oxidative stress indicators and Haematological profiles in Nigerians cement factory workers are scarce, therefore the present study is aimed at determining the effects of cement dust exposure on uric acid, creatinine, total protein, albumin, globulin, copper and selenium levels and Haematological profile in forty-five cement factory workers and thirty controls office workers. Uric acid, creatinine, albumin and total protein were determined using Hitachi 902 auto analyser, total globulin was computed by subtracting albumin level from total protein concentration while haematological parameters were determined using Sysmex. Uric acid, copper and creatinine levels were significantly higher in cement factory workers compared with controls ($p < 0.05$). Also, haemoglobin, haematocrite concentration, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin Concentration (MCHC), Mean Corpuscular Hemoglobin (MCH), lymphocytes and eosinophils are significantly higher in exposed group compared with controls while neutrophils were significantly lower in cement factory workers. Significantly higher creatinine suggests nephrotoxic effects while uric acid probably in part up regulated to combat oxidative stress. Uric acid was also significantly positively correlated with Body Mass Index (BMI) ($r = 0.38$, $p < 0.05$), probably to match the body cement dust burdens. Higher haematological profile probably support the report that cement mill workers are exposed to metals that enhance haematopoietic system while the insignificant difference of total protein, albumin suggest that cement dust does not have effects on the synthetic functions of liver. Other variables did not differ significantly.

Key words: Cement dust, creatinine, uric acid, haematology parameters and synthetic function

INTRODUCTION

Inflammatory response to workplace exposures to silica has been reported to be observed in specific organs, such as lungs, skin and the liver and if persistent may progress to fibrosis, granulomatous diseases and even cancer (Aminian *et al.*, 2008). Molecules of primary importance in cement dust basically include 60-67% calcium oxide, 17-25 silicon oxide (SiO_2), 3-5% aluminium (Al) oxide, with some amount of iron oxide, chromium (Cr), potassium, sodium, sulphur and magnesium oxide (Fell *et al.*, 2003; Gbadebo and Bankole, 2007). It has been reported that chronic exposures to aluminium could increase lipid peroxidation in different tissues resulting in

neurotoxicity, renal failure and anaemia (Mohammadirad and Abdollahi, 2011). Also, chromium is present in cement dust product via scrapes of refractory lining of kiln and steel balls used in the mills (Bhatty, 1995) and has been reported to be highly toxic and a strong oxidising agent, especially Cr (VI) which is highly present in cement dust due to oxidation, exposure to this Cr (VI) results in toxic effects in vital organs such as respiratory (lungs), kidney and liver (ATSDR, 2000) via generation of free radicals and resultant inflammatory reactions. Continuous efflux of reactive oxygen species from endogenous and exogenous sources has been known to result in accumulative oxidative damage to cellular component and alters many cellular functions (Kohen and Nyska, 2002; Adly, 2010).

Human haematopoietic system is known to be extremely sensitive to environmental influences due to rapid synthesis and destruction of cells with resultant heavy metabolic demands, making it a good indicator in toxicological studies (Jude *et al.*, 2002). Also, recent reports have shown the protective role of haematopoietic products in prevention of oxidative stress related diseases (Feng *et al.*, 2005; Gawad *et al.*, 2009). Specifically, Gawad *et al.* (2009) demonstrated the protective role of erythropoietin against apoptosis induced oxygen radicals.

The present study was aimed at predicting the nephrotoxic effects of cement dust and possible oxidative stress effect, also to determine the effect on synthetic functions of the liver and on haematological parameters.

MATERIALS AND METHODS

A total of seventy-five Nigerian males were randomly selected for the study after obtaining an informed consent. Forty-five were cement factory workers in a cement factory in Ogun state Nigeria while thirty controls were office workers that were not resident in town of study, this study was carried out between November 2008 and October 2009. Smokers, alcoholics and those with chronic illnesses were exempted from the study. The mean age of the subjects group was 35.04 ± 8.36 years while that of the control group was 31.87 ± 8.08 years. Questionnaires were administered to obtain vital information. Ten millilitre of venous blood was withdrawn; 5 mL was dispensed in a plain bottle to obtain serum while 5 mL was withdrawn into an EDTA bottle for haematological profile. Uric acid, total protein, albumin and creatinine were determined using Hitachi 902 auto analyser based on standard methods while globulin was computed by subtracting albumin level from total protein concentration. Haematology parameters were determined using Sysmex auto-analyser.

The Body Mass Indexes (BMI) of both cement factory workers and controls were computed according to the standard formula:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

All analyses were subjected to quality checks to ensure reliability of generated data. Results were only accepted if QC data fell between mean values $\pm 2\text{SD}$.

All data were expressed as Mean \pm SEM. Results were analyzed using the Students' T-test and correlation studies using Pearson's Product Moment Correlation coefficient. Differences between values in cement factory workers and controls were accepted as significant at 5% ($p < 0.05$) level.

RESULTS

Table 1 shows body mass index, copper, uric acid and selenium levels in cement factory workers compared with corresponding values in controls. Body mass index and selenium values were similar

in both cement factory workers and controls, while uric acid and copper were significantly higher in exposed group compared with office workers. Additionally, uric acid level was positively correlated with BMI. In Table 2, creatinine level was significantly higher in the test group than in control group while albumin, total protein and globulin were non-significantly higher in cement factory workers compared with controls.

Haemoglobin, percentage heamotocrite, MCV, MCH, MCHC levels were significantly higher in exposed group compared with office workers but RBC and platelets count were non-significant in both group (Table 3). Lymphocytes, basophils and eosinophils percentage levels were significantly higher while neutrophils was lower in cement factory workers compared with the controls, like RBC and platelet count monocyte and total white blood cell counts were non-significant in both groups see (Table 4). Table 5 shows the correlation of uric acid, copper, selenium and albumin against BMI.

Table 1: BMI, Uric acid, Copper and selenium levels in cement factory workers and controls

Levels	Cement factory workers (45)	Controls (30)	t-vlues	p-values
BMI	22.08±3.13	22.08±2.82	0.01	p>0.05
Uric acid (mg dL ⁻¹)	5.69±1.63*	4.38±0.83*	4.04*	p<0.05
Copper (µg dL ⁻¹)	77.36±5.05*	75.10±3.84*	2.08*	p<0.05
Selenium (µg L ⁻¹)	75.42±5.95	77.60±4.23	1.73	p>0.05

*Significant

Table 2: Creatinine, total protein, albumin and globulin in cement factory workers and controls

Levels	Cement factory workers (45)	Controls (30)	t-values	p-values
Creatinine (mg dL ⁻¹)	1.66±1.29*	0.95±0.26*	2.97*	p<0.05
Total protein (g dL ⁻¹)	9.40±11.13	7.39±0.71	0.99	p>0.05
Albumin (mg dL ⁻¹)	3.96±0.92	3.87±0.33	0.53	p>0.05
Globlin (mg dL ⁻¹)	3.67±0.92	3.51±0.53	0.77	p>0.05

*Significant

Table 3: Haemogram in cement factory workers and controls

Parameters	Cement factory workers (45)	Controls (30)	t-values	p-values
HBG (mg dL ⁻¹)	14.38±1.24*	13.50±1.64*	2.66*	p<0.05
HCT (%)	47.31±4.24*	42.23±4.92*	4.77*	p<0.05
MCV	85.66±7.55*	75.80±6.82*	5.76*	p<0.05
MCH (pg)	26.10±2.62*	24.35±2.51*	2.87*	p<0.05
MCHC (mg dL ⁻¹)	30.44±1.28*	31.87±1.08*	5.04*	p<0.05
RBC	5.56±00.70	5.51±0.56	0.31	p>0.05
PLT	216.11±60.21	215.93±77.09	0.11	p>0.05

*Significant

Table 4: Differential blood cell and total white blood cell counts in cement factory workers and controls

Blood cell	Cement factory workers (45)	Controls (30)	t-values	p-values
Neutrophils (%)	37.33±11.26*	46.53±9.82*	3.64*	p<0.05
Lymphocytes (%)	57.42±13.21*	51.10±9.54*	2.56*	p<0.05
Monocytes (%)	3.02±1.99	2.57±1.38	1.09	p>0.05
Eosinophils (%)	0.96±1.54*	0.13±0.43*	2.85*	p<0.05
Basophils (%)	0.22±0.15*	0.00±0.00*	0.82*	p<0.05
Total white blood cells(× 10 ³ /mm ³)	5.51±1.86	6.70±2.41	1.17	p>0.05

*Significant

Table 5: Correlation of uric acid, copper, selenium and albumin against BMI in cement factory workers

Parameters	R	P
Uric acid	0.38	<0.05
Copper	0.11	>0.05
Selenium	0.35*	<0.05
Albumin	0.22	>0.05

*Significant

DISCUSSION

Already by the early 1950s silica exposure was described as being associated with renal insufficiency (Saita and Zavaglia, 1951). Meanwhile, it is expected that silica content of cement dust should not exceed 2% free silica as contaminant (ICMR, 2001). Elevated creatinine levels in this study suggest nephrotoxic effects of cement dust in the test group. This is in consistent with the study of Goldsmith and Goldsmith (1993), Rapiti *et al.* (1999), Steenland *et al.* (2002) and Akinola *et al.* (2008); they all reported remarkable nephrotoxic effects of silica exposure in separate studies. Also, Colpan *et al.* (1998) reported that silicon has a dose related harmful effect on the renal structure; Histological tubular brush border, haemorrhagic alterations in the glomerular area and epithelial protrusion towards the tubular lumens were remarkable.

Two possible mechanisms might be operative: First may be due to direct toxic actions of silica (Giles *et al.*, 1978; Mauras *et al.*, 1980) and recently, possible immune mechanisms were proposed by Haustein *et al.* (1990) and Pernis (2005). Also, the nephrotoxic effect might be due to the presence of high concentration of cadmium release during cement dust production (Abimbola *et al.*, 2007).

Uric acid is a metabolic or endogenous antioxidant. The elevated urate level in cement factory workers is probably an adaptive response or mechanisms against the toxic effect of cement dust constituents. This is consistent with earlier reports of elevation of serum uric acid concentration occurring as a physiologic response to oxidative stress providing counter regulatory increase in oxidant defences (Ames *et al.*, 1981; Simic and Jovanovic, 1989; Gittleman *et al.*, 1994) have reported that uric acid may be a consistent and reliable biomarker of significant exposure to toxicants. Uric acid also acts as a repair agent of oxidative damage to DNA bases (Simic and Jovanovic, 1989), probably another reason for the increase. This probably implies haemostasis implication according to Yoshida *et al.* (2001), they inferred that there is an inverse relationship between uric acid and 8-OHdG, a marker of genotoxicity and possible mutation. This oxidative stress might have been confirmed by the increase in copper which is a known component of ceruloplasmin, an acute phase reactant and antioxidant (Tolonen, 1990). Copper is also a component of the potent cytosolic antioxidant copper-zinc superoxide dismutase (Cu-Zn SOD). This might be due to a mechanism that the body tends to retain copper to combat heavy antioxidant demands. Also, selenium though not statistically significant, it is lower in cement factory workers which suggest increased demand. Selenium is a known non-specific intracellular antioxidant which helps protect from carcinogenic chemicals (Vasudevan and Sreekumaris, 2001). Also, binds most heavy metals and militates against their toxic effects and it is a major content of antioxidant enzyme, glutathione peroxidase (Vasudevan and Sreekumari, 2001).

The increase eosinophils and basophils suggest increase activation of allergic response. This is consistent with the study of Tulinska *et al.* (2004), where they observed an increase in activation

markers on eosinophil (CD 66b and CD 69) and Ogunbileje *et al.* (2010a) also reported significant increase IgE in cement factory workers. Circulating eosinophils are elevated in patients with allergic conditions. It has been reported that eosinophils recruitment is been induced by eotaxin (Conroy and Williams, 2001) via IL-4 and IL-13 involvement (Rothenberg and Hogan, 2006), both cytokines (IL-4 and IL-13) are known to be potent pro-fibrotic mediators. Also, activated eosinophils have been reported to induce Hypobromous acid (HOBr) which has been reported to induce an array of DNA damage (Kang and Sowers, 2008). Thus, suggesting that eosinophils recruitment in cement factory workers contributes to inflammatory-mediated DNA damage in these set of workers. This inflammatory response might have contributed in part to lymphocytosis in exposed group, and this is corroborated with the increase in IgG and IgE which have been reported in cement factory workers in Nigeria (Ogunbileje *et al.*, 2010a). This is also in agreement with Jude *et al.* (2002) and Tulinska *et al.* (2004), both studies reported an increase in lymphocytes in exposed silica workers.

Meanwhile decreased neutrophils in exposed group suggest that this group might be susceptible to infectious agents. This is in agreement with the study of Meo *et al.* (2008), reporting a significant decrease in phagocytic activity of Polymorphonuclear Neutrophils (PMN) in cement workers compared with control group. This indicate that exposure to cement dust can impair both phagocytic functions and number of polymorphonuclear neutrophils in exposed group and probably increase infection susceptibility, but the mechanism for this is not fully understood.

Significant increase in HGB, HCT, MCV, MCH, MCHC in cement factory workers suggest this might be due to increased exposure of cement factory workers to iron which is known to be a major constituent of cement dust and has been reported to be higher in workers working in packing and loading section (Fell *et al.*, 2003; Faust, 1995; Ogunbileje *et al.*, 2010b). Iron is important in haemoglobin synthesis. A major transport protein of iron is transferrin, which delivers iron to tissues which have transferrin receptors, especially erythroblasts in the bone marrow, it incorporate iron into haemoglobin which is reutilized for haemoglobin synthesis (Hoffbrand *et al.*, 2001). The increased copper in this study might have also contributed significantly to the increase in haemoglobin related parameters; caeruloplasmin, a copper containing enzyme catalyses oxidation of iron to the ferric form for binding to plasma transferrin (Hoffbrand *et al.*, 2001), thus, enhancing production of haemoglobin. It probably suggests that if this exposure persist it might have its own deleterious effects in the exposed workers.

Previous studies on effects of cement dust in Nigeria cement factory workers suggest hepatotoxic effect in these set of workers (Mojimoniyi *et al.*, 2007; Ogunbileje *et al.*, 2010a), these studies examine liver enzymes and bilirubin, which indicates presence of hepatocytes injury. Meanwhile, in this study, it probably suggests that the synthetic functions of the liver are not altered with the concentration of albumin and total proteins ($p > 0.05$). Albumin is the most abundant protein produced by the liver; 12 to 15 g of albumin are synthesized daily (Goessling and Friedman, 2006). It thus suggests that further studies might be necessary to determine sectional specific effects on the liver of exposed workers.

To our knowledge, this is the first study to report creatinine levels and detail health conditions of Nigeria cement factory workers.

Creatinine levels was higher than the general populace after correction with the BMI of both cement factory workers and controls, suggesting that these set of workers are liable to come down with chronic renal failure. Other results in this study indicate inflammatory reactions which if persistent can result in chronic diseases.

CONCLUSION

Therefore, it is advisable that long term consequences of exposure to cement dust should be monitored, thus calling for collaborations between health workers and cement factory management to ensure frequent monitoring of their workers health. Also, further study is necessary to study the underline mechanism of cement dust toxicity.

ACKNOWLEDGMENT

All Staff of the cement factory who volunteer to take part in the study and the management staff for given us access to the factory. Special thanks to Mr Akinduti P.A. for helping in the collection of samples.

REFERENCES

- ATSDR., 2000. Chromium toxicity physiologic effects. Agency for Toxic Substances and Disease Registry. Case Studies in Environmental Medicine (CSEM).
- Abimbola, A.F., O.O. Kehinde-Phillips and A.S. Olatunji, 2007. The sagamu cement factory, SW Nigeria: Is the dust generated a potential health hazard. *Environ. Geochem. Health*, 29: 163-167.
- Adly, A.A.M., 2010. Oxidative stress and disease: An updated review. *Res. J. Immunol.*, 3: 129-145.
- Akinola, M.O., N.A. Okwok and T. Yahaya, 2008. The effects of cement dust on albino rats (*Rattus norvegicus*) around West African portland cement factory in Sagamu, Ogun state, Nigeria. *Res. J. Environ. Toxicol.*, 2: 1-8.
- Ames, B.N., R. Cathcart, E. Schwiers and P. Hochstein, 1981. Uric acid provides an antioxidant defense in humans against oxidant and radical causing aging and cancer: A hypothesis. *Proc. Natl. Acad. Sci. USA.*, 78: 6858-6862.
- Aminian, O., S.A. Sharifian, R. Mehrdad, H.K. Narooey and O. Giahi, 2008. Humoral Immune system alterations in silica exposed workers. *Iran. J. Public Health*, 37: 142-145.
- Bhatty, J.I., 1995. Role of minor elements in cement manufacture and use. *Research and Development Bulletin RD109T*, Portland Cement Association, Skokie, Illinois, USA.
- Colpan, L., I. Cilli and I. Aydin, 1998. The effects of silicon on serum total protein, albumin, urea and cretinine levels and histological structure of kidney tissue in rat. *T. Klin. J. Med. Res.*, 16: 116-120.
- Conroy, D.M. and T.J. Williams, 2001. Eotaxin and the attraction of eosinophils to the asthmatic lung. *Respir. Res.*, 2: 150-156.
- Faust, A.R., 1995. Toxicity summary for asbestos. Oak Ridge Reservation Environmental Restoration Program, U.S Department of Energy under Contract No. DE-AC05-84OR21400. <http://cira.ornl.gov/documents/Asbestos.pdf>
- Fell, A.K.M., T.R. Thomassen, P. Kristensen, T. Egeland and J. Kongerud, 2003. Respiratory symptoms and ventilatory function in workers exposed to Portland cement dust. *J. Occup. Environ. Med.*, 45: 1008-1014.
- Feng, L., S. Zhou, L. Gu, D.A. Gell and J.P. Mackay *et al.*, 2005. Structure of oxidized a-haemoglobuin bound to AHSP reveals a protective mechanism for haem. *Nature*, 435: 697-701.
- Gawad, A.E., L. Schlichting, O. Strauss and O. Zeitz, 2009. Antiapoptotic properties of erythropoietin: Novel strategies for protection of retinal pigment epithelial cells. *Eye Lond.*, 23: 2245-2250.

- Gbadebo, A.M. and O.D. Bankole, 2007. Analysis of potentially toxic metals in airborne cement dust around sagamu, Southwestern Nigeria. *J. Applied Sci.*, 7: 35-40.
- Giles, R.D., B.C. Sturgil, P.M. Suratt and W.K. Bolton, 1978. Massive proteinuria and acute renal failure in a patient with acute silicoproteinosis. *Am. J. Med.*, 64: 336-342.
- Gittleman, J.L., M.M. Engelgau, J. Shaw, K.K. Wille and P.J. Seligman, 1994. Lead poisoning among battery reclamation workers in Alabama. *JOM.*, 36: 526-532.
- Goessling, W. and L.S. Friedman, 2006. Evaluation of the Liver-Patient. In: *Clinician's Guide to Liver Diseases*, Reddy, K.R. and T. Faust (Eds.). Slack Inc., New Jersey, pp: 1-12.
- Goldsmith, J.R. and D.F. Goldsmith, 1993. Fiberglass or silica exposure and increased nephritis or ESRD (end-stage renal disease). *Am. J. Ind. Med.*, 23: 873-881.
- Haustein, U.F., V. Ziegler, K. Herrmann, J. Mehlhorn and C. Schmidt, 1990. Silica-induced scleroderma. *J. Am. Acad. Dermatol.*, 22: 444-448.
- Hoffbrand, V., P. Moss and J. Pettit, 2001. *Essential Haematology*. 4th Edn., Blackwell Science, Oxford.
- ICMR., 2001. Immune response to exposure to occupational and environmental agents. *ICMR Bulletin*, Vol. 31, No. 6-7.
- Jude, A.L.C., K. Sasikala, R.A. Kumar, S. Sudha and J. Raichel, 2002. Haematological and cytogenetic studies in workers occupationally exposed to cement dust. *J. Hum. Gen.*, 2: 95-99.
- Kang, J.I. and L.C. Sowers, 2008. Examination of hypochlorous acid-induced damage to cytosine residues in a CpG dinucleotide in DNA. *Chem. Res. Toxicol.*, 21: 1211-1218.
- Kohen, R. and A. Nyska, 2002. Oxidation of biological system: Oxidative stress phenomena, antioxidants, redox reactions and methods for their quantification. *Toxicol. Pathol.*, 30: 620-650.
- Mauras, Y., P. Riberi, F. Cartier and A. Allain, 1980. Increase in blood silicon concentration in patients with renal failure. *Biomedicine*, 33: 228-230.
- Meo, S.A., S. Rasheed, M.M. Khan, S. Shujaiddin and A. Al-Tuwaijri, 2008. Effect of cement dust exposure on phagocytic function of polymorphonuclear neutrophils in cement mill workers. *Int. J. Occupat. Med. Environ. Health*, 21: 133-139.
- Mohammadirad, A. and M. Abdollahi, 2011. A systematic review on oxidant/antioxidant imbalance in aluminium toxicity. *Int. J. Pharmacol.*, 7: 12-21.
- Mojimoniyi, F.B.O., I.A. Merenu, C.H. Njoku and M.T.O. Ibrahim, 2007. Regression formulae for predicting hematologic and liver functions from years of exposure to cement dust in cement factory workers in Sokoto, Nigeria. *Afr. J. Biomed. Res.*, 10: 235-240.
- Ogunbileje, J.O., O.M. Akinosun, O.G. Arinola and P.A. Akinduti, 2010a. Immunoglobulin Classes (IgG, IgA, IgM and IgE) and liver function tests in Nigerian cement factory workers. *Researcher*, 2: 55-58.
- Ogunbileje, J.O., O.M. Akinosun, P.A. Akinduti, L.A. Nwobi and O.A. Ejilude, 2010b. Serum levels of some trace metals and leucocyte differential counts in Nigeria cement factory workers: Possible toxicity implications. *Florida Int. J.*, 2: 55-58.
- Pernis, B., 2005. Silica and the immune system. *Acta Biomed.*, 2: 38-44.
- Rapiti, E., A. Sperati, M. Miceli, F. Forastiere and D. Di Lallo *et al.*, 1999. End stage renal disease among ceramic workers exposed to silica. *Occup. Environ. Med.*, 56: 559-561.
- Rothenberg, M. and S. Hogan, 2006. The eosinophil. *Annu. Rev. Immunol.*, 24: 147-174.
- Saita, G. and O. Zavaglia, 1951. Renal function in silicotics. *Med. Lav.*, 42: 41-48.

- Simic, M.G. and S.V. Jovanovic, 1989. Antioxidation mechanisms of uric acid. *J. Am. Chem. Soc.*, 111: 5778-5782.
- Steenland, K., K. Rosenman, E. Socie and D. Valiante, 2002. Silicosis and end-stage renal disease. *Scand. J. Work Environ. Health*, 28: 439-442.
- Tolonen, M., 1990. *Vitamins and Minerals in Health and Nutrition*. Ellis Horwood, London, pp: 181-184.
- Tulinska, J., E. Jahnova, M. Dusinska, M. Kuricova and A. Liskova *et al.*, 2004. Immunomodulatory effects of mineral fibres in occupationally exposed workers. *Mutation Res.*, 553: 111-124.
- Vasudevan, D.M. and S. Sreekumari, 2001. *Text Book of Biochemistry for Medical Students*. 3rd Edn., Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
- Yoshida, R., I. Shioji, A. Kishida and Y. Ogawa, 2001. Moderate alcohol consumption reduces urinary 8-hydroxydeoxyguanosine by inducing of uric acid. *Ind. Health*, 39: 322-329.