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Research Article

Cement Dust and Nephrotoxicity in Albino Rat

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Abstract: With increasing infrastructural development in developing countries, the rise in the demand of cement has also increased which has resulted in the exposure of cement in the environment and the living organisms in the environment. The aim of this study was to assess the effect of duration of cement dust exposure on kidney organs in rats. A total of 25 rats were used for this study. The rats were divided equally into 5 groups (A, B, C, D and E) with each group having 5 rats. "A" group was not exposed to cement dust (control group); "B" group was exposed to cement dust for one hour daily for 15 days; "C" group was exposed to cement dust for one hour daily for 30 days; "D" group was exposed to cement dust for one hour daily for 45 days; E group was exposed to cement dust for one hour daily for 60 days. After the durational exposure, the rats were sacrificed, blood and kidney tissue harvested for biochemical assessment of kidney function and histological studies of the kidney. The result showed that there was significant difference in the levels of kidney function parameters (sodium, potassium, chloride, bicarbonate, urea and creatinine) amongst the groups. This was confirmed in the histological reports. This study has shown that durational exposure of rats to cement dust has great impact on the kidney.

Keywords: cement, kidney, rat.

1. Introduction

Powdered limestone, laterites, clay, and gypsum form the powdered composition known as cement, which is used to make and secure building materials like blocks and bricks (Amodu and Egwuogu 2014). To put it simply, no other adhesive comes close to its prevalence and popularity in the building business. Flyovers, as well as highways, buildings, and bridges, are just some of the many uses for this material. Construction, steel, crude oil, iron, and telecommunications are all vital to modern society and economies around the world; as a result, the cement production business has played an essential part in global economic development. Manufacturing cement has been crucial to economies around the world, but it also contributes significantly to human-caused carbon dioxide emissions and trash accumulation (Okigbo 2012). With an annual production capacity of 58.9 MMT, Nigeria's cement sector is the greatest in

all of West Africa. The country has over 2.3 trillion tonnes of limestone, 568 million tonnes of which are in reserves according to the Ministry article. of Mines and Steel Development, and 11 million tonnes of which were mined in 2016 (Ayodele et al. 2021). The cement industry is a major contributor to the degradation of water quality over time due to the release of air pollutants and effluents into water bodies. Crop yields, building structures, and the health of people who live in the areas around cement and lime factories all take a hit from the noxious air pollution produced by these facilities. In 2015, the World Bank found that 94% of the Nigerian population is vulnerable to air pollution that exceed WHO standards. The production of cement results in the release of harmful gases such as sulphur dioxide (SO2), nitric oxide (NO), and carbon monoxide. Young children, the elderly, and persons with preexisting respiratory disorders like bronchitis, emphysema, or asthma are among those deemed to be most at risk. Acute silicosis, pulmonary TB, interstitial fibrosis, rheumatic problems, vascular disease, cancer, glomerulonephritis, and other nephrotogenic disorders have all been linked to crystalline silica in cement dust as a possible cause or contributor (Akpan and Atan 2011). As documented by (Rapiti et al. 1999). Toxic cement components, including as sulphur dioxide, nitrogen dioxide, volatile organic compounds, long-lived dioxins, and heavy metals, can be inhaled and deposit on lung tissue. These poisonous chemicals are known to cause kidney damage, mutations, and cancer in animals and people. They are also thought to play a role in the development of several other diseases, including cancer, lupus, immunological disease, allergies, and asthma. Because of the grave health implications of breathing in cement dust, it is crucial to evaluate the effects of cement exposure on the kidneys of rats. The primary purpose of this research is to evaluate the impact of cement dust on renal function across different time points in rats.

2. Materials and Methods

Study area

The experiments were carried out in the Animal House on the campus of PAMO University of Medical Science in Port Harcourt, Nigeria.

Ethical Approval

PAMO University of Medical Sciences obtained approval from the appropriate ethics committee.

Experimental Design

Twenty-five rodents were used, and they were all randomly assigned to one of five groups (A, B, C, D, and E). Each group of rats had five members. Group A was given no exposure to cement dust, while groups B, C, D, and E were subjected for 15, 30, 45, and 60 days, respectively, for one hour every day. We exposed the rats to the cement by placing them in a glass cage with two 3000rpm fans. Chlorofoam was used to put the animals to sleep for the duration of their exposure; afterward, they were sacrificed, blood was taken through heart puncture, and the kidneys were harvested and preserved in 10% formal saline for histological investigation (Okolonkwo et al. 2022). Blood samples were stored in heparin vials until further analysis could be

performed. The kidney function test sample was centrifuged to separate the plasma from the other components.

Laboratory Analyses

Creatinine Estimation:

Methods similar to those described by (Jain, Jain, and Jain 2020) were used to carry out this study. When combined with alkaline picrate, creatinine in the blood or plasma turns a bright yellow-red colour. Creatinine concentrations are typically represented by sample colour intensity. The resulting yellow-red color's absorbance was measured at 520nm on a spectrophotometer. When using sodium lauryl sulphate, you won't have to worry about your proteins interacting with one another. Taking a second absorbance reading after acidifying the samples with 30%acetic acid enables for correction for non-specific chromogens.

Urea Estimation:

Based on the research presented in (Patton and Crouch 1977) Serum urea can be converted to am- monia when an enzyme called urease is present. Ammonia interacts with phenol and hypochlorite in an alkaline setting to form indophenol. The depth of colour in the sample reflects the concen- tration of urea. Nitroprusside acts as a catalyst in this procedure. We then use a photo metre to measure the intensity of the light emitted by the indophenol between 530 and 570 nm.

Electrolyte Test:

Sodium and Potassium Analysis Using Flame Emission Spectrometry:

The blood salt and potassium levels were measured in relation to a reference range of 140 and 5 mmol/L, respectively. An amount of 58.45g of sodium chloride (NaCl) is dissolved in 1 litre of distilled water to make a 1.0M sodium standard solution. Constant Potassium Stock (1.0M) Once

74.55 grammes of KCl are added to one litre of purified water, the volume is exactly one litre. Deionized water was injected via the auto-miser, gas was ignited, and the flame was fine-tuned before the air compressors were turned on and the air pressure adjusted to make perfectly crisp cones. By putting in the right filters, calibrating the device with deionized water, and then adding the standard deviation (120/2) we were able to get an accurate reading of both the sodium and potassium contents simultaneously. We reduced the sodium to 120.0 and upped the potassium by

2.0. When the sodium and potassium levels in the standard were confirmed, the diluted test serum was added, and the new values were recorded (Jackson and Irwin 1957).

Serum Chloride and Bicarbonate was done using Colorimetric Technique:

As planned (Morrison 1990), method has been put into practise Mercury thiocyanate is replaced by chloride ions in an auto-analyzer to achieve this. This experiment uses a photometer to quantify the formation of the colourful complex ferric thiocyanate, which occurs when free thiocyanate reacts with ferric ions.

Histological studies of the kidney

Before embedding them in molten paraffin wax, we cleared the tissues in xylene and removed the isopropyl alcohol by first fixing them in 10% formol saline, then dehydrating them in 70%, 80%, 90%, and 100% isopropyl alcohol for 1 hour at each concentration. Histomorphological effects were visualised by slicing tissues to a thickness of 3-5 micrometres using a Leica RM 212 Rt. Rotary Microtome and staining them with Hematoxylin and Eosin (H&E). The tissue sections were inspected by a histopathologist, who established a diagnosis using a photomicroscope attached to a light microscope.

Hematoxylin and Eosin Staining Method and Principle

To learn about the histomorphology, we performed a technique known as regressive staining with hematoxylin and eosin (Li et al. 2018). Tissue acidity (the DNA-containing nucleus) is stained with the basic stain hematoxylin, while tissue basicity is stained with the acidic counter stain rosin (cytoplasm).

Statistical Analysis

Data was analysed using SPSS, the Statistical Package for the Social Sciences (SPSS version 25). The values were displayed using mean and standard deviation (Mean and SD). When analysing the parameters of kidney function, we employed one-way ANOVA and post hoc LSD. Values were considered significant at P 0.05.

3. Results

Kidney function markers are shown in Table 1 for both low and high cement dust exposure groups. The levels of sodium, potassium, chloride, bicarbonate, urea, and creatinine in rats exposed to cement dust for varying amounts of time are displayed in Table 1. These differences were statistically significant (p0.05).

Key

SS = Statistically significant

NS = Not statistically significant

Table 1. Comparison of serum urea, creatinine and electrolytes levels amongst groups

Group	Sodium µmol/l	Potassuim mmol/l	Bicarbonate mmol/l	Chloride mmol/l	UREA mmol/l	Creatinine µmol/l
A(cntrl)	183.5±31.3	2.7±0.8	16.5±2.1	60.3±31.22	18.5±8.6	128.0±28.7
B	128.5±64.9	12.6±3.1	27.0±9.1	78.0±39.3	3.5±1.3	177.5±3.7
C	192.3±55.3	4.4±1.0	22.3±7.5	124.3±22.5	9.3±1.6	195.5±29.7
D	155.3±13.8	3.3±1.0	29.8±1.7	76.8±8.7	4.6±0.3	189.0±9.6
E	345.0±47.8	3.2±0.9	23.8±3.3	77.8±9.4	22.2±8.3	107.3±16.5
F-value	13.3	26.6	3.2	3.6	9.6	14.9
P-value	0.000	0.000	0.029	0.000	0.000	0.000
Remark	SS	SS	SS	SS	SS	SS
Poshoc						

A vs B	NS(0.59)	SS(0.02)	NS(0.95)	NS(0.34)	NS(0.14)	NS(0.15)
A vs C	NS(0.99)	NS(0.18)	SS(0.04)	NS(0.63)	NS(0.39)	NS(0.09)
A vs D	NS(0.54)	NS(0.88)	NS(0.84)	SS(0.00)	NS(0.17)	NS(0.08)
A vs E	SS(0.01)	NS(0.89)	NS(0.81)	NS(0.07)	NS(0.97)	NS(0.73)
B vs C	NS(0.60)	SS(0.04)	NS(0.37)	NS(0.92)	SS(0.01)	NS(0.76)
B vs D	NS(0.91)	SS(0.03)	NS(1.00)	NS(0.97)	NS(0.55)	NS(0.32)
B vs E	SS(0.01)	SS(0.03)	NS(1.00)	NS(0.95)	NS(0.07)	SS(0.01)
C vs D	NS(0.71)	NS(0.52)	NS(0.08)	NS(0.44)	SS(0.03)	NS(0.99)
C vs E	SS(0.03)	NS(0.45)	NS(0.08)	NS(0.99)	NS(0.19)	SS(0.02)
D vs E	SS(0.01)	NS(1.00)	NS(0.81)	NS(0.12)	NS(0.09)	SS(0.00)

Data was analyzed using ANOVA followed by Games-Howell and values were considered significant at $p<0.05$.

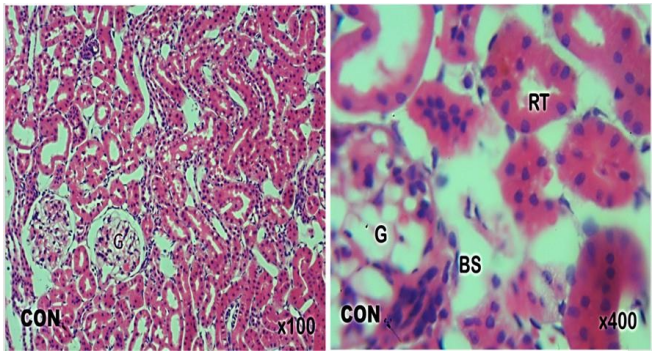

Figure 1. Photomicrograph section of control of kidney tissue shows morphology consistent with normal liver histology (H&E x100 & x400)

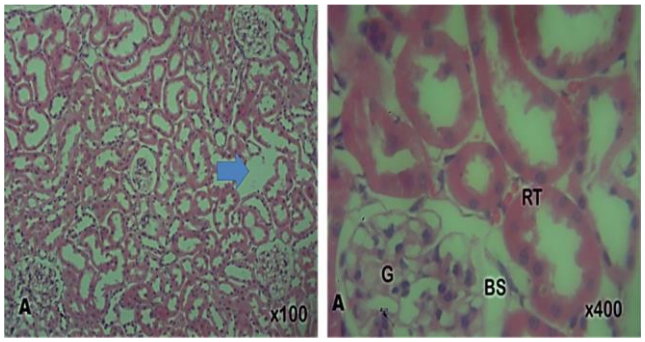

Figure 2. Photomicrograph section of the kidney tissue of albino rat exposed to cement dust for 15 days (H&Ex100 & x400)

4. Histopathological Findings

FIGURE 1 is a photomicrograph of a section of normal histologically-appearing kidney tissue from a control (CON) animal. Bowman's space, renal tubules, and glomeruli all appear healthy (BS). Haematoxylin and eosin were utilised to stain the tissue section in this case. FIGURE 2: A pho- tomicrograph of a tissue segment from the kidney of an albino rat exposed to cement dust for 15 days reveals histology that is consistent with normal kidney morphology. Kidneys have proper Bowman's space (BS) and glomerulus (G) (RT). Loss of glomerular tubules, nevertheless, may be more localised (blue arrow). the section's haematoxylin and eosin staining. FIGURE 3 is a pho- tomicrograph of a segment of the kidney from an albino rat that was exposed to

cement dust for 30 days. The histology is compatible with normal kidney morphology. Renal tubules, Bowman's space, and glomeruli all look normal. Loss of glomerular tubules is also observed locally (blue arrow). We stained the section with haematoxylin and eosin. FIGURE 4 is a photomicrograph of a cement dust-exposed albino rat kidney section. In this case, the kidney histology agrees with the expected normal kidney morphology. Disturbances manifest in the renal tubules (RT), Bowman's space (BS), and glomerulus (G). The kidneys are inflamed, there are abnormal renal corpuscles, the collecting ducts are damaged, and the glomerular tubules have been lost (blue arrow). The tissue section was stained with haematoxylin and eosin. As can be seen in FIGURE 5, a photomicrograph section of the kidney of an albino rat exposed to cement dust for 60 days reveals histology that is compatible with normal kidney morphology. Kidney structures like the glomerulus (G), Bowman's space (BS), and renal tubules can all be affected (RT). The kidneys are inflamed, there are abnormal renal corpuscles, the collecting ducts are damaged, and the glomerular tubules have been lost (blue arrow).

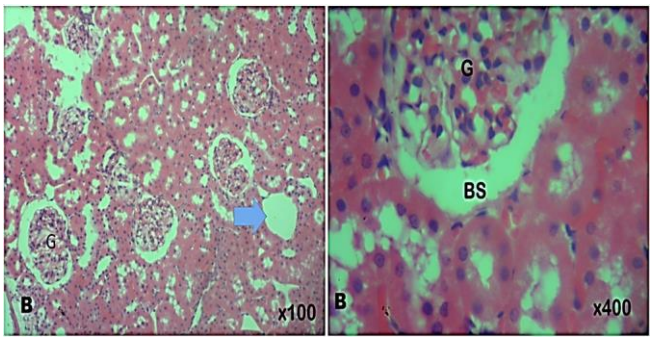

Figure 3. Photomicrograph slice of the renal tissue of albino rat subjected to cement dust for 30 days (H&Ex100 & x400) (H&E x100 & x400)

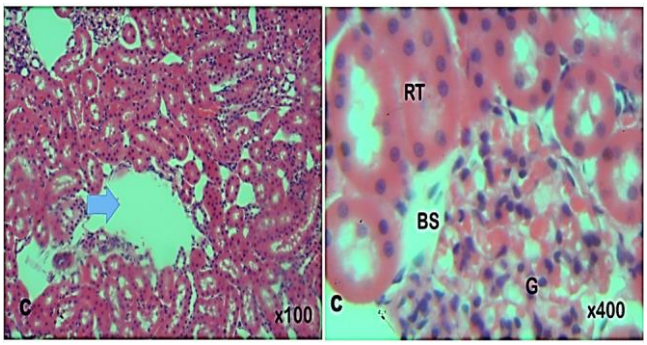

Figure 4. A photomicrograph of a slice through the renal tissue of an albino rat that has been exposed tocement dust for 45 days (H&E x100 & x400)

5. Discussion

Kidney poisoning is especially dangerous because of the kidney's essential function in maintaining internal body balance. This is due to the fact that the kidney controls numerous other physiological functions, such as fluid and salt balance, waste product removal, electrolyte homeostasis, acid- base regulation, and hormone synthesis (Garson 2016). Results showed that sodium levels were substantially lower in the experimental groups (B and D) and significantly higher in the control group (A)

(Group A). This study indicated that the bicarbonate levels were also significantly greater in the experimental groups compared to the controls, in addition to a higher blood potassium level. Thus, the levels of chloride in all the test groups were significantly higher than in the control group. The urea concentration in groups B, C, and D was significantly lower than in the control group,

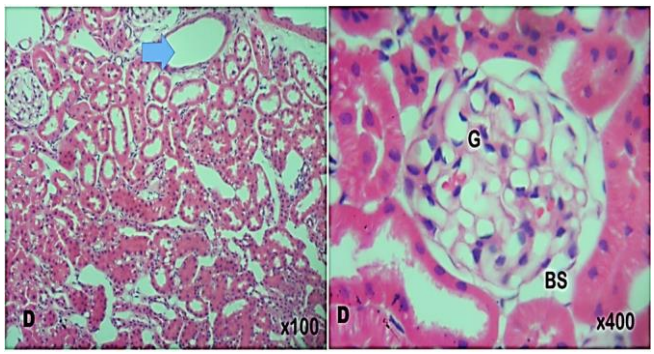

Figure 5. Photomicrograph of a piece of kidney tissue from an albino rat that has been exposed to cement dust for 60 days (H& E, x100 and x40)

whereas it was higher in group E. Variation in urea concentrations among the groups has been hypothesised to be due to the length of time each was exposed to the test substance. The results for creatinine concentration showed a considerable rise in groups B, C, and D compared to the control group, but a significant decrease in group E. These results demonstrate that exposure to cement dust causes a disruption in renal function. Cement dust may be dangerous due to the presence of heavy metals and other compounds, while its precise mechanism of action is unknown. The current study's findings are consistent with those of (Sameen 2013), which indicated that cement dust inhaled by workers in the cement industry had a nephrotoxic effect on their kidneys, leading to abnormal kidney function. Although it's possible that the latter group wore protective gear, the current study's findings are at contrast with those of (Salhen 2014), who observed no significant variations in kidney function markers in the test group of volunteer cement industry workers.

Conclusion

This study demonstrates that albino rat renal function decreases following exposure to cement dust. Symptoms could emerge as early as 15 days after exposure. This is why even brief exposure to cement dust can lead to kidney damage.

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