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## Effects of Toxic Metals on the Renal Profile of Road Construction Workers in Benin City, Edo State/Warri, Delta State, South-South Nigeria

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### Abstract

Road construction in Nigeria is an ongoing developmental project associated with modern civilization and workers in this industry are constantly exposed to occupational hazard. In this current study, one hundred and twenty-six human subjects (71 occupationally exposed road construction workers and 55 non-exposed controls) were recruited for this study. Chromium (Cr), Vanadium (V), Calcium ( $Ca^{2+}$ ) and Manganese (Mn) were analyzed using Atomic Absorption Spectrophotometer. Kidney profile of Sodium ( $Na^+$ ), Potassium ( $K^+$ ), Chloride (Cl), Urea (Ur), and Creatinine (Creat) were analyzed using Selectra ProS. Clinically, the results showed differences in the blood level of the 71 exposed workers with 55 non-exposed controls. Creatinine was found to be significantly ( $p>0.001$ ) higher in the exposed subjects ( $102.57 \pm 2.29$  mM/L) compared to controls ( $79.58 \pm 3.45$  mM/L). Plasma  $Ca^{2+}$  level was significantly ( $p>0.001$ ) lower in exposed subjects ( $5.75 \pm 0.14$   $\mu$ g/L) than in the control ( $9.23 \pm 0.18$   $\mu$ g/L). Chromium in the exposed group was also significantly ( $p>0.001$ ) higher ( $20.38 \pm 0.42$   $\mu$ g/L) than in the control ( $1.74 \pm 0.10$   $\mu$ g/L). It is evident that occupationally exposed road construction workers have elevated levels of the studied metals and may be at risk of developing kidney diseases. There is need for compliance to universal safety precautions such as personal protective equipment and clothing during work to avoid inhalation and injection of toxic metals.

**Keywords:** Effects, Toxic Metals, Renal Profile, Road Construction Workers, Benin City, Warri, State, South-South, Nigeria

### Introduction

Road construction workers are exposed to a variety of health hazards including physical and chemical hazards on construction sites. They are expected to undergo adequate training before commencing work, wear adequate protective clothing also known as Personal Protective Equipment (PPE) to protect themselves against occupational hazards (OSHA, 2012). But in developing countries like Nigeria this is not the case; road construction workers are usually seen during road constitution with inappropriate/inadequate or no protective clothing (Adebamowo *et al.*, 2006).

Road construction workers are exposed to toxic substances in the form of dust, chemicals (Carbon Tetrachloride, Petroleum Naphtha, Naphthalene, Polyurethanes fumes) and metals (cadmium and vanadium) during working hours (Cohen *et al.*, 1993). As these substances gain entrance into the body orally, via inhalation or skin absorption they



begin to accumulate over time and possibly lead to the damage of internal organs (liver, kidney, lungs) which in turn could lead to toxicological alteration of normal body metabolism (OSHA, 2012).

The functional integrity of the mammalian kidney is vital to total body homeostasis because the kidney plays a principal role in the excretion of metabolic wastes and in the regulation of extracellular fluid volume, electrolyte composition, and acid-base balance. In addition, the kidney synthesizes and releases hormones, such as renin and erythropoietin, and metabolizes vitamin D<sub>3</sub> to the active 1, 25-dihydroxy vitamin D<sub>3</sub> form (Schnellmann, 2013). A toxic insult to the kidney therefore could disrupt any or all of these functions and could have profound effects on total body metabolism. Fortunately, the kidneys are equipped with a variety of detoxification mechanisms and have considerable functional reserve and regenerative capacities (Ross *et al.*, 2011). Nonetheless, the nature and severity of the toxic insult may be such that these detoxification and compensatory mechanisms are overwhelmed, and kidney injury ensues. The outcome of renal failure can be profound; permanent renal damage may result, requiring chronic dialysis treatment or kidney transplantation (Schnellmann, 2013).

Metals are certainly one of the oldest toxicants known to humans' due to their very early use, it's use has been critical to the progress and success of human civilization (Beijer and Jernelov, 1986). Metals are unique among pollutant toxicants in that they are all naturally occurring and, in many cases, are ubiquitous within the human environment (Beijer and Jernelov, 1986). Thus, regardless of how safely metals are used in industrial processes or consumer products, some level of human exposure is inevitable (Schnellmann, 2013 and Vouk, 1986).

Road construction raw materials are known to contain toxic substances (Zalups and Lash, 1994) and exposure to these chemicals could lead to deleterious consequences, and may lead to alteration in renal profile of road construction workers. The exposure of these workers to these substances could have adverse implications on the kidneys.

This aim of this study was to investigate the toxicity of metals and the associated renal profile changes in road construction workers in Benin City and Warri metropolis.

## Materials and Methods

### Study Population

One hundred and twenty- six road construction workers employed with the Chinese Construction Company (CCC), Road Construction Company (RCC), Julius Berger (JB) and Niger Cats (NC) were recruited for this study. Fifty-five road non-construction workers who do not take food supplement or drug containing chromium, vanadium, calcium and manganese were recruited as control subjects. The population size was calculated according to the method of Naing *et al.* (2006).

**Ethical Consideration:** Ethical clearance for this study was obtained from the Hospital Management Board, (HMB) ethical committee, Benin City, Edo State.

**Study Design:** This case-control study investigated samples collected prospectively from the human subjects along with the controls (non-exposed worker) between the months of November, 2014 and May, 2015.

**Sample Collection:** Peripheral blood sample (8 ml) was collected in lithium heparin. The plasma was then separated and stored at -20 °C. Atomic Absorption Spectrophotometer and Selectra Pros analyzer with their respective reagent kit was used for the analysis of the serum level of toxic metals and kidney profile respectively.

**Statistical analysis:** Statistical Package for Social Sciences (SPSS 16.0) was employed for the statistical analysis. All values were expressed as mean  $\pm$  standard error of the mean. The independent t-test was used to determine significant difference between test parameters in the test and controls groups. Level of significance was set at ( $p \leq 0.05$ ).

**Results**

Table 1 illustrates the differences between the subjects and control when sodium (Na), potassium (K), chlorine (Cl), urea and creatinine were compared. From the results, statistically significant differences were observed between the subjects and controls in their Na, Cl and Creatinine. There was a highly significant difference was observed between

the test and control subject in the heavy metals. Table 2 shows the mean values of heavy metals among the subjects and controls. Table 3 illustrates the occupational and lifestyle of the exposed road construction workers. From the table, most of the test subjects wore just an apron as a protective covering.

**Table 1: Test of significant difference between the test subjects and controls in their Electrolyte, Urea and Creatinine (EUC)**

Parameters	Test Subject	Control Subject	p-value
Na (mmol/L)	142.63±1.23	139.76±1.12	P < 0.05
K (mmol/L)	4.31±0.63	4.15±0.12	P > 0.05
Cl (mmol/L)	103.91±0.57	101.12±0.74	P < 0.01
Urea (mmol/L)	3.79±0.15	3.89±0.26	P > 0.05
Creatinine (µ/L)	102.57±2.29	79.58±3.45	P < 0.001

*Values are Mean ± Standard Error of Mean.*

**Table 2: Mean values of heavy metals among subject and control subject**

Parameter	Control Subject	Exposed Subject	p-value
Ca (µg/l)	9.23±0.18	5.75±0.14	P<0.001
Cr (µg/L)	1.74±0.10	20.38±0.42	P<0.001
Mn (µg/L)	10.00±0.30	12.46±0.26	P<0.001
V (µg/L)	0.37±0.03	0.57±0.01	P<0.001

*Values are Mean ± Standard Error of Mean.*

**Table 3: Occupational Lifestyle status of Exposed Subjects**

Observation	Exposed Subjects (n=71)	Non-exposed subjects (n=55)
% using protective device while working	Yes {(n = 7) 11.1%} No {(n = 56) 88.9%	Not Applicable
Specified protective devices used by workers that are occupationally exposed to toxic metals	Apron	Not Applicable
Desire for Health Risk Study on workers Number occupationally exposed to toxic metals	Desirous (Yes): n = 65; 100% Willing (Yes): n = 65	Desirous (Yes) = 100% Willing (Yes) = 92.7%
Willingness to participate in the study of workers occupationally exposed to toxic metals (By granting informed consent)	(96.80%) No response: n = 2 (3.20%)	Not Willing (No) = 7.3%
Micronutrient and food supplement intake	Yes: n = 35% No: n = 65%	Yes: n = 32% No: n = 68%

## Discussion

The levels of toxic metals in body fluids and tissues represent an important indicator of the health condition of an individual (Adeniyi and Anetor, 1999). In this study, elevated blood levels of Chromium, Vanadium, and Manganese with a low level of Calcium values was observed among exposed subjects compared to the non-exposed controls. Similar observation was demonstrated by Ademuyiwa *et al* (2005) and Adeniyi and Ametor (1999). They reported similar patterns of higher concentration of heavy metals in occupationally exposed subjects compared to non-exposed controls.

Our finding was however; contrary to observations made by Ogunsola *et al* (1994) who reported that non-occupationally exposed subjects has higher concentration of same toxic metals compared with the occupationally exposed subjects. Therefore, observation made in this study shows a high level of toxic metals in occupationally exposed subjects through continuous exposure which creates a systemic build-up of heavy metals.

Studies by some authors have demonstrated high level of heavy metals in Nigeria compared with

other countries such as Kenya and Ghana (Adebamowo *et al.*, 2006 and Biney *et al.*, 1994).

In this study, the level of Chromium levels among the occupationally exposed subjects was significantly higher compared to the non-exposed ( $p < 0.001$ ) high. This shows that the exposed subjects, due to exposure to toxic metals may be liable to systemic accumulation of Chromium toxicity resulting to kidney failure with time. Schnellawn (2013) observed a similar high value and reported that such elevated values could cause nephrotic damage to the kidney by reducing its metabolic activities.

The mean values of Manganese (a trace metal) was higher among exposed subjects ( $12.46 \pm 0.26 \mu\text{g/L}$ ) compared to non-exposed controls ( $10.00 \pm 30 \mu\text{g/L}$ ). Divalence of manganese has been reported to be dangerous to human health causing toxic kinase activities (Roth and Garrick, 2006). Roth and Garrick (2006) also reported same high levels of manganese causing damage to the human organ like the kidney toxification. Studies has shown that there is high level of manganese in the kidney, liver and intestine normally, but further exposure and ingestion of manganese will result in the increase of

manganese which then becomes pathological to the organ (Crossgrove and Zheng, 2014) causing renal damage and oxidative stress to the kidney (Gerber, 2002).

The level of vanadium was also observed to be high for the exposed subjects ( $0.57 \pm 0.01 \mu\text{g/L}$ ) than for the non-exposed subjects ( $0.37 \pm 0.03 \mu\text{g/L}$ ). This could have been as a result of limitation of vanadium as a food supplement, also reports have shown that ingestion/exposure of vanadium could lead to chronic pathological condition (Barceloux, 1999). Occupational ingestion of vanadium has been reported to cause kidney damage, gestational distress, nausea and vomiting; this poses as a future disease condition to the industrial worker who is continuously exposed (Biney *et al.*, 1994).

Clinically, calcium in this study reported a low value of  $5.75 \pm 0.14 \text{ mg/L}$  for the exposed subjects and  $9.23 \pm 0.18 \text{ mg/L}$  for the non-exposed subjects. Significantly, there is a much difference ( $p < 0.001$ ), this shows that the occupationally exposed individuals have low level of blood calcium and are therefore liable to disease conditions in the body's biochemical activity such as neurotransmitter, contraction and relaxation of muscles, heart beat and cell polarization of calcium replacement of sodium ion. Giovannucci *et al.* (1998) observed that deficiency of blood calcium over time leads to poor blood clotting, risk of bone fracture and impaired kidney failure due to acid-base imbalance of water retention.

In this study, electrolytes were observed, it was seen that the  $\text{Na}^+$  was  $142.63 \pm 1.23 \text{ mMol/L}$  for exposed subjects and  $139 \pm 1.12 \text{ mMol/L}$  for non-exposed. Clinically sodium moves alongside with the chloride in the kidney as sodium chloride to maintain the acid/base balance of the plasma (Mao *et al.*, 2001).

This study shows little difference in the estimation of chloride ions at  $103.11 \pm 0.37 \text{ mMol/L}$  for the exposed subjects and  $101.12 \pm 0.24 \text{ mMol/L}$  for the non-exposed. Thus, showing no significant difference ( $p > 0.05$ ), meaning there will be no difference in the ionic exchange of the electrolyte physiologically in terms of exposure in the sodium

chloride, hydrochloride acid in the gut and other ionic content of the body fluid. Seeling (1994) recorded similar observation and reported that clinical sodium helps to regulate and maintain osmotic membrane of electrical potential of the cells/muscles contraction and water balance of the cell membrane.

Potassium ions as one of the major electrolyte in the cell was observed in the study to be  $4.31 + 0.63 \text{ mMol/L}$  for the exposed individual and  $4.15 + 0.12 \text{ mMol/L}$  for the non-exposed subjects showing little or no significant difference with the exposed individual showing normal  $\text{Na}^+/\text{K}^+$  acid/base balance regulation of osmolality of vascular fluid and maintenance of membrane potential. Similar report was made by Seeling (1994). This then shows that in this study for the occupationally exposed to toxic metals and non-exposed subjects there will be an ionic cell balance of  $\text{Na}^+ \text{Cl}^-/\text{K}^+$  in the kidney metabolism of osmotic regulation and balance (Kee *et al.*, 2010).

However, the urea level of this study recorded  $3.79 + 0.15 \text{ mol/L}$  for the exposed and  $3.39 + 0.26 \text{ mol/L}$  for the unexposed ( $p > 0.05$ ). Further study is therefore recommended for this observation. The kidney profile assessment to toxic metals, which is the creatinine level was observed to be  $102.57 \pm 29.00 \text{ mMol/L}$  for the exposed and  $79.58 \pm 3.45 \text{ mMol/L}$  for non-exposed, ( $p < 0.01$ ) subjects, thereby giving a major concern to this study that individuals exposed to toxic metals such as chromium, vanadium, manganese and calcium could suffer health risk of increased level of creatinine which may lead to chronic disease conditions such as nephrotoxicity. Miller *et al.* (2005) made similar observations.

Conclusively, chromium and creatinine can be said to be biomarkers of toxic metals in the kidney profile of the exposed road construction workers. The elevated systemic buildup of both elements in the blood system of occupationally exposed subjects could create a reduced level of serum and calcium as essential mineral elements in the body for strong bones and teeth formation, reduced vitamin D and rennin activities. This could pose as a health risk to



bone disease and renal failure for the occupationally exposed.

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