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Assessment of the renal function status in persons occupationally exposed to lead in lead acid battery manufacturing factory in Nnewi

AN OKPOGBA[1], EC OGBODO[2]✉, GI MUONEKE[2], CN CHINAKA[3], SO NWOKO[3], EP MOUNMBEGNA[3], IC EJIOGU[1], CG IKIMI[4], AO OKEZIE[5], AK AMAH[6]

[1]Department of Human Biochemistry, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Awka, Nigeria; [2]Department of Medical Laboratory Science, Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Awka, Nigeria; [3]Department of Biochemistry, Madonna University, Elele Campus, Rivers State, Nigeria; [4]Department of Biochemistry, Federal University of Otuoke, Bayelsa State, Nigeria; [5]Department of Chemical Pathology, Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Nigeria; [6]Department of Human Physiology, College of Medicine, Imo State University, Owerri, Nigeria.

✉**Correspondence**
Email ID: augustinee442@gmail.com;
Telephone number: +2348134488042.

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ABSTRACT

Lead is a naturally occurring toxic metal with widespread use which has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world. This study assessed the renal function status in persons occupationally exposed to lead in lead acid battery manufacturing factory in Nnewi. A total of 38 apparently healthy individuals working in lead acid battery manufacturing factory aged between 19 and 56 years and 79 control subjects (comprising of 39 control subjects from Nnewi (N) and 40 control subjects from Elele (E) respectively) aged between 18 and 44 years were recruited for the study. 5ml of venous blood sample was collected from each subject for the determination of biochemical parameters (potassium, sodium, chloride, bicarbonate, urea and creatinine levels) using standard laboratory methods. Results showed increased levels of sodium and chloride ($p<0.05$), decreased bicarbonate, urea and creatinine levels ($P<0.05$), with a non significant change in potassium level ($P>0.05$) in lead acid battery factory workers than in control subjects respectively. Therefore, this study revealed no deleterious effect on the kidney function of the factory workers studied.

Key words: lead, occupational exposure, electrolytes, urea, creatinine, urea- creatinine ratio, body mass index, age, length of service.

1. INTRODUCTION

Lead is a naturally occurring toxic metal found in the Earth's crust. Its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world (World Health Organization, 2019). Lead is a cumulative toxicant that affects multiple body systems with no level of lead exposure known to be without harmful effects (World Health Organization, 2019). Employees working in a variety of occupational settings may be exposed to lead hazards. Some of these lead-related industries include: Lead recycling workers, Painters and remodelers, Battery manufacturing and repair, Manufacturing or use of lead paint, inks, dyes, glazes or pigments, Lead soldering such as in the electronics industry, Salvaging and recycling scrap metals, Manufacturing leaded glass or crystal, and automobile body repair factories among others. Individuals working in these factories are normally exposed to lead by inhalation of lead particles generated by burning materials containing lead such as during informal recycling, smelting, stripping leaded paint and using leaded gasoline (WHO, 2019). Lead exposure in the work place continue to remain important issues of global discuss as it continues to impact its ravaging effects on various organs and systems in the human body, accounting for about 0.6% of the global burden of disease (WHO, 2013c). Of key interest is the fact that occupational lead exposure has severe consequences for the kidneys which plays pivotal roles in attaining and maintain homeostasis within the human body. In achieving this, the kidneys ensure the prompt and functional removal of toxic materials from the body; maintain balanced electrolyte levels, and regulate blood pressure (Tim, 2019). Several studies have shown elevated levels of lead in various factories in the study region (Adejumo *et al.*, 2017; Okpogba *et al.*, 2019; Okpogba *et al.*, 2019). Notably, reports have shown that Low-level lead exposure was associated with decreased kidney function (Harari *et al.*, 2018). Other similar works have also documented significant negative alterations in renal function status among workers that are occupationally exposed to lead in varying degrees in different work places (Onuegbu *et al.*, 2011; Amah *et al.*, 2014; Okpogba *et al.*, 2019; Okpogba *et al.*, 2020). In view of the above, the current study assessed the renal function status in persons occupationally exposed to lead in lead acid battery manufacturing factory in Nnewi viz-a-viz determining the effect of lead exposure on some biomarkers of kidney functions with respect to the age, gender and length of service of the lead acid battery manufacturing factory workers as well as ascertaining any possible correlates between parameters assayed.

2. MATERIALS AND METHODS

Study design

This is a cross-sectional study designed to assess the renal function status in persons occupationally exposed to heavy metals in lead acid battery factory in Nnewi, Nigeria.

A total of thirty-eight (38) apparently healthy individuals in the exposed group (lead acid battery factory workers) aged between 19 and 56 years were recruited for the study. The occupationally exposed group comprised workers from lead acid battery factory who were constantly being exposed to effluents from the factory. The control groups were made up of two (2) sets: The first set was made up of thirty-nine (39) staff and undergraduate students of the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus whose residential homes were at least 5-10 km from the factory sites, while the second set was made up of forty (40) staff and undergraduate students of the Faculty of Medicine, Madonna University, Elele. They were aged between 18 and 44 years. Informed consent was obtained from all individuals after being educated on the benefit of the study and completing of a structured questionnaire. Thereafter, 5ml of venous blood sample was collected from each individual for the evaluation of biochemical parameters.

Estimation of Serum Creatinine Level

Serum creatinine level was assayed using Jaffe-Slot Alkaline Picric Acid Method as described by Laron[17].

Estimation of Serum Urea

Estimation of serum urea level was done using Berthlot Method as described by Ochei and Kolhatkar[18].

Determination of Electrolyte Profile Levels

Estimation of electrolyte (sodium, potassium, chloride and bicarbonate) profile levels was done using Ion Selective Electrode (ISE) Method.

Inclusion criteria

Apparently healthy individuals aged between 19 and 56 years who are exposed to lead and control individual (non-exposed groups) were included in this study.

Exclusion criteria

Individuals of any known kidney disease, alcoholics and smokers as well as those outside the age limits were excluded from the study.

Ethical consideration

Ethical approval for this study was sought and obtained from Ethical Committee, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

Statistical analysis

The data were presented as mean±SEM and the mean values of the control and test group were compared by Students t-test and Pearson's bivariate correlation coefficient using Statistical package for social sciences (SPSS) (Version 16) software. A $P<0.05$ was considered as significant.

3. RESULTS

The sodium ion (Na^+) level of lead acid battery (128.89±1.09) factory workers were significantly elevated ($p<0.05$) compared to that of control N subjects (122.87±0.78). The K^+ level of the lead acid battery factory workers (3.29±0.05) showed no significant difference ($p>0.05$) when compared to the value obtained in the control N subjects. The Cl^- level of lead acid battery (103.61±0.74) factory workers were non-significantly elevated ($p>0.05$) compared to control subjects. The bicarbonate ion (HCO_3^-) concentrations in lead acid battery (23.97±0.37) factory workers were significantly reduced ($p<0.05$) compared to the control subjects (26.73±0.20). See table 1.

Urea concentration of lead acid battery (4.89±0.36) factory workers were reduced but not significantly ($p>0.05$) when compared to control N (5.32±0.09) subjects, however, they were significantly elevated ($p<0.05$) compared with control E (2.17±0.04) subjects. Creatinine concentration was significantly reduced in lead acid battery (60.48±2.90) factory workers compared with control N (75.591.48). The U/C ratio was significantly elevated ($p<0.05$) in lead acid battery (85.40±6.83) factory workers when compared with control N (70.70±0.66) subjects. Also, there was elevated U/C ratio in lead acid battery compared with control E (32.57±0.86) subjects. See table 1.

Table 2 presents the effect of age on the kidney function status of lead acid battery workers while the regression of these parameters with age are presented in Figure 1. There was no significant difference ($p>0.05$) between the Na^+ (except 18-30 yrs group) and urea levels and urea/creatinine ratio of the control subjects and those of all the age groups. The same trend was observed for K^+ except at the 51-60yrs age group where K^+ was significantly reduced ($p<0.05$). Although Cl^- increased significantly ($p<0.05$) in the 18-30 yr category when compared with the control, its level down the other age groups was not consistent. Creatinine level was significantly reduced ($p<0.05$) at the 51-60 yrs age group compared to the control subjects. Correlation of these with age showed that Na^+, K^+ Cl^-, urea, Cr and U/C ratio were negatively correlated while HCO_3^- was positively correlated, though non-significantly ($p>0.05$).

Table 1: Kidney function status of lead acid battery manufacturing factory workers

Factory	Na^+ ion (mmol/L)	K^+ ion (mmol/L)	Cl^- ion (mmol/L)	HCO_3^- ion (mmol/L)	Urea (mmol/L)	Creatinine (μmol/L)	U/C ratio
N (n=39)	122.87±0.78^a	3.28±0.04^a	99.25±0.18^a	26.73±0.20^b	5.32±0.09^c	75.59±1.48^{bc}	70.70±0.66^b
E (n=40)	N/A	N/A	N/A	N/A	2.17±0.04^a	67.71±1.23^{ab}	32.57±0.86^a
V (n=38)	128.89±1.09^b	3.29±0.05^a	103.61±0.74^b	23.97±0.37^a	4.89±0.36^c	60.48±2.90^a	85.40±6.83^c

Values are in mean (±SEM); within the column, mean with different superscripts are statistically significant ($p<0.05$).

KEY:

N: Control subjects from Nnewi

E: Control subjects from Elele

V: Workers from lead acid battery factory

U/C ratio: Urea/Creatinine ratio

N/A: Not Analyzed

The effect of LOS on the kidney function parameters of factory workers (Table 3) and the regression analyses (Figure 2) showed that Na^+ was significantly elevated ($p<0.05$) at the 0-5yrs and 16-20yrs LOS group while K^+ decreased significantly only at the 16-20yrs LOS group. HCO_3^- was significantly decreased in all the LOS groups with the least at the 16-20yrs while urea was also significantly decreased at the 11-15yrs LOS group compared to the control. Creatinine was significantly reduced ($P<0.05$) at the 0-5yrs LOS group while no significant difference ($p>0.05$) was observed in the U/C ratio. Correlation of the parameters with LOS showed that Na^+ and Cr were positively correlated with LOS while K^+, Cl^-, HCO_3^-, urea and U/C ratios were negatively correlated with LOS, though none was significant ($p>0.05$).

Table 2: Effect of age on the kidney function status of lead acid battery factory workers

Age group	Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)	HCO_3^- (mmol/L)	Urea (mmol/L)	Creatinine (μmol/L)	U/C ratio
N (n=39)	122.87±0.78^a	3.28±0.04^b	99.25±0.18^a	26.73±0.20^c	5.32±0.09^a	75.59±1.48^b	70.70±0.66^a
18-30yrs (n=25)	129.84±1.36^b	3.34±0.07^b	104.40±0.85^b	23.68±0.18^{ab}	5.30±0.09^a	60.11±3.71^{ab}	74.76±0.66^a
31-40yrs (n=5)	129.43±2.95^a	3.21±.09^{ab}	99.86±2.04^a	24.57±0.72^{ab}	4.29±0.47^a	61.88±7.21^{ab}	75.28±11.17^a
41-50yrs (n=2)	126.00±1.41^a	3.40±0.10^b	105.50±1.26^a	25.50±1.50^{ab}	3.86±0.77^a	64.09±6.63^{ab}	61.97±12.07^a
51-60yrs (n=2)	121.00±1.00^a	2.80±0.00^a	103.00±3.00^a	22.50±1.50^a	4.40±1.25^a	53.04±17.68^a	84.51±4.70^a

Values in mean (±SEM); within column, means with different superscripts are statistically significant ($p<0.05$)

KEY:

U/C Ratio: Urea/Creatinine ratio

Table 3: Effect of LOS on kidney function status of lead acid battery factory workers

LOS group	Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)	HCO_3^-	Urea (mmol/L)	Creatinine (μmol/L)	U/C ratio
N (n=39)	122.87±0.78^a	3.28±0.04^b	99.25±0.18^a	26.73±0.20^c	5.32±0.09^b	75.59±1.48^b	70.70±0.66^{ab}
0-5yrs (n=12)	129.33±2.13^b	3.37±0.10^b	104.25±1.08^b	24.17±0.58^b	5.30±1.98^b	56.72±4.55^a	100.64±15.06^b
6-10yrs (n=19)	128.12±1.50^{ab}	3.34±0.07^b	102.88±1.30^b	24.41±0.58^b	4.66±0.59^{ab}	60.95±4.52^{ab}	81.99±10.00^b
11-15yrs (n=2)	129.00±2.08^{ab}	3.38±0.14^b	104.00±2.20^b	24.00±1.47^b	3.40±1.83^a	56.04±8.84^a	61.15±9.31^a
16-20yrs (n=5)	130.40±4.40^b	2.90±0.11^a	104.20±2.06^b	22.00±0.55^a	4.75±0.61^b	70.72±7.40^{ab}	80.19±9.71^{ab}

Values are in mean (±SEM); within column, mean with different superscripts are statistically significant ($p<0.05$)

KEY:

N: Control subjects

LOS: Length of service

U/C ratio: Urea/Creatinine ratio

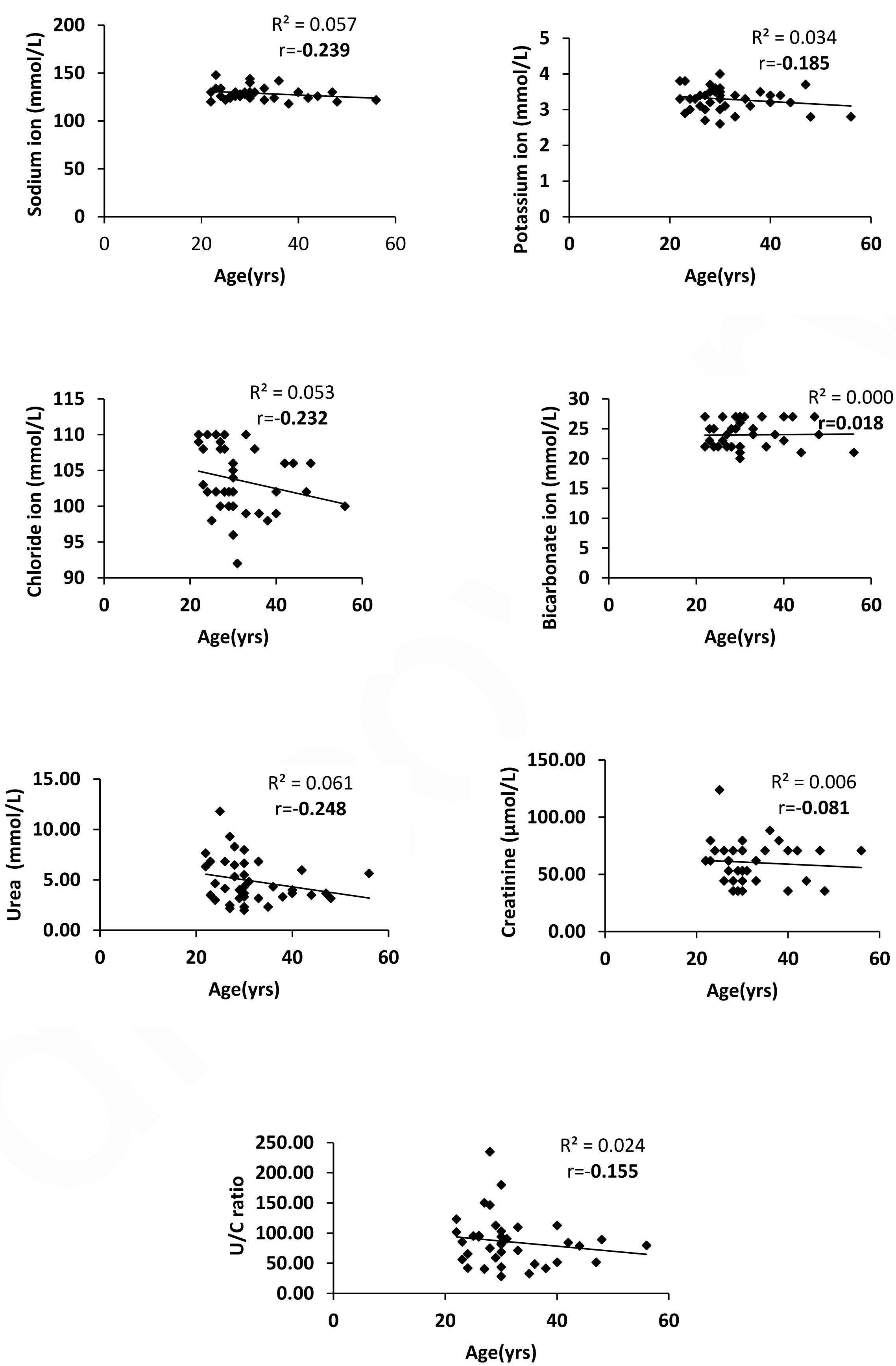

Figure 1: Regression of kidney function status of lead acid battery factory workers with age

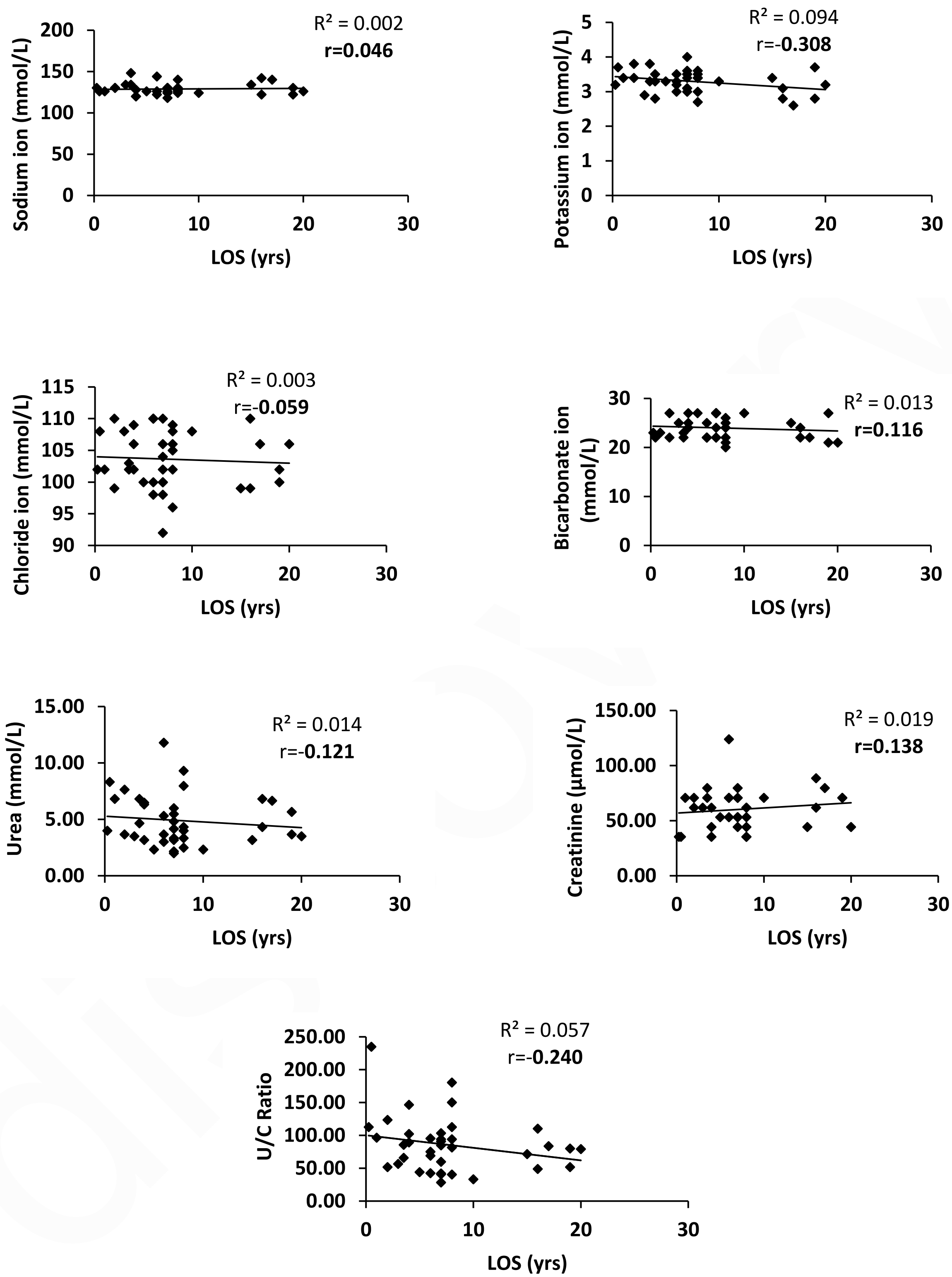

Figure 2: Regression of kidney function status of lead acid battery factory workers with LOS

4. DISCUSSION

Heavy metals such as lead with adverse health effects in human metabolism present obvious concerns due to their persistence in the environment and documented potential for serious health consequences (ATSDR, 2011). Occupational lead exposure continues to increase globally despite its deleterious effects on the various human organs and systems of the body. Importantly, exposure to lead in work places may result in lead induced nephropathy which may be acute lead nephropathy, chronic lead nephropathy or lead induced systemic hypertension (Kathuria and Jadav, 2008). The current study assessed the renal function status in persons occupationally exposed to lead in lead acid battery manufacturing factory in Nnewi viz-a-viz determining the effect of lead exposure on some biomarkers of kidney functions with respect to the age, gender and length of service of the lead acid battery manufacturing factory workers as well as ascertaining any possible correlates between parameters assayed.

This study showed that exposure of factory workers in lead acid battery manufacturing factory in Nnewi significantly increased the values of sodium and chloride in the sera of the factory workers. However, the bicarbonate ion level was significantly decreased in the lead acid battery manufactory factory workers compared with the control. This is in consonance with the findings of Okpogba *et al*. that showed significant elevations in the mean plasma concentration of sodium and chloride while documenting a significant decrease in the mean plasma bicarbonate level in occupationally exposed people working in metal fabricating factory in Nnewi (Okpogba *et al*., 2020). This report further agrees with the documented finding of Onuegbu *et al*. (2011) on the renal indices of people occupationally exposed to lead. The increased sodium level observed in this study may be as a result of excessive loss of water experienced by the factory workers; a process termed dehydration.

Interestingly, the potassium and chloride levels of the lead acid battery factory workers (3.29±0.05) showed no significant difference ($p>0.05$) when compared to the value obtained in the control subjects, whereas the bicarbonate ion (HCO_3^-) concentrations in lead acid battery (23.97±0.37) factory workers were significantly reduced ($p<0.05$) compared to the control subjects (26.73±0.20).

In this study, the urea and creatinine concentrations obtained were decreased significantly in the lead acid battery manufacturing factory workers when compared with the control. This report is in consonance with Zinat et al (2012) who reported significantly reduced urea and creatinine levels among lead-exposed Bangladesh automobile workers but does not agree with the findings of Alasi et al (2010) who showed elevated levels of both urea and creatinine in a group of lead-exposed Nigerian workers. The observed decreased urea concentration in the lead acid battery manufacturing factory workers maybe due to the fact that these workers consume protein-deficient diet as urea production is a waste product resulting from protein metabolism and this tends to be affected by the degree of protein intake. On the other hand, creatinine measurement is a good indicator or marker for kidney functionality and therefore, the decreased creatinine level observed in this study is perhaps an indication that the kidneys of the workers are not yet impaired, although it is important to note that the kidney has what is called functional reserve which allows it to keep working even when impaired until over fifty percent of the nephrons have been damaged.

Surprisingly, there was no significant difference ($p>0.05$) between the Na^+ (except 18-30 yrs group) and urea levels and urea/creatinine ratio of the control subjects and those of all the age groups. The same trend was observed for K^+ except at the 51-60yrs age group where K^+ was significantly reduced ($p<0.05$). Although Cl^- increased significantly ($p<0.05$) in the 18-30 yr category when compared with the control, its level down the other age groups was not consistent. Creatinine level was significantly reduced ($p<0.05$) at the 51-60 yrs age group compared to the control subjects.

Also, the present study showed that Na^+ was significantly elevated ($p<0.05$) at the 0-5yrs and 16-20yrs LOS group while K^+ decreased significantly only at the 16-20yrs LOS group. HCO_3^- was significantly decreased in all the LOS groups with the least at the 16-20yrs while urea was also significantly decreased at the 11-15yrs LOS group compared to the control. Creatinine was significantly reduced ($P<0.05$) at the 0-5yrs LOS group while no significant difference ($p>0.05$) was observed in the U/C ratio.

5. CONCLUSION

This study has shown an increased levels of sodium and chloride, decreased bicarbonate, urea and creatinine levels with a non significant change in potassium level in lead acid battery factory workers than in control subjects respectively. Therefore, this study revealed no deleterious effect on the kidneys of the factory workers studied.

Funding:

This study has not received any external funding.

Conflict of Interest:

The authors declare that there are no conflicts of interests.

Peer-review:

External peer-review was done through double-blind method.

Data and materials availability:

All data associated with this study are present in the paper.

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