



Assessment of Growth and Fertility Hormones of Albino Rats Exposed to Quarry Dust at a Quarry Industry

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Growth and fertility hormones of albino rats exposed to quarry dust were evaluated to determine if the inhaled quarry dust and heavy metals contained in it have any effect on the fertility and growth of the rats.

Methods: Sixty (30 in each of wet and dry seasons) male albino rats were used in this study and were housed in six (6) sterilized plastic cages with five (5) rats in each cage at Ugwuele quarry industry Uturu. The control (group 1) was housed at a distance of 7.2km from the quarry site. Group 2 was housed at the administration block of the quarry industry while groups 3,4,5,6 were housed at the gate, plant house, drilling pit and crusher positions of the quarry industry respectively. Heavy metals; lead, chromium, cobalt, arsenic, zinc and cadmium from dust samples were analyzed with atomic absorption spectrophotometer while assay for hormones was also carried out using standard analytical methods.

Results: All the analyzed heavy metals were present in the dust. Concentrations of heavy metals in the quarry dust were significantly higher ($p < 0.05$) than the control and higher in the dry season

than in the wet season. Concentrations of prolactin, follicle stimulating hormone (FSH), luteinizing hormone (LH) and growth hormone (GH) in the test samples were significantly lower ($p < 0.05$) compared to the control while the concentrations of thyroid stimulating hormone (TSH) in the test samples were significantly higher ($p < 0.05$) compared to the control. Results also show that the concentrations of prolactin, FSH, LH and GH were lower in the dry season than in the wet season whereas, the concentrations of TSH in the exposed rats were higher in the dry season than in the wet season.

Conclusion: Growth rate and fertility of the albino rats may have been compromised by the exposure to the quarry dust, since the growth and fertility hormones were all reduced.

Keywords: Hormones; growth; fertility; dust; albino rats.

1. INTRODUCTION

Occupational health and safety is currently an essential concept amongst scientists and researchers. This is due to the increasingly amount of pollutants generated at industrial work places. These pollutants pose a lot of health risks to workers in these industries especially in some countries in Africa where these workers lack appropriate personal protective equipment (PPE) or ignore their use. Recent studies by Madu et al. [1] found that the ambient air of Ugwuele quarry industry was polluted by particulate matter which was higher in the dry season than in the wet season. Numerous studies have also shown that exposure to toxicants at workplace may lead to infertility in males as these toxicants act as hormone disruptors [2]. Very low concentrations of pituitary hormones lead to retarded sperm growth thereby causing infertility in males. This is because hormones produced by the pituitary gland signal the testicles to produce sperm.

A hormone refers to a signaling molecule secreted by glands of multicellular organisms which controls the organism's functions and behavior [3]. There are different types of hormones which perform various specific functions in males which include regulation of growth, sexual development, cellular oxidation, body temperature and the metabolism of carbohydrates, proteins and fats [4]. Follicle stimulating hormone (FSH), a glycoprotein secreted by the anterior pituitary, helps to maintain the spermatogenic epithelium by stimulating the sertoli cells [5]. Excessive values can be found in primary hypogonadism in males. Low levels can be found in pituitary traumas and endocrine-inactive tumors and anorexia nervosa [6]. Luteinizing Hormone (LH) stimulates the synthesis of testosterone in leydig cells of the interstitial tissue of the testicles of males [5]. Excessive values are observed in primary

hypogonadism in males. Low levels are observed in pituitary traumas and tumors and anorexia nervosa [4]. Decreased testosterone values accompanying low levels of FSH and LH indicate reproductive toxicity [7]. Prolactin is a polypeptide hormone secreted by the anterior pituitary gland. It regulates male fertility through the upregulation of testosterone synthesis [8, 4]. Thyroid-stimulating hormone (TSH) or Thyrotropin stimulates thyroid cells to produce thyroxine and triiodothyronine. Its determination is essential in the diagnosis of disorders of the thyroid gland. Excessive levels are observed in hypothyroidism. Low levels can be in hyperthyroidism, hypopituitarism, myocardial infarction and traumas [9]. Growth hormone (GH) or Somatotropin (STH) is a polypeptide hormone that is produced by acidophil cells in the adenohypophysis. It controls and stimulates growth by inducing the right nitrogen balance and stimulating proteosynthesis [10]. Excessive levels are observed in gigantism, endocrine-active pituitary tumours and acromegaly while low levels are observed in nanism [10]. We therefore aim to determine if the inhaled quarry dust and/or its contents have any effect on the fertility and growth of the albino rats through the assessment of their hormones.

2. MATERIALS AND METHODS

2.1 Air Sampling

Ambient air samples were taken at the crusher, administration (admin.) block, gate, plant house, and drilling pit locations of the quarry. Aeroqual and crowcon Gasman monitors/analyzers were used for all the parameters except the heavy metals where, exposed filter paper was used. Average time of sampling was thirty minutes for gases and particulate matter and eight hours for heavy metals at each point. Control samples

were taken at a location outside the quarry (about 7.2 km away).

2.2 Determination of Heavy Metals from the Dust Using Atomic Absorption Spectrophotometer (AAS)

The analyzed heavy metals are lead (Pb), chromium (Cr), cobalt (Co), arsenic (As), zinc (Zn) and cadmium (Cd). The method as described by James [11] was used. The elements wavelengths were 358.0, 283.3, 229.0, 213.9nm for Cr, Pb, Cd and Zn respectively.

2.3 Animal Sampling

Sixty (30 in each of wet and dry seasons) male albino rats (*Rattus norvegicus*) aged eight weeks and weighed between 116 to 129g were used in this study. They were housed in six sterilized plastic cages with five (5) rats in each cage at Ugwuele quarry industry Uturu, located about 5.5km from Abia State University Uturu. However, the control (group 1) was housed at a distance of 7.2km from the quarry site. Group 2 was housed at the administration block of the quarry industry while groups 3,4,5,6 were housed at the gate, plant house, drilling pit and crusher positions of the quarry industry respectively. All the albino rats were allowed free access to feed and water ad libitum and monitored each morning throughout the sampling period. The experimental animals were housed for ninety (90) days in each season (wet and dry seasons) and were sacrificed. The animals were anaesthetized in a desiccator containing cotton wool soaked in chloroform then sacrificed.

2.4 Blood Sample Collection

Blood samples were drawn from the hearts of the experimental animals after they were sacrificed and put into new clean test tubes. The blood samples clotted after about 15 minutes and were spun in a centrifuge at 4000rpm for 10min. Serum was drawn with Pasteur pipette into sterile sample tubes for the assay of hormones.

2.5 Determination of Hormones

The immunoenzymometric assay method as described by Henry (1996) was used to determine the hormones.

2.6 Statistical Analyses

Values obtained were analyzed with two way Analysis of Variance (ANOVA). Means of

quintuplicate values were compared at 95% level of confidence. These were done with the statistical package for social sciences (SPSS) version 20.

3. RESULTS

The results of heavy metals in the dust at Ugwuele quarry site, Uturu are presented in Tables 1 and 2.

Co (ppm): The value of cobalt (Co) in the dust during the wet season ranged from 0.18 (at both the gate and admin-block) to 0.24 ± 0.10 (at the drilling pit). The least value (0.01 ± 0.01) was from the control. In the dry season, the values ranged from 0.20 ± 0.02 (at the gate) to 0.39 ± 0.01 (at the drilling pit). The lowest value (0.03 ± 0.00) was recorded at the control. Concentrations of Co at the various locations in the quarry site increased significantly ($p < 0.05$) compared to the control.

Zn (ppm): In the wet season, the value of zinc (Zn) in the dust, ranged from 0.04 ± 0.02 (at the admin.block) to 0.06 (at the crusher and plant house). Zinc was not detected at the drilling pit. A value of 0.24 ± 0.12 was recorded at the control point. During the dry season, the concentration ranged from 0.02 ± 0.01 (at the drilling pit) to 0.22 ± 0.04 (at the admin.block). The highest value (0.52 ± 0.01) was recorded at the control. Concentrations of Zn at the various locations in the quarry site increased significantly ($p < 0.05$) compared to the control.

Cr (ppm): During the wet season, the values of chromium (Cr) in the dust ranged from 14.62 ± 0.09 (at the gate) to 45.80 ± 1.20 (at the crusher). The least recorded value (1.36 ± 0.03) was from the control point. In the dry season the values ranged from 15.02 ± 1.05 (at the gate) to 46.70 ± 0.20 (at the crusher). The lowest recorded value (1.72 ± 0.01) was from the control. Concentrations of Cr at the various locations in the quarry site increased significantly ($p < 0.05$) compared to the control.

Cd (ppm): Cadmium (Cd) was detected at only the drilling pit and the control with the same value of 0.01, during the wet season whereas, during the dry season, the value (0.01) was the same in all the areas and control, except a value of 0.03 ± 0.01 recorded at the drilling pit.

As (ppm): During the wet season, the values of arsenic (As) ranged from 1.69 ± 0.18 (at the drilling pit) to 3.40 ± 1.20 (at the crusher). The least recorded value (0.81 ± 0.01) was from the control.

During the dry season, the values ranged from 1.69±0.18 (at the drilling pit) to 3.97±0.01 (at the crusher). The least recorded value (0.83±0.01) for the season, was from the control.

Pb (ppm): In the wet season, the concentration of lead (Pb) in the quarry dust ranged from 1.48±0.10 (at the drilling pit) to 5.24 ±0.21 (at the crusher). The least recorded value (1.10±0.10) was from the control. In the dry season, the values ranged from 1.72±0.04 (at the drilling pit) to 6.44±0.20 (at the crusher). The lowest recorded value (1.13±0.02) for the dry season was from the control. Concentrations of all these heavy metals at the various locations in the quarry site increased significantly (p<0.05) compared to the control.

Concentrations of hormones in serum samples of the albino rats are presented in Figs. 1 and 2.

Prolactin (Iµ/L): In the wet season, the concentration of prolactin in the test samples ranged from 0.80±0.01 (from the crusher and plant house) to 1.20±0.03 (from the admin.block). The highest recorded value (1.30±0.01) was from the control. In the dry season, the values ranged from 0.70±0.01 (from the plant house) to 1.00±0.00 (from the admin.block). The highest recorded value (1.26±0.06) was from the control sample. Values of prolactin in the serum of the albino rats housed at different locations of the

quarry site decreased significantly (p<0.05) compared to the control.

FSH (ng/mL): During the wet season, the concentration of follicle stimulating hormone (FSH) in the test samples varied from 5.30±0.07 (from the crusher) to 6.10 (in both admin.block and the gate). The highest recorded value (6.40±0.06) for the season was from the control. In the dry season, the concentration ranged from 5.15±0.05 (from the crusher) to 6.21±0.02 (from the gate). The control sample recorded the highest value of 6.37±0.07. Values of FSH in the serum of the albino rats housed at different locations of the quarry site decreased significantly (p<0.05) compared to the control.

LH (Iµ/L): In the wet season, the lowest concentration of leutenizing hormone (LH) detected was 0.60±0.09 in a sample from the crusher and the highest concentration, 0.80±0.01 detected in sample from the gate and also in the control. In the dry season, the lowest concentration was 0.41±0.02 in a sample from the crusher and the highest concentration (0.74±0.04) detected in a sample from the gate. The highest recorded value (0.91±0.01) was from the control sample. Values of LH in the serum of the albino rats housed at different locations of the quarry site decreased significantly (p<0.05) compared to the control.

Table 1. Concentrations (ppm) of Heavy metals in the quarry dust (Wet Season)

Heavy metals	Crusher	Admin. block	Gate	Plant house	Drilling pit	Control
Co (ppm)	0.20±0.01 ^b	0.18±0.02 ^d	0.18±0.01 ^f	0.19±0.60 ^h	0.24±0.10 ⁱ	0.01±0.01 ^a
Zn (ppm)	0.06±0.01 ^b	0.04±0.02 ^d	0.05±0.01 ^f	0.06±0.01 ^h	Nd	0.24±0.12 ^a
Cr (ppm)	45.80±1.20 ^b	15.83±0.21 ^d	14.62±0.09 ^f	21.22±0.11 ^h	26.96±1.07 ^j	1.36±0.03 ^a
Cd (ppm)	Nd	Nd	Nd	Nd	0.01±0.01 ^a	0.01±0.01 ^a
As (ppm)	3.40±1.20 ^b	2.50±0.10 ^d	2.36±0.20 ^f	3.25±0.14 ^h	1.69±0.18 ^j	0.81±0.01 ^a
Pb (ppm)	5.24±0.21 ^b	2.22±0.10 ^d	2.52±0.05 ^f	4.85±0.06 ^h	1.48±0.10 ^j	1.10±0.10 ^a

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same row, having different letters of alphabet are statistically different (p ≤ 0.05) using Least Significant Difference (LSD). Nd = Not detected

Table 2. Concentrations (ppm) of Heavy Metals in the Quarry Dust (Dry Season)

Heavy metals	Crusher	Admin. Block	Gate	Plant house	Drilling pit	Control
Co (ppm)	0.30±0.10 ^c	0.37±0.02 ^e	0.20±0.02 ^g	0.25±0.19 ⁱ	0.39±0.01 ^k	0.03±0.00 ^a
Zn (ppm)	0.08±0.03 ^c	0.22±0.04 ^e	0.09±0.02 ^g	0.11±0.02 ⁱ	0.02±0.01 ^j	0.52±0.01 ^a
Cr (ppm)	46.70±0.20 ^c	17.12±0.30 ^e	15.02±1.05 ^g	22.01±1.20 ⁱ	27.80±1.24 ^k	1.72±0.01 ^a
Cd (ppm)	0.01±0.00 ^a	0.01±0.01 ^a	0.01±0.02 ^a	0.01±0.01 ^a	0.03±0.01 ^b	0.01±0.01 ^a
As (ppm)	3.97±0.01 ^c	2.86±0.07 ^e	2.85±0.01 ^g	3.28±0.40 ⁱ	1.69±0.12 ^k	0.83±0.01 ^a
Pb (ppm)	6.44±0.20 ^c	2.92±0.05 ^e	2.97±0.04 ^g	4.87±0.01 ⁱ	1.72±0.04 ^k	1.13±0.02 ^a

Results represent mean ± standard deviation of triplicate results obtained (n=3). Mean in the same row, having different letters of alphabet are statistically different (p ≤ 0.05) using Least Significant Difference (LSD). Nd = Not detected

TSH (mIU/L): During the wet season, the concentration of thyroid stimulating hormone (TSH) in the test samples ranged from 2.50 ± 0.04 (from the crusher) to 2.80 ± 0.02 (from both admin. Block and plant house). The lowest recorded value (2.00 ± 0.10) for the season was from the control. In the dry season, the value ranged from 2.63 ± 0.03 (from the crusher) to 2.88 ± 0.08 (from the drilling pit). The lowest recorded value (2.10 ± 0.03) was from the control sample. Values of TSH in the serum of the albino rats housed at different locations of the quarry site increased significantly ($p < 0.05$) compared to the control.

GH (ng/mL): In the wet season, the concentration of growth hormone (GH) in the test samples ranged from 8.50 ± 0.10 (from the crusher) to 9.48 ± 0.03 (from the admin.block). The highest recorded value (9.80 ± 0.09) was from the control. During the dry season, the concentration varied from 7.15 ± 0.04 (from the crusher) to 8.21 ± 0.10 (from the drilling pit). The control sample recorded a value of 8.13 ± 0.04 . Values of GH in the serum of the albino rats housed at different locations of the quarry site decreased significantly ($p < 0.05$) compared to the control.

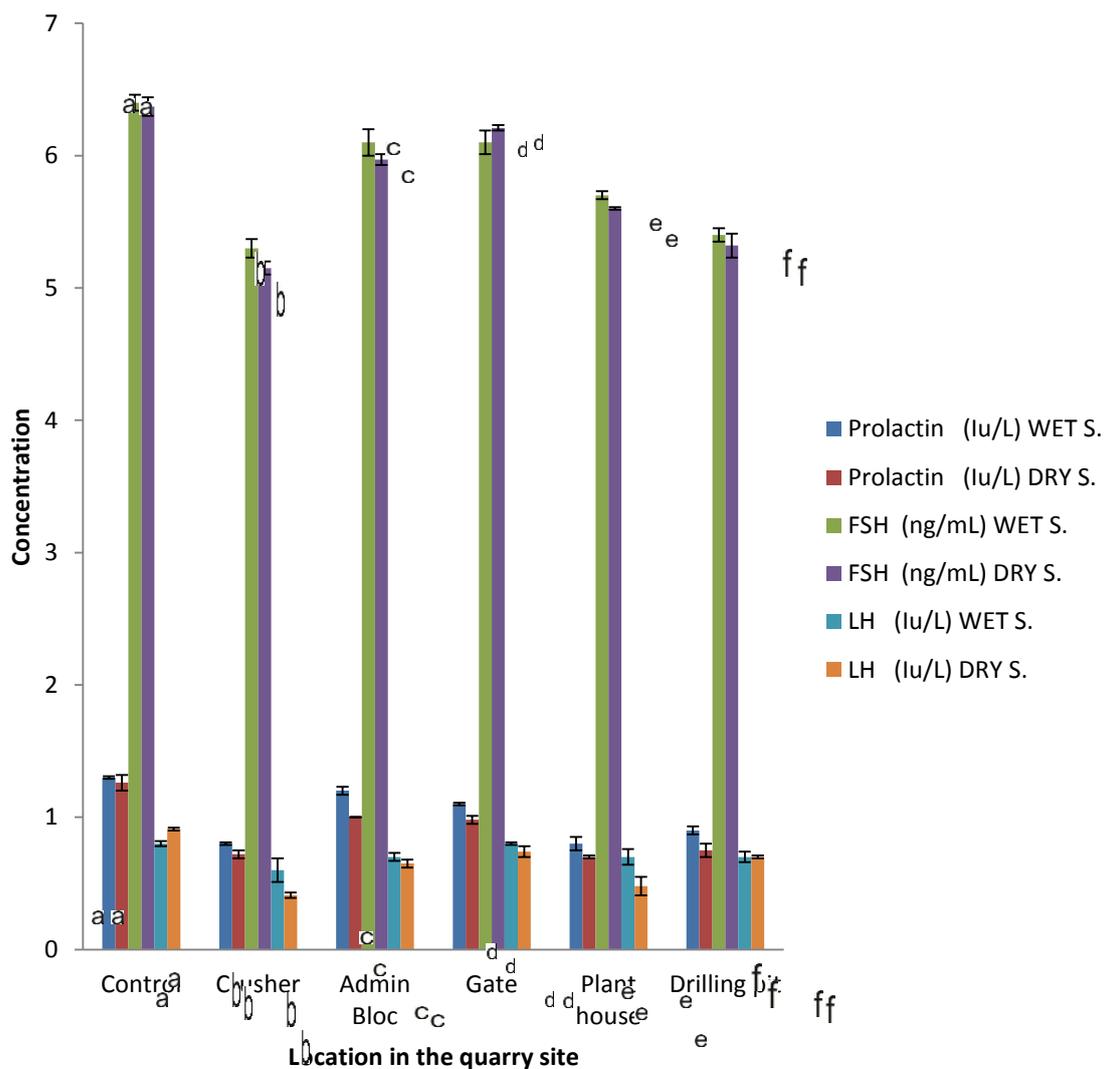


Fig. 1. Concentrations (mg/kg) of hormones (Prolactin, FSH and LH) in the blood samples of albino rats exposed to quarry dust at various locations in Ugwuele quarry site, Uturu
 Results represent mean \pm standard deviation of triplicate values. Bars of the same color having different letters of alphabet are statistically different ($p < 0.05$) using Least Significant Difference (LSD).
 Legend: Wet S. = Wet season, Dry S. = Dry season.

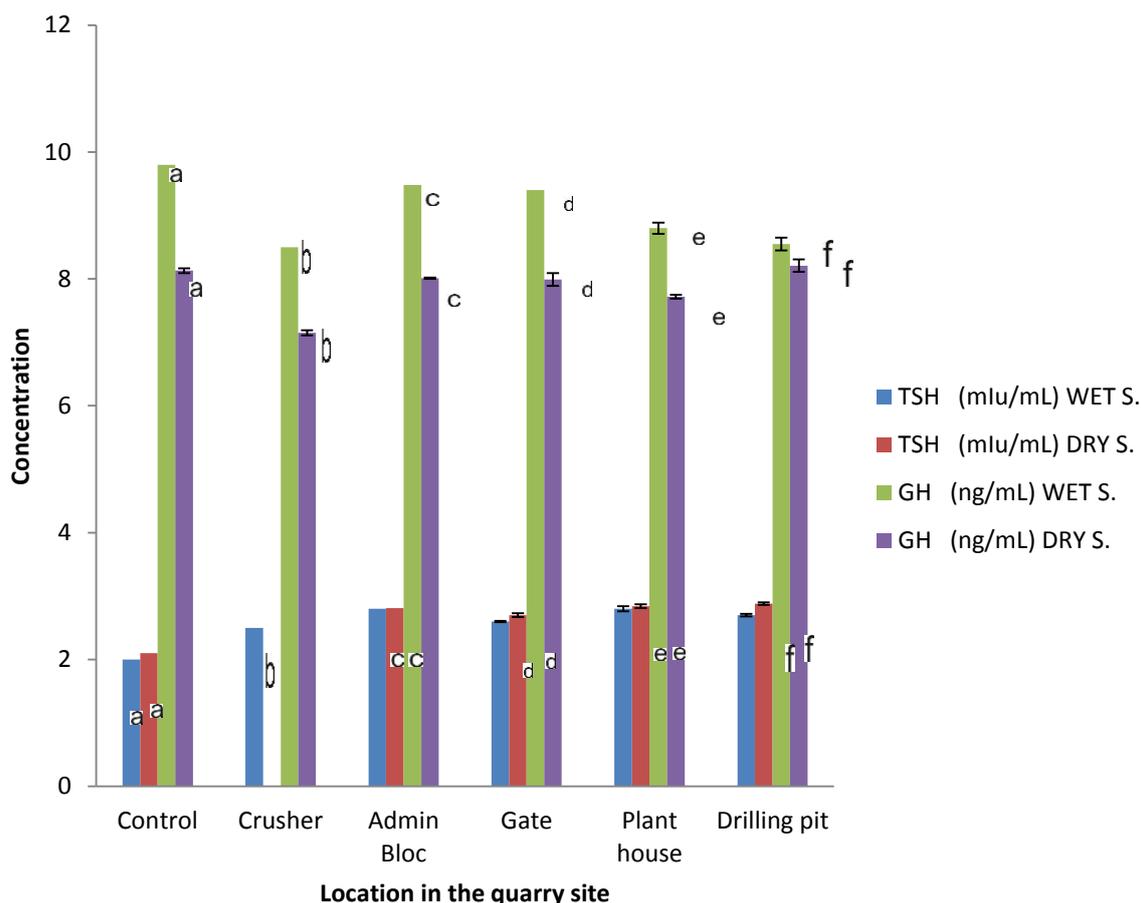


Fig. 2. Concentrations (mg/kg) of hormones (TSH and GH) in the blood samples of albino rats exposed to quarry dust at various locations in Ugwuele quarry site, Uturu

Results represent mean \pm standard deviation of triplicate values. Bars of the same color and location having different letters of alphabet are statistically different ($p < 0.05$) using Least Significant Difference (LSD).

Legend: Wet S. = Wet season, Dry S. = Dry season.

4. DISCUSSION

The results obtained from this study show that all the analyzed heavy metals (Co, Zn, Cr, Cd, As, Pb) were present in the dust. However, chromium (Cr) recorded the highest values in all the seasons. Chromium naturally occurs in rocks in the form of chromite [13]. The results also show that the levels of the heavy metals in the dust were higher in the quarry than in the control and higher in the dry season than in the wet season. Pandey et al. [14] reported similar trend of results. Constant inhalation of dust containing heavy metals can cause serious health problems. Ivo et al. [15] reported that heavy metals affect the endocrine system by the disruption of hormones.

Results from this study show that the concentrations of prolactin, FSH, LH and GH in

the test samples were significantly lower ($p < 0.05$) compared to the control while the concentrations of TSH in the test samples were significantly higher ($p < 0.05$) compared to the control. This may be caused by the impact of the toxicants from the quarry dust inhaled by the rats. The results also reveal that concentrations of the hormones in the exposed rats varied from one area of activity to other within the quarry site. This may be attributed to the difference in the levels of these toxicants at different areas in the quarry. The results from this study also show that the concentrations of prolactin, FSH, LH and GH were lower in the dry season than in the wet season whereas, the concentrations of TSH in the exposed rats were higher in the dry season than in the wet season. This may be as a result of the higher content of toxicants in the quarry dust during the dry season. Low levels of serum prolactin can cause hypoprolactinemia which

leads to oligozoospermia and premature ejaculation in humans [16]. However, FSH and LH stimulate sperm production in males. Low levels of FSH and LH as found in the present study may cause low sperm count which is responsible for most infertility cases in males [17]. Thyroid stimulating hormone (TSH) is a glycoprotein hormone that causes the synthesis and secretion of thyroxine hormone. Elevated levels can be found in hypothyroidism [18]. Growth hormone is a hormone that functions in the stimulation of protein synthesis. GH promotes growth by causing proliferation of cartilage cells, biosynthesis of chondroitin sulfate, hyperplasia and proliferation of various tissue cells and protein anabolism. It also promotes secretion of thymulin from thymus cells [19]. Deficiency of growth hormone in children can cause growth retardation in children, but fatigue, abnormal metabolism, less muscle mass and weaker bones in adults [20].

5. CONCLUSION

The results from the present study indicate that the quarry dust contained increased levels of the analyzed heavy metals. These heavy metals might have joined the blood stream of the albino rats through inhalation and feeding thereby blocking the activity of the hormones. The growth rate and fertility of the albino rats may have been compromised by the exposure to the quarry dust, since the growth and fertility hormones were all reduced. The implication is that male workers at the quarry industry may be exposed to various growth and fertility problems which may include fatigue, weakness of bones, abnormal metabolism, low sperm count and premature ejaculation. Those who work at the crusher section of the industry may be highly affected by these problems while workers at the administration block of the industry may experience the least of the problems. However quarry workers may have more relief in the wet season than in the dry season.

ETHICAL APPROVAL

Ethical approval for the use and care of animals was obtained from the research and publications unit of Abia State University, Uturu and executed according to ARRIVE guidelines.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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