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Research Article

Impact of Quarry Dust on Haematological and Hepatic Parameters of Guinea Pigs Exposed to Quarry Dust at Umuoghara and Amoffia NGBO Quarry Sites of Ebonyi State

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ABSTRACT

In recent years, Ebonyi state has experienced a rapid increase in the proliferation of quarry industries due to the high demand for stone for construction in the fast-developing state and its neighboring. This has contributed significantly to dust pollution within the vicinity of these quarry sites. We investigated the effect of quarry dust on some hematological and hepatic parameters of guinea pigs exposed to quarry dust at Umuoghara (UMR) and Amoffia Ngbo (AMN) quarry sites in Ebonyi state. The control site was the College of Agricultural Science (CAS) Campus of Ebonyi state University. A total of 288 adult male guinea pigs, weighing between 500 g to 800 g, were used for the study. They were divided into three groups of 96 guinea pigs each, labeled UMR, AMN and Clinical Trial Regulation (CTR), respectively. Each group was further subdivided into four subgroups of 24 guinea pigs each. Groups UMR and AMN were exposed to their respective quarry sites, while group CTR was kept at the control site, with analyses conducted at three-month intervals.

Hematological parameters measured included hemoglobin (Hb) concentration, Red Blood Cell (RBC) count, Packed Cell Volume (PCV), White Blood Cell (WBC) count and platelet count. Hepatic parameters assessed included activities of Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Gamma-Glutamyl Transferase (GGT), Alkaline Phosphatase (ALP), total protein, albumin and globulin in the exposed guinea pigs, with duration of exposure taken into account. The Hb, RBC and PCV levels were significantly lower $p<0.05$ in the exposed guinea pigs compared to the control group and decreased significantly $p<0.05$ with increasing length of exposure. Conversely, WBC and platelet counts were significantly higher $p<0.05$ in the exposed groups.

The activities of serum AST, ALT, GGT and ALP were also significantly higher $p<0.05$ in the exposed groups than in the controls and increased significantly $p<0.05$ with duration of exposure. Additionally, total protein, albumin and globulin concentrations were significantly lower $p<0.05$ in the exposed groups compared to the control group. It was observed that the effects of exposure to dust on the guinea pigs were more pronounced at site AMN than at UMR. The findings suggest that the adverse effects of exposure to quarry dust depend on both the quantity of dust and the duration of exposure.

Keywords: Quarry, Hematological parameters, White Blood Cell (WBC), Hepatic parameter, Dust pollution

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INTRODUCTION

Stone crushing is a common global practice for the production of graded stones used in building and road construction (Okafor FC, 1988). However, the dust emissions from this practice have raised widespread concern around the world. Air pollution is a significant environmental issue affecting both industrialized and developing nations (Shaddick G, *et al*., 2020; Garba HI, 2021).

Historically, the people of Ebonyi were predominantly agrarian, relying mainly on agriculture for their livelihoods. In recent decades, however, quarrying has emerged as a major industry in the state. Most quarry employees are illiterate men and women who possess little or no knowledge of the consequences of dust pollution and its effects.

The types of quarry industries present in Ebonyi state range from manual stone crushing to medium-scale operations, with a recent proliferation of large-scale industries employing heavy machinery for stone crushing.

Dust generated from quarries is a major source of air pollution, with its severity depending on various factors such as local climate, concentration of dust particles in the surrounding air, size of the dust particles and their chemical constituents. For instance, limestone quarries produce highly alkaline active dust, while granite quarries generate acidic dust (Ezekwe IC, 2009). The health effects of exposure to quarry dust extend beyond respiratory problems; they can also impact various organs and have systemic effects.

In Ebonyi state, quarry industries employ men and women aged between 14 years and 60 years, including pregnant women and nursing mothers who carry young children while working on-site without any protective measures. Reports indicate that dust from stone quarries contains heavy metals, metallic oxides, Polycyclic Aromatic Hydrocarbons (PAHs) and other harmful compounds that pose risks to both animals and humans (Ogbanshi ME and Akubugwo EI, 2012). These toxic substances have been implicated in numerous diseases, including pneumoconiosis, emphy-

sema, silicosis, genetic disorders, hematological issues, organ damage and cancer (Salh DM, *et al*., 2014).

If unmanaged, dust generated from surface mining sites can lead to serious environmental, health, toxicological, safety and operational impacts on both site personnel and the surrounding community. Workers in developing countries are often at risk of quarry dust exposure due to a lack of awareness regarding the associated dangers (Friday ET, *et al*., 2012). Pulmonary problems among quarry workers at Umuoghara quarry sites have been reported, while (Ogbanshi ME and Akubugwo EI, 2012) documented the concentration of heavy metals and their toxicity in rabbits exposed to quarry dust.

The increase in the number of quarry industries throughout Ebonyi state often situated very close to residential areas without intervention is a matter of significant concern. The blatant neglect of environmental laws by quarry owners and the lack of monitoring by environmental agencies pose serious dangers not only to quarry workers but also to host communities and the environment at large.

MATERIALS AND METHODS

Study area

This study was conducted between November, 2021 and October, 2022. The two quarry sites are located in the UMR community in Ezza North local government area and the AMN community in Ohaukwu local government area. The CAS campus of Ebonyi state University is located approximately 10 km from one quarry site and 20 km from another respectively. The geographical coordinates for the sites are as follows: UMR (6°18'N, 8°2'E), AMN (6°22'N, 8°9'E) and CTR (6°19'N, 8°4'E).

Experimental animal grouping

A total of 288 male guinea pigs were divided into three groups of 96 guinea pigs were designed with the labels UMR, AMN and CTR. Each group was further subdivided into four subgroups of 24 guinea pigs each, kept in separate cages.

The subgroups were labeled UMR1 to UMR4, AMN1 to AMN4 and CTR1 to CTR4. The Subgroups UMR1 were exposed to Umuoghara, and AMN4 for Ammofia Ngbo at their respective quarry sites, while CTR was kept at the CAS campus of Ebonyi state University. The exposed guinea pigs were brought out in the morning and taken into a nearby house at the end of each workday. Subgroups with subscripts 1, 2, 3 and 4 from each group were exposed for periods of three, six, nine and twelve months respectively and investigated accordingly at the end of each exposure.

Sample collection

Blood samples were collected by ocular puncture using a capillary tube after mild anesthesia with chloroform.

Determination of hematological parameters

Three milliliters of blood in an Ethylenediamine tetra acetic acid (EDTA) bottle were used for analysis without storage. Hb concentration was determined according to Lewis SM, *et al*., 1991, while RBC, PCV and total WBC count were determined using a hematology auto-analyzer Sysmex KX-21N (Barksdale RD, 1991).

Determination of liver function parameters

Five milliliters of the collected blood were allowed to clot at room temperature. The sample was then centrifuged at 3000 × g for 5 minutes to extract serum. The activities of ALT, AST and ALP were determined using test kits from Randox Laboratories, UK, following the manufacturer's instructions. GGT activity was measured. Total protein concentration was determined, while albumin levels were assessed.

Statistical analysis

Results were statistically analyzed using two-way Analysis of Variance (ANOVA) and Tukey's multiple comparison test conducted with GraphPad Prism Software version 6.0. Values at $p<0.05$ were considered significant.

RESULTS AND DISCUSSION

Effect of exposure to quarry dust on hematological indices of guinea pigs exposed at UMR and AMN quarry sites

The results of the study indicated that exposure to quarry dust significantly affected the hematological parameters of guinea pigs. Specifically, Hb, RBC and PCV were found to be significantly lower $p<0.05$ in guinea pigs exposed to quarry dust compared to control animals, with these parameters decreasing significantly $p<0.05$ with increasing length of exposure. Reduced Hb, RBC and PCV are indicative of anemia, suggesting that exposure to quarry dust is likely implicated in the observed decreases in these hematological parameters.

These findings are consistent with previous studies by (Ashwini S, *et al*., 2016; Jude AC, *et al*., 2002; Mojiminiyi FB, *et al*., 2008; Farheen A, *et al*., 2017), all of which reported significant decreases in RBC count, PCV and Hb levels during exposure to cement dust (*Figures 1 and 2*). This decrease may be attributed to the effects of components found in quarry dust, such as heavy metals, on the hematopoietic system (*Figure 3*).

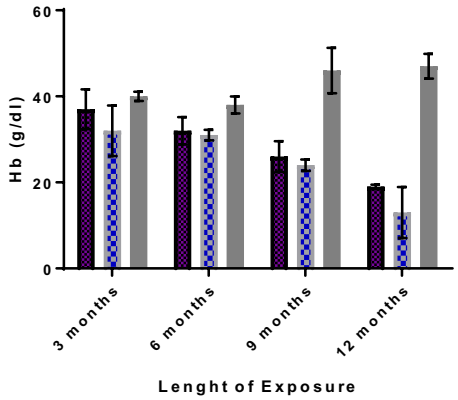

Figure 1: Hb level (g/dl) of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

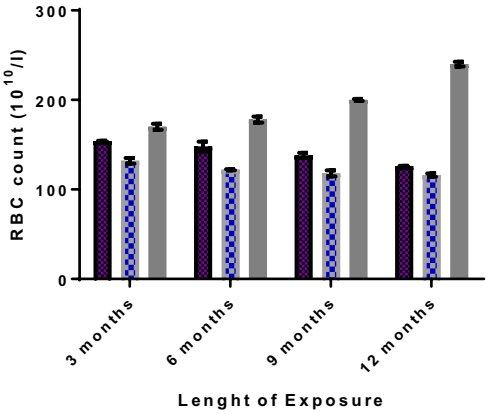

Figure 2: RBC count of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

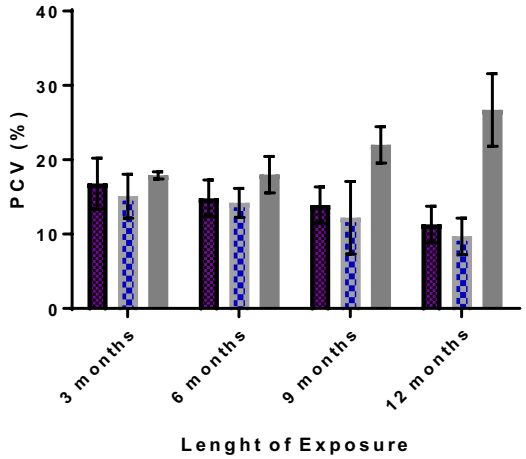

Figure 3: Percentage level of PCV of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

Similar results were also reported by (Naik J, *et al*., 2012) in workers exposed to cement dust, although no changes in Hb levels were noted in their study.

Furthermore, significantly lower levels of Hb, RBC and PCV were observed in guinea pigs exposed at the AMN site compared to those at the UMR site p<0.05. This finding correlates with the higher emissions of dust at the AMN site. The greater accumulation of dust and its components on guinea pigs at the AMN quarry site may explain this observation.

A significant decrease in Hb concentration could result from a reduction in hemoglobin synthesis in the bone marrow or a decreased concentration of Hb within the cells (Kumar P, *et al*., 2005). It has been reported that lead (Pb) inhibits enzymes involved in heme biosynthesis (Patil AJ, *et al*., 2006; ATSDR, 2005), which may have contributed to the observed decreases in Hb, RBC and PCV levels among the exposed guinea pigs.

Total WBC and platelet counts were significantly higher p<0.05 in the exposed guinea pigs compared to the control group and these counts increased significantly p<0.05 with the length of exposure (*Figures 4 and 5*).

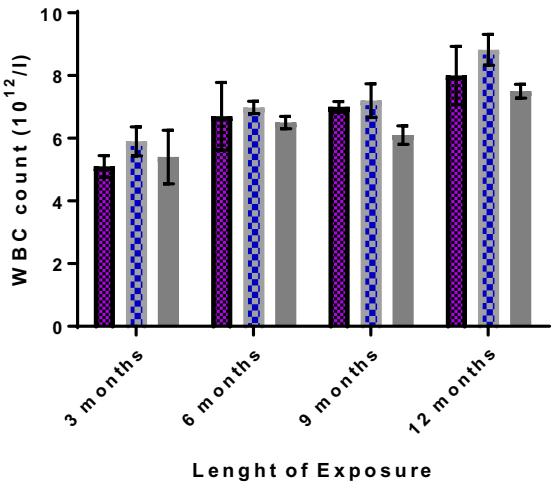

Figure 4: WBC of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

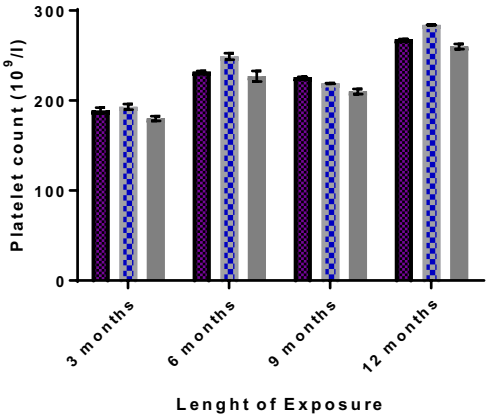

Figure 5: Platelet count of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

Numerous studies have reported an increase in WBC in both humans and animals exposed to quarry and cement dust. Our findings align with those of (Mojiminiyi FB, *et al*., 2008), who observed a significant rise in WBC and platelet counts among workers exposed to cement dust. Similarly, (Ogbanshi ME and Akubugwo EI, 2012) reported a significant increase in total WBC in rats exposed to quarry dust.

In contrast, (Jude AC, *et al*., 2002) noted an insignificant rise in white cell counts among exposed workers; however, they reported a significant decrease in platelet counts compared to unexposed individuals, whereas our study found significantly higher platelet counts in the exposed group. This discrepancy may be attributed to differences in the sample populations used.

Additionally, our results showed a significant p<0.05 increase in the activities of serum AST, ALT, ALP and GGT in the exposed groups compared to the control groups, with enzyme activities also increasing with the duration of exposure. These findings are consistent with previous studies by (Al Salhen and Khaled S, 2014; Mehere BA, *et al*., 2016) (*Figures 6 and 7*). The activities of transaminases AST and ALT serve as markers for the function and integrity of the heart and liver. AST is found in various tissues, including the liver, heart, skeletal muscle, kidneys, brain and red blood cells, while ALT is predominantly located in the liver and serves as a more specific indicator of liver inflammation than AST (Hayashi H, *et al*., 1990).

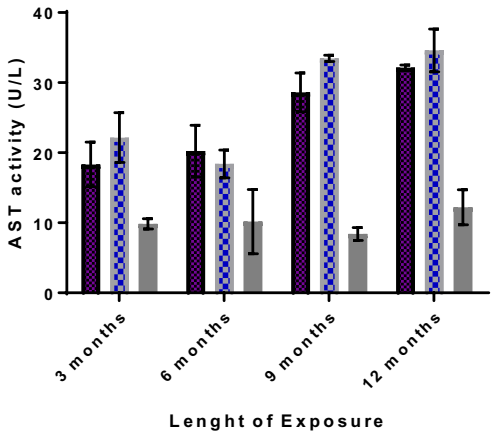

Figure 6: Activity of AST in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (■) UMR; (■) AMN and (■) CTR

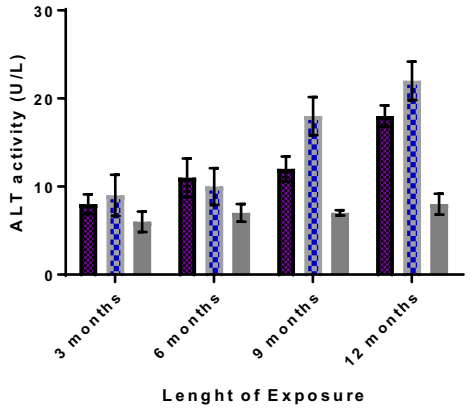

Figure 7: Activity of ALT in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

GGT is primarily used as a diagnostic marker for liver disease; elevated serum GGT activity can indicate liver, biliary system, or pancreatic diseases. GGT correlates well with ALP in detecting biliary tract diseases, providing verification that ALP elevations are due to biliary issues rather than bone diseases (Ilahi I, *et al*., 2012; Franzini M, *et al*., 2008) (*Figures 8 and 9*).

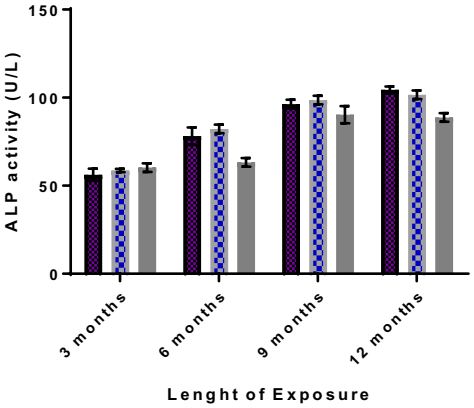

Figure 8: Activity of ALP in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

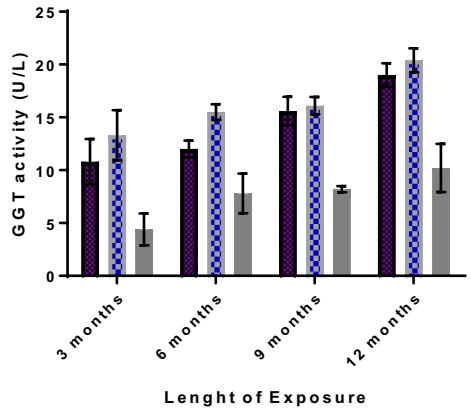

Figure 9: Activity of GGT in serum of Guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

Heavy metals such as lead, cadmium, iron, copper and manganese have been reported to accumulate in the livers of rats exposed to particulate matter (Li Q, *et al*., 2015). Therefore, the significant increase $p<0.05$ in enzyme activities observed in groups exposed to quarry dust compared to control groups may indicate hepatobiliary injury resulting from the accumulation of these heavy metals.

Furthermore, total protein, albumin and globulin levels were significantly lower $p<0.05$ in exposed animals compared to controls and decreased with the length of exposure; however, total protein levels at three months of exposure at the UMR site were significantly higher than those of the control group. Our findings are consistent with those of (Al Salhen and Khaled S, 2014), who reported a significant decrease $p<0.05$ in total protein, albumin and globulin levels among cement factory workers compared to a non-exposed control group (*Figure 10*).

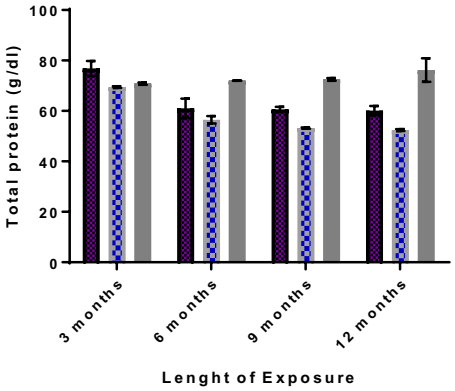

Figure 10: Total protein in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

The reduction in plasma proteins among exposed subjects may be attributed to changes in protein metabolism and synthesis of free amino acids in the liver (Bamidele TO and Atolaye BO, 2012). Low concentrations of protein in blood have also been associated with excessive loss through nephrosis or reduced protein synthesis due to increased proteolytic activity (Rana SV, *et al*., 1996).

In this study, the observed decrease in plasma proteins could partly result from the damaging effects of quarry dust on liver cells, as indicated by increased activities of plasma AST, ALT, ALP and GGT. Other reports have shown decreases in total protein levels without significant changes in albumin levels among cement dust-exposed workers (Mojiminiyi FB, *et al*., 2008; Salh DM, *et al*., 2014), which is consistent with our findings (*Figures 11 and 12*).

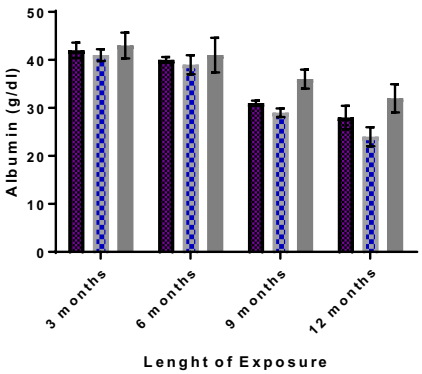

Figure 11: Albumin level in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

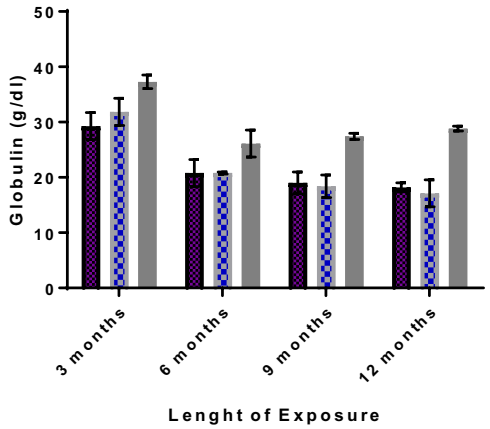

Figure 12: Globulin level in serum of guinea pigs exposed to UMR and AMN quarry dust
Note: (▬) UMR; (▬) AMN and (▬) CTR

CONCLUSION

Our findings indicate that the effects of quarry dust on hematological and hepatic parameters of exposed animals are dependent on the duration of exposure.

Therefore, we recommend that workers in quarry industries consistently wear personal protective equipment. Additionally, dust suppression measures should be implemented to reduce dust emissions within the area surrounding quarry operations.

ETHICAL COMMITTEE CONSENT

This study has been approved by the Animal Use and Care Committee (AUCC-2022/004/0321) from the National Veterinary Research Institute, Vom, Nigeria

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