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Effect of Environmental Dust Pollution (Particulate Matter of Sawdust) on the Histology of the Lungs and Hematological Parameters of Adult Wistar Rats

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ABSTRACT

Saw dusts are derived from wood during sawing of logs of timber into small sizes, as a small irregular chips or small piece which falls from the cutting edges of the saw blade to the floor during sawing operation, therefore its name. Sawdust is low in density, high in porosity, high in water retention, low in water drainage, high in bacteria forbearance, and has biodegradability at a moderate rate. Saw dust consists of hundreds of compounds such as heavy metals (arsenic, cadmium, lead, mercury, antimony, etc.) because it is an organic dust of vegetable derivative and suspended particulate matters that can affect lung development in children and teenagers negatively. This study was done to investigate the effect of environmental dust pollution (particulate matter of sawdust) on Hematological indices and Histology of the lungs of rats. 30 Adult Wistar rats were used for this study. They were grouped into two (exposed and unexposed) of fifteen rats each. The exposed group was placed in the sawmill for 3 months, while the unexposed placed distance away from the sawmill. Analysis carried out includes measurement of Particulate matter of dust, Blood for hematological parameters. Statistical analysis was done using Graph pad prism, Version 5.0. The results were expressed as mean \pm SEM and $P < 0.05$ was considered significant. Experimental site: Particulate matter ($PM_{2.5}$) Average value = $2.290mg/m^3 \pm 0.003$, PM_{10} Average value = $2.185mg/m^3 \pm 0.04$, Control site: (Pure water factory) $PM_{2.5}$ Average value = $0.013mg/m^3 \pm 0.0004$, PM_{10} Average value = $0.145mg/m^3 \pm 0.012$. Estimation of neutrophil count were significantly lower ($P < 0.05$) in exposed rats, while, Total white blood cell count, lymphocyte, monocytes, eosinophil, Red blood cell Count, mean cell haemoglobin, mean corpuscular haemoglobin concentration, mean cell volume were significantly increased ($P < 0.05$). Histopathological findings revealed obliterated alveoli spaces, thickened and hyperplastic alveolar wall, vascular congestion and infiltrates of inflammatory cells. In conclusion, sawdust readily pollute the environment, prolonged exposure to it does not only result in lung defect but caused changes in hematological indices mostly negative, as well as histopathological alterations typical of challenges in the immune system.

Keywords: Environmental, Dust Pollution, Sawdust, Histology, Lungs and Hematological Parameters

INTRODUCTION

Environmental pollution has become a global issue in the last few years as a result of the several activities of human causing the release of substances that are toxic into the atmospheric environment, these toxic substances ranging from dust, fumes, gases, heat, noise etc, which emanate from work places. The toxic substances, however, differ in reactions, composition of chemicals, emissions, effects on human health and persistency in the environment [1]. Sawdust is a by-product of wood that is obtained mostly from woodwork industries. Some of its characteristics are adsorption and ion exchange. It can also be defined as tiny-sized and dusty wood waste derived by the sawing of wood. The kind of wood from which the sawdust is gotten and the teeth of saw determines the size of sawdust particles [2]. Research has shown that there is a possible usage of sawdust for adsorption of different metal ions [3]. In milling operations about 10-13% of the overall volume of the wood log is reduced to sawdust which usually depends on the average thickness scrutiny on physical properties of the saw kern and the thickness of the timber sawed [4]. According to [5], Saw dusts are derived from wood during sawing of logs of timber into small sizes, as a small irregular chips or small piece which falls from the cutting edges of the saw blade to the floor during sawing operation, therefore its name. Sawdust is low in density, high in porosity, high in water retention, low in water drainage, high in bacteria forbearance, and has biodegradability at a moderate rate. These physical properties can be augmented by combining sawdust of different sizes in a definite percentage [6]. Saw dust consists of cellulose, hemicelluloses, lignin and hundreds of compounds such as heavy metals

(arsenic, cadmium, lead, mercury, antimony, etc.) because it is an organic dust of vegetable derivative [7] and other chemicals such as antheocol from African mahogany, (R)-3,4-dimethoxydalbergione and its quinol from Machaeriumscleroxylon and mono- and dimethoxy-substituted quinonesorquinols from cocobolo, iroko, teak, Ropaliland and mansonina known as "wood extractive". Wood dust or saw dust comprises of suspended particulate matters. Particulate matter (PM) consists of a compound combination of solid, liquid or solid and liquid particles of organic and inorganic substances suspended in the air. The transport and removal of particles from the air is determined by the particulate sizes, they also determine their settling within the respiratory system, chemical composition and sources of particles also have a part to play. Because of this, particles are generally sampled and described on the foundation of their smooth diameter, namely; PM₁₀: diameter <10 µm (coarse fraction), PM_{2.5}: diameter <2.5 µm (fine fraction), Diameter <0.1 µm (ultra-fine fraction). The main components of particulate matters particles such as ash, dust, sea salt, water (H₂O), organic carbon (OC) and elemental carbon (EC) are emitted directly into the atmosphere. The common components of atmospheric particles are sulphate (SO₂), nitrate (NO_x) and primary gaseous organics. These components reach the particulate phase through several gas-phase photo chemical (GPP) processes. Different sources emit different Particles of aerodynamic diameters. Mechanical processes forms coarse particles while fine and ultrafine particles such as diesel soot are formed and emitted from gaseous precursors of chemical reactions. Metal vapours and combustion particles makes up fine and ultra-fine particles while road dust, industry and earth crust materials makes up coarse particles. Positive relationship has also been established between air pollution in urban area and respiratory symptoms in infant. PM can affect lung development in children and teenagers negatively as reported by [8]. It has been reported that exposure to air pollution over eight years causes remarkable shortfalls to respiratory system development and hence causing lung function deficits after ten years. PM has also been remarkably related to causing of asthma, wheezing, bronchitis and lower respiratory tract symptoms as well as morbidity and mortality due to pneumonia, pulmonary emboli and COPD [9]. Globally, WHO has published that 3.1 million deaths are caused annually by particulate matter because; largest part of the world's population is exposed to it [10]. Histological examination of the lung tissues from animals exposed to saw dust showed some degree of inflammatory changes [11]. PM that falls under their own weight of gravity deposits by sedimentation while diffusion deposits smallest particles as they are transferred by random gas motion and it primarily occurs in minute airways and gas exchange regions of the lung. A thin liquid layer (ELF) lined the respiratory tract; various agents such as antioxidants, lipids and proteins made up the layer [12]. The main component of the ELF is surfactants, which decrease surface tension and displace PM less than 6µm in diameter [13]. Also proteins in the surfactant help macrophages target and clear PM (Kendall *et al.*, 2002). Hence, lung phagocytes are the first line of guard in the cellular response of the lungs to inhaled PM [14]. While human lung parenchyma retains PM_{2.5}, particles larger than 6µm only reach the proximal airways, where they are eliminated by mucociliary clearance if the airway mucosa is intact. The alveolar macrophages (AM) and bronchial alveolar epithelial cells are the principle cells that process inhaled airborne particles in the lung. They generate pro-inflammatory mediators that have the capability to stimulate both a local inflammatory response in the lung tissues and also a systemic inflammatory response [15]; [16]. The use of blood examination as a way of assessing the health status of animals has been documented [17]; [18] [19]. This is because it plays a vital role in physiological, nutritional and pathological status of organisms [17]. They range from giving the level of the blood to detecting ailments or disorders through them. Blood examination has its tangible values in poultry rearing business, e.g. it provides information on the assessment of poultry health such as the items on traumatic injury, parasitism, organic disease, bacteria septicaemia, nutritional deficiency and also physiological changes in growth with time of broilers [20]. Hematological profiles both in humans and in animal sciences is an important index of the physiological state of the individual. The ability to interpret the state of blood profile in normal and in diseased condition is among its primary tasks. It has been seen by many researches that there is a definite change in the profile of the blood cells throughout life [21]. Not only the blood picture changes with the advancement of the age but it also varies with certain conditions as stress, bacterial infection, viral infection and intoxication. Hematological indices are those parameters that are related to the blood and blood-forming organs [22]. Hematological indices are blood characteristics, which affect both the health and nutritional state of an animal. The nutritional value of a feed stuff could therefore be reflected through parameters such as: white blood cell (WBC), red blood cell (RBC), packed cell volume (PCV), haemoglobin (Hb), mean corpuscular haemoglobin (MCH), lymphocytes and neutrophils.

The full blood count (FBC), sometimes referred to as a full blood examination or complete blood count, is one of the most commonly performed blood tests, as it can tell us so much about the status of our health. It is important for diagnosing conditions in which the number of blood cells is abnormally high or abnormally low, or the cells themselves are abnormal. A full blood count measures the status of a number of different features of the blood, including the amount of haemoglobin in the blood, the number of red blood cells (red cell count), the percentage of blood cells as a proportion of the total blood volume (haematocrit or packed cell volume), the volume of red blood cells (mean cell volume), the average amount of haemoglobin in the red blood cells (known as mean cell haemoglobin), the number of white blood cells (white cell count), the percentages of the different types of white blood cells (leucocyte differential count) and the number of platelets. Red blood cell is erythrocyte which specializes in transportation of oxygen due to the presence of haemoglobin within the erythrocytes which also contributes to red coloration of the blood. Red cell count is an estimation of the number of red blood cells per litre of blood. Abnormally low numbers of red blood cells may indicate anaemia as a result of blood loss, bone marrow failure and malnutrition such as iron deficiency, over-hydration, or mechanical damage to red blood cells. Abnormally high numbers of red blood cells may indicate congenital heart disease, some lung diseases,

dehydration, kidney disease or polycythaemia vera. Haemoglobin is the respiratory pigment in the blood that carries oxygen. Its concentration in an animal system is in proportion of the animal to sustained muscular activities or ability to meet demand for sudden burst of speed [23]. Haemoglobin molecule consist photoporphyrin, native globulin and ferrous iron. The iron content is 3.35mg/g of haemoglobin. This implies that haemoglobin is an iron containing compound found in the red blood cells, which transports oxygen around the body. Measuring the concentration of haemoglobin in the blood can help diagnose anaemia, a condition caused by a deficiency of haemoglobin. This measurement may also detect abnormally high concentrations of haemoglobin. This may occur in higher animals with chronic lung disease, as an adaptation to high altitudes, or because of an abnormal increase in red cell production by the bone marrow (polycythaemia vera). Packed Cell Volume is derived from the red blood cell [24]. Anaemia is reflected when the mean ratio of red cell in fluid is below normal in the blood or when there is a fall in packed cell volume below the minimum range of the wide species study. Haemo-concentration is the opposite of anaemia which results when packed cell volume exceeds the maximum of the normal range, although decrease of fluid could arise as a result of lowered intake of water or excess loss of water, thereby increasing red blood concentration [25]. Mean cell volume is the expression of the average volume of individual erythrocytes (red blood cells). It is useful for determining the type of anaemia an animal might have [26]. Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration, are further guides to the investigation of anaemia. The MCH is the haemoglobin content of the average red cell. The MCHC is the average haemoglobin concentration in a given volume of packed red cells. The MCH may be low in types of anaemia where the red blood cells are abnormally small or high in other types of anaemia where the red blood cells are enlarged. The MCHC is low in iron deficiency, blood loss, pregnancy and anaemia caused by chronic disease. White blood cell is an intrinsic body defense system. They are produced in the bone marrow and carried in the blood stream. A low level of white blood cell in the blood could be as a result of no disease condition or low production from bone marrow [27]. According to [28], leucocyte differential count provides an estimate of the numbers of the 5 main types of white blood cells; these are: neutrophils, monocytes, lymphocytes, eosinophils, and basophils. Each of the 5 types has a specific role in the body [29]. Hence this study was designed to investigate the effect of environmental dust pollution (sawdust) on haematological parameters and histological examination of the lungs of animal exposed to saw dust as well as measurement of particulate dust concentration in sawmills as an index of degree of exposure.

MATERIALS AND METHOD

Experimental Animals

Thirty adult male albino rats weighing (160-200g) were purchased from the faculty of pharmacy animal house, University of Benin, Benin city and they were fed with grower mash which was purchased from Uselu market and provided with clean water. Animals acclimatized for two weeks before being grouped and taken to the experimental cage designed for the study.

Experimental Design

The animals were grouped into two groups (A, and B) with group A serving as the experimental group and group B serving as control respectively. Group A was put in sawmill, while Group B was placed distance away (3KM) from sawmill where there is no exposure to saw dust. Exposure to saw dust was enhanced by placing the animals in an enclosed animal cage surrounded with wire gauge beside the sawing machine for ninety (90) days; all animals were fed with grower mash and clean water throughout the experimental period and treated in accordance with the guide for the care and use of Laboratory Animals.

Sacrificing of Animals

On completion of the 90 days of the experiment, both groups of rats were sacrificed after anaesthetizing with chloroform. This was done by placing each group of rats in different containers, having cotton wool soaked with chloroform and covered for five minutes. Thereafter each rat from each group was brought out and incision made on them using a dissecting set. Blood was withdrawn from the abdominal aorta using a 5ml sterile syringe (one each for all the rats) and released into an EDTA and plain sample container. They were labeled appropriately and subsequently taken for analysis at the hematological department of the University of Benin Teaching Hospital (UBTH) for the various hematological parameters.

Hematological Analysis

Blood samples from the control and experimental animals were taken for hematological analysis. The number of the different blood cells was counted and recorded electronically [30]. Packed cell volume, White blood cell count, Red blood cell count, Hemoglobin concentration, platelet count, mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration of each sample were determined by using standard laboratory procedures at the University of Benin Teaching Hospital.

Histological Examination of the Lung of Experimental Animals

The histological examination of both the experimental and control groups (Wistar rats) was carried out. In order to study tissues with a microscope they were preserved (fixed) and cut into sections thin enough to be translucent. Following fixation, blocks of tissue was cut into thin sections. Sections 3 to 10 microns (3 to 10 thousandths of a millimeter) in thickness were cut on steel knives mounted in an instrument called a microtome, which has a precise mechanical advance. The sections were considerably less than one ten-thousandth of a millimeter (0.1 micron, μm) thick. This was accomplished by embedding the tissue in a plastic such as Epson or araldite (epoxy resins) and cutting on special ultra-microtomes equipped with a fine mechanical or thermal advance. Sections were cut with glass or diamond

knives and mounted on copper mesh grids. The lung tissue sections for general tissue structure were stained by Hematoxylin plus Eosin technique. The slides were examined under a light microscope and photomicrographs were taken.

Quantification of Dust

This was carried out from randomly selected work place using the calibrated dust collection apparatus known as Casella micro product monitor. The particulate matter was collected using Casella Cel-712 Micro dust Pro Real-time Dust Monitor with polyurethane foam (PUF) and a glass fiber filter (GFF).

Sample Collection

The fine particulate matter (PM_{2.5}) was collected using Casella Cel-712 Micro-dust Pro Real-time Dust Monitor with polyurethane foam (PUF) and a glass fiber filter (GFF). The sampler was placed at heights of 1.5 m above ground level and within the human breathing zone. The glass fiber filter (GFF) was used to collect the fine particulate matter. The sampler was connected to a pump with a flow rate of 2 L/min for a sampling period of 8 hours/day. A size selective polyurethane foam (PUF) fixed in the sampler probe served as a collecting medium and a glass fiber filter also fitted in the probe collected PM_{2.5} screened through the PUF as described by [31]. Meteorological parameters such as humidity and temperature were simultaneously measured using thermo-hygrometer during the period of sampling. At the end of each sampling day, samples were carefully wrapped in a polyethene bag and kept in a plastic container to avoid contamination prior to measurement.

Statistical Analysis

Data were entered into the Microsoft excel spread sheet (version 10) prior to descriptive analysis. The data were represented as mean ± SEM. The data were analyzed using the paired sample students't-test and Duncan's multiple range analyses of variance, ANOVA (p<0.05) and correlation analyses were done using the Pearson's correlation (p=0.05), Graph pad prism, Version 5.0.

RESULTS

Parameters Of Dust Extracted From Sawmill, Over An Eight (8) Hour Work Period:

Particulate Matter (PM) 2.5 Average Value=2.296mg/m³

PM10 Average Value=2.168mg/m³

Control Site; (Pure Water Factory)

PM_{2.5} Average Value=0.012mg/m³

PM10 Average Value=0.153mg/m³

Values of Particulate Matter (PM) Of Dust Extracted from Experimental and Control Site

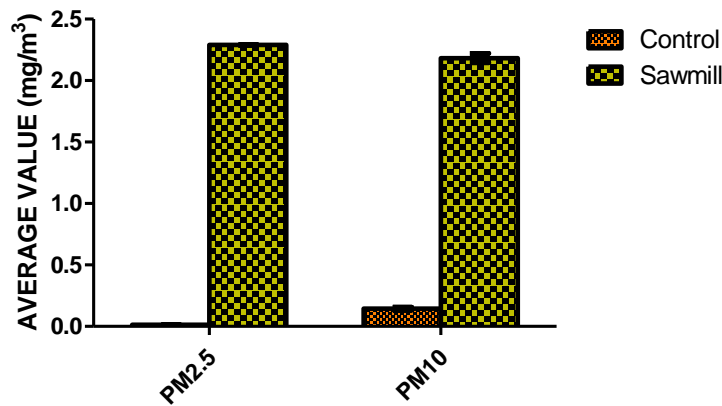


Figure 1: Value of Particulate

Matter of Dust from Control and Experimental Sites.

The result is presented as Mean ±SEM. This result shows that there is significant increase (p<0.05) in PM_{2.5} and PM₁₀ of experimental site compared with control.

Hematological Parameters of Adult Wistar Rats exposed to Sawdust compared with Control.

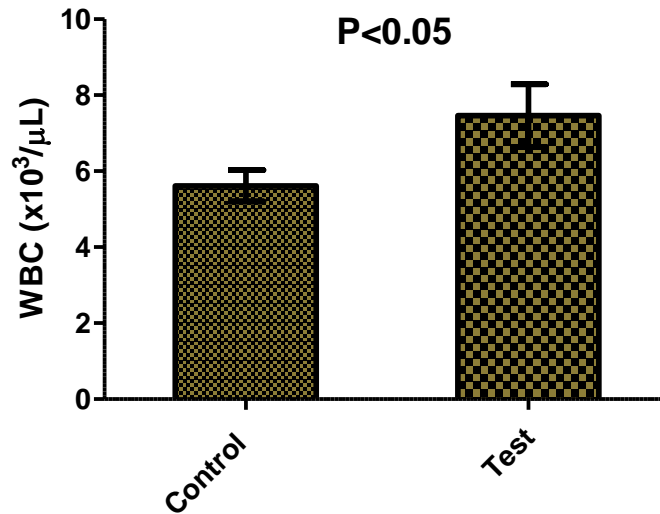


Figure 2: Total White Blood Cell Count (TWBC) of Rats Exposed to Sawdust compared with Control. This result indicates that, there was significant increase ($P<0.05$), in the Total white blood cell count of rats exposed to dust compared with control.

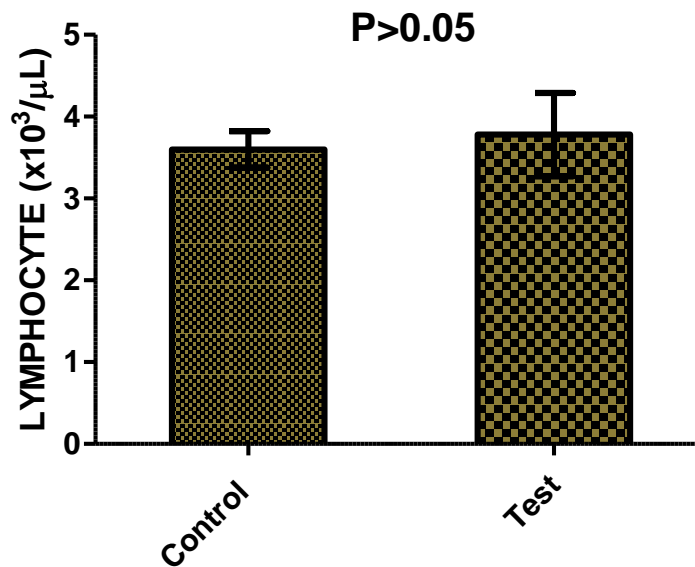


Figure 3: Lymphocytes Count of Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates that, there was no significant difference ($P>0.05$), in the lymphocyte count of rats exposed to dust when compared with control.

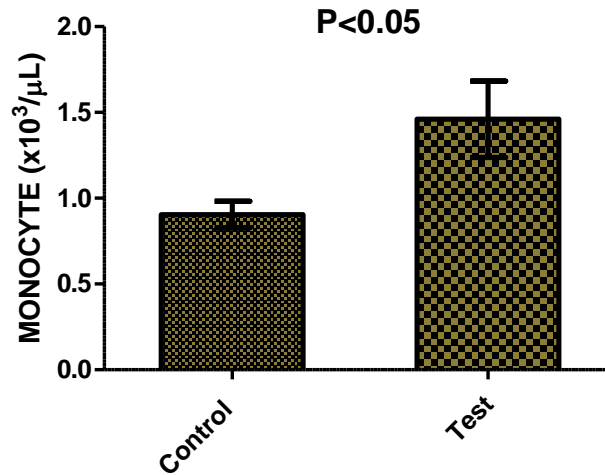


Figure 4: Monocytes Count of Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates that, there was significant increase ($P < 0.05$), in the monocytes count of rat exposed to dust when compared with control.

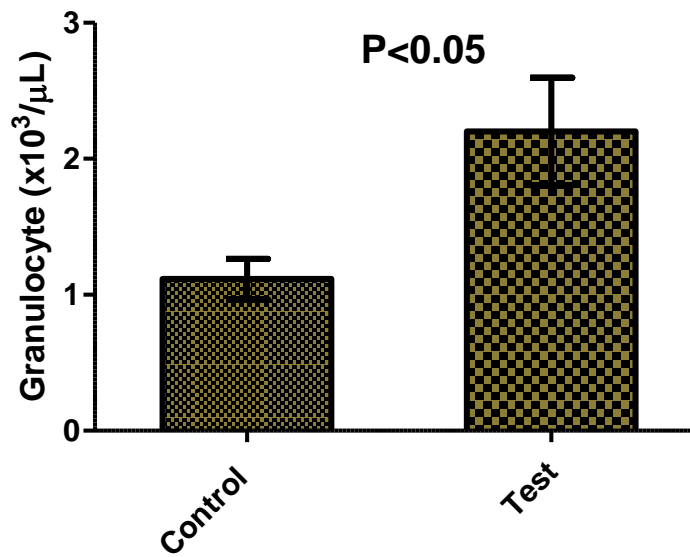


Figure 5: Granulocyte Count of Adult Wistar Rats Exposed to Sawdust compared with Control. This result indicates significant increase ($P < 0.05$), in the granulocyte count of rat exposed to dust when compared with control.

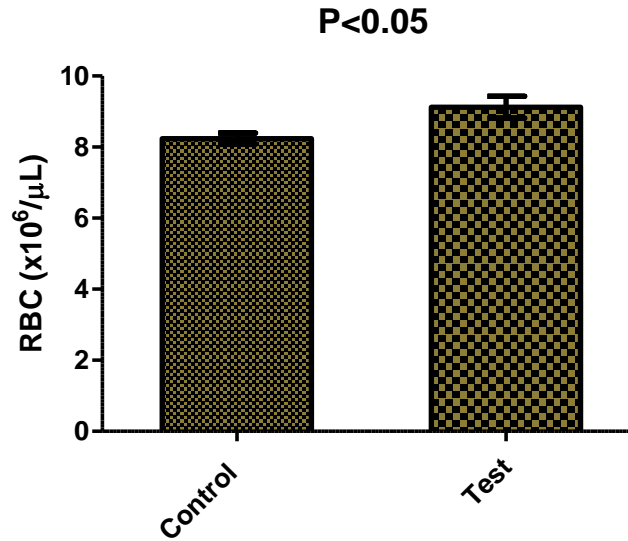


Figure 6: Red Blood Cell Count of Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates significant increase ($P < 0.05$), in the Red blood cell count of rat exposed to dust compared with control.

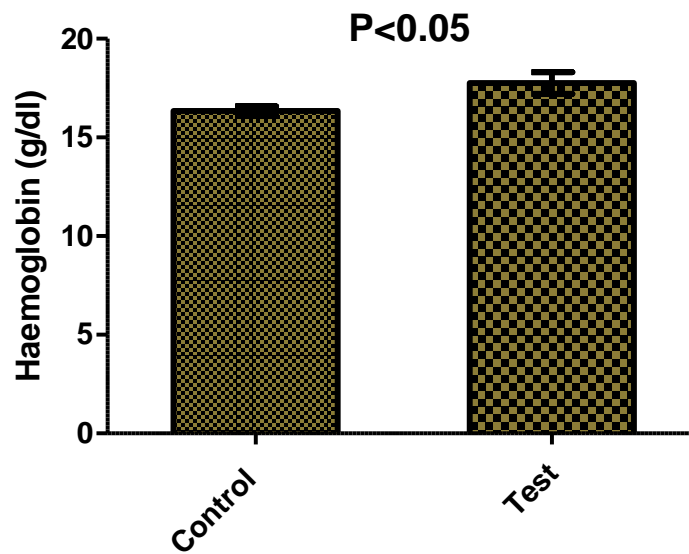


Figure 7: Haemoglobin Concentration of Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates significant increase ($P < 0.05$) in haemoglobin concentration of rat exposed to dust compared with control.

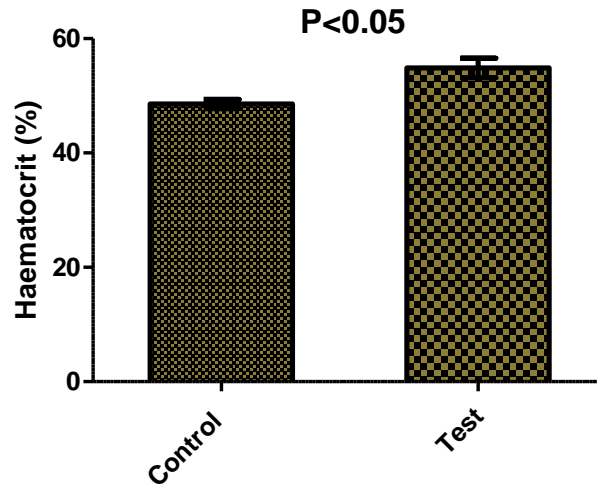


Figure 8: Percentage Haematocrit Concentration of Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates significant increase ($p < 0.05$) in the haematocrit count of rat exposed to dust compared with control.

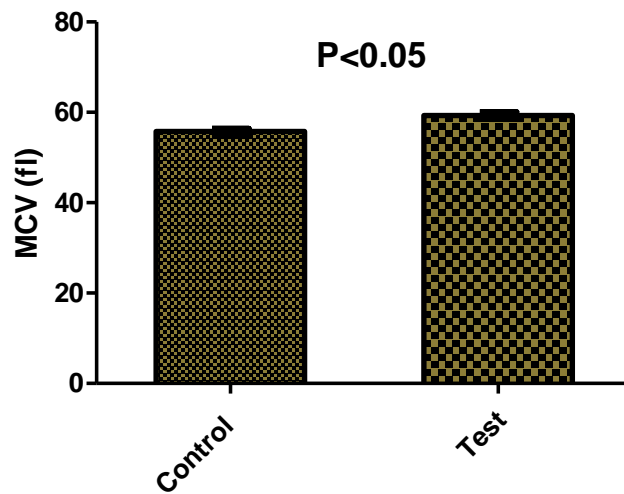


Figure 9: Mean Cell Haemoglobin Volume (MCV), Adult Wistar Rats Exposed to Sawdust compared with Control. The result indicates significant increase ($P < 0.05$) in the MCV of rat exposed to dust compared with control.

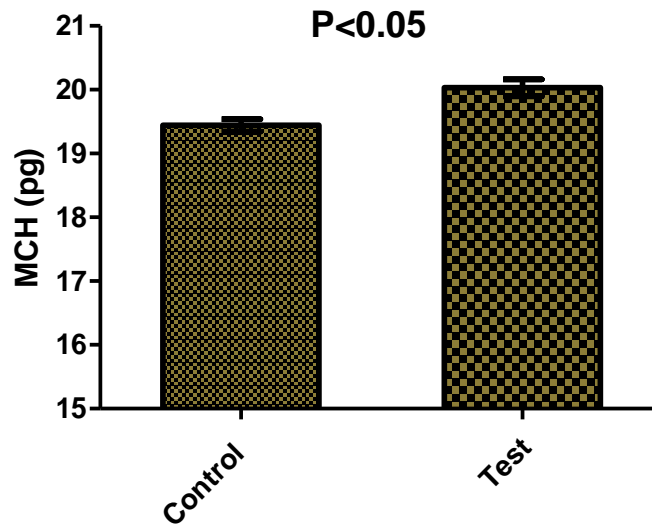


Figure 10: Mean Cell Haemoglobin of Adult Wistar Rats Exposed to Sawdust compared with Control. This result indicates significant increase ($P < 0.05$) in the MCH of rat exposed to dust compared with control.

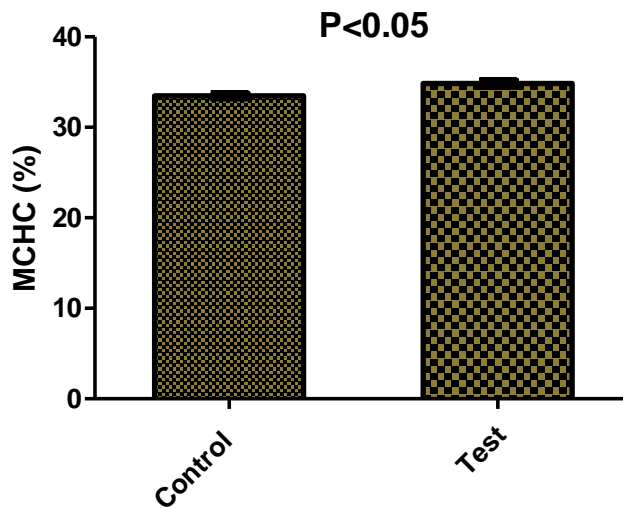


Figure 11: Mean Cell Haemoglobin Concentration (MCHC) of Adult Wistar Rats Exposed to Sawdust compared with Control. This result indicates significant increase ($P < 0.05$) in the mean corpuscular haemoglobin concentration of rat exposed to dust compared with control.

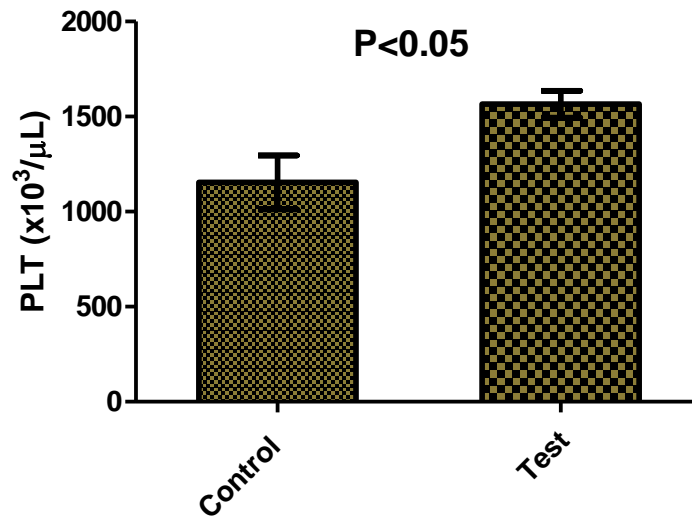


Figure 12: Shows the result of Platelet Count of Rats exposed to Saw dust and Control at $P < 0.05$. The result indicates significant increase in the Platelet count of rat exposed to dust compared with control ($P < 0.05$).

Table 1: Showing the correlation matrix of the heavy metals and the red blood cell indices.

	Lead	Cadmium	Chromium	RBC	Hgb (mg/dl)	HCT (%)
RBC	$r = -0.018,$ $P > 0.05$	$r = -0.017,$ $P > 0.05$	$r = 0.029,$ $P > 0.05$		$r = 0.6078,$ $P < 0.05$	$r = 0.716,$ $P < 0.05$
Hgb (mg/dl)	$r = -0.115,$ $P > 0.05$	$r = -0.295,$ $P > 0.05$	$r = -0.280,$ $P > 0.05$	$r = 0.6079,$ $P < 0.05$		$r = 0.605,$ $P < 0.05$
Haematocrit (%)	$r = 0.360,$ $P > 0.05$	$r = 0.331,$ $P > 0.05$	$r = 0.289,$ $P > 0.05$	$r = 0.7166,$ $P < 0.05$	$r = 0.6052,$ $P < 0.05$	
MCV (fl)	$r = 0.339,$ $P > 0.05$	$r = 0.321,$ $P > 0.05$	$r = 0.295,$ $P > 0.05$	$r = -0.5085,$ $P < 0.05$	$r = -0.117,$ $P > 0.05$	$r = 0.1739,$ $P > 0.05$
MCH (pg)	$r = -0.158,$ $P < 0.05$	$r = -0.402,$ $P < 0.05$	$r = -0.363,$ $P < 0.05$	$r = -0.2949,$ $P > 0.05$	$r = 0.554,$ $P < 0.05$	$r = -0.0676,$ $P > 0.05$
MCHC (mg/dl)	$r = -0.474,$ $P < 0.05$	$r = -0.660,$ $P < 0.05$	$r = -0.598,$ $P < 0.05$	$r = 0.0688,$ $P > 0.05$	$r = 0.6519,$ $P < 0.05$	$r = -0.2048,$ $P > 0.05$

The result shows negative correlation between heavy metals and hematological parameters, however not statistically significant.

Histological Examination of the Lungs

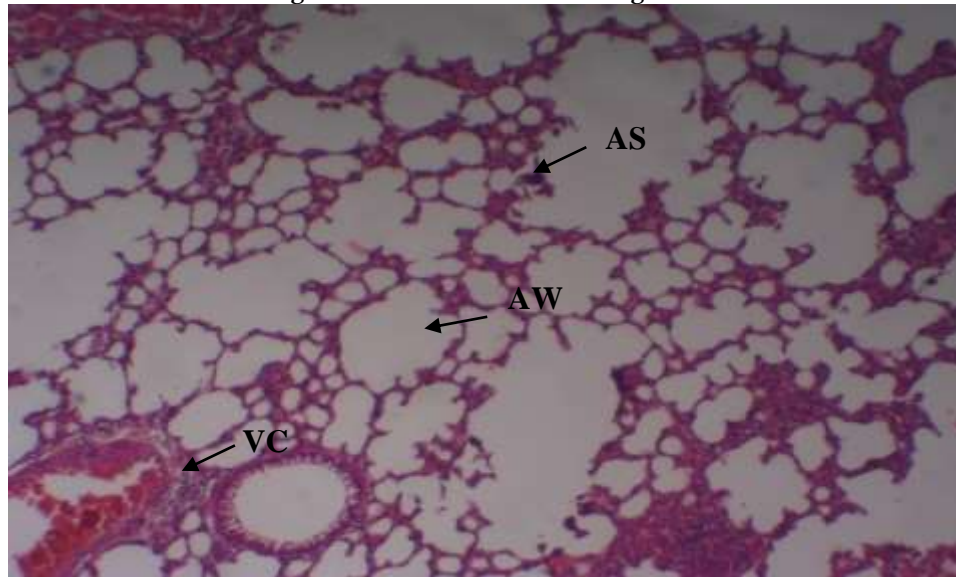


Figure 13: Micrograph of lungs of control rats showing Alveolar space (AS), Alveolar wall (AW), vascular congestion (VC) H&E x 400.

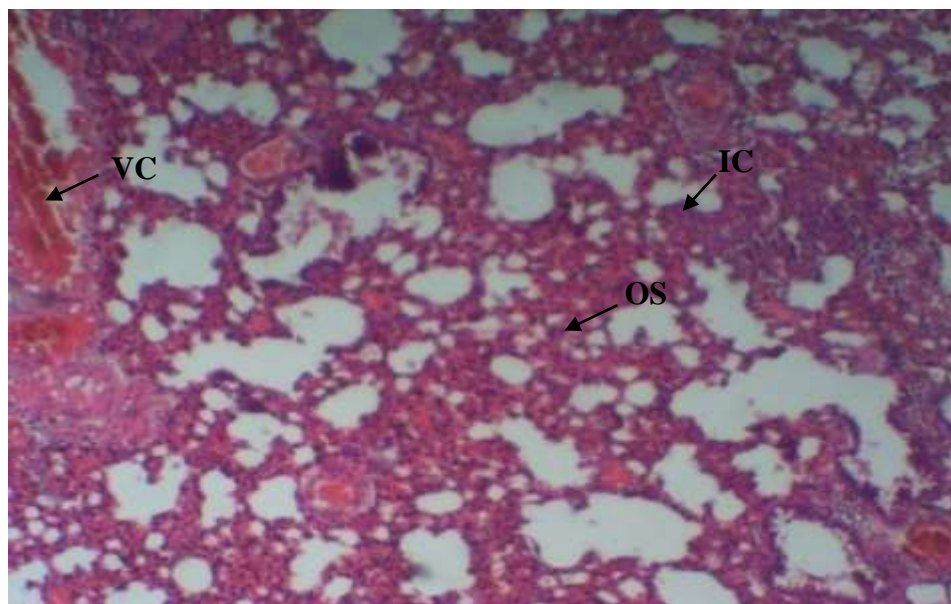


Figure 14: Micrograph of lungs of male rats exposed to dust showing obliterated alveolar space (OS), Alveolar wall (AW), hyperplasia of the alveolar wall (HP), vascular congestion (VC), infiltrates of inflammatory cells (IC) H&E x 400.

DISCUSSION

The major challenge to human health is environmental dust pollution, being a leading cause of respiratory diseases [32]. The concentration of dust particles, (Inhalable and Respirable particles), in the study site was significantly higher than that of the control site. This value far outweighs the recommended $1\text{mg}/\text{m}^3$ safety limit documented by the European Union scientific committee on occupational exposure limit and American conference of Governmental industrial hygienist threshold limit value committee. Similar observation was also documented by [33]; [34]. This increase could be attributed to absence of dust control device within sawmill. Furthermore the preferential significant increase in respirable particles ($\text{PM}_{2.5}$) compared with the inhalable particles (PM_{10}), could be attributed to the size and weight of the particulate matter. The heavier PM_{10} settles faster to the ground than the lighter $\text{PM}_{2.5}$, and as such are not fully captured by the gravimetric air sampler, which measures air borne dust. $\text{PM}_{2.5}$ has been implicated as the deadliest form of particulate matter [35] being able to travel faster and deeper into the respiratory tract. They excite inflammatory reactions which result in manifestations of symptoms that may resolve over time with eventual remodeling of the respiratory tract. Histological findings from this study have shown features of inflammations; these features include obliterated alveolar space, hyperplasia of the alveoli wall, vascular congestion as well as infiltration of inflammatory cells into the alveoli spaces as shown by the micrograph (Fig.13-14). Similar observation was also documented by [11] and

[36], who worked on rats exposed to cement dust. These observations are evidences that sawdust is deleterious to respiratory system.

Also the increase in white blood count (Fig.2-4), granulocyte count (Fig.5) observed in this study postulates inflammatory reaction. These inflammatory reactions may be due to the effect of dust particles lodged within the respiratory tract and the toxic effect of heavy metals on the lungs. Thus the combine effect of these two results in tissue degeneration, as marked on the tissue micrograph of the lung of the rats. Similar observation was seen in the work done by [37]. However the lymphocyte count was not statistically significant. This could be attributed to the duration of exposure of the rats in this study. A similar observation was seen by [38] and [11], who studied the effect of exposure of rats to cement dust, and reported inflammatory changes.

There was also observable increase in red cell indices which include, Red blood cell count (Fig.6), Haemoglobin concentration (Fig.7), Packed cell volume (Fig.8). This agrees with the work done by [39]. But however contrary to the views of [40]; [41]; [11]; [42] who reported a decrease in haematocrit as a result of hemolysis. This increase in red cell indices which include, Red blood cell count, Haemoglobin concentration, packed cell volume could be adaptive responses to tissue hypoxia caused by toxic effect of the heavy metals on the lungs, which results in degeneration of the alveoli cells. Heavy metals have been implicated in the degeneration of the alveoli cells. It has been documented that, Lead and chromium exert its effect by producing reactive oxygen species which destroys cell membrane [43] and [44], including red blood cells. However the concomitant destruction of red cells and alveoli cells, results in tissue hypoxia. This stimulates erythropoietin production, which results in increase proliferation of red cells, haemoglobin synthesis, and subsequent increase in packed cell volume observed in this study.

Also observed in this study were increases in MCV (Fig.9), which is due to excessive stimulation by erythropoietin on the bone marrow. The increase in MCH (Fig.10) and MCHC (Fig.11), are evidences of structural damage to red cell membrane due to increase proliferation of red cells, caused by teratogenic, carcinogenic and mutagenic effect of heavy metals on the bone marrow [45], which is also in part responsible for the hypoxic proliferation of red blood cells from the bone marrow.

Also observed in this study is significant increase in platelet count ($P < 0.05$). This is contrary to the findings of [43]. The increases in platelet count are evidences of tissue destruction and inflammation.

CONCLUSION

This study has established that long term exposure to sawdust can result in lung defect as well changes in level of hematological parameters in the body. The effect of particulate matter of sawdust on the lungs is multifactorial, involving several factors acting synergistically to excite immune responses, which often present as symptoms typical of obstructive defect. From this study, exposure to sawdust caused significant increases in white blood cells ($p < 0.05$), monocyte count, granulocyte count, red blood cells, packed cell volume, mean corpuscular volume, mean cell hemoglobin, mean corpuscular haemoglobin concentration, platelet count but no significant difference ($p > 0.05$) was recorded in level of lymphocyte; this implies that exposure to saw dust has deleterious effect on the body.

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