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Effect of Environmental Dust Pollution (Particulate Matter of Sawdust) on the Serum Heavy Metals of Adult Wistar Rats

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ABSTRACT

Wood dust is released into the atmosphere during processes of wood sawing, sanding, planning, routing etc and is common with carpenters, sawmillers and furniture making companies. A lot of wastes which include, wood off-cuts, sawdust, plain shavings, wood backs, wood rejects among others are produced in sawmills. Wood dust comprises of suspended particulate matters. These Particulate matters are the deadliest form of air pollutants due to their ability to infiltrate deep into the lung and blood stream. This study was done to investigate the effect of environmental dust pollution (particulate matter of sawdust) on Serum Heavy Metals of Adult Wistar rats exposed to sawdust. 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, and Blood for heavy metals. Statistical analysis was done using Graph pad prism, Version 5.0. The results were expressed as mean ± SEM and $P<0.05$ was considered significant. Experimental site: Particulate matter ($PM_{2.5}$) Average value =2.290mg/m^3 ±0.003, PM ($_{10}$) Average value = 2.185mg/m^3 ±0.04, Control site: (Pure water factory) $PM_{2.5}$ Average value = 0.013mg/m^3 ±0.0004, $PM_{(10)}$ Average value= 0.145mg/m^3 ±0.012; Serum cadmium, lead and chromium level were significantly increased ($P<0.05$). In conclusion, sawdust's particulate matter readily pollute the environment, prolonged exposure to it increases serum level of heavy metals.

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]. These substances have been shown to affect human health negatively [2]; [3]; [4]. Although the concentration and persistence of environmental pollution vary from place to place, dust arising from many industrial processes such as sawmills, cement factories, poultries etc. has been shown to be a leading cause of occupational hazard in third world countries due to the particulates released into the atmosphere [5]; [6]; [7]; [8]. Wood dust is released into the atmosphere during processes of wood sawing, sanding, planning, routing etc. [9] and is common with carpenters, sawmillers and furniture making companies. A lot of wastes which include, wood off-cuts, sawdust, plain shavings, wood backs, wood rejects among others are produced in sawmills [10]. The total number of wood work industries in Nigeria accounts 93.32% [11]; [12]; [13]. Dust generated in sawmill easily exceed the safety occupational exposure limit of the United States National Institute of Occupational Health and Safety threshold safety limit level of 5mg/m^3 over an 8hour work period [14]; [15]. 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 [16]. Research has shown that there is a possible usage of sawdust for adsorption of different metal ions [17]. 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 [18]. According to [19], 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. [20], reported an association between continual exposure to wood dust, nasal cancer and asthma. Wood

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dust comprises of suspended particulate matters. These Particulate matters are the deadliest form of air pollutants due to their ability to infiltrate deep into the lung and blood stream. Based on aerodynamic diameter, particulate matters are characterized into inhalable particles (PM between 2.5μm and 10μm), and respirable particles (PM less than 2.5μm) [21]. Woodworking industries produce wood dust as a derivative of industrialized wood products. Dust particles collected from diverse areas have been observed to have broad differences in elemental concentrations of manganese, cobalt, iron, chromium, arsenic and selenium [22]. The toxicity of these metals is due to the fact that, they are not metabolized by the body and thus builds up in soft tissue. There are 23 heavy metals out of 35 metals of residential or occupational exposure hazard and they are; antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc [23]. They are mostly found in the environment and diet and required in small quantity to maintain good health but large quantity can become toxic or dangerous. The heavy metals that usually cause problems in humans are lead, mercury, cadmium, arsenic, nickel and aluminum. These metals tend to accumulate in the brain, kidneys and immune system where they can severely interrupt normal function [24]; [25]. Damage to the brain, lungs, kidney, liver, blood composition and other important organs functions can be as a result of heavy metal toxicity. Exposure for a long period of time can lead to physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy, cancer can even results repeated prolong exposure to some metals and their compounds [26]. Hence this study was designed to investigate the effect of environmental dust pollution (sawdust) on adult Wistar rats using the analysis of selected toxic metals in the particulate matters of dust in the Sawmill and 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 a plain sample container for the analysis of toxic metals (lead, cadmium and chromium).

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 (PM2.5) 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 PM2.5 screened through the PUF as described by [27]. 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 ($p<0.05$) were done using 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/m^3

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PM10 Average Value=2.168mg/m^3
Control Site; (Pure Water Factory):
PM2.5 Average Value=0.012mg/m^3
PM10 Average Value=0.153mg/m^3
Values of Particulate Matter (PM) Of Dust Extracted from Experimental and Control Site

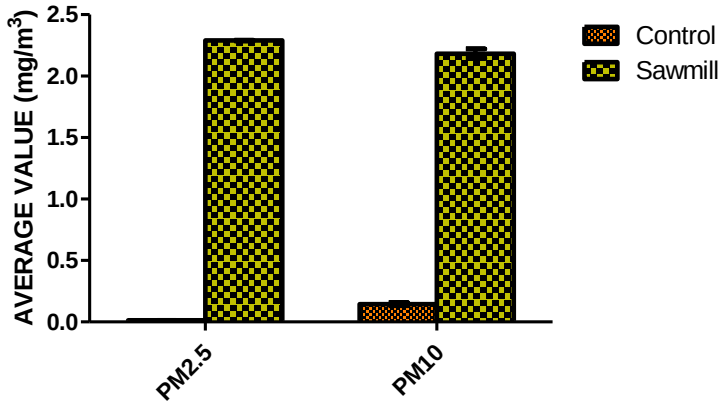

Figure 1: Value of Particulate Matter of Dust from Control and Experimental Sites.
The result is presented as Mean ±SEM. This result shows that there is significant increase ($p<0.05$) in $PM_{2.5}$ and PM_{10} of experimental site compared with control.
Concentration of Heavy Metals in the Particulate Matter ($Pm_{2.5}$) of Dust extracted from the Sawmill compared with Control.

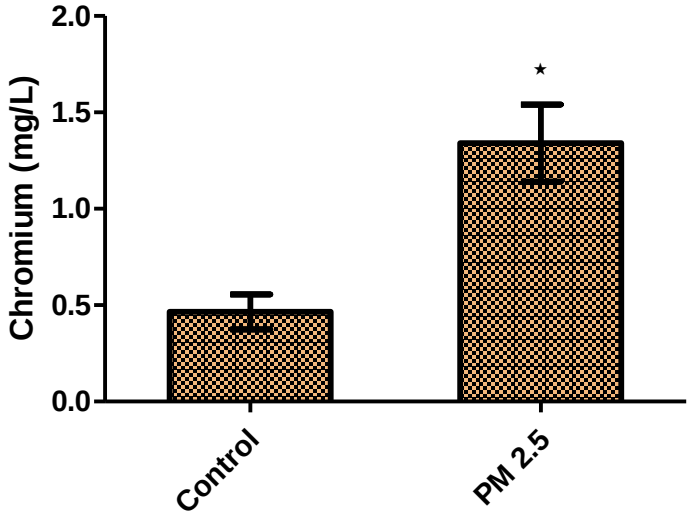

Figure 2**:** Concentration of Chromium in Particulate Matter of Sawdust from Experimental Site, compared with Control**.** This result indicates that there was significant increase ($P<0.05$) in concentration of Chromium in $PM_{2.5}$ compared with control.

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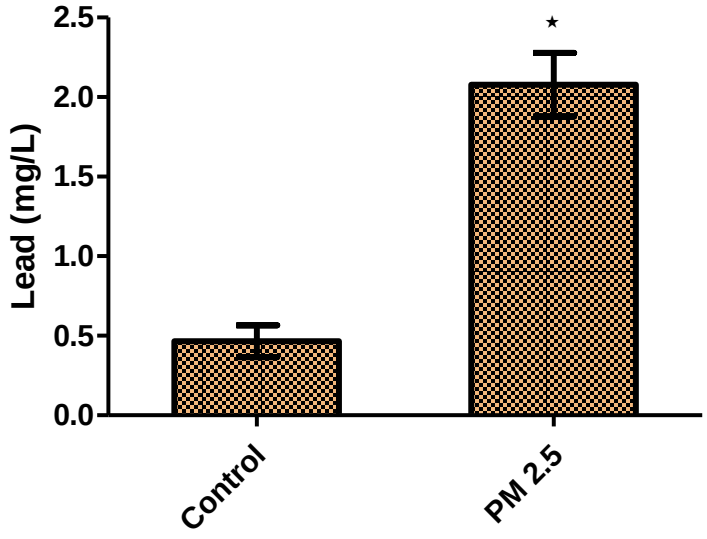

Figure 3: Concentration of Lead in Particulate Matter of Sawdust from Experimental Site compared with Control. This result indicates that there was significant increase ($P<0.05$) in concentration of Lead in $PM_{2.5}$, compared with control.

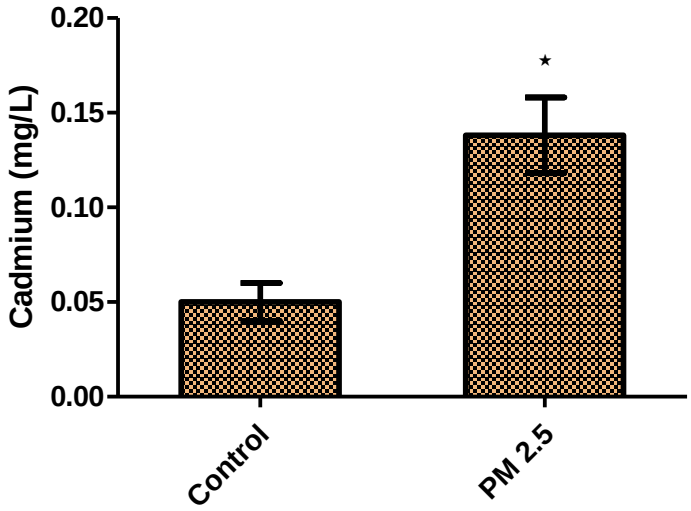

Figure 4: Concentration of Cadmium in Particulate Matter of Sawdust from Experimental Site compared with Control. This result indicates that there was significant increase ($P<0.05$) in the concentration of Cadmium in $PM_{2.5}$, compared with control.

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SERUM CONCENTRATION OF HEAVY METALS OF ADULT WISTAR RATS EXPOSED TO SAWDUST COMPARED WITH CONTROL.

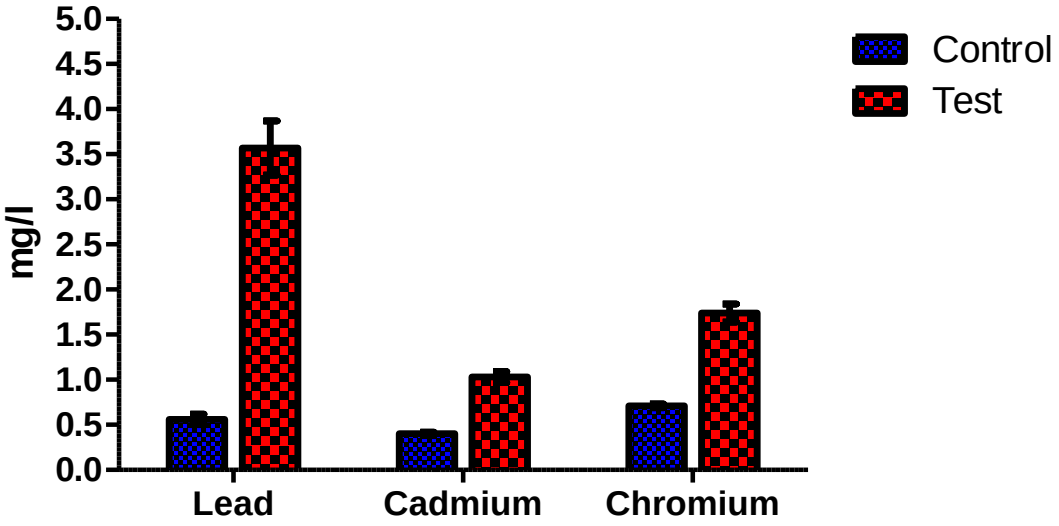

Figure 5: Serum Level of Heavy Metals of Adult Wistar Rats Exposed to Sawdust.

This result indicates that, there was significant increase ($P<0.05$) in the serum level of heavy metals (lead, cadmium and chromium) of rat exposed to saw dust when compare with control.

DISCUSSION

The major challenge to human health is environmental dust pollution, being a leading cause of respiratory diseases [28]. 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 1mg/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 [29]; [30]. This increase could be attributed to absence of dust control device within the Sawmill. Furthermore the preferential significant increase in respirable particles ($PM_{2.5}$) 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 $PM_{2.5}$, and as such are not fully captured by the gravimetric air sampler, which measures air borne dust. $PM_{2.5}$ has been implicated as the deadliest form of particulate matter [31] being able to travel faster and deeper into the respiratory tract.

Results from this study on rats exposed to sawdust have shown significant elevation in heavy metals concentration (Fig. 5), this is in line with the work done by [32]. [33], reported an increase in serum lead concentration of rats exposed to saw dust. Although limited literatures exist on the effect of exposure of animals to saw dust particulate matter and its constituent heavy metals, comparison is therefore made with cement dust. [34] and [35] reported an increase in serum heavy metals concentration of rats exposed to cement dust. Heavy metals have been implicated as the most toxic components of particulate matter and have also been shown to be strong stimulants for teratogenesis, mutagenesis and carcinogenesis [36];[37]. These heavy metals which include lead, chromium and cadmium has also been documented to have deleterious effect on lung functions [38]; [39]; [40]. [41] attribute their toxicity to be due to their non-degradable and bio accumulative properties.

CONCLUSION AND RECOMMENDATION

This study has established that long term exposure to sawdust can result in elevated serum level of heavy metals which is toxic to the human body. This finding have proved that inhalation of sawdust is toxic to both human and animals, hence it is recommended that machine that is able to suck out dust produced during the sawing process be used which will help reduce the amount of dust released into the atmosphere, thus reducing environmental pollution.

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