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Effect of Wood Dust on Serum Heavy Metals and Histology of the Lungs of Adult Male Wistar Rat

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ABSTRACT

Background: Wood dust is a by-product of wood processing containing particles. Heavy metals are defined as elements of high relative atomic mass such as lead, copper, nickel and chromium which play important roles in biological processes such as protection against oxidative damage in cellular respiration, immunity, cell signaling etc. Exposures to high levels of heavy metals have been implicated in acute poisoning and chronic diseases such as lung cancers.

Objectives: The objective of this study was to evaluate the effect of wood dust on Serum heavy metals levels and histology of lungs in adult male Wistar rat.

Methods: Twenty-four (24) adult male Wistar rats weighing between 157-226g were used for this study and randomly grouped into two groups: Control and Exposed (n = 12/group). The exposed group was taken to the furniture factory at least three times in a week. Analysis carried out includes collection of blood for serum heavy metals and histopathological examination of the lungs' tissue. Statistical analysis was done using Graph pad prism (8.1) and values of $P<0.05$ were statistically significant.

Results: There was a significant increase in serum nickel and lead concentration but none in copper concentration while the histological examination showed bronchiolar and interstitial hemorrhage, infiltration of inflammatory cells, vascular stenosis and presence of foreign body giant cells.

Conclusion: It can be deduced from this study that wood dust causes an elevation in serum heavy metals level which results in both immunological and inflammatory responses.

Keywords: Wood dust, Heavy metals, Respiratory System, Lungs.

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INTRODUCTION

Wood is a natural, renewable and highly versatile material of excellent performance that has been commonly used by man since the dawn of history (1). It is also the largest reservoir of sequestered carbon in terrestrial environments. However, its chemical composition and structure make it prone to bio-deterioration and fungi are the main wood degraders (1, 2). It is a by-product of wood processing or wood handling and the sizes of wood dust particles depends on the activity from which they are generated (3). The main components of wood including softwood are cellulose, hemicelluloses and lignin. Some of these components protect against injury or attack from insects, bacteria and fungi, but they may also have toxic, irritant or sensitising effects on humans (4). Wood dust causes lung diseases. High levels of small dust particles that penetrate into the bronchial tubes or smaller airways may produce irritation and bronchitis. Exposure to wood dust has been associated with high prevalence of respiratory symptoms and diseases including irritations of the mucous membranes and nasal airways, chronic and acute deterioration of lung functions, asthma and allergies (6, 7). Additionally, exposure to wood dust is also associated with pathogenic microorganisms such as fungi and bacteria and is said to increase the risk of nasal cancer in most exposed individuals (8).

Carpentry is an occupation that involves the use of woods routinely on daily basis. However, these woods are preserved through the application of certain chemicals, some of which happens to be heavy metals such as chromium, nickel, copper and arsenic; other chemicals include pentachlorophenol and creosote (9, 10). When these woods are processed, the heavy metals together with wood dust are released into the work environment and when this is inhaled or involuntarily ingested over a period, it may result in bioaccumulation of the heavy metals (10). Nwajei and Iwegbue (11) carried out a study to determine the concentrations of some heavy metals (lead, cadmium, chromium, barium, arsenic and mercury) in wood dust particles collected in the environment of sawmill in Sapele and concluded that wood dust particles contained elevated levels of these heavy metals.

Several acute and chronic toxic effects of heavy metals affect different body organs. Gastrointestinal and kidney dysfunction, nervous system disorders, skin lesions, vascular damage, immune system dysfunction, birth defects and cancer are examples of the complications of heavy metals toxic effects (12-15). High-dose of heavy metals exposure, particularly mercury and lead, may induce severe complications such as abdominal colic pain, bloody diarrhea and kidney failure (16, 17). On the other hand, low-dose exposure is a subtle and hidden threat, unless repeated regularly, which may then be diagnosed by its complications e.g., neuropsychiatric disorders including fatigue, anxiety and detrimental impacts on intelligence quotient (IQ) and intellectual function in children (18). Carcinogenic metals such as arsenic, cadmium, and chromium can disrupt DNA synthesis and repair (19, 20). The toxicity and carcinogenicity of heavy metals are dose dependent (21). The toxic mechanism of heavy metals functions in similar pathways is usually via reactive oxygen species (ROS) generation, enzyme inactivation and suppression of the antioxidant defense (21, 22).

The increasing prevalence of respiratory diseases among workers who are exposed to occupational hazards has prompted this study. The respiratory system being easily prone to this hazard by way of inhalation has necessitated the quest to use rat model as a back-up study to confirm the several researches done on humans. Hence, this study was designed to investigate the effects of wood dust on serum heavy metals and histology of the lungs of adult male Wistar rats.

METHODOLOGY

Study Area

This research was conducted in Benin City, Edo State at the animal house of the Department of Anatomy, University of Benin and Furniture Workshop, dept. of Maintenance, University of Benin Teaching Hospital, Benin City, Nigeria. Materials used for this research include: 2000D machine, Weighing balance, Hand gloves, Cotton wool, Syringes, Plain bottles, Choloform, 10% formalin etc.

Experimental Animals

Twenty four (24) adult male Wistar albino rats (Rattus norvegicus) weighing between 157-226g were used for this study. The animals were purchased and maintained in the Animal house of the

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Department of Anatomy, School of Basic Medical Sciences, College of Medical Sciences, University of Benin, Benin City. They were kept in cleaned cages, maintained at room temperature with 12hours light and dark cycle and also allowed free access to drinkable water and rat feed ad libitum. The animals were acclimatized for a period of two weeks to the laboratory conditions prior to the commencement of experiment at the animal house of the Department of Anatomy.

Experimental Design

After two weeks period of acclimatization to laboratory conditions, the rats were randomly grouped into two groups: each group consisting of twelve animals (n=12).

Table 1: Grouping of Experimental Animal

GROUPS	DESIGNATION
Group A	Control Group
Group B	Exposed Group

The control group weight ranges from 140g-150g while the Exposed group weight ranges from 150g-170g. The Exposed group rat was taken to the furniture factory at least three times in a week for exposure to the wood dust and exposed for 8 to 10 hours per exposure (day). Exposure to wood dust was enhanced by placing the animals in an enclosed animal cage surrounded with wire gauge beside the Table saw machine around the furniture workshop with the particles of wood dust inhaled. The weight was checked subsequently at the end of the week.

Duration of the Study

Pre-experimental preparations including; procurement of test animals, cage preparation, initial weighing of test animals and animal acclimatization lasted for two (2) weeks, while the main experiment which include; taking the rat to the furniture factory for at least three times weekly and subsequent weighing for the period of the research. This study was conducted for six weeks including acclimatization period.

Collection of Blood Samples and Serum Heavy Metal Assay

Before sacrifice, the final weights of the rats were taken using compact electric weighing machine scale, after taking their final weights; the rats were put into an enclosed container with cotton wool soaked with about 50ml of chloroform for anesthesia. After anesthetizing, the rats were placed on a dissecting table on a supine position. Abdominal incision was made to expose the abdominal viscera. Thereafter, the blood sample was collected from the inferior vena cava using 5ml syringes. The blood sample was collected into plain bottles and serum heavy metals assay was done using atomic absorption spectrophotometer (Buck 210 VGP).

Histopathological Procedure

The lungs were collected and were placed into a plain container containing 10% formalin. The procedure used was prepared using the method of Avwioro (23) and Baker (24).

Statistical Analysis

The data were expressed as means ± standard error of mean (SEM) with values analyzed for statistical significance by One-way ANOVA using the Graph Pad Prism Statistical Software, version 8.1. Data were statistically significant at $P<0.05$.

RESULTS

The findings from the result showed that wood dust has effect on serum levels of heavy metals as it can be seen from Figures 1 and 3 with a significant increase in their concentrations as well as the histological findings.

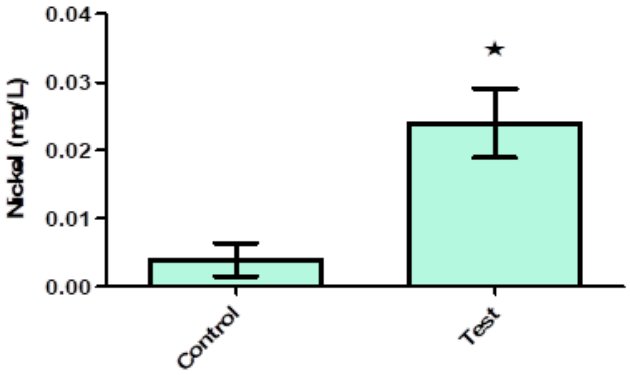


Figure 1. The effects of wood dust on serum Nickel concentration of male Wistar rats.
There was a significant increase in the test group when compared with the control ($P<0.05$).

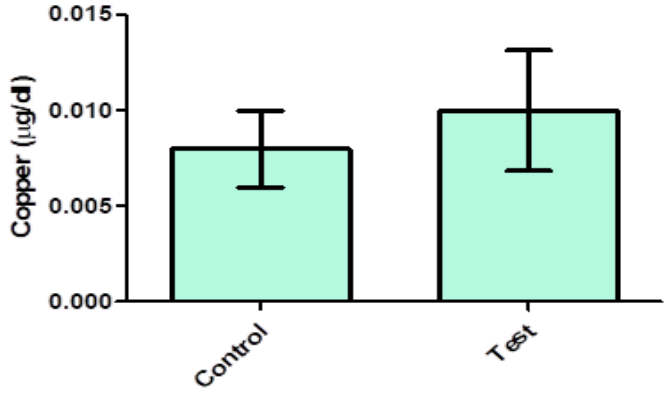


Figure 2. The effects of wood dust on serum Copper concentration of male Wistar rats.
There was no significant difference but a statistical increase in the test group when compared with the control group (*P>0.05*).

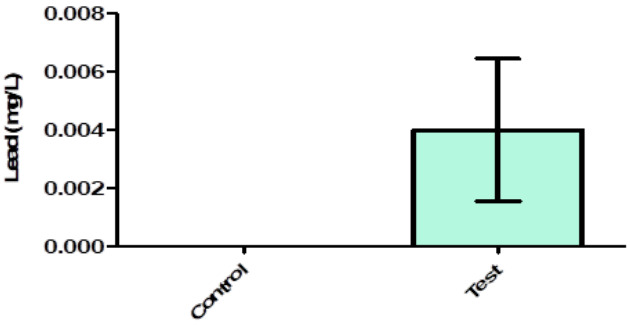


Figure 3. The effects of wood dust on serum Lead concentration of male Wistar rats.
There was a significant increase in the test group when compared with the control group ($P<0.05$).

Histological Examination of the Lungs

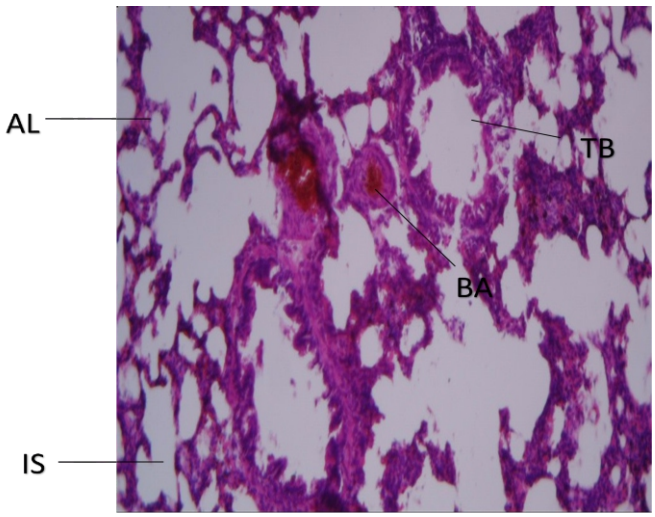


Figure 4. Micrograph of lungs of control rats showed the normal tissue architecture: Alveoli (AL), Bronchiole (TB), Bronchial Artery (BA), Interstitial Space (IS). H&E x 100.

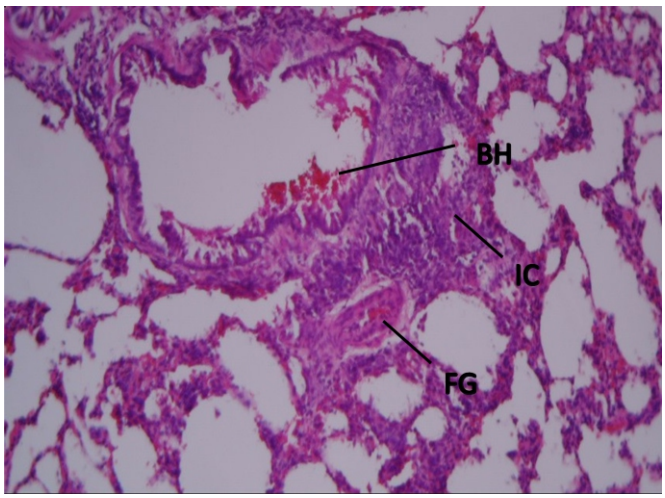


Figure 5. Micrograph of rat lungs exposed to wood dust showed bronchiolar hemorrhage (BH), interstitial infiltrates of inflammatory cells (IC), foreign body giant cell (FG) H&E x 100.

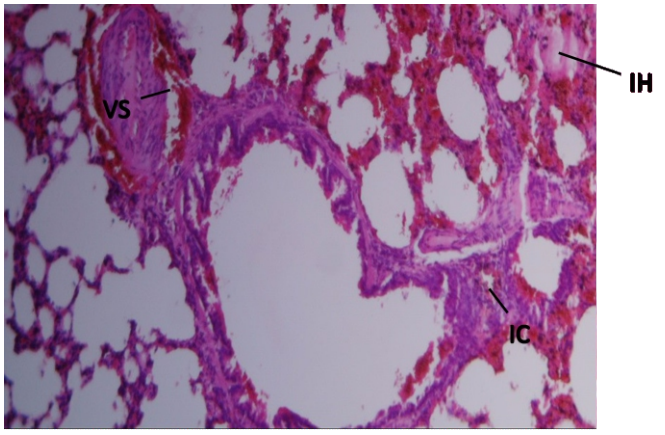


Figure 6. Micrograph of rat lungs exposed to wood dust showed vascular stenosis (VS), interstitial hemorrhage (IH) and inflammatory infiltrates (IC) H&E x 100.

DISCUSSION

The major challenge to human health is environmental dust pollution, being a leading cause of respiratory diseases (25). Exposure to wood dust being one of the contributors to environmental dust pollution in work place has posed a great occupational hazard to different wood workers. From the result, the elevated serum lead and nickel levels in the exposed rats (figure 1 and 3) could be explained by the heavy metal chemicals utilized in the woods as preservatives. As a result of the wood processing, these chemicals may have been inhaled along with wood dust, bio-accumulated and eventually raised the serum levels of these heavy metals. This observation is in consonance with the work done by Nwajei and Iwegbue (11), who observed a similar increase in serum heavy metals of workers in a sawmill in Sapele, Nigeria.

However elevation in serum lead and other heavy metals level has also been documented by Omigie et al. (26) in saw millers exposed to sawdust which can produce both inflammatory and immunological responses by the production of superoxide radicals which can destroy tissues and the presence of foreign body giant cells which further potentiate the effect of wood dust particles. Ibama and Amadi (10) also reported significant higher serum levels of chromium, nickel and arsenic in carpenters exposed to wood dust and concluded that occupational exposure to wood dust may predispose carpenters and other wood workers to heavy metal intoxication.

Also observed in this study was the increase in the mean serum copper level; however the increase was not statistically significant among the rats exposed to wood dust when compared to the control (Figure 2) which may be due to routes of administration/exposure and the duration of exposure has documented by Bánfalvi (27) and ATSDR (28).

The result of the histopathological examination of the lungs of the exposed rats (Figures 4, 5 and 6) revealed the bronchiolar and interstitial hemorrhage, infiltration of inflammatory cells, vascular stenosis and presence of foreign body giant cell suggesting that the exposure to wood dust triggered an inflammatory reaction in the lungs as a result of irritation from breathing in wood dust particles and exposure through the toxicity mechanism of heavy metals (21, 29). The toxicity is as result of ROS generation, weakening of the antioxidant defense, enzyme inactivation and oxidative stress (22). Jarup (30) attributed their toxicity to be due to their non-degradable and bio accumulative properties.

CONCLUSION

It can be deduced from this study that wood dust causes an increase in serum heavy metals level which resulted in both immunological and inflammatory responses. This finding probably have shown that inhalation of sawdust is toxic to animals as a model to humans; hence it is recommended that machine that is able to suck out dust that is produced during the sawing process be used which will help to reduce the amount of dust released into the atmosphere thereby reducing environmental pollution. Further studies can also be done to really ascertain the level of particulate matter and toxicity level of heavy metals in wood dust.

REFERENCES

1. Brischke C, Alfredsen G. Wood-water relationships and their role for wood susceptibility to fungal decay. AMB. 2020;104:3781-3795.
2. Goodell B, Qian Y, Jellison J. Fungal Decay of Wood; Soft Rot – Brown Rot – White Rot. In: Development of Commercial Wood Preservatives, American Chemical Society (ACS Symposium Series); Washington DC, USA. 2008;982:9-31.
3. Deshpande A, Afshan A. Effect of Chronic Exposure of Sawdust in Workers Employed in Sawmills: A Cross-Sectional Study. SJAMS. 2014; 2(4A): 1202-1205.
4. Hagström K, Schlünssen V, Eriksson K. Exposure to Softwood Dust in the Wood Industry. In: de la Guardia M, Armenta S (eds) Comprehensive Analytical Chemistry, Elsevier. 2016;73:801-823.
5. IARC (International Agency for Research on Cancer). A review of human carcinogens, part C: arsenic, metals, fibres and dusts. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Lyon, France. 2012; 100.
6. Douwes J, McLean D, Slater TP. Respiratory Symptoms in New Zealand Pine Processing Sawmill Workers. AJIM 2001; 39(6): 608–615.
7. Estlander T, Jolanki R, Alanko K, Kanerva L. Occupational allergic contact dermatitis caused by wood dusts. CD. 2001; 44:213–217.
8. Baran S, Teul I. Wood dust: an occupational hazard which increases the risk of respiratory disease. JPP. 2007; 585(1):43–50.
9. North Carolina Department of Labor (NCDL). A Guide to Occupational Exposure to Wood, Wood Dust and Combustible Dust Hazards. Retrieved from http://www.nclabor.com/osha/etta/indguide/ig19.pdf. 2012. Accessed July 29, 2023.
10. Ibama O, Amadi FC. Assessment of Serum Levels of Some Heavy Metals in Carpenters Residing in Port-Harcourt in Relation to their Lifestyle. AJRIMPS, 2018;4(4): 1-7.
11. Nwajei GE, Iwegbue CMA. Trace Elements in Sawdust Particles in the Vicinity of Sawmill in Sapele, Nigeria. PJBS. 2007; 10:4311-4314.
12. Fernandes Azevedo B, Barros Furieri L, Peçanha FM, Wiggers GA, Frizera Vassallo P, Ronacher Simões M. Toxic effects of mercury on the cardiovascular and central nervous systems. BioMed Res Intern. 2012;2012:1-11.
13. Cobbina SJ, Chen Y, Zhou Z, Wu X, Zhao T, Zhang Z. Toxicity assessment due to sub-chronic exposure to individual and mixtures of four toxic heavy metals. JHM. 2015; 294: 109–120.
14. Costa M. Review of arsenic toxicity, speciation and poly-adenylation of canonical histones. TAP. 2019; 375:1–4.
15. Gazwi HSS, Yassien EE, Hassan HM. Mitigation of lead neurotoxicity by the ethanolic extract of *Laurus* leaf in rats. EES. 2020; 192: 110297.
16. Bernhoft RA. Mercury toxicity and treatment: a review of the literature. JEPH 2012;10: 1155.
17. Tsai MT, Huang SY, Cheng SY. Lead poisoning can be easily misdiagnosed as acute porphyria and nonspecific abdominal pain: Case reports in emergency medicine 2017. CREM. 2017;2: 1–4.
18. Mazumdar M, Bellinger DC, Gregas M, Abanilla K, Bacic J, Needleman HL. Low-level environmental lead exposure in childhood and adult intellectual function: a follow-up study. EH. 2011;10(1): 24.
19. Clancy HA, Sun H, Passantino L, Kluz T, Muñoz A, Zavadil J, et al. Gene expression changes in human lung cells exposed to arsenic, chromium, nickel or vanadium indicate the first steps in cancer. Met. 2012;4(8): 784–793.
20. Koedrith P, Kim H, Weon JI, Seo YR. Toxicogenomic approaches for understanding molecular mechanisms of heavy metal mutagenicity and carcinogenicity. IJHEH. 2013;216(5): 587–598.
21. Gorini F, Muratori F, Morales MA. The role of heavy metal pollution in neurobehavioral disorders: a focus on autism. Rev. J. Autism Dev. Disord. 2014;1(4):354–372.
22. Balali-Mood M, Naseri K, Tahergorabi Z, Khazdair MR, Sadeghi M. Toxic Mechanisms of Five Heavy Metals: Mercury, Lead, Chromium, Cadmium and Arsenic. FP. 2021;12: 1-19.
23. Avwioro G. Histochemical Uses Of Haematoxylin - A Review. JPCS 2011;1: 24-34.
24. Baker JR. Experiments on the Action of Mordants; Aluminium-haematein. QJMS. 1962;103: 493-517.
25. Iyawe VI, Ebomoyi MI. Current developments in the physiology and Smoking and lung function in sawmill workers in management of asthma. NJPS. 2005;20: 19–29.
26. Omigie MI, Iyawe VI, Agoreyo FO, Omorogiuwa A. Effect of Sawdust on Serum Heavy Metals of Sawmillers exposed to Sawdust. ECRTD. In Press.
27. Bánfalvi G. Heavy metals, Trace Elements and their cellular Effects. Banfalvi, G (ed.) Cellular Effects of Heavy Metals, Springer 2011;3.
28. ATSDR (Agency for Toxic Substances and Disease Registry). Toxicological Profile for Copper. U.S Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia; stacks.cdc.gov 2004; 1.
29. Hertland RB, Myhre O, Lag M, Hongve D, Schwarze PE, Refsnes M. Importance of soluble metals and reactive oxygen species for cytokine release induced by Mineral particles. Toxicol. 2001;165: 133-144.
30. Jarup L. Cadmium overload and toxicity. NDT. 2002; 17(2): 35-39.