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RESEACH ARTICLE

COMPARATIVE HISTOMORPHORLOGICAL ANALYSIS OF LUNG AND TRACHEAL ALTERATIONS DUE TO PARTICULATE MATTER EXPOSURE IN RURAL AND URBAN *COLUMBIDAE*

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Abstract

Air pollution is regarded as a major global problem, in both developed and developing countries. There has been an increase in urbanization due to higher activities in transportation and industrialization. This research aims to identify structural changes in airways of *Columbidae* and establish potential relationships between particulate matter exposure and respiratory health. **Methods:** A total of 12 pigeons (6 from urban areas and 6 from rural regions) were humanely euthanized using ketamine hydrochloride (50 mg/kg BW) under approved ethical protocols. Immediately following euthanasia, the birds were placed in dorsal recumbency and de-feathered lung and tracheal tissues were carefully extracted. The weight, length, and width of the lungs were measured morphometrically. Standard histological procedures, such as sectioning, fixation in formalin, and staining in hematoxylin and eosin (H&E) for microscopic inspection, were used to prepare tissue samples. To evaluate structural variations between urban and rural pigeons, the histological features were examined. Data from these measurements were statistically compared between the urban and rural groups to determine the significance of the observed differences related to particulate matter exposure. **Results:** The findings revealed that urban *Columbidae* shows tracheal chondrocytes necrosis, indicated by presence of empty lacunae, suggesting structural alterations while the rural *Columbidae* have intact tracheal architecture. Also, the lung tissues of urban *Columbidae* showed numerous nucleated cells, which are indicative of an inflammatory response to particulate matter exposure suggesting a higher level of air pollution exposure compared to their rural counterparts. **Conclusion:** This study revealed that the urban group of *Columbidae* had ingested carbon particles through their macrophages as seen in the lung parenchyma histologically In contrast the lungs and trachea of the rural group of *Columbidae* seemed to be relatively clean as compared to it's urban counterpart, highlighting the more pronounced impact of air pollution in urban communities.

Keywords; *Columbidae*, Particulate Matter, air pollution

INTRODUCTION

Air pollution is regarded as a major global problem, in both developed and developing countries. This issue has been receiving much attention because both in developed and developing countries there is an increase in wide range of diseases related to short- and long-term exposure to air pollution (WHO, 2016; Cohen *et al*., 2017).

Air pollution poses a significant risk to public health, particularly through its association with respiratory diseases; asthma, chronic obstructive pulmonary disease and lung cancer (Pope & Dockery, 2006). Urban areas are especially vulnerable, as transportation sources contribute extensively to air quality deterioration. The detrimental impacts of air pollution on respiratory health have emerged as a critical concern, highlighting the urgent

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need for comprehensive awareness and action by relevant stakeholders. With urbanization and industrialization rapidly increasing, the concentration of harmful pollutants in the atmosphere has reached alarming levels, affecting environmental quality. These pollutants not only exacerbate existing respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD) but also contribute to the development of new respiratory ailments in otherwise healthy individuals. Understanding the complex relationship between air quality and respiratory health is essential for crafting effective policies and interventions aimed at mitigating these risks.

It has been reported that indoor air particulate matter is responsible for around 28%of illness and death in developing nations. This estimation is backed by findings from Nigeria (Onabowale & Owoade, 2015) and is confirmed by worldwide evaluations that comprise information from areas like Somalia, Bahrain, Sierra Leone, Togo and Afghanistan (WHO, 2002; Smith *et al*. 2014), articulate matter often written as PM is made up of tiny pieces of dust, dirt, soot, smoke, droplets of liquid and other pollutants. Sometimes you can see the fine particles, but other times they can only be seen with a microscope (American Lung Association, 2024). Particulate matter (PM) has health effects on man and animals such as ischemic heart disease, lung cancer, chronic obstructive pulmonary disease (COPD), lower-respiratory infections (such as pneumonia), stroke, type 2 diabetes, and adverse birth outcomes in both developed and developing countries (Abulude & Akinnusotu 2016) it is also one of the principal causes of human disabilities resulting from air pollution (Park *et al.,* 2021). Laing *et al* (2010) reviewed studies indicating that exposure to inhaled particulate matter is associated with increased mortality and morbidity from pulmonary and cardiovascular diseases. In 2019, it was determined by State of global air, pollution that long-term exposure to PM2.5 pollution contributed to 4.14 million deaths worldwide, accounting for 62% of all air pollution attributable deaths (Venter *et al.* 2020).

According to the American lung association in 2024, when particles from the air travel deep into the body system, they can have negative impact on the body system. PM could be so small they go into the lungs all the way to the lungs alveoli. Once there, they can irritate and corrode the alveoli wall, damaging the lungs and causing lung cancer, pneumonia as well as heart disease, and stroke.

This research aims to contribute to our understanding of the impact of particulate matter on avian respiratory health and provide valuable insights into the potential risks posed by air pollution in both rural and urban environments, this study addresses critical questions regarding the effects of particulate matter on animals. The findings are anticipated to offer valuable insights into potential risks, not only for avian populations but also indirectly for human communities, thereby making a noteworthy contribution to both scientific knowledge and societal awareness of the economic ramifications associated with such environmental concerns.

MATERIALS AND METHODS

Twelve (12) apparently healthy adult pigeons (*Columbidae*) were reared (parent generation) and the first filial generation (F1) were used, six (6) from urban area (Mandawari) and six (6) from rural localities (Yarimawa) of Kano State, Nigeria. They were exposed to high levels of particulate matter for 1 month during peak pollution in Kano State (the dry season) before being euthanized immediately. Studies have shown that pollutant concentrations are notably higher during dry season due to reduce precipitation, lower humidity and high temperature.

The birds were transported in standard laboratory cages to the Gross Anatomy Laboratory in the Department of Veterinary Anatomy, BUK.

The morphometric measurements were taken using a weighing balance with a capacity of 1000g (model JJ1000, USA, sensitivity of 0.01g) and a digital Vernier caliper (MG6001DC, General Tools and Instruments Company, New York; sensitivity: 0.01mm).

Each bird was euthanized using ketamine hydrochloride at (50mg/kg BW) (Azizpour & Hassani, 2012). The birds were then de-feathered and placed on dorsal recumbency. A mid-ventral incision was made from the point of keel bone to caudal 1/3rd of the abdominal cavity to expose the abdominal content. The lungs were then carefully extracted using thumb forceps and Scalpel blade.

The extracted lungs and trachea samples were fixed in 10% Neutral buffered Formalin for 48hrs.

The glass slides containing the tissue for the H and E staining were placed in xylene to dewax (remove excess paraffin wax) for two minutes.

The tissues were rehydrated by passing through descending alcohols of absolute 1, absolute 2, 90%, 70%, and 50%for two minutes each. The tissues were then stained with hematoxylin (LMO5971311) for 30 minutes and rinsed in water for 10 seconds.

Differentiated in 1% acid alcohol for two minutes, and rinsed with water for 10 seconds.

Stained in eosin solution for 15 seconds, and rinsed with water.

Then dehydrated in ascending grades of alcohol from 50%, 70%, 80%, 90%, absolute 1 and absolute 2 respectively.

Cleared in xylene for 1 minute.

The sections were mounted in DPX and covered with a coverslip, making them ready for microscopic examination.

Plate I: Extraction process of the lungs and trachea

RESULTS

Physical Observation

No physical signs of illness or intoxications were noticed in the *Columbidae* used over the period of the study and during the extraction process of the organs used for the study.

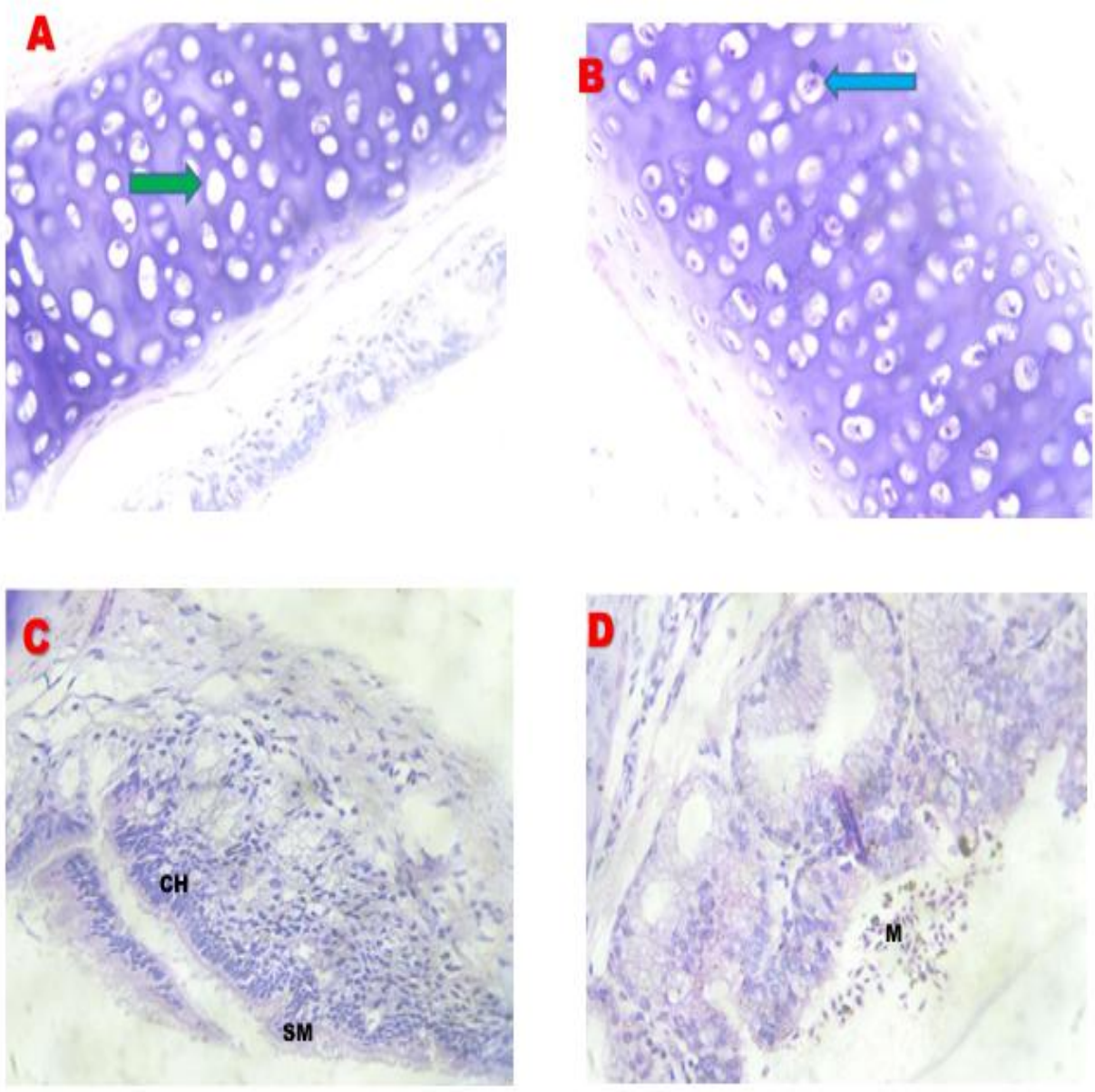

Plate II: Examination of the tracheal segment in A (Mg x400 H & E); urban *Columbidae* revealed chondrocyte necrosis, indicated by the occurrence of empty lacunae (pointed by green arrow) this indicates structural deterioration. The tracheal segment of rural *Columbidae* in B shows chondrocytes within the lacunae, hence depicting intact structure of the trachea. In C (Mg x100 H & E), the tracheal section of urban *Columbidae*. CH=Chondrocytes, SM=smooth muscle, D shows tracheal segment of rural *Columbidae* (Mg x100 H & E) M=Mucosa.

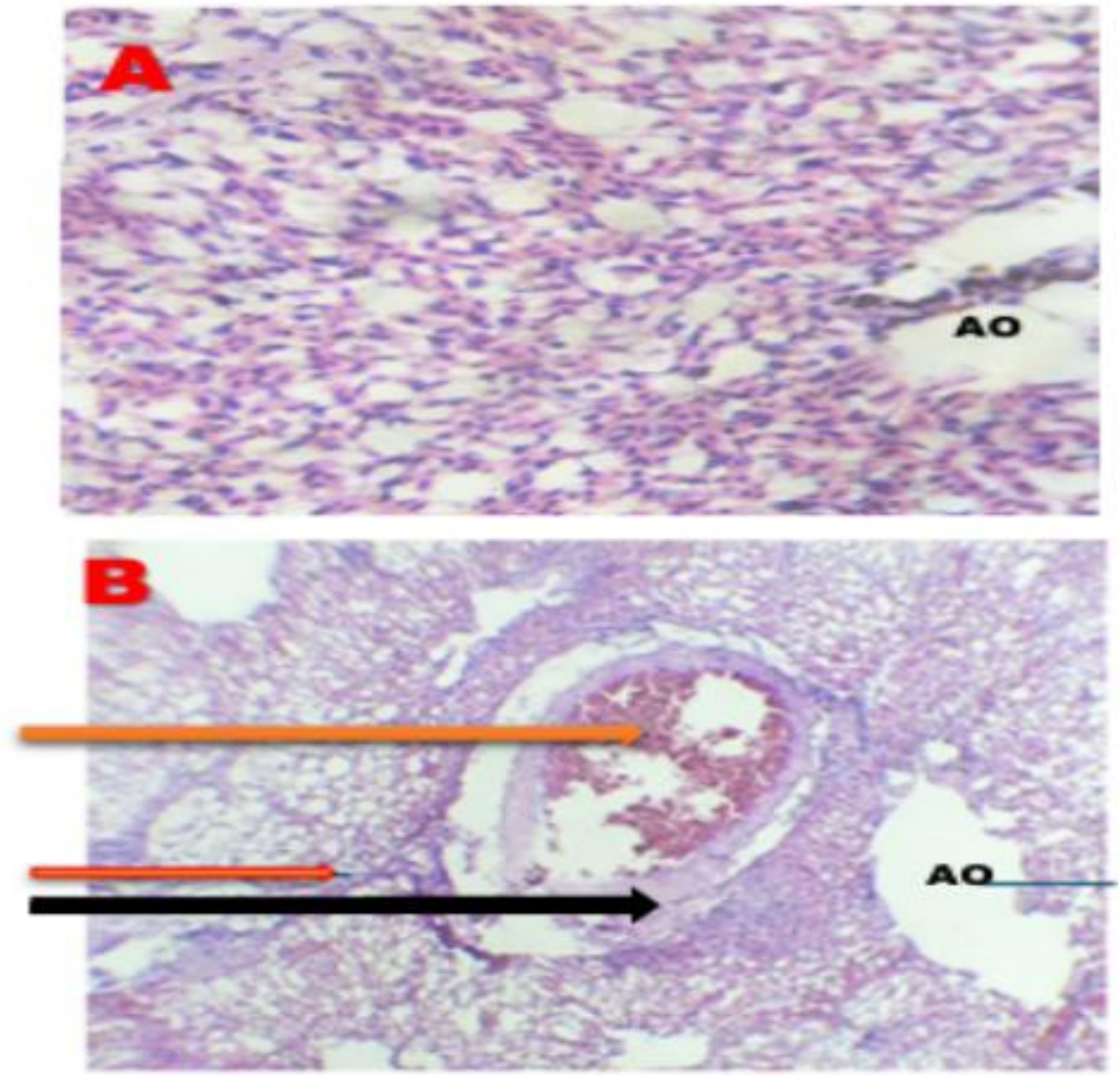

Plate III; histological section of the lung tissue of urban *Columbidae* (B) showed the existence of carbon particles (Mg. x400 H & E). Furthermore, nucleated cells were noted (pointed by yellow arrow), indicating a possible inflammatory response or cellular reaction to exposure to particulate matter. In A, there is absence of nucleated cells, with only a very few present. There was no evidence of carbon particle build up, suggesting minimal or no particulate matter infiltration in this section. Black arrow=blood vessel, orange arrow=smooth muscle and AO=Atrial opening.

DISCUSSION

Environmental pollutants are one of the major challenges to the health, the impact of these pollutants on avian species has garnered much attention due to rising pollution levels. The pigeon family (*Columbidae*) whom are found widely in both urban and rural environments, they act as reliable bio-indicators for air quality. This is a comparative histo-morphological study of lung and tracheal alterations in rural and urban *Columbidae* resulting from exposure to particulate matter (PM) in the environment.

Physical examination showed no signs of injuries or illness visible before the procedure was carried out. However, the histological slides revealed that the urban group of *Columbidae* had ingested carbon particles, this is ascertain by presence of nucleated cells, this depict that there's evidence of inflammatory responses (Plate IIIB), also in the tracheal cartilage of urban *Columbidae* there is evidence of chondrocytes necrosis due to presence of few empty lacunae (Plate IIA), in contrast the lungs and trachea of the rural group of *Columbidae* seemed to be relatively clean as compared to its urban counterpart as shown in plate III. The cartilaginous matrix of both urban and rural *Columbidae* appears uniform with no obvious areas of calcification or degeneration, also the extracellular matrix looks intact and smooth in both groups, this depicts that the damage to the tissue in urban *Columbidae* group is minimal, since the exposure is not prolonged.

From the histological findings, the respiratory health of urban *Columbidae* is significantly compromised by carbon particulate matter in air pollution which will equally affect the human populace, numerous studies support this findings by linking exposure to harmful pollutants with various respiratory and allergic conditions such as, weakened immune system, decrease in lung function etc. (Wang *et al.* 2019). For instance, research conducted assessed the impact of traffic-related air pollution and the London Low Emission Zone (LEZ) on respiratory and allergic symptoms among 8-9-year-old schoolchildren in East London revealed a clear association between traffic-related air pollutants such as nitrogen oxides (NO) and particulate matter (PM2.5) and the prevalence of rhinitis, underscoring how urban air quality directly influences respiratory symptoms (Wood *et al,* 2015). Findings from this research reinforce the role of birds as bio-indicators and stress the need for environmental interventions to reduce air pollution.

Conclusion

This study shows air pollution presents a significant threat to respiratory health, warranting urgent attention from both individuals and policymakers. Key pollutants, such as particulate matter, nitrogen dioxide, and sulfur dioxide, can exacerbate existing respiratory conditions. The detrimental impact of these pollutants is particularly pronounced in urban areas as seen in the lung and tracheal tissues of urban *Columbidae*, where industrial emissions and vehicle exhaust are prevalent. A comprehensive approach to address air quality can yield substantial benefits, not only for public health but also for overall quality of life. Implementing stricter regulations on emissions, promoting cleaner energy alternatives, and increasing public awareness about pollution sources are vital strategies.

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Conflict of interest

The authors declare that they have no any conflict of interest related to this study.

Author (s) contribution

YKM: Writing- review and editing of resources, data curation, photomicrograph analysis, methodology, investigation and analysis. SU: Writing- original draft, data curation and conceptualization, write up editing and concept development, funding acquisition, and tissue procession. WS: Methodology, tissue processing and funding acquisition. ADR: methodology, rearing of birds and funding acquisition. TMA: Tissue processing and Histological slides capture. MSS: Writing – review & editing and supervision. TM: Birds identification, post mortem identification and methodology. MM: Writing – review & editing, funding acquisition. AG: Writing- Review and editing original draft. RIF: Writing: Review and editing.

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