

Assessment of histopathological effect of factory effluents on the liver and kidney tissues of chickens (*Gallus gallus domestica*) reared around factory sites in Nnewi Metropolis, Anambra State, Nigeria

A.N. Okpogba¹, E.C. Ogbodo^{2*}, M.N. Izuogu³, A. K. Amah⁴, D.C. Ejiofor⁵, I. Wopara⁶, F.N. Ujowundu⁷, C. Nwanegwo⁸, E.U. Modo⁹, C.N. Chinaka¹⁰

¹Dept. of Human Biochemistry, Faculty of Basic Medical Sciences, ²Dept. of Medical Laboratory Science, Faculty of Health Sciences and Technology, ³Dept. of Human Anatomy, Faculty of Basic Medical Sciences, ^{4,5,8}Dept. of Human Physiology, ^{6,7,9,10}Dept. of Biochemistry, ^{1,2,3}Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria, ^{4,5,8}College of Medicine, Imo State University, Owerri, Nigeria, ^{6,7,9,10}Madonna University, Elele Campus, Rivers State, Nigeria

***Corresponding Author: E. C. Ogbodo**

Email: augustinee442@gmail.com

Abstract

Exposure to factory effluents comes with deleterious consequences. The purpose of this study was to assess the histopathological effect of factory effluents on the liver and kidney tissues of chickens (*Gallus gallus domestica*) reared around factory sites in Nnewi Metropolis, Anambra State, Nigeria. A total of twenty-nine chicks comprising of sixteen chicks exposed to factory sites and thirteen non-exposed chicks were grown to adult birds (chickens) for the study and were allowed to feed from the surrounding homeland of the factories including lead acid battery manufacturing factory (A), metal fabricating factory (B) and metal forging factory (C) respectively until they were aged between four and five months as adult birds (chickens) for the study. The chickens were sacrificed to obtain the liver and kidney tissues for histological analyses. The histopathological evaluation of the effect of the factory effluents on the liver and kidney tissues of birds reared around the four factories (A-D) and control were done by microscopic examination of haematoxylin and eosin (H&E) stained sections. The results obtained in factory A, B and C showed widening of the liver central vein and thickening of the vessels with invasion of the surrounding areas by chronic inflammatory cells as against the controls which showed fairly normal liver tissues with normal liver parenchyma cells with a central vein containing blood cells. Also, the photomicrographs of the kidney tissues of birds reared around factory A, B and C showed evidence of marked glomerulo-nephritis and hypercellularity with evidence of glomerulosclerosis and hyalinization of the glomeruli as against the normal glomeruli and tubules found in the control birds. These results indicate that the environment where these birds are reared is a potential threat to the lives of the birds reared around these factories.

Keywords: Factory site, Factory effluents, Liver, Kidney, Chicken (*Gallus gallus domestica*), Nnewi metropolis.

Introduction

Metabolic activity has been shown to be an important factor that enhances the success of adaptation of vertebrates to their environment.¹ The vertebrate liver is involved in absorption of nutrients from the digestive tract which are subsequently processed and stored. The metabolic functions of the liver include protein synthesis, storage, bile secretion, detoxification and inactivation of harmful substances.² The basic structural and functional unit of the liver is the acinus, which consist of hepatic lobule and portal triad (also called Glisson's sheath).³ The hepatic lobules are the functional units of the liver. The sinusoids are capillary networks which are localized in the spaces between hepatic plates. The liver synthesizes bile which eventually empty into the gall bladder.⁴ The sections of a normal *Gallus gallus domestica* liver showed hepatocytes disposed in cords and clusters. The hepatocytes possessed centrally placed nuclei. The intervening fibro-vascular connective tissue displayed nucleated red cells with congested hepatic veins and portal triad similar to those of mammals.⁵

The kidneys are a pair of bean-shaped organs present in all vertebrates. They remove waste products from the body, maintain balanced electrolyte levels, and regulate blood pressure.⁶ The kidneys of *Gallus gallus domestica* are flattened organs embedded in ventral surface of synsacrum bone and each incompletely divided into three lobes; cranial, middle and wider-largest caudal lobes.⁷ Kidney

lobes of *Gallus gallus domestica* show a subdivision into units called lobules. Each lobule has a cortex and medulla.⁸ The nephron is the functional unit of kidney and greatly varies in its structure amongst different vertebrates; also the structure of nephrons shows variable degree of differences among species. In birds, kidneys have two kinds of nephrons; a reptilian type --small sized, with no loops of Henle, and a mammalian type large size with long or intermediate loop length.⁹

Environmental pollution is a major global problem posing serious risk to man and animals. The development of modern technology and the rapid industrialization are among the foremost factors for environmental pollution. The environmental pollutants are spread through different channels, many of which finally enter into food chain of livestock and man.¹⁰ There is increasing concern about environmental pollutants emanating into the livestock production systems.¹¹ Pollution of the environment has significant impact on living organisms. Reports from developed countries have documented adverse impact of pollution on domestic and wild animals in the form of specific chemical toxicities, behavioural changes and population decline. Heavy metals are one of such chemical effluents released by industries. Heavy metals from industrial waste contaminate drinking water, soil, air, fodder and food.

The toxic heavy metals like Cadmium, lead and mercury affect biological functions, affecting hormone system and growth.¹² Many heavy metals accumulate in one or more of the body organs in food animals and are transmitted through food causing serious public health hazard. These toxicants are accumulated in the vital organs including liver and kidney and exert adverse effects on domestic animals. Many surveys involving human population in industrial, mining and urban areas have indicated toxicities due to effluents. Pesticides, heavy metals and other agro-chemicals are some of the major causes of environmental toxicity in farm animals.¹² Liver is the major target organ for xenobiotics and thus, is frequently cited as the site of parenchymal damage following exposure to various chemical agents.¹³⁻¹⁴ Kidney is severely affected by different toxic chemical which is evident in form of pathological changes such as necrosis of hematopoietic tissue, vacuolation of tubular cells, dilation of glomerular capillaries and degeneration of epithelial cell linings.¹⁵ In kidney, histopathological changes were seen in glomeruli, tubuli and interstitial tissue. There was thickening of the glomerular basement membranes and hypercellularity. Epithelial degeneration of the tubules and intracytoplasmic hyaline droplets were detected in many tubules.¹⁶ Basement thickening was also seen in tubular basement membranes. In addition, hyaline casts were detected within the some tubules. Some degenerative and necrotic changes, especially, pyknosis, were observed. Hepatocytic degeneration is a common histopathological finding following toxicity of heavy metals.¹⁶ Therefore, the purpose of this study was to assess the histopathological effect of factory effluents on the liver and kidney tissues of chickens (*Gallus gallus domestica*) reared around factory sites in Nnewi Metropolis, Anambra State, Nigeria.

Materials and Methods

Experimental Site

This study was carried out around three factories including lead acid battery manufacturing factory (A), metal fabricating factory (B) and metal forging factory (C), all located within Nnewi Metropolis, Anambra State, Nigeria.

Experimental Design

This is a cross sectional study designed to assess the histopathological effect of factory effluents exposure on the Liver and Kidney tissues of chickens (*Gallus gallus domestica*) reared around factory sites in Nnewi Metropolis, Anambra State, Nigeria. A total of twenty-nine (29) chicks comprising of sixteen (16) chicks exposed to factory sites and thirteen (13) non-exposed chicks were grown to adult birds (chickens) for the study. The chicks in the exposed group were obtained from the surrounding households, about 250m, to these factories under study (lead acid battery manufacturing factory, metal fabricating factory and metal forging factory) while the chicks to serve as control were obtained in Elele. They were aged between four (4) and five (5) months. They were allowed to feed from the surrounding homeland until they were due for the experiment. Control chickens of the same age group were obtained from

environments outside Nnewi. The chickens were sacrificed to obtain the kidney and liver tissues for analyses.

Histopathological Examination

The liver and kidney tissues from each group of rats were collected in 10% formalin for 15 days. Thereafter, the well fixed tissues were processed, sectioned and stained following standard procedure.¹⁷ The histopathological evaluation of the effect of the factory effluents on the liver and kidney tissues of birds reared around the three factories and control were done by microscopic examination of haematoxylin and eosin (H&E) stained sections.

Ethical Consideration

Ethical approval for the research was obtained from Ethical Committee, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

Results

The histopathological evaluation of the effect of the factory effluents on the liver and kidney tissues of birds reared around the three factories and control were done by microscopic examination of haematoxylin and eosin stained sections. The effect of the factory effluents were evaluated by histological examination of haematoxylin and eosin stained sections of liver tissues of the birds. The control birds showed normal liver structure with minimal fatty change. Fig. 1 (a) and (b) show the photomicrographs of control liver tissues from Elele and Nnewi, respectively, showing normal liver parenchyma cells architecture with a central vein containing no vacuoles and inflammatory processes.

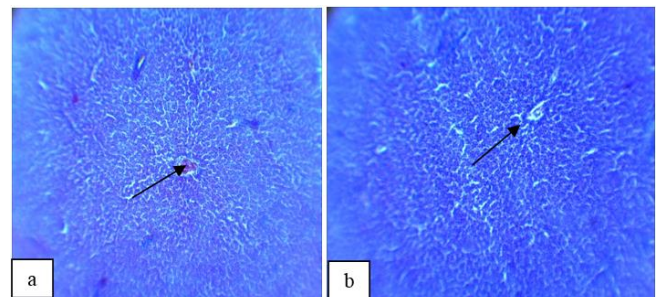


Fig. 1 a: Photomicrographs of the liver of control birds reared in Elele; **(b)** Nnewi

The photomicrograph of liver tissues around acid battery manufacturing factory birds is presented in Fig. 2. The photomicrograph shows widening of the central vein and thickening of the vessels. There is also invasion by chronic inflammatory cells around the central vein with a probable evidence of liver damage.

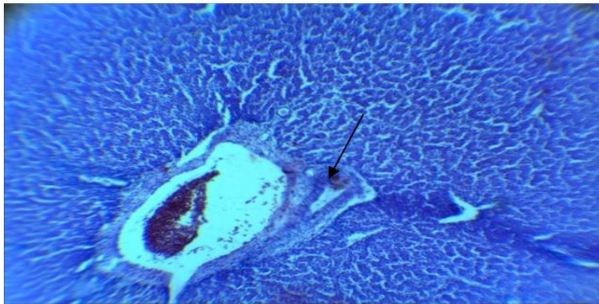


Fig. 2: Birds reared around a lead acid battery manufacturing factory (A) in Nnewi

Fig. 3 (a) and (b) show the photomicrographs of liver tissues from birds reared around metal fabricating factory showing liver necrosis involving the peri-central vein and surrounding areas.

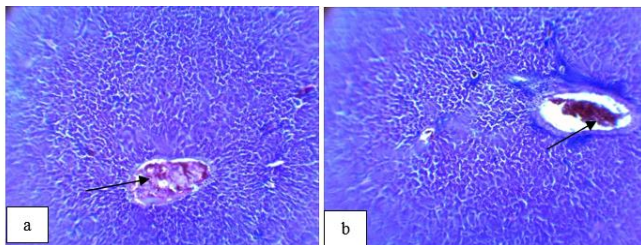


Fig. 3: Liver of chickens reared around a metal fabricating factory (B) in Nnewi (a) and (b)

Fig. 4 (a) and (b) present the photomicrographs of liver tissues of birds reared around the metal forging factory (C) showing widening of the central vein and thickening of the vessels with invasion of the surrounding areas by chronic inflammatory cells (and evidence of hepatitis).

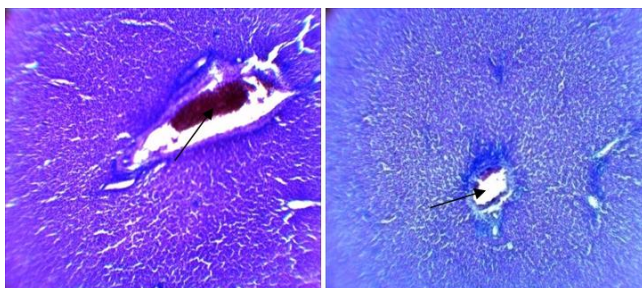


Fig. 4: Liver tissues of birds bred around a metal forging factory (C) in Nnewi

Fig. 5 (a) and (b) present the photomicrographs of control kidney tissues from Elele and Nnewi, respectively, showing normal cellular and physiological characteristics of glomeruli and tubules.

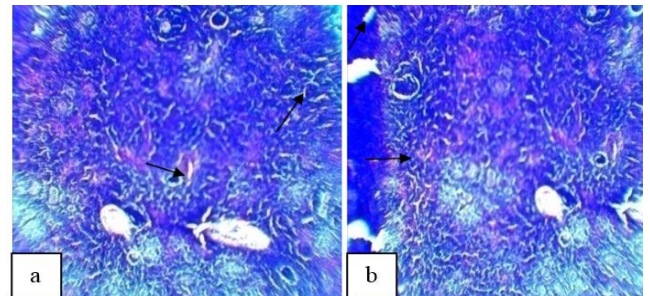


Fig. 5: Photomicrographs of the kidney tissues of control birds in Elele (a) and Nnewi (b), respectively

Fig. 6 (a) and (b) show the photomicrographs of kidney tissues from acid battery manufacturing factory (A) birds. The glomeruli showed marked glomerulo-nephritis and hypercellularity with diffuse glomerulosclerosis and tubular necrosis.

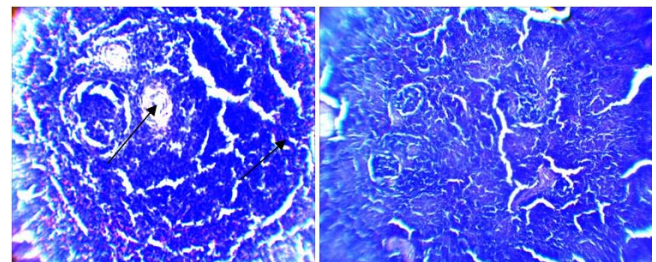


Fig. 6: Photomicrographs of tissues of kidney of birds bred around lead acid battery factory (A) in Nnewi (a) and (b)

The photomicrographs of kidney tissues from metal fabricating factory birds are shown in Fig. 7 (a) and (b). The glomeruli show evidence of marked glomerulo-nephritis and hypercellularity with evidence of global sclerosis and hyalinization of the glomeruli.

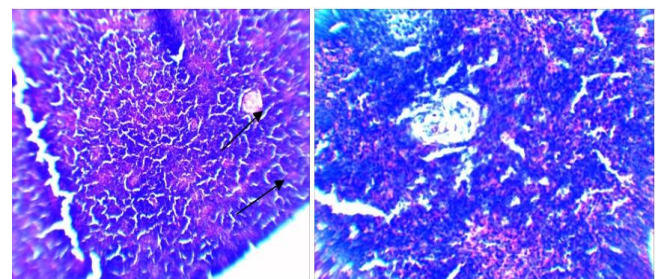


Fig. 7: Photomicrographs of kidney tissues of a metal fabricating factory (B) in Nnewi (a) and (b)

The Photomicrographs of kidney tissues from metal foundry factory birds are presented in Fig. 8 (a) and (b). While the glomeruli show marked glomerulonephritis. There is also diffuse glomerulosclerosis and hyalinization with extensive tubular necrosis.

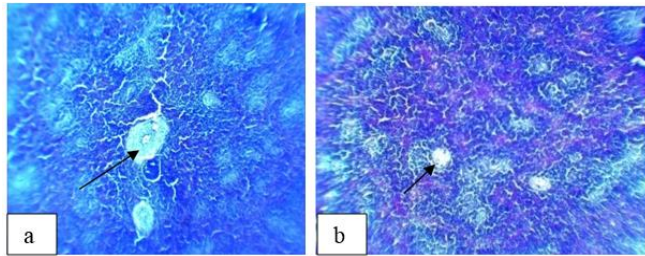


Fig. 8: Photomicrographs of kidney tissues of chickens reared around a metal forging factory (C) in Nnewi (a) and (b)

Discussion

All birds are vulnerable to the effects of heavy metal poisoning such as Pb,¹⁸ but their response shows distinct intra-specific and inter-specific differences.¹⁹ Lead accumulation in tissues is affected by the physiological status of the birds and levels of accumulation differ between species.²⁰ On the other hand, the accumulation of heavy metals varies significantly from one tissue to another within an animal, and varies also between one animal and another.²¹ The photomicrographs of the histopathological studies of liver of the factory birds around the lead acid battery manufacturing, metal forging and metal fabricating factories showed widening of the liver central vein and thickening of the vessels with invasion of the surrounding areas by chronic inflammatory cells as against the controls which showed fairly normal liver tissues with normal liver parenchyma cells with a central vein containing blood cells.

On the other hand, the photomicrographs of the kidney tissues of birds reared around the lead acid battery manufacturing, metal fabricating and metal forging factories showed evidence of marked glomerulo-nephritis and hypercellularity with evidence of glomerulosclerosis and hyalinization of the glomeruli as against the normal glomeruli and tubules found in the control birds. There is paucity of information regarding the histopathological effects of factory effluents on the liver and kidney tissues of chickens reared around factory sites and as a result of which, it was practically difficult comparing the present findings with other studies. However, these results indicate that the environment where these birds are reared is a potential threat to the lives of the birds reared around these factories.

Conclusion

The present study has shown various histological alterations on the liver and kidney tissues of chickens exposed to factory effluents and these indicate that the environment where these birds are reared is a potential threat to the lives of the birds reared around these factories.

Conflict of Interest: None.

References

1. Barbara Y, Geraldine O, Phillip T. Histology of the digestive tract: Wheater's Functional Histology. 2014; 11th ed. Philadelphia: Elsevier, Churchill Living Stone, Pp. 274-80.
2. Singh I. Digestive System: Textbook of Human Histology. New Delhi, India: Jaypee Brother's Medical Publishers (P) Lt. 2014;249-57.
3. Guyton AC, Hall JE. Metabolism and temperature control: The liver as an organ. In: Hall JE, editor. Guyton and Hall Textbook of Medical Physiology. 2010; Vol. 13. 12th ed. Philadelphia, Pennsylvania: Saunders, Pp. 536-40.
4. Sáez L, Zuvia T, Amthauer R, Rodríguez E, Krauskopf M. Fish liver protein synthesis during cold acclimatization: Seasonal changes of the ultrastructure of the carp hepatocyte. Journal of Experimental Zoology 2012;230:175-86.
5. Emmanuel IO, Emmanuel IO. Comparative histologic anatomy of vertebrate liver. *Ann Bioanthropol* 2015;3(1):1-5.
6. Tim, N. What do the kidneys do?. Medical News Today 2019;1:1-5.
7. Al-Ajeely, RA, Fadhil SM. Morphohistological study on the development of kidney and ureter in hatching and adulthood racing pigeon (*Columba livia*). *Domestica J* 2012;3(3):665-77.
8. Casotti, G., Lindberg KK, Braun EJ. Functional morphology of the avian medullar cone. *Am J Physiol, Regul, Integr Comp Physiol* 2000;279:1722-5.
9. Reece WO. Dukes' Physiology of Domestic Animals. 2004; 12th Ed. Cornell University Press, Ithaca, Pp. 107-113.
10. Kaplan O, Yildirim NC, Yildirim N, Cimen N. Toxic Elements in animal products and environmental health. *Asian J Anim Vet Advancement* 2011;6:228-32.
11. Rajaganapathy, V. Effect of pollution in livestock production systems. Proceedings of the National Seminar on Recent Trends in Animal Welfare and Production 2006;1-3.
12. Rajaganapathy V, Xavier F, Sreekumar D, Mandal PK. Heavy metal contamination in soil, water and fodder and their presence in livestock and products: a review. *J Environ Sci Technol* 2011;4(3):234-49.
13. Gingerich WH, Weber LJ. Hepatic Toxicology of Fishes. In: Aquatic Toxicology, Weber, L.J. (Ed.). Raven Press, New York, 1982:55-105.
14. Montaser, M., Mahfouz, M. E., El-Shazly, S. A. M., Abdel-Rahman, G. H. and Bakry, S. Toxicity of heavy metals on fish at Jeddah Coast KSA: Metallothionein expression as a biomarker and histopathological study on liver and gills. *World J Fishes Mar Sci* 2010;2:174-85.
15. Abdel-Baki, A. S., Dkhil, M. A. and Al-Quraishy, S. Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah. Saudi Arabian. *Afri J Biotechnol* 2011;10:2541-7.
16. Miyase, C. A., Arzu, Y., Ilkay, Y., Ertan, O., Ozkan, D. and Metin, Ar. Cadmium Induced Changes on Growth Performance, Some Biochemical Parameters and Tissue in Broilers: Effects of Vitamin C and Vitamin E. *Asian J Anim Vet Adv* 2011;6(9):923-34.
17. Luna, L.G. Manual of Histopathologic Staining Methods of the Armed Forces Institute of Pathology. 1968, 3rd edn. McGraw-Hill Book Company, London.
18. Okpogba, A.N., Ogbodo, E.C., Ugwu, E.C., Oguaka, V.N., Dike, C.C., Ujowundu, F.N. Comparative assessment of heavy metal levels in chickens (*Gallus gallus domestica*) in rural (Elele) and urban (Nnewi) Areas. *Asian J Sci Technol* 2018;9(11):9056-9.
19. Almansour, M.I. Inter-Species differences between lead concentration in the feathers of Bayer, W.N., Spann, J.W., Sileo, L. and Franson, J.C. Lead poisoning in six captive avian species. *Arch Environ Contamination Toxicol* 1988;17:121-30.
20. Pycnonotus leucogenys and Streptopelia senegalensis from different cities of Saudi Arabia. *Int J Zoological Res* 2007;3:200-6.
21. John, H.H and Jeanne, I.R. Food additives, contaminants and natural toxins In: Maurice E.S., James, A.O., Moshe, S.L. and Febiger, (eds.) Modern nutrition in health and disease, 1994; 8th ed., part II. Pp: 15]