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Suspended Particulate Matter (SPM) and Trace Metals Emission from the Combustion of Tyres in A Nigeria Abattoir

*DIBOFORI-ORJI A. N.; EDORI O. S.
Department of Chemistry Ignatius Ajuru University of Education, Rumuolumeni, P. M. B 5047, Port Harcourt, Rivers State, Nigeria.
*E-mail of the orresponding author: jc_orji@yahoo.com +2348039572370

ABSTRACT

Air samples from two different abattoir environment where vehicle tyres and wood are used to burn cattle skin to remove the fur were collected to examine the concentration levels of suspended particulate matter and some trace metals. The samples were collected with a portable high volume sampler and allowed to pass through a membrane filter which was dried in a dessicator and weighed. The samples were then analysed for suspended particulate matter (SPM) and trace metals. The samples were then digested and analysed for trace metals using the atomic absorption emission spectrophotometry (AAES). A calibration curve was developed to determine the metal concentrations. The suspended particulate matter from burning tyre emissions ranged from 45-88.3 μm/m^3, while those of the firewood emissions ranged from 6.51-6.57 μm/m^3. Trace metals analysed in the abattoir were tyre burning was used were iron (Fe): 0.023-0.063μg/m^3, zinc (Zn): 0.009-0.060μg/m^3, while chromium (Cr), cadmium (Cd) and vanadium (V) were undetected. In the abattoir where wood was used, only Zn metal was detected and ranged from 0.002-0.032μg/m^3. However, total SPM detected at the abattoir where tyre was used exceeded the World Health Organization recommended value in the environment and this could pose deleterious to the environment.

Keywords: Suspended particulate matter, Trace metals, Abattoir, Environment, Pollution.

1. INTRODUCTION

The concept of toxicity is usually associated with “trace metals” or “heavy metals” or more generally trace elements which include mercury, cadmium, copper, zinc, cobalt, manganese, lead, molybdenum, nickel, iron, arsenic, silver, etc. Trace element emanate from natural processes and human activities. Major natural sources are rock weathering, releases from terrestrial and submarine volcanoes. Trace metals emanating from these natural sources are introduced into the environment through river and land run-offs. For a few metals, such as mercury, lead, cadmium and zinc, the atmospheric route is important (WHO, 1983).

Human activities introduce a lot of trace metals into the environment. For instance, lead, an atmospheric pollutant comes from manufacturing sources, pesticides and from leaded gasoline, which when burnt in automobile engines, is a major source of air borne lead in urban areas. Other trace metals, such as zinc, chromium, cadmium, and vanadium enter the atmosphere from manufacturing sources and wear e.g. brake linings, oil leakages, wearing of tyres, etc (Tedder *et al*., 2002; IPRDB, 2002).

Some metals (Fe, Cu, Zn, Mn, etc.) are known as essential nutrients, because they are vital to everything from normal bone growth to components of the smallest enzymes involved in the minutest physiological process (Blezinger, 2003). An insufficient supply will cause deficiency diseases (Gillespe, 2002; Green *et al.,* 1997; Johnson & Raven, 1999). However, metals such as lead, mercury, arsenic, silver, cadmium, etc. have no dietary relevance but are highly carcinogeric.

Table 1: Organs adversely affected by heavy metals.

Organs/ Area	Heavy metal/ compound	Broad Health Effect
Central Nervous System	CH_3, Hg^+, Hg^{2+}, Pb, Tl	Brain damage, reduced neuropsychological functioning, brain tumours.
Peripheral Nervous System (PNS)	CH_3, Hg^+, Hg^{2+}, Pb^{2+}, Tl, As	Abnormal movement and reflexes, peripheral neurological effects, peripheral neuropathy, polyneuritis.
Renal System	Cd, Hg^{2+}, As	Tubular and glomerula damage, proteinuria, Tubular nephrosis (inflammation of the kidneys).
Liver	As	Cirrhosis (chronic and often fatal diseases of the liver).
Blood System	Pb^{2+}, Cd^{2+}, Hg^+, As	Inhibits biosynthesis of haem, slight anaemia, oral or Nasal mucosa, ulcers, stomatitis.
Respiratory Tract	Cd, As, Hg^+, Sc	Seemphysema, emphysema and fibrosis, bronchial effect respiratory inflammation.
Skeleton	Cd, As	Osteomalacia (bone malformation, tooth caries).
Cardiovascular system	Cd, As	Heart diseases, often fatal heart failure causing death.
Reproductive system	CH_3, Hg^+, Tl	Spontaneous abortion, brain or body deformation, deformed babies, teratogenesis
Prostrate gland, lung, skin	Cd, As	Cancer.
Gene carrying organs, Chords or nerve	Cd, As	Chromosomnal aberrations

Source: Zielhuis (1979)

Suspended Particulate Matter or SPM are those suspended particles in the air that is 10 micrometers or less. These particles may occur in nature which comes from volcanoes, dust storms, vegetation or sprays from sea movement. Others may be from man's activities such as burning of fossil fuels, manufacturing activities, quarrying and the like, because these particulate matter are small enough to be breathed in, they can cause detrimental effects to man. It is said that particulate matter that is 2.5 micrometers or less is harmful as these cannot be expelled from the body and cause long term effects such as lung cancer, allergies, asthma, and other respiratory diseases, some type of birth defects as well as premature death. Suspended Particulate Matter (SPM) are introduced into the environment through natural sources and Human activities (Seinfeld and Pandis 1998). Fly ash, dust and soot make up the SPM in the environment. In a polluted environment, particles of metals may be initiated absorbed on particulates and transported to the lungs and thence to the blood stream. SPM also enhance the damage to lungs caused by SO_2 because they carry SO_2 to deep regions of the lungs that are not otherwise reached. Apart from the synergistic effect SPM have on SO_2 carcinogens such as polyaromatic

hydrocarbons (PAHs) could also be transported to the lungs by articulates (Culp *et al*., 1998; Paralaks, 1976; Philips, 1983).

Particles less than 2µm in size are the greatest threat. They penetrate the deeper structures of the lungs, including the alveolar sacs, where no protective mucous blanket exists. Inhaled particles greater than 10µm could be lodged in the nostrils. Particles in the size range from 5µm to 10µm could be captured by the mucous living in the upper air way. They are carried to the throat and swallowed. Therefore any activity that introduces SPM into the environment should be deemed hazardous to human health.

In most major abattoirs in the south-east and south-western parts of Nigeria, where an average of thirty animals of the cattle family are slaughtered. The animal furs are burnt off using burning automobile tyres. The resultant skins (generally called Kpomo or Kanda) are washed and sold as meat to the ultimate consumer. Usually underneath the skin surface is blackered with carbon soot or deposits. During this cattle skin processing operation, large quantity of thick dark smoke is emitted into the atmosphere (Dibofori-Orji and Braide 2011)

Considering the chemical composition of tyre, there is the possibility of the emission of trace metals and suspended particulate matter into the environment, especially the atmosphere during combustion. Tyre is majorly composed of Natural and synthetic rubber (Isoprene units). Sulphur, zinc oxide, antioxidants and lubricant as well as fabrics and wire make up the rest of the composition of the tyre.

This study was therefore carried out to measure some trace elements (relevant to composition of tyre), and SPM in the air within the abattoir and the environ as a result of the combustion of automobile tyres to process cattle skin.

2.0 EXPERIMENTAL PROCEDURE (ASTM, 2000)

2.1 Suspended Particulate Matter (SPM)

A portable high volume air sampler [Air metric (R)] with a pre-weighted membrane filter (45µm) was used to collect SPM within the abattoir environment. Air was drawn through the membrane filter by means of a heavy duty turbine blower at a constant flow rate of 1.1 and 1.7 cubic meter per min (m^3/min). The membrane filter was dried in a desiccator and weighed to the nearest microgram. Measuring the weight of particles, diving by the volume of air sampled, enabled calculation of the mass concentration. This method is sensitive enough to measure SPM as low as 1µm/m^3.
Calculation:

$$V = q \times t$$

V = [Volume of Air (m^3)] = Flow rate (q) – xTm of Sampling (t)

q = m^3/hr

Concentration of SPM (µm/m^3) = mf – mi/v

where:

mf = final weight of paper after sampling (µg)

mi = Initial weight of paper before sampling (µg)

v = Volume of air sample (m^3).

2.2 Trace Metals

Trace metal in the SPM were determined by Atomic Absorption / Emission spectroscopy (AAES). The membrane filters used for SPM determination was digested with 20ml of concentrated trioxonitrate (V) acid (HNO_3), 5ml of tetraoxosulphate (VI) acid (H_2SO_4) and 10ml of Oxochlorate (VIII) acid ($HClO_4$) the digested solution was filttered, ready for analysis. A standards solution was prepared by weighing a pure solute of the element of interest to form the stock solution. From the later, social dilutions were made, their absorbance measured on the AAES, and a Calibration curve developed. The filtrate from the digested membrane filter was also found in the AAES and the absorbance measured. Through extrapolation, the concentration of the element in question was obtained. Trace metals of interest in this

analysis were iron, zinc, chromium, cadmium and vanadium. This is in relation to the chemical composition of tyre.

To make for effective comparison, the SPM and trace metals were also measured in an environment where firewood was burnt to remove the fur on the cattle skin. Tables II and III show the various results respectively.

3.0 RESULTS AND DISCUSSION

Table 2: Emission of SPM from Burning Tyre and Firewood

Experimental Runs	Burning Tyre Emission (μm/m^3)	Firewood Emission (μm/m^3)
1.	85.0	6.55
2.	66.0	6.51
3.	56.3	6.53
4.	45.0	6.57
5.	88.3	6.55

Table III: Emission of Trace Metals from Tyre and Firewood Burning for Processing of Cattle Skin

Treatment	Experimental Runs	Metals (μg/m^3)				
Tyre Burning		**Fe**	**Zn**	**Cr**	**Cd**	**V**
	1	0.060	0.050	<0.001	<0.001	<0.001
	2	0.026	0.009	<0.001	<0.001	<0.001
	3	0.060	0.020	<0.001	<0.001	<0.001
	4	0.063	0.060	<0.001	<0.001	<0.001
	5	0.023	0.023	<0.001	<0.001	<0.001
Firewood Burning	1	<0.001	0.032	<0.001	<0.001	<0.001
	2	<0.001	0.004	<0.001	<0.001	<0.001
	3	<0.001	0.007	<0.001	<0.001	<0.001
	4	<0.001	0.002	<0.001	<0.001	<0.001
	5	<0.001	0.002	<0.001	<0.001	<0.001
	$\overline{X}$	**<0.001**	**0.003**	**<0.001**	**<0.001**	**<0.001**

Emission of SPM from burning tyre (45.0µm/m^3 – 88.3µm/m^3) exceeded those resulting from firewood environ (6.51µm/m^3 – 6.57µm/m^3) and allowable limit 15µm/m^3 (WHO, 2000).

The characteristic black smoke emission from tyre burning obviously introduces a lot of suspended particles into the atmosphere. In addition to carbon particles, and trace metals (ash), organic acids, nitrates and sulphates and other organic compounds such as Polyaromatic hydrocarbons, could be adsorbed on the particulates and remain suspended in the atmosphere. Most of these compounds, in the presence of high sun light, are converted to radicals which take part in photochemical reactions in the atmosphere leading to smog formation and ultimately green house effect (Int Panis, 2008).

SPM also contributes to green house effect in the atmosphere by absorbing infra red radiation from the earth. The trapped radiation increases the global temperature. The grim effect is droughts, excessive rainfalls and flooding, and adverse effect on world food supply (Haywood and Boucher, 2000).

Continuous emission SPM reduces the general aesthetics of the environment. This is a true picture of the Abattoir environment. The settling of soot particles on roofs, leaves and clothes on drying lines is visible within and award the abattoir environment. Atmospheric suspended particulate matter affect the climate of the earth by changing the amount of incoming solar radiation and outgoing terrestrial long wave radiation retained in the earth's system. This happens through several distinct mechanisms which may be direct or indirect (Twomey, 1977). This climatic effect creates non-reliability and uncertainty in future climate predictions. Forster *et al*., (2007) reported that climate change and radiative forcing due to greenhouse gases may be determined to a reasonable high degree of accuracy while the uncertainties related to suspended radiative forcings remains and rely to a large extent on the estimates from global modelling studies that are difficult to verify at the present time. This situation results from the presence of suspended particulate matter in the atmosphere which affect visibility and radiation absorption.

Trace metals have the ability of being bio-accumulated in the body through the food chain. This is why they are of a great concern to the environmentalist. No matter how little their concentration, once inhaled or ingested they could be bio-accumulated overtime. This might result in disease condition from this study, iron (Fe) and zinc (Zn) were detected from tyre burning emissions with the highest concentrations being 0.063ug/m^3 and 0.060µg/m^3 respectively.

Chromium (Cr), Cadmium (Cd) and Vanadium (V) were below detectable limit (<0.001µg/m^3). On the other hand, only zinc was detected in firewood burning emission (0.003mg/m^3).

4.0 CONCLUSION

The issue of Toxic pollution from burning tyre-derived fuel cannot be over emphasized. According Federal Environmental protection Agency, Berlin (2003), certain metals present in tyres serve as catalysts for dioxin formation, providing a surface on which dioxins can readily form during and after the combustion process. If cattle skin must be processed and consumed as meat, alternative processing methods are available. For instance, the fur on the skin could be shaved using sharp objects like razor blade or knife. Alternatively, hot water could be used to clean the skin of the fur. Also, used automobile tyres could find alternative uses in the society. For example, such tyres could be used in the manufacture of materials for asphalt pavement for road construction (Eleazer and Berlaz, 1992). They could be used to manufacture foot wears. They could also be used as fuel source for municipal incinerators and the resultant heat used to heat up boilers that could drive turbines which eventually could be converted to electric energy. Electricity could be harnessed from source of power for the municipality.

In a study conducted by Dibofori-Orji and Braide, (2011), there was deposition of polyaromatic hydrocarbon (PAHs) and some trace metals on the skin of Cattle processed with burning automobile tyres. Consumption of such product definitely would expose the consumers to health risks.

REFERENCES

ASTM (2000). American Society for Testing and Materials. United States Environmental Protection Agency, Washington DC 20402.

Blezinger, S. B. (2003). Improve Your Herd Health Status Through Nutrition. *Animal Health Journal, 1, 1-5.*

Culp S.J; Gaylor D.W; Sheldon W. G.: Goldstein L.S. & Beland F. A. (1988). A Comparison of the *Tumors* Induced by Coaltar and Benzo (a) Pyrene in a 2 – year Bioassay. *Carcinogenesis,* 19, 117-124.

Dibofori-Orji A. N. and Braide S. A. (2011). Trace Metals and Polycyclic Aromatic Hydrocarbons (PAHs) Levels in Cattle Skin (Kanda) Processed with Burning Tyres. *International Journal of Applied Environmental Sciences,* 6(2), 133-141.

FEPA (1991). Federal Environmental Protection Agency. National Interim Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Waste Management in Nigeria.

Forster, P., Venkatachalam, R., Paulo, A., Terje, B., Richard, B., David, W. F. and James, H. (2007).Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change in Climate Change: The Physical Science Basic. In: S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor, and H.L. Miller. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. pp. 129–234.

Gillespie P. (2002). Improving Bone Density and Building Stronger Bones. *Veterinary Professional Journal,* 10(2), 5 – 8.

Green N. P. O; Stout G. W. & Taylor D. J. (1997). *Biological Science* 3rd Edition. Cambridge University Press, Cambridge U. K.

Haywood, J. and Boucher, O. (2000). Estimates of the direct and indirect Radiative forcing due to tropospheric aerosols: A Review. *Reviews of Geophysics,* 38 (4): 513.

IRRDB (2001). International Rubber Research and Development Board. http://www.irrdb.org

Int Panis, L.L.R. (2008). The Effects of Changing Background Emissions on External Cost Estimates for Secondary Particulates. *Open Environmental Sciences* 2: 47–53.

Johnson G. B. & Raven P. H. (1999). *Biological Science*. 5th Edition, The McGraw Hill Companies, Dubuque, IA 52001 USA. pp 135-138.

Panalaks T. (1976). Determination and Identification of Polycyclic Aromatic Hydrocarbons in Smoked and Charcoal – Boiled Food Products by HPLC and *GC. Environ. Sci Health,* B11, 299-315.

Philips D. H. (1983). 50 Years of Benzo (a) Pyrene. *Nature, 303,* 468-472.

Seinfeld, J. and Spyros, P. (1998). *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change* (2nd ed.). Hoboken, New Jersey: John Wiley & Sons, Inc. p. 97

Tedder J. M. Nechvatal A. & Jubb, A. H. (1979). *Basic Organic Chemistry* – Part 5. Industrial Products, I. C. I. Ltd. Runicom.

Twomey, S. (1977). "The influence of pollution on the shortwave albedo of clouds". *Journal of the Atmospheric Sciences,* 34 (7): 1149–1152.

WHO (1983): Management of Hazardous Wastes. WHO Regional Publication No. 14, European Series, Copenhagen.

WHO (2000). Ambient Air Quality Guidelines. WHO Regional Office for South – East Asia.

Zielhuis, R. L. (1979). General Report: Health effects of trace metals , In: D. Ferrante (ed). Trace Metals: Exposure and Health: CEC/ Pergamon, 239-247.