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Emission of No_x, So_x and Co from the Combustion of Vehicle Tyres in an Abattoir

[1]DR. DIBOFORI-ORJI, A.N. [2]PROF. BRAIDE S.A.
[1]Senior Lecturer, Department of Chemistry
Ignatius Aguru University of Education, Rumuolumeni,Port Harcourt, Rivers State, Nigeria.
[2]Professor, Institute of Pollution Studies,
Rivers State University of Science & Technology, Nkpolu Port Harcourt, Rivers State Nigeria.

Abstract
Oxides of nitrogen (NOx), Sulphur (Sox) and Carbon II Oxide arising from the combustion of old tyres in an abattoir environment were measured. The method used was that of American Society for Testing and Materials (ASTM, D-3249-95, 2000). Air samples from the emitting environment were drawn and quantified by means of modules in the flue gas analyzer. Results obtained showed that the concentrations of NOx (0.73mg/m^3) and Sox (0.11mg/m^3) exceeded WHO Allowable limits (0.021-0.026mglm3 for NOx and 0.019mg/m^3 for Sox). However CO emission (0.67mg/m^3) was below the allowable limit. The health effects of pollutant emissions on man and recommendation for alternative use of waste tyres are also discussed in this paper.
Keywords: NOx, Sox, CO, Tyre, Emission, Combustion.

Introduction

Atmospheric (air) pollution, one of the major aspects of environmental pollution, results from the introduction of pollutants into the atmosphere either through gas flaring, bush burning, automobile and aircraft exhausts, metallurgical and chemical processes, power generation from coal burning and refuse incineration etc. These processes introduce pollutants such as carbon (II)oxide (CO), carbon (IV)oxide (CO_2), Nitrous oxides (NO_x), sulphur oxides (So_x), ash, trace metals, organic acids etc. into the atmosphere.

According to Schwatz (1994), air could also be polluted through emission of particulate matter (Black carbon) that occurs during the burning of fuels such as diesel or coal. The release of noxious gases such as So_x, CO, NO_x and chemical vapours and particulate matter could lead to air pollution. Hence, air pollutants are either particulates or gases. Gaseous and particulate pollutants may share some common sources, but create distinctly different kinds of problems.

CO is a colourless and an odourless gas formed when carbon in fuel is not burned completely. CO_2 is formed when carbon is completely burned in excess of oxygen. It is not generally regarded as a pollutant. The atmosphere is supposed to contain about 0.03% by volume of CO_2 in the atmosphere. However, CO_2 in perpetually being added to the atmosphere through fossil fuel burning since it is a natural end product of the complete combustion of carbon-bearing fuels (US-EPA, 1984). As a result of this, the concentration of atmospheric CO_2 has increased over 10% in the last century giving rise to an upsurge in the green house effect heating of the atmosphere.

The Combustion of vehicle tyres exudes a pungent smell which could probably be attributed to sulphur-bearing components. Sulphur (IV) oxide (SO_2) is the major sulphur gas produced via human activities which even in low concentrations could be hazardous. It is a colourless and poisonous gas with a strong unpleasant smell (Wong, 2002).

The main source of oxides of Nitrogen (NO_X) in an urban environment is combustion of fossil fuel, such as coal, petrol and other carbon containing materials such as tyres. The geochemistry of NOx in the atmosphere is complex since nitrogen and oxygen occur chiefly as free elements in air. The reaction between nitrogen and oxygen requires very high temperature for the formation of nitrogen (IV) oxide (NO_2). Other oxides of nitrogen include trioxonitrate (V) acid (HNO_3) and nitrogen (II) oxide (NO)

In Nigeria, some abattoir workers engage in combustion of old vehicle tyres as fuel to burn the fur on cattle skin. This process releases dark sooty smoke into the atmosphere. Tyre is composed of natural and synthetic rubber, sulphur, filler, accelerators, antioxidants, fabrics and optionally steel wires. For the fact that majority of the components of tyre are of hydrocarbon origin; and for the fact that very high temperatures are employed in the combustion processes, the emissions from such operations are most likely to contain air pollutants.

Therefore, this study was carried out to assess the emission of NOx, SOx and CO from the combustion of tyres in an abattoir. Suggestions are also proffered on ways to put such abattoir practice in check.

Materials and Methods

Instrument: a validated flue gas analyzer.
Sample: air drawn from different points within and around the experimental site (an abattoir).

The method used for the gaseous pollutant emission was that of the American Society for Testing and Materials (ASTM, D – 3249-95, 2000). Monitoring sites were classified into three types: upstream, midstream, downstream. In selecting a monitoring site, the wind direction was taken into consideration. The predominant wind direction at the time of monitoring, determined sites chosen as upstream, midstream or downstream as the case may be.

A validated Testo 350 XL flue gas analyzer was used. It is as instrument equipped to perform automatic analysis of air sample through the use of output signal. Air was continuously extracted from the atmosphere and a portion of the sample was sent to the analyzer for the quantification of the pollutant gases. The analyzer contains modules of different gases. Inserting the module of a particular gas automatically measures the quantity of the gas. In this way, modules for NO_x, SO_x and CO were used to quantify their concentrations in the air sample in mg/m^3

Results and Discussion

Results obtained from this study showed that emission of NO_X ($0.73mg/m^3$) and SO_X ($0.11mg/m^3$) exceeded WHO Allowable Limits ($0.026mg/m^3$) and ($0.019mg/m^3$) respectively. CO emission ($0.67mg/m^3$) was below the Allowable Limit of $10mg/m^3$ (Table I).The obtained values for NO_X and SO_X are worrisome because as primary pollutants they are capable of having harmful effects on public health especially the asthmatics, children and the elderly.

Apart from WHO standard for ambient air, the Environmental Protection Agency (EPA), States and Local Governments work as partners to reduce emission of environmental pollutants. The main approach is to establish National Ambient Air Quality Standards (NAAQS), to require national controls for motor vehicle emissions, combustion emissions from fuels and to require reduction from large industrial facilities. For this reason, the EPA Office of Air Quality Planning and Standard (OAQPS) and NAAQS has set standards for six principal pollutants known as criteria pollutants, as shown in Table II.

NO_2 formed during high combustion temperature, reacts with water vapour to give HNO_3, an irritant and highly corrosive substance (Wong, 2002). NO_2 contributes to the formation of ground level (tropospheric) ozone and fine particle pollution. It is linked with a number of adverse effects on the respiratory system. This includes airway increased respiratory symptoms in people with asthma. High levels of NO_2 are associated with worsening of already existing lung diseases. NO_2 combines in high concentrations with scorching sunlight to form photochemical smog. This occurs from the photochemical breakdown of NO_2 to produce NO and free oxygen atom (O) which reacts with molecular oxygen (O_2) in air from ozone (O_3). O_3 is an eye irritant and is detrimental to those with lung ailments (Dibofori-Orji, 2004).

High concentration of SO_2 can result in breathing problems with asthmatics while short-term exposure has been linked to wheezing, chest tightness, and shortness of breath (Wong, 2002). Its high solubility in water yields tetraoxo (VI) sulphate (H_2SO_4) which is highly corrosive. SO_2 is also an eye irritant. It is responsible for 60-70% of acid deposition that occurs globally (Pidwirny, 2001). SO_2 and NO_2 emitted into the atmosphere from various sources can fall to the ground as dry deposition. Like SO_2, NO_2 can be converted to acids in the presence of water.

The emission of SO_X from combustion of tyre can be traced to the presence of sulphur in tyre. To increase the tensile strength and durability of tyre, sulphur is usually incorporated as raw material during the vulcanization process. It is used to create strong chemical cross-links between intertwined polymers of rubber through disulphide bridges (IRRDB, 2001). When sulphur or sulphur containing compound is heated in abundant supply of air, SO_2 is formed.

Low emission of CO during tyre combustion might indicate high CO_2 emission. This is suggestive of high degree of complete combustion of the fuel material (tyre). CO_2 was not monitored in this study because CO_2 does not have any direct harmful effect on human health. As mentioned earlier, it is not regarded as a pollutant per se. However, anthropogenic CO_2 is rapidly on the increase due to increased man's industrial and technological activities. The grim effect of this is green house effect and global warming. CO is a more deadly pollutant and higher levels of it generally occur in areas with heavy traffic congestion. CO causes harmful health effects by reducing the delivery of oxygen to the body organs and tissues. It does this by combining with hemoglobin of blood to form carboxy hemoglobin which interferes with the oxygen-carrying capacity of blood, resulting in a state of tissue hypoxia (Neil, 1997). The amount of carboxy hemoglobin formed depends on the concentration and duration of exposure, ambient temperature, health and metabolism of the individual.

It is worthy to add that measured values used in this study were done midstream or within the emitting environment. Downstream measurements would be necessary to ascertain the extent of pollutants dispersion with respect to the prevailing wind speed and direction of the time of measurement and the communities most likely to be affected by the dispersed pollutants.

Table I: Mean values of NO_x, So_x, and CO (mg/m^3)

POLLUTANTS	MEASURED VALUE (mg/m^3)	WHO ALLOWABLE LIMIT (mg/m^3)	AVERAGING TIME
Oxides of nitrogen (NO_X)	0.73	0.021-0.026	1 hour
Oxides of sulphur (SO_X)	0.11	0.019	3 hours
Carbon monoxide (CO)	0.67	10.0	8 hours

Table II: US – EPA Standards for Six Principal Pollutants.

POLLUTANTS	SAFE CONCENTRATION ZONE ($\mu g/m^3$, ppm, ppb, mg/m^3)	AVERAGING TIME
Carbon monoxide	9ppm ($10mg/m^3$)	8- hours
Sulphur dioxide	0.017ppm (50 $\mu g/m^3$)	24 – hours
Nitogen dioxide	10ppm	1 hour
Ozone	0.075ppm	8 hours
Lead	0.15 $\mu g/m^3$	
Particulate matter (Pm10)	150 $\mu g/m^3$	24 hours
Particulate matter (Pm2.5)	15.0 $\mu g/m^3$	24 hours

Source: US Environmental Protection Agency (1984).

Conclusion/Recommendation

From the findings of this study, uncontrolled open-air burning of waste vehicle tyre results in atmospheric pollution via the emission of pollutants implicated with human health. Considering the chemical composition of tyres, combustion thereof could also release other hazardous compounds into the environment. According to Reisman, (1997), hazardous substances such as styrene, and 1, 3- butadiene which may be present in tyre-derived fuels is suspected human carcinogens. Open air burning of tyres may also contain polyaromatic hydrocarbon (PAHs). PAHs are a class of compounds derived mainly from the incomplete combustion of coal and other hydrocarbon – derived fuels. They are also implicated with cancer in human (Otti and John, 1978).

This study recorded low emission of CO which may also suggest low emission of PAHs. However, PAHs are capable of bioaccumulation in the cell, which might bring about uncontrolled growth of cells (cell mitosis) or cell mutation, over time. Appropriate measures should therefore, be taken to prevent their emission.

In conclusion, the practice of burning waste tyre to remove the fur on the skin of animals (cattle, goat etc) is an unwholesome practice that should be stopped. Perpetual exposure to the fumes from the burning tyres is hazardous to the health of abattoir workers and those residing within the abattoir.

It is therefore, recommended that waste tyres should be put to other uses such as fuel for municipal incinerators, to harness electrical energy for municipal electricity. Waste tyres could also be deployed in the manufacture of materials for asphalt pavement for road construction (Eleazar & Berlaz, 1992).

Reference

1. American Society for Testing and Materials (2000). United States – EPA, Washington DC 20402
2. Eleazer, W.E. & Berlaz, M.A. (1992). Technologies for Utilizing Waste Tyres in Asphalt Pavement in: Utilization of Waste Materials in Civil Engineering Construction. Inyang, H.L and Berges on, K.L. Eds. Proceedings of Sessions Sponsored by the Materials Engineering Divisions of Civil Engineers, Australia.
3. IRRB, (2001). International Rubber Research & Development Board: http://www.irrb.org
4. Neil, C. (1997). Hazards of Burning Tyres. Academic Press, New York.
5. Otti, W.R and John W.R ((1998). Everyday Exposure to Toxic Pollutants. Scientific American Report on Toxic Pollution
6. Pidwirny, A.J (2001) Environmental Pollution. 2nd Edition. The Megraw Hill Companies USA
7. Riesman, J.L. (1997). Air Emissions from Scrap Tyre Combustions. United State Risk Management. Environmental Protection Research Laboratory. I.A 45268
8. Schwartz, N.D (1994). Emissions of Air Pollutants ICI Ltd, Runicom
9. US-Environmental Protection Agency (2010). Standards for Six Pollutants. Environmental Quality Washington DC.
10. World Health Organization (WHO) (2000). Ambient Air Quality Guidelines, Who Regional Office for South-East Asia.
11. Wong, T.W (2002). Health Effects of Air Pollutants. Department of Community and Family Medicines, Chinese University Press, Hong Kong.

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