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# Possible Health Risk due to the Environmental Exposure of High Levels of Lead in Exhaust Soot of Automobiles in Parts of Accra, Ghana

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**Abstract**
Internal combustion engines produce soot as a result of incomplete gasoline and diesel combustion. Leaded exhaust soot emitted into the atmosphere has serious health and environmental concerns. Lead has been outlawed as an automotive gasoline additive in most countries including Ghana because of its cumulative toxicity in humans especially children and damaging effect on catalytic converters in automobiles. Nevertheless, leaded fuels are apparently being produced, imported and used illegally in some countries as octane rating booster because of its profitability. Refined gasoline and diesel are imported into Ghana through bulk oil distribution firms. This preliminary study assessed the level of lead in automotive exhaust soot from randomly selected automobiles in parts of Accra. Exhaust soot samples obtained from ten diesel and ten gasoline automobiles were collected for analysis of its lead concentration using atomic absorption spectrophotometry. The results showed the presence of lead in 4(40%) and 10(100%) of the randomly selected diesel and gasoline vehicular exhaust soot respectively. The concentration of lead in the exhaust soot of diesel-powered automobiles ranged from 0.060mg/kg to 0.435mg/kg and that of the gasoline-powered vehicles recorded values ranging from 0.195mg/kg to 2.055mg/kg. With this rather high level of lead in the vehicular soot, it could be concluded that the exhaust soot can be a significant source of lead in the atmosphere in parts of Accra. Lead exposure is known to cause debilitating developmental and neurological effects in children and cardiovascular effects in adults. The high levels of lead in the exhaust soot may be attributed to the possibility of lead additives in the gasoline and diesel used by those automobiles. Regulators of the petroleum downstream industry such as the National Petroleum Authority must routinely test for lead in imported refined petroleum products and enforce the ban on the importation, sale and usage of the outlawed leaded fuel in Ghana. Further studies should be conducted on the levels of lead in air and blood lead levels in fuel dispensers, fuel tanker drivers and fuel loading workers of bulk oil distribution firms.
**Keywords**: Lead, Exhaust, Soot, Gasoline, Automobile

## 1.0 Introduction

Gasoline (petrol) and diesel are the major sources of fuel in automobiles, generators and industrial plants (Almeida, 2015). Internal combustion engines produce soot as a result of incomplete fuel combustion of hydrocarbons. Gasoline and diesel usage have serious health and environmental concerns when incompletely burnt and especially when they contain lead additives. Lead is a naturally occurring toxic metal found in the earth's crust. Its extensive usage has resulted in significant human exposure and public health concerns in the world.

Tetraethyl lead was added to gasoline to reduce engine knocking and boost octane ratings (Scott, 2011) but leaded-fuels has been outlawed in most parts of the world because of its cumulative toxicity in humans and damaging effect on catalytic converters in automobiles (Copper, 2015). Nevertheless, leaded fuels are apparently being produced, exported and used illegally in some countries as octane rating booster because of its profitability (Chung, 2013).

Refined gasoline and diesel are imported into Ghana through Bulk Oil Distribution Companies. Leaded fuels were out-lawed in Ghana in 2003 by the enactment of the Petroleum Amendment Regulation L.I. 1732 and the regulation prohibited the production, importation, sale and usage of leaded gasoline.

Pollution created by vehicular exhaust emissions from diesel and gasoline vehicles has become a great source of concern because of the health threat it poses to the humans, animals and plants particularly when it has lead in it. The major sources of lead emissions in the air are leaded gasoline, metal processing, mining, industrial wastes, lead-based paints, leaded aviation fuel and lead-acid battery (WHO, 2016).

Lead exposure results in debilitating developmental and neurological effects in children and cardiovascular effects (high blood pressure and heart disease) in adults. The neurological effects in children include learning deficits, behavioural problems and lowered IQ. Adverse effects of lead exposure on kidney function,

reproductive systems and oxygen carrying capacity of the blood are well documented (WHO, 2016). Exposure of pregnant women to high levels of lead can cause miscarriage, stillbirth, premature birth and low birth weight, as well as minor deformities (WHO, 2016).

This study sought to determine the level of lead in automotive exhaust soot from randomly selected vehicles in parts of Accra.

## 2.0 Materials and Methods

### 2.1 Equipment and Reagents

The equipment used for the analysis is VARIAN AA 240FS- Atomic Absorption Spectrometer (VARIAN Inc., USA) using 30% of concentrated hydrogen peroxide ($H_2O_2$), 65-67% of concentrate nitric acid ($HNO_3$).

### 2.2 Sampling

Exhaust soot samples were randomly collected from 10 gasoline and 10 diesel automobiles in parts of Accra for analysis of its lead levels using atomic absorption spectrophotometer (AAS). Two grams (2g) of exhaust soot was collected from each of the 20 vehicles.

### 2.3 Hot Plate Acid Digestion of Exhaust Soot Sample

Two grams (2g) of exhaust soot sample was taken and put in a 100ml class A beaker. Twenty millilitres (20ml) of concentrated $HNO_3$ and 10ml of $H_2O_2$ were added to it in the fume chamber. The beaker was then covered with a cling film, placed on the hot plate and digested for 3 hours at a temperature of 45°C. After the acid digestion, the sample was transferred into a 30ml volumetric flask and was topped to the l00ml mark with distilled water. The whole content was then transferred into a test tube for analysis of lead (Pb) levels using AAS in an acetylene-air flame.

### 2.4 Lead Content Determination

The level of lead was determined by exposing the sample to a strong acid and moderate temperature which led to a thermal decomposition of the sample and the solubility of heavy metals in solution. The lead content was then quantified through the AAS elemental techniques at Nuclear Chemistry and Environmental Research Center (NCERC) of Ghana Atomic Energy Commission.

### 2.5 Calculation of Lead Concentrations in milligram/kilogram (mg/kg)

Since there was no dilution factor, final concentrations of lead (mg/kg) in the diesel and gasoline exhaust soot samples were calculated as shown below:

$$Final\ concentration\,(mg/kg) = \frac{concentration\,(mg/L)\ x\ nominal\ volume\,(ml)}{sample\ weight\ (g)}$$

### 2.6 Reference Standards

The reference standards (Sigma-Aldrich Inc, USA) used for the elements of interest, blanks and duplicates of samples were digested under the same conditions as the samples. These served as internal positive controls.

### 2.7 Quality Control/Quality Assurance

The following quality control and quality assurance techniques were used during the analysis:
Blanks: They were to check contamination during sample preparation.
Duplicates: To check the reproducibility of the method used.
Standards: To check the efficiency of the equipment used.

### 2.8 Calibration and recovery analysis

Calibration standards of 0.00, 2.00, 3.00 and 4.00 mg/L Pb as shown in table 1 were made by dilution of commercial BDH high quality standards for atomic absorption analysis. Calibration graphs as indicated in figure 1 were electronically generated which was used for the estimation of the concentrations of lead in the digested soot samples.

**Table 1: Calibration standards prepared for the AAS analysis**

| # | Pb standards | Mean Abs |
|---|---|---|
| 1 | 0.00 | 0.0000 |
| 2 | 2.00 | 0.0802 |
| 3 | 3.00 | 0.2006 |
| 4 | 4.00 | 0.4010 |

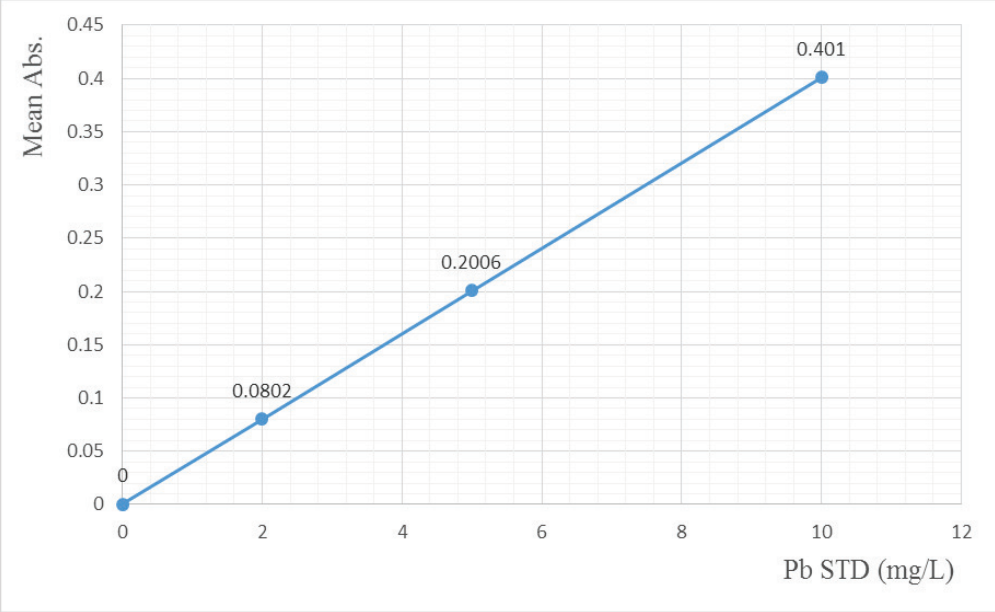


**Figure 1: Standard calibration curve for the samples**

A recovery test of the total procedure was carried out for lead by spiking analyzed samples with aliquots of the lead standard and reanalyzing the sample. The result for the recovery analysis for the metal was greater than 94.5 %.

## 3.0 Results

### 3.1 Concentration of Lead in Exhaust Soot

Figures 2 and 3 show the final concentrations of lead in the diesel and gasoline exhaust soot samples after calculations using the formula above. The final concentrations show traces of Pb in the vehicular exhaust soot sample.

According to figure 2, the ten (10) diesel soot samples had six (6) of the samples recording below the instrument detection limit while the other four (4) reported detectable values as per results shown. The highest value recorded was 0.435mg/kg and the lowest value was 0.060mg/kg.

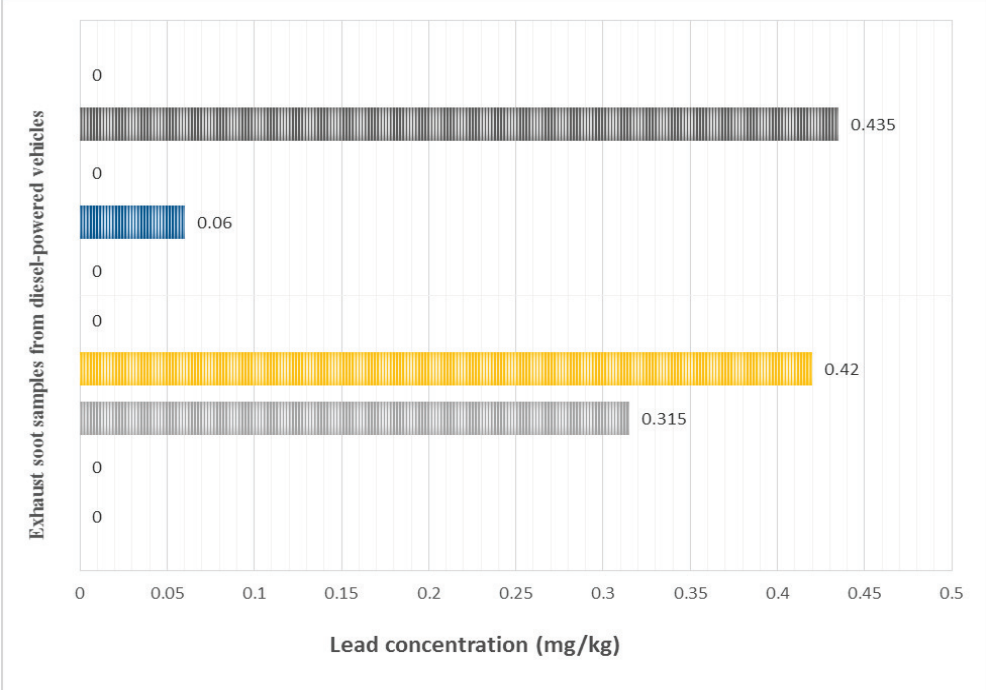


**Figure 2**: Lead concentrations in exhaust soot samples from diesel-powered vehicles

Figure 3 showed that the ten (10) gasoline soot samples presented higher concentration of lead than that of the diesel. For the gasoline soot samples the highest value recorded was 2.055mg/kg and lowest value recorded

 

was 0.195mg/kg.

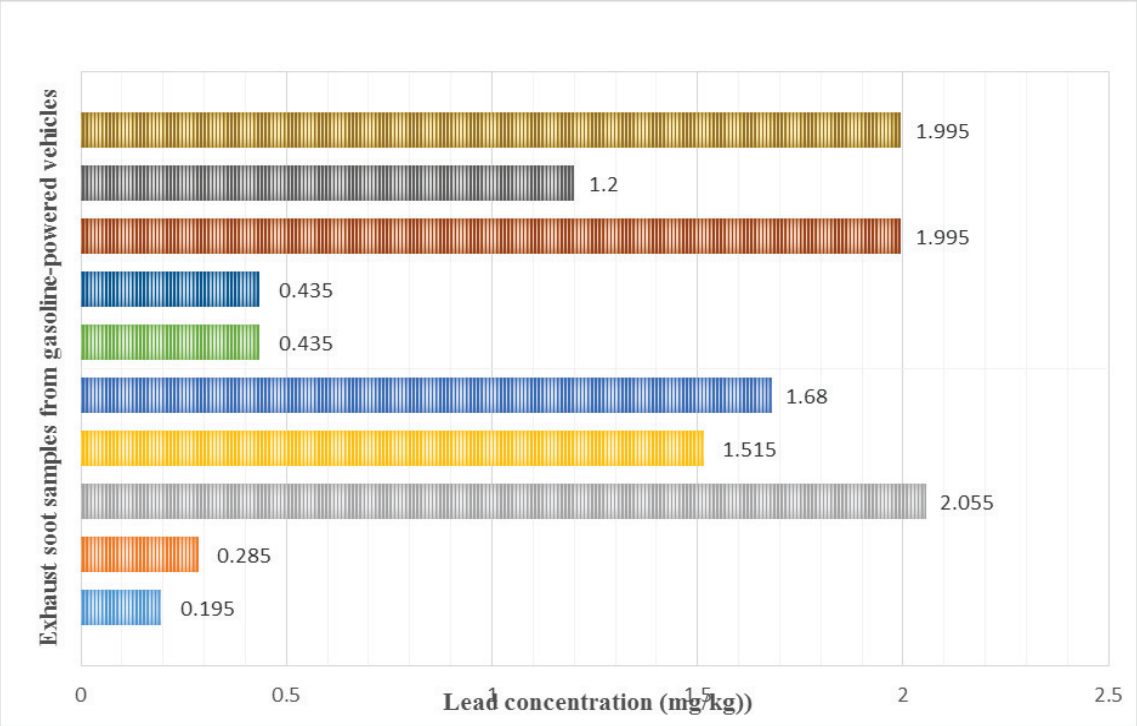


**Figure 3**: Lead concentrations in exhaust soot samples from gasoline-powered vehicles

**4.0 Discussion**

Exhaust from fuel combustion has long been associated with adverse health and environmental effects. The combustion of fuel results in the release of gases and particulate matter in the atmosphere. Some years ago, leaded fuel was a major source of air pollution in most countries due to the presence of tetraethyllead in automotive gasoline.

Since the ban of leaded fuel in the 21st century, the concentration of lead in the air has reduced considerably. Nevertheless, aviation fuel may not be regulated for lead content and so contain some lead in them (WHO, 2016). However, some unscrupulous individuals and institutions may continue to produce and trade in leaded gasoline due to their high profit margins (Kovarik, 2011) ignoring the massive health and environmental challenges that lead emissions bring to the population and ecosystem.

Exhaust soot produced from incomplete combustion of fuel are emitted into the atmosphere as pollutants. In situations where the soot contain high lead concentration, it is likely to result in adverse developmental and neurological effects in children and cardiovascular (high blood pressure and heart disease), reproductive and kidney function effects in adults (Akumu, 2012).

A study by Antwi-Baffour *et al* in 2015 reported mean blood lead concentration of 3.44µg/dl among fuel station attendants in selected areas in Accra. Although elevated blood lead levels is stated to be 10µg/dl, health effects are known to become apparent when the blood lead is <5µg/gl (CDC, 2012). It was thought that blood lead level of 5µg/dl was safe, but recent evidence is suggesting that such low blood lead levels may result in decreased intelligence, behavioural difficulties and learning problems in children (WHO, 2016). According to WHO, there is no known safe blood lead concentration but it is known that , as lead exposure increases, the range and severity of symptoms and effects also increases (WHO, 2016).

According to Nerquaye-Tetteh (2010) of the Environmental Protection Agency (EPA) of Ghana, the roadside lead levels reduced from a range of 2 —188 ug/$m^3$ in 2002-2003 before the phase out of leaded gasoline to a range of 0 – 0.38 ug/$m^3$ in 2008. She further stated that the mean blood lead level for subjects decreased from 26 ug/dl in 2003 to 5.33 µg/dl in 2006.

The source of lead pollutants are varied with leaded gasoline, metal smelting, mining, industrial wastes, leaded paints, leaded aviation fuel, lead-acid battery recycling, ingesting of leaded-contaminated dust, water from leaded pipes and food from lead-glazed containers (WHO, 2016). The relatively low lead recorded in the diesel automobile exhaust soot (0.060mg/kg - 0.435mg/kg) in this study may have emanated from exhaust pipes made of lead alloy or lead particles from the engine. Also, some weak engines may combust both the fuel and the engine oil which may contain lead due to leakages in the engine. Lead in engine oils have not been regulated

hence there is the possibility of the engine oil also containing lead.

However, there is also the possibility that the high level of lead in gasoline automobile exhaust soot (0.195mg/kg - 2.055mg/kg) is due to usage of leaded gasoline by these automobiles. Although, leaded gasoline has been outlawed in Ghana, some dealers may take advantage of regulatory lapses to trade in leaded gasoline to maximize their profits (Kovarik, 2011). This is because there is no measures in place to routinely check the possibility of leaded fuels being imported in Ghana. Moreover, the reported unavailability or the frequent breakdown of the equipment used to test for leaded fuels at the Tema Oil Refinery help to fuel the suspension that leaded fuels are being traded in Ghana although it has been outlawed. Although other additives could also boost the octane rating, leaded gasoline is known to be cheap to produce and profitable to sell (Kovarik, 2011).

It could be argued that the recorded concentration of lead in the exhaust soot of diesel-powered automobiles (0.060mg/kg to 0.435mg/kg) and that of the gasoline-powered vehicles (0.195mg/kg to 2.055mg/kg) may be a major source of lead pollution of the atmosphere. This situation calls for urgent steps to monitor and control the possible sources and routes of lead pollution of the atmosphere due to the debilitating health effects on humans, particularly children.

According to the United Nations Environmental Programme (2016), there are now only three countries (Algeria, Yeme and Iraq) that continue widespread use of leaded fuel. In Ghana, the National Petroleum Authority (NPA) regulates, oversees and monitors the petroleum downstream industry according to the NPA Law 2005 (ACT 691). Since lead is outlawed in Ghana, there is the possibility that there is no routine monitoring for lead in gasoline imported into the country by Bulk Oil Distribution Companies and gasoline sold at the pump at the fuel service stations.

## 5.0 Conclusions

This study has demonstrated the high level of lead in automotive exhaust soot ranging from 0.060mg/kg to 2.055mg/kg and therefore exhaust soot and fume could be contributing significant amounts of lead into the atmosphere with its attending adverse health and environmental effects. The high lead concentration in vehicular exhaust soot may be due to the usage of leaded fuel being imported into the Ghanaian market at the blind side of the authorities. Regulators of the petroleum downstream industry such as the National Petroleum Authority must routinely test for lead in imported refined petroleum products and enforce the ban on the importation, sale and usage of the outlawed leaded fuel in Ghana. Further studies should be conducted on the blood lead level in fuel dispensers, fuel tanker drivers and fuel loading workers of bulk oil distribution firms.

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## References

Akumu, J. (2012). Harmful Effects of Leaded Gasoline. http://www.unep.org. Accessed 10 June 2015.

Almeida, A. (2015). Diesel vs. Unleaded Gasoline. http://www.carsdirect.com. Accessed 15 June 2015.

Antwi-Baffour, S., Darko, E., Adjei, D., Kyeremeh, K. (2015). Effects of blood lead levels on haematological indices of fuel station attendants. *Advances in Biochemistry Biotech*. 1(1) 1-10.

CDC (2012). Fourth National Report on human exposure to environmental chemicals. US Department of Health and Human Sciences.

Chung, K. (2013). TEL for MOGAS manufacture in China – LEAD project final report. The LEAD Group Incorporated.

Cooper, D. (2011). Leaded vehicular fuel and the global effort to eliminate lead poisoning: Factors constraining the global endeavour to eliminate lead additives from vehicular fuel, The LEAD Group Inc., Summer Hill. https://www.lead.org.au. Accessed 16 June 2015.

Kovarik, B. (2011). Leaded gasoline. http://www.sourcewatch.org. Accessed 24 November 2016.

Nerquaye-Tetteh, E. (2010). Vehicular Emissions Reduction Programme in Ghana - UNEP. http://www.unep.org/transport. Accessed 2 June 2015.

Scott. (2011). Why lead used to be added to Gasoline. http://www. todayifoundout.com. Accessed 15 May 2015.

UNEP (2016). Leaded petrol phased-out: global status as at June 2016. http://www. unep.org/ Accessed 25 November 2016.

WHO (2016). Lead poisoning and health. http://www. who.int. Accessed 25 November 2016.