Assessing the Presence of Soil Lead Contamination on the Premises of Air Liquide Ghana Limited in Tema, Ghana

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Authors’ contributions

This work was carried out in collaboration among all authors. Author PMG designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AS and FOA managed the analyses of the study. Authors MM and CTE managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to determine the extent of site contamination by Lead (Pb) present in the soil on the premises of Air Liquide Ghana Limited, and give the appropriate recommendation for decontamination, where necessary. Eighteen (18) soil samples were collected from the study area using an augur. The geographical coordinates and elevations of the samples were recorded with the GPS. The samples were analyzed in the laboratory using Atomic Absorption Spectrophotometer. In the absence of present standards from the Ghana Environmental Protection Agency (EPA), both the Dutch List and the International List standard were used to evaluate the concentration levels of Pb in the soil. Results from the analysis revealed that the concentration of lead (Pb) initially exceeded the international threshold of the Dutch intervention value of 530 mg/kg.
in some sample areas. Nine locations of the sample areas where diesel was being stored, S2-Diese Tank and Smoking Area S5-Smoking Area recorded values of 636.4 mg/kg and 602 respectively which is above the recommended threshold. The control recorded below the threshold value of 530 mg/kg. The study also showed that Lead compounds attached to soil particles took a shorter time to break down to reduce the levels of concentration over time.

**Keywords:** Lead; Air Liquide Ltd; Tema; industrial waste; heavy metal.

1. **INTRODUCTION**

Lead (Pb) occurs naturally in soils, typically at concentrations that range from 10 to 50 mg/kg [1]. Lead is one of the abounding heavy metals within and on the earth’s crust [2]. Although it is a very useful metal, the availability of lead, especially beyond the acceptable standards, poses a danger to environmental and human health problems. Since lead is stable in contaminated sites, and because of its complexity of mechanism in biological toxicity [3], it is most dangerous for children below six years as it can cause their mental retardation when lead exists with an abnormal concentration in a liquid body substance. Lead (Pb) contamination has been found in gasoline, paint, air, water, interior dust, soil and food [4,5]. Heavy metals are non-degradable and persistent, their presence in soil is stable and long-term [6].

A WHO/FAO published report recommends that we should consume a minimum of 400 g of vegetables and fruits per day, excluding potatoes and other starchy tubers, for prevention of chronic diseases such as heart diseases, cancer, diabetes, and obesity, and for prevention and alleviation of several micronutrient deficiencies, especially in less developed countries [7]. In the past five decades, 800,000t of lead have been released into the environment globally, much of which has accumulated in soil resulting in serious levels of pollution [8]. In areas within the vicinity of mining and industrial establishments, ingestion of soil and dust contaminated with heavy metals is a primary source of lead exposure [9,10]. Ghana, in West Africa, has a long history of lead use [11]. Leaded petrol was in use till 2004, whereas used and new lead-acid batteries are still common imports. A lot of lead-acid battery recycling factories dots the country. Tema, Ghana’s largest seaport and a major Centre for industrial activity, is among the nation’s suspected hot spots for lead contamination. Despite this, there is no adequate data to map out lead-contaminated sites for authorities to prepare suitable clean-up plans. In effect, Ghana does not have safe blood lead reference levels to help guide decisions, on heavy metal control and management.

Air-Liquide Ghana Ltd is a company based in the heavy industrial area of Tema, of the Greater Region of Ghana, which produces a range of industrial and medical gases, and supplies to the oil and gas, mining, automotive and fabrication, food and pharma markets, and healthcare outlets. It has been involved in this business for over sixty years with over sixty employees within its premises alone, excluding casual carrier labourers. Air-Liquide Ghana Ltd before December 2016 shared a wall with Gravita Ghana Limited, a company which was involved in the production and recycling of lead (Pb) heavy metal. The activities of this company were believed to have caused contamination of Pb in the premises of Air Liquid Limited.

A series of studies were carried out to assess the levels of Pb concentrations in the soils within the premises of Air-Liquide Ghana Ltd. These studies, at three different times, were carried out in December 2016, April 2018 and November 2018, respectively. The studies were conducted to ensure that the workers of Air-Liquide Ghana Ltd and visitors to the premises are safe from the contamination of Pb in line with environmental policy of the Government of Ghana.

2. **MATERIALS AND METHODS**

The three (3) acre premise of Air-Liquide Ghana Ltd, which is located in Tema, within the Tema Metropolitan District of the Greater Accra Region of Ghana, is surrounded by Gravita Ghana Limited to the south-west, a fallow land to the north-west and northern part, MTN and Reroy Cables offices at the east, and the Tema branch of Driver and Vehicle Licensing Authority (DVLA) of Ghana to the south. The entire area can be located between latitudes 5°41’12”N and 5°41’15”N and longitudes 0°0’09”W and 0°0’03”W. The location of the site in relation to other companies is provided in Fig. 1.
2.1 Soil Sampling

Soil samples were collected at the premises of Air Liquide Ghana Ltd at two levels of depths (0-50 cm and 50-100 cm) giving a total of 14 samples. Four (4) soil samples were also collected at MTN and Medisoft company road junctions, outside the premises of Air Liquide Ghana limited, as control. These samplings were done in the years 2016 and 2018 in December and April. Soil properties such as depth, colour, and texture, and structure, consistency, contents of gravel, stones and concretions were recorded. In addition to providing site information of the pits, geographical coordinates and elevations were also recorded with a GPS.

2.2 Laboratory Assessment

Soil samples were analysed using the Council for Scientific and Industrial Research (CSIR) standard procedure. The parameter determined at the laboratory was heavy metal, lead (Pb): The determination of heavy metal concentrations in the soils was by the Atomic Absorption Spectrophotometer (A.A.S).

3. RESULTS AND DISCUSSION

The concentrations of lead in the soils were evaluated using both the Dutch List (530 mg/kg), and the international list standards (US EPA threshold of 400 mg/kg), in the absence of present published standards from Ghana EPA, for ease of comparison.

According to the laboratory results, topsoil (0-50 cm) lead (Pb) values at the sampled points were generally above the thresholds in Dec 2016 and Apr 2018 but fell below the US EPA threshold of 400 mg/kg and the Dutch intervention value of 530 mg/kg (Fig. 2a).

Thus, a comparison of November 2018 values with values from the previous two studies (in April 2018 and December 2016) show that lead (Pb) concentrations in the soils reduced considerably from an average of 1583 mg/kg to 210 mg/kg and then to 98 mg/kg in both topsoils (from 466 mg/kg to 274 mg/kg and then to 140 mg/kg) and sub-soils (2700 to 121 and then to 55 mg/kg) from December 2016 through April 2018 to November 2018 respectively.

In spite of these significant reductions, some locations witnessed some increases in November 2018 compared to April 2018 values. Smoking area 1 (surface) increased from 108 mg/kg to 188 mg kg in the topsoils (Fig. 2a), whereas Smoking area 2 (bottom) also increased from 79 mg/kg to 111 mg/kg in top and subsoils (Fig. 2a and 2b). Lime area 1 (surface) witnessed an increase from 113 to 134 mg/kg and Diesel Tank area (subsoil) increased from 14 mg/kg to 64 mg/kg (Fig. 2b). There were also marginal
increases at locations such as O₂ Plant and Quads areas in both top and subsoils (Fig. 2a and Fig. 2b). Given the lighter texture of the soil at the site, it is possible for soil water movement to be fluid and consequently move concentrations of heavy metals, including lead, through the soil, vertically down the profile and horizontally from one location to another. In spite of these movements, concentration levels have been decreasing over time partly due to leaching of the mineral through the soil [11,12].

However, the levels in November 2018 were all within the safety range (Chen, 1997; Tiwari et al. [3]; Hung et al., 2018) with respect to the health of staffs and visitors. Lead is naturally present in all soils averaging between 15 and 40 milligrams lead per kilogram of soil (mg/kg). Thus, it can be inferred from Fig. 2a and 2b that the rate of probability of encountering lead (Pb) concentrations has been reducing over time, which is good for the safety levels of the concentrations within the premises of Air Liquid Limited.

Aboh et al. [13] determine the concentration of lead in soil from selected sites in Tema and how these levels relate to local pediatric blood lead predictions and found out that lead exposure positively demonstrated high levels of contamination, in some areas exceeding the U.S. and other national regulatory limits.

![Fig. 2a. Lead concentrations in topsoils within Air Liquide and threshold value](image1)

![Fig. 2b. Lead concentrations in subsoils within Air Liquide and threshold value](image2)
Physical field tests of the soil particles were generally dark brown to olive loose sandy soils, which fall within Cumulic Anthrosols (ATc) under the FAO Soil Map of the World soil classification [14].

4. CONCLUSION

The physical properties of the soils notably the texture, colour, etc., are very good and clearly indicate the capability of aiding in leaching of heavy metals. Lead heavy metals which tend to give rise to the greatest amount of concern with regards to human health, agriculture and ecotoxicology, were present in a minimum amount in the soil, except at a medium level (slightly above the threshold of 530 mg/kg) at the S2-Smoking area 2 and the S5-Diesel Tank Area locations with records of 636.4 mg/kg and 602.1 mg/kg respectively within Air Liquide premises. It can be deduced from the study that Lead compounds attached to particles in the soils have taken a shorter time to break down to reduce the levels of concentration over the time period since the previous study in December 2016. It can, therefore, be inferred that the soils in Air Liquide premises are now free from Lead contamination suspected to be emitted from Gravita Ghana Limited who are into the recycling of lead. Thus, current Lead concentrations in the soils within Air Liquide premises do not pose any danger to human health. Soil, as a complex natural body [15] that has the ability to heal or cleanse itself from heavy metal contamination when given the time to do so [16,17,18].

There is no need for any remediation as Gravita Ghana Limited has stopped its operations and therefore will not cause any further contamination. It is therefore recommended that the area should be limed if there is an increase in lead concentration in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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