INVESTIGATION OF SOIL CONTAMINATION AT LEAD BATTERY RECYCLING PLANTS IN DOUALA CAMEROON

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Executive Summary

Lead battery recycling is poorly regulated in Cameroon. This investigation of the three licensed recycling plants in Douala, Cameroon has revealed extensive soil contamination inside the plants and in surrounding residential areas. The overall mean soil lead level from the 23 samples was 22,952 parts per million (ppm or 2.2%) with levels inside the facilities ranging up to 76,000 ppm (7.6%). Soil lead contamination at the fence lines of the three plants tested, ranged from 17,000 ppm to 150,000 ppm (1.7% to 15%). One of the three facilities had no baghouse or other apparent air filtration on the furnace emissions. None of the facilities is operating with negative pressure enclosures or any ventilation for dust or fume generation processes. There is an immediate need to address the regulatory gaps identified and the lack of adequate infrastructure at these facilities to protect public health and the environment.

1. Introduction

Lead battery recycling is an extremely hazardous industry that receives little attention in Cameroon and other African countries. The objective of this study is to evaluate potential lead soil contamination in and around licensed lead battery recycling plants in Cameroon which are all located within Douala city limits.

This report updates an investigation carried out in 2017 in Cameroon and six other African nations that was later published in Environmental Research. (Gottesfeld, P, et al. 2018)[1]. Additional studies published from other African countries have also demonstrated that lead-acid battery recycling facilities operate with significant lead emissions that result in soil contamination at levels that have serious public health implications. Although emissions from lead battery recycling are a global problem, rapid urbanization, a growing vehicle fleet and the increasing demand for backup

[1] Gottesfeld, P., Were, F. H., Adogame, L., Gharbi, S., San, D., Nota, M. M., & Kuepouo, G. (2018). Soil contamination from lead battery manufacturing and recycling in seven African countries. *Environmental research*, *161*, 609-614.

power storage applications has spurred the growth of lead battery recycling industries in many African countries including Cameroon.

Previously we documented off-site lead contamination from lead recycling plants in neighboring communities in Douala. The 2018 investigation identified high levels of lead in soils around the licensed lead battery recycling plants operating at that time (METAFRIQUE Cameroon SA and BOCOM recycling). Despite making specific recommendations to improve operations and minimize the impact of this industry, the Ministry of Environment, Protection of Nature and Sustainable Development (MINEPDED) has issued environmental permits for two new plants in Cameroon without strengthening the regulatory requirements for environmental emissions.

We report on lead soil contamination inside, at the perimeter and in surrounding neighborhoods of the three licensed lead battery recycling plants currently operating in Cameroon. In addition, during our site visits we observed the inadequate air and water pollution controls at the three facilities.

It is intended that the findings of this study will be used to inform Cameroon's participation in the revisions to the Basel Convention's Waste Lead Batteries Technical Guidelines currently under review. In addition, the findings of this report can help inform the MINEPDED in the development of national regulations and industry-specific standards to address the environmentally sound management of used lead-acid batteries (ULABs).

2. Sampling and Analytical Procedures

According to information from the Ministry of Environment (MINEPDED), there are currently three licensed lead battery recycling plants in Cameroon (METAFRIQUE Recycling Cameroon, KYSEN and GANESHA) located in the Douala metropolitan area, the economic center of Cameroon with over 2 million inhabitants. The BOCOM recycling plant that previously operated in Douala was reported to have stopped recycling lead batteries.

In preparation of the field work we obtained a letter issued by the Minister of Environment to lead battery recyclers informing them about the project, its importance in helping Cameroon fulfill its commitments within the Basel

Convention, and seeking their collaboration by allowing access to their facilities. Site visits were scheduled in coordination with local staff of the Ministry in the Wouri Division who participated in the investigation of these recycling plants.

Soil samples were taken at the soil surface (at depths of 0-3 cm) at locations on the interior and exterior of these facilities. Samples were collected from either a single location or as composite samples collected with multiple aliquots at the two edges and center of 1 m^2 area of bare soil. Each sample was collected directly with plastic sampling tube or a hand trowel and placed in a labeled Ziplock plastic bag The hand trowel was cleaned with tissue paper and alcohol after collecting each sample to minimize cross contamination. All sample containers were properly labeled with a permanent marker indicating the sampling number, the initials of the plant's name or neighborhood location. Soils samples were collected inside these facilities, outside at the fence line and in adjacent neighborhoods as described below.

2.1. METAFRIQUE Cameroon SA

METAFRIQUE Cameroon SA is located in the BASSA industrial zone neighboring the Oyack residential quarter in Douala. It is located one block north of METAFRIQUE Steel plant (that previously recycled lead batteries but is reportedly only recycling scrap metal into rebar). During the field visit on July 6, 2023, we toured the plant and obtained the cooperation of the plant's management, including information used in selecting sample locations inside the facility.

Three samples were taken inside METAFRIQUE Cameroon SA and three from outside the perimeter of the plant. In addition, we collected nine samples from surrounding neighborhoods mainly within the Oyack residential quarter. These samples were collected from 50-500 m from the plant in residential areas north and northeast of the plant close to a school, hospital, and food shops.

2.2. KYSEN Global Sarl

KYSEN Global Sarl lead battery recycling plant in Douala is located around 600 meters from METAFRIQUE Cameroon SA in the BASSA industrial zone. The plant was licensed and operational since 2022, making it the most recent lead battery recycling plant among the three included in this study.

During the field visit on July 6, 2023, we toured the interior of the plant and collected two samples, one close to the entrance of the hanger hosting the recycling equipment and another on a bare soil 50 meters from the main hangar.

2.3. GANESHA Cameroon Sarl

GANESHA Cameroon Sarl is located in the Bonaberi Free Enterprise Zone, in the western Douala metropolitan area. The plant which was established in 2018 is adjacent to agricultural land where corn and vegetables are grown and there is a food company situated about 300 m east.

During the field visit on July 6, 2023, the CREPD team met with the plant management who facilitated access to the site. Three samples were taken inside GANESHA Cameroon Sarl plant at the two entrances on the main hangar. Outside the plant, one sample was collected close to the fence line and two composite samples were collected at approximately100 and 350 m from the plant in agricultural fields.

3. Results

A total of 23 soils samples were collected and shipped to EMSL Analytical, Inc, an accredited laboratory in the U.S. under the National Lead Laboratory Accreditation Program (NLLAP) for lead analysis in soil. Analysis was performed with EPA SW-846 Test Method 7000B for Flame Atomic Absorption Spectrometry. The sample results are listed in Table 1. Soil lead concentrations ranged from less than 40 parts per million (ppm) to 150,000 ppm. The mean soil lead level was 22,952 ppm.

Table 1: Lead Concentrations in Soil Samples

Sample Number	Company	Sample Location	Result (ppm)
MA1	METAFRIQUE	Inside the recycling plant, behind the battery's storage yard	**58,000**
MA2	METAFRIQUE	Inside the recycling plant, behind the battery's storage yard	**38,000**
MA3	METAFRIQUE	Inside the recycling plant, behind the battery's storage yard	**21,000**
MA4	METAFRIQUE	Outside the recycling plant, close to the front fence	**22,000**
MA5	METAFRIQUE	Outside the recycling plant, close to the front fence	**32,000**
MA6	METAFRIQUE	Outside the recycling plant, close to the front fence	**17,000**
MA7	METAFRIQUE	Neighborhood of the recycling plant at about 80 m away	**6,500**
MA8	METAFRIQUE	Neighborhood of the recycling plant at about 80 m away	**5,000**
MA9	METAFRIQUE	Neighborhood of the recycling plant at about 80 m away	**4,900**
MA10	METAFRIQUE	Neighborhood of the recycling plant, within the OYACK residential area	**780**
MA11	METAFRIQUE	Neighborhood of the recycling plant, within the OYACK residential area	**460**
MA12	METAFRIQUE	Neighborhood of the recycling plant, within the OYACK residential area	**730**
MA13	METAFRIQUE	Neighborhood of OYACK residential area about 500 m, close to Centre Medical OYACK	**< 40**
MA14	METAFRIQUE	Neighborhood of OYACK residential area about 500 m, close to Centre Medical OYACK	**48**
MA15	METAFRIQUE	Neighborhood of OYACK residential area about 500 m away, close to Centre Medical OYACK	**< 40**
MAP	METAFRIQUE	Neighborhood of the recycling plant, about 500 m away in the High School	**71**
KA2	KYSEN	Inside the recycling plant, at entrance of the smelting yard	**76,000**
KA3	KYSEN	Inside the recycling plant, away from the smelting yard	**8,300**
GA1	GANESHA	Inside the recycling plant, close to the back fence entrance	**3,7000**
GA2	GANESHA	Inside the recycling plant, close to the front office	**22,000**
GA3	GANESHA	Outside the recycling plant at about 10 m away on a bare soil	**150,000**
GA4	GANESHA	Outside the recycling plant at about 100 m away in agricultural land	**28,000**
GA5	GANESHA	Outside the recycling plant at about 350 m away in agricultural land	**72**

Mean	**22,952**
Median	**8,300**

Table 2 presents the arithmetic mean (average) lead concentrations from soils collected within the lead recycling plants. The overall mean soil lead concentration inside the three plants (Metafique, GANESHA and KYSEN) was 37,000 ppm with levels ranging from 21,000 to 76,000 ppm. The average soil concentration at the fence lines of METAFRIQUE Cameroon SA was 23,666 ppm with a range from 17,000 to 32,000 ppm (Table 1). The only sample collected on bare soil outside GANESHA Cameroon Sarl had a lead concentration of 150,000 ppm.

Table 2. Mean lead concentrations in soils inside lead battery recycling plants

Recycling Facility	Average (ppm)
GANESHA Cameroon Sarl	29,500
KYSEN Global Sarl	42,150
METAFRIQUE Cameroon SA	39,400

The soil lead concentration in the neighborhoods around METAFRIQUE Cameroon SA and GANESHA Cameroon Sarl plants ranged from less than 40 to 28,000 ppm (Table 1). All the three plants had soil sample locations that exceed 800 ppm, the screening level that U.S. Environmental Protection Agency (EPA) uses for lead in soil for non-residential sites.

The results generally showed a decreasing trend in soil lead levels with distance from the recycling plants for samples collected in the neighborhoods around METAFRIQUE Cameroon SA and GANESHA Cameroon Sarl ranging from 80 – 500 m away. Lead soil contamination was noted in the range of 730 to 6,500 ppm around the METAFRIQUE Cameroon SA facility, and around the GANESHA Cameroon Sarl plant lead soil contamination ranged from 72 to 28,000 ppm.

Cameroon has no regulatory requirements for lead soil contamination. Note that California uses 320 ppm as the lead screening level for commercial or industrial properties. However, cleanup goals are generally set based on specific site conditions and vary based on the results of a human health risk assessment based on the exposed population, exposure duration, bioaccessibility and other factors. In the U.S. and Mexico, a lower lead soil contamination standard of 400 ppm is

applied to residential areas. In California, the state government uses a residential screening level of 80 ppm.

4. Observations Regarding Environmental and Occupational Controls

Direct observation and interviews with workers at these facilities revealed that the collection of ULABs and the transportation to the recycling plants are not done in an environmentally sound manner. Existing practices differ from Basel Convention Guidelines as outlined below:

- Recyclers purchase dry batteries after collectors drain the electrolyte acid from used batteries. This is contrary to the Basel Convention Guidelines stating that "draining needs to be handled at licensed, permitted or authorized dismantlers or smelters, who have proper procedures in place to collect and manage the acid."[2]
- Used lead batteries are transported to the plants loosely loaded in ordinary lorries. The Basel Convention Guidelines call for the batteries to be placed in containers or on a pallet and arranged in layers of equal height and separated by cardboard or other material to minimize movement during transit. The pallets should be shrink-wrapped with plastic and strapped to minimize any movement.
- Generally, there are no measures in place to control the leaking of battery acid during transport as observed in a lorry truck bringing used lead batteries to the GANESHA plant.
- At all the three plants, discarded batteries are kept in piles outdoors and/or in the hangar on a concrete surface with no precautions to collect the leaking acid.
- At all the three plants there is no effluent treatment plant to treat acidic waste or runoff before it is released into the environment.

[2] UNEP, Basel Convention, Technical guidelines for the environmentally sound management of waste lead-acid batteries (2003), available at: https://www.basel.int/Portals/4/Basel%20Convention/docs/pub/techguid/tech-wasteacid.pdf

Figure 1. ULABs storage and battery breaking area at METAFRIQUE Cameroon SA.

Although the three plants are located within industrial zones, other siting recommendations in the Basel Guidelines are not being followed (See figures 2 and 3). We noted the following discrepancies:

- The METAFRIQUE Cameroon SA and KYSEN Global Sarl facilities are located adjacent to residential areas.
- The GANESHA Cameroon Sarl site is surrounded by agricultural fields and adjacent to a food and beverage company.

Figure 2. METAFRIQUE Cameroon SA (red circle) is located in a densely populated residential area of Douala City. Google Earth (2023) *Douala* https://earth.google.com/web/ (Accessed: 18 July 2023).

Figure 3. GANESHA Cameroon Sarl (red circle) plant located in an agricultural area. Google Earth (2023) *Douala* https://earth.google.com/web/ (Accessed: 18 July 2023).

At all three plants the battery breaking is done manually with parts being separated by workers without proper personal protective equipment. Manual battery breaking

is associated with very high occupational exposures and extensive site contamination and therefore indoor mechanical breaking with adequate ventilation is recommended.

The KYSEN Global Sarl and GANESHA facilities have a baghouse filter on their furnace emissions. However, the METAFRIQUE Cameroon SA facility has no controls in place for furnace emissions. None of these facilities have any ventilation or air filtration system and none operate with negative pressure enclosures. Consequently, releases of airborne lead from the recycling processes, along with fugitive emissions from these substandard facilities are likely to contributing to airborne emissions and soil lead contamination at levels associated with elevated blood lead levels in children.

ULAB recycling facilities are known to produce waste products including dross, slag, floor sweepings, and baghouse wastes which are generally classified as hazardous waste. None of the three plants visited have in place a system for the management of these waste streams.

There is no system for tracking hazardous waste generated within the ULAB recycling plants visited. For example, a sanitation company (SECA Cameroon) contracted to dispose of the smelting residues collected from GANESHA Global Sarl does not own a licensed hazardous waste landfill nor any kind of hazardous waste treatment facility to appropriately fulfill its contract. No information was available on the ultimate disposal of slag and other residues collected from any of the three facilities.

Figure 4. Untreated effluent discharged into an adjacent residential area outside of METAFRIQUE Cameroon SA. Note the corrosive effect of the acidic effluent on the concrete.

Figure 5. Baghouse at KYSEN recycling plant (left) and partial view of the GANESHA Cameroon Sarl plant (right).

5. Comparative levels of contamination reported in other studies

Lead levels of soils inside lead batteries recycling plants in Cameroon reported in this study range from 21,000 to 76,000 ppm reflecting extensive site contamination. This level of contamination is similar to those reported for soil samples collected inside lead battery recycling plants in Ghana with a range from 740 to 130,000 ppm (P. Gottesfeld et al. 2018). The same authors reported lead soil contamination ranging from 480 to 140,000 inside lead batteries recycling plants in Nigeria.

Similarly, Adie and Osibanjo (2009)[3] reported lead concentrations in soil collected inside the premises of a shuttered lead battery manufacturing plant in Nigeria in the range of 243 to 126,000 ppm with 98% of the samples greater than 400 ppm.

Lead soil contamination at the fence lines at the three plants in Cameroon ranged from 17,000 ppm to 150,000 ppm. These lead levels are higher than the levels reported from outside ULAB recycling plants near a secondary lead smelter in northern France with lead values ranging from 880 to 9,030 ppm.[4] Similarly, these results are significantly higher than the results reported from seven African countries by Gottesfeld et al. (2018) indicating an overall mean lead concentration of 2,600 ppm.

We found soil lead concentrations in agricultural fields and residential neighborhoods surrounding these plants ranging up to 28,000 ppm. In comparison, surface soil lead concentrations in an area outside of a formal sector lead battery recycling plant in Banten Indonesia ranged from 240 to 1,780 ppm at distances from 300 to 600 m from the plant.[5] Overall the results from this study reflect extensive lead soil contamination on and off-site in locations surrounding these facilities.

[3] Adie, Gilbert U., Osibanjo, Oladele, 2009. Assessment of soil-pollution by slag from an automobile battery manufacturing plant in Nigeria. Afr. J. Environ. Sci. Technol. 3, 9.

[4] Schneider, Arnaud R., et al., 2016. Lead distribution in soils impacted by a secondary lead smelter: experimental and modelling approaches. Sci. Total Environ. 568, 155–163. Schoof, R.A., Johnson, D.L., Handziuk, E.R., Van Landingham, C., Feldpausch, A.M., Gallagher, A., Dell, L.D., Kephart, A., 2016. Assessment of blood lead level declines in an area of historical mining with a holistic remediation and abatement program. Environ. Res. 150, 582–591.

[5] Adventini, N. et al. 2017. Lead identification in soil surrounding a used lead acid battery smelter area in Banten, Indonesia. In: Proceedings of the International Nuclear Science and Technology Conference Journal of Physics: Conference Series 860.

6. Environmental health implications of these findings

Several studies have demonstrated that soil contamination near lead battery recycling plants can lead to significant lead exposures in surrounding communities.[6,7,8] A review summarizing available published studies showed elevated blood lead levels among children living in the proximity of lead battery recycling plants in developing countries averaged 29 µg/dl.[9] The Kenyan Ministry of Health documented elevated blood lead levels in the Owino-Uhuru Settlement adjacent to a now shuttered lead battery recycling plant in Mombasa County, Kenya.[10] A study documenting blood lead levels from over 800 children in communities around a lead battery recycling facility in Brazil found decreasing blood lead levels with increasing household distance from the plant.[11]

To our knowledge there is no data on blood lead levels among the populations living near these lead battery recycling plants in Cameroon. There is a need to fill this gap by developing capacity for blood lead testing to better assess exposures particularly in the Oyack quarter where we noted alarming levels of lead soil contamination in an area occupied by poor and marginalized communities.

7. Conclusions

Cameroon has no industry-specific regulatory requirements for soil contamination, ambient air levels, stack emissions and occupational health and safety that apply to lead battery recycling. Without significant regulatory improvements, the recycling plants visited are unlikely to invest in adequate pollution control equipment that is standard for ULAB recycling plants in other countries.

Lead soil samples collected within and around the three ULAB recycling plants in Cameroon suggest that inadequate environmental controls are contributing to

[6] Daniell, William E., et al., 2015. Childhood Lead Exposure From Battery Recycling in Vietnam. 2015 BioMed research international.
[7] Levallois, P., et al., 1991. Blood lead levels in children and pregnant women living near a lead-reclamation plant. CMAJ: Can. Med. Assoc. J. 144 (7), 877.
[8] Wang, Jung-Der, et al., 1992. Lead contamination around a kindergarten near a battery recycling plant. Bull. Environ. Contam. Toxicol. 49 (1), 23–30.
[9] Gottesfeld, Perry, Pokhrel, Amod K., 2011. Lead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities. J.Occup. Environ. Hyg. 8 (9), 520–532
[10] Kenya Ministry of Health, 2015. Report on Lead Exposure in Owino-Uhuru Settlement, Mombasa County, Kenya April unpublished
[11] de Freitas, C. U., De Capitani, E. M., Gouveia, N., Simonetti, M. H., e Silva, M. R. D. P., Kira, C. S., ... & de Abreu, M. H. (2007). Lead exposure in an urban community: investigation of risk factors and assessment of the impact of lead abatement measures. *Environmental Research*, *103*(3), 338-344.

extensive contamination in these areas. ULAB recycling at these facilities is the main source of soil lead contamination in these areas. There is an urgent need to regulate this polluting industrial activity in Cameroon to avoid further uncontrolled environmental emissions. Given that two of these facilities are relatively new with operational licenses issued in the past five years, these findings should trigger an immediate investigation by the Cameroonian authorities.

Measures urgently needed at the national level include establishing a regulatory level of lead in soil for residential and industrial areas, limiting lead levels in ambient air at lead battery recycling plants, requiring adequate ventilation and pollution controls, stack emission standards, and limits on waste water effluent levels. All new facilities should be required to have a minimum annual throughput capacity to ensure the scale necessary to afford and maintain adequate environmental controls. These measures are needed in order to protect human health and the environment from these ongoing operations. In addition, the extensive soil lead levels identified require remediation to protect these communities.

As the lead battery industry in Africa continues to expand, it is expected that the number and size of lead battery recycling plants will grow to meet the forecasted demand. There is an immediate need to address ongoing exposures in surrounding communities, emissions from this industry and to regulate site closure financing procedures to ensure that we do not leave behind a legacy of lead contamination that will impact communities throughout Africa.

The findings of this study can contribute to ongoing efforts to better inform the Basel Convention in the process of revising outdated guidelines for this industry. The extensive contamination identified also suggest that there is a need to strengthen the regulatory framework in Cameroon and other African countries.

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