Pollution and Perceptions of Lead in Automobile Repair Shops in Dhaka, Bangladesh

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Background. Lead acid batteries are widely used, dependable, and inexpensive. Lead from these batteries can contaminate the surrounding ecosystem due to improper disposal and contribute to lead poisoning. Lead poisoning is an important public health issue that can cause adverse human health impacts.
Objectives. The present study aimed to assess exposure to lead released from automobile repair shops handling lead acid batteries in the city of Dhaka, Bangladesh, as well as shop owner and worker perceptions of lead pollution.
Methods. Ten dust samples were collected for atomic absorption spectrophotometer analysis to determine the concentration of lead. In addition, a questionnaire survey (N=75) was conducted to determine the level of knowledge of lead exposure and associated risks.
Results. Lead contamination was found in all dust samples, with lead concentrations ranging from 11.40 ppm to greater than 1000 ppm. In addition, 80% of respondents did not have any knowledge about the harmful effects of lead pollution.
Conclusions. The present study suggests the importance of defining permissible air lead levels and improving worker education on lead pollution.
Ethics Approval. The study was approved by the Ethics Committee of the Department of Environmental Science, Stamford University, Bangladesh.
Competing Interests. The authors declare no competing financial interests.
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Introduction

Advances in technology have led to a high level of industrialization that can result in the discharge of heavy metals into the environment. In recent years, human activities have increased the emissions of heavy metals into the atmosphere, land, and water bodies.[1] Working in lead processing industries is often an attractive livelihood due to its potential to improve wealth within communities, regardless of the risks involved. Children also work in the lead processing industry as a means of contributing to family income.[2,3] Lead used by industries comes from mined ores (primary), lead-acid batteries (secondary), and recycled scrap metals. Today, most of the lead involved in global commerce is obtained from recycled, used lead-acid batteries (ULABs). Globally, since 1990, 80% of lead has been produced for lead-acid batteries, and 50% comes from recycled ULABs.[4-7] According to the United States Environmental Protection Agency (USEPA), 98.9% of used lead-acid batteries were recycled in the United States in 2014 and 99% were recycled in the European Union from 2010-2012.[8,9] Lead has been used in petrol as an antiknock agent, and petrol is one of the prime contributors to total lead pollution in the environment globally.[10-12]

Previous studies have been carried out in auto repair workshops.[13-15] Along with the proliferation of auto repair shops, new forms of services and support industries have emerged, including compulsory vehicle insurance and businesses dedicated to the repair, maintenance, and customization of vehicles. Currently, there are thousands of small- to medium-sized workshops that service vehicles in Bangladesh. As a result, the use of highly toxic and hazardous materials, such as paint and solvents, has been gradually increasing.[16,17] Due to the small size and limited resources of these auto body and auto repair shops, hazardous substances are often mishandled and improperly disposed of into the environment.[18,19] Moreover, controversy has arisen over the regulation of these businesses, which concerns not only the condition of the surrounding environment, but the health and safety of workers as well. Many of the chemicals in these solvents are extremely dangerous to humans and the environment.[20,21] The improper handling of these chemicals can lead

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to emissions into the atmosphere, contaminate water sources and soil, and can also result in the inhalation, ingestion, or absorption of toxins.[22-24] Furthermore, automobile workshops use various types of cleaning agents, chemicals, metals, and solvents which are hazardous, such as oil, lead, cadmium, and barium, and these substances and materials can cause adverse effects on workers' health if improperly handled.[23,25] In addition, airborne dusts containing lead or lead compounds can be deposited onto vegetation, contaminate ground and water sources and could transfer to humans through the food chain. The chemical and physical properties of lead and the biogeochemical processes within ecosystems can influence the movement of lead throughout ecosystems, as it accumulates in the environment. In certain chemical environments, lead can be transformed in such a way as to increase its solubility (e.g., formations of lead sulfate in soils), bioavailability, and toxicity.[26,27] The present study aims to assess exposures and levels of lead pollution from automobile repair shops in order to better inform mitigation measures to eliminate or reduce the hazards associated with the use of lead in these activities.

Abbreviations

ULAB	Used lead-acid batteries	*USEPA*	United States Environmental Protection Agency

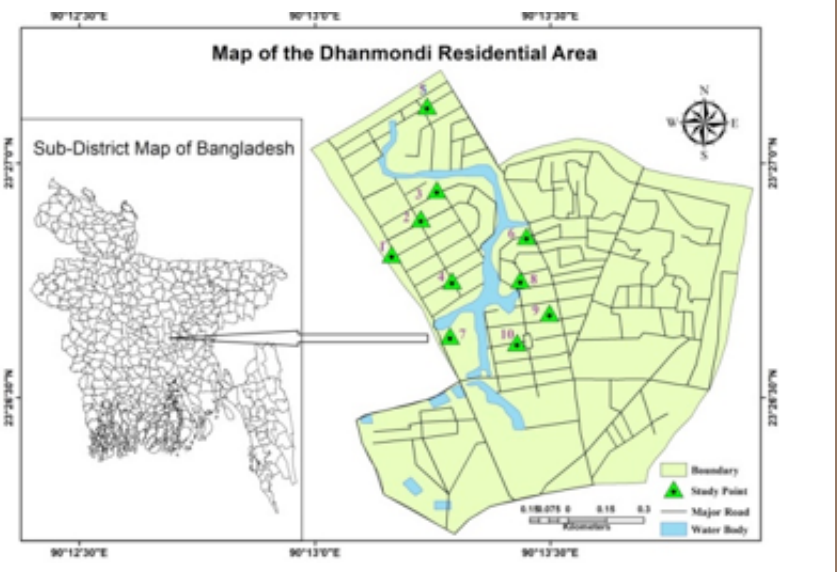

Figure 1 — Map of Study Area

Methods

The present study was conducted in November 2015 to determine the emissions of lead from automobile repair shops in the Dhanmondi Residential Area, Dhaka, as well as to assess the knowledge and perceptions of shop owners and workers of the effects of lead pollution on the environment and human health.

Study area

Dhanmondi is one of the oldest residential areas in Dhaka, Bangladesh. The area is home to a number of auto repair workshops serving the surrounding residential areas. It consists of 15 wards with an area of 4.34 km^2 and lies between 23° 44' 18' N latitude and 90° 23' 6' E longitude (*Figure 1*).

Sampling

Dust samples were collected from inside of each workshop. Ten (10) mg of surface dust for each sample was taken from the floor into a lead-free plastic tube container using gloves. All of the filters and dust samples were prepared for atomic absorption spectrophotometer (Shimadzu model AA-6300) analysis. Five (5) gm of soil sample was transferred from a plastic tube into a crucible and (4 to 5 drops) of concentrated nitric acid was added under a fume hood. Subsequently, the crucible was heated for 5 to 6 hours at 600°C. Next, 10 ml of 5M HCl added into the ash and boiled to digest the samples under a fume hood. After boiling, at which point the sample became colorless or transparent, the extracts were filtered into a 100 ml volumetric flask through 12.5 cm Whatman grade 1 filter paper and made up to 100 ml volume with deionized water.

In addition, prior to the collection of dust samples, a survey questionnaire

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Sex ratio of the respondents (N=75)			
Male	75 (100%)		
Female	0		
Age range of the respondents	**Shop owners**	**Workers**	**Total**
11-20 Years	0	55 (73%)	73%
21-30 years	3 (4%)	8 (11%)	15%
Above 31 Years	9 (12%)	0	12%
			100%
Education level of respondents	**Shop owners**	**Workers**	**Total**
Primary Level	0	26 (35%)	35%
Secondary Level	4 (5%)	37 (49%)	54%
Higher than Secondary level	8 (11%)	0	11%
			100%

Table 1 — Demographic Characteristics of the Respondents

Sample Number	Location	Lead	USEPA Standard[a] (Soil)
01	Dhanmondi 15	11.40	
02	Dhanmondi 9/A	62.78	
03	Dhanmondi 10/A	72.50	
04	Dhanmondi 8/A	>1000	
05	Dhanmondi 27	235.31	400 ppm
06	Dhanmondi 13	27.21	
07	Dhanmondi 6/A	30.95	
08	Dhanmondi 5	25.96	
09	Dhanmondi 4	12.41	
10	Dhanmondi 1	11.73	

[a] Adapted from Lead Toxicity: Case Studies in Environmental Medicine.[28]

Table 2 — Concentration of Lead in Samples Across Study Locations

was conducted with shop owners and workers to determine the extent of their knowledge about lead pollution. All shop owners and workers selected for the study agreed to participate. The Ethics Committee of the Department of Environmental Science, Stamford University, Bangladesh approved this study. Informed consent was obtained from workers and shop owners. The questionnaire can be found in Supplemental Material. In the present study, there were in total 75 subjects, 12 shop owners and 63 workers. All of the respondents were male, shop owners ranged in age from 28-45 years, and workers ranged in age from 12-28 years, with the majority (70%) being children. An overview of demographic characteristics of the respondents is shown in Table 1.

Results

The results showed lead concentrations in all 10 samples, ranging from a minimum of 11.40 ppm to more than 1000 ppm, which may cause serious health problems for workers. The workshops sampled in the present study were sites where lead batteries were being reconditioned. In addition to repair activities, workshops associated with samples 3, 4, and 5 also carry out informal ULAB processing. The present study found lead in all samples, and one sample exceeded the USEPA standard (*Table 2*).

Two samples in the present study showed very high lead concentrations; one measured at 1000 ppm and another at 235.31 ppm, whereas other samples ranged from 11.40 ppm to 72.50 ppm.

Shop owner and worker perceptions of lead

The present study found that 80% of surveyed shop owners and workers did not have any knowledge of the harmful

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health effects of lead pollution. Of the 20% of those that were aware of the harmful effects of lead, 47% replied that cancer is the main consequence of lead exposure, 33% believed that it causes kidney dysfunction, and 20% thought that lead exposure can cause high blood pressure.

The present study also assessed the perception of respondents of the adverse impacts of lead on environmental ecosystems. Forty percent (40%) of study participants perceived that lead pollution can lead to degradation of soil fertility, 35% reported that lead is a water pollutant and 25% perceived that it can cause air pollution.

In the present study, 70% of the workers were children aged 12-16 years old who work directly and indirectly in the workshops. In addition, most of the shops (80%) disposed of their lead-contaminated dust directly on the roadside. The remaining shops either dumped waste in the sewage or sanitation drain or transferred it to the municipal dustbin. The overall perceptions of respondents are shown in Table 3.

Perceptions of the health effects of lead	**Shop owners**	**Workers**	**Total**
Cancer	3 (20%)	4 (27%)	7 (47%)
Kidney dysfunction	2 (13%)	3 (20%)	5 (33%)
High blood pressure	2 (13%)	1 (7%)	3 (20%)
Knowledge of lead environmental pollution	**Shop owners**	**Workers**	**Total**
Soil fertility decrease	2 (3%)	28 (37%)	30 (40%)
Water pollution	2 (3%)	24 (32%)	26 (35%)
Air pollution	8 (10%)	11 (15%)	19 (25%)
Reported use of child labor in workshops in the present study			
Child labor			44 (70%)
No child labor			19 (30%)
Method of dust disposal			
Roadside			8 (80%)
Municipal dustbin			1 (10%)
Open drain			1 (10%)

Table 3 — Shop Owner and Worker Knowledge of Lead Pollution

Discussion

The present study found that lead concentrations in most of the sampled locations were within the USEPA permissible levels for soil (400 ppm). Some of the automobile shops had higher concentrations due to different reconditioning methods. In most cases, in the recycling process, batteries are broken either mechanically or manually in order to separate acid and other metallic components. This process releases lead particles and oxide dust that contaminates the workshops, soil and the environment, eventually leading to lead exposures among the workshop workers.[29-32] The present survey demonstrated that workers and owners are not aware of all of the adverse health effects of lead pollution and have no knowledge of the effects of lead on behavioral and cognitive development in children. These adverse effects occur when lead exposure disrupts various brain mechanisms and inhibits healthy brain function by mimicking calcium in a manner that allows it to attach with its structures.[33-36]

Several studies found that the average lead concentration in the blood of workers in developing countries is 47 µg/dL in battery manufacturing facilities and 64 µg/dL in recycling plants (as compared to the US standard of 10 µg/dL).[7] Child workers have a higher risk because acute exposures may cause death if blood lead levels exceeds ≥ 150 µg/dL.[37,38] Workshop owners employ children because they can pay them low wages and maintain greater control over them. Subsequently, child workers are compelled to work in highly hazardous environments without proper occupational health, safety, and hygienic working conditions. Children worked in the shops in the present study without personal safety equipment in activities involving battery reconditioning, changing and cleaning engines or vehicle body parts. Moreover, child workers were observed consuming food inside the workshops in unhygienic conditions. Dust and particulate matter generated from repair activities were retained in the confined workshop environment and undoubtedly inhaled and ingested by workers. Consequently, working in these conditions increases the risk that workers may suffer from dust-related diseases such as cancer, asthma, allergic alveoli, irritation, and non-respiratory illnesses.

In addition to harming human health, lead can cause degradation of the environment. In present study, roadsides are the final destination for most of the lead-contaminated dust from these shops. Soil particles can absorb the lead-contaminated dust if it reaches the upper layer of soil. These soils can also spread to surface water bodies and eventually may contaminate groundwater, which is a source of drinking water for local residents.[39]

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Hence, recycling of ULABs poses a high degree of risk to the environment if not managed properly.[40] Due to enforcement capabilities and lack of regulations, developing countries have a higher risk of environmental lead pollution than developed countries.[7] It has been estimated that lead industries may double within the next 5-10 years in developing countries.[7,41] Thus, formal, advanced, safe and effective processes for environmentally sound ULAB treatment will help to mitigate the adverse effects of lead pollution on human health and the environment.

Conclusions

Concern regarding the occupational safety of workers in auto repair shops is warranted, as workers in this industry are consistently exposed to lead pollution. During the reconditioning of ULABs, the process of breaking down parts within the shop can release a large amount of leaded dusts into the surrounding environment. Governmental oversight of the illegal processes associated with ULAB recycling is needed, especially reconditioning operations, among the many informal battery recycling operations in Bangladesh. Informal methods of reconditioning ULABs exacerbate the problem of environmental pollution. The treatment of ULABs requires a formal process similar to that adopted in developing countries. In addition, employers need to be made aware of the harmful effects of lead pollution, and to ensure and provide a safe working environment. Dust collection and minimization techniques should be introduced into these workshops along with proper ventilation systems and appropriate personal protective equipment. Shop owners should be responsible for educating their employees on the correct processes and proper personal protective measures. According to the National Child Labour Elimination Policy 2010, child labor is not legal in Bangladesh.[42] Enforcing this policy would reduce occupational exposures in children.

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