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How to Stop Automotive Battery Recycling from Poisoning Our Children

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KEY POINTS

- Lead is a harmful substance that, if not properly handled, can impair cognitive development in children and severely undermine the health and productivity of adults.
- Developing Asia is home to at least half of 800 million children worldwide whose blood lead levels have reached levels associated with harmful effects to human health.
- One main source of lead pollution is informal, open-air recycling of automotive batteries, particularly in developing countries. Smelting lead in an open furnace releases this toxic element into the air, soil, and water.
- Countries need to establish and enforce standards for automotive batteries to prevent the spread of lead into the environment.
- Manufacturers must be held responsible for the whole life cycle of these batteries, including the recycling process, to ensure compliance at every stage of the supply chain.
- Consumers can also promote responsible recycling if end-user inspections and safety seals enable them to make educated decisions about the batteries they purchase.

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Lead is an extremely harmful toxin. According to the World Health Organization (WHO), even low levels of exposure can impair cognitive development, and children are particularly vulnerable because exposure can obstruct the rapid development that typically occurs at young ages. Lead exposure can also cause aggressive behavior that contributes to higher crime rates. Acute exposure can cause diseases in the blood, heart, kidneys, and nervous system and in extreme cases, can lead to death.[1]

It is commonly perceived that the battle against lead pollution ended with bans on leaded gasoline and paint. However, lead can be found in other products, especially in developing countries. Alarmingly, recent data reveal that over 800 million children worldwide are estimated to have blood lead levels at or above the level associated with decreased intelligence, behavioral difficulties, and learning problems. At least half of these children live in developing Asia.[2] Lead can be found in lead-based paints and pigments, some toys and jewelry, spices, food cans, traditional cosmetics, ceramic glazes on dishes and cookware, aluminum cooking pots, water pipes and fixtures, and herbal, traditional, and ayurvedic medicines.

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Note: ADB recognizes "China" as the People's Republic of China.

[1] World Health Organization. 2017. *Recycling Used Lead-Acid Batteries: Health Considerations.* Geneva: WHO.

[2] United Nations Children's Fund (UNICEF) and Pure Earth. 2020. *The Toxic Truth: Children's Exposure to Lead Pollution Undermines a Generation of Future Potential.*

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However, the greatest use of lead today globally is for lead-acid batteries, mainly for automobiles, which accounts for 85% of lead available worldwide (footnote 1). The rising demand for vehicles, especially in emerging markets, thus underpins the steady growth in the global consumption of refined lead from about 5 million tons in the 1990s to 13 million tons by 2020. In 2020, global production of lead plateaued at just below 5 million tons.[3] This means that most consumed lead is recycled[4] and much of the demand for lead-acid batteries is being met using recycled lead from used lead-acid batteries, or ULABs. Given the high demand for lead, recycling ULABs is very profitable, especially if costs can be minimized. For this reason, a major source of lead exposure in developing countries where regulations are less stringently enforced is unsafe practice in the informal recycling of ULABs.

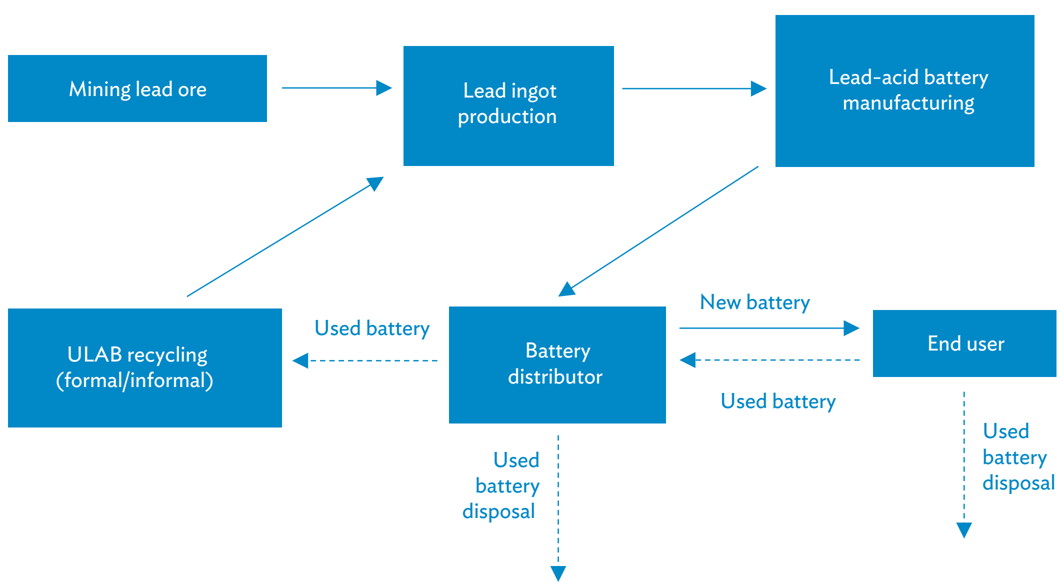
Most vehicle batteries use lead because it is an efficient conductor that is much less expensive than alternatives like nickel–cadmium and lithium-ion. Lead is submerged in an electrolyte containing sulfuric acid to facilitate a controlled chemical reaction which causes the battery to produce electricity. An automobile's lead-acid battery typically dies out after about 2–3 years of regular use, depending on the type of vehicle and the quality of battery.

A new battery can be purchased from a battery retailer or distributor, who often offers to take the ULAB in exchange for a small fee. Materials in this ULAB can be recycled to make a new battery (Figure 1).

In an automated, enclosed process that recycles ULABs safely, a hammer mill or shredder breaks up the batteries into its components: lead materials, plastics, and sulfuric acid. The acid is strained by machine, poured onto collection tanks, distilled from dissolved lead, and either reused as sulfuric acid or neutralized into water, undergoing waste water treatment. Alternatively, it is recycled into sodium sulfate, an odorless powder commonly used as an ingredient for laundry detergents, textiles, or glass.[5]

The solid parts are put into water-filled tanks where the components are separated by gravity—lead and other heavy metals sink to the bottom of the tank while plastics float on top of the water. Plastic components are sieved and taken through their own recycling process. Lead parts are taken inside smelting furnaces and subjected to high temperatures until they reach a liquid state. When molten, they are poured into casting molds and after cooling are transported to battery manufacturers.[6]

Figure 1: Life Cycle of Lead-Acid Batteries



ULAB = used lead-acid battery.

Source: Authors.

[3] US Geological Survey. Lead Statistics and Information. https://www.usgs.gov/centers/national-minerals-information-center/lead-statistics-and-information.
[4] International Lead Association. 2021. *Lead Recycling Fact Sheet*.
[5] CJD E-cycling. Lead-Acid Battery Recycing. https://www.cjdecycling.com/lead-acid-battery-recycling-need-know/#:~:text=Old%20battery%20acid%20or%20sulfuric,meets%20with%20clean%20water%20standards.
[6] E. Osmanbasic. 2020. Battery Recycling Technologies – Part 2: Recycling Lead-Acid and Li-ion. Engineering.com/ https://www.engineering.com/story/battery-recycling-technologies-part-2-recycling-lead-acid-and-li-ion.

In a manual recycling process typically used by informal recyclers, the electrolyte is drained by hand and the batteries are dismantled using electric saws, machetes, or axes. The electrolyte containing acid and dissolved lead is disposed of without undergoing treatment. When it leaks out or is poured onto the ground, dissolved lead is absorbed by the soil and becomes a source of lead dust (footnote 2).

The solid components are sorted by hand. Plastics are either taken to plastic recyclers, disposed of, or incinerated. The lead materials are taken to an open-air furnace, which, in practice, is just a huge, uncovered pot sitting on top of a fire. Once molten, lead is poured into casting molds then transported to battery manufacturers (footnote 1).

Substandard manual recycling processes release huge volumes of lead particles into the environment. Workers may absorb lead through inhalation and skin contact, exposing themselves and their families after coming home without washing or changing clothes. Recycling ULABs in open spaces emit toxic smoke that spreads lead into the air, soil, and water. People in surrounding areas can ingest lead particles from the air and soil. This toxic substance is ingested by children who play in contaminated soil and can also enter through their mouths if they eat with bare hands. Wastewater containing lead and acid can flow into surrounding fields and be absorbed by crops that people eat. It can also seep into the groundwater that people drink (Figure 2).

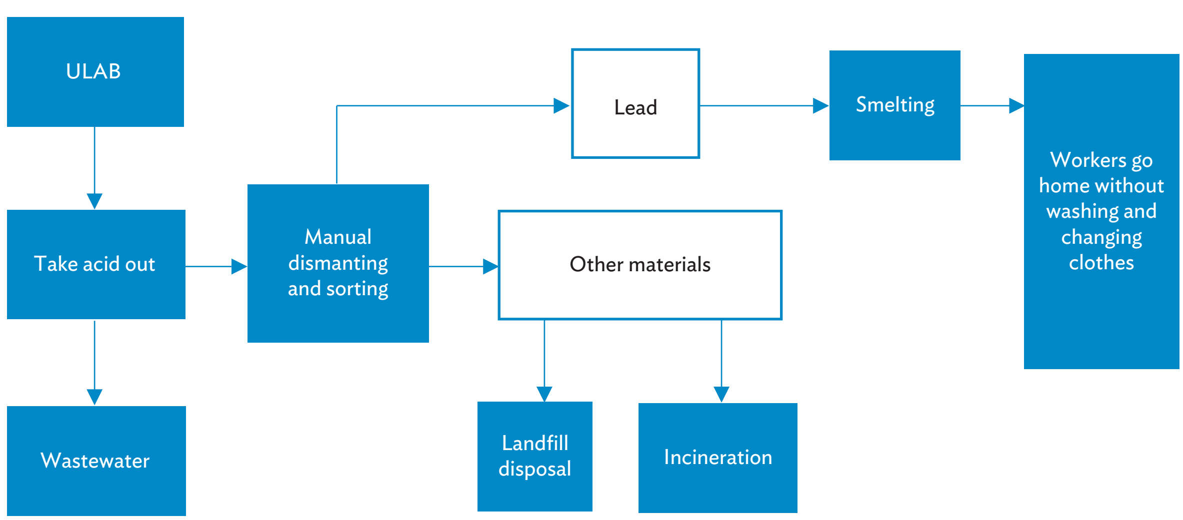
Lead-acid batteries that are not properly disposed of can also contribute to lead pollution. When these batteries are disposed of in landfills, the lead can leach out into the soil and groundwater, leading to contamination. In some cases, discarded batteries may also be illegally dumped or burned, leading to the release of lead into the air and soil.

AUTOMOTIVE BATTERY RECYCLING IN DEVELOPING COUNTRIES

Rich natural endowments of lead and rapid economic development and rising demand for vehicles in Asia make the region a major extractor, producer, and manufacturer of refined lead. Crude recycling practices in developing countries pollute the environment with huge amounts of lead. Emissions in Asia are highest at the waste management and recycling stages of the lead life cycle.[7]

Battery recycling in developing countries is typically not covered by specific regulations on ULABs and often operates without the necessary protocols and technologies for effective pollution control. Most nonregulated, informal ULAB recycling activity is

Figure 2: Pathways of Contamination from Manual ULAB Recycling



ULAB = used lead-acid battery

Source: Authors.

[7] J.S. Mao, J. Dong, and T.E. Graedel. 2008. The Multilevel Cycle of Anthropogenic Lead: II. Results and Discussion. *Resources, Conservation and Recycling.* 52 (8–9). pp. 1050–1057.

carried out by small family businesses, often within the vicinity of their homes, and sometimes in secret. Waste products from these activities, often containing lead, are typically dumped without undergoing treatment (footnote 1). In some cases, children are enlisted to help pull the batteries apart and wash battery parts.[8] Workers are mostly unaware of how toxic lead really is.[9] Often located in urban or peri-urban areas, informal ULAB recycling can put large numbers of people living in nearby communities at risk.[10]

Lead poisoning has occurred among children and adults who reside near informal smelters or work in backyard recycling of automotive batteries.[11] Blood lead levels among children who live near or work in ULAB recycling sites in several developing countries have been found to be about five times higher than those in unexposed children.[12]

Even registered, industrial-scale recycling operations can contaminate the environment and cause human exposure to lead when standards are inadequate or when controls are not adequately enforced (footnote 1). A review of published literature from 37 developing countries found high airborne lead concentrations and seriously elevated blood lead levels among workers in formal-sector ULAB manufacturing and recycling plants.[13] Airborne lead concentrations around battery plants in these developing countries were found to be seven times higher than the permissible exposure limit in the United States (US), and blood lead levels of children living near these plants were about 13 times greater than in the US.

Comparison of Viet Nam and the United Kingdom

One of the authors led a study of the ULAB industry in Viet Nam to examine pathways of lead exposure and the regulations necessary to reduce exposure and childhood poisoning in developing countries. Previous studies in Viet Nam found that blood lead levels exceeded the safety threshold set by the Centers for Disease Control and Prevention in all tested children living in a battery recycling craft village.[14] In Viet Nam, a craft village specializes in either a cultural handicraft or an industrial activity like leather tanning, metalworking, or plastic or metal recycling (footnote 9).

The study reviewed and contrasted legislation related to lead production, import, and waste management in Viet Nam with that of a country with more established environmental control practices, i.e., the United Kingdom (UK). Practices in production, disposal, recovery, and lead pollution management were compared. Operational, environmental, and occupational control measures were also compared and contrasted.

The Viet Nam study confirmed that used lead-acid batteries are mostly recycled manually, often in craft villages. Children live, play, and interact within those areas and the immediate surroundings. The environment around craft villages is surrounded by toxic heavy metal dust generated during recycling and metallurgy. Clusters of foundries also polluted water channels that feed into the main village surface waters including both streams and lakes. Most of the metal slag from untreated smelters is discharged into the surrounding fields which are mostly abandoned, unable to grow crops because of heavily polluted soil and water.

In the UK, ULABs are typically generated as waste materials at vehicle repair centers, facilities for treatment of waste electrical and electronic equipment, and end-of-life vehicle dismantlers or recyclers. They are bulked up for collection and taken to intermediate bulking sites, then to either UK-based recycling facilities or exported under close controls. Pollution control measures are in place. Operating permits require monitoring of emissions.

Most of the workers in craft villages in Viet Nam conducting manual recycling of ULABs have direct contact with heavy metals, smoke and fumes, and extreme heat. They consider it normal to handle ULABs without the use of personal protective equipment or specific health and safety protocols. In the UK, by contrast, all personnel in battery recycling facilities wear protective equipment such as high-visibility vests, safety glasses, safety boots, and chemical-resistant gloves.

8 T.J. van der Kuijp, L. Huang, and C.R. Cherry. 2013. Health Hazards of China's Lead-Acid Battery Industry: A Review of its Market Drivers, Production Processes, and Health Impacts. *Environmental Health.* 12, pp. 1–10.

9 W.E. Daniell et al. 2015. Childhood Lead Exposure from Battery Recycling in Viet Nam. *BioMed Research International.* 2015: 193715; T.J. van der Kuijp, Health Hazards of China's Lead-Acid Battery Industry.

10 P. Haefliger et al. 2009. Mass Lead Intoxication from Informal Used Lead-Acid Battery Recycling in Dakar, Senegal. *Environmental Health Perspectives*. 117 (10). pp. 1535–1540; World Health Organization. 2017. *Recycling Used Lead-Acid Batteries.*

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13 P. Gottesfeld and A.K. Pokhrel. 2011. Lead Exposure in Battery Manufacturing and Recycling in Developing Countries and among Children in Nearby Communities. *Journal of Occupational and Environmental Hygiene.* 8(9). pp. 520–532.

14 W.E. Daniell, et al. 2015. Childhood Lead Exposure from Battery Recycling in Viet Nam. *BioMed Research International.* 2015: 193715; T. Noguchi, et al. 2014. Exposure Assessment of Lead to Workers and Children in the Battery Recycling Craft Village, Dong Mai, Viet Nam. *Journal of Material Cycles and Waste Management*. 16. pp. 46–51; A.P. Sanders, et al. 2014. Toxic Metal Levels in Children Residing in a Smelting Craft Village in Viet Nam: A Pilot Biomonitoring Study. *BMC Public Health*. 14(1). pp. 1–8.

The Control of Lead at Work (CLAW) Regulations 2002 in the UK requires regular blood tests for all personnel who deal with lead and sets occupational exposure limits. The CLAW Regulations also prohibit young persons and women of reproductive capacity from employment in specific activities that involve the handling, treatment, refining, or smelting of ores or materials containing at least 5% lead. They are also prohibited from cleaning any place where any of these processes are being carried out, in order to prevent them from getting exposed.

Existing regulations in Viet Nam provide guidelines on dealing with hazardous chemicals in general, but there are no legislated standards specific to the collection, transport, storage, recycling, and disposal of used lead-acid batteries. Without clearer safety standards, recyclers are left to their own devices. In contrast, the UK gives comprehensive guidelines on the recovery and recycling of lead-acid batteries.[15]

Recent legislation in Viet Nam mandates recycling responsibility by manufacturers and traders of lead-acid batteries[16] and requires a minimum recycling rate of 12% per year for 2024–2026. By contrast, the “Batteries Directive” in the European Union (EU)[17] requires a recycling rate of 65% for all batteries; in practice, almost 100% of lead-acid batteries are recycled cleanly. A higher recycling rate reduces the amount of hazardous waste that can be generated from batteries disposed of in unknown ways as long as recycling is done safely.

Recent legislation on mandatory recycling rates in Viet Nam does not come with financial incentives, penalties, and environmental guidelines to promote compliance. Even if new regulations assign recycling responsibility to battery manufacturers, they do not link producers with retailers and distributors of lead-containing products. In the UK and Europe, producer responsibility requirements create a direct link between manufacturers using potentially hazardous materials and the responsibility for sound recovery at the end of the useful life of the product. The system ensures provision of funds from the manufacturers to the recycling companies, backed up by stringent pollution control measures. Battery recyclers in the UK are required to gather all of the information required by the “Batteries Directive” and submit them to the Waste Regulation Authority by a fixed deadline each year in order to enable the regulator to collect battery recycling information and find out if there are gaps in the recycling system.

While Viet Nam has issued laws and regulations[18] related to soil pollution, they mainly focus on general pollution management and do not address the issue of contaminated land comprehensively. The regulations do not specify penalties for noncompliance or the mechanisms for monitoring and enforcing compliance. While Viet Nam’s regulations[19] do specify the criteria for classifying contaminated land and the permissible values for heavy metal pollutants, they do not provide clear guidance on how to remediate contaminated land. Moreover, the legal framework does not provide sufficient information on the funding mechanisms to support remediation activities.

In contrast, the UK and the EU regulations are clear on the identification, management, and treatment of contaminated land. The Contaminated Land Regulations of 2006 in the UK require local authorities to maintain an updated register of likely contaminated land that could cause significant harm or pollution. A local authority can escalate responsibility for a site that may pose a serious risk to people’s health to more specialized environmental agencies to investigate and, if merited, mandate improvement plans for the remediation of the site.

WHAT CAN BE DONE TO CURB LEAD POLLUTION?

Five key steps can prevent further environmental contamination and human exposure to lead from informal recycling of ULABs in developing countries. Best practices from other countries provide examples for the design and implementation of these solutions.

1. Raise awareness of the dangers of lead exposure. The public must be made aware of the dangers, sources, and prevalence of lead exposure. This can be done through public education campaigns that appeal directly to parents, youth associations, schools, healthcare workers, and community leaders (footnote 2). To be more effective in reaching the target audience, communication campaigns should use television, radio, the internet, and/or text messages—whichever form of media is widely used in the community.

Workers and owners of ULAB recycling and smelting areas must be educated about their occupational risks and how they can protect themselves, their families, and their communities from being exposed to lead. Communities residing near ULAB recyclers and smelters should be informed of the activity, the dangers of lead exposure, and what they can do about it.

15 These guidelines are specified in the Best Available Techniques (BAT) reference document for the Non-Ferrous Metals Industries Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control), which are used by large-scale processors. The BAT reference document outlines two main types of processes for the recovery of lead from automotive batteries: the blast furnace recycling process and the mechanical battery separation process followed by smelting.

16 Appendix XXII, Decree No. 08/2022/ND-CP – Decree on Elaboration Of Several Articles of the Law on Environmental Protection.

17 Commission Regulation (EU) No. 493/2012, pursuant to Directive 2006/66/EC of the European Parliament and of the Council.

18 Law No. 72/2020/QH14 On Environmental Protection.

19 Circular No. 02/2022/TT-BTNMT, Detailing A Number Of Articles Of Law On Environmental Protection. Viet Nam’s National Technical Regulation QCVN 03-MT:2015/BTNMT.

2. Enact and enforce safety standards for ULAB recycling. Setting clear safety standards specific to ULAB recycling is a necessary first step in ensuring that recycling practices do not harm the environment and public health, especially the health of children. A set of minimum standards for "eco-friendly smelters" should be legislated to give specific guidelines on the collection, storage, recycling, and disposal of lead-acid batteries. Legislation must also set limits on workers' occupational exposure, including requirements for protective equipment and blood tests for workers in ULAB recycling plants. Guidelines like these can be found, for example, from the technical operating standards developed by Pure Earth and the WHO (footnote 1).

Once these standards have been set, operating permits and certificates of compliance can be required and made contingent on meeting safety, monitoring, and pollution control requirements as in England and Wales.[20] They also require reporting data on types and tonnages accepted, treated, and dispatched or disposed of. The permits require monitoring of emissions and enforcement authorities must verify self-reported emissions by taking their own samples.

A certificate of compliance, sometimes in the form of stickers or safety seals, is a visible badge that signals a product or producer adheres to the standards. Such a certificate can be required for lead-acid batteries being sold in the market. It can serve a similar purpose as Import Commodity Clearance stickers on helmets and car seats, for example, which signal to buyers that the products passed safety requirements. Thus, vehicle manufacturers and end-users may buy only batteries with a certificate or sticker of compliance. A foolproof verification system must be in place to guard against counterfeit certificates or stickers. A blockchain database is one way to set it up, like the Import Commodity Clearance Verification System app accessible to all users.

Safety standards for ULAB recycling can be incorporated by certification bodies when issuing certification systems like International Organization for Standardization (ISO) 14001 (Environmental Management System) to battery manufacturers. If issuance requires compliance by the entire supply chain, manufacturers aiming for ISO 14001 certification, for instance, would be motivated to monitor compliance by suppliers, including ULAB recyclers.

3. Extend producer responsibility throughout the whole life cycle of batteries. Producers can facilitate compliance of the supply chain if they are held accountable for the whole life cycle—from the time a new battery is produced, through collection and transport of ULABs, through the recycling process, all the way to the production of new batteries using recycled lead. Best practices from the UK and Brazil illustrate how producer responsibility can promote safe management of ULABs.

Battery manufacturers in the UK have a "take-back obligation," which means they have the responsibility to collect used batteries and have them recycled in an environmentally sound manner by a certified recycler. A cooperative scheme is in place for producers to pool funds in collecting ULABs and deliver them safely to certified recycling facilities. Under this scheme, the cost of recycling is reflected in the price of new batteries.

The UK's Waste Batteries and Accumulators Regulations of 2009 requires approval for treatment and recycling of batteries and issuance of evidence on correct recovery and recycling.[21] Documentation of compliance and a full audit trail are required for an operator to become an approved battery treatment operator. These regulations are coupled with inspection of production and recycling sites for compliance to safety standards. The threat of prosecution keeps battery manufacturers and recycling operators in check.

The Brazilian government instituted a "reverse logistics" system to ensure that ULABs flow into legal recycling operations.[22] Responsibility was assigned to every part of the supply chain—from retailer, to distributor, transporter, manufacturer, and smelter. Used batteries are exchanged for new batteries, one-for-one, at every stage of the supply chain each time a new battery is sold. Manufacturers set up systems to deliver new batteries at the same time used batteries are collected, retailers are obligated to return used batteries to the distributors, and distributors are mandated to send them to the legal smelters contracted by the manufacturers (Figure 3). Manufacturers are allowed to contract legal smelters only. A penalty at every stage applies to suppliers who fail to comply.

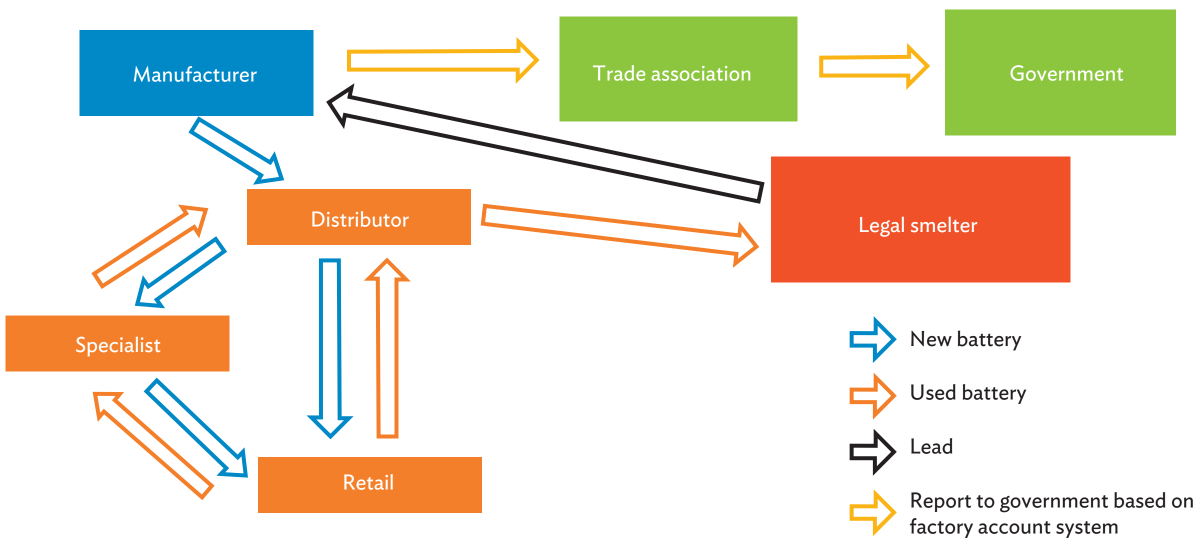
To make sure that acid is not manually drained, the Brazilian government made it mandatory to keep it in the used batteries until they reach the proper recycling facility. Trucks and drivers are also made to follow standards on the transport of ULABs.

20 See the Environmental Permitting Regulations of 2016 in England and Wales which requires a permit for a site to accept, store, and treat waste materials—including ULAB. The permits specify safety, monitoring, and pollution control requirements.

21 Details on the Waste Batteries and Accumulators 2009 can be found at https://www.legislation.gov.uk/uksi/2009/890/contents/made.

22 Brazil's Law No. 12305 of 2 August 2010 institutes the National Policy on Solid Waste. Details of this law can be found at https://www.braziliannr.com/brazilian-environmental-legislation/law-no-12305-brazilian-national-policy-solid-waste/.

Figure 3: Reverse Logistics System in Brazil



Source: Adapted from C. Zaim. 2022. Lead Acid Batteries Reversal Logistic: The Brazilian Experience. Presentation at the Lead-Acid Battery Working Group Meeting. New Delhi. 10 October.

Manufacturers are required to report the quantity of new batteries sold and the quantity of used batteries that went to smelters. The government's regulatory role is simplified because it focuses on monitoring the manufacturers instead of controlling thousands of shops, distributors, and smelters. Taxes on recycled batteries were abolished in order to remove an artificial price advantage of illegal smelters. Recycling activities shifted into legal smelters, thus improving the environment's condition and increasing tax revenues.

4. Ensure compliance by mobilizing aware consumers. Consumers, in this case vehicle owners, also have a role to play. If vehicle owners only purchase batteries that comply with safe recycling practices, demand can influence supply. Clean production marks like safety seals provide information to consumers that enables them to make educated purchase decisions. If they care about the public harms of lead poisoning, especially to children, they can demand strict adherence to safety standards at every stage of the supply chain when buying a new battery. If such safety seals are mandatory, vehicle registration can include end-user inspection of batteries for this safety seal. A verification system needs to ensure that safety seals cannot be forged.

Consumers can also have an active role in a "reverse logistics" system. A deposit–refund system for ULABs, following similar practices for glass and plastic bottles, could facilitate the return of used batteries to retailers who are part of the manufacturers' collection system. Where available, mobile apps can inform consumers of proper drop-off points for electronic waste, including used batteries.

5. Strengthen enforcement mechanisms and remediate contaminated sites. The solutions outlined above involve new regulations and strict enforcement which requires strengthening the capacity of implementing agencies. Technical assistance may be provided for building the capacity to legislate standards, enforce regulations, monitor compliance, and build effective reporting systems.

Financial incentives, penalties, and environmental guidelines should be set up to promote compliance with mandatory recycling rates and proper treatment of hazardous waste. Companies must be encouraged to invest in environment-friendly and efficient waste treatment technologies. Waste reduction efforts need to be promoted.

Clear guidelines on the identification, management, and treatment of contaminated land need to be established. Technical assistance may also be provided to affected communities. Funding for remediation may be collected through an array of sources, like higher tax revenues from legalized smelters, penalties from noncompliance, and a pool of funds from industry players who wish to contribute motivated by corporate social responsibility or environmental, social, and governance goals.

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