Leaded Batteries

Mapping the Toxic Waste Trail
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About Toxics Link

Toxics Link is an Indian environmental research and advocacy organization set up in 1996, engaged in disseminating information to help strengthen the campaign against toxics pollution, provide cleaner alternatives and bring together groups and people affected by this problem.

Toxics Link’s Mission Statement - “Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world.”

Toxics Link has a unique expertise in areas of hazardous, medical and municipal wastes, international waste trade, and the emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination etc. from the environment and public health point of view. We have successfully implemented various best practices and have brought in policy changes in the afore mentioned areas apart from creating awareness among several stakeholder groups.
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<th>Description</th>
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<tr>
<td>ACSR</td>
<td>Aluminium Conductor Steel Reinforced</td>
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<td>BLL</td>
<td>Blood Lead Level</td>
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<tr>
<td>BSNL</td>
<td>Bharat Sanchar Nigam Limited</td>
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<tr>
<td>CAGR</td>
<td>Compound Annual Growth Rate</td>
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<tr>
<td>CPCB</td>
<td>Central Pollution Control Board</td>
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<tr>
<td>DMRC</td>
<td>Delhi Metro Rail Corporation</td>
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<tr>
<td>DTC</td>
<td>Delhi Transport Corporation</td>
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<tr>
<td>EPR</td>
<td>Extended Producer Responsibility</td>
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<td>LAB</td>
<td>Lead Acid Battery</td>
</tr>
<tr>
<td>MTNL</td>
<td>Mahanagar Telephone Nigam Limited</td>
</tr>
<tr>
<td>Pb(OH)$_2$</td>
<td>Lead Hydroxide</td>
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<tr>
<td>Pb</td>
<td>Metallic Lead</td>
</tr>
<tr>
<td>PbO</td>
<td>Lead Oxide</td>
</tr>
<tr>
<td>PbS</td>
<td>Lead Sulfide</td>
</tr>
<tr>
<td>PCC</td>
<td>Pollution Control Committee</td>
</tr>
<tr>
<td>PPEs</td>
<td>Personal protective equipments</td>
</tr>
<tr>
<td>SLI</td>
<td>Starting-Lighting-Ignition</td>
</tr>
<tr>
<td>SMA</td>
<td>Stationary and Motive Applications</td>
</tr>
<tr>
<td>SPCB</td>
<td>State Pollution Control Board</td>
</tr>
<tr>
<td>ULAB</td>
<td>Used Lead Acid Battery</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterrupted Power Supply</td>
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</table>
“Used Lead Acid Battery recycling was the world’s worst polluting industry in 2016”— The World’s Worst Pollution Problems 2016: The Toxics Beneath Our Feet
I. Introduction

Lead is a soft and malleable metal found in the Earth’s crust. It melts at a relatively low temperature and hence it can be easily molded and combined with other metals to form alloys. It has a wide range of applications from lead acid batteries to paints and pigments, solder, stained glass and crystal glassware, ceramic glazes, jewellery, toys and even traditional medicines. Until few years back, it was also added to gasoline to increase engine efficiency in automobiles.

The lead acid battery industry has been one of the largest consumers of lead in the world since the invention of lead acid batteries. Lead acid batteries are rechargeable batteries very commonly used in automobiles for starting, lighting and ignition (SLI). They are also used for a variety of other purposes such as in inverters and UPS (uninterrupted power supply), in telecommunication and the railways. Their ability to supply high surge currents to start the motor makes them a viable option for use in automobiles while their ability to store charge for a long time explains their use in power storage devices such as UPS and inverters. So, from starting automobiles to providing vital support in hospitals and telecom towers; they can do it all. With such wide usage, these batteries command 40 percent of the global battery market even after 158 years of their invention. Apart from their wide range of applications, this can be attributed to their convenient use and cost-effectiveness. It also has the advantage of being tolerant towards overcharging and can have indefinite shelf life if stored without electrolyte or can even be left on float charge for a long duration.

These batteries can be charged many times before the plates finally lose their ability to store energy. This is when such batteries become unusable and it is a common practice all over the world to exchange them for new batteries with some discount on their price. After collection, these are sent to recyclers and smelters to recover mainly lead and sometimes plastic. The recovered resources can then be sold to battery manufacturers to make new batteries. The manufacturing and recycling of lead-acid batteries is practised worldwide in both regulated industries and unregulated, informal establishments. Used lead acid batteries have been classified as ‘hazardous waste’ under the Basel Convention and their disposal is strictly regulated in all OECD countries. In addition to lead usage and lead production including mining, smelting and manufacturing activities, unorganised recycling too is a major source of environmental contamination. Particularly in the developing and under-developed countries, this is a flourishing large-scale industry.

Recycling, which is supposed to be a boon to the environment and to the future generations, unfortunately ends up doing severe harm to human health and the environment in case of batteries- if not managed in sound manner. Unregulated recycling activities are carried out in deplorable conditions with no preventive measures taken to prevent environmental damage and occupational exposure. As a result, exposure to lead, a highly toxic element along with Arsenic and Cadmium, causes innumerable health problems, ranging from developmental to neurological disorders, not just among workers but in people living in areas far-away from recycling sites too. Pure Earth and Green Cross Switzerland conducted a study on the risk associated with the battery recycling industry and estimated that it potentially puts close to one million people at risk. The report also points out that most of the used lead acid battery recycling polluted sites are in South East Asia, Africa and Central and South America. It is one of China’s and South Asia’s prominent industries.

However, if recycling is carried out in an organised way, this closed-loop cycle has the potential to meet the growing demands of the rapidly industrialising and urbanising world and reduce the pressure on countries with limited lead ores to import lead from elsewhere.
Types of Batteries

Broadly, there are two types of batteries:

1. **Primary batteries:** These are designed to be discarded after a single use. This is because electrochemical reactions are not reversible in these cells. Hence, they can be used only once and cannot be recharged unlike secondary (rechargeable) batteries. Primary batteries are useful for applications where a small amount of current is required for a device to function. Zinc Carbon cells, alkaline cells, Lithium cells and silver oxide cells are examples of primary cells. They are commonly used in flashlights, clocks, remote control systems for TVs and ACs, etc.

2. **Secondary batteries:** These are rechargeable batteries which have reversible electrochemical reactions and hence can get discharged and recharged over many cycles. They are also called accumulators because they can accumulate and store charge over long periods of time. Lead acid, nickel cadmium, nickel metal hydride and lithium ion batteries are some examples of secondary cells. They are used in cameras, cell phones, automobiles, power back-up devices like inverters and UPS, telecommunication systems and photovoltaic solar installations among many other equipments and devices.

History of Lead Acid Batteries

The foundation of the modern lead acid batteries was laid by Alessandro Volta, an 18th century Italian physicist and chemist. He invented a Voltaic Pile in 1799, which was the first electrical battery, to provide a continuous current to a circuit. He stacked up several pairs of alternating discs (electrodes) of copper (or silver) and zinc. These were separated by a cloth or a cardboard soaked in brine (electrolyte) to increase conductivity. When the top and bottom of the pile were connected by a wire, current was seen to be flowing through the pile and the wire. Later, Michael Faraday built a better version of Volta's battery by refining the function of electrolytes to improve conductivity. Gautherot, a scientist from France, was the first to observe in 1801 that wires that had been used for electrolysis provided secondary current, albeit a small amount, even after the battery had been disconnected. The first practical version of the rechargeable lead acid battery was then invented by Gaston Plante in 1859. Plante’s lead acid battery was the first such battery that could be recharged by passing a reverse current. It had two lead sheets (separated by rubber strips) rolled into a spiral. These were used to light up train carriages when they stopped at stations. Around twenty years later, Camille Alphonse Faure invented an improved market-able version, which was easier to mass-produce, consisting of a lead acid battery lattice made into a plate with lead oxide paste. Henry Tudor was the first manufacturer of lead acid batteries (in the late 1880s) and set up the first mass-producing factory in Luxembourg. After this, there was a massive expansion of the lead acid battery manufacturing industry.¹

Types of Lead Acid Batteries

Lead acid batteries can be SLI (starting-lighting-ignition), deep-cycle or dual batteries.

I. **SLI:** The SLI types are designed for automobiles and there is a continuous cycle of charge and discharge in the battery. These cannot give power continuously but rather give high power at once. Apart from giving power to the starter and ignition system to start the engine, they also supply the extra power necessary when the charging system is not able to fulfil the vehicle’s electrical load.

II. **Deep Cycle Batteries:** These lead acid batteries, on the other hand, provide a low and steady power and charge and discharge power over thousands of charging and discharging cycles.

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III. Dual Batteries: There are dual batteries as well, which discharge surges of high power when required to start an engine and can also store power to discharge as and when required. These are used to provide abundant power to accommodate large power demands. For batteries to provide power for an even longer duration, the plates are made of calcium and lead.

Flooded and Sealed Lead Acid Batteries

1. Flooded lead acid batteries or wet cell batteries are closest to the original Danielle cell in having the electrolyte in liquid form. The electrolyte is a combination of sulphuric acid and water. Since they are refillable, they require high maintenance but last longer than sealed batteries. Because of the liquid electrolyte, they must be handled with care and oriented appropriately. Regular care should be taken to maintain the correct level of water in the battery and store it in a well-ventilated area, for extreme climatic conditions can reduce the life of the battery.

2. Sealed, or maintenance free batteries, do not contain a liquid electrolyte like their sealed counterparts. These are of two types: gel (valve regulated lead acid) and AGM (absorbed glass mat). Addition of water, like in the flooded batteries, is not required. Also, they require less regular maintenance or ventilation, and can withstand varying climates better than flooded batteries.

Market Size and Demand

The Indian lead acid battery market was valued at $4.47 billion in 2016 and was expected to grow at a CAGR of 8.36% in terms of value, to reach close to $8 billion by 2022. This rate of growth has been predicted on the basis of the expansion of the market of automobiles, telecommunication infrastructure, solar power projects and the ever-growing IT industry. An increasing demand for power back-up devices, coupled with the favourable demographics in India is bound to have a direct impact on the lead acid battery market. Two of the largest primary producers of lead, Hindustan Zinc Limited and Indian Lead Limited have an annual production capacity of 2,00,000 tonnes.

Almost half the value of the market share of lead acid batteries is of stationary and motive applications (SMA). Among the SMA segment, UPS and inverters representing 60 percent of the SMA market, will be the most significant drivers of growth in this sector. Solar installations and hybrid and electric vehicles are also estimated to contribute to the growth of the market. According to Central Pollution Control Board, based on data received from State Pollution Control Boards, the amount of new batteries sold in 2016-17 was 198,250 tonnes (data from 17 states).

Table 1: Batteries sales, India (Source: CPCB)

<table>
<thead>
<tr>
<th>Period</th>
<th>Data submitted by number of SPCB/PCCs</th>
<th>MT of new batteries sold by Manufacturers, assemblers, Importers, Dealer and Re-conditioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-14</td>
<td>14</td>
<td>18,018</td>
</tr>
<tr>
<td>2014-15</td>
<td>16</td>
<td>136,933</td>
</tr>
<tr>
<td>2015-16</td>
<td>22</td>
<td>296,510</td>
</tr>
<tr>
<td>2016-17</td>
<td>17</td>
<td>198,250</td>
</tr>
</tbody>
</table>


Composition of Lead Acid Batteries

A lead-acid battery is made up of the below mentioned components, enclosed within a plastic or ebonite box or casing. A series of negative and positive plates plus separators makes up a battery element, and the battery elements are separated by plates of the same material as the battery box. The elements are bathed in a sulfuric acid electrolyte solution, which can be topped up via the plugs.

The main components of a lead acid battery are:

- **Active Mass:**
  1. Positive and negative terminals made of lead, which provide the connection points to external devices.
  2. Lead Peroxide (PbO$_2$) is used to make up the positive plate, coated with porous metallic lead paste,
  3. Sponge lead (Pb), which is used as the negative plate, coated with lead dioxide paste

- **Dilute sulphuric acid (H$_2$SO$_4$).** The lead-peroxide and sponge lead plates are dipped in dilute sulphuric acid.

- **A separator made of an insulating material** (such as porous sheets of PVC or polyethylene plastic, glass microfibre, or phenolic resins) is also kept between the two plates mainly to prevent shorting between electrodes. In sealed or maintenance or sealed lead acid batteries, electrolyte is absorbed on the porous separator to facilitate conduction of ions between the electrodes to achieve chemical reactions.

![Figure 1: Composition of a lead acid battery](image)

All these are kept in a plastic container. Finally, a load may be connected externally between the two plates.

In batteries, electrical energy is stored as chemical energy (through charging) and this chemical energy can be converted into electrical energy, also called discharging, as and when required.

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Recycling and the Impact of Unregulated Recycling

Globally, lead acid batteries top the list of highly recycled consumer products. From the table below, it is clear that lead acid, at 98%, is far ahead of other products in terms of recycling rates.

Table 2: Recycling rates (globally)

<table>
<thead>
<tr>
<th>Recyclable Items</th>
<th>Recycling (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Acid Batteries</td>
<td>98</td>
</tr>
<tr>
<td>Aluminium Cans</td>
<td>55</td>
</tr>
<tr>
<td>Newspapers</td>
<td>45</td>
</tr>
<tr>
<td>Glass Bottles</td>
<td>26</td>
</tr>
<tr>
<td>Tyres</td>
<td>26</td>
</tr>
</tbody>
</table>

In contrast to many other recyclable materials, indefinite recycling of lead without any or little reduction in quality is possible, making it perfect for a circular economy. It is believed that the quality of secondary lead is as good as the metal obtained from mining, if done properly. In fact, as per International Lead Association, globally more lead is produced by recycling than mining. Mining of lead is done only to fill in the gaps, between demand and supply, not met by secondary lead circulating efficiently in the economy. In India, secondary lead production meets three-fourth of the demand according to the 12th five-year plan (2012-17) of Government of India. Interestingly, recycling lead is an energy efficient process which saves energy and produces less carbon emissions than mining and processing lead ores.

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7 ibid
Almost all parts of a lead-acid battery can be recycled. After dismantling, the lead containing components are put into the furnace for smelting, after which the slag is removed and the molten unrefined lead may be poured into moulds and cooled or it may immediately be directed for refining. The aim of the refining process is to produce lead of high purity for reuse. Recyclable plastic components are washed then shredded and melted for the extrusion process. In many smaller recycling facilities in low- and middle-income countries, the plastic battery cases are often not recycled and may be dumped or burned. The electrolyte may be recovered for re-use or neutralized with alkali and treated to remove lead and other contaminants before being released into the sewage system. At each of these stages, lead contamination can occur. The use of automated, enclosed processes with pollution control devices, in a formal setup, reduces these emissions.

However, improper recycling of lead batteries has the potential to have disastrous consequences. The main pathways of exposure to lead from recycling used lead-acid batteries arise from environmental emissions. These occur at various stages in the recycling process. WHO has documented the sources of pollution from different stages of recycling that has caused lead contamination and poisoning. In the first step of collection and transportation, the sulphuric acid electrolyte solution is sometimes drained out to reduce the weight of the batteries or because a higher price is offered for drained batteries. If not done at this stage then the electrolyte may be drained out at the recycling site or may leak out of damaged batteries during storage and transportation. The electrolyte contains dissolved lead and, if the electrolyte leaks out or is poured onto the ground or in water bodies, rather than into collection tanks, the lead becomes incorporated into soil particles or may contaminate water.

![Figure 4: Battery recycling-Contamination points](source:WHO)
The next step is to break open the hard components made of lead and plastic. Manually breaking up the batteries releases lead particles and lead oxide dust, which are a source of lead exposure to the workers. The dust and particles also settle in the surrounding soil and may be blown to more distant areas, contaminating the wider environment. These emissions even happen during transportation or conveyance of the broken lead parts from the dismantler to the smelter, apart from smelting and refining operations.

The smelting or refining can generate large amounts of lead fume, especially if the furnace is not under negative pressure or if the plant has inadequate ventilation and/or emission controls. In informal setups where smelting is done in open furnaces, fugitive lead emissions can be substantial. Lead fumes are particularly hazardous as the small particle size enables the lead to be inhaled into the lower respiratory tract and absorbed. The fumes will eventually settle as lead particles on surrounding surfaces and the soil, creating lead dust, which can also be inhaled. Sometimes ash from the smelting process is manually shifted to retrieve metal particles, dispersing lead-contaminated dust into the air. Fume, lead particles and dust released at various stages in the recycling process, apart from being inhaled, may even settle on the workers’ clothes, shoes, vehicles and food. So, their families are also at risk of lead poisoning due to inhalation, ingestion and dermal contact.

The recovered plastic and rubber components are either dumped or burnt indiscriminately leading to the emission of sulphur dioxide, dioxins and dibenzofurans, all of which are toxic to human health.

According to a Review Paper titled "Lead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities", the average blood lead level (BLL) in workers was found to be 47 μg/dL in battery manufacturing plants and 64 μg/dL in recycling facilities in workers in 37 developing countries. Airborne lead concentrations averaged 367 μg/m³ as reported in battery plants in developing countries, which is seven times higher than OSHA's permissible exposure limit of 50 μg/m³.

Frameworks Globally

Lead is one of the most strictly regulated substances in industrialized countries. As used lead acid batteries are regarded as hazardous waste, various laws, decrees and guidelines are developed on international levels to deal with these materials. For used lead acid batteries often specific legislation is developed in combination with household batteries. Some of the frameworks are mentioned below:

European Union: Under Directive 2006/66/EC Member States are required to ensure that producers, or third parties, set up schemes to collect automotive batteries from end-users or from an accessible collection point in their vicinity, where collection is not carried out as part of an end-of-life vehicle programme. Furthermore, where the batteries have originated from private, non-commercial vehicles, the schemes may not involve any charge to end-users when discarding waste batteries, nor any obligation to buy a new battery. Member States are also required to ensure that producers of industrial batteries, or third parties, do not refuse to take back waste industrial batteries from end-users, regardless of chemical composition and origin.

United States: Lead-acid batteries are subject to mandatory deposit systems in several states—Arizona, Arkansas, Connecticut, Idaho, Maine, Minnesota, New York, South Carolina and Wash-

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ington—and voluntary deposit systems in most other areas. Many of the states have used model legislation developed by the Battery Council International (BCI), which recommends that retailers charge a US$10 fee (deposit) on all batteries sold, with the fee waived or returned if the customer brings back a used battery within 30–45 days of purchase.

**Canada:** The “lead-acid battery product category” is managed in British Columbia in accordance with the stewardship plans approved under the Recycling Regulation. Province-wide lead-acid battery Stewardship Plans have been developed by the Canadian Battery Association[vii] (CBA) and Interstate Battery System of Canada[viii] (IBSC). All costs are borne by CBA and IBSC, and ULABs are accepted for free at participating retailers. To compete with independent recyclers CBA members may implement a business-to-business programme (at the wholesale level) involving a core charge (deposit) to encourage the return of ULABs from the retailer to the manufacturer. Typically these core charges are CAD$10 per automotive battery with greater amounts for larger sizes.

**Global Initiatives**

**Basel Convention:** The Basel Convention on the control of Transboundary Movements of Hazardous Waste and their disposal was a global treaty adopted on 2nd March, 1989 in Basel, Switzerland. It finally came into force in 1992. It aims to reduce the generation of hazardous waste and promote environmentally sound management of this waste at the site of disposal. It also aims to restrict the transboundary movement of hazardous waste and establish a regulatory system for cases where transboundary movements are permissible.

The convention defines a used battery as a battery which is no longer capable of being recharged or properly retaining its charge. With respect to lead acid battery scrap, it enlists measures for environmentally sound pre-recycling (collection, storage and transportation) and recycling practices of used lead acid batteries along with environmental control processes. It discusses the importance of a well-planned battery collection infrastructure to prevent pollution at the source and occupational exposure. Drainage of battery electrolyte, for instance, demands safety equipment, containers and tools. The Basel convention also prohibits manual breaking of batteries. Till the 80's, this was a standard practice globally but from 1980 onwards, many of the modern smelting plants became completely mechanized. The Convention also has technical guidelines which are meant to provide guidance to countries which are planning to improve their capacity in order to manage the used lead-acid battery wastes. The guidelines provide recommendation on different steps of pre-recycling, including collection, transportation and storing. Do's and Don'ts of recycling, including battery breaking, lead reduction and lead refining have been elaborated in this document from the Secretariat.

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Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children. Lead in the body is distributed to the brain, liver, kidney and bones. It is stored in the teeth and bones, where it accumulates over time. Human exposure is usually assessed through the measurement of lead in blood. Lead in bone is released into blood during pregnancy and becomes a source of exposure to the developing fetus. There is no known level of lead exposure that is considered safe.

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In mechanical processing facilities, batteries are broken into small pieces in hammer mills or other crushing mechanisms in such a way so as to ensure that lead plates, connectors, plastic boxes and electrolyte are separated in subsequent steps. Then lead oxides and sulphates are separated from other materials by gravity in water by a system of moving mesh conveyers. The metal components (lead plates, grids, connectors and terminals) are separated from their organic components (plastic boxes and separators mainly) by hydraulic separators. Some other processes utilizing density and hydraulic mechanisms separate the broken battery pieces in three different layers: light fractions (plastic), fine granular pieces of lead oxide and sulphates and the third one (heaviest layer) consists of lead plates and connectors. The layer comprising organic material is further separated into light organics (polypropylene), heavy organic material (ebonite) and separators. Washing off the light organics is done to rinse away any trace of lead oxides after which they are hammer milled into small pieces, according to their future use. If a mechanised breaking system is not available, the Convention recommends that the electrolyte be drained and the top of the battery be removed with lead plates, grids and separators. This must be sent to smelters and the plastic casing can be sent to battery manufacturers for reuse.

The battery scrap so obtained is usually a mixture of metallic lead, lead oxide (PbO), lead sulphate (PbSO₄) and other metals like Copper, Calcium, Antimony, Arsenic, Tin and sometimes Silver. Pyrometallurgical and Hydrometallurgical methods or their combination are a few ways to separate metallic lead from the mixture.

**Pyrometallurgical Methods:** It aims to obtain reduced metallic form of all metallic compounds by heating and providing adequate fluxing and reducing substances.

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Desulphurization before smelting is necessary to reduce the amount of slag formation and sulphur dioxide released in the air. To achieve this, the lead sulphate paste must be reacted with a mixture of sodium carbonate and sodium hydroxide to obtain lead oxide from lead sulphate. Ferric Oxide and limestone may also be used as desulphurizing agents. The electrolyte must also be treated with sodium hydroxide to precipitate lead as lead hydroxide. This is then filtered or decanted and smelted in the furnace. The metallic fractions along with fluxing agents (to reduce lead smelting temperature and provide a liquid solvent to trap several unwanted compounds during the smelting and reducing processes) and reducing agents (to reduce lead oxide and hydroxide to metallic lead) such as coke or other carbon sources are then added to the furnace, which is heated with the help of gas, coke, electricity, etc. Smelting may be carried out in one out of many different types of furnaces like rotary, reverberatory, blast or electric furnace, rotary kiln, etc.

**Hydrometallurgical Methods:** The main objective of this method or electrolytic methods is to electrically and selectively reduce all lead compounds to metallic lead, such as in the PLACID technology, as shown below:

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In an electrolytic process, lead compounds are converted into a single chemical species, such as oxidation state +II (Pb^{2+}) in the given case, which is electrolytically reduced to produce metallic lead.

![Diagram of Electrochemical Process in Metallurgical Lead Production](image)

**Figure 8: Electrochemical Process in Metallurgical Lead Production**

Lead, which gets deposited as dendrites or sponge, is collected on a conveyer belt and pressed to form platelets of pure lead. This can then be directed towards a melting kettle for casting into ingots.

The guidelines under the Basel Convention also lay down environmental control measures including EIA and technological interventions at different stages of battery recycling to prevent leakage and contamination of our environment.

**Legal framework in India**

At present, India has a legal framework in the form of the Batteries Management and Handling Rules (BMHR) 2001, with amendments in 2010 to deal with the issue of recycling ULABs. Salient features of Batteries legislation:

- Apply to every manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, consumer and bulk consumer involved in manufacture, processing, sale, purchase and use of batteries or components thereof.
- Responsibilities of manufacturer and importer to ensure that the used batteries are collected back against new batteries sold and to set up collection centres either individually or jointly at various places for collection of used batteries from consumers or dealers.
- They have to direct these batteries to registered recyclers and buy recycled lead only from registered recyclers.
- Consumers to return used batteries and manufacturers / assemblers / reconditioners / importers responsible for collection of batteries and transport to registered recyclers.
- Bulk consumers can auction used batteries only in favour of registered recyclers.
- Dealers are also responsible for collection.
- Collection of batteries 50% in the first year, 75% in the second year and 90% from the third year onwards.
II. The Study Background and Framework

The purpose of this study was to understand and evaluate the status of the implementation of Batteries (Handling and Management) Rules in different parts of our country. Through this study, we were also keen to gauge the level of awareness about the Rules and of the impact of improper processing of ULABs on our health and the environment. Extensive research carried out by the WHO, Pure Earth and other credible international research organisations has shown that unauthorized recycling of ULABs has a detrimental effect on the environment and our health. Thus, after a brief recce of the current scenario, an extensive survey was conducted in four states in India to comprehend the flow of used batteries from consumers to recyclers, awareness about the Batteries Rules and the environmental and health impact of unauthorized collection and recycling practices. Some recycling units were also visited to assess the processes of dismantling and recycling and associated environmental leakages which is harming to human health as well.

The scope of the study was as follows:

- Understanding the value chain and economics of spent lead batteries along with the role of different stakeholders in the entire chain of collection, dismantling and recycling of such batteries.
- Identifying areas of ULAB recycling in and around the study areas.
- Understanding the dismantling and recycling practices in formal and informal facilities, material recovery and fate of non-recyclables.

This would encourage our policy-makers to look for ways to strengthen the implementation of the rules to control and formalise unauthorized recycling. Through this study, we also aim to create awareness in the common citizen and other stakeholders involved in collection and processing to responsibly channelize their waste lead batteries to prevent damage to the environment and human health.

Study Framework

Objectives

Objectives of the study are:

i. To review literature to understand the use and end-of-life management practices of lead acid batteries.

ii. To document the current practices of ULAB collection and recycling (in formal and informal sectors) along with the economics of the ULAB value chain in four cities in India, namely, Delhi, Jaipur (Rajasthan), Vijaywada (Andhra Pradesh) and Ranchi (Jharkhand) along with a small town and village close to each of these cities.

iii. To understand the impact of unorganised recycling on human health and environment.

iv. To gauge the awareness about the Batteries (Management and Handling) Rules, 2001 (amended 2010) among different stakeholders and the effects of improper handling and recycling practices of ULABs.

v. To make recommendations to strengthen the implementation of the Batteries (Management and Handling) Rules, 2001 (amended 2010).
Methodology

The study was conducted in two phases:

i. The first phase involved secondary research on lead acid batteries (LABs), their applications, market analysis and impacts of inappropriate collection and recycling practices of spent LABs across the globe.

ii. In the second phase of the study, an extensive survey of the stakeholders involved in the management of end-of-life lead acid batteries was conducted to understand the collection and recycling practices, occupational safety measures adopted (if any) and awareness about Battery Management and Handling Rules in different parts of India.

First Phase

The first phase involved gathering information from research papers, government websites, websites of battery manufacturers and international studies conducted by WHO and other organisations on the

• Applications of lead acid batteries,
• Current collection practices and recycling norms of end-of-life batteries in India and in other developing countries, and
• Health and environmental risks associated with informal recycling practices.
• Current status of Implementation of Batteries Rules in India

Second Phase

On the basis of secondary research and a few interviews with dealerships, kabadiwallas and workshops, survey questionnaires were designed for stakeholders, namely, consumers (also referred to as consumers in the study), scrap dealers or kabadiwallas, dealerships, workshops and informal and formal recyclers. Four states were selected in different regions of India to get a holistic view of the scenario:

Table 3: Survey areas

<table>
<thead>
<tr>
<th>S. No.</th>
<th>State/Union Territory</th>
<th>City</th>
<th>Town</th>
<th>Village/Rural Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Delhi</td>
<td>New Delhi</td>
<td>Ghaziabad</td>
<td>Bawal</td>
</tr>
<tr>
<td>2.</td>
<td>Rajasthan</td>
<td>Jaipur</td>
<td>Dausa Urban Area</td>
<td>Dausa Rural Area</td>
</tr>
<tr>
<td>3.</td>
<td>Jharkhand</td>
<td>Ranchi and Tata Nagar (Jamshedpur)</td>
<td>Dhourwa</td>
<td>Khunti</td>
</tr>
<tr>
<td>4.</td>
<td>Andhra Pradesh</td>
<td>Vijaywada</td>
<td>Vuyyuru</td>
<td>Kankipadu</td>
</tr>
</tbody>
</table>

The aim of the survey was to

• Understand the collection and recycling practices along with the safety measures adopted to minimise occupational exposure to lead (and other harmful constituents of LABs) and prevent environmental damage.
• Gauge the level of awareness and knowledge about Battery Rules in India and the detrimental impact of improper recycling of batteries on the environment and health of the various stakeholders.

The questionnaires had questions pertaining to types of batteries bought or dealt with, sellers and buyers of ULABs (Used Lead Acid Batteries), frequency of collection, processing and disposal mechanism, health issues faced by the different stakeholders, take-back systems of dealers, economics of the value chain of collection and transfer of batteries for recycling, filing of returns by
dealers, waste generated after recycling and their disposal along with environmental and occupational safety measures being followed. The prominent areas or hotspots of collection, dismantling and/or recycling of LABs in and around the study areas were also mapped out.

Finally, conclusions were drawn to understand why a large quantum of spent LABs reaches the informal sector instead of the formal recycling units. Policy measures to encourage authorized recycling practices and best practices of recycling adopted globally have also been suggested.

Limitations
1. The study was only conducted in four states due to resource constraints.
2. Many stakeholders were reluctant to reveal the truth about their sales and profits made on selling old batteries and the different buyers to whom they sell their stock of spent LABs. Some of them even refused to divulge any detail apart from the type of batteries they were dealing with. So, the information on recycling practices, take-back and returns may not be complete.
3. It was very challenging to find the address of the recycling units (authorized/unauthorized) in the areas for the survey. Even after illegal smelting units were located, it was a task to interview their owners and employees, enter the premises and take photographs.
4. Updated information from regulatory agencies was also not available.
**III. Study Findings**

Toxics Link, in collaboration with partners, carried out surveys, interviews and focussed group discussions in Delhi, Rajasthan, Jharkhand and Andhra Pradesh, primarily to evaluate the implementation of Batteries Rules. This was done by studying the flow of end-of-life lead acid batteries from consumers to industries which receive secondary lead from recyclers. In all the areas visited, a common pattern was identified for collection, transfers and recycling. Lead acid battery collection and recycling in India involves a sequence of steps, as shown below:

![Figure 9: End of life battery flow](image)

Lead, being a valuable metal, is not disposed of in landfills, but is rather extracted from ULABs sent by dealers, workshops, scrap dealers (also called *kabadiwallas* in India), refurbishers or collection centres, and then smelted and refined in recycling units. These secondary smelting units dismantle the batteries to recover the metal along with plastic and sometimes paper. The smelted lead is cast into slabs or ingots after which it is used to make new batteries or other leaded products like paints.

**Table 4: LABs life span**

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Life span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four and Three wheelers</td>
<td>3-5 years</td>
</tr>
<tr>
<td>2 wheeler</td>
<td>2-3 years</td>
</tr>
<tr>
<td>UPS</td>
<td>2-3 years</td>
</tr>
<tr>
<td>Solar devices</td>
<td>5 years</td>
</tr>
<tr>
<td>E-rickshaw</td>
<td>6 months</td>
</tr>
</tbody>
</table>

Battery consumption has gone up, as mentioned in the chapters above. But all of them obviously do not reach their end of life in the same time frame. Each of the different types of batteries has a different lifespan ranging from 6 months to around 5 years. E-rickshaws, which are now commonly used in many areas of Delhi and are being promoted as a last mile connectivity option, have batteries which probably last the shortest and must be changed every six months. Four and three wheelers use batteries which easily last for at least three years and for a maximum of five years. Two wheeler batteries and UPS have a lifespan of about two to three years. Solar batteries which are used in solar plants and devices have a lifespan of about five years.

After the batteries have run their life span, consumers largely hand over their automobile, inverter, UPS and other batteries to dealers in exchange with new batteries. Some of them also get their automobile batteries changed at workshops during servicing. Small batteries used in UPS and two wheelers are sometimes sold to cabadiwallas for greater profit and for the sake of convenience. In villages, due to the absence of a sufficient number of dealers, consumers sell their used batteries to workshops and kabadiwallas. While dealers further sell their batteries to battery manufacturers or kabadiwallas, workshops mostly trade with kabadiwallas only. These kabadiwallas transfer these
batteries to informal recyclers who sometimes receive lead bricks and dust too from other industries. Hence, a considerable volume of lead acid batteries reach the informal sector from dealers and workshops. It was found out that close to 90 percent of ULABs reach the informal recycling sector.

Figure 10: Source of raw material for informal lead acid battery recyclers

As depicted in the figure above, the informal recyclers receive raw material, i.e. used lead acid batteries from different sources. Though dealers do send some amount of battery back to Battery manufacturing companies, a sizable amount, especially in smaller towns and villages are sent to informal trader or recyclers. Workshops were generally seen to be sending their waste to the informal chain. The informal recyclers also get lead dust or other lead containing waste etc from other industries. The recyclers extract lead and mostly sell this to big smelting companies but also sell the unrefined one to small informal units for further use.

The drawback of this informal sector is that the processing technologies in use are mostly rudimentary and cause a host of environmental and health issues. Taking this into consideration, Batteries Handling and Management Rules were formulated in India in 2001 and later amended in 2010. Battery manufacturers are mandated by Battery Rules to take back used batteries and ensure that the lead in them gets recycled in an environmentally sound way. They may either have their own authorized recycling facility such as Exide has at present or may sell the collected batteries to formal recyclers authorized by CPCB. As per our sources in the formal recycling sector in India, 12 lakh tonnes of batteries entered the recycling industry in the year 2017-18, 90 percent of which were processed in the informal recycling units.

Formal recyclers, in contrast from the informal, mainly receive their waste from Dealers, Battery manufacturing companies and Bulk consumers.

Figure 11: Source of raw material for formal recyclers
In many of the formal recycling companies, though the process seemed streamlined; it also appeared that many companies claiming to have formal license (difficult to comprehend whether they really had the licenses as they refused to show it to the surveyors) carried out operations which were not very different from the informal sector. Hence it does seem that these units are not properly monitored by the regulatory agencies.

Depending on the kind of collection and recycling practices and the steps involved, the wide ranging effects of improper processing of ULABs are listed below.¹²:

1. In the absence of a proper neutralisation or safe disposal system, the battery electrolyte (sulphuric acid) may be disposed of carelessly and percolate into the groundwater table, rivers and the sewage system.

2. In the absence of exhaust emission filters, the air in and around recycling and smelting units may have a high concentration of lead (along with cadmium, arsenic and other toxic elements) thus posing a serious risk to the health of workers and the people living in the vicinity.

3. Furnace residues along with other components of batteries (like separators) which are often disposed of carelessly in and around lead smelting premises are unstable and leachable and hence can also percolate into the water table and nearby streams or aggravate the waste management issues.

These practices were found to be common in all the states where the surveys were done.

Overall, the awareness levels seemed low among consumers, who were unaware about the hazards related to lead acid batteries as well as mostly oblivious of the Battery Rules which have been in force for many years. The other players in the value chain, namely, dealers, workshops, traders were aware of the Rules and the need to treat the ULABs in a safe manner. But most of them chose economic gains over environmental or health concerns.

The on ground situation clearly pointed towards the failure of the Rules and apathy towards treating hazardous materials. The section below, details out the findings from each of the states included in this important study.

A. Delhi

Background and Survey Findings

Delhi is one of the most populous cities in the world with an estimated population of about 16.7 million. ⁹⁷ percent of the households have been categorised as urban. Add to this the population living in nearby towns and villages and travelling to Delhi for work and one will get a much larger number. The per capita income in Delhi was Rs 3,03,073 as per the findings of the census of 2011.⁴ Owing to an increase in commercial activities and purchasing power, the automotive and industrial battery market has shown a sharp rise. Also, the increasing population has resulted in growing power needs and shortfall in supply has resulted in growth in lead acid battery based invertors markets. Car and other four wheelers, two and three wheelers, e-rickshaws, inverters and UPS are some of the most commonly available usages of LABs in Delhi NCR. Solar battery sales have also shown an upward trend in recent times. But, comparatively it’s still smaller.

During our survey, it was found that almost all the major companies with major shares in the LAB market in India are sold in Delhi. Most of the dealers interviewed claimed that sealed (or maintenance-free) and open or flooded batteries (refillable with distilled water) have equal shares in the

¹³ http://www.delhi.gov.in/wps/wcm/connect/ f508bc8046667b0e9c6bcf5a4ed47e7/STATISTICAL+ABSTRACT+2016%281%29.pdf?MOD=AJPERES&lmod=1528597023&CACHED=508bc8046667b0e9c6bcf5a4ed47e7
¹⁴ ibid
market. Although, a large percentage of four-wheeler batteries in Delhi are of flooded type, the two-wheeler battery market is dominated by sealed batteries.

Delhi has an elaborate network of workshops, dealers, kabadiwallas and recyclers to collect and recycle used lead acid batteries. There is economic gain for all the stakeholders involved including consumers. But that is because none of them are accounting for the loss to the environment and human health! The collection and recycling hotspots are located on the outskirts of Delhi. Intermittently, these units, mostly informal, are shut down by the government because of the concerns of air pollution from these units. But they return back in sometime. Interview with stakeholders also indicated that some batteries are sent to places like Jaipur, Alwar, Rewari and Meerut for recycling.

Material Flow

In Delhi, the survey to understand the flow of used lead acid batteries from consumers to recyclers was carried out in New Delhi and its neighbouring areas Ghaziabad and Bawal. Surveys during the study period indicated that consumers return old batteries at the time of buying new batteries or servicing (automobile and inverter batteries) from dealers and workshops. The pattern was similar in all the three places. Majority of the consumers, which was more than 85 percent of those interviewed, preferred dealers and workshops.

![Figure 12: Consumers- LABs disposal](image)

Most of them are given a rebate in cash or kind by the dealers and workshops depending on the type of battery returned. Sometimes, they are given free servicing by workshops rather than a monetary value for the used battery. In some areas, consumers were found to be giving their batteries to kabadiwallas against cash. In such cases, the batteries returned are usually industrial LABs (inverters, UPS, etc.). Convenience, for consumers, was the top reason for their disposal practices. Few consumers choose kabadiwallas instead if they were more accessible or there were concerns of storage.

Some consumers were first time users and hence had not disposed off their batteries yet. Interesting to note that the first time users or people who have not disposed off batteries varied a lot- in the city Delhi, it was a very small segment whereas it became bigger as we went to small neighbourhoods.

Most of the workshops in New Delhi, **close to 72 percent of those surveyed, were found to be selling the waste batteries collected to kabadiwallas.** Their reason for giving away LABs to kabadiwallas was convenience of pick-up and lack of storage space. They also cited billing issues involving time consuming paper work as a major concern while dealing with distributors and formal recyclers. Kabadiwallas don’t ask for bills unlike company distributors and dealers who need to file returns to the SPCB. Some workshops prefer dealers and kabadiwallas interchangeably depending...
on the difference in the monetary compensation offered by them. Many of the dealers, however, return some batteries to the company distributors or manufacturers.

Small kabadiwallas and traders in New Delhi get their supply of used batteries mainly from workshops and dealers. A large percentage of them visit sellers almost three times a week to collect used batteries. Some kabadiwallas even make daily trips to their sellers. Apart from greater convenience and a better profit margin many a times, they are even ready to collect smaller quantities of batteries as opposed to dealers who are more interested in collecting larger quantities. The dealers and workshops confirmed this by claiming that kabadiwallas are more frequent visitors than distributors or company representatives who send their vehicles only once in one or two months.

Most of the small kabadiwallas sell their collection to traders and recyclers. The traders also sell their supply of spent batteries taken from kabadiwallas to recyclers, many of whom are not registered with the concerned Pollution Control Board. This is how a large percentage of the used batteries in Delhi NCR, lead scrap and dust reach the unauthorized informal sector in Delhi.

Economics

Apart from convenience, monetary gain was a key driver for the material flow. Consumers received a cash back or discount in most cases for their batteries.

Table 5: Rebate received by Consumers for old LABs

<table>
<thead>
<tr>
<th>Batteries given to</th>
<th>Average Amount received by Consumers (in Rs/piece of battery)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>Dealers</td>
<td>700</td>
</tr>
<tr>
<td>Workshops</td>
<td>600</td>
</tr>
<tr>
<td>Kabadiwallas</td>
<td>10-20 percent on the original price of a battery</td>
</tr>
</tbody>
</table>

The profit made by the workshops and dealers, all of whom buy batteries from consumers, differs for different types of batteries, as shown below. From the information provided by the stakeholders, it appears that profits increase with the increase in the weight of batteries. Inverter and e-rickshaw batteries being heavier than the other types of batteries yield greater profit.

Table 6: Economics for Dealers and workshops, Delhi

<table>
<thead>
<tr>
<th>Types of Used Batteries sold by Dealers and Workshops</th>
<th>Average Profit Margin of Dealers and Workshops (Rs/piece)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>150-200</td>
</tr>
<tr>
<td>Two wheelers</td>
<td>50-100</td>
</tr>
<tr>
<td>Inverters</td>
<td>250-300</td>
</tr>
<tr>
<td>UPS</td>
<td>50-100</td>
</tr>
<tr>
<td>E-Rickshaw</td>
<td>100-500</td>
</tr>
</tbody>
</table>

Kabadiwallas, on the other hand, make equal profit over a wide range of batteries, earning only Rs 2-3 per kg exclusive of operational costs. If labour, electricity and other costs are included, this would come down to 50 paise to Re 1 per kg of batteries. They also make profits on the plastic casing depending on the type of plastic used (PVC, bakelite, etc.). Large batteries used in trucks and other heavy-duty vehicles have casings made of Bakelite which makes such batteries cheaper than PVC batteries (smaller automobile and industrial batteries) by about Rs 12.
Hotspots of Lead Acid Battery Collection and Recycling

The areas dealing with collection of lead acid batteries in Delhi are very widespread. Most of the collection centres are located in Tis Hazari, Paharganj, Mustafabad, Seelampur, Madangir, Dakshinpuri, Siraspur and Turkman Gate. Formerly, used LABs would be taken by kabadiwallas from collection centres to informal recycling units in areas like Mandoli, Siraspur, Mongolpuri, Bakoli, Sultanpur, Majra and Nangloi in Delhi. These were recycling centres because of being located close to battery collection markets. But, after government intervention due to rising concerns about pollution, these units had to shut shop. As a result, traders have to send their batteries to recyclers in Ghaziabad and Meerut in Uttar Pradesh, and Jaipur and Ajmer in Rajasthan. These have now emerged as major hotspots.

In Ghaziabad, LalKuan area was found to be dotted with informal lead recycling units. They receive raw material in different forms from industries and recyclers in Delhi and neighbouring areas in Ghaziabad itself. Additionally, there are areas like Khachra Industrial area in Dasna-Masuri, Murad Nagar, Modi Nagar, Nekpur, Khatauli which are battery collection and recycling hubs.

In Delhi and its neighbouring areas, a large volume of the used batteries reach the informal recycling units located on the outskirts of the city such as Ghaziabad. Traders, after collecting old batteries from small scale kabadiwallas, dealers and workshops, deposit them at recycling facilities. There are small and large-scale recyclers on the outskirts of Delhi-mostly informal, who take batteries of different types, lead scrap and lead dust from kabadiwallas, different industries and other recyclers. Some factories located in industrial areas also send lead in the form of lead dust and huge bricks to these units. These units are either involved in dismantling and separation of the battery components or smelting recovered lead or both.
The Recycling Process

In both small and large-scale units, dismantlers break open the batteries using hammers or other similar heavy tools. The plastic casing, separators and lead grids are separated after which all the components other than lead are sold off to their respective processing units for recycling and reuse. Plastic casings and the separator are processed to make pellets which are melted and remoulded to make objects of daily use. If the dismantling units are also involved in informal battery making, they reuse the plastic components within the unit instead of selling them. The hydrochloric acid, if any, is drained out on land or in drains. However, usually, the acid is drained out by small-scale scrap collectors to decrease the weight and help transportation.
The extracted lead grids are then smelted in chambers (open or close) or pits called bhatts. Upon melting, they are poured into moulds for casting. Recyclers receive lead even in the form of huge bricks and lead dust, as mentioned before. The bricks are sprinkled with water to make them softer.

This softened raw material is dipped in a small pond to turn it into dust.

Further, this dust is dried and heated at 600-700 degree Celsius in an open heating chamber or bhatti (as shown below) using coal.

The chamber or bhatti is then closed with a lid. The lead, being heavy, settles down at the bottom of the chamber while the impurities float on the top. The purified lead is taken out of the chamber with a large spatula made of heat-resistant alloy and poured into casting moulds.

Figure 16: Bhatti in an informal lead smelting unit

Figure 17: Lead smelting and Refining in the open
The lead is also melted in a closed furnace, like the one shown below.

Figure 18: Closed chamber running on electricity for smelting lead

The above chamber is powered by electricity and at the time of collection of pure lead, the chamber is rotated to pour out the molten metal into moulds.

Figure 19: Refined Lead obtained after smelting and refining process
The molten lead is taken to form ingots after which they are sold to battery manufacturing units or the paint industry which require lead as raw material. The purified lead may also be used to make lead grids within the unit.

The molten lead is poured into grid casts and then coated with red or grey lead oxide paste depending on the type of plate to be made-positive (red) or negative (grey). The lead paste is a mixture prepared in the unit itself using lead oxide powder and a few other chemicals and fibres (petroleum products). The paste is put into place by using plastic pouches to hold the grids. The pouches are removed and then these plates are dipped in an acid bath for 5-6 days. After being taken out, they take 2-3 days to dry.

![Prepared Lead grid](image)

The grids are then finally used to make batteries within the unit or are sold to battery manufacturers. The plastic casing, acid and pouches are purchased or recovered from old batteries received from the scrap dealer. Acid is purchased in concentrated form and diluted for filling up LABs or preparing lead grids in acid bath.

Since most of these processes are carried out in open, with no regard to safety and environmental safeguards, there is a huge risk to the surrounding environment and health. The step by step process indicates dearth of technologically advanced processing and disposal techniques and thus risk of lead contamination and exposure.

**Profits made by Informal Recyclers in Ghaziabad**

During a visit to informal recycling units in Ghaziabad, we tried to understand the economics of the informal recycling business. These recyclers deal with different types of lead dust and scrap received from different industries. The lead recovered ranged from 15 to 25 percent of the raw material. One of the types of lead dust yielded close to 500 kilograms of lead from 3000 kilograms of dust. The raw material was bought at the rate of Rs 2 per kilogram and the recovered lead was sold in the form of ingots at the rate of Rs 170 per kilogram of lead.
Occupational Safety precautions provided and used during the process and for the workers

The workers in ULABs value chain battle huge risk while handling and processing these. The batteries being handled by stakeholders (kabadiwallas, workshops and dealers) are a mix of dry and wet batteries, the latter having a high probability of leaching out sulphuric acid during transfers. Kabadiwallas, workshop workers and dealers, who sometimes accidentally touch the acid leaching out of the battery or while draining out the acid, did not have any safety equipment such as gloves to minimize dermal contact.

Dismantlers, who use hammers and machetes to break open batteries, have no protection against injuries. While loading and unloading such heavy batteries onto trucks and from them, kabadiwallas and workers in dealer shops, workshops and recycling units also often drop the batteries on their feet and have physical injuries. While taking out molten lead from the bhadd and pouring it into casting moulds, workers in recycling units run the risk of dropping the hot molten metal on their bare feet. The workers are not even given any type of special footwear, like rubber boots, to protect them from such accidents. There is no provision for breathing masks although gloves are given to some workers. Also, they wear their own clothing during their shifts and don’t get the opportunity to dust off the lead before going back home.

Environmental Impact

As mentioned before, kabadiwallas and workshops, very often, empty the acid content just after collection from consumers. This is done to maximise monetary gains from the used batteries since the acid does not yield much profit. They pour out the acid at the site of receipt - on soil or in drains. Although the sulphuric acid in LABS is diluted, it may contain dissolved and dispersed lead which on repeated dumping on the same spot may destroy the flora and fauna of the area and pollute the groundwater and even other water bodies where the drain water finally reaches. This is the first major point of pollution in the recycling chain.

Dismantlers, while breaking open the batteries, expose the surrounding air, soil and water to lead dust, leading to severe contamination. The separators retrieved from batteries, made of plastic or paper, are often dumped on the ground along with plastic pouches (used to make lead grids) around dismantling units as seen in the picture below.

Figure 21: Separators and other battery scrap dumped in the open at LalKuan, Ghaziabad
Unorganised smelting units, receiving lead scrap and dust, often leave this raw material out in the open, exposed to the wind and rains. As a result, the air around smelting units is often laden with lead dust, like the survey team observed in Ghaziabad. Lead bricks, received as raw material from some factories, must be dipped in a pond for some time for softening, as mentioned above. This may lead to contamination of the ground water and those areas where the dirty water from the pond (heavily concentrated with lead) is dumped periodically.

Smelting operations are mostly carried out in the open in bhattis. Even in units where closed chambers are used, basic pollution control equipment like filters were found to be missing to collect ash (containing lead) from the exhaust pipe. In Ghaziabad, the land right outside smelting units was seen to be contaminated with lead. It can be deduced that smelters may dispose of processed raw material or slag (containing lead in small quantities not enough for extraction) from bhattis in the open.

The units we visited in Ghaziabad were lacking in pollution control measures or waste management systems. Many LAB recycling units in Mandoli, however, had been shut down by government authorities in the last quarter of 2017. Some of these unregistered units had in fact been run over by cranes after repeated warnings to stop such polluting operations in the open. But, as seen in the pictures below, the authorities had failed to ensure that the extracted parts of batteries and other raw material in the form of lead scrap and dust were moved inside or covered to prevent further contamination of the surrounding environment.

Figure 22: Lead dust dumped in the open at LalKuan, Ghaziabad

Figure 23: Recycling units shut down by government authorities in Mandoli, Delhi
Health Impact

All the workers in workshops, dealers’ units and in the recycling sector were male, mostly above 18 years of age. A unit in Mandoli (which had stopped its operations after the raid) told us that they had some female workers as well who would separate the different components of LABs. Many labourers are migrants from Uttar Pradesh coming to the city for lack of a better paying job. Many of these stakeholders involved in the collection and recycling of used batteries, from kabadiwallas to recyclers, are exposed to the acid and lead in the batteries. They are even prone to injuries during manual work. In fact, 7 to 8 percent of the kabadiwallas and workers in dealers’ shops whom we had interviewed in Delhi confessed to having suffered from accidents like acid spills from LABs, especially from wet batteries. Almost 60 percent of the workers in recycling units we met during the survey in Delhi told us that they have suffered from molten lead spills and injuries due to heavy batteries falling on their feet during onloading and offloading.

The workers in recycling units are at the greatest risk of suffering from lead contamination because of the high degree of exposure to lead. Basic health and safety standards are missing in such work environments. Many workers were seen to have been covered in the silver metal from head to toe. This also puts their family at risk of suffering from symptoms of acute lead poisoning. Also, in the absence of separated mess areas, they are forced to eat and drink in the open in the highly contaminated factory area. Apart from lead in the air, lead dust from their clothes and hair too may contaminate their food. None of the dealers, workshops or recycling facilities provide any kind of health benefits such as insurance and compensation against medical bills to their employees.

Lead Poisoning among workers in Delhi

Dr. Surendra Chaddha has been running Patliputra Nursing home, in Samaypur Badli, Delhi for the last twenty years. The nursing home is situated near an industrial area and specializes in treating patients with lead poisoning. Patients are generally workers (including women), in the in the age group of 20 -40 years, from battery or paint industries-mostly from the surrounding areas but patients also come from Punjab, Haryana and Uttar Pradesh. Typical symptoms of lead poisoning found in lead affected patients are- acute abdominal pain, frequent vomiting, constipation, fits and faints in extreme cases. Patients would mostly be anemic and physical changes like gum deposits are also observed.

Blood Lead level observed among the workers: While the average blood lead level in the patients vary from 150 to 300 µg/dL, the highest recorded has been 700 µg/dL. Workers who have been working in these units for 3-4 months report around 100 µg/dL blood lead level. There are some patients who have been working in the battery recycling units for the last 10 -20 years and have much higher lead levels and come repeatedly for treatment.

Awareness

Merely 8% of the consumers were concerned about the way old batteries are processed on being told that smelting activities take place on the outskirts of the city. In contrast, none of the consumers in Ghaziabad and Bawal showed any concern for spent LAB recycling.

While in Delhi, 64 percent of the consumers were found to be unaware of the consequences of informal recycling of batteries on human health and environment, in Bawal a whopping 96 percent of the consumers interviewed were oblivious to the same. Furthermore, 8 percent and 4 percent of the consumers in Delhi and Bawal, respectively, claimed that used battery recycling is harmless to their health and the environment. On a positive note, however, more than 20 percent of them in Delhi and Ghaziabad were conscious of the fact that such unregulated activities take a toll on their well-being and the environment.
Furthermore, only 15 percent of the consumers in Delhi, Ghaziabad and Bawal were aware that battery manufacturers in India take back old batteries.

![Figure 24: Awareness on Takeback- Delhi](image)

Even after more than 15 years of the notification of the Batteries Rules (2001), awareness about the rules among consumers in Delhi, Ghaziabad and Bawal was found to be very low, as can be seen below.

![Figure 25: Rules on Awareness- Delhi](image)

The awareness among owners and workers in workshops was even more dissatisfying than that of consumers. None of them, in Delhi, Ghaziabad or Bawal, knew about Batteries Rules and maybe that’s why they continue to prefer kabadiwallas over dealers to hand over batteries.

Among the kabadiwallas and traders too, only 86 percent of them were found to be aware of the rules and even among those who were aware, nobody claimed to sell their batteries to formal recyclers. Much to our surprise, only 14 percent of the dealers knew about the provisions of the Batteries Rules(2001) although 34 percent of the dealers claimed to file returns for the used batteries received. However, all the dealers have a take-back system in place to buy back old batteries from consumers and workshops.
B. Jharkhand

Background and Survey Findings

Jharkhand is a state in the eastern region of India with a population of around 3.2 Crores\(^1\) with a majority living in the rural areas of the state. The per capita income at Rs 56,737\(^2\) is one of the lowest in the country. This may be one of the reasons for a greater preference for flooded lead acid batteries, which are cheaper, in comparison to sealed batteries. According to the study findings, the flooded LABs capture 75 to 80 percent of the overall battery market in Jharkhand. Another reason for this preference could be for the reason that the aging flooded lead acid batteries can be restored by adding chemical to the electrolyte to dissolve the build-up of lead acid batteries on the lead plate, replacing the evaporated distilled water of the electrolyte or the lead plates. This makes flooded lead acid batteries last longer than their sealed counterparts, in turn, making them more economical than the latter. In the two wheeler market in Jharkhand, though, sealed batteries capture 95 percent of the market according to our survey. Apart from two wheelers, the most common applications of lead acid batteries in Ranchi are in buses and three wheelers. Cars are another important usage but lesser in number as relatively few people own cars at present. The inverter market is also a market segment which is gradually picking up pace but not yet very big.

A large percentage of these batteries at their end of life reach the large network of informal units present in and around Ranchi. Ranchi is the hotspot of collection and recycling of spent lead acid batteries coming from small cities/towns in Jharkhand like Khunti, Simdega, Gumla, Lohardaga and others. The big cities in Jharkhand such as Dhanbad, Jamshedpur, Bokaro and Deoghar, on the other hand, send their batteries to Kolkata in West Bengal because of their proximity to Kolkata.

\(^{16}\) http://pib.nic.in/newsite/PrintRelease.aspx?relid=169546
Our interactions with the various stakeholders involved indicated that more than 60 percent of ULABs generated in the state are sent to smelting units in West Bengal, close to 20 percent are recycled informally within Ranchi and the remaining 20 percent of the batteries are returned to battery manufacturers for formal recycling.

**Material Flow**

In Jharkhand, the survey to understand the flow of used lead acid batteries from consumers to recyclers was carried out in Ranchi, Tata Nagar (Jamshedpur), Dhurwa and Khunti. This chain has been in place for years because of the economic benefits it provides to the stakeholders involved in it.

![Figure 27: ULABs disposal](image)

While more than 70 percent of the consumers return their used batteries to dealers, the rest 30% goes to kabadiwallas and workshops. The factors behind their choice were monetary gains and convenience. The reason behind the transaction with kabadiwallas is because some consumers preferred getting cash rather than a discount on the price of a new battery purchased. The dealers usually offer discount on new purchases.

During our survey, it was noticed that small scrap LABs like two wheelers and UPS batteries are sold by consumers to kabadiwallas, while big scrap LABs like inverter batteries and commercial vehicle batteries like car and truck batteries are given to dealers. The main reason for selling small batteries to kabadiwallas was found to be the low resale value/price of such batteries, and because it is more convenient to sell them directly from their residence instead of carrying them to dealers or workshops. This leads to a preference for kabadiwallas for selling smaller LABs and dealers for larger LABs.

![Figure 28: Material flow](image)

Dealers were found to sell close to 80 percent of their stock of used batteries to traders, as that gets them better margins. The remaining 20 percent is sold to battery manufacturers for the sake of seeming to comply with the Battery Management and Handling Rules, 2001 (refer to the Rules section). The dealers interviewed quoted better price, transport facility and labour availability as reasons for choosing buyers of used LABs. Apart from transaction gain, transportation involves extra expenses for the dealers as they have to take the batteries to the companies on their own. The availability of labour to ensure that all the batteries sent get delivered at the company and to collect...
the receipt is also not guaranteed at all times. Dealers prefer the informal sector over battery manufacturers for the sale of ULABs since kabadiwallas and traders visit the dealers on a regular basis to buy old batteries. However, since the dealers have to give back a certain percentage of batteries to manufacturers, thus, a maximum of only 20 percent of old batteries are sold to the companies.

Automobile Workshops, too, do most of their dealing, for greater monetary gains, with these traders, who are directly linked with informal recyclers. The main reasons for this are better price, lack of transportation for sending ULABs to battery manufacturers and even the absence of loading equipment for loading heavy batteries onto trucks and pick-up vehicles. Thus, informal traders not only help them make better profits but also provide the convenience of frequent collection without having to worry about transportation or lack of manpower and injuries while loading.

Apart from this, availability of storage space is also a key reason for the flow to the informal value chain as company representatives don’t visit frequently and the dealers and workshops are not able or willing to store the large numbers in their own premises for long.

These informal traders, then, sell the collected batteries to informal recyclers, who are not authorised by the Pollution Control Board. In addition to the dealers and workshops, the informal sector also gets used batteries from Kabadiwallas who collect from households or individual consumers.

**Hotspots of Lead Acid Battery Collection and Recycling**

Ranchi, being the capital of Jharkhand, receives waste batteries from many small towns, cities and rural areas in the state. In Ranchi, the major focal point for collection of used batteries is Karbala Chowk. It is a small densely populated area situated in the heart of the city. There are approximately 45 to 50 small traders in Karbala Chowk who are involved in the sale of used LABS. There are close to 6 large scale traders too who are involved in the sale of used batteries to recyclers and smelters operating in cities like Kolkata, Kanpur and Benaras.

In Ranchi, there are a few smelting units as well. We were able to locate three such units functioning in major industrial areas close to state highways, namely, Kokar, Tupudana and Tatisilway. Their location (proximity to highways) makes it easier for them to transfer refined lead to industries which need them.
Economics

It is clear from the material flow that it is primarily governed by economics. It is interesting to note the financial exchange between the consumers and the different buyers. Though the difference is very little, the dealers usually offer better economic returns to consumers.

Table 7: ULABs Economics, Jharkhand

<table>
<thead>
<tr>
<th>ULABs disposed off to</th>
<th>Average Amount/Discount received by Consumers (in Rs/piece of battery)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>Dealers</td>
<td>700-1000</td>
</tr>
<tr>
<td>Workshops</td>
<td>600-850</td>
</tr>
</tbody>
</table>

Dealers make a profit of about Rs 4 per kilogram of lead batteries when they deal with the informal sector. The profit the workshops earn per kilogram of batteries by selling ULABs to traders is Rs 4 to 5.

Figure 29: Average Profit Margin (Rs/Kg of Batteries) of different Stakeholders in the used LAB value chain

Kabadiwallas profit amounts to Rs 4 to 6 per kilogram of lead acid batteries excluding labour cost, rent, electricity and other operational expenses. Informal recyclers, who receive scrap batteries from traders and dealers, claimed to sell the recovered lead for Rs 165 to 168 per kilogram. They were not willing to share their profit margins though.

Status of LAB Recycling

Three recycling units were found to be operational (in Kokar and Tipudana industrial areas). Out of these three, only one unit claimed to be authorized. However, the owner of the licensed unit was not willing to show the relevant documents to prove his claim. The web portal of SPCB too has no details of these units. All the three units were found to be dealing with large quantities of used lead batteries ranging between 24 and 68 tonnes per month and have been functioning for more than ten years.

The Recycling Process

Recyclers receive pre-drained used batteries. Simply put, the traders sell used batteries to recyclers only after draining out the acid for reducing the weight of batteries. The batteries are then manually hammered.

Figure 30: Manual Breaking of ULABs
The plastic casing and separator extracted are sold to scrap dealers or collectors. The recovered material comprises plastic (10-12 percent), paper (4-5 percent) and iron (2 percent) apart from lead (close to 80 percent). The lead plates are smelted in a bhatti using coal at high temperatures.

Figure 31: Smelting Unit

While the molten lead is poured into moulds and left for cooling to form ingots, the smoke is redirected to a cooling chamber and then to a cyclone machine which helps the heavy particles in smoke to settle down. The lighter smoke is further passed to a bag-house where the harmful components get separated from smoke. The carbon dioxide though escapes from the chimney. Dirty water from the cooling chamber is treated with lime water in the tank. The hardened lead blocks are then sold to battery manufacturing plants in Kolkata and other parts of India. Plastic parts are sold to traders and scrap dealers in Ranchi, Kanpur, Varanasi and Kolkata.

Figure 32: Cyclone for filtering emissions from the smelter
The waste generated from used lead acid batteries comprises of wet paper (separator) and dust. There was found to be no proper disposal mechanism in place for this waste material as a result of which they are thrown in open unutilized fields or pits are made to bury it underground.

**Occupational Safety**

Apart from gloves, no other safety equipment was found to be used by the workers in the informal recycling unit we visited.

**Reporting mechanism by formal recycling units**

As has already been mentioned above, one of the recycling units we visited which claimed to have been authorized by the SPCB for ULAB recycling could not produce any certificates to prove their claim. They also were not willing to verbally reveal how they file their returns or to whom if at all they do file returns. So, practically, there were no formal recycling units in Ranchi or its nearby areas.

**Environmental Impact**

During the survey, it was discovered that the acid present in the batteries is flushed out by scrap collectors or traders in open areas and rivers. During the smelting process of lead plates or grids, carbon dioxide (among other gases) is released through the chimney into open air. The ashes obtained after lead smelting are thrown out on the side of the road, on fields or in open pits, raising concerns of further contamination and exposures. Drainage of acids in the open areas leads to seepage into ground water sources and consequent acidification and lead contamination since battery acids often have powdered lead.

**Health Impact**

Kabadiwallas, traders and recyclers told us that they get injured while loading and unloading heavy lead acid batteries and sometimes get burns due to the acid present in the batteries. Close to 25 percent of the kabadiwallas told us that they get injured while handling these heavy batteries. In recycling units especially, the chances of cuts and bleeding are high due to manual breaking and dismantling of batteries.

Additionally, all the workers spend around 10 to 12 hours in a day in the unit which is bound to cause severe lead contamination-related health issues. While the owner claimed to be healthy, he seemed to look dull and fatigued, possibly because of exposure to lead. From smelting units, which do not employ smoke filtration systems, the nearby population is at a great risk of developing health issues resulting out of exposure to lead and other toxic substances present with lead in batteries.

**Awareness**

Lead acid batteries are common commodities and the general consumers in Jharkhand seem to be aware of the hazard related to it. Around 56 percent of the consumers contacted during the survey knew that improper disposal of used LABs can be harmful to human health or the environment. Despite this, the concern amongst them about how old batteries are processed after disposal was found to be dismal. A meagre 17 percent of the consumers interviewed in Jharkhand were concerned about how these batteries are disposed at their end of life. Besides, in Khunti village, none of the consumers interviewed knew that manufacturers have a take-back facility for used batteries and maybe that’s why 33 percent of them in this village prefer kabadiwallas and workshops over dealers for returning used batteries. In the cities and towns surveyed, however, close to 33 percent of the consumers were aware of take-back systems of manufacturers. Over 70 percent of the consumers residing in Ranchi, Tatanagar (both cities) and Dhurwa (town) sell used LABs to dealers.
The level of awareness about Battery Management and Handling Rules was very low among the different stakeholders. Among all the consumers interviewed, only 3 percent were aware of the rules. Among the dealers, only one claimed to have heard of the rules but could not give further explanation. Thus, not surprisingly, not even a single dealer interviewed claimed to file return to the pollution control board. The kabadiwallas, workshops and recyclers too did not have any knowledge about the Batteries Rules.

C. Rajasthan

Background and Survey Findings

Rajasthan, the largest state (area-wise) of India, has Jaipur as its capital. With a population of close to 7 crores and per capita income of close to Rs 76,000, the market of lead acid batteries in the state is huge. Jaipur is a major business hub in the northern part of the country while centres like Dausa have both urban and rural areas. According to the stakeholders met during the course of the study, branded and non-branded, both have a market in the state. Some of the branded batteries sold are Exide, Amaron, MTEKPOWER, Luminous, Festo, LEADEER, PR-ESTOLITE, TATA etc. Some of the local companies were Mangal, SHIVA, BASE, KYOTO, LICKOE, EXEL, BHARAT, SWASTIK etc.

Between the types of batteries, wet and dry batteries had almost equal share as elucidated in the table below (Table 8).

Table 8: Dry / Wet market share

<table>
<thead>
<tr>
<th>Type of Batteries</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Battery</td>
<td>48</td>
</tr>
<tr>
<td>Wet battery</td>
<td>52</td>
</tr>
</tbody>
</table>

Lead acid battery dealers are not available in the rural areas with the 8000-10000 population. Those living in these towns buy batteries from the block headquarters or cities for domestic use. Four wheeler dealers also buy batteries from cities.

Like in the other states, kabadiwallas in Rajasthan too are preferred by consumers in many areas, especially for smaller batteries, because they offer frequent collection services among many other benefits. The monetary gain is also higher for selling two wheeler and UPS batteries to the informal group of collectors: Dealers and workshops are also able to avoid paperwork and reduce expenses on storage and transportation of used batteries when they deal with kabadiwallas and traders. Kabadiwallas go to villages as well and buy batteries. During interview with recyclers, it appeared that the ULABs come from Delhi, Haryana and Ghaziabad as well. Many big traders give the waste to the traders of Jaipur while some recyclers have direct contacts with the Kabadiwallas and traders of other states.
The Value Chain model, Financials and Stakeholder Behaviour

A survey was conducted in Jaipur, Dausa and a few villages such as Sainthal, Sikandra, Boroda and Bapi in Rajasthan to understand the value chain. Lead acid batteries reach the recycling units from consumers in the following way:

It was found during the survey that in Jaipur and Dausa (urban area), most of the consumers hand over their used batteries to dealers while in the rural areas in Dausa and nearby villages, these are primarily given away to workshops. Though overall 50 percent of the consumers included in the survey shared that they sell end-of-life lead acid batteries to dealers, it varied in urban and rural areas. In an urban space like Jaipur, 74 percent of the consumers interviewed preferred to give ULABs to dealers. But in the neighbouring villages, the trend was a bit different and more than 50 percent of the consumers interviewed claimed to hand over their batteries to workshops in return for cash. Absence of dealers in the rural area could be one major reasons for the same.

According to the information gathered from the field, the dealers and workshops send the ULABs mainly to the informal sector. A very small percentage of spent batteries reach the battery manufacturers or formal recyclers. Figuratively, more than 50 percent of the dealers and workshops claimed to hand over spent LABs to kabadiwallas and/or traders. Kabadiwallas further hand over their stock of batteries mainly to traders and some directly deal with recyclers, most of whom are unauthorized. Workshops also sell scrap batteries to informal recyclers. The profit that these dealers and workshops make per kilogram of batteries ranges between Rs 2 to 8.

Economics

The rebate offered by different buyers of old batteries to consumers is as given below:

Table 9: Buy back economics for consumers, Rajasthan

<table>
<thead>
<tr>
<th>Batteries given to</th>
<th>Average Amount received by Consumers (in Rs/piece of battery)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>Dealers</td>
<td>1000-1100</td>
</tr>
<tr>
<td>Workshops</td>
<td>900-1200</td>
</tr>
<tr>
<td>Kabadiwallas</td>
<td>800</td>
</tr>
</tbody>
</table>

It can be seen from the table above that dealers offer more monetary benefit in comparison to workshops and kabadiwallas to consumers for ULABs. Inspite of this, a considerable percentage of consumers give away their batteries to workshops and kabadiwallas due to the absence of dealers in towns and villages.
Table 10: ULABs Economics, Rajasthan

<table>
<thead>
<tr>
<th>Type of battery</th>
<th>Workshop</th>
<th>Dealer</th>
<th>Kabadiwalla</th>
</tr>
</thead>
<tbody>
<tr>
<td>4wheelers</td>
<td>83</td>
<td>90-92</td>
<td>85</td>
</tr>
<tr>
<td>3wheelers</td>
<td>84</td>
<td>90-92</td>
<td>83</td>
</tr>
<tr>
<td>2wheelers</td>
<td>77</td>
<td>87-90</td>
<td>75</td>
</tr>
<tr>
<td>UPS</td>
<td>85</td>
<td>85-90</td>
<td>85</td>
</tr>
<tr>
<td>Solar</td>
<td>88</td>
<td>90-95</td>
<td>83</td>
</tr>
<tr>
<td>Inverter</td>
<td>85</td>
<td>87-88</td>
<td>85</td>
</tr>
</tbody>
</table>

Recyclers, who receive waste from different sources, separate the lead from the plastic container and sell the plastic to plastic recyclers which also yields some profit. They make gains of Rs 3 to 7 per kilogram of batteries but on taking account of the cost of labour, land, electricity and other operational expenditure, it is a little lesser.

![Diagram of Hotspots of Lead Acid Batteries](image)

**Hotspots of Lead Acid Batteries**

In Jaipur, Moti Dungari, Chandpole, Sansar Chand Road and Sitapura Industrial areas were identified as the prime areas of collection of ULABs in and around Jaipur. These areas have a network of traders who deal with huge quantities of ULABs. Not only do they collect from workshops and other stakeholders in the city, they also receive batteries from kabadiwallas who visit smaller towns and villages to collect lead acid batteries used in the households and two wheeler batteries.

The informal recycling units are concentrated in Bagru, Mangalam and Jaitpura Industrial areas along with Kaladera, Manda Harsoli and Sarna Doongari in Jaipur and Reengas in Sikar. The formal recycling units are also located in many of these areas like Sanganer on Jaipur-Phagi Road, Kaladera and Sarana Dungari. The ULABs not only come to these recycling units in Jaipur from other parts of Rajasthan, they come from other states too. In north India, Rajasthan is a preferred location for sending used batteries because of the large number of informal and formal recyclers in the state.

**Status of LAB Recycling**

Jaipur has a number of recycling units, as mentioned before, including both informal and formal recycling facilities. While the informal units receive lead batteries from kabadiwallas and traders, the formal units receive their stock from dealers mainly. They dismantle batteries and separate the recovered components, which may or may not undergo further processing within the same facility.
In the formal units all the extracted components were found to be handled responsibly. While the plastic casings and separators are sold to plastic recyclers who grind them to make granules for Rs 40 to 60 per kilogram, the sulphuric acid remaining is emptied out in a tank and treated in an ETP before disposal. The lead grids are smelted and refined in an open coal-based heating chamber fitted with an elaborate smoke purification system consisting of a cooling chamber, a bag-house filter, a cyclone and a water tank other than a chimney. Smoke consisting of small particles of lead and impurities in the lead being melted along with ash particles is passed through a cooling chamber where the heavier particles settle down. This is collected and treated as lead dust. This is
again made to undergo the refinement procedure of heating and collecting. The remaining air-borne contaminants are passed through bag filters made of cloth in which a major portion of the contaminants get collected. Further, this filtered smoke is circulated vigorously in a cyclone for settling the heavier particles. After this, the treated smoke is also passed through a partially filled water tank but by the time the emissions reach this stage, there is not much impurity remaining for settling in the water.

The melted lead is collected in moulds and sold to industries which require lead as raw material at around Rs 167 to 173 per kilogram. However, the refined lead sold by the formal units was not labelled as ‘recovered lead’ (as mandated by Batteries Rules).
The informal recycling units, on the other hand, use completely rudimentary processes similar to used in Delhi. They also dispose off acid and ash in rivers and drains and on land.

**Occupational Safety**

Many of the workers (close to 95 percent) were observed to be wearing gloves in the units we visited. But, very few of the employees were wearing masks (approximately 5 percent of the workers observed). We were told that the masks are not provided by the facilities for free and hence they are either purchased by the workers or they prefer to go without masks to save money.

![Figure 40: Female Workers wearing Gloves while manually breaking batteries](image)

**Reporting mechanism by formal recycling units**

While the workers in one of the formal units which had air-pollution control equipment in place claimed to file half yearly returns to the Rajasthan Pollution Control Board, the workers in the other recycling units, some of them claiming to be formal, were not even aware of the return filing system.

**Health Impact**

The workers were found to suffer from nausea and respiratory issues while working. Some of them also suffer from skin diseases due to acid spills during loading and offloading of batteries. The acid sometimes even splashes on their faces. There have been cases where the batteries fell on their limbs and caused fractures. One of the workers also expressed concern over exposure to lead causing impotence. Heightened irritability was also found to be a cause of concern due to exposure to lead.

**Environmental Impact**

The waste after dismantling batteries which includes separators (sometimes) made of plastic or paper and sulphuric acid containing dispersed lead are disposed of on land or in streams and rivers. Moreover, many recycling units are spewing lead containing fumes and dust into the surrounding air during smelting as well as breaking of batteries.
Awareness

The awareness level in the surveyed areas of the state was quite bad. Among the consumers, the percentage of them who knew about Batteries Rules stood at a dismal 2 percent. Among the other stakeholders involved in the value chain, only two kabadiwallas and one dealer knew about the Rules. Though most kabadiwallas were not aware of the Rules, they were aware about requirement of license for dealing with this toxic waste stream. Only 12 percent of the consumers were concerned about the disposal of batteries and 24 percent thought that spent LABs are harmful to the environment and/or to human health.

![Figure 41: Consumer awareness- Rajasthan](image)

Also, only 44 percent of the dealers claimed to file returns to the pollution control board.

D. Andhra Pradesh

Background and Survey Findings

Andhra Pradesh, one of the ten most populated states in India, has Amravati as its capital, which along with Vijaywada and Guntur, is called the Amravati Metropolitan region. The state has some of the largest lead acid battery manufacturing facilities in India. Andhra Pradesh is also mulling over setting up an automotive industrial hub.

A survey to evaluate the status of implementation of Batteries (Management and Handling) Rules (2001) was conducted in Vijaywada, Vuyyuru (small town) and in a rural area named Prasadampadu.

The Value Chain model, Financials and Stakeholder Behaviour

There were minor variations observed in the material flow in the three surveyed areas. Close to 66 percent of the consumers interviewed overall told us that they sell used lead acid batteries to dealers in exchange with new batteries, for the simple reason of convenience. The rest of the consumers return old batteries to workshops when they send their vehicles for servicing. While the former comprised owners of different types of lead acid batteries like inverters and UPS apart from automobiles, the latter owned only vehicles including two-, three- and four-wheelers.

Since the automobile usage is probably lesser as we moved from large city to smaller town and then to village, the consumers preferring workshop also reduced marginally in the same pattern.
Among the dealers we spoke to, 60 percent of them claimed to sell used batteries to company distributors while the rest of them prefer kabadiwallas and dismantlers. Their basis for deciding the buyers of used batteries are convenience and profit margin. Among the workshops, the trend was a bit different as 85 percent of them sell their collection of scrap batteries to kabadiwallas. Some of these workshops also trade with dealers and dismantlers. Their motivation for selling scrap batteries to kabadiwallas was a greater monetary gain apart from convenience. The kabadiwallas further deal with traders or recyclers. Some workshops also specialize in battery dismantling. In such a case, recovered lead and plastic is sold to kabadiwallas for sale to smelting units. Thus, batteries reach informal smelting units mainly from workshops. The total volume treated in such units is presumably lower than in other states we surveyed because the dealer waste is not reaching this chain. The flow of used batteries is as shown below:

<table>
<thead>
<tr>
<th>Surveyed areas</th>
<th>Vijaywada</th>
<th>Vyuyuru</th>
<th>Prasadampudu</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumer disposal behaviour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 42: ULABs disposal in Andhra Pradesh**

Economics

The rebate received by consumers for different types of batteries from different buyers is as follows:

**Table 11: Consumer Economics-Andhra Pradesh**

<table>
<thead>
<tr>
<th>Batteries given to</th>
<th>Average Amount received by Consumers (in Rs/piece of battery)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car Battery</td>
</tr>
<tr>
<td>Dealers</td>
<td>600</td>
</tr>
<tr>
<td>Workshops</td>
<td>500</td>
</tr>
<tr>
<td>Kabadiwallas</td>
<td>NA</td>
</tr>
</tbody>
</table>
As can be seen from the table above, the rebate received from kabadiwallas for three wheeler batteries is very low. Hence, most of the consumers prefer visiting dealers and workshops to return old three-wheeler batteries.

The profit earned by dealers, workshops and kabadiwallas on the purchase and sale of old batteries is shown in the table below.

Table 12: Profit margins-Andhra Pradesh

<table>
<thead>
<tr>
<th>Types of Used Batteries</th>
<th>Average Profit Margin of Dealers (Rs/piece)</th>
<th>Average Profit Margin of Workshops (Rs/piece)</th>
<th>Average Profit Margin of Kabadiwallas (Rs/piece)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three- and Four-Wheelers</td>
<td>50-100</td>
<td>200-300</td>
<td>50-300</td>
</tr>
<tr>
<td>Two wheelers</td>
<td>50</td>
<td>30-50</td>
<td>100</td>
</tr>
<tr>
<td>Inverters</td>
<td>200-500</td>
<td>100-300</td>
<td>NA</td>
</tr>
<tr>
<td>UPS</td>
<td>NA</td>
<td>NA</td>
<td>100</td>
</tr>
</tbody>
</table>

The dismantlers were not willing to share information on the profit they make for lead recovery from used batteries and other recyclable material like plastic.

**Hotspots of Lead Acid Batteries**

Autonagar, Eluru Road and Benz Circle are prominent hubs of lead battery workshops and dealerships. These workshops not only take-back or repair batteries, some of them even extract lead and sell it to traders dealing with informal smelters and recyclers in Hyderabad and Bangalore.

**Status of LAB Recycling**

Vijaywada, Vuyyuru and Prasadampadu do not have informal battery recycling units and thus, old batteries are sold to traders from Hyderabad and Bangalore. Some workshops, though, are also involved in dismantling activity. Lead recovered by them is also sold to traders coming from Hyderabad and Bangalore.

**Occupational Safety**

We observed that, that none of the workers in workshops or kabadiwallas were wearing gloves, masks or any other equipment to protect themselves from acid spills or lead dust (during manual breaking).

**Environmental Impact**

The areas covered in the survey had limited pre processing and almost no processing. The only operations which were observed were collection and dismantling. It was seen that most kabadiwallas pour out the acid from batteries at the point of receipt to reduce the weight of the batteries. The acid is poured in open areas or drains, thereby creating the risk of contaminating the soil and groundwater. Dismantlers also dump separators on land although some dismantlers sell plastic components in used batteries for recycling.

**Awareness of the Batteries (Handling and Management) Rules (2001)**

We also found that the awareness about the Batteries Rules and the impact of irresponsible disposal of used batteries among the different stakeholders was dismal. Among the consumers, only 3 percent were familiar with the Batteries Rules. Surprisingly, only about 16 percent of the
dealers were aware of the rules despite their claim that a majority of the stockpile of used batteries are sold to battery manufacturers. While none of the workshops knew about Batteries Rules, close to 15 percent of kabadiwallas knew about the rules.

Figure 44: Consumer awareness, Andhra Pradesh

Unexpectedly, the take-back scheme of battery manufacturers was known to close to 70 percent of the consumers interviewed. Further, close to only 20 percent of the consumers interviewed in Vuyyuru and Prasadampadu were aware of the harmful effects of improper battery recycling on environment and/or human health. Thus, it was not surprising to note that no more than 22 percent of the consumers were concerned about the ill-effects of improper recycling of spent batteries. The awareness regarding the harmful impact was more in the large city, i.e. Vijaywada.

**Bulk Consumers in India**

Bulk consumers, as per the definition by Batteries (management and handling) Rules (2001), include state and central government departments such as Department of Railways, Telecom, Post and State Transport Corporation, who purchase hundred batteries or more in a year. Toxics Link tried to obtain information regarding the disposal of used batteries by some of these bodies along with the details of returns filed to the SPCB and CPCB.

Table 13: ULAB disposal by bulk consumers

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Govt. Department</th>
<th>Returns filed to SPCB/CPCB in 2015-16 and/or 2016-17</th>
<th>Batteries disposed to whom</th>
<th>Process</th>
<th>Battery Specifications and Rate (per battery)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DMRC*</td>
<td>Information Unavailable</td>
<td>Battery Manufacturers, Formal Recyclers</td>
<td>Tendering (Electronic and physical) and Auctioning</td>
<td>2V, 300 Ah: Rs 825; 2V, 400 Ah: Rs 1100; 12V, 65 Ah: Rs 1819; 12V, 100 Ah: Rs 2798; 12V, 150 Ah: Rs 4197, etc.</td>
</tr>
<tr>
<td>2.</td>
<td>MTNL** (Delhi Division)</td>
<td>N/A (since it did not purchase more than 100 batteries in 2015-16 and 2016-17)</td>
<td>Formal Recyclers</td>
<td>e-Tendering and Auctioning</td>
<td>Information Unavailable</td>
</tr>
<tr>
<td>3.</td>
<td>BSNL* (Rajasthan Division)</td>
<td>No</td>
<td>No Information shared</td>
<td>No Information shared</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Northern Railways (Delhi Division)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>DTC**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Delhi Metro Rail Corporation  **Mahanagar Telephone Nigam Limited
#Bharat Sanchar Nigam Limited  ##Delhi Transport Corporation
Challenges faced by Stakeholders

During our survey, interviews and focused group discussions, almost all the stakeholders were found to face some challenges affecting their day-to-day functioning and their way of handling and managing lead acid batteries and lead scrap. Some of these issues are reasons why close to 90 percent of spent LABs reach the informal sector and should be looked into to plug the gaps in implementation of Batteries (Management and Handling) Rules, 2001 (amended 2010).

Consumers: Very few knew about the hazards and the rules related to ULABs. This was the key reason why the consumers never understood the impact of their disposal practices. Hence, owing to a general lack of awareness and interest, consumers become the first point from where the flow of batteries into the informal sector begins. Many of them, especially in Jharkhand, confessed that they are forced to return relatively new batteries if it develops a technical glitch instead of getting them repaired because of the absence of battery repair shops. That is why a large number of batteries which have not reached their end-of-life also reach recycling units.

Many two wheeler users in the villages were not aware of the rebate payable to them on returning ULABs.

Dealers: In Delhi, a dealer told us that they receive fewer batteries from consumers and workshops (combined) in comparison to kabadiwallas because kabadiwallas offer 2 percent more rebate. Further, some of the dealers also sell the used batteries collected to kabadiwallas because of the better prices offered by them, along with the benefit of lower storage costs and taxes. Another major reason for doing so is the convenience of frequent collection by kabadiwallas as opposed to distributors who only collect LABs in large quantities and that too just once or twice in a month. The dealers also claimed that they face space constraints and some of them even claimed to pay for space to store scrap batteries. Many a times, take back of batteries is not carried out directly by companies but by vendors authorized by them. In such cases, it becomes a task for the dealers to contact the vendors. Even then, their visits are infrequent in comparison to that of kabadiwallas who are also ready to collect smaller quantities.

Kabadiwallas: The rules specify that the consumers, including the bulk, have to discard their ULABs to registered recyclers only. Hence, their inability to participate in bulk consumer tendering procedures was considered by many kabadiwallas as a challenge. Sometimes they are also harassed by police, since they do not have license to collect batteries. A few kabadiwallas shared with us that many consumers give away their used batteries to dealers because of very little difference in the price offered by the two parties and the ease of getting used LABs exchanged with new batteries during servicing.

Price fluctuation of scrap batteries due to their lead content was also quoted as a problem by them. They face losses due to the volatility in the market rate of lead acid batteries. Besides, many a times, they do not receive payments from traders. Big traders do not give the payments on time. Because of the monopoly of the traders, the kabadiwallas have to suffer loss.

They also claimed that they are able to make better profit for dealing with wet batteries (mostly non-branded) but the market for these has been overtaken by dry batteries. Besides, they are not able to make much profit on large batteries such as those in heavy automobiles (in comparison to smaller LABs) for they are made of Bakelite. Bakelite is heavier than other plastics and thus, large batteries are sold cheaper than the small LABs made from PVC and other types of plastic.

Workshops: Workshop owners claimed that usually, they sell off their stock of used LABs (collected from consumers) to kabadiwallas. Since distributors and even dealers are not willing to collect small quantities of used LABs and they do not have space, they are left with no other option other than selling the ULABs to kabadiwallas. But the kabadiwallas buy branded and non-branded battery at the same price which results in loss sometimes.
The workshops also accepted that since the mechanics do not use PPEs during the change of battery, many a times the acid ill causes injury.

**Formal Recyclers:** For them, the biggest challenge is to set up the facility and arrange the huge fund required. Also, legal formalities for the same are extremely time-taking. But the main challenge to the Formal recycler comes from the Informal sector. All of them said that the informal sector is a big competition and because of this, formal plants are mostly running below capacity.

The formal sector is also plagued with the problem of frequent staff turnover. Labour force mainly comprises of migrants from Bihar, Madhya Pradesh and Uttar Pradesh and do not stay for long periods. In addition, they do not have skilled trained staff. They also receive little support from the Battery manufacturing companies.

Many formal recyclers also have the illegal informal units.

**Informal Recyclers:** Informal groups are aware of the illegality of their operation and hence fear legal proceedings for unauthorized recycling of batteries. Hence they have to carry out such activities at night. Informal recyclers often don’t get themselves authorized with the Pollution Control Board because the paper work and follow-ups involved are time-consuming. They also find the procedure to be very complicated. Obviously the formal recyclers are the main challenge for the informal recyclers.

The workers in informal recycling units do not have any access to masks or clothing to be worn in the workplace which they can change after their shift gets over. As a result, many workers had a layer of the silver metal and lead dust all over their face, hands and clothes.

**Status of Implementation of Batteries (Management and Handling) Rules, 2001 as amended**

State Pollution Control Boards are the prescribed authority to ensure compliance by stakeholders, namely manufacturers, dealers, bulk-consumers, assemblers, re-conditioners, recyclers, importers and auctioneers. SPCBs are required to submit annual compliance status reports to CPCB which is then complied by CPCB. Though the report of 2016 on the status of implementation was available on CPCB website, repeated requests to CPCB to send us latest information were ignored.

Unfortunately, there has been a major lag in this, as reported by CPCB itself. Out of a total of 36 agencies (SPCB and PCC), not even 50% filed reports. And in 2015-16, only 5 out of 36 Boards submitted details! The CPCB report in 2016 does claim to have sent regular reminders to SPCBs, but it was not clear if any further action was taken as this is clearly violation of the Batteries Rules and therefore Environment Protection Act.

**Table 14: SPCB accountability missing**

<table>
<thead>
<tr>
<th></th>
<th>2013-14</th>
<th>2014-15</th>
<th>2015-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of SPCBs/PCCS which submitted ACSR</td>
<td>11</td>
<td>14</td>
<td>5</td>
</tr>
</tbody>
</table>

(Source CPCB)

In the 2016 report, CPCB does admit to a lack of inventory and also states that there is no data with the agency regarding sale of new lead acid batteries.
According to information provided by CPCB, the battery sent to registered recycler is much less than the mandated 90%.

Table 15: ULABs in formal chain

<table>
<thead>
<tr>
<th>Period</th>
<th>Data submitted by number of SPCB/PCCs</th>
<th>MT of new batteries sold by Manufacturers, assemblers, Importers, Dealer and Re-conditioners</th>
<th>MT of used batteries sent to Registered recyclers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-14</td>
<td>14</td>
<td>18,018</td>
<td>48,727</td>
</tr>
<tr>
<td>2014-15</td>
<td>16</td>
<td>136,933</td>
<td>27,757</td>
</tr>
<tr>
<td>2015-16</td>
<td>22</td>
<td>296,510</td>
<td>79,362</td>
</tr>
<tr>
<td>2016-17</td>
<td>17</td>
<td>198,250</td>
<td>102,198</td>
</tr>
</tbody>
</table>

(Source CPCB)

The information from CPCB clearly shows that the data is inconsistent. In 2013, though 18018 MT battery were sold, the registered recyclers received almost thrice the amount. This could be because only 14 states sent in their data and though the sales were from these 14 states, the recyclers situated in these states may have received waste from other states as well. But there could be other reasons as well, like misreporting. 2015-16 shows 296510 MT of batteries sold, but this figure comes down in 2016-17 in which only 198250 MT of batteries were sold. But again, the first data in from 22 states and the next one from 17 states. So, the data compiled by CPCB is clearly very inconsistent and not reliable.
IV. Summary, Discussion and Recommendations

Lead-acid batteries are the biggest consumers of lead and the growth in the use of renewable energy sources as well as the increasing demand for vehicles mean that the demand for lead-acid batteries will continue to soar in coming years. In the current times, when resource recovery, especially of non-renewable resources is gaining importance, it is crucial, from both environmental and economic perspective, that lead batteries are recycled to augment metal supplies that come from mining sources. The best part is that lead can be recycled indefinitely and efficiently with little loss if efficient recycling processes are deployed. Unfortunately, in a developed country like India, a large quantum of ULABs end up in informal recycling units where processes are crude, resulting in significant environmental pollution, and inefficient, resulting in non-optimal recovery of valuable lead.

From the current study, it is clear that there are huge gaps. The entire process, from collection of the batteries, transportation, dismantling, smelting and disposal of the components, is not done in environmentally sound manner. The practice does not meet requirements of existing relevant guidelines and laws and poses a high risk of contamination to human health and the environment. In India, even after several years of legal framework being in place, majority of used batteries are estimated to reach the informal recycling sector.

Figure 45: LAB consumer practices

Our survey to assess unregulated collection and recycling practices has shown that a large number of consumers dispose off their batteries to dealers. Though the trend did not vary majorly between the cities and smaller towns and villages, sometimes accessibility and convenience governed the choices. In the larger cities, in all the four states covered in the survey, the consumers preferred dealers and workshops, with very little waste directly going to the kabadiwala, but in smaller towns those percentages increased. Lack of kabadiwallas or ones dealing with this waste stream, made the consumers in villages turn back to dealers and workshops.

But it was evident from the entire study that dealers receive the most amounts of ULABs from consumers. The most interesting part was that dealers sell only a small percentage of their stock to battery manufacturers. Kabadiwallas and traders take away a huge percentage of used batteries from dealers by quoting higher prices or visiting almost daily, thus saving the dealers’ efforts in storing ULABs or contacting the company. Some dealers sell used batteries to unauthorized dismantlers and recyclers. Better monetary gain was also found to be a good reason in some places for selling used batteries to the informal sector.
There was a huge variation in this among the states covered. In Jharkhand the dealers mainly sold ULABs to kabadiwallas; but in Andhra Pradesh, it mainly went to the Battery manufacturing companies. Presence of large number of recyclers (both formal and informal) resulted in lot of dealers directly selling their waste to them. Absence of any recyclers in Jharkhand meant that there was hardly any transaction of that nature there. Most surprising was lack of ULAB flow to Battery manufacturing companies in Rajasthan and Jharkhand- this mainly indicated complete failure of take back system mandated under the Rules.

The reasons behind the choice of buyers of used batteries sold by the dealers and workshops were varied (as shown in the graph below), convenience of storage and transportation, profit margin and billing issues with battery manufacturing companies and formal recyclers among a few others.
The kabadiwallas and traders also sell scrap batteries to the informal dismantling and recycling sector, citing better prices as the main reason. Bulk consumers, though, carry out auctioning to sell used lead acid batteries and sell them to authorized recycling units and battery manufacturers.

As evident from the state wise status, once the battery reaches the unorganised sector, the processes are deplorable. Unauthorized smelting or recycling units, across 4 states, lacked even basic precautionary measures to prevent battery acid and lead from polluting the environment and the workplace. In recycling units, while the smelting activities are carried out in open bhati mostly, gloves for safety of the workers is a rare sight, let alone masks, aprons and shoes. Other than the workers, the neighbouring communities too are at risk of suffering from potentially life threatening diseases arising out of exposure to lead. Some international studies have shown that larger communities can be affected due to cross-contamination into products made of other components of the battery such as plastic.\textsuperscript{17} Secondary plastic is often used to make buckets, toys, tanks and cookware.

\textsuperscript{17} Recycling used lead acid batteries: health considerations(2017). World Health Organization. Available at http://apps.who.int/iris/bitstream/handle/10665/259447/9789241512855-eng.pdf?sequence=1
The current scenario does force us to rethink on the current framework and system. For instance, the Ministry of Environment and Forests or an agency designated by it has been mandated by Batteries (Management and Handling) Rules, 2001 (amended 2010) to develop a system for computerized tracking of distribution and sale of batteries; collection, auction, transport and re-processing of used batteries; sale of re-processed lead by registered recyclers; and sale of lead from all domestic producers or importers. But, based on the information that Toxics Link collected, there seem to be no computerized tracking of batteries. Even most SPCBs have limited information on their websites regarding lead acid battery management in their states.

Experience around the globe has also clearly shown us that consumer participation is key to success of a programme like this. To make this happen, they have to be not just made aware of the Rules but also be sensitized about the detrimental impact of improper disposal and processing of used batteries. The graph given below shows the current level of awareness amongst consumers in the four states we surveyed, which clearly shows that a lot of work needs to be done in this direction.
Key Findings

• Majority of individual consumers, especially in major cities, return used batteries to dealers or workshops.
• Bulk consumers, mainly dispose off used batteries through auction or tenders
• Dealers are the key players in the value chain and often decide whether the waste flows in formal or informal chain—decided on basis of market price and convenience.
• Though most battery manufacturers appear to have a takeback system, there is no information available on the percentage of battery they are able to collect back.
• Large quanta of used lead acid batteries are still recycled in the informal sector.
• Many kabadiwallas and traders pour out the acid from used batteries on land or in drain.
• Conditions in the informal units are deplorable, with huge risk of lead pollution.
• In recycling units the smelting activities are carried out in open bhattis.
• No PPEs are used by workers in these units.
• Lack of awareness among consumers

Recommendations

The current study clearly points out towards failure of the Batteries Rules in India. On one hand the informal sector continues to recycle in appalling conditions, and on the other hand the companies have not been able to bring back batteries in the clean channel. Most of the take back system appears to be on paper has not translated into real action on ground. The existing regulations for waste battery management should be strengthened and implementation made stricter with heavy penalties for violations of rules.

The first and foremost will be to relook at the regulatory framework and improve environmental monitoring and compliance. The current status shared by CPCB undoubtedly shows that monitoring has failed. According to Rules, all SPCBs are to compile status of used lead acid battery management in their status and share it with CPCB. But CPCB records from 2013 onwards, indicates that even SPCBs are not taking their role seriously and this is for an industry which is considered one of the most polluting industries globally. Only 17 SPCBs submitted records in 2016-17. And it is difficult to say if effective monitoring was done in these states. Presence of informal units in the 4 studied states and the condition of many formal recycling units do not give very positive indication either. Both the state and Central Pollution Control Boards are expected to play more active roles and they must take all necessary action as mentioned in the rules and provided in EP Act to ensure that the rules are effectively implemented.

EPR framework has been part of batteries rules since the beginning but there is a need to strengthen it as the current system has failed. There is probably a need to make companies more accountable and penalize them for not meeting specified targets. Inaction from regulatory agencies leads to companies not willing to invest in improving their system for collection, and also encourages free riders. Another way of probably making manufacturers more accountable is use of green tax, which can be levied on manufacturers making batteries out of primary lead or a subsidy given to manufacturers reusing secondary lead to make new batteries. This will encourage companies to collect, recycle and improve lead recovery, thus leading to more ULABs in clean channel. Specifying a minimum limit for utilization of recycled lead in manufacturing new batteries can also be beneficial as this will encourage the companies to invest in good recycling facility and reclaim the lead to put it back into production.

The collection system will need to be worked upon. The study brought to light the fact that the dealers often sell off the ULABs to the informal channel as it was more convenient. Most dealers have small units and hence can’t store a large quantity of batteries for long. So, the companies...
have to make an effort to make their collection system more convenient and more regular. Solution will also need to be found for acid as many dealers tend to empty that before sending it ahead.

Currently the collection system is robust but unfortunately in the informal chain. Streamlining of collection system through EPR mechanism should ideally result in waste flowing into clean channel but there has to be massive effort to improve the recycling infrastructure and its monitoring. The current unorganised units cannot obviously continue as the processes are completely crude and have to be closed down. But efforts need to be made to ensure that registered recycling units should be equipped with adequate engineering and emission control measures for dismantling, smelting and refining along with trained staff and environmental and occupational monitoring. Smelting should be carried out only in closed furnace systems to avoid any kind of exposure. Environmental and occupational exposure monitoring must be done from time to time. It must also be ensured that the other recyclables and non-recyclables from lead acid batteries are effectively sanitised and sold to registered recycling units. While plastic can be reused to make a host of useable items, sodium sulphate crystals can be separated from used electrolyte (sulphuric acid) and reused to make glass, textiles and detergent or new batteries.

Occupational safety has to be taken more seriously. There is a need to educate the workers. PPEs have to be provided and it is important that these equipments are regularly cleaned and maintained in good condition. The team observed that no warning signs were placed on any factory areas and where operations are carried out.

Figure 52: Steps ahead

Preventing or closing down informal recycling presents a number of challenges. Recycling is often carried out in a covert way, e.g. at night or in locations hidden from direct eye. Therefore, identifying operations in order to close them down will be crucial. Also, closing down operations have to be sustained for long periods, otherwise these units sprung back after few weeks. But it is clear that lead acid battery recycling cannot be done in informal spaces and these operations need to be shut down.
The Lead Acid Battery Rules were framed in 2001 and since then it has never been evaluated for its effectiveness. The study suggests that the rule has not been implemented in its true spirit and no one has been held accountable for this lapse. It is time that we created an independent body to carry out effectiveness evaluation of such laws at periodic intervals so that some of the gaps that come to fore are presented in the highest legislative body and remedial measures are initiated.

Consumer education can be a tool to improve lead acid battery management in the country. Deposit or refund scheme that would price lead batteries at a level closer to the actual intrinsic value of the lead and more than the informal sector would be willing to pay is surely going to be helpful.

Lastly, there is a need to extend the study to other states in the country and involve analysis of lead in the environment and do human-health monitoring. Lead battery recycling is associated with significant environmental contamination and therefore investigations are warranted in the vicinity of these formal and informal facilities. All potential environmental pathways, including soil and dust, air, and groundwater should be analysed for lead. This will help us to understand the extent of the problem and then put an appropriate plan in place. Certainly all stakeholders will have a role to play.