Worcester Polytechnic Institute
Interactive Qualifying Project
Costa Rica Project Center E'01

Lead-Acid Battery Recycling in Costa Rica

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Sponsored by el Centro de Investigaciones en Contaminación Ambiental

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June 28, 2001

Dr. Ronald Arrieta
Centro de Investigaciones en Contaminación Ambiental
Universidad de Costa Rica
San Pedro de Montes de Oca
Costa Rica

Dear Dr. Arrieta:

Enclosed is our report entitled *Lead-Acid Battery Recycling in Costa Rica*. The report was written in Costa Rica during the period of May 14 through June 28, 2001. Preliminary background work was completed in Worcester, Massachusetts, prior to our arrival in Costa Rica. Copies of this report are simultaneously being submitted to Professors Elmes and Salazar for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time that you have devoted to us.

Sincerely,

Jill M. Pouliot

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Jason Trovato

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el 28 de junio, 2001

Dr. Ronald Arrieta
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San Pedro de Montes de Oca
Costa Rica

Estimado Dr. Arrieta:

Junto con esta carta es nuestro proyecto titulado *El Reciclaje de las Baterías de Plomo-Ácido en Costa Rica*. El proyecto fue escrito en Costa Rica durante el período del 14 de mayo hasta el 28 de junio, 2001. Investigaciones preliminaries fueron acabados en Worcester, Massachusetts, antes de nuestra llegada en Costa Rica. A la vez, se presentan unas copias de este proyecto a Profesores Elmes y Salazar para evaluación. Después de la revision de la facultad, la copia original de nuestro proyecto será catalogado en la biblioteca de Gordon de Worcester Polytechnic Institute. Nos agradecemos el tiempo que Ud. nos han dedicados.

Atentamente,

Jill M. Pouliot

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Centro de Investigaciones en Contaminación Ambiental

LEAD-ACID BATTERY RECYCLING IN COSTA RICA

June 28, 2001

This report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expresses herein are those of the authors and do not necessarily reflect the positions or opinions of Centro de Investigaciones en Contaminación Ambiental or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

Abstract

Due to the rising recognition of environmental and health issues caused by lead contamination of water and soil and other forms of lead poisoning, many countries have implemented lead-acid battery recycling programs. By conducting interviews and researching possible solutions to this problem, a manual describing the process to develop a formalized recycling program, including a set of recommendations, was submitted to el Centro de Investigaciones en Contaminacion Ambiental, CICA, the sponsor of this project. The recommendations, made specifically for Costa Rica, deal with improving the current system of recycling.

Acknowledgements

In the completion of this Interactive Qualifying Project, we would like to thank our liaison, Dr. Ronald Arrieta, as well as our advisors, Professor Guillermo Salazar and Professor Michael Elmes, for their guidance throughout the project. Additionally, we would like to thank Randolph Armrhein, Orlando Rodriguez, Brian Wilson, Sergio Musmanni and Carlos Perera for their enthusiasm, guidance, and support during our stay in Costa Rica. And we would like to give special thanks to Elizabeth Salazar for all her help in conducting translations in our interviews throughout the project.

Authorship Page

This report entitled, *Lead-Acid Battery Recycling in Costa Rica*, has been completed on June 28, 2001 with equal contributions from Jill Pouliot, Jason Trovato, and Kristina Yim. Although some sections were written individually, they were collectively edited and revised. The following is a list of who wrote the first draft of each section, although the final draft of each section was edited and revised by all group members.

Introduction: JP, JT, KY
Literature Review:
- 2.1-2.2: JT
- 2.3-2.4: KY
- 2.5-2.6: JP
- 2.7: JP, JT, KY
- 2.8: JT

Methodology: JP, JT, KY
Data Presentation:
- 4.1-4.3: JT
- 4.4: JP
- 4.5: KY
- 4.6: JP, JT, KY

Data Analysis:
- 5.1-5.2: JT
- 5.3-5.4: JP
- 5.5-5.8: KY

Conclusions: KY
Recommendations: JP, JT
References: JP, JT, KY
Appendices: JP, JT, KY

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Executive Summary

Lead-acid batteries are at the top of the list of the most recycled products in the world. Many countries have developed and implemented programs to recycle lead-acid batteries that have gone on to be very successful and reduce environmental pollution. The need for a recycling program for lead-acid batteries is very evident, now more than ever, as we are becoming more aware of the damage that lead-acid batteries can cause to the environment and the health problems that can arise if they are not recycled.

Costa Rica currently lacks a formalized recycling program for lead-acid batteries. Although there is an informal system in place, this system has many flaws that make it inefficient and unsafe to the environment. Currently, most of the used batteries in the San José area are collected and recycled in some way. One of the flaws that exists in this program are that some of the batteries end up at "black box" battery makers, or people who take used batteries, take them apart and reuse the good parts to make new batteries. These people do not handle the batteries in a safe manner and expose themselves and possibly others to the dangers of lead poisoning on a daily basis. They also do not treat the sulfuric acid correctly before releasing it into the environment.

Another flaw in this program is that not all the batteries are being collected. Some of them end up staying in peoples' homes or in the land surrounding their homes where they can break open and contaminate the soil and ground water. Together with the help of Dr. Ronald Arrieta of the University of Costa Rica, this project hopes to improve this current situation in Costa Rica.

This report investigates each aspect of the recycling process and provides recommendations for the implementation of a recycling program for lead-acid batteries in

Costa Rica. Dr. Ronald Arrieta will use the recommendations contained in this report to further his knowledge on the subject and to try and propose a solution to the problem. The report will also be of use to the Centro Nacional de Producción Más Limpia, the Ministry of Health in Costa Rica, and the International Lead Management Council when studying the lead-acid battery situation in Costa Rica.

The methods we used in this report include interviews with taxi drivers, storeowners and mechanics to find out what happens to a used battery when the consumer buys a new one. Also included are interviews with representatives from two large collection companies, representatives from the Ministry of Health, the Centro Nacional de Producción Más Limpia and a representative from a large recycling facility in El Salvador. The background section contains some of the technological options for recycling and how to implement these into a recycling program, along with the health and safety issues associated with lead-acid batteries and their recycling.

The results of the interviews are analyzed in the data analysis section and the conclusions were drawn based on this analysis. The conclusions state that Costa Rica is in need of a lead-acid battery recycling program and the recommendations give two different options for implementing a recycling program. One option is to build on the current system and the other is a total reconstruction and implementation of a new system.

The results of this project are being submitted to Dr. Ronald Arrieta in the form of a recommendations manual, which accompanies this report. While this project was designed to meet the specific needs of a recycling program in Costa Rica, it can serve as a model for recycling programs in developing countries around the world. It illustrates the importance of a lead-acid battery recycling program, along with the social challenges of implementing such a program.

Chapter 1. INTRODUCTION

This Interactive Qualifying Project (IQP) provides recommendations to facilitate the development of a formalized lead-acid battery recycling program in Costa Rica. The project was completed with help from the Centro de Investigaciones en Contaminación Ambiental (CICA), an environmental research branch of the University of Costa Rica. The organization is interested in establishing a lead-acid battery recycling program in Costa Rica.

> This report was prepared by members of Worcester Polytechnic Institute Costa Rica Project Center. The relationship of the center to the Centro de Investigaciones en Contaminación Ambiental (CICA) and the relevance of the topic to CICA are presented in Appendix A.

1.1 Hazardous Waste and Recycling

Hazardous waste pollution is a major problem in the world today, and every country is concerned with how this problem can be addressed. One favorable option for curbing pollution is recycling. Although recycling does not always reduce pollution, it may be aimed at more efficient use of resources. One of the more toxic products that may cause pollution to the environment is the car battery, or lead-acid battery. In the United States, the lead-acid battery is considered a hazardous material and, if left out in the open, can cause serious health and environmental problems. The lead-acid battery contains lead and sulfuric acid. The lead can contaminate soil and any ground water around it, and the sulfuric acid can cause burns or can also contaminate ground water. This only becomes a problem if the plastic battery casing is broken open or erodes in the ground, which can happen if left out in the environment.

1.2 The Problem in Costa Rica

Every day more and more countries are becoming aware of the pollution in their environment and are taking the necessary steps to help prevent it. Currently, there exists an informal system for recycling used car batteries in Costa Rica. This system does not recycle all of the used car batteries, but only about 60-75% of them. This recycling system is very informal and is not as effective as it could be if there was a formal system in place. There are also many unsafe practices taking place in this informal system. One possible reason why these practices are taking place is because there is a lack of knowledge of the harm that lead-acid batteries can do to the environment and because there are no laws governing the disposal of lead-acid batteries. There is also a lack of law enforcement in Costa Rica which makes any laws that are in place useless.

1.3 Project Goal

The task of developing a plan of action for recycling lead-acid batteries has become one of many environmental concerns for the Centro de Investigaciones en Contaminación Ambiental, CICA. CICA, however, has not been the only organization that has been concerned with the current method of recycling lead-acid batteries in Costa Rica. The Ministry of Health of Costa Rica, Producción Más Limpia which is a subdivision of the Costa Rican equivalent of the Chamber of Industry in the United States, and the International Lead Management Center have also expressed interest in this project.

CICA invited students from Worcester Polytechnic Institute, WPI, to work with them in conducting a study of lead-acid battery recycling programs in the United States as well as in other countries that may be applied to Costa Rica. Through interviews with consumers, private collectors, recyclers, distributors, and government officials we have investigated the informal recycling system, as it exists now and have made recommendations in the form of a manual on how to improve and formalize this system. The main focus is on documenting the current system in Costa Rica, and developing a collection program that safely disposes of batteries once they are collected.

Another major part of the project was to determine what the current life cycle of a lead-acid battery is in Costa Rica. This was important in order to develop recommendations on how to improve the situation. We have also determined the best option for recycling the batteries generated by a collection program. One option for recycling may be shipping more batteries to the recycling facility in El Salvador due to its close location and the fact that Costa Rica is currently sending a portion of their spent lead-acid batteries there. This is an option that was investigated further.

Another part of the project was an economic analysis describing the entire recycling system. This analysis includes both the costs and revenues of a collection program, including the costs to ship the batteries to a recycling facility. There is also a section describing the profits that can be made by implementing such a program.

1.4 Why Our Project is an IQP

An Interactive Qualifying Project, IQP, is a project that relates science and technology to society, and must be completed by all WPI students for graduation. The study of lead-acid battery recycling programs in the United States and elsewhere to be implemented in Costa Rica fits the criteria for being an IQP. The science and technology in this project involves the actual recycling of lead-acid batteries: how they are recycled and what exactly is recycled, as well as the damage lead-acid batteries can do to humans and the environment if they are left in landfills and on roadsides. This project relates to society through the effects that lead-acid batteries, which are improperly disposed of, have on people and the environment. This project also relates to society through the issue of the willingness and interest of the people to participate in a lead-acid battery recycling program. The people need to be educated about the consequences of not recycling lead-acid batteries. The problem of lead-acid batteries not being disposed of properly is a very serious problem plaguing many countries. This problem can have many negative effects on the environment and the people within it. This project sets out to improve upon, if not solve, this problem.

Chapter 2. BACKGROUND INFORMATION

2.1 Introduction

The lead-acid battery is one of the most used batteries in the world, and its disposal has become a problem for many nations around the world. This type of battery is rather large compared to other batteries because of the substantial amount of power that its applications require. The average life of an automotive lead-acid battery is about four years (Jackson & Tansel, 1994, p. 97). When these batteries are dead and it is time to buy a new one, there are a few options as to what to do with the old battery. Up until the past 15 years, landfills and junkyards have been the final disposal site of automotive batteries.

The Environmental Protection Agency of the United States, EPA, added lead-acid batteries to its list of hazardous waste materials in 1985. There are studies that show that a high percentage of the lead from the batteries deposited in landfills has leached out into the groundwater, causing many health and safety concerns (Jackson & Tansel, 1994, p. 97). Leaching is defined as the contaminants of lead seeping through the soil, which eventually drains into the ground water. The polluted ground water may then be used as drinking water for the surrounding areas, which can be very harmful to one's health due to the lead contamination. Now, in the United States and many other countries around the world, there are laws that control the disposal of lead-acid batteries because of the harm that they can cause to the environment. These are just a few of the many reasons to consider recycling as an option for used lead-acid batteries.

Costa Rica is a developing country, and according to Professor Arrieta of the University of Costa Rica (personal communication, 27 March 2001), it lacks any type of formal program or laws regarding the disposal of lead-acid batteries. Presently, there is an informal recycling program for batteries in Costa Rica. Either they are recycled through one of the many private collection companies, or they are disposed of in a manner that is unsafe to the environment. These unsafe methods of disposal include being thrown out in the regular mainstream waste system, where they can eventually make their way into landfills. Another possible unsafe disposal method occurs mostly in the rural areas where the batteries may be thrown in back yards or in rivers and streams of the surrounding areas. The batteries can also remain in the consumer's house after they are spent or used. This is a more serious issue in rural areas as opposed to urban areas due to the lack of any type of battery collection.

Last year, students from WPI (Arthur, Caswell, & Wheeler, 2000) developed recommendations for a consumer plastics recycling program in Costa Rica. Many of the government officials in Costa Rica are aware of the environmental pollution that not recycling can cause, and are taking steps to try and solve this problem. This is evident from the personal communication with the representative from the Ministry of Health and the Centro Nacional de Producción Más Limpia in Costa Rica.

With the annual rate of batteries disposed of in the United States increasing at a rate of about 2.4 percent per year, it is apparent that the need for a recycling program across the world should no longer be ignored (Jackson & Tansel, 1994, p. 98). Refer to Figure 2.1 below for a table that shows the percentage of discarded materials recycled in the United States in 1996. This shows that lead-acid batteries are at the top of the list of recycled materials.

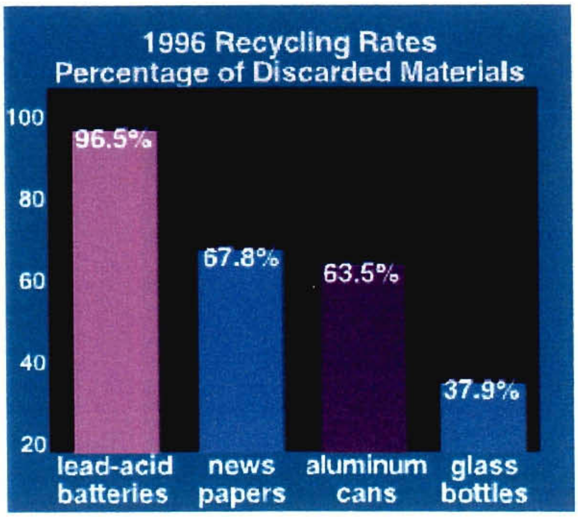

Figure 2. 1: Percentage of Recycled Materials in the U.S.

When talking about the recycling industry, lead-acid batteries can be looked at as an environmental success story (ILMC, 2001). When comparing lead-acid batteries to the usual "flagship" recycled materials, lead-acid batteries are the clear leader. In fact, used lead-acid batteries have been at the top of the list of the most highly recycled consumer products in the industrialized world for over a decade. The figure above is from Battery Council International (Battery Council International, 2001).

2.2 The Lead-Acid Battery

Gaston Planté invented the lead-acid battery in 1859 (Encarta, 1999). The lead-acid battery is a storage container that stores energy. Inside each lead-acid battery, or automobile battery, there is a group of cells, which are connected together in series. Each cell contains a lead plate, a lead oxide plate, and an electrolytic solution of sulfuric acid. These types of batteries can be recharged when they run dead by passing a current through them in the opposite direction that the current normally flows when the battery is fully charged. A lead-acid battery can only be recharged so many times before it can no longer hold a charge. This may take anywhere from 6 months to 5 years, depending on the climate and the use of the battery. The average automobile battery consists of about 1 gallon of sulfuric acid, 1.5 pounds of plastic or rubber, and 18-22 pounds of lead (Jackson & Tansel, 1994, p. 97). Refer to the figure below for an illustration of the components of a lead-acid battery.

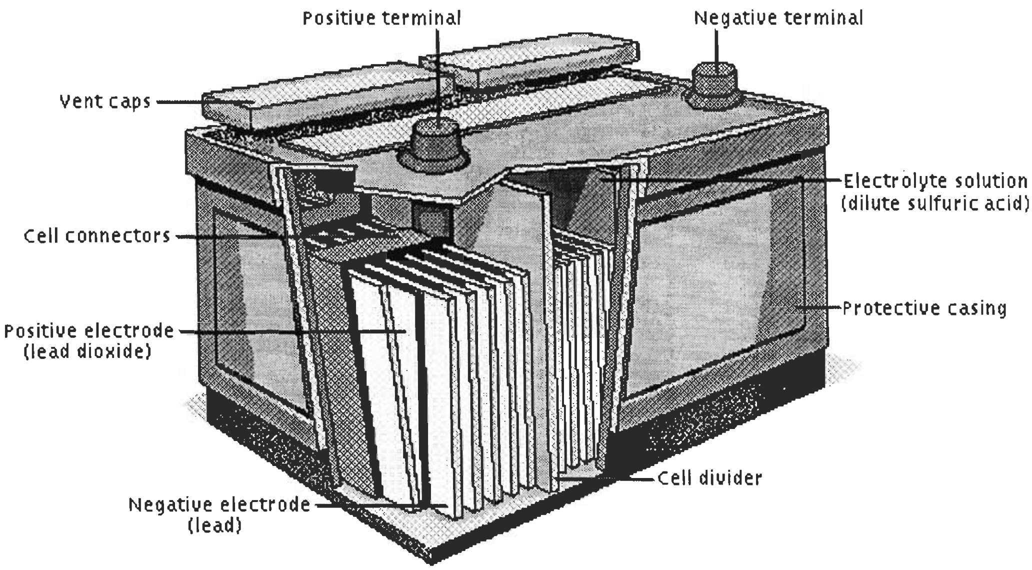

Figure 2. 2: Components of a Lead-Acid Battery (Encarta Online, 2001)

A battery creates its energy by converting chemical energy to electrical energy (Lund, 1993, pp. 19.1-19.32). The sulfuric acid that is in an automobile battery is the liquid through which the current travels and is called the electrolyte. There is an anode, also known as the negative electrode, and a cathode, also known as the positive electrode. In a lead-acid battery, the anode is made of lead, and the cathode is made of lead dioxide.

These three components are what make up all basic batteries, the lead being the most harmful, and the sulfuric acid also being a harmful substance.

Lead-acid batteries, like those found in automobiles, are one hundred percent recyclable (Lund, 1993, pp. 19.1-19.32). The casing is made of plastic, which can be recycled a few times before it starts to break down and becomes unstable. The sulfuric acid can be managed by using a base to neutralize the acid, and the lead can be recycled by a process called lead smelting. The process of lead smelting will be explained in detail later in this report in a section entitled: Recycling Process.

2.3 General Health and Safety Issues

There are many health and safety issues associated with the contents of lead-acid batteries that are used in automobiles and other motor vehicles. Lead can be found in soil and water and is toxic when humans are exposed to it. Chronic and acute exposure includes breathing in lead particles and swallowing lead that has contaminated food and drinks. Lead exposure can lead to major health problems and repeated exposure causes buildup in the body. Low levels may cause tiredness, mood changes, headaches, weakness, and memory problems (Cheremisinoff & Cheremisinoff, 1993, p.13). Lead can also cause serious permanent kidney and brain damage at high levels. This exposure can also increase the risk of high blood pressure and can affect the central nervous system, especially during the early stages of a child's development (Buchanan, et al., 1996, p. 282). While working with batteries, humans can also be exposed to sulfuric acid, a corrosive chemical that can be fatal if ingested. The risks associated with working with sulfuric acid are explained in a later section entitled: Sulfuric Acid.

Those among the greatest risk from exposure to lead are fetuses, infants, and children under the age of seven (Cheremisinoff & Cheremisinoff, 1993, p.49). Pregnant women put their children at risk because the fetuses that they carry are at risk from a high level of lead in the mother's blood. Children may have lead poisoning without having any symptoms. The only way to detect lead poisoning is with a blood-screening test.

Lead, in soil, has very low mobility, which means once the soil is contaminated, the lead will not move to other areas. It will stay in the same area that is contaminated originally (Cheremisinoff & Cheremisinoff, 1993, p.12). Once the soil is contaminated, it usually remains contaminated. This has adverse consequences for soil fertility, the ability of the soil to grow crops, if the concentration of lead in the soil is high. In areas where there is contamination of lead, concentrations range from 2 to 200mg/kg with most samples being in the range of 5 to 25 mg/kg.

Lead in drinking water can increase a person's total lead exposure (Cheremisinoff & Cheremisinoff, 1993, p.13). Lead enters drinking water as a result of corrosion of materials contained in water distribution systems and household plumbing. When water stands in lead pipes or plumbing systems containing lead for several hours or more, the lead may dissolve into the drinking water.

2.3.1 Safety Issues Due to Lead Exposure

The exposure to lead can cause many problems within the human body (Buchanan, et al., 1996 pp. 282, 285). The exposure to lead can cause impairments of cognitive and behavioral development in children whose blood lead concentrations are as low as 100µg/l. Also at this low blood lead concentration there is an inhibition of aminolevulinate dehydratase (ALA-D), an enzyme, which can lead to impaired heme synthesis, where heme is the part in the blood that synthesizes iron, and a decrease in the blood-hemoglobin concentration, an indication of oxygen movement in the body. There are also some indications of sensory-neural hearing impairment, an impairment of neuropsychological function, vitamin D metabolism, and hematopoiesis.

There are many cases where humans in many countries have been exposed to the lead and the sulfuric acid that are contained in motor vehicle batteries (Buchanan, et al., 1996, p. 285; Ong & Suplido, 2000, p.232). These cases show that humans have high blood lead levels where there are facilities working with the lead. These problems are not only risks to those working with the actual batteries, but also to their friends and families, and to the people living next to or near lead and sulfuric acid facilities.

In developing countries, lead battery recycling and radiator repair are often small-scale businesses. These businesses are often located in heavily settled areas, and most of them are located in the backyards of the people who work at these facilities. Humans can be exposed orally to lead from hands, tools, food, soil, and drinking water. Also simple inhalation can increase the blood lead level in the human body.

One case of lead exposure was documented in Manila, the Philippines (Ong & Suplido, 2000, pp. 232-237). This case was a study conducted in Manila, where small-scale battery recyclers, automobile radiator mechanics, and their children were tested. Unexposed residents were also tested. Blood lead and hemoglobin levels were taken from the exposed people and compared to the results of the unexposed people.

In Manila, the lead battery recycling and radiator repair facilities were very small businesses that were run out of peoples' homes. The workers were not protected very well, nor were their families. Occasionally meals were eaten in the working area, which were adjacent to the workers' homes. Often family members would have to walk through the work area to get into their home. The areas in which they worked were not very well ventilated, and none of the workers used respirators. In the battery recycling facilities, the workers separated the batteries into component parts that were transported to other shops for further processing. In the tested facilities, only one of them did lead smelting, but the others had workers that delivered to large lead smelting companies. All the workers were exposed to lead at many different times throughout their working day.

The conclusion of this case is that lead exposure was significant among the workers and their families (Ong & Suplido, 2000, pp. 232-237). These shops were located very close to the workers' homes and the members of the workers' families were being subjected to lead exposure daily. Both the workers and children from the battery shops had blood lead levels that were much higher than those that were not exposed to lead. The study concluded that in order to solve such a problem that has become prevalent in developing countries, the battery shops should be moved to less densely populated areas outside of the city, and also these shops should be located away from the workers' homes. Lowering the blood lead levels in the children and workers is likely to require environmental measures that may be beyond the financial capabilities of small-scale shops. The acknowledgement by the Philippines government that lead poisoning is one of many environmental problems in the Philippines is a very good beginning to finding new measures of lead poisoning prevention.

Another case of lead exposure occurred in the Ecuadorian Andes (Buchanan, et al., pp. 282, 285). This case is slightly different. Not only can the lead in motor vehicle batteries be harmful during the recycling process, but it can also be harmful when taken out of batteries and used to produce the glaze put onto tiles. This was just the case in two Andean villages in Ecuador. The children living in these two villages were tested for their blood lead levels. The children's families had cottage-type industries, where the industries extract lead (Pb) from discarded lead-acid batteries for the production of the glazed tiles.

There are about 200 small-scale tile-glazing shops in this area that are run by one or a few families (Buchanan, et al., pp. 282, 285). The lead used in the glaze is extracted from discarded lead-acid batteries after manually crushing the battery cases and detaching the electrode packages. The battery metals are then churned with water to slurry, which is then applied onto the tiles. The glaze coating is then put into sawdust-fired kilns, which emit a dense, black smoke. Protective devices are not used at all during this process.

The results from this case were that the children that lived in the area had very high blood lead levels (Buchanan, et al., pp. 282, 285). It was also noted that the families that were not directly a part of the tile-glazing shops were also found to have an increase in their blood lead levels. This may have been because of the considerable level of lead pollution in the environment. This blood lead level of 210 μg/l exceeds the current occupational biological exposure limits in Europe and the United States, which is 100 μg/l. It is very important that intervention programs be established in order to reduce the level of lead exposure in tile-glazing areas.

2.3.2 Sulfuric Acid

Human exposure to sulfuric acid is also very dangerous. It is very corrosive and may be fatal if swallowed or in contact with skin (J.T. Baker, 2001). Liquid and mist forms of this chemical can cause severe burns to all body tissue. The chemical, if inhaled, can also be harmful to the skin and tissues of the body. The chemical affects teeth and is water reactive, and in the form of inorganic mists containing sulfuric acid, is it also a cancer hazard. The risk of cancer depends on the duration and level of exposure

There are many serious health risks caused by exposure to sulfuric acid. If sulfuric acid is inhaled, the chemical can cause damage to the mucous membranes and upper respiratory tract. Symptoms may include irritation of the nose and throat and labored breathing. If inhaled, sulfuric acid can cause lung edema. Lung edema, also known as pulmonary edema, is the abnormal build up of fluid within lung tissue and makes it difficult for lungs to give oxygen to the blood (Adam Brochert, M.D., 2001). Symptoms can include shortness of breath (which is worse with activity or laying flat), coughing up phlegm (that can also contain blood), a fast heartbeat (tachycardia), anxiety, and excessive sweating. Lung edema is unavoidable and the long-term effect of this disease is death. This disease can be diagnosed through a chest x-ray and there are some types of treatments for this disease. In one type of treatment patients can be given oxygen, or for severe cases, a ventilator (artificial breathing machine). Another type of treatment is prescribing fluid pills to the patient.

When sulfuric acid is ingested, it is corrosive (J.T. Baker, 2001). Swallowing can cause severe burns of the mouth, throat, and stomach, which can lead to death. Sulfuric acid can cause sore throat, vomiting, and diarrhea. A circulatory collapse can also occur due to the ingestion of sulfuric acid. Clammy skin, weak and rapid pulse, shallow respirations, and reduced urinary activity may follow ingestion or skin contact of sulfuric acid. Circulatory shock is often the cause of immediate death. Symptoms that occur when sulfuric acid gets in contact with skin are redness of the skin, pain, and severe burn. When sulfuric acid gets into contact with the eyes, it can cause blurred vision, redness, pain and severe tissue burns. Eye contact can also lead to blindness. Persons with pre-existing disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

2.4 Waste Management and Pollution Policies

In many parts of the world, recycling lead-acid batteries has become an issue in reducing pollution (Lund, 1993, pp.19.10-19.13). Many countries have developed laws to prevent the disposal of batteries in landfills and on roadsides. These laws have been constructed in order to protect the environment and the people who work in the area of the battery recycling facilities. Battery Council International, BCI, has developed model legislation to be used by states in developing a lead-battery collection program. The main parts of the BCI model legislation are as follows: 1.) Any person is prohibited from disposing of a lead-acid battery into mixed Municipal Solid Waste, MSW. 2.) Each battery improperly disposed of constitutes a violation subject to a fine. 3.) And there is also a take-back provision, stipulating that any person selling lead-acid batteries must accept used lead-acid batteries and post written notices indicating that batteries can be returned.

2.4.1 Waste Management Policies in Costa Rica

According to Dr. Arrieta, there are currently no restrictions that pertain to lead-acid batteries in Costa Rica (personal communication, 27 March 2001). There are general laws regulating the disposal of waste, but no specific laws for car batteries. The Ministry of Health in Costa Rica does not consider lead a hazardous waste product.

Currently, Costa Rica is working to promote environmental awareness about lead-acid batteries and the harm they can cause. They have been working with the International Lead Management Center and the Basel Convention to try to develop a program similar to what this project sets out to do. The laws that are in place now only regulate the disposal of solid waste, but there is no law regulating the pollution caused by lead smelting because it is not seen as a hazardous bi-product at this time. According to Orlando Rodriguez of the Ministry of Health in Costa Rica, there are plans in the works, however, to implement laws regulating emissions from the smoke stacks of factories in Costa Rica (personal communication, 31 May 2001).

2.4.2 Waste Management Policies in the United States

The model legislation created by Battery Council International has been used by many states in the United States. As of 1994, 43 states had legislation on battery recycling (Battery Council International, 2001). Most of them are very similar, with some states offering deposits on the batteries, such as the process of requiring deposits on plastic bottles and cans to encourage recycling in Massachusetts. Most lead-acid batteries are collected at local automotive service or repair garages. Some of these batteries are collected through household hazardous waste collection programs that are implemented by local governments. The automotive service and repair garages serve as collection points. The batteries are collected by battery distributors and are then transported to reclamation centers where lead and polypropylene are recovered, generating a toxic residue that requires special disposal.

2.4.3 Waste Management Policies in Massachusetts

Out of 28 states that have enacted disposal prohibitions on lead-acid batteries since 1990, 25 of them have laws stating that any place that sells a lead-acid battery must take one back upon the purchase of a new one, or a deposit will be charged until the old battery is brought back. Massachusetts is one of these 28 states (Lund, 1993, p.19-10). The laws and regulations that are in effect in Massachusetts are based on the recommendations that were set forth in a model developed by the Battery Council International (BCI) to be used by states in developing a lead-acid battery recycling program.

2.5 Recycling

2.5.1 Process of Recycling

The recycling of lead-acid batteries is an intricate process due to the many components of the battery that can be recycled (Bourson, 1995, p.81). These components are lead materials (metallic, oxide, and sulfate), plastic (polypropylene or polyvinylchloride), residues (fibers, ebonite, and separators), and acid (sulfuric). The actual process of recycling batteries can be divided into the following sections: the breaking of the batteries, the smelting of lead, the refining of lead, recycling the plastic, and recycling the sulfuric acid.

The breaking of batteries is the process of separating the battery into its components (Jolly & Rhin, 1994, pp. 141-142). The batteries are crushed, and the individual components are separated based on their physical properties, such as particle size and density. Battery paste, consisting of lead oxide and lead sulfate, are separated first, and then the remaining fragments are crushed again. Polypropylene is successfully separated from the ebonite and separators by hydraulic separation, which utilizes the different densities of the remaining components (ebonite, density=1.3; polypropylene, density=.9; lead, density=11.4).

The next section of the recycling process is lead smelting. Lead smelting is the process of producing crude lead from battery paste (Bourson, 1995, pp.81-82). Rotary furnaces are generally used in this process due to their ability to be interrupted without causing disruption of the final goal, the wide range of materials that can be used, such as drosses, flue dust, and filter-press cakes, and the low amount of waste emptied into the environment. The rotary furnace is a tilting furnace, so it can easily pour the liquid lead into ladles, which can then be poured into kettles that will undergo refining in the next stage. Being equipped with a gas-oxygen burner, the rotary furnace produces less gas that will need to be cleaned before it can be released into the environment. The process gases are mixed with the atmospheric air in order to cool the gases to roughly 100 degrees Celsius, and then the gases are filtered through a bag filter.

The next stage of the recycling process is the refining stage (Bourson, 1995, p. 82). The liquid lead is refined to the specifications of its use through stirrers at specific temperatures. The now refined lead is moved to the casting machine, which will mold the liquid lead into different products. How the lead is treated will determine what the final product will be. Through the process described above, most of the lead from lead-acid batteries is reused.

After the battery is broken and the individual components are separated, the plastic pieces, usually polypropylene, are washed and dried and sent to a plastics recycler

(ILMC, 2001). There the plastic chips are melted and then molded into pellets for use in the manufacture of new lead-acid batteries.

Sulfuric acid can be recycled by four different methods (ILMC, 2001). One method is to neutralize it with a base so that it meets clean water standards and then be released into the public sewer system. The second method is to reclaim it from the spent batteries, top it off with new, concentrated acid, and then reuse it in new batteries. The third method is to chemically treat the acid and convert it to either an agricultural fertilizer using ammonia or to a powered sodium sulfate for use in the glass and textile manufacturing industry or as a filler or stabilizer in household laundry detergent. The final method of recycling sulfuric acid is to convert it to gypsum for use in the production of cement or in the manufacture of fiberboard for the construction industry. In Figure 2.3, a chart showing the process of recycling a lead-acid battery follows, adapted from Battery Council International's website, www.batterycouncil.org.

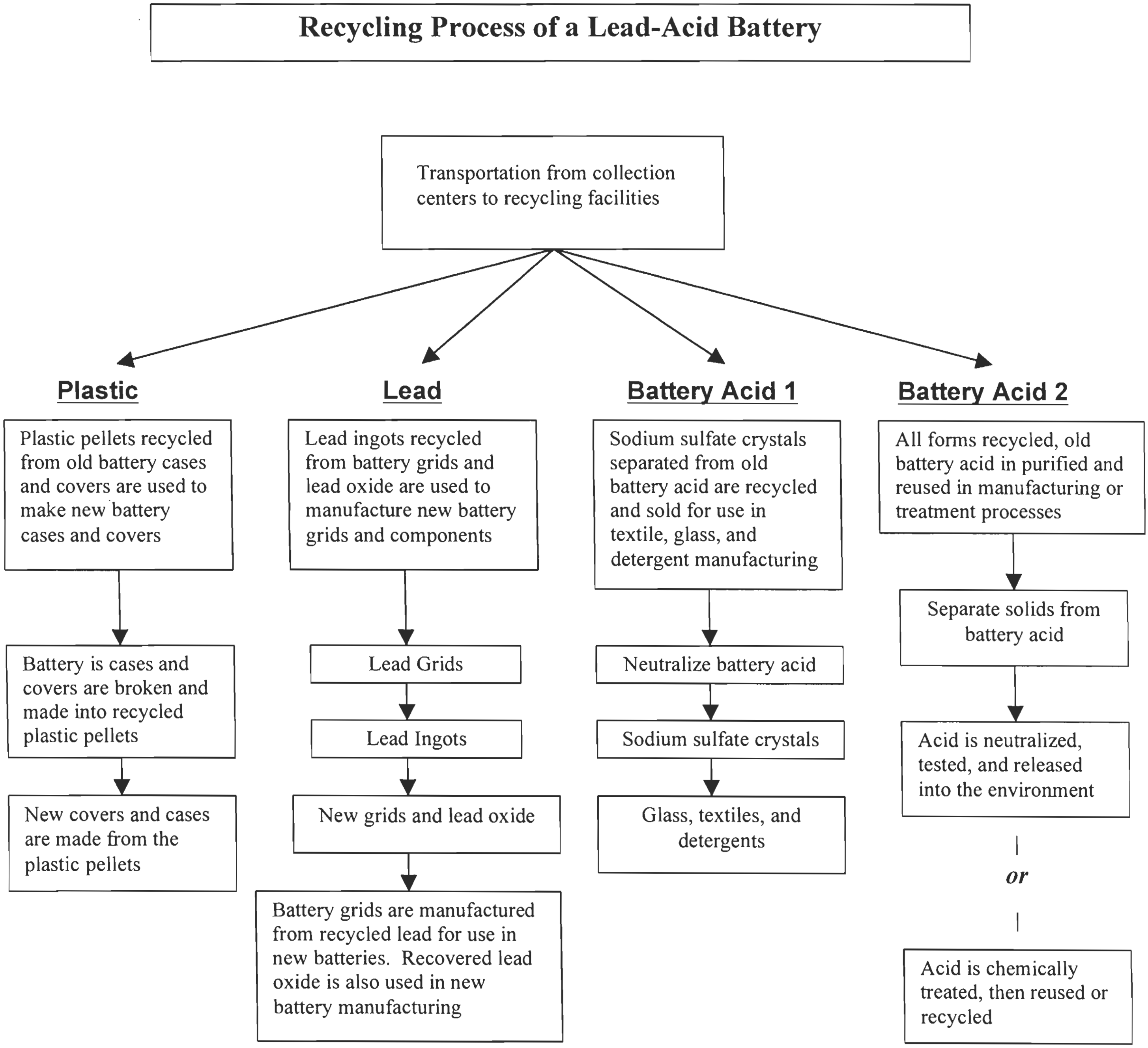

Figure 2. 3: Recycling Process for a Lead-Acid Battery (Adapted from Battery Council International)

2.5.2 Implementing a Recycling Program

In order to implement a successful lead-acid battery-recycling program, Quirijnen gives a list of five important key factors (Quirijnen, 1999, p. 267). These factors are: a local, or target market of at least 2,000,000 available spent batteries per year, a favorable regulatory structure, an efficient collection program, a competitive and environmentally friendly recycling technology, and financial backing.

According to Quirijnen, the local or target market is defined as a country or region where at least 2,000,000 spent batteries are available per site per year (Quirijnen, 1999, pp. 267-268). This means that in order for a recycling plant to be successful, there must be at least 2,000,000 batteries available per year for the plant to operate efficiently. At times it is necessary to include more than one country if this specification cannot be met. For a local market to be good, the geographical location must be taken into account, as well as the population, number of cars, and distances. The geographical location must be considered because the program must be located in an area that has enough batteries to be able to run efficient collection programs. If there is a collection center in a town with a population of 30, the program is not going to be operating very efficiently. This is why population and location must be taken into account.

The regulatory structure is based on the laws or regulations enforced by the local government with the common goal of maximizing recycling, for environmental and health related reasons (Quirijnen, 1999, p. 268). Examples of regulations that should be included are: to prohibit battery dumping in landfills, to limit storage time and quantity of batteries, and to license only those collectors who comply with the laws regarding environmental and human safety. The main goal of the government should be to develop a system in which a minimum of 97% of spent batteries is recycled.

Quirijnen defines an efficient collecting system as one that "produces a collection rate of above 95%" (Quirijnen, 1999, p. 268). Collection points can be mechanic's garages or retail stores. Each collection site should have the appropriate acid-resistant bins, trucks, and warehouses to prevent acid from entering the environment.

The technology needed for recycling must be "cost-effective", according to Quirijnen (Quirijnen, 1999, pp. 268-269). In order for technology to be cost-effective, it must produce high yields while keeping energy consumption, maintenance, and labor costs low. The actual recycling, the smelting, must comply with EPA regulations if in the U.S., but if this is not possible, the batteries must be shipped to another plant that can comply with the necessary regulations. Each country has its own version of the EPA.

The financial backing needed to implement a recycling plant must have a sufficient return on investment (Quirijnen, 1999, p. 269). The recycling plant must operate at full capacity for at least eleven months per year, twenty-four hours per day, seven days per week, according to Quirijnen. This can only occur if the supply of raw materials is guaranteed through an adequate market.

2.6 Recycling Programs

2.6.1 Recycling Programs in the United States

The United States, as well as numerous other countries throughout the world, has recognized the dangers that arise due to leaving used lead-acid batteries in landfills and on roadsides. Over thirty-five states have passed laws declaring that all lead-acid batteries must be recycled (Wachtel, 1993, p. 82). These states, along with many of the remaining states, have implemented recycling programs for lead-acid batteries, the most prominent being take-back programs. Another popular program is the drop-off center program.

The take-back program has proven to be a very effective method for collecting lead-acid batteries for recycling. Of the thirty-five states that have passed legislation mandating that lead-acid batteries be recycled, fifteen of these passed obligatory take-back laws (Wachtel, 1993, p. 82). A take-back program simply states that a used battery must be turned over to the company where a new battery is purchased. This ensures that the battery will go to a recycling center and not into a landfill. Companies that would likely serve as take-back centers would be mechanic's garages, car dealerships, and automotive parts stores (Steinbrunner, 1995, p.17).

In the United States, some of the states can make a profit by enforcing the take-back laws. When a battery is traded in, there is a deposit that needs to be paid by the consumer, and so much of the deposit goes to the battery collection site (Battery Council International, 2001). These deposits can be used to pay for the recycling program in the town or state.

Another program for recycling lead-acid batteries is the drop-off center program. Typical drop-off centers include service stations, retail stores that sell automotive parts, and car dealerships. A different type of drop-off center is one that solely deals with recycling. This type of center is a central location for citizens to bring their used batteries, knowing that they will then, in turn, be brought to a recycling plant (Powelson, 1992, pp. 265-267).

2.6.2 Recycling Programs in Norway

The battery recycling program in Norway is much like the programs in the United States, except that it is based solely on the responsibility of the producer (Hagen, 1998, p. 270). The lead-acid battery recycling program is an industry-organized program, developed from the agreement made between the lead battery industry of Norway and the Norwegian Ministry of Environment in 1993. Also in 1993, the battery manufacturers and importers of Norway founded an organization, AS Batteriretur, to take on the responsibility for managing waste produced from their product as well as a nationwide battery recycling system.

Due to the unique geography of Norway, it was required for all 10,000 battery retailers, scrap dealers, and refuse dumps of the country to become drop-off centers for used batteries (Hagen, 1998, pp. 270-271). At these drop-off centers, there are bins designed to hold the hazardous batteries so that the damaging components of the battery cannot leak out into the environment. From these bins, the batteries are transported to one of the two storage centers in Norway, which are then in turn, transported to Sweden and England, where the batteries are separated into their components and recycled.

2.6.3 Recycling Programs in Mexico and South America

With the world's vehicle population rapidly increasing over the last fifteen years, lead consumption in 1995 reached 4.928 million tons (Valdez, 1996, pp. 219-223). As the demand goes up for lead-acid batteries, the suppliers must expand their plants. Japan is an example of one of many countries, which has had to relocate its recycling facilities due to rapid growth.

The developing countries in Latin America are the next big area in the world for building bigger recycling plants. The countries of Latin America tempt private investors with low labor costs, less stringent environmental regulations and enforcement, new facilities from the governments, and potential growth of their economies. There are some drawbacks to setting up new plants in Latin America. Some examples of the risks that must be considered according to Valdez are: exchange rate instability, high inflation rates, high market inconsistencies, economic bubbles, highly protectionist policies, tax evasion practices, and environmental control laws (Valdez, 1996, p. 219-220).

In Mexico, Venezuela, Colombia, Brazil, Argentina, and Peru there are lead recycling plants (Valdez, 1996, pp. 220-222). They do not all, however, comply with the environmental regulations dictated by the Environmental Protection Agency, EPA. Two plants in Mexico and one in Venezuela have been closed down by their local environmental regulatory agency for not meeting environmental regulations. Many plants in the Latin America region are vague on whether or not they comply with EPA regulations. Each country has their own version of the EPA and these dictate the environmental practices in each country. Costa Rica's version of the EPA is MINAE, or Ministerio del Ambiente y Energía.

Valdez states "Latin America has still a long way to go to reach the necessary stabilization and maturity in its battery markets" (Valdez, 1996, p. 223). With the unstable economies in these countries, new facilities are considered a great risk; however, once efforts are made to design plants that comply with EPA regulations, Latin America can be a major lead recycling option.

2.6.4 Recycling Program in Malaysia

The major lead producer in Malaysia is Metal Reclamation Industries, MRISB, located in Taman Selayang Baru in Selangor (Phillips & Lim, 1998, p. 11). The goal of MRISB is to build a larger and more modern smelter in Pulau Indah, West Port, which would meet the lead demand and comply with Malaysian environmental regulations.

The plans for the new plant in Pulau Indah include a collection program that is designed to receive batteries still containing acid, and prevent the common practice of draining the batteries into the environment (Phillips and Lim, 1998, pp. 11-15). The actual battery storage area will be acid-proof in order to collect the acid still present in the batteries. The acid will be collected from this storage area and the spent electrolytes will be further recycled. A hammer mill will then crush the batteries and the different components will be separated. The crushed batteries will be screened to separate the plastics from the battery paste. The polypropylene will be sent for further recycling to plastic recyclers. The lead paste still remaining will then be sent to the smelter, where it will be cleansed and recycled. This process is very similar to the smelting process described in 2.4.1. The final stage for the process is the refining stage, where the lead will be alloyed according to purchaser's specifications.

All processes will comply with the environmental regulations (Phillips and Lim, 1998, pp. 15-16). The electrolytes and waste-water will be treated with chemicals to make them environmentally friendly, and all the metals, such as lead, cadmium, copper, and iron, will be sent to the metal recovery furnace. The effluent gases from the smelting process will be cooled with water sprays and then filtered to remove lead fumes. All sulfur dioxide emissions will be analyzed such as to remove 95% of the toxic gas. The gas will be passed through limestone slurry to produce calcium sulfate, which is a valuable component in the cement and wallboard industries. No solid wastes will be allowed to leave the plant except for small amounts of non-recyclable PVC separators, which can be safely discarded in landfills.

2.7 Different Views on Recycling

There are different viewpoints on the subject of recycling. Many favor the idea, once initiated, but the way recycling is handled in a country is often controversial and can be subjected to many different opinions. This means that people may not be willing to participate in a recycling program because it may be an inconvenience for them or the cost may have a factor in whether a company wants to serve as a take back center. The country needs to make the program easy to adopt and beneficial to the consumer.

2.7.1 Benefits of Recycling

There are many advantages to be gained from recycling, both environmental and economic. One advantage is that recycling saves natural resources (ILMC, 2001). If a battery is made from recycled lead, this reduces the need to mine for more lead and deplete the country's natural resources. Recycling also saves energy because secondary lead bullion takes four times less energy to make than primary lead. Another advantage to recycling is that it saves clean air and water by making less air pollution than manufacturing products from virgin materials. Landfill space is also conserved by recycling because the space is not needed for the products that are recycled. The last of the main advantages of recycling is that it saves money and makes jobs available for towns. There are many more job opportunities available in a recycling plant than in a landfill.

2.7.2 Consequences of Not Recycling Properly

Recycling can be a benefit to a country and many good things can come from it. But when a recycling program is not run properly, there can be consequences for not only the country recycling the batteries, but also for other developing countries. This is because many industrialized countries send the toxic waste produced from recycling to developing countries in order to save money.

After an investigation completed by Greenpeace, it was determined that much of the toxic waste produced from battery recycling is being exported from major industrial countries to many developing countries (Cobbing and Divecha, 2001). This kind of toxic waste is in the form of the internal lead components of the battery. The reason why this transfer of wastes takes place is mainly due to the cheaper labor and the ineffective laws and regulations regarding waste management found in many Third World countries. These are good incentives to send the wastes to developing countries rather than pay the high rates to follow the strict regulations in industrialized countries. The low prices of secondary lead, or lead that has been recycled, and the greater enforced environmental regulations found in industrial countries are other factors that contribute to the transfer of wastes to developing countries.

England, the United States, and Australia, three of the major lead waste exporters, dump roughly 61,500 tons of waste per year in Third World countries such as Brazil, Indonesia, Mexico, the Philippines, Taiwan, and Thailand (Cobbing and Divecha, 2001). In these third world countries, health and environmental codes are violated in the secondary lead factories every day. Greenpeace investigators have found that smelting workers in the United States must wear full-body protective suits to defend themselves against the dangerous fumes and liquids, but in Third World countries many workers use their bare hands while handling batteries. Factory workers and their families in third world countries have reported to Greenpeace investigators that the acid from the batteries is discarded in the water streams and solid wastes are dumped outside of the facilities. The workers from Brazil have reported black dust emissions from the factory that has killed cattle, and their young children have exceptionally high lead blood levels. In Indonesia, there have been reports of ashes from the factory settling in drinking wells and on food, and a chronic cough among many area residents. People in the Philippines have experienced burning eyes, sore throats, severe breathing problems, and witnessed black rivers that have been polluted by smelting plants (Cobbing and Divecha, 2001).

2.8 Interviewing Methods

Berg defines interviewing as a conversation with a purpose to gather information (Berg, 2001, p. 57). Interviewing can be a very integral method of gathering information when conducting research.

There are three different types of interviews: standardized, unstandardized, and semistandardized (Berg, 2001, p. 59). A standardized interview is a formally structured schedule of interview questions. This method is used when the interviewer knows the information they want to uncover and they use a set of predetermined questions. An unstandardized interview is the opposite of a standardized interview. The interviewer goes into the interview not knowing what specific information he/she wants to uncover or what questions to ask. This method is very informal and can be considered a conversation between the interviewer and interviewee. The third and final type of interview is the semistandardized interview. This is a mix of the standardized and unstandardized methods. The interviewer goes into the interviewer with a set of questions but may probe further on certain subjects.

Content analysis is a way of analyzing interview data. When conducting an interview or reviewing interview notes, content analysis consists of looking for key ideas within the conversation. Using content analysis can help the researcher get the key ideas from the interview or conversation. Content analysis is a method that is very commonly used when researching in the field and conducting interviews and can be very helpful when analyzing interviews. There are two different types of analysis that can be made, qualitative and quantitative. Qualitative analysis shows how researchers can examine ideological mind-sets, themes, topics, symbols, and similar phenomena, while grounding such examinations to the data (Berg, 2001, pg. 242). Quantitative analysis shows how researchers can create a series of tally sheets to determine specific frequencies of relevant categories.

Chapter 3 METHODOLOGY

3.1 Current Public Awareness of Waste Disposal and Recycling

Upon our arrival in Costa Rica, we had our first meeting with our liaison. During this meeting, we learned about the serious problem with solid waste in Costa Rica, especially with the municipalities. Dr. Arrieta showed us a slide show that he made of a study he did on the problem of solid waste disposal in Costa Rica. This slide show was very informative and gave us a good background in order to understand how the government and municipalities work in Costa Rica.

We visited a school in Cartago to determine if the children of Costa Rica are being educated on the importance of recycling and how to follow through on it. The school we visited, recommended by our liaison, was hosting an ecological fair called Festival Ecologico held on May 18th and 19th. We observed how the children viewed recycling by closely examining the different exhibits the children made for portraying their knowledge and views of recycling. We walked around each of the rooms that had exhibits and viewed the children's creativity illustrated in their projects. We collected data by taking photographs of some of the projects and we analyzed the data by reporting what we saw.

3.2 Investigation of the Informal Recycling System

In order to accurately develop a manual with recommendations to improve upon the informal recycling program for CICA, we first examined the current recycling situation is in Costa Rica. By examining the current situation, we sought to figure out what was already in place as a system of recycling. Not only did we learn about the technical aspects of recycling, but also we were able to construct the complete life cycle of a battery from the time it is imported into the country to the time it is discarded.

Berg defines interviewing as a conversation with the sole purpose of gathering information (Berg, 2001, p. 66). The informal system that the Ticos currently follow to dispose of their batteries was investigated and explored further by conducting open-ended and closed-ended interviews, depending on what type of information we were looking for, with the various stakeholders who played a role in the recycling process. We used interviews as a mean of investigating instead of surveys because surveys are more formal and we did not know how much of a response we would receive. We also conducted interviews because the interviews allowed us to see how batteries were handled and stored. We interviewed people from each level of the informal recycling process, including a representative from the Ministry of Health of Costa Rica, a representative from Baterías Record de Costa Rica S.A., the owner of a small-scale collection facility, two black box battery makers, sixteen taxi drivers, five auto-parts stores, and three mechanics from repair shops.

3.2.1 Ministry of Health

We conducted an informal, open-ended interview with Ing. Orlando Rodriguez, a representative from the Ministry of Health of Costa Rica. This interview was conducted in this manner because it gave Orlando Rodriguez an opportunity to tell us everything without being restricted to specific questions. Professor Salazar accompanied us to the informal meeting and served as a translator. Orlando Rodriguez was one of two men from Costa Rica who attended a conference in Trinidad to plan for the upcoming Basel Convention, which will focus on the problem of lead-acid battery pollution in Central

America. This interview was held in order to determine the standing of the government on various issues, including what legislation currently exists and what legislation is in the process of being developed in Costa Rica. By conducting this interview, we hoped to learn what was discussed at the conference in Trinidad about lead-acid battery recycling. We also wanted to find out the viewpoint of the government on issues such as the position of society on recycling and the role of the government in the recycling system. Mr. Rodriguez's contribution to the interview led us to the analysis of the government's role in the recycling system. A detailed summary of this interview can be found in Appendix H.

3.2.2 Chamber of Industry

We also conducted an informal, open-ended interview with Dr. Sergio Musmanni, the Director of Centro Nacional de Producción Más Limpia, and also the Sub-Director, Ing. Carlos Heinrich. This interview was also conducted in this way because it allowed them to tell us a lot of information without being restricted to specific questions. This interview was conducted in order to see what plans were developed for the implementation of a lead-acid battery program in Costa Rica and also if they knew anything about the current situation of lead-acid batteries in Costa Rica. We also hoped to find out more about the role of the government in the recycling system. Another piece of information we hoped to gain from them was the number of motor vehicles in Costa Rica and the number of motor vehicles and lead-acid batteries that are being imported into the country. The approach that we took to analyze their answers was the method of content analysis, in order to determine the role of the government in the future. We chose content analysis because it enabled us to get the important information from the interview in order to see what their actions and thoughts were related to the informal recycling system. A detailed summary of the interview with Dr. Sergio Musmanni and Ing. Carlos Perera can be found in Appendix I.

3.2.3 Importers

We conducted an informal interview with Randolph Armrhien, who is an importer of lead-acid batteries. This interview was conducted informally because it gave him an opportunity to tell us everything without being restricted to questions. From his interview, we determined the role played by importers throughout Costa Rica in the informal recycling process of lead-acid batteries. We also determined a rough estimate of how many batteries are imported and disposed of in Costa Rica per month. From the information he provided us, we were able to calculate and analyze the relevant costs and revenues.

3.2.4 Consumers

In order to determine what role the average car owner played in the informal recycling process, we, with the help of Professor Salazar, interviewed a total of sixteen taxi drivers, thirteen in the San José/San Pedro area and three in the Quepos/Jacó area. We continued to interview taxi drivers until the answers we received were consistent with each other. These interviews were informal and semi-standardized. The interviews were conducted in this manner because it allowed us to ask questions that would help us determine the current methods of disposal of lead-acid batteries in urban and rural areas. These interviews gave us a good understanding of where lead-acid batteries are bought and how the average car owner disposes of his spent lead-acid battery. We randomly picked taxi drivers who were located at the taxi stop directly outside of the San Pedro Mall, and we also interviewed those taxi drivers who brought us on other unrelated trips throughout the country. A translator was brought with us to conduct these interviews. The interview questions asked of these taxi drivers and their answers can be located in Appendix B.

3.2.5 Collectors

We conducted interviews with two collectors from the San José area. These semi-standardized, informal interviews were conducted in this fashion because the questions we asked sought information that would help us understand what role these two collectors play in the informal recycling system.

We conducted an interview with Eric Jiménez, the owner of Recoprimax, a small-scale collection facility. Elizabeth Salazar attended this interview as a translator. This facility collects all recyclable materials, including aluminum cans, plastic bottles, paper, lead-acid batteries, and all other types of solid waste that are not biodegradable. This interview was conducted to give us an idea of what the collector's role is in the informal recycling process and the costs and revenues that are involved with this part of the process, which are the costs of collecting batteries and the net revenues that are made from exporting the batteries. He provided us with a detailed sketch of the informal process that currently exists in Costa Rica. His answers helped us to construct the flow chart on the informal recycling process in Costa Rica, illustrated in Figure 5.1, in the Data Analysis chapter. He was referred to us by our liaison, Dr. Ronald Arrieta. The interview questions that were asked of Eric Jiménez and his answers can be found in Appendix E.

Mr. Luis Romero, referred to us by Eric Jiménez, is a representative from Baterías Record de Costa Rica S.A. This company deals with the importation and exportation of lead-acid batteries to and from El Salvador and is also a collection point for spent lead-acid batteries. Luis Romero explained to us the process of recycling lead-acid batteries that is currently followed by Costa Ricans as well as the prices for which he buys and sells batteries. His answers also helped us to fill in the flow chart of the informal recycling process. The interview questions that were asked of Luis Romero and his answers can be found in Appendix F.

Informal interviews were also conducted with the mechanics from repair shops and auto parts stores. The interviews that were conducted with the mechanics and storeowners were informal because by asking them questions that sought to identify their role in the informal process, they helped us to determine their place within the flow chart of the informal process. These interviews also gave us a good understanding of their role in the informal recycling process and what happens to the spent batteries when they are taken from motor vehicles. These interview subjects were chosen at random as we passed them on the streets of San José and the surrounding area. A translator also accompanied us to these interviews. The interview questions that were asked of these mechanics and auto-parts stores can be found in Appendix C and D, respectively.

3.2.6 Reconditioned Battery Makers

The "black box" battery makers, or those who make reconditioned batteries, play a vital role in the informal lead-acid recycling process in Costa Rica. Because black box battery makers are very small recycling facilities, through interviewing two of them, we determined the technical process that they undertake in order to make the black box batteries. They represent a very informal and unsafe way of recycling lead-acid batteries. These people were interviewed randomly and informally, either referred to us by local citizens of Costa Rica or found by us on one of our walks throughout the city of San José and the surrounding area. These two interviews were conducted randomly and informally because these black box battery makers were found by chance. The questions asked found out what role the black box battery makers play in the informal recycling process. We also asked questions to find out what process they use to make the batteries. The information that was founded from these two interviews was then used to put in the flow chart of the informal recycling system. The interview questions asked of these black box battery makers and their answers can be found in Appendix C.

3.2.7 Exporters

We conducted an informal telephone interview with Saul Rosa, a representative from Baterías de El Salvador, the recycling facility in El Salvador. This interview was conducted this way because the questions we asked sought the costs and revenues of the company. Professor Salazar acted as a translator for this interview. We conducted this interview to determine the transportation costs of shipping the batteries from the four different private collection companies in Costa Rica to El Salvador. Carlos Heinrich referred us to Alexander Roman, a man who works with the collection and exportation of aluminum. This interview was also an informal phone interview and was conducted in this way to learn what he knew about the costs of transportation. We interviewed him because he was able to give us an approximate idea of what the costs would be to transport batteries from place to place. Interview questions and answers for Saul Rosa can be found in Appendix J.

3.3 Investigation of Current Laws

Another aspect of research that we investigated through the informal interviews with Ing. Orlando Rodriguez and Dr. Sergio Musmanni were the present laws and legislation that are related to solid waste disposal in Costa Rica, lead-acid batteries in particular. We conducted these interviews in this manner to see whether we could determine what laws were in place for the disposal of hazardous materials. We also received a handout developed by CEDARENA, Centro de Derecho Ambiental y de los Recursos Naturales, a consulting agency located in San José. The handout that we looked through had information on what laws and what permits, if any, were needed when dealing with solid waste disposal. This gave us an idea of what laws are lacking in Costa Rica regarding the disposal of lead-acid batteries so we could then make recommendations to CICA for laws that would formalize a recycling program. Orlando Rodriguez and Sergio Musmanni told us what the current laws on solid waste were in Costa Rica and the actual laws can be found in Appendix K. The laws pertaining to the importation and exportation of new and spent lead-acid batteries were found through the company Baterías de El Salvador. With the knowledge of these laws we were then able to make some of our recommendations based on the findings.

3.4 Determining Economic Impact

The economic factors of a recycling program were very important to consider while making recommendations to CICA. There are many economic factors that are associated with battery recycling, such as the costs incurred and the revenues generated from the lead-acid batteries by vendors, collectors, and distributors One of the first things we did when we arrived in Costa Rica was to talk with Randolph Armrhien, an importer of batteries, who helped us to get a better idea of the current situation of battery recycling in Costa Rica. He told us the number of imported lead-acid batteries per month. In order to determine the battery market in Costa Rica, we needed to determine how many cars there are currently in the country and what the costs and revenues will be to recycle the spent lead-acid batteries. From the interviews with Orlando Rodriguez and Sergio Musmanni and Carlos Perera we determined an estimate of the number of cars that are currently registered in the country and the rate at which the number of registered cars increases per year.

By interviewing auto parts storeowners and mechanics throughout the San José area, we determined a rough estimate of the cost of a battery to the consumer and of what percentage of this cost is profit for the vendors. By using these numbers, we identified and developed the current economic model of the battery market in Costa Rica. We determined through interviews with battery collectors, importers, and exporters the different costs that are involved in the complete life cycle of the battery, including the transportation costs, the buying and selling costs of batteries for the collectors, as well as for the recycling facilities. We analyzed the costs and revenues by making some calculations based on the numbers that were collected from the interviews. The calculations were then placed into the flow chart of the informal recycling process in Costa Rica.

The first cost was the cost of transporting the batteries from the collection points to a recycling facility. Although there are other nearby recycling facilities located in Panama, El Salvador, and Venezuela, the most feasible recycling facility that we researched was the recycling facility in El Salvador. It has been determined through our previous interviews with lead-acid battery collectors, importers, and exporters that many spent lead-acid batteries are already being sent from Costa Rica to El Salvador by private companies. Through an interview with Saul Rosa, a representative from Baterías de El Salvador, the recycling facility located in El Salvador, we were able to determine the costs for transportation from a collection center from Costa Rica to the recycling facility in El Salvador.

From the interviews with Luis Romero and Eric Jimenez, we were able to find the costs and revenues for their companies from the purchase of the old batteries and what they receive in return for collecting the batteries. From all the costs we collected, we were able to put numbers into our model of the current recycling system in Costa Rica.

Chapter 4. DATA PRESENTATION

This chapter contains the results that we obtained through the methods previously described in Chapter 3. We gathered this data to develop a manual with recommendations for lead-acid battery recycling in Costa Rica. In this chapter, quantitative data are presented in tables and qualitative data are discussed in detail in order to better analyze these results.

4.1 Public Awareness of Recycling and Solid Waste Disposal

One of the first things that we learned in Costa Rica is that it does not have an effective trash collection and recycling system because the municipal authorities lack confidence in the citizens of Costa Rica. Due to this lack of confidence, the municipal authorities are reluctant to develop any type of formal recycling system. Our liaison, Dr. Arrieta, told us that there is a significant problem with solid waste disposal in the country. Solid waste is not collected on a regular basis and by walking down any street and seeing the trash that has piled up, one can see this. This is not so much a problem with the public not knowing how to dispose of their trash, but a problem with the municipalities not collecting it properly as they should.

We were also shown that the children are being educated on how to recycle in schools at very young ages. The only problem with this is that when they come home and try to put their knowledge to use, there is no program in place to dispose of the separated waste. The people of Costa Rica are not accustomed to recycling and it takes a lot to change how they have done things since they were born. We saw an example of this effort to educate the children firsthand when we attended an ecological fair, Festival Ecologico, in Cartago held on May 18th and 19th. There were many projects and exhibits that dealt with recycling which showed that the children are informed about recycling, but are unable to apply their knowledge due to the lack of a formal collection program. The problem, according to our liaison, Dr Arrieta, lies within the municipalities.

4.2 Data on the Number of Lead-Acid Batteries in Costa Rica

The preliminary information that we found on the number of batteries imported to Costa Rica was from Randolph Armrhein. Mr. Armhein owns a large store that sells new batteries in Costa Rica. He told us that Costa Rica imports roughly 12,000-17,000 batteries per month. This does not include the batteries that are imported already installed in new cars.

We found the number of registered vehicles in Costa Rica through interviews with Sergio Musmanni and Orlando Rodriguez. Sergio Musmanni told us that there are approximately 677,000 registered vehicles and that each year 50,000 more vehicles are becoming registered, while Orlando Rodriguez estimated a number of 650,000 registered vehicles. Please refer to Appendices H and I for the detailed summaries of these interviews.

4.3 Mechanic and Storeowner Interviews

In our investigation to uncover the current situation of lead-acid battery recycling in Costa Rica, we conducted interviews with three mechanic shops and five stores that sell lead-acid batteries. We grouped the interviews of the mechanics and the auto-parts stores together because these two types of businesses both have the option of collecting old batteries when they sell new ones to the consumers. All of the mechanics were asked the same set of standardized questions and all of the auto-parts stores were asked a different, but very similar set of standardized questions. The questions that were asked and their answers from interviews can be found in Appendices C and D. The questions we asked at these businesses gave us a better understanding of what happens to a lead-acid battery once it is taken out of a car, and also the revenues and costs of selling lead-acid batteries.

The primary purpose for these interviews was to find out where the stores get their batteries, how much they cost, how much they sell each battery for, how much profit they make on each battery, if they collect the old batteries from the customers, and what they do with old batteries if they do collect them.

Table 4. 1: Point of Purchase (Auto-Parts Stores/Mechanics)

	Distributors	Respective Companies
% of Interview Respondents	87.5	12.5

The first question we asked of both the auto-parts stores and mechanics was where they obtained their new batteries. As shown in Table 4.1, the majority of respondents, seven out of eight or 87.5 percent, told us that their new batteries of various brand names came from distributors. Only one of the eight respondents told us that their new batteries of various brand names come directly from the respective battery company.

Table 4. 2: Collection of Spent Lead-Acid Batteries

	Yes	No
% of Interview Respondents	87.5	12.5

The second question asked of both interview groups pertained to the collection of spent lead-acid batteries. Refer to Table 4.2 to see the percentages of those companies who collect spent batteries. Seven of the eight interviewed responded positively to collecting spent batteries. Of these seven respondents who collect spent batteries, two of them pay those who drop off the battery. One of the mechanics pays roughly 500 colones per battery, while one of the auto-parts stores pays between 200 and 250 colones per battery. The remaining five respondents do not pay anything to those who bring in their spent batteries. Only one of the eight respondents told us that his store was not a collection point for used lead-acid batteries.

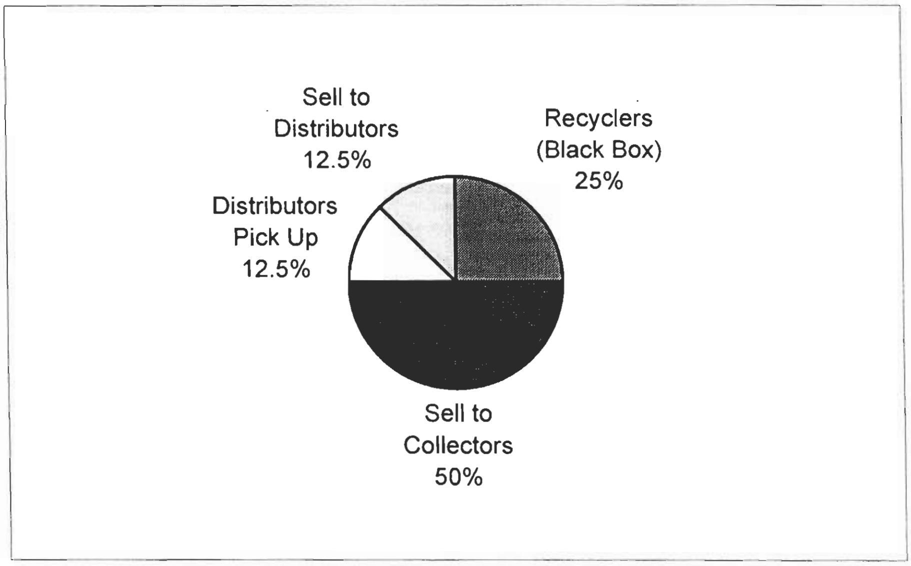

Figure 4. 1: Disposal of Lead-Acid Batteries (Auto-Parts Stores/Mechanics)

The third question we asked of auto-parts stores and mechanics was in reference to the disposal of the spent lead-acid batteries after they have been collected. Figure 4.1 shows the breakdown of how the auto-parts stores and mechanics dispose of the batteries that they collect. All three of the mechanics interviewed, or 43 percent, told us that they recycle the batteries that they collect themselves. Of the four auto-parts stores interviewed, two stores sell their batteries to recyclers for roughly 200 colones per battery. One of the auto-parts stores serves as a storage facility for the spent batteries.

They hold on to the batteries until a distributor comes to pick them up. The final auto-parts store sells their batteries to a distributor for 500 colones per battery.

We asked the auto-parts stores three background questions to help us get a better understanding of the battery market. Two of these background questions included which types of batteries are available and which battery is the most popular. We found that there are many different kinds of batteries that these stores sell. There are about 8 different sizes or models of batteries, the most popular range being from N40 to N70 for cars, and many different brand names. The brand names we found are Rocket, Die Hard, Record, Raider, Vulcan, and Koba. These batteries are imported from places all over the world, ranging from Korea to Mexico. There is no brand name that is more popular than another, and according to the auto-parts stores interviewed, all of the batteries sell about the same volume, although the prices may vary from store to store. For the questions and answers to these questions, please turn to Appendices C and D. The most popular size of battery is the N50, which is used in most passenger cars. There are also smaller batteries that are used in motorcycles and larger ones that are used in diesel cars and trucks.

The third background question we asked of auto-parts stores was in reference to the profit they made by selling new batteries. The profit that each vendor makes on each battery ranges from 20-40%, with 30% being the most common answer. The batteries sell for anywhere from 6,000 colones to 35,000 colones, depending on where you get them from and what size they are. The batteries that are on the lower end come from the black box battery makers. The profit margin for these black box makers is generally higher than the regular stores because they do not have as many costs to operate their business. Their batteries normally sell for 6,000-15,000 colones and come with a warranty that ranges from 3 months to 2 years, depending on the store and the car that it is sold to. Taxi drivers, for example, get a very short warranty, if any, because of the amount of use that their vehicle gets.

We asked two background questions of the mechanics to get a better understanding of what happens with reconditioned batteries. The first question we asked dealt with what happens to a lead-acid battery after a car has been in an accident. Two of the mechanics told us that when a car is in an accident, they assess the damage done to the battery. If the damage is minimal, they recondition, or fix, the battery. If the damage is irreparable, they take the battery apart and use its separate components to make new batteries. The third mechanic told us that when a battery is damaged after a car accident, he gives the battery to those who deal with the recycling of old batteries, such as the two mechanics listed above.

The second background question we asked of the mechanics was if they knew anything about black box battery makers. One of the mechanics told us that black box batteries were out of the market, while the other two mechanics told us that they made black box batteries. These two mechanics run small stores that collect used batteries and recondition them and sell them to consumers again. They are known as black box makers because they used to use tar to seal the batteries, but now they use the old battery covers. They also paint the batteries black before they sell them. We uncovered this information at the interviews because prior to the interview, we did not know exactly what a black box battery was.

The first black box maker that we interviewed collects batteries from people that bring them to him. Refer to Figure 4.2 below to see the process followed by this black box maker. Some people give them to him for nothing and others he pays 500 colones per battery. Once he has the batteries, he breaks them apart and takes the acid out and puts it into a large container. Some of the acid is reused and the rest is drained into a holding tank underground that lets the untreated acid seep into the ground. He takes the old lead plates out of the batteries and sends them to Baterías Record, who then sends them to El Salvador to be recycled. The new lead plates that he uses are plates that are bought from El Salvador and made from recycled lead. He goes through Baterías Record to obtain these lead plates and to send the old ones to El Salvador. The boxes come from the old batteries that he takes apart. If the battery has not exploded and ruined the box, then he reuses it. If the box is no longer good, then he claims to send the plastic to the United States to be recycled. He sells his batteries for 10,000-35,000 colones depending on the size of the battery. Taxi drivers get a 6-month warranty and regular cars get a 1-year warranty. He claims to make about 2-3 batteries per day and sells an average of 3-4 per day.

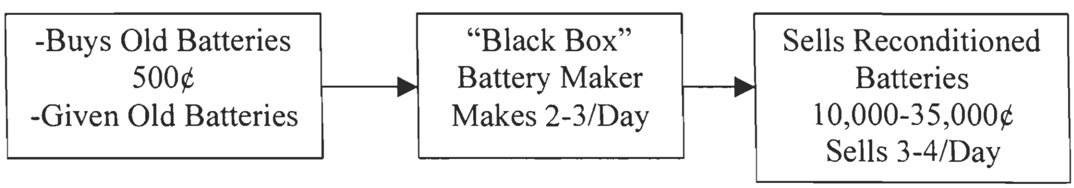

Figure 4. 2: Flowchart of "Black Box" Battery Maker #1

The second black box maker that we interviewed follows a very similar process with a few differences, shown in Figure 4.3 below. He collects the batteries from those left on the streets, as well as those from people that bring and give them to him for free. He first takes apart the batteries and removes the acid and lead. He reuses all of the acid by putting it in a large container and adding concentrated acid to it in order to make it usable again. He also reuses the lead plates if they are still good and if they are not, he just throws them away in the regular solid waste. He also buys new lead plates to replace the bad ones that he throws away. He uses the plastic cases over again if they are still good and throws away the ones that are not usable. This black box maker only deals with car sized batteries and sells them all for 6,000 colones each. They come with warranties that range from 3-6 months. He claims to produce about 3-4 batteries per day and sells an average of 5-6 per day.

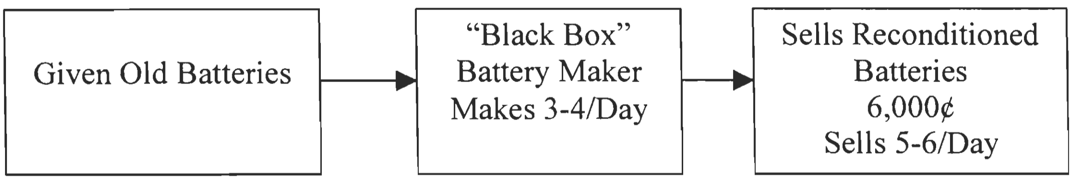

Figure 4. 3: Flowchart of "Black Box" Battery Maker #2

4.4 Taxi Driver Interviews

While in Costa Rica, we interviewed a total of sixteen taxi drivers-thirteen in the San Pedro area, and three in the Quepos area. All of the taxi drivers were asked the same standardized questions. These questions and their answers can be found in Appendix G. These taxi drivers were interviewed in order to determine their role in the informal recycling system that presently exists in Costa Rica. Please note that for Questions 4 through 10 we were unable to receive complete answers from all of the taxi drivers due to the time constraints encountered by interviewing them at a taxi stop while they were on duty.

Table 4. 3: Origin of Battery: Taxi Drivers

	Bought	Installed
% of Interview Respondents	93.8	6.2

The first question asked of the taxi drivers pertained to the origin of their lead-acid battery. When asked if they bought their own battery separately or if it was installed when they purchased their car, the majority, fifteen of the sixteen taxi drivers, responded positively to buying their own battery, as can be seen in Table 4.3. Only one of the sixteen taxi drivers interviewed responded positively to having their battery installed.

Table 4. 4: Condition of Purchased Battery

	New	Reconditioned
% of Interview Respondents	87.5	12.5

The second question asked of the taxi drivers was whether or not the battery in their taxi was new or reconditioned. As shown in Table 4.4, the majority, fourteen out of sixteen taxi drivers, answered positively to the battery in their car being new. Two out of the sixteen taxi drivers interviewed responded that the battery in their taxi was reconditioned. The follow-up question to Question 2 was asked of those taxi drivers who possessed reconditioned batteries. We asked them if they knew anything about black box batteries, and we received conflicting views from the two taxi drivers who owned reconditioned batteries. One taxi driver claimed that the black box batteries are cheaper than brand new batteries, but the life span of the black box battery is much shorter. The other taxi driver owning a reconditioned battery claimed that the black box batteries lasted much longer than the new batteries.

Table 4. 5: Point of Purchase

	Store	Car	Black battery
% of Interview Respondents	80.0	6.7	13.3

The third question asked of the taxi drivers pertained to the point of purchase of their lead-acid battery. As shown in Table 4.5, the majority of taxi drivers, twelve out of the fifteen who responded to this question, answered that they bought their lead-acid battery from an auto-parts store. One taxi driver told us that his lead-acid battery came with his taxi, and two taxi drivers responded that the point of purchase of their lead-acid battery was someone who made reconditioned batteries, or black box batteries.

Table 4. 6: Prices Paid for Batteries (in Colones)

	0-14,999	15,000-19,999	20,000-25,000
% of Interview Respondents	40.0	40.0	20.0

The fourth question we asked of the taxi drivers pertained to the price paid by the taxi drivers for their lead-acid battery. Table 4.6 shows that out of the five taxi drivers who answered this question, the two who answered that they paid less than 14,999 colones for their battery were the two who also answered that they possess a reconditioned battery. The next two taxi drivers whose answers fall into the middle price bracket represent the average for buying new batteries. The fifth taxi driver whose battery cost the most told us that he bought a diesel lead-acid battery; diesel batteries are generally more expensive because they are bigger in order to start diesel engines.

Table 4. 7: Battery Guarantees

	Yes	No
% of Interview Respondents	84.6	15.4

The fifth question we asked taxi drivers was if their battery was guaranteed for any period of time. As Table 4.7 shows, the majority, eleven out of the thirteen respondents, answered yes to having a guarantee on their battery. Two out of the thirteen respondents told us that they do not have a guarantee on their battery and both also claimed that no guarantees are ever given to taxi drivers.

Table 4. 8: Period of Time Guaranteed

	3 months	6 months	1 year
% of Interview Respondents	10.0	40.0	50.0

We asked a follow-up question to Question 5 of how long each battery was guaranteed if the taxi drivers responded yes. As shown by Table 4.8, only one of the eleven taxi drivers responded with a three-month guarantee, and he was also one of the two taxi drivers who had bought a reconditioned battery. Four out of the eleven taxi drivers told us they had a guarantee for six months, and the majority of these four taxi drivers told us that six month guarantees were the average for taxi drivers. However, the table above shows that the majority of the taxi drivers that answered this question, a total of five, responded with a guarantee of one year.

Table 4. 9: Methods of Disposal

	Trash	Store	Give Away	Sell It
% of Interview Respondents	46.7	26.7	13.3	13.3

The sixth question we asked of the taxi drivers-and the most important-pertains to their method of disposal of the spent lead-acid batteries. The majority of the taxi drivers, shown in Table 4.9, seven out of fifteen, admitted to throwing their battery away along with their regular garbage. Four out of the fifteen brought their old battery to the point of purchase-an auto-parts store. Two out of the fifteen gave their batteries away to random collectors who come to their neighborhood, and another two out of the fifteen sold their old batteries to collectors for either 150 or 200 colones per battery.

Table 4. 10: Methods of Disposal After Thrown Away

	Garbage men	Collectors	No one
% of Interview Respondents	46.7	26.7	13.3

We asked a follow-up question to Question 6 to determine what happens to the battery after it is thrown away. Two out of the eight taxi drivers who threw away their old batteries told us that they keep their batteries separate from their regular trash and that those who pick up the garbage take the batteries to a collector. Another two taxi drivers said that collectors come to their neighborhood and collect any old batteries that are left on the streets. As shown in Table 4.10, four out of eight taxi drivers said that no one picks up their old battery. They do not separate their old battery from their regular trash and the battery then proceeds to a landfill.

Table 4. 11: Payment for Disposal

	Yes	No
% of Interview Respondents	13.3	86.7

The final question we asked the taxi drivers pertained to any payment they may have received for disposing of their battery. As shown in Table 4.11, the majority of the taxi drivers, thirteen out of fifteen responded "no" to receiving payment for discarding their batteries. All of these taxi drivers fall into the following disposal method categories: throw away in the trash, bring it back to the point of purchase, and give it to collectors. Two out of the fifteen taxi drivers sold their old batteries to collectors for 150 and 200 colones each.

4.5 Key Roles in Informal Recycling System

In our efforts to uncover exactly how the informal recycling system in Costa Rica works, we conducted interviews with some of the key players in the system. The first person we interviewed was Eric Jiménez. Mr. Jiménez runs one of the large collection facilities in Costa Rica and exports batteries to El Salvador to be recycled. We also interviewed Luis Romero, a representative from Baterías Record, who explained to us the relationship his company has with Baterías de El Salvador, a recycling facility located in E Salvador. Another key player that we interviewed was Orlando Rodriguez. Mr. Rodriguez works for the Ministry of Health in Costa Rica. He attended a conference sponsored by the Basel Convention in Trinidad. This conference was to promote awareness of lead-acid battery recycling in Central America, and provided many documents for the attendees to take back to their country for use in developing a lead-acid battery-recycling program. Two more interviews were conducted with Sergio Musmanni and Carlos Heinrich. These two men work for the Centro Nacional de Produccion Mas Limpia, which is the National Center for Cleaner Production in Costa Rica. They are also interested in doing the same type of work as we set out to do in this project and provided us with some useful information. We also conducted a formal interview with Ana Gonzalez, the owner of a small-scale lead smelting facility in San José. This facility collects batteries and smelts the lead to make lead ingots and sells the lead ingots to companies that buy recycled lead. The results of the interviews follow and the detailed interview transcripts can be found in Appendices E, F, G and H.

4.5.1 Baterías Record Representative-Luis Romero

In our interview with Luis Romero, a representative from Baterías Record, we found out information about the relationship between this company and the recycling facility in El Salvador. The detailed questions and answers of this interview are found in Appendix G. At this company, located in San José, batteries are collected and sent to El Salvador. A flow chart of the role that Baterías Record plays in the recycling process is illustrated in Figure 4.4. One hundred forty tons of batteries are collected per month, and there are five trips to El Salvador per month. There are six main collectors that send batteries to El Salvador through Baterías Record. Some of these are companies, and some of them are the private collectors. These collectors and companies sell their batteries to Baterías Record for 18-20 colones per kilogram.

In order to acquire the materials to make new batteries, Baterías de El Salvador pays for the transportation and labor costs to transport the batteries to their facility in El Salvador. According to Luis, 70% of all batteries collected by Baterías Record are sent to El Salvador and the other 30% are sent to a recycling facility in Panama. The number of batteries that are sent to El Salvador or Panama varies depending on the price that the two companies are offering for the batteries.

In Mr. Romero's opinion, 80% of the batteries in Costa Rica are recycled and the other 20% are just thrown away. The batteries are completely recycled at the El Salvador facility. The lead is extracted and smelted, the acid is removed and treated with sodium carbonate and then released into the sewage system, and the plastic is sent to the United States to be recycled. The old lead is made into new lead plates, which are used to manufacture complete new batteries in the same plant. The new plastic boxes are shipped from the U.S. The company also sells just the recycled lead plates to the black box makers, who make their own batteries with the recycled lead.

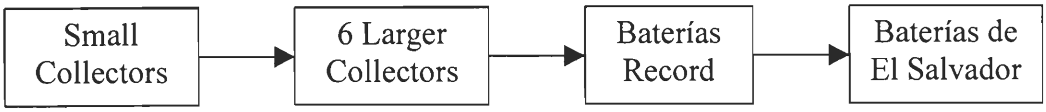

Figure 4. 4: Flow Chart of Baterías Record Role in the Recycling Process

4.5.2 Private Collector-Eric Jiménez

In the interview with Eric Jiménez, we learned more about his responsibilities as a collector and his role in the informal recycling process of lead-acid batteries. The detailed questions and answers from this interview can be found in Appendix E. His company, Recoprimax, is a collection facility that collects waste, such as lead-acid batteries, aluminum cans, and paper, and ships these materials elsewhere. They have been doing this for the past 20 years.

In Eric Jiménez's version of the life cycle of a lead-acid battery, many of the lead-acid batteries are imported into the country and some of the batteries, the black box batteries, are made in the country. Lead-acid batteries are imported from everywhere, such as El Salvador, Mexico, and Korea. These batteries are used in motor vehicles and when they are spent, people leave these batteries outside their homes or leave them at the stores where they purchase new batteries or at their mechanics. These batteries are either given to Mr. Jiménez for free or he pays the people 15 colones per kilogram for the battery and the batteries are collected from all over the country in tractors and trucks. A flow chart of Recoprimax's role in the recycling process is pictured below in Figure 4.5.

At the site of Recoprimax, there are piles of batteries of up to 80,000 kilograms, the amount of batteries that can be stored on his land. Once he has accumulated 21 tons, which is approximately between 1300 to 1400 batteries, he packs and ships them by truck to El Salvador. In El Salvador, the batteries are recycled. First the batteries are broken, then the lead is smelted, and the plastic cases and covers are sent to the United States to be recycled. The new plastic cases and covers are sent to El Salvador for the production of more batteries. Once the new batteries are completed, they are sent to Costa Rica and to other countries for distribution.

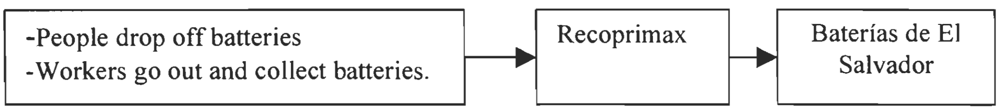

Figure 4. 5: Flow Chart of Recoprimax's Role in the Recycling Process

4.5.3 Ministry of Health Representative-Orlando Rodriguez

Through our interview with Ing. Orlando Rodriguez, we learned that 99% of the lead in Costa Rica comes from lead-acid batteries, and the other 1% comes from lead paint and lead wires. He also estimated the number of cars in Costa Rica to be about 650,000, but he suggested that we contact the registry to get an exact number. According to Mr. Rodriguez, the price of car batteries ranges from 16,000-28,000 colones, depending on the type of battery. The price depends on the number of lead plates in the battery, which can range from 4-32, depending on the size and type of battery. The life of a battery ranges from 2-5 years with normal use, with the average being 3.5 years. The warranties that come with these batteries can range from 6 months to 2 years.

In Mr. Orlando Rodriguez's opinion, 60% of the batteries discarded in Costa Rica are collected and recycled, but this estimation is not backed by any facts. He says that the reason why not all the batteries are being collected is because there is no culture in Costa Rica for recycling and the people of Costa Rica are too lazy. According to Orlando

Rodriguez, one program, called Copacrea, which is a program for drug addicts, collects batteries and sells them to collectors for up to 1,000 colones. This number may be higher than what they actually get for the batteries, but this is what Mr. Rodriguez said he thought they received.

We also learned that there are no laws in Costa Rica for the disposal of hazardous wastes. One reason why the government is taking the initiative to start a lead-acid battery recycling program, according to Mr. Rodriguez, is because there are health risks from being exposed to the vapors of metallic dust and its evaporation. But as of now, there have been no records of people having lead problems.

We also learned that lead smelting is not illegal in Costa Rica, it is only illegal if the facilities are not registered. There are a lot of small-scale smelting facilities that use the lead from batteries to make lead ingots, but there are also fishermen who smelt the lead to make fishing weights. A lot of these small smelters are illegal because they are not registered to be operating a business.

Orlando Rodriguez also said that people are using the used battery cases and covers for other purposes. In one case they are being used as a fuel at "trapiches", or places that burn sugar cane to manufacture candy and sweets. According to Dr. Arrieta, this is a problem because some of these boxes are made of PVC, polyvinylchloride, which is toxic to the environment when burned at temperatures 600°C or lower.

Orlando Rodriguez also informed us of some of the actions that have taken place since the beginning of 2001. Recently, on May 26, a representative from El Salvador visited Costa Rica to see how the batteries were being packaged and sent to El Salvador to make sure they were using safe practices. He also told us that there is research and information that has to be completed by April of 2002 about starting a lead-acid battery recycling program in Costa Rica.

4.5.4 National Center for Cleaner Production Representatives-Sergio Musmanni and Carlos Perera

By conducting an open-ended interview with Dr. Sergio Musmanni, the director of Centro Nacional de Producción Más Limpia, and the sub-director, Ing. Carlos Perera, we found that their future plans for research on lead-acid battery recycling in Costa Rica are parallel to the goals of this project. They plan on investigating the informal recycling program in Costa Rica and making recommendations on how to improve it or formalize the system. They are waiting for the funding from the United Nations to start this project.

Sergio Musmanni first explained to us the current situation of landfills in Costa Rica. He explained that all solid waste is currently brought to landfills. Some landfills have standards of separating hazardous from non-hazardous materials, and others put all waste into one pile. One of the newer landfills in Alajuela is built to the standards of separating waste, which means they have a separate cell for hazardous waste, but it is privately run and charges the municipalities to dump their waste by the kilogram.

The Centro Nacional de Producción Más Limpia has seen the problem of lead-acid batteries and has asked for material from the United Nations. One document that they have received is from UNEP, the United Nations Environmental Program, on "Environmental and Technological Issues related to Lead-Acid Battery Recycling: A Workbook for Trainers". This document provides some case studies and situation scenarios that can be used as a basis for training people for developing a lead-acid battery-recycling program.

Currently, the Centro Nacional de Producción Más Limpia has not done anything because they are waiting for the funding, but when they do start, they plan to check out the facilities that collect and recycle batteries, figure out the current situation, and then develop an action plan to reduce environmental pollution. They are also going to check to see if Costa Rica is following other countries' laws on exportation and importation of goods. When goods are imported or exported to other countries, the laws of the importing country and the laws of exporting country must be followed as they apply to the material being imported or exported.

4.5.5 Small Scale Smelting Plant

We interviewed Ana Gonzalez, one of the owners of a small lead smelting facility called Recouperadora Nacional de Plomo. Detailed questions and answers can be found in Appendix F. This facility is located in San Francisco de Dos Ríos in the back yard of the owners' home and the business has been running for 25 years. She described the life cycle of the lead-acid battery from its introduction in new cars of stores to when it gets to their smelting plant.

People who either collect or have their own old batteries bring the batteries to the plant and the plant buys them for 18 colones per kilogram, but some people give the batteries to them for free. Once the battery is at the plant, it is broken by one of the three workers who work in the plant. A second worker operates the furnace and a third does maintenance work around the plant. According to Gonzalez, the batteries are all bought without sulfuric acid, which minimizes the problem of acid disposal. The lead is extracted from the battery and put into burlap bags and then put into the rotary furnace. The lead is then melted at very high temperatures and the impurities are removed. The purified lead is then put into a mold to make lead ingots, which are blocks of purified lead that weigh 32 kilograms each. Each week, 3 tons of lead, which can make approximately 454 batteries, is smelted at the plant.

While visiting this plant, we observed dangerous and unclean methods of handling the batteries. The lead was handled with bare hands and sometimes with gloves. The ventilation system in place did not appear to be working properly, due to the large amounts of black smoke escaping from the furnace. The furnace was not securely contained within a safe area and there were no warning signs visible. This means that anyone could walk up to it and be injured or contaminated by the lead or lead fumes.

The plant sells the lead ingots to two primary clients, United Batteries and Martin Quesada, the owner of a place in Grecia that makes batteries. The facility sells their lead depending on the market price of lead and the needs of their clients. The average price is about $750-$770 per ton, or 244,500-251,020 colones per ton. The plastic cases are just thrown away with the regular waste once the lead is extracted from them.

4.6 Costs of Recycling

We investigated the costs associated with recycling by talking to all of the various people involved in the current process. The first cost we investigated was how much a battery costs to buy, both for the vendor and the consumer. The price for a new battery for the vendor ranges from about 11,000 to 24,500 colones and they sell these batteries for 16,000-35,000 colones, depending on the brand and size of the battery. These numbers were calculated using a 30% profit on the cost of a new battery, the average profit that we found in our interviews with stores.

The next cost was the amount of money that is paid for used batteries at the different levels of the recycling process. There is a very wide range of prices that collectors will pay for a used battery. The range goes from free up to 1,000 colones per battery. Many people will give their used batteries to a store or a collector for free, or some stores will pay 150-2,000 colones to take the used battery from a customer. The stores will subtract this amount from the cost of the new battery. Some private collectors will go door to door and pay up to 500 colones for a battery. Once the batteries are at these small collection sites, they then get sold to a larger collector, who may pay up to 15-20 colones per kilogram. These larger collectors also get batteries given to them for free in addition to the batteries they pay for. Once the batteries are at the primary collection sites, they are then brought to El Salvador via trucks that Baterías de El Salvador sends to one of the four companies that collect the batteries. Baterías de El Salvador also pays for the batteries to be sent to its manufacturing facility in El Salvador where the batteries are completely recycled. The collectors are paid 26-29 colones per kilogram for the batteries that are sent to El Salvador. The following table is a brief summary of the various prices that a used lead-acid battery may be sold for in Costa Rica.

Table 4. 12: Purchase Prices for Batteries at Various Points in Life Cycle

Person who Purchases Battery:	Customer (From Stores or Mechanics)	Small Collectors	Stores and Mechanics (New Batteries from Distributor)	Stores and Mechanics (Used Batteries from Customer)	Four Large Collectors	Baterías de El Salvador
Amount Paid (colones):	16,000-35,000	0-500	11,000-24,500	0-2,000	18-20 per kilogram	26-29 per kilogram

We also investigated the cost of transportation of batteries from different areas in Costa Rica. We did this by talking to Alexander Roman, a man that works with the collection and exportation of aluminum, a reference given to us by Carlos Heinrich. The person we talked to collects aluminum and other recyclable metals from all over the country and helped us with finding the costs for transportation. He said for a truck that can carry 3,000 kilograms, it costs 70,000 colones for 200 kilometers of travel. This works out to be about 22 colones per kilogram for a distance of 200 kilometers.

We conducted a phone interview with Saul Roza, a representative from Baterías de El Salvador, the recycling facility in El Salvador. We found out transportation costs and the amount paid to the collectors, as well as how the lead-acid batteries get from Costa Rica to El Salvador. Mr. Saul Rosa told us that the transportation is subcontracted through a Costa Rican based transportation country. Baterías de El Salvador pays $1,000 US per trip. There are about 2-10 trips per month depending on the number of batteries available for transport. Each truckload can hold 20,000 kilograms or 20 metric tons of batteries. This is equal to about 1,300-1,400 batteries per trip. In addition to the cost of transportation, Baterías de El Salvador also pays the collectors $110 US per metric ton for the batteries. Mr. Saul Rosa also told us that they buy the batteries without the sulfuric acid in them. The collection companies in Costa Rica are supposed to remove the acid and neutralize it by treating it with Sodium Carbonate. Mr. Saul Rosa was reluctant to tell us the exact numbers and told us he was giving numbers for academic purposes only.

Chapter 5. DATA ANALYSIS

This chapter contains the analysis of the data that we presented in the previous chapter. The assessment of the current recycling process includes the following areas of concern: the informal recycling process, the roles of various people in the process, including the manufacturers, the distributors, the consumers, the collectors, and the recyclers. We have also included the role that government officials play in the recycling process.

5.1 An Informal System of Battery Recycling in Costa Rica

Upon our arrival in Costa Rica, we were under the impression that there was no lead-acid battery-recycling program in effect. Early in our research, we found that there is indeed an extremely informal lead-acid battery-recycling process in existence in urban areas. We investigated each step in the current informal process and analyzed each of these steps in the subsequent sections. We also found out what costs are involved at each level of the process. These costs include how much each person gets paid for the used batteries at the different levels of the collection and recycling process. In Figure 5.1, which follows, we have made a chart describing how the informal lead-acid battery recycling process works in Costa Rica. The text following the chart explains in detail the different sections and how they work.

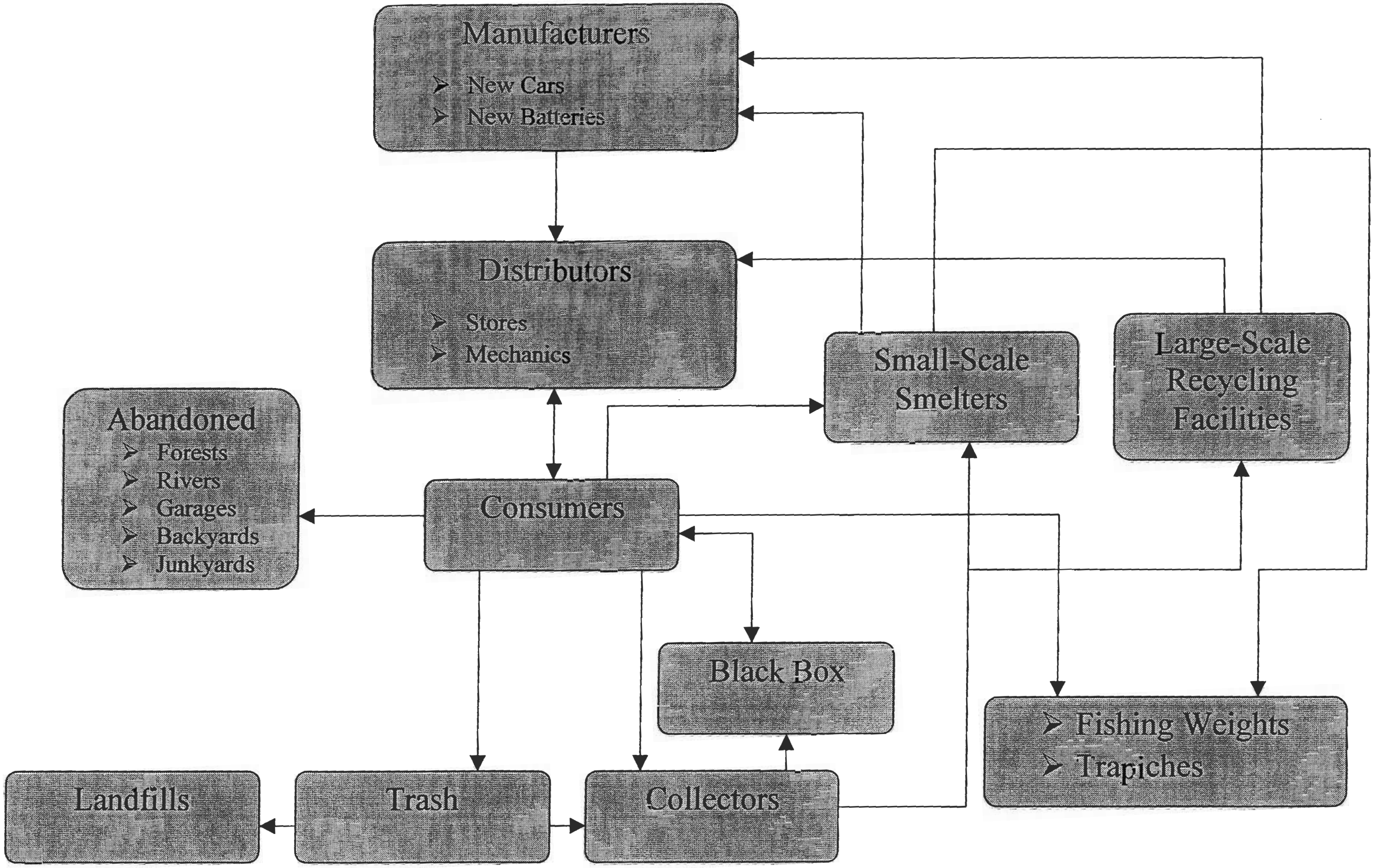

Figure 5. 1: Flow Chart of Informal Recycling Process

The process starts with a new battery being sold for 10,000-35,000 colones, depending on the size and brand of battery. The vendor makes a 20-35% profit on the batteries that they sell. When the battery expires, consumers have to determine how they want to dispose of the dead battery before they buy a new one. The battery can either end up abandoned in forests, rivers, backyards, garages, or junkyards, or in the trash, which can go to landfills or to collectors. The consumers can also bring the battery directly to a collector. The collectors sometimes pay 150-200 colones for the used batteries, or receive them for free. The consumers can also bring their batteries directly back to the vendors when they buy a new battery. Some stores will give up to 2,000 colones discount off of a new battery when the old one is traded in. The consumer can also bring their battery to a black box maker and just drop it off for free or sometimes receive up to 500 colones per battery. The consumers may also give their batteries to trapiches, which are places that burn the plastic cases and covers to make candy and sweets.

When a small collector has a battery, there are a couple of options that he has for recycling the batteries. He can either sell it to a larger collector for 18-20 colones per kilogram or to a small-scale recycling facility for 18 colones per kilogram. If it is one of the six larger collectors in the country, they can sell the batteries to a large-scale recycling facility for 26-29 colones per kilogram.

From the small scale smelting facilities, they sell the recycled lead ingots to battery manufacturers for 243,750-250,250 colones per ton. The small-scale smelters may also sell their lead to be used for fishing weights. When a large-scale recycling facility gets the batteries, they recycle them and make either new batteries or new lead plates. They sell the batteries to stores or car manufacturers and they sell the lead plates to the black box battery makers.

The other costs that are associated with the informal battery recycling are the costs to transport the batteries. From our phone interview with Saul Rosa of Baterías de El Salvador, we found out the costs of transporting the batteries from Costa Rica to El Salvador. As discussed in the previous chapter, the total cost for the transportation from San Jose to El Salvador is $1,000 US or 326,000 colones per trip. This cost does not include the amount that Baterías de El Salvador pays the collectors in Costa Rica for the batteries. This amount comes out to about $110 US per metric ton or 35,860 colones per metric ton. In each shipment, there are 20 metric tons or about 1,300-1,400 batteries. When you multiply $110 US times 20 tons, this comes out to be $2,200 US for about 1350 batteries. This is about $1.62 US per battery or 531 colones per battery.

This information coincides with the information provided by Luis Romero and Eric Jiménez on how much they get paid per kilogram for the batteries. A battery weighs about 15 kilograms, so at 29 colones per kilogram, they get paid about 435 colones per battery. This number is very close to the number of 531 colones obtained by the estimate from Baterías de El Salvador. The reason for the difference of 100 colones could be because the representative from El Salvador was not giving us exact numbers. He was very reluctant to disclose the information and told us that he was giving us approximate numbers.

5.2 Profits for Lead-Acid Battery Recyclers

In our data collection we found out how much a vendor sells a battery for and how much profit they make on each battery. From these investigations, we were able to find out who makes money, and approximately how much, in the recycling process. The person who makes the most money in the informal process in Costa Rica is the larger recycler who sells the batteries directly to El Salvador.

In the case of Baterías Record of San José, they buy used batteries for 18-20 colones per kilogram and they receive 29 colones per kilogram when they sell the batteries to Costa Rica. This means their profit is 9-11 colones per kilogram for all the batteries that they collect. When you take the numbers of 5 trips per month with 20 tons of batteries each, this translates to about 1,250,000 kilograms of batteries per year sent to El Salvador. At about 10 colones per kilogram, the net revenue on the batteries from a place like Baterías Record is about 12,500,000 colones per year or about $38,343 per year. These companies do not have to worry about any costs for shipping the batteries because Baterías de El Salvador pays for the costs of shipping, but they do have other costs that they were not able to give us figures for, like the costs for labor, taxes, insurance, and other costs associated with running the business.

Another example of one of these large collectors is Eric Jiménez of Recoprimax in the San José area. He pays 18 colones per kilogram for his batteries and gets paid 26 colones per kilogram from Baterías de El Salvador. This gives him a profit of 8 colones per battery and sometimes more than this because he does not always pay for the batteries. If you take into consideration that he makes 3 trips a month of 21 tons each, this works out to about 60,000 kilograms of batteries per month and about 720,000 kilograms of batteries per year. The net revenue on this amount is about 5,760,000 colones per year or about $17,668 per year. There are also other costs that are not included in this analysis like labor, insurance, and taxes that were not given to us.

In order to get a general idea of how much Baterías de El Salvador makes, we took the amount of money that they pay for a used battery, which includes the cost to ship them from Costa Rica and the amount that they pay the collectors in Costa Rica, and subtract that from the amount that they sell a new battery for. The cost of a used battery for Baterías de El Salvador is about 772 colones per battery. This number was calculated by using the data of $110 per ton to the collectors and $1,000 per truckload of batteries for shipment from Costa Rica to El Salvador. We added these costs and figured the total cost per shipment to be $3,200. When you divide this by the average number of batteries per shipment, 1350, you can get the amount that Baterías de El Salvador pays for each battery, which is about $2.36 or 772 colones. They sell a new battery for about 15,000 colones. This means their net revenue is about 14,228 colones per battery. This number does not include any costs for the new boxes, the sulfuric acid that they have to purchase to make the new batteries, the costs of labor to make the new batteries, the cost of energy to operate the business or the taxes they have to pay. This makes the number a very rough estimate and the profit will be considerably less than the number stated.

If we were to implement changes to the current system, the smaller collectors would most likely go out of business because they would not be making any money anymore if the batteries are collected at stores. The black box makers would most likely go out of business because the changes implemented would include laws regulating the handling of lead and sulfuric acid. If these were implemented, the black box makers do not have the ability to make their operations comply with these laws, which will eventually put them out of business. The larger collectors would be able to stay in business if a new system were implemented because they could still serve as central collection points before the batteries are sent to El Salvador. Although some of the large collectors may have to make changes in order to safely dispose of the sulfuric acid and handle the batteries properly.

5.3 Role of Consumers (Taxi Drivers)

The data presented in Chapter 4, the interviews with the taxi drivers, was analyzed both qualitatively and quantitatively to determine the role that the consumers play in the informal recycling process currently in effect in Costa Rica. For this project, the taxi drivers interviewed will serve to represent general consumers, taking into consideration that the taxi drivers buy more batteries in a lifetime than general consumers do. For our analysis, we assumed that the taxi drivers pay the same price for the batteries as a normal consumer would because we have no data that would suggest otherwise. The analysis of these data will, in turn, allow us to make rational conclusions and recommendations, which can be found in Chapters 6 and 7, respectively.

Early on in our research, we talked with Randolph Armrhein, an importer of batteries, who had told us about black box batteries. From this unstructured interview we were under the impression that black box batteries were very common in the battery market. After we interviewed sixteen taxi drivers, however, we found that fourteen drivers, or 87.5 percent bought their battery brand new and 80.0 percent of those taxi drivers bought their battery from an auto-parts store. From our data on Questions 1, 2, and 3, we can see a trend of taxi drivers, and therefore consumers, buying new lead-acid batteries from an auto-parts store, as opposed to buying a reconditioned, or black box battery. This is most likely caused by skepticism on the taxi driver's part of how reliable a reconditioned battery is.

The analysis of Questions 4, 5, 5a, and 7, which deal with costs and guarantees of various batteries can be found in section 5.1. An analysis of the various costs at each level of the system and a description of the informal process can be found in that section.

The most important factor dealing with the role of the consumer is how the lead-acid batteries are disposed of. The majority of the taxi drivers, 46.7 percent, throw their batteries away with their garbage. Of this 46.7 percent, 50 percent of the batteries fall into the abandoned category (see Figure 5.1: Flow Chart of Informal Recycling Process). From this data, we can see a strong trend of consumers throwing away, or abandoning their batteries for one of the following reasons: there is no knowledge of any type of recycling program, there is a lack of education about the importance and dangers of not recycling lead-acid batteries, or there is a lack of collectors in the area. From the taxi drivers interviewed in the Quepos area, we believe that the rural consumers fall into the third category. One taxi driver in particular mentioned that a collector came into their town on scheduled visits at one point in time, but now no longer comes. Without a formal recycling program with scheduled collections of the batteries, consumers in rural areas have no method of properly disposing of their batteries. The reason they do not have a method to properly dispose them is because stores in the rural areas do not collect batteries because there are no larger collectors there to sell the batteries to. The reason for there being no large collectors is most likely because of the low margins of operating these businesses. And in the rural areas there are not enough batteries to make it worth it. The remaining 50 percent of the 46.7 percent who throw their batteries away told us that they separate their batteries from their regular trash to be picked up by either private collectors or garbage men who then sell the batteries to private collectors. Each of these means of disposal account for 25 percent of the total 46.7 percent. This shows that roughly half of the consumers are either aware of the importance and dangers of not recycling, are aware of a recycling program, however informal, or both.

The remaining 53.3 percent of consumers participate in recycling their batteries, either directly or indirectly. Those who either give or sell their old battery to a private collector, or bring their battery back to the point of purchase, fall into the previous categories. The consumer participates directly if he is aware of a recycling program and brings his battery to someone knowing that it will be recycled. The consumer participates indirectly, however, if he brings or sells his battery to someone without knowing the real purpose behind the transaction.

5.4 Role of Mechanics and Storeowners

The mechanics and storeowners play a very important role in the informal recycling process here in Costa Rica. They are the first person that the consumer comes in contact with once they have a used battery in their possession. When the consumer buys a new battery from a store or garage, they now have an old battery to deal with. All but one of the stores that we interviewed takes back the old battery when a consumer purchases a new one. We believe that this does not occur in the rural areas because there are no larger collectors to buy the batteries from the stores, therefore creating no market for collecting batteries at the stores. This eliminates many problems that may occur if the consumer has to deal with the disposal of the battery on his/her own.

Some of the problems that can occur if the vendor does not take the battery are that the battery could end up thrown away in the garbage and possibly make it to a landfill. This usually doesn't occur however, because the garbage men will separate the batteries from the regular waste and sell the batteries to collectors to make money. Some of the consumers will also keep the used batteries collected in their houses or in the yards of their houses. This can be harmful if the battery becomes broken and the contents start to leak out of it.

By collecting the batteries at their stores and garages, the vendors are doing a lot to prevent pollution from the lead-acid batteries. Some even go a step further by offering an incentive to the consumers for leaving their battery with them. By offering a discount off of a new battery by returning the old one, it encourages the consumer to bring their battery back and have it recycled. Right now, the vendors, which include mechanics and auto-parts stores, who do collect the batteries send them to different places like larger collectors, programs for drug addicts, or small collectors that come by and collect the batteries in order to sell them to a larger collector. This is good in the fact that the batteries are being collected and eventually recycled, but there needs to be a more formalized way of doing this because there are many collectors and black box makers that are handling the batteries in an unsafe manner. This will mean that many people may lose their jobs or lose a way of making money, but in the long run this will benefit the people of Costa Rica by making sure that all batteries are being collected and recycled properly without causing harm to the environment. It will also create more jobs at the collection facilities.

Another big problem is the black box battery makers. At both of the two black box makers who we visited, we observed many unsafe practices that need to be addressed. At one of the places, the sulfuric acid was being extracted from the batteries and put directly into the environment without being treated. This is very unsafe and something needs to be done about it. At the same place, the lead plates were being handled with bare hands with no protection. The owner of this place also melted some of the lead to be used for joining two pieces of lead together through a process similar to soldering. This was actually a very small-scale form of smelting, which was done with no protection or filtration for the fumes produced by smelting the lead. The only good thing about this place was that most of the lead is sent to El Salvador to be recycled and the plastic cases that are no longer usable are sent to the United States to be recycled.

At the other black box battery maker, the used lead is thrown away with the regular waste if it is no longer usable. This is dangerous because it goes directly into landfills. And, because the lead is already out of the battery case, leaching can occur as soon as the battery goes to the landfill. The acid that is extracted from the batteries is used again by adding more concentrated acid to make it stronger, and the plastic cases are used over again, unless they are not usable, which means they are thrown away with regular waste. These two private battery manufacturers are operating very unsafe businesses that are causing harm to the environment. In our opinion, the government needs to do something to prevent places like this from continuing to operate.

5.5 Role of Collectors

The people who collect lead-acid batteries play a very simple, but important role in the recycling system. In the urban areas of Costa Rica, collectors are more prominent than in rural areas because the population is so spread out that it is not worthwhile to collect them in the rural areas.

There are numerous collectors in the San José area, but there are only 4 main collectors that send the batteries directly to El Salvador. Two of these collectors whom we interviewed are Baterías Record and Recomprimax. When we talked to Baterías de El Salvador, the representative was unwilling to give us the names of the other two collectors. The smaller collectors in the area sell their batteries to these 4 main collectors for a price of 18-20 colones per kilogram. Once these collectors have stored enough batteries, they ship them off to El Salvador to be recycled. In Recoprimax's case, they send the batteries 3 times per month to El Salvador, carrying 20 tons of batteries per trip. But in the case of Baterías Record, they make 5 trips per month, carrying 20 tons per trip. Baterías de El Salvador sends a truck to pick up the batteries from each collector and has the batteries transported to El Salvador. This process is repeated month after month and the batteries are completely recycled at the El Salvador plant to make new batteries and lead plates.

5.6 Role of Smelters

Lead smelters hold an integral position in the process of a lead-acid battery recycling program. The lead that is extracted from the batteries and smelted, which is the recovery of metals in molten form, is required to manufacture new batteries or other items such as lead weights for fishing uses.

This same process is followed for the large-scale lead smelters, except the operations are much larger and there are more clients to serve. In places like the El Salvador plant, the lead is extracted and made into new lead plates and grids and put into new batteries, which are manufactured at the same plant. This facility also treats the sulfuric acid with a sodium carbonate solution and then tests it to make sure it is no longer toxic before releasing it into the environment.

These lead smelters must have in place good filtration systems that make the fumes produced by the lead smelting safe to release into the environment. In the case of the small-scale lead smelter, there was a filtration system in place, but it did not look like it was working very well because there was a lot of black smoke coming from the furnace and not from the smoke stacks that are supposed to release the purified air. The facility in El Salvador supposedly has all these safety measures in place, and it looked like they did when we watched a video provided by Baterías Record that described what the El Salvador plant does and how they do it.

In order for a lead-acid battery program to be successful and to reduce pollution to the environment, the batteries must be sent to a recycling facility that will treat the hazardous materials safely. The facility must also be safe for workers to work in. This means that there are many safety measures that must be followed when working with the lead and the sulfuric acid, because of their level of toxicity. These are some of the things that must be kept in mind when determining where to send the lead-acid batteries once they are collected.

5.7 Role of the Government -Ministry of Health

From our interview with Ing. Orlando Rodriguez, a representative from the Ministry of Health, we found out that the government plays an indirect role in the lead-acid battery recycling cycle, but that it is a very important role because the government is able to put a program into effect. Our project could not have come at a better time because the government has the same objectives and goals as this project. From the information that they provided us, we took an interpretive approach "to discover the practical understandings of their meanings and actions" (Berg, 2001).

Orlando Rodriguez's role in the development of a recycling program in Costa Rica is that he has to find out whether it is worthwhile for Costa Rica to have a lead-acid battery recycling facility in the country. He and a representative from the Chamber of Industry attended a conference in Trinidad to promote awareness and planning for a lead-acid battery-recycling program in Central American and Caribbean countries. In Trinidad he received a lot of information on the situation of lead-acid batteries, their role in society, and how a program can be set up. One of the things that are being done is that a questionnaire has to be completed by April, 2002 entitled "Used Lead-Acid Battery Recycling Plant Study Questionnaire", courtesy of ILMC, International Lead Management Center. This needs to be completed and handed in to the ILMC for further evaluation on whether Costa Rica should build a lead-acid battery recycling plant.

5.8 Role of Centro Nacional de Produccion Mas Limpia

From the interviews with Dr. Sergio Musmanni, Director of Centro Nacional de Produccion Mas Limpia, and Ing. Carlos Heinrich, the Subdirector of Centro Nacional de Produccion Mas Limpia, we found out about their role in developing a lead-acid battery recycling program in Costa Rica. Their roles are also indirect with regard to lead-acid battery recycling cycle, but they are important because they will be providing solutions for the problem from a national level.

Sergio Musmanni and Carlos Heinrich are two of the people who are also going to be evaluating Costa Rica and its informal lead-acid battery recycling system. Their plans are to define the problem and then make suggestions to make the system better. Their major concern is to reduce environmental pollution. Our project will assist them in the future because the data we are collecting is part of the work that they are going to have to do as soon as they get the funding to start their project.

Chapter 6. CONCLUSIONS

At the introduction of this project, Dr. Arrieta of CICA presented to us his concern with the current condition of the disposal of lead-acid batteries in Costa Rica. The goal of this project was to investigate the current method of disposing of lead-acid batteries in Costa Rica and based upon our findings, develop a manual with a set of recommendations on the disposal of batteries. Our objectives for this project were to document the current system of recycling in Costa Rica, and then to develop a collection program that will safely dispose of and recycle batteries once they are collected.

Once we had figured out what the informal recycling system consisted of, we were able to base our recommendations on that information to formalize the current recycling system. Within the first week, we found out that the children in Costa Rica are being informed of how recycling is done, but are not able to bring what they learn home and have it done properly. From this information we concluded that the parents should also be informed of recycling. When most of the people in Costa Rica realize the dangers of not safely disposing of and recycling lead-acid batteries properly, they will hopefully take the initiative to take care of themselves and their families and to protect themselves from the hidden dangers of lead-acid batteries.

From our investigation and analysis of our results, we conclude that Costa Rica is in need of a formalized lead-acid battery recycling system. We found that there is an informal collection and recycling system in place in the San José area, but that this system needs substantial improvement in order for it to become efficient. Another reason for the need for a new system is to make the recycling process safe.

Currently, the process involves many steps in which the health of the participants is compromised. This was evident in our interviews with the two black box battery makers, the small-scale lead smelter and the interview with Luis Romero, in which we were told that Eric Jiménez dumps sulfuric acid in the river behind his business. Our visits to the black box makers also showed us that they do not dispose of the sulfuric acid properly and that they handle lead with their bare hands. In some cases, lead is thrown away with regular waste or smelted in small smelting ovens without any protection from the fumes. This shows the need for laws regulating the handling of lead and sulfuric acid as hazardous materials.

The formal system that we propose is something that Costa Rica will have to work hard for in order for it to work. It will require participation from all levels, from the consumers up to the large collectors. If implemented, this system will take time to be adopted by the citizens of Costa Rica. The reason that it will take time is because of the way the culture is in Costa Rica and their slow way of getting things done. In our seven week stay in Costa Rica, we found that the government of Costa Rica is not very efficient in getting the municipalities to work well and takes a lot of time to get things done, if they get done at all. This will have a big effect on how the system will work because many aspects of it will depend upon the enforcement of laws that are passed to govern the proper disposal of lead-acid batteries.

The proposed system will also require funding in order for it to operate. This funding will have to come from the government, the taxpayers, or possibly from sponsors, like the United Nations or the Basel Convention. There is a need for outside funding in order to make a recycling system work. The funding would go towards things like: paying for incentives to vendors in order to get them to participate in the program, the costs for shipping batteries from the stores to the central collection facilities, the costs for building and operating the collection facilities and the labor costs for the collection facilities. We did not have the time to investigate what these costs are, so they should be investigated further when developing a recycling program.

The funds that are provided for this program should be handled by one agency that is in charge of running the recycling program. One of the most logical choices for this would be el Centro Nacional de Producción Más Limpia because of their interest in conserving the environment. Our interviews with Sergio Musmanni and Carlos Perera showed us their willingness to participate in helping the environment. If not as a central agency to run the program, they would make a good consulting agency for anyone who wants to develop a recycling program.

Without the enforcement of the laws we recommend or funding to make the program work, the program that we propose may not be feasible. But we are confident that the program will be successful in years to come because of the level of involvement that the Ministry of Health and the Centro Nacional de Producción Más Limpia have shown in our interviews with their representatives. A lead-acid battery recycling program will be very beneficial to Costa Rica because it will help to improve the hazardous waste problem. It will also likely cost money, but will improve the quality of life in the long run.

During the completion of this project we also came across some limitations. We were only able to interview a few people from the rural areas of Costa Rica; therefore our knowledge of the system in the rural areas is very limited. Further investigation of these areas may be necessary in order to develop a program better adapted to these areas. We were also unable to find all costs for developing a recycling program in Costa Rica, such as the costs of building a recycling facility in Costa Rica.

Our findings are presented in the form of a manual that describes the current informal lead-acid battery-recycling program in Costa Rica and also describes our recommendations for the development of a formalized recycling program. This manual also presents our results and recommendations in a manner that will be available for CICA, the Ministry of Health, el Centro Nacional de Producción Más Limpia, a subdivision of the Chamber of Industry, and also to the International Lead Management Center. This project can also serve as a reference for other developing countries on the road to developing their own lead-acid battery-recycling program. Overall, our project explains the process of lead-acid battery recycling and provides practical solutions to the problem of lead-acid battery disposal in the country of Costa Rica.

Chapter 7. RECOMMENDATIONS

The recommendations found in this chapter reflect both the analysis of the data presented in the previous chapters as well as the background information that was collected in the United States and Costa Rica. These recommendations serve as a basis for creating a concise recommendations manual, written in both English and Spanish, which can be found in Appendices T and U, respectively. This manual was made accessible to CICA, the Ministry of Health, Centro Nacional de Producción Más Limpia a subdivision of the Chamber of Industry, and the International Lead Management Center for the purpose of improving the current informal lead-acid battery- recycling program within the country.

One set of recommendations we made will improve upon the informal recycling process, beginning with suggestions for educating the general public on the importance of recycling as well as improving public participation in the program. The other set of recommendations requires a total change in the current recycling process. These recommendations address new laws to be passed, a new collection schedule, economic incentives, and the effects on and changes to all members of the current system.

7.1 Public Awareness

We recommend an educational campaign concerning the importance of recycling lead-acid batteries be established throughout the entire country of Costa Rica. This campaign should address not only the importance of resource conservation, but also the health and environmental hazards that can occur by not recycling lead-acid batteries. This campaign should include educational posters, or pamphlets describing in detail the effects of lead and sulfuric acid on the human body and the environment. A possible sponsor of this educational campaign could be Centro Nacional de Producción Más Limpia, considering the fact that they have already published posters on the importance of recycling. A second possibility could be the International Lead Management Center since they are a major contributor to the Basel Convention, which is going to be held in the fall of 2001 in order to discuss the organization of a formal lead-acid battery recycling program in Central America. These should be available in all places where a lead-acid battery can be purchased.

7.2 Funding for Recycling Programs

Throughout our recommendations, we make many references to incentives, costs, and facilities that would arise if the suggestions we made are followed. For any recycling program to be successful, outside funding is necessary. In this case, we hope that Costa Rica will receive funding from the United Nations, el Centro Nacional de Producción Más Limpia, and the local government, namely the Ministry of Health.

7.3 Total Reconstruction of Current System

7.3.1 Collection of Lead-Acid Batteries

We recommend that all points of purchase for lead-acid batteries be mandated to take back the spent lead-acid battery when a new battery is purchased. This should be strongly enforced by the government, which may prove to be a difficult task due to the lack of regulatory enforcement at the present time. In order to encourage these stores to collect and store the spent batteries, an economic incentive must be offered. Basing this incentive on those offered in Massachusetts, the stores should be offered a flat price for each battery they collect, roughly 200-250 colones per battery. An incentive might also need to be offered if the vendors are required to transport the batteries to a larger collection facility. This will eliminate any improper disposal of lead-acid batteries in forests, rivers, backyards, garages, and landfills because there will be no chance for the small-scale smelters to buy these spent batteries. This will also discourage the current practice of reconditioning batteries where the acid is often carelessly disposed of in rivers and soil. It will also minimize the improper handling and smelting of lead in homes, which can emit harmful toxins into the air. Offering incentives to consumers can enhance this take-back program. Our recommendation is to offer consumers a discount of at least five percent off of their new battery when they bring back their old one. This will encourage consumers to participate in the program because they have an incentive to bring their battery back. This may mean that vendors will have to raise their battery prices by five percent to counter the five percent "given back" to the consumer, which will make the system work better in the long run.

While each point of purchase for lead-acid batteries will serve as a small storage facility, we recommend that there be one larger, central facility located in each of the seven provinces of Costa Rica. The size of these facilities will depend on the population of the province. For example, in the San José area, a warehouse may be ideal location, such as Baterías Record located in the "El Pacifico" area of the city. However, in the less populated areas, a larger store or garage may be sufficient. Based on our data on the collectors in place now, unsafe methods of disposing of the sulfuric acid are being practiced, which is why a certified warehouse qualified to dispose of acid safely is suggested. If a law were to be passed and enforced governing the proper disposal of sulfuric acid, then the current collectors could remain as the larger collection facilities throughout the area if they abide by the new laws that are passed. The batteries from each of the points of purchase will be collected and transported to the larger collection facilities by truck at least once every month, depending on the volume of batteries collected. These trucks may be provided by the government if there is the funding to do so, or by any other sponsoring agency. If there is no outside funding, then it may be necessary to provide an incentive to the vendors to transport the batteries to the central collection facilities in their region. This may be in the form of a law mandating them to do so or a monetary incentive. Based upon our analysis of the system as it is now, El Salvador pays the larger collectors roughly 500 colones per battery to be recycled. If the vendors were offered half of that price, 250 colones per battery, to transport the batteries to the larger collectors, then both sides would be receiving payment and be encouraged to participate in the program.

The batteries from each of the larger collection facilities will have to be transported to a recycling facility. Our recommendation is to ship the batteries to Baterías de El Salvador, where many batteries from Costa Rica are currently sent. Based on our conversation with Luis Romero of Baterías Record, the facility in El Salvador can handle the increase in batteries from Costa Rica each year and would welcome the business. The facility in El Salvador sub-contracts a transportation company to pick up the batteries from the collection sites and bring them to El Salvador. This means that the transportation from Costa Rica to El Salvador is paid for by Baterías de El Salvador.

While the recommendations above apply to all batteries purchased after the program is in effect, there are still many used batteries that remain in consumers' houses, backyards, landfills, and roadsides. Our recommendation to improve upon this problem is to hold a one-time collection of these spent batteries. The consumers would need to bring any spent batteries they have around their homes to a designated collection point, and in return they would receive a payment of at least 500 colones per battery. The payment to the consumers can be paid for by splitting the cost between the collectors and the government. As it is, the collectors are paying for their old batteries, so they can continue to do so, while whatever remaining costs can be covered by the government or any other outside sources. We feel that anything less than 500 colones will not be enough of an incentive to encourage the consumers to bring in their batteries. Hopefully by offering this incentive to landfill workers, it will encourage them to bring in those batteries that are currently in landfills.

7.3.2 Model Laws

It is our recommendation that laws be passed to govern the disposal of lead-acid batteries. These laws will help to regulate the recycling of lead-acid batteries in Costa Rica. One example of a law that would need to be passed and then enforced is a law that makes it illegal and punishable by fines to dispose of lead-acid batteries in regular municipal solid waste. There should also be a law passed regulating the disposal of lead, sulfuric acid, and plastic. This law should mandate that each of these materials be recycled properly, as described in Chapter 2. Another example is a law that makes it mandatory for all points of purchase to collect the used batteries when a new one is sold to the consumer. This law should also state that the vendors are punishable by fine if they do not take back the old batteries from the consumers. While we feel these laws are necessary to ensure the success of a recycling program implemented in Costa Rica, we are unsure of the support the local government will provide, considering the lack of support we have already witnessed. Please refer to Appendix M for the exact laws that are in place in the state of Massachusetts, USA. These laws were requested by our liaison, Dr. Ronald Arrieta, and can serve as a basis for the laws that are implemented in Costa Rica.

7.3.3 Effects of Reconstructed System

If the current system were to be totally reconstructed, the effects on all of the current players would be great. The vendors, consumers, collectors, and recyclers would all experience slight changes from what their job descriptions are now.

The vendors would be affected only by the new laws they must follow; their economic standing would not change, or at least would not change significantly. The vendors would have to become small storage facilities, the size of which depends on the size of the store itself, for those batteries that they collect when the mandatory take-back law is passed. A recommendation for making the take-back law more effective is to give a discount of five percent off of any new battery purchased when the old battery is turned in. In order to keep their businesses alive, the vendors will most likely have to increase their battery prices by five percent. The vendors may also receive funding for storing their batteries, roughly 200-250 colones per battery, paid by the government and the larger collectors as described in the previous section.

The new take-back law would also affect the consumers. They would have to bring their old battery with them to a point of purchase when they buy a new battery. Consumers would in essence be paying five percent more for each battery, even though they believe that they would be receiving a five percent discount.

The collectors would perhaps suffer the most effects from this change. The large collectors may be losing money if they have to pay the smaller collectors (the auto-parts stores) to transport the batteries to them. While the larger collectors may be losing money, they will, however, be guaranteed the business of all the batteries in Costa Rica being recycled, instead of only the 60 percent we believe are being recycled at this point.

The larger recycling facilities, namely Baterías de El Salvador, would not experience any effects from this change. The smaller recycling facilities, such as Recuperadora Nacional de Plomo and the black box battery makers would be greatly affected. These businesses would slowly be put out of business once the new take-back law is in effect. Once the law is in effect, there would be no possible way for batteries to make their way into the hands of these small-scale recyclers.

If this recommended program were implemented, the life of a battery would be described as follows in Figure 7.1.

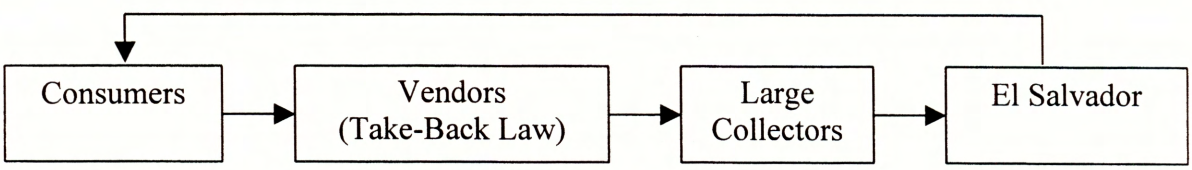

Figure 7. 1: Flowchart for a Battery in New System

In the new system, the used battery starts at the consumers and from there it goes directly back to the vendors. From the vendors, they are transported to the large collectors and then picked up by Baterías de El Salvador to be recycled.

7.4 Building Upon the Current System

There are some aspects of the current system that work well and could be made to work more efficiently if a few changes are made. The first change that would need to be made would be in new laws. There would have to be laws passed that regulate the disposal of each of the toxic contents of the lead-acid battery: the lead and the sulfuric acid. Currently, the lead is either being smelted in homes or thrown away, and the acid is dumped into rivers and the soil. The law passed regulating the disposal should prohibit the disposal of lead and sulfuric acid in the municipal solid waste, as well as mandating that all sulfuric acid be chemically treated to neutralize it. If the smelters and black box battery makers are allowed to stay in business, then there must be laws passed to regulate the ventilation that comes with lead smelting. This would include the emissions and imissions that are created when lead is smelted.

If this recommended program were implemented, the life of a battery would be described as follows in Figure 7.2.

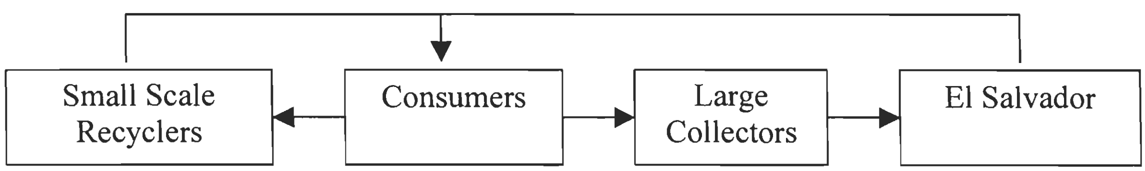

Figure 7. 2: Flowchart for a Battery in Improved System

The used battery starts at the consumers and from there can go to a small-scale recycler or to one of the large collectors. From the large collectors, Baterías de El Salvador picks the batteries up and transports them to El Salvador to be recycled. In the new system, the small-scale smelters follow laws to make their operations safe to the environment and themselves.

There were some limitations that we had on our project due to the time constraints that we had in Costa Rica. There are some aspects that need to be investigated further in order to gain a better understanding of the problem and to help make a recycling program a success. We recommend that the recycling situation in the rural areas of Costa Rica be investigated further in order to gain a better understanding of the situation in the areas outside of San José. Due to the insufficient amount of time, we were unable to conduct an investigation outside of the urban area of San José and do not know what exactly happens to the used lead-acid batteries in the rural areas of Costa Rica. The only information we do know is that we conducted two interviews in the Quepos area and they said they do not have any type of collection system there. The batteries are likely thrown away in the garbage with all other waste. A further investigation of the situation and possibly some better solutions should be investigated in this area.

7.5 Additional Recommendations

The following recommendations were made during the discussion following our final presentation on June 28, 2001. Dr. Ronald Arrieta told us that there are laws in effect that regulate the disposal of all waste. However, Dr. Arrieta also told us that it is difficult for the Costa Rican people to follow laws considering that they are poorly enforced. He suggested that there be a higher deposit for used batteries in order to gain the cooperation of the people. He suggested a deposit of 5,000 colones per battery. It was also suggested to have local drop-off centers for batteries that need to be disposed of if a new battery is not going to be purchased. This would most likely occur when a vehicle has reached the end of its life and is going to be sent to the scrap yard. There would also need to be a high economic incentive, roughly 20% of the original battery price, for people to bring batteries from these situations to the drop-off center. During this discussion, it was determined that there would be no government support for a formal battery recycling system if one were to be implemented in Costa Rica. The support would need to come from a coalition of private initiatives, such as el Centro Nacional de Producción Más Limpia, the Ministry of Health, the Basel Convention and private investors.

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APPENDICES

Appendix A: Mission and Organization of CICA

The Centro de Investigaciones en Contaminación Ambiental (CICA) is a research facility. This research facility was founded in 1982. The organization operates in conjunction with the University of Costa Rica located in San Pedro (Arthur, Caswell, & Wheeler. 2000). For the past nineteen years, CICA has been utilizing a variety of techniques for investigating and analyzing environmental pollution. Their technical instruments are currently among the most advanced in the country. CICA's mission is to contribute scientific information that will help in eliminating the destruction of the natural environment. The organization specifically focuses on the investigation of water quality, atmospheric emissions, and the chemistry of pesticides. Its team consists of forty-three researchers including physicists, chemists, biologists, toxicologists, pharmacologists, chemical engineers, and microbiologists.

The Bicounselorship for Research helps CICA to do their budget (Dr. Carazo, 8 June 2001). CICA receives funding from three different sources. The university's administration provides a small amount of funding for some of CICA's projects. Another source of funding is from consulting "services" within the country, such as chemical analysis and sampling. The final source of funding is the national and international organizations to which CICA directs most of its research and project efforts. Some of these organizations include the Inter-American Development Bank, the National Organization of Atomic Energy, the Pan American Health Organization, the United Nations Development Program, the Institute of Municipal Promotion and Advisory, and the National Service of Underground and Irrigation Waters.

Each research center receives a set of by-laws, or reglamentos, from the government. CICA has a committee called the "Consejos Scientificos" that set the policies for their research center. The director of the center enforces the policies of CICA (Dr. Carazo, 8 June 2001).

Currently, CICA is involved in several projects that pertain to the recycling of specific waste products. Within this organization Dr. Ronald Arrieta, our project liaison, is involved in one area of waste management, the organic waste program. In addition to his contributions within his specified department, he is also responsible for overseeing many community and university projects related to waste management, such as this project. Our study relates to CICA's mission because by presenting a set of recommendations to CICA, a formalized lead-acid battery recycling program will be initiated, and will hopefully reduce the number of lead-acid batteries that are discarded directly into the environment. Our project will impact the organization because the project will help the organization become involved with the planning to make such a recycling program be successful.

Dr. Arrieta is currently working on many projects on his own without the aid of CICA. He does these projects because he cares about the environment and wants to make a difference. He is currently involved in a study of families in Santa Ana, Costa Rica to see if they can recycle. This study was done to determine if the general public is able to separate the biodegradable from non-biodegradable wastes in order for them to be recycled. The study was successful and showed that consumers are able to go through the steps needed to recycle. According to Dr. Arrieta, it was the municipalities, however, that prohibited the program from working.

Original Project Description from CICA

We would like a diagnostic of the problem of discarded automobile batteries in the country and a set of recommendations for developing a full-scale program for recycling withing the country. The project has great societal meaning since discarded batteries that make their way into landfills or sit by the side of the road cause a safety hazard.

For developing a plan to recycle them, the objective is to do a full diagnostic by

1. estimating the quantity of batteries thrown away, finding out where they can be recycled,
2. describing the health and safety issues for peoplee working in the places where they are recycled,
3. identifying the importers of batteries,
4. identifying the technological options for recycling, and
5. doing an assessment of the costs of recycling, as well as weighing those costs against the benefits to Costa Rica to keep them out of landfills.

Organizational Chart for CICA

Laboratory of Water Quality (Laboratorio de Calidad de Aguas)

Alex Rodríguez	Kattia Villalobos
Jorge Campos	Víctor Vázquez
Juan J. Araya	Mario Araya
Jorge Herrera	Paola Fuentes

Laboratory of Pesticide Analysis (Laboratorio de Análisis de Plaguicidas)

*Desireé Sauma	
Edipcia Roque	Jendro Acuña
Mario Segnini	Evelyn Abarca
Michael Arias	Max Chavarría

Laboratory of Metabolism and Degradation of Pesticides (Laboratorio de Metabolismo y Degradación de Plaguicidas)

*Elizabeth Carazo	
Lisbeth Araya	Luis Monge
Giselle Abarca	Luis Calderon
Mercedes Barquero	Glenda Solano
Jorge Lobo	Wanda Cope

Laboratory of Air Quality (Laboratorio de Calidad de Aire)

Milton Alvarez
Alfonso Salazar
Fernando Silesky
Jose F. Rojas

Laboratory of Management of Solid Waste (Laboratorio de Manejo de Desechos Sólidos)

Ana G. Peréz
*Ronald Arrieta
Alejandra Fernández

Laboratory of Water Microbiology (Laboratorio de Microbíología de Aguas)

Maria L. Arias
Rocio Montenegro

Laboratory of Immunization (Laboratorio de Inmunoensayos)

Manuel Jiménez

Administrative Services (Servicios Administrativos)

*Ruth Mora
Paula Monge Andrea Hernández

Unity of Quality Assurance (Unidad de Aseguramiento de Calidad)

Patricio Solís
Adolfo Salazar
Randall Chavarría
Glenda Solano

Laboratoty Assistant (Auxiliar de Laboratorio)

Juan C. Sánchez

Other Specialities (Otras Especialidades)

Edgar Valverde

Sampling (Muestreo)

Randall Chavarría

Advisor (Consejería)

Gloria Loría

*Head of Laboratory

Appendix B: Interviews for Taxi Drivers

TAXIS

Questions:

1. The battery that is in your car, did you buy it or was it installed?
2. Is it a new battery or is it reconditioned?
2ª. If it is reconditioned, do you know anything about "black box" batteries?
3. Where did you buy your battery?
4. How much did you pay for your battery?
5. Do you have a guarantee?
5ª. If you have a guarantee, how long is it for?
6. What do you do with your old battery?
6ª. If you leave it in the street, who picks it up?
7. Are you paid for disposing of your battery?

**Extra information provided by the taxi driver.

Answers:

Taxi 1
1. bought it
2. new
2ª. ------
3. store
4. 19,000 colones
5. yes
5ª. 1 year
6. throw it away
6ª. garbage men
7. no-give it away

Taxi 2
1. intstalled
2. new
2ª. ------
3. came with the car
4. ------
5. no
5ª. ------
6. trade when I buy a new one
6ª. -------
7. no

Taxi 3
1. bought it
2. reconditioned
2ª. I have a "black box"
3. Puente Cañas-mechanic (taxis, buses)
4. 13,000 colones
5. yes
5ª. 6 months
6. throw it away
6ª. garbage men
7. ------
**black batteries last longer

Taxi 4
1. bought it
2. new
2ª. ------
3. store
4. 25,000 colones
5. yes
5ª. 6 months
6. -------
7. no

Taxi 5
1. bought it
2. new
2ª. ------
3. store
4. ------
5 yes
5ª.6 months
6. sold it
7. 150 colones

Taxi 6
1. bought it
2. new
2ª. ------
3. store
4. ------
5. yes
5ª. 6 months
6. sold it
7. 200 colones

Taxi 7
1. bought it
2. new
2ª. ------
3. store
4. 20,000
5. yes
5ª. 1 year
6. give it away
6ª. ------
7. give it away

Taxi 8
1. bought it
2. new
2ª. ------
3. -------
4. -------
5. yes
5ª. 1 year
6. ------
6ª. ------
7. -----

Taxi 9
1. bought it
2. new
2ª. ------
3. store
4. ------
5. yes
5ª. 5 years
6. return it to the store
6ª. ------
7. no

Taxi 10
1. bought it
2. reconditioned
2ª. ------
3. they are cheaper but not better
4. 12,000 colones
5. yes
5ª. 3 months
6. drop it off at a recycling facility
6ª. ------
7. give it away
**recycling facilities pay up to 1000 colones

Taxi 11
1. bought it
2. new
2ª. ------
3. store
4. ------
5. ------
5ª. ------
6. drop it off at the store
6ª. .-------
7. give it away
**one battery lasts 1 year

Taxi 12
1. bought it
2. new
2ª. ------
3. store
4. ------
5. ------
5ª. -------
6. basura
6ª. lugares de reciclaje
7. give it away

Taxi 13
1. bought it
2. new
2ª. ------
3. store
4. ------
5. yes
5ª. 1 year
6. throw in trash
6ª. no one
7. no
**didn't know lead was dangerous

Taxi 14
1. bought it
2. new
2ª. ------
3. store
4. ------
5. ------
5ª. ------
6. throw in trash
6ª. no one
7. no

Taxi 15
1. bought it
2. new
2ª. ------
3. store
4. ------
5. no
5ª. ------
6. throw in trash
6ª. no one
7. no

Taxi 16

1. bought it
2. new

2[a]. ------

3. store
4. ------
5. yes

5[a]. 1-2 year

6. throw in trash

6[a]. no one

7. no

**the life of a battery
is 1-1 1/2 years

Appendix C: Interviews for Auto-Parts Stores

Questions:

1. What different kinds of batteries are there?
2. Which battery is most popular?
3. Where do you obtain your batteries?
4. What percentage of the profit you do receive from the sales of batteries?
5. Do you collect old batteries?

5ª. What do you do with the old batteries?

Answers:

Store 1

1. Record, Diehard, Rocket
2. Record
3. from the respective companies
4. 25-30%
5. yes

5ª. Sell them for 500 colones to a recycler

Store 2

1. Raider, Vulcan, Rocket, Koba-8 tipos
2. N50z-different brands
3. distributor-Korea, México, Columbia, US
4. 25-30%
5. yes

5ª. Sell them to garbage men for 200-250 colones

Store 3

1. 2-wet & dry- N40-70z
2. dry N50
3. distributor-sent here
4. on the sale-gain 1000 colones
5. no

5ª. ------

Store 4

1. 4 types
2. Rocket, Koba
3. distributor-sent here
4. 20 %
5. distributor collects them

5ª. -------

Store 5

1. 40 types
2. N40-50z
3. plant in El Salvador
4. 30-40%
5. yes

5ª. Send to El Salvador (lead weights, batterias)

Appendix D: Interviews with Mechanics

Questions:

1. Where do you obtain your batteries?
2. When a car is in an accident, what do you do with the old battery?
3. Do you collect old batteries?

3ª. What do you do with the old batteries?

4. Do you know anything about "black box" batteries?

4ª. How many batteries do you make per day?

4b. How many batteries do you sell per day?

Answers:

Mechanic 1 ("black box" battery)

1. from the public for 500 colones each
2. take it apart if impacted, send to a garage
3. yes-the public brings them to me

3ª. Recycle them

4. Make them

4ª. 2-3

4b. 3-4

Mechanic 2 ("black box" battery)

1. warehouse
2. use it, sell it, or throw it away
3. yes-people bring them to me, and I collect them from the street

3ª. Recycle them

4. Make them

4ª. 3-4

4b. 5-6

Mechanic 3

1. Importadora Mundial de Equipos/ Sechang Global Co.
2. give them to people who specialize in removing lead
3. yes

3ª. Send them to people who specialize in removing lead

4. they are out of the market

Appendix E: Interview Questions and Answers for Eric Jiménez

Owner of Recoprimax, S.A.
Thursday, May 24, 2001, 10:00am
Recoprimax, S.A.

1. *Can you describe the life cycle of a battery in Costa Rica from its introduction in the market to its disposal?*

   The batteries come from other countries and from in the country. Some are imported and the rest are collected by him from all over Costa Rica. They are then sent on a truck to El Salvador, where they are completely recycled and then sold back to Costa Rica.

2. *Can you describe which role you and your business have in this cycle?*

   Eric's company is only a collector. They collect the batteries until they have accumulated 21 tons, the max. limit by law that they can send on a truck. They then use their own trucks to ship them to El Salvador at no cost to them.

3. *How and where do you get your batteries?*

   People set aside the batteries in their houses or he collects them from garbage collectors and stores. He gets them from anywhere they might have them. He uses a tractor to go around and collect them. He uses a truck to send them to El Salvador.

4. *Do you pay or do you get paid for the batteries and how much?*

   He pays people 15 colones per kilogram and he gets paid 26 colones per kilogram when he sells them to El Salvador.

5. *What do you do with the batteries after you have received them?*

   Once he has accumulated 21 tons (or roughly 1237 batteries), he packs and ships them to El Salvador. He does not break them or discharge them. He only collects them and ships them out.

6. *How much does it cost you to send the batteries from your business?*

   It costs him nothing to ship them to El Salvador because he uses his own trucks. He doesn't clean them or anything before shipment.

7. *What do you do with your batteries? Do you sell them or give them away and do you get paid for them? If so, how much do you get paid?*

   El Salvador pays 26 colones per kilogram.

8. *Who do you sell or give the batteries to?*

   They sell the batteries to El Salvador, where there is a complete recycling facility. They break the batteries, send the plastic box to the U.S. to be recycled, and then use new boxes sent from the U.S. to make new batteries. They sell the new batteries back to stores in Costa Rica.

9. *How many trips do you make per month?*

   We make 3 trips per month to El Salvador and Baterías Record pays for each trip.

Other Information:

- 2% of all batteries stay in the country and are resold because they are made in the country. The other 98% are sold to El Salvador.

- El Salvador's facility meets all environmental regulations that exist there. These types of laws are not enforced in Costa Rica. There are supposedly recycling laws for all of Central America.

- Recipromax, Eric's company, has been in business for 20 years now.

- Eric gave us another reference to talk to. It is Battery Records of Costa Rica. This is the representative for the El Salvador facility and they are a private company that knows a lot of information about the recycling process. He gave us the number and the name of the guy in charge, Don Luis. It is also in Hatillo so we can visit this place also and have an interview with him.

- They also trade other materials for the new batteries to El Salvador. For example, they may trade cardboard for the new batteries.

Appendix F: Interview Questions and Answers for Luis Romero

Representative of Baterías Record
Wednesday, June 6, 2001 2:00PM
Baterías Record

1. *How many batteries do you send to El Salvador each month? How many trips per month?*

   140 tons per month, 5 trips per month

2. *How many companies collect batteries for you? What are their names?*

   6 places, some are private companies and some are just people who collect.

3. *How much does it cost to send the batteries to El Salvador? (Transportation costs)*

   El Salvador pays for the shipment and labor costs because they are the ones that want the batteries.

4. *In your opinion, what percentage of all the batteries in Costa Rica is recycled?*

   About 80% of the batteries in the country are recycled. 70% of all batteries from Baterías Record are sent to El Salvador and the other 30% are sent to Panama to be recycled.

5. *What laws are there in Costa Rica and El Salvador for recycling batteries?*

   There were no laws one and a half years ago. They are still in the process of getting the permits to make the laws. There are inspectors from Honduras that come to make sure they are packing the batteries safely because they carry them through their country. The only laws are laws that require permission to jump waste.

6. *Do you know what happens with the sulfuric acid from the batteries?*

   Many people just throw the acid in the streets or rivers. At Baterías Record, they neutralize it with sodium sulfate and throw it away after it has been tested.

7. *How long have you been in business for?*

   Four and a half years.

8. *Does the El Salvador plant sell only complete batteries or do they sell parts to people so they can make their own batteries?*

They only sell the lead plates to people who they know that make reconditioned batteries.

Appendix G: Interview Questions and Answers for Ana Gonzalez

Owner of Recuperadora Nacional de Plomo, S.A.
Wednesday, June 6, 2001, 10:00am
Recuperadora Nacional de Plomo, S.A.

1. *Can you describe the life cycle of a battery in Costa Rica from its introduction in the market to its disposal?*

   The life of a battery begins in the vehicle and then it is brought to our plant. From there the battery is broken apart and we separate the contents. We take out the lead, put it in the rotary furnace, smelt it, and then pour it into ingots of 1 ton.

2. *Can you describe which role you and your company have in this cycle?*

   We smelt the lead that is found in the batteries and pour it into ingots to be sold. The client then makes its own products with our lead.

3. *How and where do you get your batteries?*

   The public brings their batteries to our plant.

4. *Do you pay or get paid for your batteries and how much?*

   We pay for the batteries. We buy them, without acid, for 18 colones per kilo.

5. *What do you do with the batteries after you obtain them?*

   We break them, separate the lead and smelt it, and the rest we throw away.

6. *How much does it cost you to prepare the material for each battery?*

   Approximately 50 colones to prepare the material for each battery.

7. *How much does your lead cost?*

   Our lead costs between $750-770 (US) per ton.

Other Information

- *We've been in this business for 25 years.*
- *We smelt 3 tons of lead each day.*
- *Two of our clientes are Baterías United and Grecia.*
- *We have 3 employees:battery breaker, furnace operator, cleaner/repairman.*

Appendix H: Detailed Summary of Interview with Orlando Rodriguez

Representative from the Ministry of Health
Thursday, May 31, 8:00AM
Ministry of Health

Through our interview with Ing. Orlando Rodriguez, we learned that 99% of the lead in Costa Rica comes from lead-acid batteries, and the other 1% comes from lead paint and lead wires. He also estimated the number of cars in Costa Rica to be about 650,000, but he suggested that we contact the registry to get an exact number. According to Rodriguez, the prices of batteries for cars ranges from 16,000-28,000 colones, depending on the type of battery. The price depends on the number of lead plates in the battery, which can range from 4-32, also depending on the size and type of battery. The life of a battery ranges from 2-5 years with normal use, with the average being 3.5 years. The warranties that come with these batteries can range from 6 months to 2 years.

In Mr. Rodriguez's opinion, 60% of the batteries discarded in Costa Rica are collected and recycled, but this estimation is not backed by any facts. He says that the reason why not all the batteries are being collected is because there is no culture in Costa Rica for recycling and the people of Costa Rica are too lazy. One program, called Copacrea, which is a program for drug addicts, collects batteries and sells them to collectors for 1,000-2,000 colones.

We also learned that there are no laws in Costa Rica for the disposal of hazardous wastes. One reason why the government is taking the initiative to start a lead-acid battery-recycling program, according to Rodriguez, is because there are health risks from being exposed to the vapors of metallic dust and its evaporation. But as of now, there have been no records of people having lead problems.

We also learned that lead smelting is not illegal in Costa Rica, it is only illegal if the facilities are not registered. There are a lot of small-scale smelting facilities that use the lead from batteries to make lead ingots, but there are also fishermen who smelt the lead to make fishing weights. A lot of these small smelters are illegal because they are not registered to be operating a business.

Rodriguez also said that people are using the used battery cases and covers for other purposes. In one case they are being used as a fuel at "trapiches", or places that burn sugar can to manufacture candy and sweets. This is a problem because some of these boxes are made of PVC, polyvinyl chloride, which is toxic to the environment.

Mr. Rodriguez also informed us of some of the actions that have taken place since the beginning of 2001. Recently, on May 26, a representative from El Salvador visited Costa Rica to see how the batteries were being packaged and sent to El Salvador to make sure they were using safe practices. He also told us that there is research and information that has to be completed by April of 2002 about starting a lead-acid battery-recycling program in Costa Rica.

Appendix I: Detailed Summary of Interview with Sergio Musmanni and Carlos Perera

Director and Sub-Director of Centro Nacional de Producción Más Limpia, respectively
Thursday, June 7, 2001
Chamber of Industry

The interview started with Mr. Musmanni explaining what the National Center for Cleaner Production's plans are for lead-acid battery recycling in Costa Rica. He told us that they are waiting for the funding for his company to begin a study on the current situation and then make recommendations for how to improve the problem.

We then asked if Costa Rica has formal landfills or if there are just dumps where all the waste is dumped together. He told us that there are some private landfills, like one in Alajuela, that have separate cells for hazardous wastes. These places are privately owned and charge money for the municipalities to dump there, so they don't use them very often. So the hazardous wastes in Costa Rica are all dumped together in one pile.

The Centro Nacional de Producción Más Limpia saw this problem and asked for help to try and fix it. The haven't done anything yet, but they are going to check the current facilities, check the current situation, and then make an action plan to try and reduce environmental activity. They are also going to check to see if Costa Rica is following other countries' laws for hazardous waste. He told us that the Ministry of Health is working on developing standardized labels for all imports and exports. This will make it easier to identify all products coming in and going out of the country.

Mr. Musmanni and Mr. Perera then gave us some sources to look into for information. These included: The Journal of Cleaner Production, The Journal of Ecology and a contact at University of Massachusetts in Lowell, MA that is involved in chemicals who may be able to help with the technological options for recycling. They also gave us some advice on how to find the number of batteries that are not recycled in Costa Rica. The advice that he provided us was to find the number of batteries imported into the country and the number of batteries exported out of the country. The amount that remains after you subtract the exports is the amount of batteries that are not being recycled. We also got the name of a contact to give us information on the costs of shipping batteries in Costa Rica. They gave us a manual on lead-acid battery recycling that was from the United Nations Environmental Programme. The meeting was then adjourned.

Appendix J: Interview Questions and Answers for Saul Rosa

Representative from Baterías de El Salvador
Monday, June 18, 2001
Phone Interview from San Jóse (Conducted by Prof. Salazar for translation)

1. *Who do you get the old batteries from in Costa Rica?*

   From Costa Rica, we receive old batteries from 4 suppliers.

2. *What type of transportation carries the batteries to El Salvador?*

   Twenty ton trucks brings the batteries to El Salvador. The transportation is subcontracted through Javier Diaz in Costa Rica.

3. *How much do you pay for the transportation of the batteries?*

   For a full truckload, we pay $1000 US for the transportation, which carries 1300-1400 batteries.

4. *How many trips are made to El Salvador each month?*

   2-10 trips a month.

5. *Are there any laws in El Salvador, Costa Rica, or Central America that needs to be followed?*

   Shipments are done according to the Free Trade Agreement in Central America, which means that there is no custom fee because junk is being transported out of the country, but Javier Diaz arranges all the paper work.

6. *Do you buy the old batteries with or without sulfuric acid?*

   Without acid- the acid is taken out in Costa Rica. In Costa Rica, sodium carbonate is supposed to be added to the sulfuric acid and the solution is checked with pH paper to see whether is is neutralized.

7. *What types of batteries do you sell?*

   We sell only Baterías Record to Costa Rica, but we also sell other brands to other countries.

8. *Do the trucks return to Costa Rica with new batteries?*

   Sometimes, if it is arranged, but we only pay $1000 US for the transportation of batteries to El Salvador.

9. *How many trips do you make per month?*

We make 3 trips per month to El Salvador and Baterías Record pays for each trip.

10. *What are the names of the companies in Costa Rica that send batteries to you?*

I cannot disclose that information.

11. *How much do you sell the new batteries to companies in Costa Rica for?*

I cannot disclose that information.

Appendix K: Waste Disposal Laws for Costa Rica

The following are the exact laws that Costa Rica has pertaining to waste disposal (Arrieta, 1995).

ANEXO 2

Leyes relacionadas con el manejo de desechos sólidos

LEY DE AGUAS
(N° 276 del 27 de agosto de 1942)

ARTICULO 162°:
Sufrirá prisión de tres meses a un año o multa de ciento ochenta a setecientos veinte colones:

I- El que arrojare a las cauces de agua pública lamas de las plantas beneficiadoras de metales, basura, colorantes o sustancias de cualquier naturaleza que perjudiquen el cauce o terrenos de labor, o que contaminen las aguas haciéndolas dañosas a los animales o perjudiciales para la pezca, la agricultura o la industria, siempre que tales daños causen a otro pérdidas por suma mayor de cien colones.

CODIGO MUNICIPAL
(Ley N° 4574 del 4 de mayo de 1970)

ARTICULO 87°:
Las municipalidades cobrarán tasas por los servicios urbanos que presten, las que serán elaboradas tomando en consideración el costo efectivo del servicio y un porcentaje de utilidad para desarrollo.

Los servicios de alumbrado público, limpieza de las vías y recolección de basuras, deberán pagarse aunque no se tenga interés en ellos.

Los servicios estrechamente vinculados a la salud de la comunidad, como la recolección de basura y la distribución de agua, podrán ser subvencionados por las respectivas municipalidades con el ingreso del Impuesto Territorial a fin de reducir las tasas.

CODIGO PENAL
(Ley N° 4573 del 4 de mayo de 1970)

ARTICULO 400°:
Será castigado con tres a treinta días multa:

1) El que arrojase a la vía pública o en parajes públicos, piedras, materiales, aguas, objetos o sustancias de cualquier clase que puedan causar daño o molestia, aunque no los produzcan.

LEY DE CONSTRUCCIONES
(Nº 833 del 2 del noviembre de 1949)

ARTICULO 38º:
Queda estrictamente prohibido a los concurrentes a parques, jardines y prados, arrojar en ellos basuras, desperdicios o cualesquiera otra clase de objetos que perjudique el buen aspecto que deben presentar los prados, o la vida misma de las plantas en ellos sembradas.

ARTICULO 71º:
Se prohibe dar curso a las aguas residuales de desechos industriales, cuando sean perjudiciales para la salud del hombre o de los animales, o cuando por su proporción química o su temperatura ataquen el sistema de atarjeas establecidas o cuando perjudiquen las tierras destinadas a la agricultura.

ARTICULO 72º:
Los demás desechos industriales deberán ser alejados de tal manera que no perjudiquen la salud de los interesados y a terceras personas.

LEY ORGANICA DEL MINISTERIO DE SALUD
(Nº5412 del 8 de noviembre de 1973)

ARTICULO 47:
Las municipalidades atenderán todas las medidas sanitarias que el Ministerio indique para la conservación de la higiene y para prevenir y combatir epidemias."

ARTICULO 48º:
Las Municipalidades no podrán iniciar la ejecución de obras públicas de carácter sanitario, como Mataderos, Mercados, Hospitales, Hospicios, Crematorios, Basureros y otras de naturaleza análoga, sin la previa autorización del Ministerio, al cual remitirán oportunamente los planos y sus especificaciones, presupuesto y demás datos y antecedentes que contribuyan a formar concepto de dichas obras.

LEY DEL RELLENO SANITARIO DE RIO AZUL
(Nº 5973 del 8 de noviembre de 1976)

ARTICULO 1º:
Todo vehículo que ingrese a depositar basura al relleno sanitario de Río Azul pagará, por cada vez que lo haga, una cuota de dos colones. El Convenio Cooperativo Intermunicipal pagará, en vez de la cuota señalada en el párrafo anterior, una subvención anual fija, que será determinada por la Contraloría General de la República, de acuerdo con los análisis de costos de operación del relleno sanitario. El producto de las suma recaudadas percibirá la Asociación de Desarrollo Comunal del lugar.

LEY GENERAL DE SALUD
(1973)

CAPITULO I DEL AGUA PARA EL USO Y CONSUMO HUMANO Y DE LOS DEBERES Y RESTRICCIIONES A QUE QUEDAN SUJETAS LAS PERSONAS EN LA MATERIA

ARTICULO 276°:
Sólo con permiso del Ministerio podrán las personas naturales o jurídicas hacer drenajes o proceder a la descarga de residuos o desechos sólidos o líquidos u otros que puedan contaminar el agua superficial, subterránea, o marítima, ciñéndose estrictamente a las normas y condiciones de seguridad reglamentarias y a los procedimientos especiales que el Ministerio imponga en el caso particular para hacerlos inocuos.

CAPITULO II DE LAS OBLIGACIONES Y RESTRICCIONES RELATIVAS A LA RECOLECCION Y ELIMINACION DE RESIDUOS SOLIDOS

ARTICULO 278°:
Todos los desechos sólidos que provengan de las actividades corrientes personales, familiares o de la comunidad y de operaciones agrícolas, ganaderas, industriales o comerciales, deberán ser separados, recolectados, acumulados, utilizados cuando proceda y sujetos a tratamiento o dispuestos finalmente, por las personas responsables a fin de evitar o disminuir en lo posible la contaminación del aire, del suelo o de las aguas.

ARTICULO 279°:
Queda prohibido a toda persona natural o jurídica arrojar o acumular desechos sólidos en lugares no autorizados para el efecto, utilizar medios inadecuados para su transporte y acumulación y proceder a su utilización, tratamiento o disposición final mediante sistemas no aprobados por el Ministerio.

ARTICULO 280°:
El servicio de recolección, acarreo y disposición de basuras, así como la limpieza de canoas, acequias, alcantarillas, vías y parajes públicos estará a cargo de las municipalidades las cuales podrán realizarlo por administración o mediante contratos con empresas o particulares, que se otorgarán de acuerdo con las formalidades legales y que requieran para su validez la aprobación del Ministerio.

Toda persona queda en obligación de utilizar dicho servicio público y de contribuir económicamente a su financiamiento de conformidad con las disposiciones legales y reglamentarias pertinentes.

ARTICULO 281°:
Las empresas agrícolas, industriales y comerciales, deberán disponer de un sistema de separación y recolección, acumulación y disposición final de los desechos sólidos provenientes de sus operaciones, aprobado por el Ministerio cuando por la naturaleza o cantidad de éstos, no fuere sanitariamente aceptable el uso del sistema público o cuando éste no existiere en la localidad.

ARTICULO 282°:
Los propietarios de terrenos desocupados en áreas urbanas están obligados a mantenerlos cerrados y en buenas condiciones higiénicas.

Quedarán obligados, asimismo, a realizar las prácticas u obras, dentro del plazo que la autoridad de salud les ordene, cuando tales terrenos constituyen un foco de contaminación ambiental.

ARTICULO 283°:
Queda prohibida la recuperación de desechos y residuos sólidos en lugares no aprobados por la autoridad de salud para tales efectos.

Las personas naturales o jurídicas que se ocupen de la recuperación, aprovechamiento, comercio o industrialización de tales materias, deberán solicitar permiso previo a la autoridad de salud y ésta podrá otorgarlo cuando se compruebe que los trabajos de selección, recolección y aprovechamiento de los desechos y residuos, no impliquen peligro de contaminación del ambiente o riesgos para la salud de las personas que trabajen en tales faenas o de terceros.

ARTICULO 284°:
La autorización a que se refiere el artículo anterior durará un año y podrá ser cancelada en cualquier tiempo cuando el titular no cumpliere las disposiciones reglamentarias pertinentes o

necesarios para resguardar la salud de las personas, o el saneamiento de la operación.

CAPITULO VI DE LOS DEBERES Y RESTRICCIONES RELATIVOS A LAS URBANIZACIONES Y SALUBRIDAD DE LA VIVIENDA

ARTICULO 314°:
Toda persona, además deberá mantener en forma higiénica las basuras en su casa hasta que sean entregadas a los servicios de recolección y deberá cuidar que los servicios de agua potable y disposición de aguas negras y servidas de ésa, se mantengan en buenas condiciones y funcionamiento.

OTROS DECRETOS Y REGLAMENTOS

Además se recomienda consultar los siguientes Decretos y Reglamentos:

Decreto Ejecutivo N° 22595-S
Reglamento sobre rellenos sanitarios
Decreto Ejecutivo N° 19049-S
Reglamento sobre el manejo de basuras
Decreto Ejecutivo N° 22932-S-MIRENEN
Declaración del plan Nacional de Manejo de Desechos como marco de referencia para las estrategias de solución al problema de los desechos sólidos.

Appendix L: Table Explaining Laws and How They Apply

The following is a table explaining which laws apply to different solid wastes and what they mean. The table was provided by the Centro de Derecho Ambiental y de los Recursos Naturales (CEDARENA, 2000).

2. Desechos sólidos ordinarios y peligrosos				
Legislación nacional	**Artículos**	**Requisitos legales**	**Requisitos operativos**	**Autoridad administrativa**
Ley General de Salud	263 340-342 (MS)		Prohibición de acciones que deterioren el medio ambiente. Obligación de eliminar elementos perjudiciales para la salud humana.	Ministerio puede dictar medidas generales, particulares o especiales y normas técnicas para esos propósitos.
	275		Prohibición de contaminación de cualquier agua con cualquier sustancia o desecho sólido.	
	276	Permiso Ministerial para descargar residuos o desechos en aguas superficiales		Ministerio de Salud
	281		Obligación de tener un sistema de tratamiento de desechos sólidos	
	285		Correcta eliminación de excretas.	
	300	Demostrar cumplimiento con zonificación, saneamiento básico, manejo de desechos, según la legislación.		Ministerio de Salud
	344		Sujeción instituciones que administran abastecimiento y manejo de aguas o desechos sólidos a normas técnicas y vigilancia del	Ministerio de Salud

			Ministerio	
Ley de Aguas	162		Penas de prisión por contaminación de aguas con desechos industriales	
Ley de Uso, Manejo y Conservación de Suelos	33	Medidas para manejar residuos de productos de fertilización y agro tóxicos dependen de nivel de contaminación.		Ministerio de Agricultura y Ganadería, Ministerio de Ambiente y Energía, Ministerio de Salud
Ley Orgánica del Ambiente	68 69	Debe controlarse la disposición de residuos que constituyan fuente de contaminación y acatar las medidas correctivas		Mins
	17 18-23 81-89	Las actividades que alteren o destruyan elementos del ambiente o generen residuos materiales, tóxicos o peligrosos, requieren un EIA, previo a iniciar actividades, obras o proyectos		SETENA
Reglamento sobre las características y el listados de los desechos peligrosos industriales	5 anexo 2		Lista fuentes industriales especificas de desechos tóxicos	
24653	1-5		Declara calamidad pública el problema del manejo y disposición final de los desechos sólidos en todo el país	Comisión Nacional de Emergencias, Instituciones del Estado, Municipalidades
Reglamento sobre importación de materias primas, procesamiento, control de calidad, almacenamiento, uso, manejo seguro y disposición de desechos de bolsas tratadas con insecticida para uso agrícola.	5 –12		Requisitos de producción de las bolsas	
	13		Requisitos de	

			etiquetado de bolsas	
	14 –18		Obligaciones de los usuarios de las bolsas	
	19-25		Desecho de las bolsas con insecticidas	
Reglamento sobre manejo de basuras	8-10	Requisitos de contratos privados de recolección de basuras		Municipalidades
	11-13		Obligaciones de los particulares para el almacenamiento de basuras	
	23-42	Forma y Requisitos de operación para empresas que recolectan, transportan y disponen de las basuras		Ministerio de Salud
	44-55	Forma y Requisitos de operación para empresas que recolectan, transportan y disponen de residuos especiales		Ministerio de Salud
	55-74	Lugares de separación y almacenamiento de basura, vías públicas y sitios de disposición de la basura		
Reglamento sobre Rellenos Sanitarios	7	Características de terrenos para rellenos sanitarios		Departamento de Control Ambiental de la División de Saneamiento Ambiental del Ministerio de Salud
	8	Permisos necesarios para rellenos sanitarios		Departamento de Control Ambiental de la División de Saneamiento Ambiental del Ministerio de Salud
	9	Requisito de estudio hidrogeológico y de suelos		Departamento de Control Ambiental de la División de Saneamiento Ambiental del Ministerio de Salud
	13		Requisitos técnicos para rellenos sanitarios	Departamento de Control Ambiental de la División de Saneamiento Ambiental del Ministerio de Salud

	15-16		Requisitos mínimos de rellenos manuales y mecanizados	Departamento de Control Ambiental de la División de Saneamiento Ambiental del Ministerio de Salud
	17-19	Obligación de facilitar la vigilancia estatal del relleno		
Reglamento sobre registro, uso y control de Plaguicidas agrícolas y coadyuvantes	11		Requisitos de etiquetado	
	capitulo XIII	prohibiciones sobre desechos y residuos	Procedimiento de destrucción de envases y residuos	
Reglamento de Construcciones	31		Ductos para basura en construcciones	
	capitulo VII		Deposito y almacenamiento de desechos domésticos	
	capitulo XX		Procesamiento de aguas residuales de la industria	Ministerio de Salud
Reglamento de Higiene Industrial	35		evacuación diaria de desperdicios y basuras en recipientes metálicos con cierre hermético	

Appendix M: Models of Legislation

Battery Council International Model Legislature (Battery Council International, 2001):

BATTERY COUNCIL INTERNATIONAL
PROPOSED MODEL BATTERY RECYCLING LEGISLATION
BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF _

Section 1. LEAD-ACID BATTERIES; LAND DISPOSAL PROHIBITED.

(a) No person may place a used lead-acid battery in mixed municipal solid waste, in any landfill, or municipal solid waste incinerator.

(b) No person shall dispose of a used lead-acid battery except by delivery to a retailer or wholesaler, or to a secondary lead smelter, or to a collection or recycling facility authorized under the law of (state) or by the U.S. Environmental Protection Agency.

(c) No retailer shall dispose of a used lead-acid battery except by delivery to the agent of a wholesaler or a secondary lead smelter, or to a battery manufacturer for delivery to a secondary lead smelter, or to a collection or recycling facility authorized under the law of (state) or by the U.S. Environmental Protection Agency.

(d) Each battery improperly disposed of shall constitute a separate violation.

(e) For each violation of this section a violator shall be subject to a fine not to exceed $_______ and/or a prison term not to exceed _______ days (as appropriate under state code).

Section 2. LEAD-ACID BATTERIES; COLLECTION FOR RECYCLING.

A retailer selling replacement lead-acid batteries in the state shall:

(a) Accept from customers, at the point of transfer, used lead-acid batteries of the same general type and in a quantity at least equal to the number of new batteries purchased, if offered by customers;

(b) Collect a deposit of at least $10.00 on the sale of an automotive type replacement lead-acid battery that is not accompanied by the return of a used lead-acid battery of the same general type. All deposits shall inure to the benefit of the retailer unless the person paying the deposit pursuant to this subsection returns a used automotive lead-acid battery to the retailer within thirty days of the date of sale, in which case the deposit shall be returned to the customer; and

(c) Post written notice which must be at least 8-1/2 inches by 11 inches in size and must contain the universal recycling symbol and the following language:

(1) "It is illegal to discard a used lead acid battery.";

(2) "Recycle your used batteries."; and

(3) "State law requires us to accept used lead-acid batteries for recycling in exchange for new batteries purchased."

Section 3. INSPECTION OF BATTERY RETAILERS.

The (appropriate state agency) shall produce and print the notices required by Section 2 and shall distribute such notices to all places where replacement lead-acid batteries are offered for retail sale. In performing its duties under this section, the division may inspect any place, building, or premises where batteries are sold at retail. Authorized employees of the agency may issue warnings and citations to persons who fail to comply with the requirements of Section 2. Failure to post the required notice following warning shall subject the establishment to a fine of $______ per day (as appropriate under state code).

Section 4. LEAD-ACID BATTERY WHOLESALERS.

Any wholesaler selling replacement lead-acid batteries shall accept from customers at the point of transfer, used lead-acid batteries of the same general type and in a quantity at least equal to the number of new batteries purchased, if offered by customers. A wholesaler accepting batteries in transfer from a retailer shall be allowed a period not to exceed 90 days to remove batteries from the retail point of collection.

Section 5. PLASTIC CODING.

Lead-acid battery cases shall not be required to bear an SPI, SAE or other resin identification code otherwise required for rigid plastic containers.

Section 6. DEFINITIONS.

For the purposes of Sections 1-5:

(a) The term lead-acid battery means a battery that:

(1) consists of lead and sulfuric acid;

(2) is used as a power source; and

(3) is not intended as a power source for consumer products.

(b) The term retailer means any person who engages in the sale of replacement lead-acid batteries directly to the end user.

(c) The term wholesaler means any person who sells replacement lead-acid batteries for resale.

(d) The term consumer product means any device that is primarily intended for personal or household use and is typically sold, distributed, or made available to the general population through retail or mail-order distribution. Such term does not include vehicles, motorcycles, wheelchairs, boats or other forms of motive power. The term does include, but is not limited to, computers, games, telephones, radios, and similar electronic devices.

Section 7. ENFORCEMENT.

The (appropriate state agency) shall enforce Sections 2 and 4. Violations shall be a misdemeanor under (applicable state code).

Section 8. SEVERABILITY.

If any clause, sentence, paragraph or part of this chapter or the application thereof to any person or circumstance shall, for any reason, be adjudged by a court of competent jurisdiction to be invalid, such judgment shall not affect, impair, or invalidate the remainder of this chapter or this application to their persons or circumstances.

* * * *

BATTERY COUNCIL INTERNATIONAL
401 North Michigan Ave.
Chicago, IL 60611
Telephone (312) 644-6610
Fax (312) 321-6869

Massachusetts Legislature (The Commonwealth of Massachusetts, 2001):

HOUSE, No. 1254

By Mr. Petersen of Marblehead, petition of Douglas W. Petersen, Carol A. Donovan, Matthew C. Patrick, Patricia D. Jehlen, Anthony J. Verga and J. James Marzilli, Jr., for legislation to provide for the recycling of lead-acid motor vehicle and marine batteries. Natural Resources and Agriculture.

The Commonwealth of Massachusetts

In the Year Two Thousand and One.

AN ACT TO PROVIDE FOR THE RECYCLING OF LEAD-ACID MOTOR VEHICLE AND MARINE BATTERIES.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Section 8 of chapter 21H of the General Laws, as appearing in the 1998 Official Edition, is hereby amended by inserting the following definition:
"Lead-acid battery", a battery that consists of lead and sulfuric acid, including those used as a power source for vehicles, motorcycles, wheelchairs, boats and farm equipment The term does not include batteries which power computers, games, telephones, radios, and similar electronic devices.
Section 8 of chapter 21H of the General Laws, as so appearing, is hereby amended by inserting in line 1, after the words "provision of", the following:— sections three through seven of.

SECTION 2. Said section 8 of said chapter 21H, as so appearing, is hereby further amended by striking out, in line 3, the words "this chapter" and inserting in place thereof the following:— said sections.

SECTION 3. Said chapter 21H, as so appearing, is hereby further amended by inserting at the end thereof the following new sections:—
Section 9. (a) No person may place a used lead-acid battery in a mixed municipal solid waste facility, nor discard or otherwise dispose of a lead-acid battery, except by delivery

to a retailer or wholesaler of lead-acid batteries, to a collection or recycling facility authorized under the laws of the Commonwealth, or to a secondary lead smelter permitted by the United States Environmental Protection Agency.
(b) No person who sells lead-acid batteries at retail, or offers such batteries for retail sale in the commonwealth, may dispose of a used lead-acid battery, except by delivery to the agency of a battery wholesaler, to a battery manufacturer for delivery to a secondary lead smelter permitted by the United States Environmental Protection Agency, or directly to such a secondary lead smelter.
(c) Any person who violates subsection (a) or (b) of this section shall be punished by a fine of not more than five hundred dollars, or by imprisonment of not more than sixty days, or both. Each battery improperly discarded shall constitute a separate violation. The department shall enforce the provisions of this section.
Section 9A. (a) All persons selling lead-acid batteries at retail, or offering lead-acid batteries for retail sale in the Commonwealth shall:
(1) accept at the point of transfer, from their customers who so offer them, used lead-acid batteries in a quantity at least equal to the number of new batteries purchased; and
(2) collect a deposit of ten dollars on the sale of any lead-acid battery that is not accompanied by return of a used lead-acid battery of the same or similar type. All deposits shall inure to the benefit of the retailer unless the person paying the deposit pursuant to this subsection returns a used lead-acid battery to the retailer within thirty days of the date of sale, in which case the deposit shall be returned to the customer; and
(3) post a sign, at least eight and one-half inches by eleven inches in size, containing the universal recycling symbol and the following language, conspicuously displayed:
(i) "It is illegal to discard lead-acid batteries."
(ii) "Recycle your used batteries", and
(iii) "State law requires us to accept used lead-acid batteries for recycling, in exchange for new batteries purchased."
(b) The department shall produce, print and distribute the signs required by subdivision (3) to all premises from which lead-acid batteries are sold at retail or offered for retail sale.
(c) The department shall enforce the provisions of this section. In doing so, it may inspect any premises to which this section is applicable. Any lead-acid battery retailer, or offeror for retail sale of such batteries, who fails to post the required sign shall be subject to a fine of one hundred dollars for each day the sign is not posted.
Section 9B. Any person selling new lead-acid batteries at wholesale, or offering such batteries for wholesale, shall accept at the point of transfer, from their customers who so offer them, used lead-acid batteries in a quantity at least equal to the number of new batteries purchased. Said lead-acid battery wholesalers, or offerors for wholesale of such batteries, upon acceptance of used batteries in transfer from lead-acid battery retailer, shall be allowed a period not to exceed ninety days to remove the used batteries from the retailers' point of collection.

Appendix N: Summary of The Basel Convention and Its Consequences for Lead-Acid Battery Recycling

The following paper provides and explanation of what the Basel Convention is and the consequences of lead-acid battery recycling. Provided by United Nations Environmental Programme (UNEP, 1996).

3.4.7 Summary of the Basel Convention and its consequences for lead-acid battery recycling

The implementation of recent decisions taken under the Basel Convention may influence the market for secondary lead smelting considerably, since many lead-acid batteries are transported across borders to be recycled elsewhere.

The consequences of the Basel Convention, in terms of environmental problems in developed and developing countries, are not clear yet. However, trainers may find it interesting to consider the impact of a restriction on transboundary transportation of hazardous wastes destined for recycling, and its effect on environmental quality.

Compilation of press releases and decisions on the Basel Convention.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, adopted by the Conference of Plenipotentiaries in Basel in 1989, was developed under the auspices of the United Nations Environment Programme. The Convention passed into force during the First Meeting of the Conference of the Parties, held in Pririapolis, Uruguay, in 1992. The second meeting was held in Geneva, Switzerland, in 1994. During this meeting, it was decided to ban transboundary movement of hazardous wastes for final disposal from OECD to non-OECD states immediately. Exportation of hazardous wastes from OECD to non-OECD nations for recovery or recycling would cease by the end of 1997.

The Basel Convention represents a first step in defining the global means to reduce and strictly control the movements of hazardous wastes and to ensure that these wastes are disposed of in an environmentally sound manner. It provides realistic measures to strengthen the protection of the global environment from the possible harmful effects of the transboundary movements of hazardous wastes and their disposal. It focuses on the protection of human health and the environment. It includes the obligation to reduce the generation of hazardous wastes to a minimum and to ensure that the sovereign right of each State to ban the import of hazardous wastes into its territory is observed. It also prohibits the export and import of hazardous wastes from and to non-Parties to the Convention unless such movement is subject to bilateral, multilateral or regional agreements or arrangements whose provisions are not less stringent than those of the Basel Convention. It requests that hazardous wastes should be disposed of as close as possible to their source of generation and that transboundary movement of hazardous wastes could only be allowed if it is carried out in accordance with the strict control system provided by the Convention, which includes prior informed consent by the importing country as well as by the transit country.

Transboundary movements of hazardous wastes carried out in contravention of the provisions of the Basel Convention are to be considered illegal traffic and a criminal act.

Implications for lead-acid battery recycling

Article I of the Basel Convention states that "... wastes that belong to any category contained in Annex I unless they do not posses any of the characteristics contained in Annex III ...," are regarded as hazardous wastes for the purposes of the Convention.

Lead, lead components and acids are regarded as hazardous wastes under the Convention. Lead and lead compounds are named under Y31, and acidic solutions or acid in solid form are named under Y31 of Annex I. The characteristics of lead also comply with the characteristics listed under H11 and H12 of Annex III: Lead has toxic effects both delayed and chronic, and ecotoxic effects. Sulphuric acid possesses the characteristic described under H8 in Annex III: it causes severe damage when in contact with living tissue.

Final disposal operations of hazardous wastes from OECD countries in non-OECD countries which do not lead to the possibility of resource recovery, recycling, reclamation, direct re-use or alternative uses (Section A of Annex IV) is prohibited under the provisions of the Convention. This is also valid for lead-acid batteries.

Recycling/reclamation of metals and metal compounds and regeneration of acids is listed in Section B of Annex IV, stating the operations which may lead to resource recovery, recycling reclamation, direct re-use or alternative uses of hazardous wastes. Therefore the transboundary movement of lead-acid batteries for recycling is subjected to the regulations under the Basel Convention as of the end of 1997.

Further information	Secretariat of the Basel Convention (SBC), Geneva Executive Center, 15 chemin des Anémones, CH-1219 Châtelaine - Geneva, Switzerland. Tel: (41 22) 979 92 18. Fax: (41 22) 797 34 54.

Appendix O: Occupational Safety and Health Association Guidelines for Lead Smelting

The following are the specific guidelines for lead smelting that have been developed by OSHA. Provided by the United Nations Environmental Programme (UNEP, 1996).

3.4.6 Lead smelting: occupational safety and health guidelines

This article gives an example of safety and health guidelines for (secondary) lead smelting. The article also gives you an idea of what preventative measures can be taken to avoid exposure to lead. When addressing human exposure at the workfloor, it is important to realize that emissions from the secondary lead smelter can vary considerably depending upon the degree *of good housekeeping practice, supervision, and control exercised at the plant.*

In: **Occupational Health and Safety Guidelines**
The World Bank, Office of Environmental Affairs
Washington DC, USA

[1984]

Editorial comments

(i) Note that personal protective equipment is *always* necessary when working in a lead recycling facility, even if all appropriate emission control measures are installed.

(ii) The guidelines given in this article were produced by the World Bank in 1984. Many national agencies produce their own guidelines, and users are encouraged to update this information regularly. Currently, guidelines for the European Community are being developed.

The World Bank
Office Of Environmental Affairs

April 1984

LEAD SMELTING

Occupational Safety and Health Guidelines

Introduction

1 In the lead smelting industry, serious safety hazards are burns from splattering and streaming of molten metal or slag, injuries from machinery, and strains from lifting and pulling. Other types of injuries are to the eyes, slips and falls and from moving objects.

2 The most serious health hazard is from dust and fumes. However, exposures coming from lead or other chemicals such as arsenic, sulphur dioxide, carbon monoxide, from excessive noise and from heat stress can also be dangerous.

These guidelines will cover recommendations on safety and health that will help prevent and reduce accidents and occupational diseases among employees.

Safety

3 Good housekeeping practices should be developed to reduce accidents. Individuals should be assigned clean-up responsibilities. Maintaining a clean and orderly workplace will reduce the danger of fires. Combustible materials will be stored in places which are isolated by fire resistant construction.

4 Well constructed bins for the storage of large quantities of raw materials will reduce the chances of injuries due to the falling of heavy materials.

5 Mechanical handling equipment must be provided for heavy loads.

6 All machinery must have guards on all moving parts to protect workers from injury.

7 Electrical equipment must be grounded and checked for defective insulation. All electrical installation and equipment must be in accordance with the standards of the National Electrical Code.

8 When necessary, the workers will be provided with personal protective equipment, including adequate clothing, safety helmets, non-slip footwear, face protection, gloves, aprons, leggings, etc.

Health

Lead

9 Lead is the major toxic product in the air in lead smelting and refining operations. Poisoning may occur through the inhalation of fumes and dust or accidental ingestion of dust. Other metals, such as arsenic, antimony, copper, silver, zinc, gold and bismuth are found in the ore and generate fumes or dust which may be hazardous.

10 Lead poisoning symptoms include loss of appetite, metallic taste, anaemia, headache, nervous irritability, muscle and joint pains, and abdominal cramps. In the advanced stages of chronic poisoning, several body functions and organs, such as the liver, kidney and nervous system may be affected.

It is necessary to monitor the plant for lead and other metal fumes and dusts, and exposure should not be allowed to go above the following threshold limit values (TLVs):

Lead	50 µg/m³
Arsenic and compounds (As As)	10 µg/m³
Antimony and compounds (As Sb)	0.5 mg/m³
Copper fumes	0.2 mg/m³
Copper, dusts and mists	1 mg/m³
Silver, metal	0.1 mg/m³
Zinc oxide fumes	5 mg/m³

Editors Note:
Readers are encouraged to consult relevant authorities for recent updates of national TLVs. Refer also to the IPCS Materials Safety Data Sheets in Part V.

12 Local exhaust ventilation should be provided for all processes which generate lead fumes or dust. Good housekeeping and personal hygiene practices can reduce the amount of lead inhaled and ingested. Dust control measures, preferably hosing down with water, should be undertaken in all dusty areas to help reduce it. Separate lockers for work and street clothes should be provided. It is forbidden to eat, drink and smoke on the job. If circumstances dictate, the use of approved respirators is recommended. A co-operative program involving management, the industrial hygienist and the plant physician is strongly recommended. In order to control excessive absorption of lead and eliminate lead poisoning, this program should include the following points:

a Air levels breathed by the employees must be monitored.

b Periodic medical examinations for all employees, including the level of coproporphyrin or aminolevulinic acid (ALA) in the urine. The use of protoporphyrin free of erythrocyte or zinc protoporphyrin in red blood cells, is another process to screen, however it does not correlate as well at poisoning levels. If one of the tests is positive, it will be confirmed through analysis of the level of lead in the blood, which will not exceed 75 mg of 100 grams.

c Regular analysis of the air and biological concentrations will dictate the measures to take for reducing the hazards. An excessive amount of lead levels will require decreasing fumes and dusts by technical measures; the use of approved respirators and, if necessary, removal of the worker from the work area.

Other air contaminants

13 Sulphur dioxide may occur from the furnaces during the roasting of ores. This contaminant irritates the mucous membranes of the upper respiratory tract. Chronic effects include rhinitis, dryness of the throat and cough.

14 Carbon monoxide is a colorless and odorless gas which results from incomplete combustion. Symptoms of poisoning are headache, fatigue, poor judgement, shortness of breath, weakness and dizziness, leading to nausea, vomiting and at high concentrations unconsciousness.

15 It is necessary to monitor those air contaminants, whose levels should be kept below the following TLVs:

Carbon monoxide	50 ppm	55 µg/m³
Sulphur dioxide	5 ppm	10 µg/m³

Refer to *Editors Note* on previous table.

16 If workers are exposed to excessive amounts of toxic products, engineering measures will be taken. The best solution to capture and remove these products is to use local exhaust ventilation.

17 Roasting and smelting operations produce other irritating gases such as hydrogen sulphide and nitrogen dioxide. These irritating fumes may cause or intensify disease in humans, harm plants, damage paint, concrete and metals.

Heat stress

18 Workers can be exposed to excessive heat, particularly at the furnace and refining operations. Early symptoms of heat stress are weakness, extreme fatigue, dizziness, nausea, headache and thirst. More serious symptoms are leg, arm and stomach muscle spasms, irregular or increased heart beat, extreme thirst and fainting.

19 Where high temperature is a problem, general ventilation must be provided. Cool drinking water and salt tablets should be available to employees in a lead dust free atmosphere.

Noise

20 Excessive noise can cause permanent hearing loss. Loud back ground nose (90 dBA) dulls human senses, including visual acuity, and increases accident rates. If the noise level around the machinery is higher than 90 decibels, those working on or near the equipment should be supplied with ear muffs. In situations where a worker must stay permanently near the equipment, a noise-insulated room should be provided from which he can watch the piece of equipment through a window.

21 Noise levels can be reduced by the separation and isolation of noisy operations, as well as impact reduction and vibration dampening by lamination or lining with acoustic materials. Mufflers on compressed air equipment exhausts, and proper lubrication and maintenance of machinery will also reduce noise levels. Consideration of the noise producing characteristics should be given before purchasing new equipment.

Sanitary facilities and requirements

22 Good sanitary and washing facilities, including shower accommodations must be provided. Separate lockers for work and street clothes should be provided. Employees should be encouraged to wash up before eating. A separate lunchroom should be provided outside the work area.

Medical examination

23 Pre-employment and periodic medical examinations of all workers are recommended. Medical program should include biological monitoring for blood lead as described under paragraph for lead (para. 12 b).

Training and education

24 The education and training of employees in good safety practices is the responsibility of management. Employees should be instructed in safety and good working practices in all phases of their work. This should include regular training programs in the proper use of all equipment and machinery, safe lifting practices, location and handling of fire extinguishers, first aid procedures, the awareness of the danger of lead poisoning, and the use of personal protective equipment.

Record keeping

25 Management is required to keep records of all accidents and illnesses which have involved the employees in the plant. This information should be made available to the World Bank. An evaluation of injury and health data will assist the Bank to evaluate the effectiveness of its occupational health and safety program.

Appendix P: Safety Data Sheets for Inorganic Lead, Lead Oxide and Sulfuric Acid

The following safety data sheets provide valuable information for anyone that will be working with lead or sulfuric acid. The United Nations Environmental Programme provided them (UNEP, 1996).

Figure 5.8 Material Safety Data Sheet for lead (II) oxide

Lead (II) Oxide

ICSC: 0288

CAS# 1317-36-8 ICSC# 0288 EC# 082-001-00-6	**Lead monoxide** **PbO** **Molecular mass: 223.2**	**HAZARD SYMBOL** *Consult national legislation*

Types of Hazard/Exposure	Acute Hazards/Symptoms	Prevention	First aid/Fire fighting
FIRE	Not combustible		In case of fire in the surroundings, all extinguishing agents allowed.
EXPLOSION			

EXPOSURE		***Prevent dispersion of dust. Strict hygiene. Avoid exposure of pregnant women. Avoid exposure of adolescents and children***	
• Inhalation	Cough, headache, nausea.	Local exhaust or breathing protection	Fresh air, rest, and refer for medical attention
• Skin	Redness.	Protective gloves.	Remove contaminated clothes, rinse skin with plenty of water or shower.
• Eyes	Redness, pain.	Safety goggles.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible) then take to a doctor.
• Ingestion	Abdominal cramps, constipation, diarrhoea, headache, nausea, vomiting.	Do not eat, drink, or smoke during work.	Rinse mouth , give nothing to drink, and refer for medical attention

Spillage Disposal	Storage	Packaging and Labelling
Sweep spilled substance into containers, carefully collect remainder (extra personal protection P2 filter respirator for harmful particles).	Separated from sodium, aluminium.	**Further information on labelling:** *Consult national legislation.*

Additional Information

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0288 V1.0
IMPORTANT LEGAL NOTICE ON BACK

continued ...

<table>
<tr><td>Important data</td><td>Physical State Appearance:
Red to yellow-red crystals.
Chemical Dangers:
The substance decomposes on heating, producing toxic fumes (see ICSC#0052). Reacts violently with sodium and aluminium.
Occupational Exposure Limits:
TLV (as Pb) 0.15mg/m³ (as TWA) (ACGIH 1988–1989).
Routes of Exposure:
The substance can be absorbed into the body by inhalation and by ingestion.</td><td>Inhalation Risk:
Evaporation at 20°C is negligible: a harmful concentration of airborne particles can, however, be reached quickly if powdered.
Effects of Long-Term or Repeated Exposure:
The substance may have effects on haemosynthesis, resulting in anaemia. Disturbance of the central and peripheral nervous system and damage to the kidneys may occur. May impair male fertility. This compound may disturb the development of the central nervous system of the newborn.</td></tr>
<tr><td>Physical properties</td><td colspan="2">Melting point .... 888°C
Relative density (water = 1) 9.5
Solubility in water .... none</td></tr>
<tr><td>Environmental data</td><td colspan="2"></td></tr>
<tr><td>Notes</td><td colspan="2">Also consult ICSC #0052 on lead (inorganic).</td></tr>
<tr><td>Additional information</td><td colspan="2"></td></tr>
</table>

ICSC: 0288	© CEC, IPCS, 1991	Lead (II) oxide

Figure 5.9 Material Safety Data Sheet for sulphuric acid

Sulphuric Acid

ICSC: 0362

CAS# 7664-93-9 RTECS# WS5600000 ICSC# 0288 UN# 1830 EC# 082-001-00-6	Sulphuric acid H_2SO_4 Molecular mass: 98.1	HAZARD SYMBOL *Consult national legislation*

Types of Hazard/Exposure	Acute Hazards/Symptoms	Prevention	First aid/Fire fighting
FIRE	Not combustible. Many reactions may cause fire or explosion.	No contact with flammable substances.	No water.
EXPLOSION			In cases of fire, keep drums etc. cool by spraying with water but **no** direct contact with water.

EXPOSURE		***Avoid all contact!***	
• Inhalation	Sore throat, cough, laboured breathing.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest, half-upright position, artificial respiration if indicated, and refer for medical attention.
• Skin	Pain, serious skin burns.	Protective gloves, protective clothing.	Remove contaminated clothes, rinse skin with plenty of water or shower, and refer for medical attention.
• Eyes	Pain, severe deep burns.	Face shield or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible) then take to a doctor.
• Ingestion	Severe pain, vomiting, shock.	Do not eat, drink, or smoke during work.	Rinse mouth , give plenty of water to drink, do **not** induce vomiting, and refer for medical attention

Spillage Disposal	Storage	Packaging and Labelling
Evacuate danger area, collect leaking liquid in sealable containers (extra personal protection: complete protective clothing including self-contained breathing apparatus).	Separated from other materials (see Notes), store in stainless steel containers.	Unbreakable packing: put breakable packaging into closed unbreakable container. **Further information on labelling:** *Consult national legislation.*

Additional Information

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0362 V1.0
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continued ...

Important data	**Physical State Appearance:** Colourless, oily, hygroscopic liquid with no odour. **Chemical Dangers:** On combustion, forms toxic fumes (sulphur oxides). Upon heating, toxic fumes are formed. The substance is a strong oxidant and reacts violently with combustible and reducing materials. The substance is a strong acid – it reacts violently with bases and is corrosive to most common metals, forming a flammable gas (hydrogen: see ICSC#0001). Reacts violently with water and organic materials with evolution of heat. **Occupational Exposure Limits:** TLV 1mg/m³ (as TWA), 3mg/m³ (as STEL) (ACGIH 1988–1989). **Routes of Exposure:** The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.	**Inhalation Risk:** Evaporation at 20°C is negligible: a harmful concentration of airborne particles can, however, be reached quickly by spraying. **Effects of Short Term Exposure:** The substance is very corrosive to the eyes, the skin and the respiratory tract. Corrosive on ingestion as well. Inhalation of an aerosol of this substance may cause lung oedema (see Notes). **Effects of Long-Term or Repeated Exposure:** Lungs may be affected by repeated or prolonged exposure to an aerosol of this substance. Risk of tooth erosion upon repeated or prolonged exposure to an aerosol of this substance.
Physical properties	Boiling point (decomposes) .... 340°C Melting point .... 10°C Relative density (water = 1) .... 1.8 Solubility in water .... miscible Vapour pressure Pa at 146°C .... 0.13 Relative vapour density (air = 1) 3.4	
Environmental data	Possible harmful effects to aquatic life due to acidity.	
Notes	The symptoms of lung oedema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation is therefore essential. **Never** pour water into this substance: when dissolving or diluting, always add it slowly to the water. Store in an area having corrosion resistant concrete floor. Transport Emergency Card: TEC(R) – 10b NFPA Code: H3, F0, R2, W	
Additional information		

ICSC: 0362	© CEC, IPCS, 1991	Sulphuric acid

Figure 5.7 Material Safety Data Sheet for lead (inorganic)

Lead (inorganic)

ICSC: 0052

CAS# 7439-92-1
RTECS# OF7525000
ICSC# 0052

Lead metal
Plumbum
Pb
Atomic mass: 207.2

Types of Hazard/Exposure	Acute Hazards/Symptoms	Prevention	First aid/Fire fighting
FIRE	Not combustible		
EXPLOSION			

EXPOSURE		*Prevent dispersion of dust! Strict hygiene!*	
• Inhalation	Headache, nausea, abdominal spasm.	Local exhaust or breathing protection	Fresh air, rest, and refer for medical attention
• Skin			
• Eyes			
• Ingestion	Headache, nausea, sore throat, abdominal spasm.	Do not eat, drink, or smoke during work.	Rinse mouth , induce vomiting (*only in conscious persons!*) and refer for medical attention

Spillage Disposal	Storage	Packaging and Labelling
Sweep spilled substance into containers, carefully collect remainder (extra personal protection P2 filter respirator for harmful particles).		

Additional Information

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ICSC: 0052 V1.0
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Prepared in the context of cooperation between the IPCS and the Commission of the European Communities © CEC, IPCS, 1990

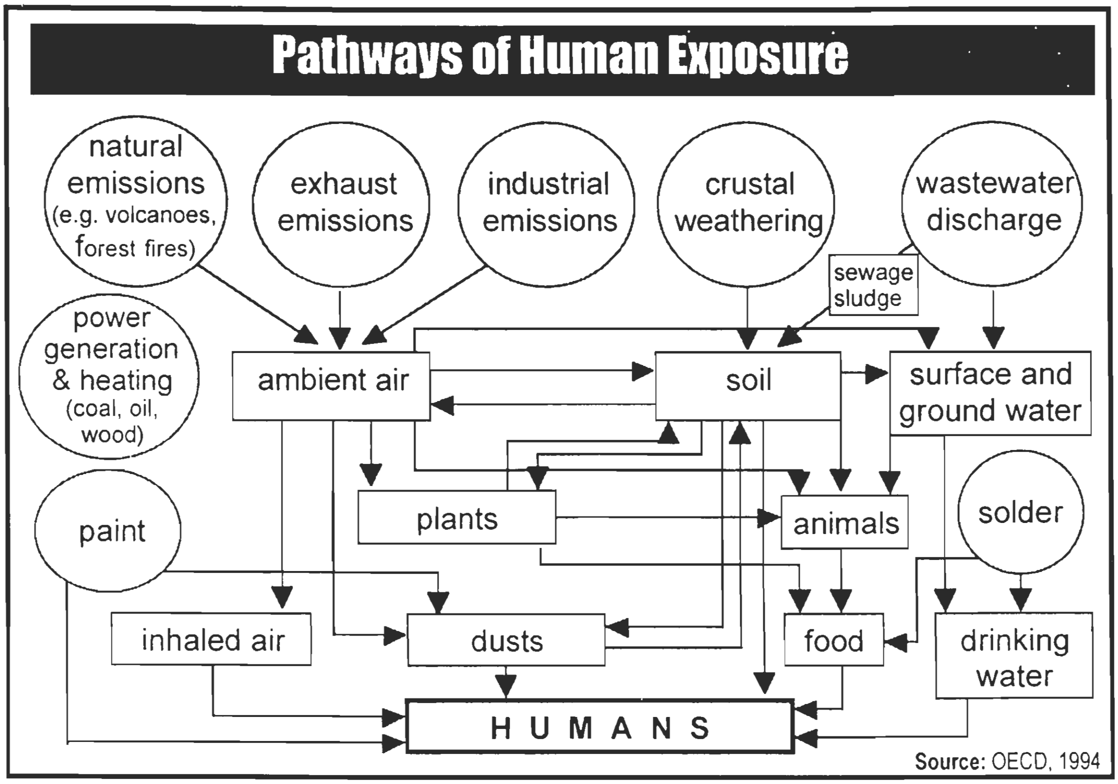
continued ...

Important data	**Physical State Appearance:** Bluish white or silvery grey solid in various forms. **Chemical Dangers:** The substance decomposes on heating, producing toxic fumes. The substance is a strong reducing agent. **Occupational Exposure Limits:** TLV ppm 0.15mg/m³ (as TWA) (ACGIH 1989). PDK (as aerosol) 0.007mg/m³ 0.01mg/m³ C (USSR 1988). **Routes of Exposure:** The substance can be absorbed into the body by inhalation and by ingestion.	**Inhalation Risk:** Evaporation at 20°C is negligible: a harmful concentration of airborne particles can, however, be reached quickly. **Effects of Long-Term or Repeated Exposure:** The substance may have effects on the nervous system and kidneys. This substance may cause anaemia and cold. May impair male fertility. May cause retarded development of the new-born. Danger of cumulative effects. Effects may be delayed.
Physical properties	Boiling point .... 1740°C Melting point .... 327°C Relative density (water = 1) .... 11.3 Solubility in water .... none Vapour pressure, Pa at 25°C .... < 0.1	
Environmental data	This substance may be hazardous to the environment. Special attention should be given to air pollution. In the food chain important to humans, bioaccumulation takes place specifically in shellfish.	
Notes	Explosive limits are unknown in literature. Depending on the degree of exposure periodic medical examination is indicated. Do NOT take working clothes home. Refer also to Cards for specific lead compounds e.g. Lead chromate (ICSC # 0003), Lead (II) Oxide (ICSC # 0288).	
Additional information		

ICSC: 0052	© CEC, IPCS, 1990	Lead (inorganic)

Appendix Q: Pathways of Human Lead Exposure

The following diagram shows the different ways that humans can be exposed to lead. The United Nations Environmental Programme provided this diagram (UNEP, 1996).



This transparency explains the pathways through which lead reaches humans. This can be used when giving an introduction to lead-acid battery recycling, and explaining the dangers involved.

Appendix R: Contact Information

Liaison

Dr. Ronald Arrieta
Professor de Química, UCR
Tel.: (506) 255-3711

Baterías de El Salvador

Saul Rosa
Representative
Tel.: (503) 281-7777
(503) 281-7766

Baterías Record de Costa Rica, S.A.

Luis Romero
Contador Privado
Tel.: (506) 258-2868

Centro Nacional de Produccion Mas Limpia

Dr. Sergio Musmanni
Director
Tel.: (506) 281-0006 Ext: 144

Ing. Carlos Perera
Sub-Director
Tel.: (506) 281-0006 Ext. 144

Importer

Randolph Armrhein
Tel.: (506) 257-2120
(506) 220-3338
(506) 284-2964

Ministerio de Salud

Ing. Orlando Rodríguez
Jefe de Unidad Tecnica Especializada
Tel.: (506) 255-3711

Recoprimax, S.A.

Erik Jimenez
Owner
Tel.: (506) 254-1360
(506) 222-8617

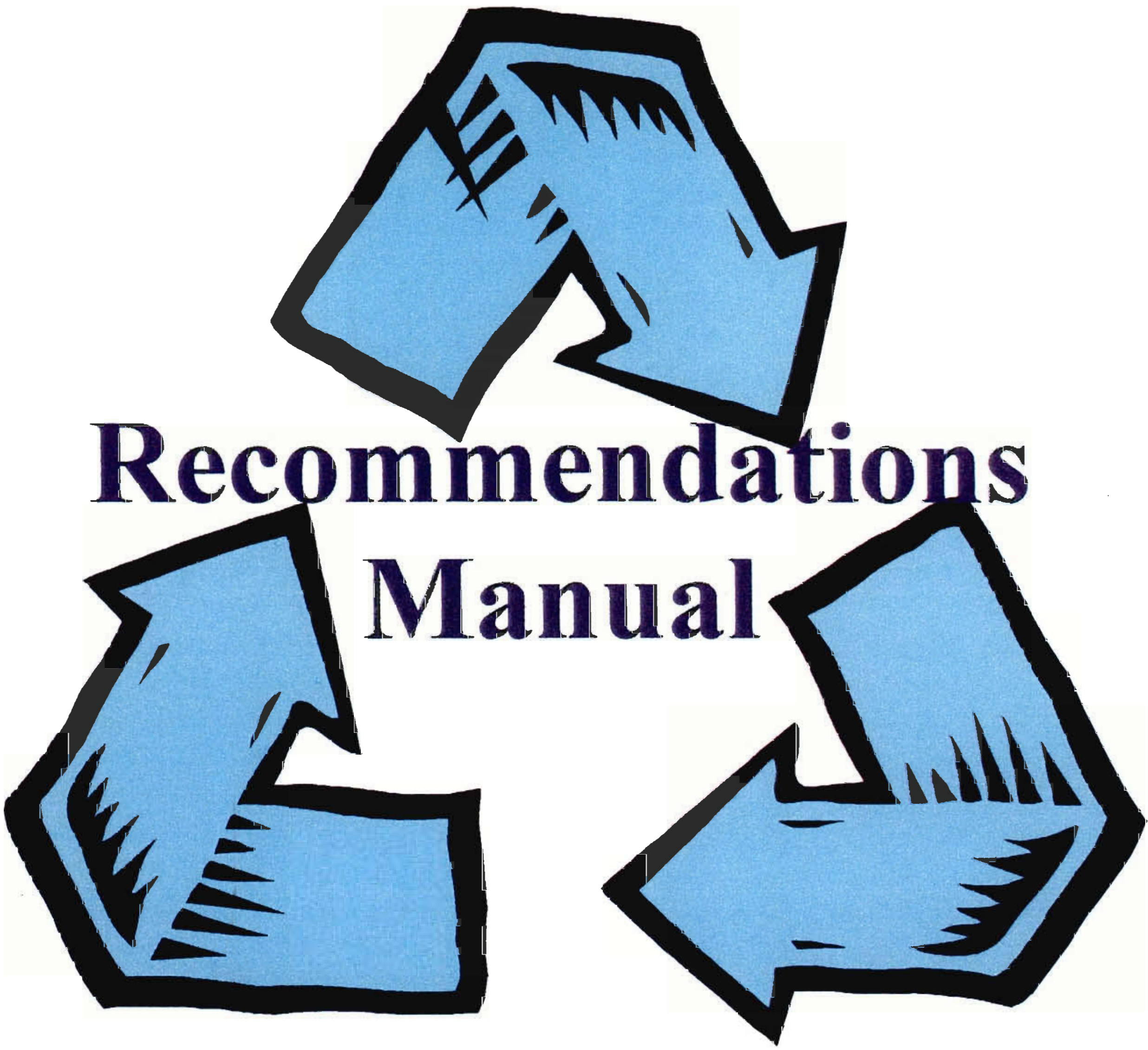
Recuperadora Nacional de Plomo, S.A.

Ana Gonzalez
Lead Smelter
Tel.: (506) 272-0561

Appendix S: Recommendations Manual

The following is a recommendations manual that we submitted to our liaison as a supplement to this report. It contains a summary of all the important facts along with the recommendations to implement a lead-acid battery recycling program in Costa Rica.

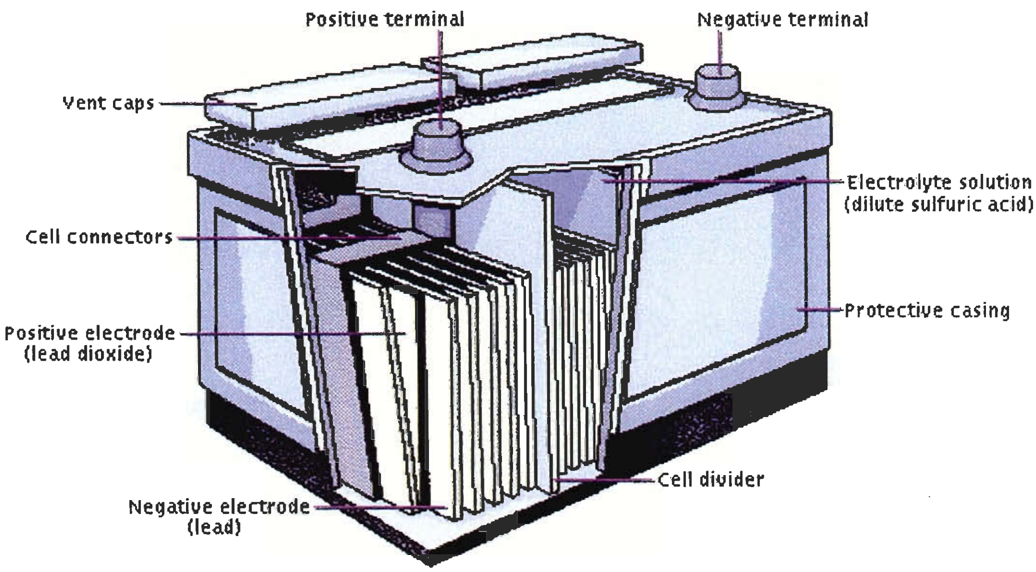
Lead-Acid Battery Recycling in Costa Rica



Recommendations Manual

Developed by:
Jill Pouliot
Jason Trovato
Kristina Yim

Components of a Lead-Acid Battery (Encarta Online, 2001)



In order for a product to be recycled all of its components must be recyclable (ILMC, 2001). The modern lead-acid battery is made up of:

- A plastic container, which is usually made of polyethylene, but more and more are being made from alternative co-polymers or reinforced, but the case material can be metallic or a synthetic rubber.

- Positive and negative internal lead plates. The positive electrode (cathode) typically consists of pure lead dioxide supported on a metallic grid, whereas the negative electrode (anode) consists of a grid of metallic lead alloy containing various elemental additives that includes one or more of the following and sometimes others not mentioned, antimony, calcium, arsenic, copper, tin, strontium, aluminum, selenium and more recently bismuth and silver. These alloying elements are used to change grid strength, corrosion resistance, reduce over-potential or maintenance, and internal resistance.

- Porous synthetic plate separators are increasingly made from rib-reinforced polyethylene, but are also available in PVC and fiberglass.

- The plates are immersed in a liquid electrolyte consisting of 35% sulfuric acid and 65% water. It is the electrolyte that facilitates the chemical reactions that enable the storage and discharge of electrical energy and permit the passage of electrons that provide the current flow.

- The positive and negative lead terminals used to connect the battery to the car and pass the current from the individual cells via a series of connecting lugs and bridges.

General Health and Safety Issues

The following are some general health and safety issues that must be considered when working with lead-acid batteries. For more detailed risks from the exposure to lead and sulfuric acid, please refer to the charts at the end of this section.

There are many health and safety issues associated with the contents of lead-acid batteries that are used in automobiles and other motor vehicles. Lead can be found in soil and water and is toxic when humans are exposed to it. Chronic and acute exposure includes breathing in lead particles and swallowing lead that has contaminated food and drinks. Lead exposure can lead to major health problems and repeated exposure causes buildup in the body. Low levels may cause tiredness, mood changes, headaches, weakness, and memory problems (Cheremisinoff & Cheremisinoff, 1993, p.13). Lead can also cause serious permanent kidney and brain damage at high levels. This exposure can also increase the risk of high blood pressure and can affect the central nervous system, especially during the early stages of a child's development (Buchanan, et al., 1996, p. 282). While working with batteries, humans can also be exposed to sulfuric acid, a corrosive chemical that can be fatal if ingested. The risks associated with working with sulfuric acid are explained in a later section entitled: Sulfuric Acid.

Those among the greatest risk from exposure to lead are fetuses, infants, and children under the age of seven (Cheremisinoff & Cheremisinoff, 1993, p.49). Pregnant women put their children at risk because the fetuses that they carry are at risk from a high level of lead in the mother's blood. Children may have lead poisoning without having any symptoms. The only way to detect lead poisoning is with a blood-screening test.

Lead, in soil, has a very low mobility, which means once the soil is contaminated, the lead will not move to other areas. It will stay in the same area that it contaminated originally (Cheremisinoff & Cheremisinoff, 1993, p.12). Once the soil is contaminated, it usually remains contaminated. This has adverse consequences for soil fertility, the ability of the soil to grow crops, if the concentration of lead in the soil is high. In areas where there is contamination of lead, concentrations range from 2 to 200mg/kg with most samples being in the range of 5 to 25 mg/kg.

Lead in drinking water can increase a person's total lead exposure (Cheremisinoff & Cheremisinoff, 1993, p.13). Lead enters drinking water as a result of corrosion of materials contained in water distribution systems and household plumbing. When water stands in lead pipes or plumbing systems containing lead for several hours or more, the lead may dissolve into the drinking water.

Three charts follow that show the types of exposure, the symptoms, the prevention, and the first aid steps to take when exposed to sulfuric acid, inorganic lead, and lead oxide. The United Nations Environmental Programme provided the charts.

SULFURIC ACID

Type of Exposure	***Symptoms***	***Prevention***	***First Aid***
Inhalation	Sore throat, cough, labored breathing	Ventilation, local exhaust, or breathing protection.	Fresh air, rest, half-upright position, artificial respiration if indicated, and refer for medical attention.
Skin	Pain, serious skin burns.	Protective gloves, protective clothing.	Remove contaminated clothes, rinse skin with plenty of water or shower, and refer for medical attention.
Eyes	Pain, severe deep burns.	Face shield or eye protection in combination with breathing protection	First rinse with plenty of water for several minutes (remove contact lenses if easily possible) then take to doctor.
Ingestion	Severe pain, vomiting, shock.	Do not eat, drink, or smoke during work.	Rinse mouth, give plenty of water to drink, do not induce vomiting, and refer for medical attention.

LEAD (INORGANIC)

Type of Exposure	*Symptoms*	*Prevention*	*First Aid*
Inhalation	Headache, nausea, abdominal spasm.	Local exhaust or breathing protection.	Fresh air, rest, and refer for medical attention.
Skin			
Eyes			
Ingestion	Headache, nausea, sore throat, abdominal spasm	Do not eat, drink, or smoke during work.	Rinse mouth, induce vomiting (only in conscious persons) and refer for medical attention.

LEAD (II) OXIDE

Type of Exposure	*Symptoms*	*Prevention*	*First Aid*
Inhalation	Cough, headache, nausea.	Local exhaust or breathing protection.	Fresh air, rest, and refer for medical attention.
Skin	Redness.	Protective gloves	Remove contaminated clothes, rinse skin with plenty of water or shower.
Eyes	Redness, pain.	Safety goggles.	First rinse with plenty of water for several minutes (remove contact lenses is easily possible) then take to a doctor.
Ingestion	Abdominal cramps, constipation, diarrhea, headache, nausea, vomiting.	Do not eat, drink, or smoke during work.	Rinse mouth, give nothing to drink, and refer for medical attention.

Recycling Process

The recycling of lead-acid batteries is an intricate process due to the many components of the battery that can be recycled (Bourson, 1995, p.81). These components are lead materials (metallic, oxide, and sulfate), plastic (polypropylene), residues (fibers, ebonite, and separators), and acid (sulfuric). The actual process of recycling the batteries can be divided into the following sections: the breaking of the batteries, the smelting of lead, the refining of lead, recycling the plastic, and recycling the sulfuric acid.

The breaking of batteries is the process of separating the battery into its components (Jolly & Rhin, 1994, pp. 141-142). The batteries are crushed, and the individual components are separated based on their physical properties, such as particle size and density. Battery paste, consisting of lead oxide and lead sulfate, are separated first, and then the remaining fragments are crushed again. Polypropylene is successfully separated from the ebonite and separators by hydraulic separation, which utilizes the different densities of the remaining components (ebonite, density=1.3; polypropylene, density=.9; lead, density=11.4).

The next section of the recycling process is lead smelting. Lead smelting is the process of producing crude lead from the battery paste (Bourson, 1995, pp.81-82). Rotary furnaces are generally used in this process due to their ability to be interrupted without causing disruption of the final goal, the wide range of materials that can be used, such as drosses, flue dust, and filter-press cakes, and the low amount of waste emptied into the environment. The rotary furnace is a tilting furnace, so it can easily pour the liquid lead into ladles, which will then be poured into kettles that will undergo refining in the next stage. Being equipped with a gas-oxygen burner, the rotary furnace produces less gas that will need to be cleaned before it can be released into the environment. The process gases are mixed with the atmospheric air in order to cool the gases to roughly 100 degrees Celsius, and then the gases are filtered through a bag filter.

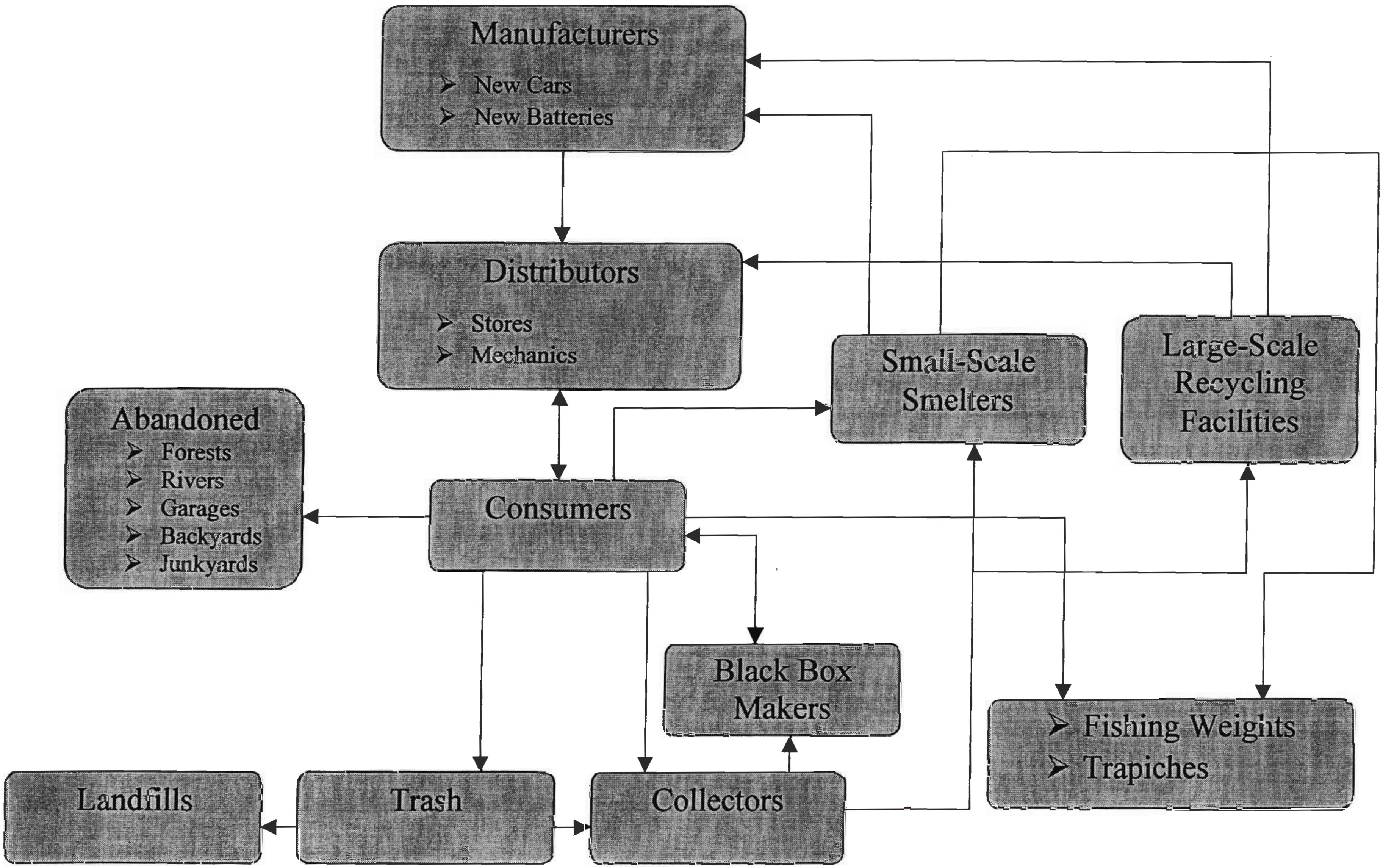
The next stage of the recycling process is the refining stage (Bourson, 1995, p. 82). The liquid lead is refined to the specifications of its use through stirrers at specific temperatures. The now refined lead is moved to the casting machine, which will mold the liquid lead into different products. How the lead is treated will determine what the final product will be. Through the process described above, most of the lead from lead-acid batteries is reused.

After the battery is broken and the individual components are separated, the plastic pieces, usually polypropylene, are washed and dried and sent to a plastics recycler (ILMC, 2001). There the plastic chips are melted and then molded into pellets for use in the manufacture of new lead-acid batteries.

Sulfuric acid can be recycled in four different methods (ILMC, 2001). One method is to neutralize it with a base so that it meets clean water standards and then release it into the public sewer system. The second method of recycling the acid is to reclaim it from the spent batteries and top it off with new, concentrated acid and then reuse it in new batteries. The third method is to chemically treat the acid and convert it to either an agricultural fertilizer using ammonia or to a powered sodium sulfate for use in the glass and textile manufacturing industry or as a filler or stabilizer in household laundry detergent. The final method of recycling sulfuric acid is to convert it to gypsum for use in the production of cement or by the construction industry in the manufacture of fiberboard.

Informal Lead-Acid Battery Recycling in Costa Rica

Upon our arrival in Costa Rica, we were under the impression that there was no lead-acid battery-recycling program in effect. Early in our research, we found that there is indeed an extremely informal lead-acid battery-recycling process in existence in urban areas. We investigated each step in the current informal process and have analyzed each step in the subsequent sections. We also found out what costs are involved at each level of the process. These include how much each person gets paid for the used batteries at the different levels of the collection and recycling process. In Figure 5.1, which follows, we have made a chart describing how the informal lead-acid battery recycling process works in Costa Rica. The text following the chart explains in detail the different sections and how they work.


Manufacturers
New Cars
New Batteries
Distributors
Stores
Mechanics
Small-Scale Smelters
Large-Scale Recycling Facilities
Abandoned
Forests
Rivers
Garages
Backyards
Junkyards
Consumers
Black Box Makers
Fishing Weights
Trapiches
Landfills
Trash
Collectors

The process starts with a new battery being sold for 10,000-35,000 colones, depending on the size and brand of battery. The vendor makes a 20-35% profit on the batteries that they sell. From here, the consumers have the battery and then they have to determine how they want to dispose of the dead battery when they buy a new one. The battery can either end up abandoned in forests, rivers, backyards, garages, or junkyards, or in the trash, which can go to landfills or to collectors. The consumers can also bring the battery directly to a collector. The collectors sometimes pay 150-200 colones for the used batteries, or they are given to them for free. The consumers can also bring their batteries directly back to the consumers when they buy a new battery. Some stores will give up to 2,000 colones discount off of a new battery when you trade in the old one. The consumer can also bring their battery to a black box maker and just drop it off for free or some of them may pay up to 500 colones per battery. The consumers may also give their batteries to trapiches, which are places that burn the plastic cases and covers to make candy and sweets.

When a collector has a battery, there are a couple of options that he has for recycling the batteries. He can either sell it to a larger collector for 18-20 colones per kilogram, to a small-scale recycling facility for 18 colones per kilogram, or if it is one of the six larger collectors in the country, they can sell the batteries to a large-scale recycling facility for 26-29 colones per kilogram.

From the small scale smelting facilities, they sell the recycled lead ingots to battery manufacturers for 243,750-250,250 colones per ton. The small-scale smelters may also sell their lead to be used for fishing weights. When a large-scale recycling facility gets the batteries, they recycle them and make either new batteries or new lead plates. They sell the batteries to stores or car manufacturers and they sell the lead plates to the black box battery makers or other battery manufacturers.

Recommendations for Implementing a Recycling Program in Costa Rica

After doing our research and investigation of the lead-acid battery situation Costa Rica, we developed a set of recommendations for how to improve the current situation. We have come up with two different options, one that consists of a total reconstruction of the current system, and another that consists of modifying the current system in order to utilize some of its strengths and fix some of its weaknesses.

Public Awareness

We recommend an educational campaign concerning the importance of recycling lead-acid batteries be established throughout the entire country of Costa Rica. This campaign should address not only the importance of resource conservation, but also the health and environmental hazards that can occur by not recycling lead-acid batteries. This campaign should include educational posters, or pamphlets describing in detail the effects of lead and sulfuric acid on the human body and the environment. A possible sponsor of this educational campaign could be Centro Nacional de Producción Más Limpia, considering the fact that they have already published posters on the importance of recycling. A second possibility could be the International Lead Management Center since they are a major contributor to the Basel Convention, which is going to be held in the fall of 2001 in order to discuss the organization of a formal lead-acid battery recycling program in Central America. These should be available in all places where a lead-acid battery can be purchased.

Funding for a Recycling Program

Throughout our recommendations, we make many references to incentives, costs, and facilities that would arise if the suggestions we made are followed. For any recycling program to be successful, outside funding is necessary. In this case, we hope that Costa Rica will receive funding from the United Nations, el Centro Nacional de Produccion Mas Limpia, and the local government, namely the Ministry of Health.

Total Reconstruction of Current System

We recommend that all points of purchase for lead-acid batteries be mandated to take back the spent lead-acid battery when a new battery is purchased. This should be strongly enforced by the government, which may prove to be a difficult task due to the lack of regulatory enforcement at the present time. In order to encourage these stores to collect and store the spent batteries, an economic incentive must be offered. Basing this incentive on those offered in Massachusetts, the stores should be offered a flat price for each battery they collect, roughly 200-250 colones per battery. An incentive might also need to be offered if the vendors are required to transport the batteries to a larger collection facility. This will eliminate any improper disposal of lead-acid batteries in forests, rivers, backyards, garages, and landfills because there will be no chance for the small-scale smelters to buy these spent batteries. This will also discourage the current practice of reconditioning batteries where the acid is often carelessly disposed of in rivers and soil. It will also minimize the improper handling and smelting of lead in homes, which can emit harmful toxins into the air. Offering incentives to consumers can enhance this take-back program. Our recommendation is to offer consumers a discount of at least five percent off of their new battery when they bring back their old one. This will encourage consumers to participate in the program because they have an incentive to bring their battery back. This may mean that vendors will have to raise their battery prices by five percent to counter the five percent "given back" to the consumer, which will make the system work better in the long run.

While each point of purchase for lead-acid batteries will serve as a small storage facility, we recommend that there be one larger, central facility located in each of the seven provinces of Costa Rica. The size of these facilities will depend on the population of the province. For example, in the San Jóse area, a warehouse may be ideal location, such as Baterías Record located in the "El Pacifico" area of the city. However, in the less populated areas, a larger store or garage may be sufficient. Based on our data on the collectors in place now, unsafe methods of disposing of the sulfuric acid are being practiced, which is why a certified warehouse qualified to dispose of acid safely is suggested. If a law were to be passed and enforced governing the proper disposal of sulfuric acid, then the current collectors could remain as the larger collection facilities throughout the area if they abide by the new laws that are passed. The batteries from each of the points of purchase will be collected and transported to the larger collection facilities by truck at least once every month, depending on the volume of batteries collected. These trucks may be provided by the government if there is the funding to do so, or by any other sponsoring agency. If there is no outside funding, then it may be necessary to provide an incentive to the vendors to transport the batteries to the central collection facilities in their region. This may be in the form of a law mandating them to do so or a monetary incentive. Based upon our analysis of the system as it is now, El Salvador pays the larger collectors roughly 500 colones per battery to be recycled. If the vendors were offered half of that price, 250 colones per battery, to transport the batteries to the larger collectors, then both sides would be receiving payment and be encouraged to participate in the program.

The batteries from each of the larger collection facilities will have to be transported to a recycling facility. Our recommendation is to ship the batteries to Baterías de El Salvador, where many batteries from Costa Rica are currently sent. Based on our conversation with Luis Romero of Baterías Record, the facility in El Salvador can handle the increase in batteries from Costa Rica each year and would welcome the business. The facility in El Salvador sub-contracts a transportation company to pick up the batteries from the collection sites and bring them to El Salvador. This means that the transportation from Costa Rica to El Salvador is paid for by Baterías de El Salvador.

While the recommendations above apply to all batteries purchased after the program is in effect, there are still many used batteries that remain in consumers' houses, backyards, landfills, and roadsides. Our recommendation to improve upon this problem is to hold a one-time collection of these spent batteries. The consumers would need to bring any spent batteries they have around their homes to a designated collection point, and in return they would receive a payment of at least 500 colones per battery. The payment to the consumers can be paid for by splitting the cost between the collectors and the government. As it is, the collectors are paying for their old batteries, so they can continue to do so, while whatever remaining costs can be covered by the government or any other outside sources. We feel that anything less than 500 colones will not be enough of an incentive to encourage the consumers to bring in their batteries. Hopefully by offering this incentive to landfill workers, it will encourage them to bring in those batteries that are currently in landfills.

Model Laws

It is our recommendation that laws be passed to govern the disposal of lead-acid batteries. These laws will help to regulate the recycling of lead-acid batteries in Costa Rica. One example of a law that would need to be passed and then enforced is a law that makes it illegal and punishable by fines to dispose of lead-acid batteries in regular municipal solid waste. There should also be a law passed regulating the disposal of lead, sulfuric acid, and plastic. This law should mandate that each of these materials be recycled properly, as described in Recycling Process section. Another example is a law that makes it mandatory for all points of purchase to collect the used batteries when a new one is sold to the consumer. This law should also state that the vendors are punishable by fine if they do not take back the old batteries from the consumers. While we feel these laws are necessary to ensure the success of a recycling program implemented in Costa Rica, we are unsure of the support the local government will provide, considering the lack of support we have already witnessed.

Building Upon the Current System

There are some aspects of the current system that work well and could be made to work more efficiently if a few changes are made. The first change that would need to be made would be in new laws. There would have to be laws passed that regulate the disposal of each of the toxic contents of the lead-acid battery: the lead and the sulfuric acid. Currently, the lead is either being smelted in homes or thrown away, and the acid is dumped into rivers and the soil. The law passed regulating the disposal should prohibit the disposal of lead and sulfuric acid in the municipal solid waste, as well as mandating that all sulfuric acid be chemically treated to neutralize it. If the smelters and "black box" battery makers are allowed to stay in business, then there must be laws passed to regulate the ventilation that comes with lead smelting. This would include the emissions and imissions that are created when lead is smelted.

Recommendations for the Future

There were some limitations that we had on our project due to the time constraints that we had in Costa Rica. There are some aspects that need to be investigated further in order to gain a better understanding of the problem and to help make a recycling program a success. We recommend that the recycling situation in the rural areas of Costa Rica be investigated further in order to gain a better understanding of the situation in the areas outside of San Jóse. Due to the insufficient amount of time, we were unable to conduct an investigation outside of the urban area of San Jóse and do not know what exactly happens to the used lead-acid batteries in the rural areas of Costa Rica. The only information we do know is that we conducted two interviews in the Quepos area and they said they do not have any type of collection system there. The batteries are likely thrown away in the garbage with all other waste. A further investigation of the situation and possibly some better solutions should be investigated in this area.

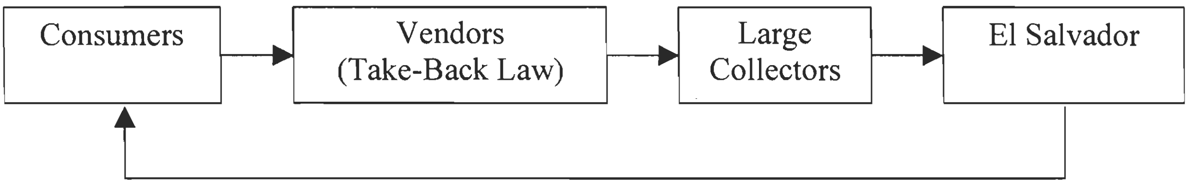
On the following page are two flow charts describing the life cycle of a battery after the program is implemented. One chart shows the life cycle if a totally reconstructed system was implemented and the other shows the life cycle if the current system was modified.

The following recommendations were made during the discussion following our final presentation on June 28, 2001. Dr. Ronald Arrieta told us that there are laws in effect that regulate the disposal of all waste. However, Dr. Arrieta also told us that it is difficult for the Costa Rican people to follow laws considering that they are poorly enforced. He suggested that there be a higher deposit for used batteries in order to gain the cooperation of the people. He suggested a deposit of 5,000 colones per battery. It was also suggested to have local drop-off centers for batteries that need to be disposed of if a new battery is not going to be purchased. This would most likely occur when a vehicle has reached the end of its life and is going to be sent to the scrap yard.

There would also need to be a high economic incentive, roughly 20% of the original battery price, for people to bring batteries from these situations to the drop-off center. During this discussion, it was determined that there would be no government support for a formal battery recycling system if one were to be implemented in Costa Rica. The support would need to come from a coalition of private initiatives, such as el Centro Nacional de Producción Más Limpia, the Ministry of Health, the Basel Convention and private investors.

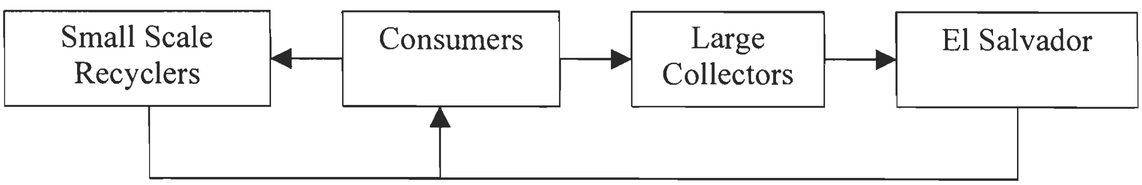
Total Reconstruction:

In the new system, the used battery starts at the consumers and from there it goes directly back to the vendors. From the vendors, they are transported to the large collectors and then picked up by Baterías de El Salvador to be recycled.



Modification of Current System:

The used battery starts at the consumers and from there can go to a small-scale recycler or to one of the large collectors. From the large collectors, Baterías de El Salvador picks the batteries up and transports them to El Salvador to be recycled. In the new system, the small-scale smelters follow laws to make their operations safe to the environment and themselves.



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Appendix T: Recommendations Manual (Spanish)

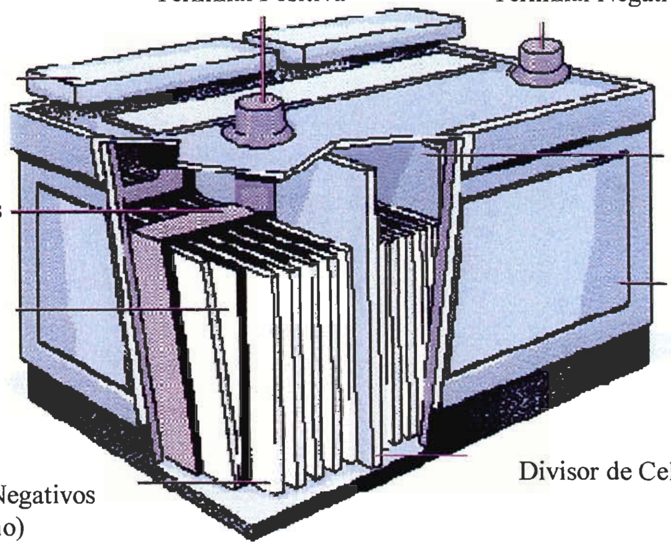
The following is a recommendations manual in Spanish that we submitted to our liaison as a supplement to this report. It contains a summary of all the important facts along with the recommendations to implement a lead-acid battery recycling program in Costa Rica.

El Reciclaje de las Baterías de Plomo Ácido en Costa Rica

Manual de Recomendaciones

Desarrollado por:
Jill Pouliot
Jason Trovato
Kristina Yim

Componentes de una Batería de Ácido y Plomo (Encarta en línea, 2001)



A fin de que un producto pueda ser reciclados, todos sus componentes deben ser reciclables. La batería moderna de ácido y plomo está hecha de:

- Un contenedor de plástico el cual usualmente está hecho de polietileno, pero cada vez más y más están hechas de co-polímeros alternativos o reforzados, pero el material de la caja puede ser de metal o caucho sintético.

- Placas de plomo positivas y negativas. El electrodo positivo (cátodo) generalmente consiste de dióxido de plomo puro el cual tiene como soporte una malla metálica en donde también el electrodo negativo (ánodo) consiste de una malla de una aleación metálica que contiene varios aditivos elementales entre los cuales se incluyen uno o más de los siguientes y a veces otros no mencionados, antimonio, calcio, arsénico, cobre, estaño, estroncio, aluminio, selenio y recientemente bismuto y plata. Estos elementos de aleación se usan para cambiar la fortaleza de la malla, resistencia a la corrosión, reducir el sobre calentamiento o mantenimiento, y la resistencia interna.

- Los separadores, los cuales son sintéticos y porosos cada vez más están hechos de polietileno reforzado, pero también están disponibles en PVC y fibra de vidrio.

- Las placas se sumergen en una solución líquida de electrolitos que consiste de 35% de ácido sulfúrico y 65% de agua. Es el electrolito el que facilita las reacciones químicas que permiten el almacenamiento y descarga de energía eléctrica y permite el paso de electrones que proveen el flujo eléctrico.

- Las terminales de plomo (negativas y positivas) las cuales se usan para conectar la batería al carro y que pase la corriente desde las celdas individuales hacia una serie de puentes y agarraderas los cuales están conectados entre sí.

Consideraciones sobre la Salud y la Seguridad

Los siguientes son algunos asuntos sobre salud y seguridad que se deben tomar en cuenta cuando se trabaja con baterías de ácido y plomo. Para riesgos más detallados sobre la exposición al plomo y al ácido sulfúrico, por favor refiérase a los cuadros al final de esta sección.

Hay muchas consideraciones sobre salud y seguridad que se asocian con los contenidos de las baterías de plomo y ácido usadas en automóviles u otros vehículos de motor. El plomo se puede encontrar en la tierra y el agua y es tóxico para los humanos si estos se exponen a ellos. Exposiciones crónicas incluyen respirar partículas de plomo y tragar el plomo que ha contaminado los alimentos y las bebidas. La exposición al plomo puede conllevar a mayores problemas de salud y la exposición continua produce una acumulación en el cuerpo. Niveles bajos pueden causar sueño, cambios de humor, dolores de cabeza, debilidad y problemas de memoria (Cheremisinoff & Cheremisinoff, 1993, p.13). El plomo, en niveles altos, también puede causar serios y permanentes daños en el cerebro y los riñones. Esta exposición también puede incrementar el riesgo de presión alta y puede afectar el sistema nervioso central, especialmente durante las primeras etapas del desarrollo de un niño (Buchanan, et al., 1996, p.282). Mientras trabajan con baterías, los humanos también se exponen al ácido sulfúrico, un químico corrosivo que puede ser fatal si se ingiere. Los riesgos que se asocian al trabajar con ácido sulfúrico se explicarán en otra sección titulada: Ácido Sulfúrico.

Entre los más afectados debido la exposición al plomo están los fetos y los niños menores de siete años (Cheremisinoff & Cheremisinoff, 1993, p.49). Las mujeres embarazadas ponen en riesgo a sus niños porque los fetos les afecta el alto nivel de plomo en la sangre de la madre. Los niños pueden intoxicarse con plomo sin haber presentado síntomas. La única manera de detectar el envenenamiento con plomo es a través de un examen de sangre.

El plomo en la tierra, tiene una movilidad muy lenta, lo que significa que una vez contaminado el suelo, el plomo no se desplazará a otras áreas. Se quedará en la misma área que contaminó originalmente (Cheremisinoff & Cheremisinoff, 1993, p.12). Si la tierra se contamina, usualmente se queda contaminada. Esto tiene consecuencias adversas para la fertilidad del suelo, la capacidad de éste para dar crecimiento a los cultivos, si la concentración de plomo en el suelo es alta. En áreas donde hay contaminación de plomo, las concentraciones varían de 2 a 200 mg/kg mientras que la mayoría de las muestras varían de 5 a 25 mg/kg.

El plomo en agua para beber pueden incrementar la exposición total de la persona al plomo (Cheremisinoff & Cheremisinoff, 1993, p.13). El plomo se combina con esta agua como resultado de la corrosión de materiales de los sistemas de distribución de aguas y la tubería de las casas. Cuando el agua se queda por varias horas en tubos de plomo o en un sistema de plomería que contenga plomo, ése se puede disolver y mezclarse con el agua.

En los siguientes tres cuadros se muestran los tipos de exposición, los síntomas, la prevención y los pasos de primeros auxilios que hay que llevar a cabo cuando hay exposición al ácido sulfúrico, plomo orgánico y óxido de plomo. El Programa Ambiental de Las Naciones Unidas facilitó estos cuadros.

ÁCIDO SULFÚRICO

Tipo de Exposición	*Síntomas*	*Prevención*	*Primeros auxilios*
Inhalación	Dolor de garganta, tos, dificultad al respirar.	Ventilación, extractores de aire, o protector de respiración.	Aire fresco, descanso, posición mita hacia arriba, respiración artificial si se indica, buscar atención médica.
Piel	Dolor, quemaduras.	Guantes protectores, ropa protectora	Quitar ropa contaminada, lavar la piel con bastante agua o ducharse y buscar atención médica.
Ojos	Dolor, quemaduras severas y profundas.	Protector para ojos o cara en combinación con de protector de respiración.	Primero lave con suficiente agua por varios minutos (quitar lentes contacto suavemente) llevar al doctor
Ingestión	Dolores fuertes, vómito, shock.	No comer, beber o fumar mientras trabaja.	Lavar la boca, dar mucha agua para tomar, no inducir al vómito, buscar ayuda médica

PLOMO (INORGÁNICO)

Tipo de Exposición	*Síntomas*	*Prevención*	*Primeros Auxilios*
Inhalación	Dolor de cabeza, náuseas, espasmos abdominales.	Extractores de aire o protector de respiración.	Aire fresco, descanso, y atención médica.
Piel			
Ojos			
Ingestión	Dolor de cabeza, náuseas, dolor de garganta, espasmos abdominales.	No comer, beber o fumar durante el trabajo.	Lavar la boca, inducir al vómito (sólo en personas consientes) y acudir al médico.

PLOMO (II) ÓXIDO

Tipo de Exposición	*Síntomas*	*Prevención*	*Primeros Auxilios*
Inhalación	Tos, dolor de cabeza, náuseas.	Extractores de aire o protector de respiración.	Aire fresco, descansar, buscar atención médica.
Piel	Irritación.	Guantes protectores.	Remover ropa contaminada, lavar la piel con bastante agua o ducharse.
Ojos	Irritación, dolor.	Anteojos de seguridad	Primero lavar con suficiente agua por varios minutos (remover lentes de contacto suavemente) llevar al doctor.
Ingestión	Calambres abdominales, diarrea, estreñimiento, dolor de cabeza, náuseas, vómito.	No comer, beber o fumar mientras trabaja.	Lavar la boca, dar mucha agua para tomar, no inducir al vómito, buscar ayuda médica.

El Proceso de Reciclaje

El reciclaje de una batería de plomo y ácido es un proceso complicado debido a los muchos componentes de la batería que pueden ser reciclados (Bourson, 1995, p.81). Estos componentes son materiales de plomo (metálico, óxido y sulfato), plástico (polipropileno), residuos (fibra, ebonita y separadores), y ácido (sulfúrico). El proceso de reciclaje de las baterías se puede dividir en las siguientes secciones: el rompimiento de las baterías, la fundición del plomo, el refinamiento del plomo, el reciclaje del plástico y el reciclaje del ácido sulfúrico.

El rompimiento de las baterías es el proceso de separar las baterías por componentes Jolly & Rhin, 1994, pp. 141 – 142). Las baterías se trituran, y los componentes individualmente se separan basándose en sus propiedades físicas tanto por el tamaño de sus partículas como por su densidad. La pasta de batería, la cual consiste de óxido de plomo y sulfato de plomo, primero se separan, y después, los fragmentos restantes se trituran otra vez. El polipropileno se separa exitosamente de la ebonita y los separadores bajo separación hidráulica, los cuales utilizan las diferentes densidades de los componentes restantes (ebonita, densidad = 1.3; polipropileno, densidad = 0.9; plomo, densidad = 11.4).

La siguiente sección del proceso de reciclaje es la fundición del plomo. Este es un proceso de producir plomo bruto a partir de la pasta de batería (Bourson, 1995, pp. 81 - 82). Generalmente, en este proceso se utilizan hornos rotatorios debido a su capacidad de ser interrumpidos sin causar ningún trastorno en la meta final, una amplia gama de materiales puede ser utilizada, por ejemplo escorias, polvo de conducto de humo y la pequeña cantidad de residuos que va al ambiente. El horno rotatorio es un horno que gira, entonces puede verter el plomo líquido dentro de los calderos, y el cual después se vierte en hervidores para que en la siguiente etapa sea refinado. Al estar equipado con un quemador de oxígeno, el horno rotatorio produce menos gas del que necesita para limpiarse antes de que se libere al ambiente. Los gases procesados se mezclan con el aire atmosférico para que se enfríen bruscamente hasta los 100 °C, y después los gases se filtran en un filtro de bolsa.

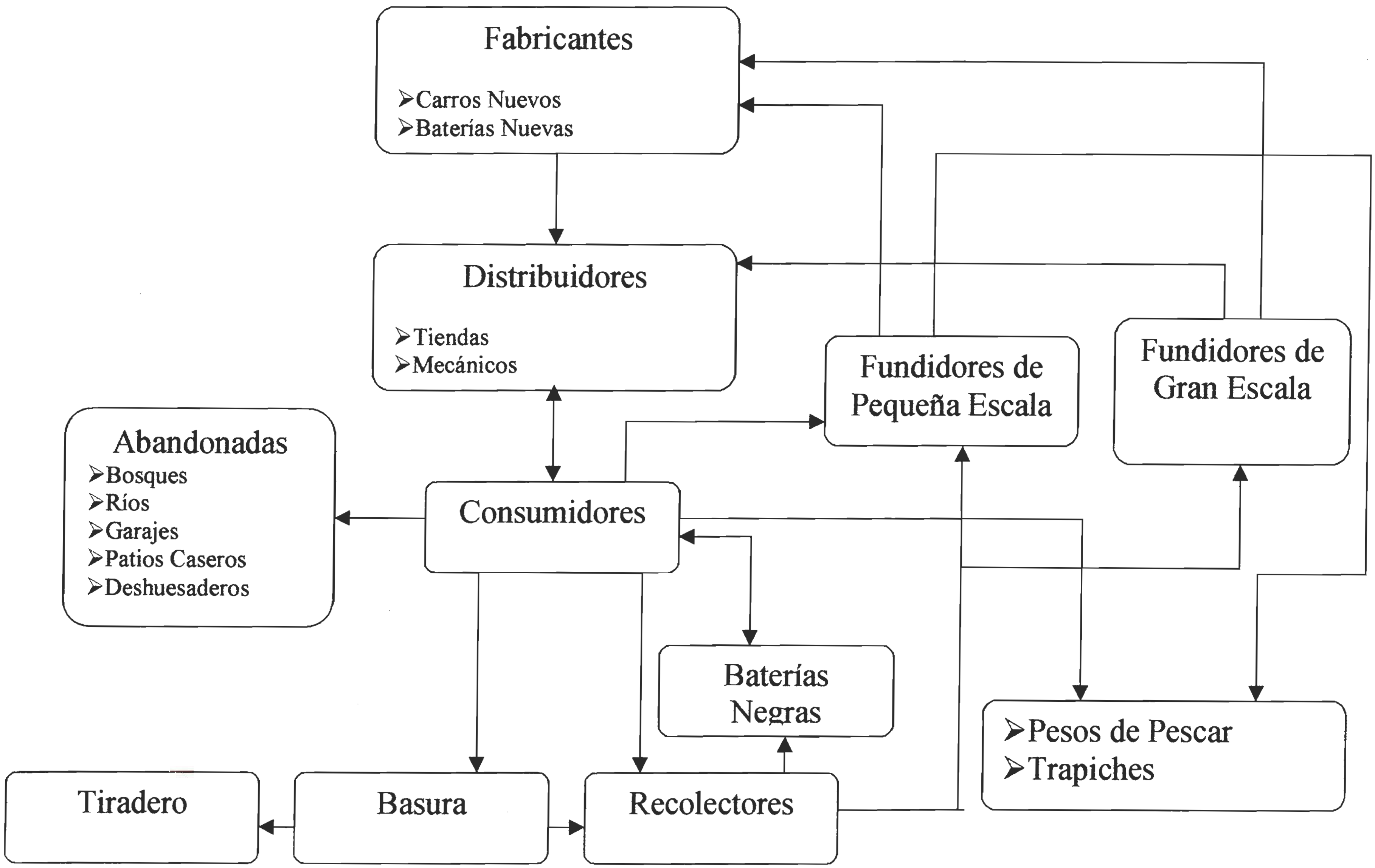
La siguiente etapa del proceso de reciclaje es el refinamiento (Bourson, 1995, p.82). El plomo líquido se refina de acuerdo con sus especificaciones de uso a través de agitadores a temperaturas específicas. El plomo que ahora está refinado se pasa a los moldes los cuales transformarán el plomo líquido en diferentes productos. La manera de tratar el plomo determinará las características del producto. A través del proceso descrito anteriormente, la mayoría del plomo de las baterías de plomo y ácido es reutilizado.

Después de que la batería se rompe y los componentes individuales se separan, las piezas plásticas, usualmente polipropileno, se lavan y se secan y se mandan a una recicladora de plásticos (ILMC, 2001). Allí, las piezas plásticas se derriten y se moldean para hacer pelletes para utilizarlos en la producción de nuevas baterías de plomo y ácido.

El ácido sulfúrico se puede reciclar por medio de cuatro métodos diferentes (ILMC, 2001). Un método es neutralizándolo con una base para que se mezcle con agua limpia para pasarlo por el sistema de alcantarillado público. El segundo método para reciclar ácido es sacándolo de las baterías gastadas y completando la cantidad con ácido nuevo y concentrado para después reutilizarlo en baterías nuevas. El tercer método es tratar el ácido químicamente y convertirlo ya sea en un fertilizante para agricultura usando amoníaco o en un sulfato de sodio en polvo para utilizarlo en la industria de vidrios y textiles o como un relleno o estabilizador en detergentes para lavandería. El método final de reciclar ácido sulfúrico es convirtiéndolo en gypsum para utilizarlo en la producción de cemento o en la industria de construcción para producir fibropaneles.

Reciclaje Informal de Baterías de Ácido y Plomo en Costa Rica

Al llegar a Costa Rica, quedamos impresionados al ver que no había un programa de reciclaje de baterías de plomo y ácido. Al principio de nuestra investigación encontramos que existe un proceso extremadamente informal que se practica en zonas urbanas. Nosotros investigamos cada paso en este proceso y lo analizamos en las secciones subsiguientes. También encontramos cuáles son los costos de cada uno de los niveles del proceso. Esto incluye cuánto gana cada persona por las baterías usadas en las diferentes etapas del proceso de la recolección y del reciclaje. En la figura a continuación, hemos creado un esquema resumen que describe cómo trabaja en Costa Rica el proceso de reciclaje de las baterías de plomo y ácido. El texto que sigue este esquema explica en detalle las diferentes secciones y también cómo trabaja cada una de ellas.


Fabricantes
➢Carros Nuevos
➢Baterías Nuevas
Distribuidores
➢Tiendas
➢Mecánicos
Fundidores de Pequeña Escala
Fundidores de Gran Escala
Abandonadas
➢Bosques
➢Ríos
➢Garajes
➢Patios Caseros
➢Deshuesaderos
Consumidores
Baterías Negras
➢Pesos de Pescar
➢Trapiches
Tiradero
Basura
Recolectores

El proceso comienza con una nueva batería que se vende por ¢10. 000 - ¢35. 000, dependiendo del tamaño y la marca de ésta. El vendedor obtiene de 20-35% de ganancia por las baterías que venda. De aquí, los consumidores consiguen la batería y tienen que determinar qué van a hacer con la batería cuando ésta muera y tenga que comprar una nueva. La batería puede ya sea terminar abandonada en bosques, ríos, patios, cocheras o hueseras, o en la basura, las cuales de ahí pueden ir a rellenos sanitarios o a recolectores. Los consumidores también pueden llevar la batería directamente al recolector. Los recolectores generalmente pagan de ¢150 - ¢200 por las baterías usadas o las obtienen regaladas. Los consumidores también pueden regresarlas directamente donde la compraron cuando van por una nueva. Algunos negocios dan un descuento de ¢2. 000 al comprar una batería nueva cuando se cambia por la vieja. El consumidor también puede llevar la batería a un productor de cajas negras y regalarlas o algunos de ellos pagan ¢500 por batería. Los consumidores también pueden regalarlas a los trapiches los cuales son lugares que queman las cajas y tapas de plástico para utilizarlas en la producción de confites y dulces.

Cuando el recolector consigue una batería, éste tiene una serie de opciones para reciclarlas. Él puede venderla a un recolector más grande por un precio de ¢18 - ¢20 por kilogramo, a una recicladora por ¢18 por cada kilogramo, o si es uno de los seis recolectores más grandes del país, puede vender las baterías a una recicladora de gran escala a ¢26 - ¢29 por kilogramo.

Las fundidoras de pequeña escala vende los lingotes de plomo a productores de baterías por ¢243, ¢250 ó ¢750 por tonelada. Los fundidores a pequeña escala también pueden vender el plomo para producir pesas para pescar. Cuando una recicladora de gran escala obtiene la batería, las recicla y hacen ya sea nuevas baterías o nuevas placas de plomo. Ellos venden las baterías a negocios o ensambladoras de carros y venden las placas a los productores de cajas negras para baterías u otros productores de baterías.

Recomendaciones al Implementar un Programa de Reciclaje en Costa Rica

Después de hacer nuestra investigación sobre la situación de las baterías de ácido y plomo en Costa Rica, hemos desarrollado una serie de recomendaciones de cómo mejorar la situación actual. Tenemos dos diferentes opciones, una que consiste en la reconstrucción total del sistema actual y otra que consiste en modificarlo a fin de utilizar algunas de sus fortalezas y arreglar algunas de sus debilidades.

Advertencia Pública

Recomendamos una campaña educacional que apoye la importancia de establecer un programa de reciclaje de las baterías de plomo y ácido en todo el territorio costarricense. Esta campaña no sólo debe estar dirigida a la importancia de la conservación de recursos, sino también a la salud y los desastres ambientales que pueden ocurrir al no reciclar las baterías de ácido y plomo. Esta campaña debe incluir afiches educacionales, o panfletos que describan en detalle los efectos del plomo y del ácido sulfúrico en el cuerpo humano y en el ambiente. Un posible patrocinador de esta campaña educacional puede ser el Centro Nacional de Producción Más Limpia, considerando el hecho de que ellos ya han publicado afiches sobre la importancia del reciclaje. Una segunda posibilidad puede ser el Centro Internacional de la Administración del Plomo ya que es uno de los contribuidores más grandes en la Convención de Basilea, la cual se llevará a cabo en el otoño de 2001 con la finalidad de discutir la organización de un programa formal de reciclaje en Centro América. Esto debe estar disponible en todos los lugares donde vendan baterías de plomo y ácido.

Financiación para un Programa de Reciclaje

En nuestras recomendaciones hacemos referencia a incentivos, costos y facilidades que surgirán si se siguen nuestras sugerencias. Para que cualquier programa de reciclaje sea exitoso, la financiación externa es necesaria. En este caso, esperamos que Costa Rica reciba la financiación por parte de las Naciones Unidas, el Centro Nacional de Producción Más Limpia, y el gobierno local, en otras palabras, el Ministerio de Salud.

Reconstrucción Total del Sistema Actual

Recomendamos que todo punto de venta de baterías de plomo y ácido tenga la obligación de recibir de vuelta la batería gastada en el momento de comprar una nueva batería. Esto debe ser forzado por el gobierno lo cual probaría ser una tarea difícil debido a la falta de regulación hoy día. A fin de motivar a estos negocios a recolectar y guardar las baterías gastadas, se debe ofrecer un incentivo económico. Basando este incentivo en los ofrecidos en Massachusetts, deberían de ofrecer a los negocios un monto fijo por cada batería que obtengan, más o menos de ¢200 - ¢250 por batería. Se necesitará dar un incentivo también si los vendedores requieren transporte para llevar las baterías a un colector más grande. Esto eliminaría cualquier evacuación impropia de las baterías de plomo y ácido en bosques, ríos, patios, cocheras y rellenos sanitarios porque así no habrá chance para las fundidoras de pequeña escala de comprar estas baterías gastadas. Esto también desmotivará la práctica actual de reacondicionar las baterías en donde el ácido es evacuado descuidadamente en ríos y en el suelo. También disminuirá la manera incorrecta de tratar y fundir el plomo en el hogar, el cual puede emitir toxinas dañinas hacia el aire. El ofrecer incentivos a los consumidores puede ayudar con este programa de devolución.

Nuestra recomendación es ofrecer al consumidor por lo menos un cinco por ciento de descuento en una batería nueva al traer la vieja. Esto motivará a los consumidores a participar en el programa porque tienen un incentivo al traer su batería devuelta. Esto significa que los vendedores tendrán que subir los precios de las baterías en un cinco por ciento para compensar el cinco por ciento que se ha "devuelto" al consumidor, lo cual hará que el sistema funcione mejor mientras se aplique.

Como cada punto de venta de baterías de plomo y ácido servirá de bodega, recomendamos que haya una central más grande que esté localizada en cada una de las siete provincias de Costa Rica. El tamaño de éstas dependerá de la población de la provincia. Por ejemplo, en el área de San José, un depósito puede ser el lugar ideal como Baterías Récord localizada en una zona de la ciudad llamada "El Pacífico". Sin embargo, en las áreas menos pobladas, un negocio más grande o un taller sería suficiente. Basándonos en los datos sobre los colectores que existen ahora, se están practicando métodos inseguros al evacuar el ácido sulfúrico. Si el gobierno pasara e hiciera cumplir una ley sobre la evacuación correcta del ácido sulfúrico, los colectores actuales seguirían siendo los mayores del área si ellos acataran estas nuevas leyes. Las baterías de cada uno de los puntos de venta se recolectarán y transportarán en camión a un recolector más grande por lo menos una vez al mes, dependiendo del volumen de las baterías que se colecten. Estos camiones deben ser proveídos por el gobierno si hay financiamiento para hacerlo, o por otra agencia que lo patrocine. Si no hay financiación externa, entonces será necesario proveer un incentivo a los vendedores para transportar las baterías al colector central de la región. Esto se debe hacer bajo una ley que los obligue o un incentivo monetario. Basado en el análisis del sistema que rige ahora, El Salvador paga a los colectores más grandes aproximadamente ¢500 por batería que se recicle. Si a los vendedores se les ofreciese mitad de ese precio, ¢250 por batería, para transportarlas a colectores más grande, entonces ambas partes estarían recibiendo dinero y se motivarían a participar en el programa.

Las baterías de cada uno de los grandes colectores tendrán que ser transportadas a una recicladora. Nuestra recomendación es embarcarlas a Baterías de El Salvador, adonde muchas de las baterías de Costa Rica se están enviando actualmente. Basándonos en nuestra conversación con Luis Romero de Baterías Récord, El Salvador puede manipular el aumento de baterías de Costa Rica por año y aceptaría gustosamente el negocio. En El Salvador se sub-contrataría una compañía de transporte para que recoja las baterías en los sitios recolectores y los lleve hasta El Salvador. Esto significa que el transporte desde Costa Rica hasta el Salvador lo pagaría Baterías de El Salvador.

Debido a que las recomendaciones anteriores sólo aplican para todas las baterías compradas después de que el programa sea efectivo, todavía quedarían muchas baterías usadas en las casas de los consumidores, patios, rellenos sanitarios y orillas de las carreteras. Nuestra recomendación para solucionar este problema es llevar a cabo una sola recolección de estas baterías gastadas. Los consumidores tendrán que llevar cualquier batería gastada que tengan alrededor de sus casas a un designado punto recolector y a cambio recibirán un pago de por lo menos ¢500 por batería. El pago a los consumidores puede realizarse mediante la división de costos entre los recolectores y el gobierno. Como es sabido, los recolectores están pagando por las baterías viejas, y para que ellos puedan continuar haciéndolo, algunos costos restantes pueden ser cubiertos por el gobierno u otras fuentes externas. Nosotros pensamos que cualquier monto menor a los ¢500 no sería suficiente como incentivo para motivar a que los consumidores lleven sus baterías. Siendo optimistas, al ofrecer este incentivo a trabajadores de rellenos sanitarios, esto los motivará a entregar esas baterías que actualmente se encuentran en estos lugares.

Leyes Modelo

Recomendamos que se pasen leyes sobre la evacuación de las baterías de plomo y ácido. Estas leyes ayudarán a reciclar estas baterías en Costa Rica. Un ejemplo de una ley que se necesitará pasar y hacer cumplir es una ley que hace ilegal y castigable por medio de multas la acción de evacuar las baterías de plomo y ácido en los botaderos municipales. También deberá haber una ley que regule la evacuación del plomo, ácido sulfúrico y plástico. Esta ley debe obligar que cada uno de estos materiales se recicle correctamente, como se describieron en la sección del Proceso de Reciclaje. Otro ejemplo es una ley que obliga a todo punto de venta recolectar las baterías usadas cuando se venda una nueva al consumidor. Esta ley también debe establecer que los vendedores serán castigados con una multa si no reciben las baterías usadas de los consumidores. Nosotros pensamos que estas leyes son necesarias para asegurar el éxito de un programa de reciclaje implementado en Costa Rica, de lo que sí no estamos seguros es del apoyo que el gobierno local proveerá, considerando la falta de ayuda de la cual hemos sido testigos.

Modificando el Sistema Actual

Hay algunos aspectos del sistema actual que trabajan bien y que pueden ser aprovechados eficientemente si se realizan algunos cambios. El primer cambio que se necesitará hacer será en las leyes. Tendrán que pasarse leyes que regulen la evacuación de cada uno de los contenidos tóxicos de la batería de plomo y ácido: el plomo y el ácido sulfúrico.

Actualmente, el plomo se ha fundido o se ha botado y el ácido se ha echado en los ríos y el suelo. La nueva ley que regule la evacuación debería prohibir el mandar el plomo y el ácido sulfúrico a los botaderos municipales, y también debería obligar que todo ácido sulfúrico sea químicamente tratado para neutralizarlo. Si las fundidoras y los productores de cajas negras están permitidos a seguir con sus negocios, entonces debe haber leyes que regulen la ventilación que conlleva la fundición del plomo. Esto incluirá las emisiones e imisiones que ocurren cuando se funde el plomo.

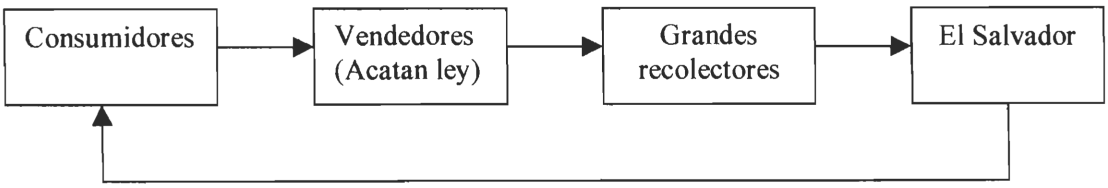
Recomendaciones para el Futuro

Hubo algunas limitaciones en nuestro proyecto debido al corto tiempo que estuvimos en Costa Rica. Hay algunos aspectos que deben ser investigados más afondo para que se tenga un mejor entendimiento del problema y para ayudar a que la elaboración del programa de reciclaje sea un éxito. Recomendamos que la situación de reciclaje en las zonas rurales de Costa Rica sea investigada más profundamente con el propósito de comprender mejor la situación de las áreas fuera de San José. Debido a la insuficiente cantidad de tiempo, no se pudo llevar a cabo una investigación fuera de la zona urbana de San José y no se sabe qué es lo que exactamente sucede con las baterías de plomo y ácido utilizadas en las áreas rurales de Costa Rica. La única información que sabemos es a través de dos entrevistas que se realizaron en el área de Quepos y nos dijeron que allí no había ningún tipo de sistema de recolección. Las baterías son tiradas a la basura con todos los demás desechos. Se debería hacer una investigación más amplia sobre la situación y de ser posible, proponer mejores soluciones.

En la siguiente página hay dos esquemas que describen el ciclo de vida de una batería después de que el programa se lleve a cabo. Un esquema muestra el ciclo de vida si se implementara el sistema totalmente reconstruido y el otro muestra el ciclo de vida si el sistema actual se modificara.

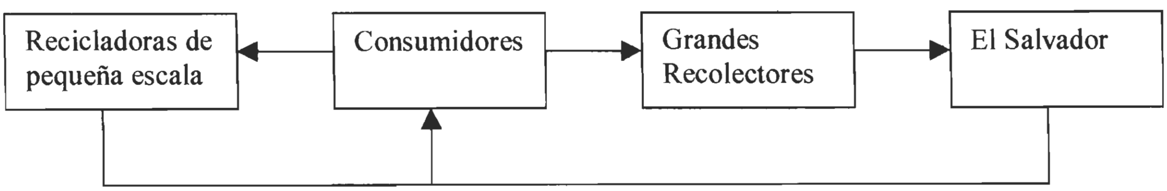
Reconstrucción Total:

En el nuevo sistema, la batería usada comienza por el consumidor y de ahí va directamente al vendedor. Del vendedor, es transportada a los grandes recolectores y después recogidas por Baterías de El Salvador para ser recicladas.



Modificación del Sistema Actual:

La batería usada comienza por el consumidor y de ahí puede ir a una recicladora pequeña o a uno de los recolectores grandes. De los recolectores grandes, Baterías de El Salvador recoge la batería y la transporta a El Salvador para ser reciclada. En el nuevo sistema, las fundidoras a pequeña escala siguen leyes para que sus operaciones sean seguras para el ambiente y para ellos mismos.



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Appendix U: Weekly Progress Reports

DATE: WEEK 1- 5/21/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Revised our interview questionnaire and translated into Spanish	everyone
2. Translated Powerpoint presentation	everyone
3. Gave our presentation to our liaison, Ronald, and a battery importer, Randolph -discussed current solid waste recycling situation in Costa Rica	everyone
4. Visited Cartago school for the Ecological Festival -this festival demonstrated how there is recycling awareness in the schools	everyone

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS	
1. Develop a detailed outline for the final report	everyone
2. Revise Appendix A	everyone
3. Revise Chapter I, Introduction	everyone
4. Chapter II, Literature Review	everyone

DATE: WEEK 2- 5/25/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Developed our final report outline and filled in the progress chart.	everyone
2. Met with our liaison and received more information on battery recycling in Costa Rica. -He also will be setting up more appointments for interviews.	everyone
3. Made up the interview questions for Eric Jimenez for our scheduled interview on Thursday at 10am.	everyone
4. Met with Eric Jimenez and received a lot of information on the current recycling habits in Costa Rica -Eric Jimenez also gave us a contact, a company called Battery Records. The representative for the company is Don Luis.	everyone +Lizzie
5. Worked on Introduction and Literature Review -researched more on sulfuric acid -researched more on El Salvador and Central American laws	everyone Kristina Jill + Jay

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS	
1. Finalize first draft of literature review and the introduction	everyone
2. Hopefully, have more interviews scheduled and completed	everyone
3. Revise Chapter III, Methodology	respective parts each of us has written

DATE: WEEK 3- 6/1/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Made changes to the introduction and the literature review.	everyone
2. Made up questions for the interviews with the taxi drivers, storeowners, and mechanics. -Prof. Salazar looked over the translations.	everyone
3. Made an appointment with Orlando Rodriguez from the Ministry of Health for Thursday 8am.	everyone
4. Revised the methodology.	everyone
5. Interviewed the taxi drivers, mechanics, and storeowners	everyone +Lizzie
6. Made up interview questions for Orlando Rodriguez -Translated the questions to Spanish.	everyone
7. Interviewed Orlando Rodriguez	everyone+Prof. Salazar
8. Typed up results from the interviews with the taxi drivers, storeowners, and mechanics	Jill
9. Printed out information from Brian Wilson	Kristina +Jay

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS	
1. Revise first draft of literature review and introduction	everyone
2. Hopefully, have more interviews scheduled and completed -Taxi drivers, mechanics, storeowners -Ministry of Public Works -Luis Romero, Battery Records -People from San Francisco de Dos Rios -Customs	everyone

3. Revise Chapter III, Methodology	respective parts each of us has written

DATE: WEEK 4- 6/8/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Made interviews. -Luis Romero from Baterías Record -Alvaro from San Francisco de Dos Rios, a lead smelter -Sergio Musmanni from Produccion Mas Limpia -A person from Recouperadora Nacional	everyone+ Lizzie
2. Wrote out questions for each interview.	Jill
3. Revised literature review.	everyone
4. Interviewed someone from Alvaro's smelting facility.	everyone
5. Interviewed someone from Recouperadora Nacional.	everyone
6. Interviewed Luis Romero from Baterías Record.	everyone +Lizzie
7. Researched at the Internet café. -Lead sulfate -Picture of a battery -Philippine Report	everyone Jill Jay Kristina
8. Deciphered chart from literature and created a new chart.	Jay
9. Typed up interviews.	Jill
10. Typed up letter of transmittal in English and Spanish.	Kristina
11. Interviewed Sergio Musmanni.	Jay + Kristina
12. Revised Appendix A.	Kristina
13. Made a phone call to Dr. Elizabeth Carazo.	Lizzie
14. Made a trip to Ministerio de Obras Públicas	Jay + Prof. Salazar

15. Made a trip to CICA to get information about it.	Jill + Kristina

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS

1. Make a phone call to the El Salvador recycling plant.	everyone
2. Revise methodology and introduction.	everyone
3. Write data presentation and analysis.	everyone
4. Rewrite abstract.	everyone
5. Fix Table of Contents, List of Figures, and List of Tables	Kristina

DATE: WEEK 5- 6/15/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Revised Appendix A, created Table of Contents, List of Figures, and List of Tables.	Kristina
2. Split up data presentation and analysis.	
-Taxi Drivers	Jill
-Mechanics and Storeowners, Cost of Recycling	Jay
-Interviews	Kristina
3. Went to Baterías Record for more questioning and asked for the number for the El Salvador plant.	Jill + Jay
4. Created flow chart on informal process in Costa Rica.	Kristina
5. Went with Prof. Arrieta on a road trip to find the people we had interviewed that make the reconditioned batteries and also the lead smelter.	everyone
6. Wrote authorship page and acknowledgements.	Jay

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS	
1. Make a phone call to the El Salvador recycling plant.	everyone +Prof. Salazar
2. Revise methodology and introduction.	everyone
3. Revise literature review and Appendix A.	everyone
4. Revise abstract and write executive summary.	everyone
5. Write Conclusions and Recommendations.	everyone
6. Revise Data Presentation and Analysis.	everyone

DATE: WEEK 6- 6/22/01

STUDENTS: Jill Pouliot, Jason Trovato, Kristina Yim

TASKS ACCOMPLISHED THIS WEEK	BY WHOM
1. Wrote 1st draft of Conclusions.	Kristina
2. Wrote 1st drat of Recommendations.	Jill + Jay
3. Revised 1st drafts of Data Presentation and Analysis.	everyone
4. Revised 2nd draft of Methodology.	Kristina
5. Revised 2nd draft of Introduction.	Jill
6. Revised 2nd draft of Literature Review.	Jay
7. Revised Appendices. -Include questions and answers to all interviews. -Weekly progress reports. -Contact Information. -Appendix A	everyone
8. Write Manual.	everyone
9. Put together 1st draft of full report.	everyone
10. Called El Salvador.	everyone + Prof. Salazar
11. Wrote executive summary.	Jay
12. Typed up interview questions and answers for Saul Rosa.	Kristina
13. Revised 1st draft of Conclusions.	Kristina
14. Revised 2nd draft of Recommendations.	Jill
15. Revise 2nd drafts of Data Presentation and Analysis.	everyone
16. Typed a letter for the Aduanas for information.	Jill

TASKS TO BE ACCOMPLISHED IN THE NEXT 7 DAYS

1.	Finish final report.	everyone
2.	Translate the manual.	everyone
3.	Create power point presentation for the final presentation.	everyone
4.	Make the final presentation.	everyone