LEAD ASTRAY – THE POISONOUS LEAD BATTERY WASTE TRADE

A Greenpeace Report

1st edition, March 1994

Greenpeace publishes a quarterly newsletter which reveals the schemes and trends in toxic trade. It is available in Spanish, French and English.
To order or to obtain a full list of Greenpeace Toxic Trade campaign publications, please contact:

Greenpeace USA
Toxic Trade Publications
1436 U St NW
Washington DC 20009
USA
Ph +1 (202) 462 1177
fx +1 (202) 462 4507

Greenpeace Editors and Researchers:

Madeleine Cobbing, Simon Divecha, Jim Vallette, Mark McLellan, the Greenpeace International Exeter Laboratories (Simone Troendle, Paul Johnston, Ruth Swindlehurst), Mark Huxham, Sonia Rossi, Ann Leonard, Nick Morgan, Stephanie Mills, Stephane Gingras.

This report was researched by Greenpeace campaigners and scientists and was made possible by the donations of over five million Greenpeace supporters around the world.

Contents

Executive summary 1

Greenpeace investigators have followed a trail of discarded lead acid batteries from heavily industrialized countries (particularly Australia, the United Kingdom, and the United States) to Asia and Latin America. Here is a summary of what they found along the way:

• Lead acid batteries are extremely hazardous products. The metal, lead, is one of the most pervasive and toxic of all environmental contaminants. Neurological, neuropsychological and metabolic disorders can result from acute or chronic exposure to lead. The international trade in discarded batteries transfers this hazard from industrial to developing countries. Wherever lead battery scrap is processed, damage to workers, people living nearby, and the environment, is sure to follow.

• The wastes move for economic reasons: waste brokers are paid more by lead acid battery smelters in developing countries than by companies operating in industrialized countries. Lead battery recycling companies in Asia and Latin America can offer more money because they do not pay the price of complying with environmental and occupational health regulations that recyclers in the exporting countries face. Lead is one of the most strictly regulated toxic substances in industrial countries. Most lead battery recycling plants in the United States have closed over the past 10 years, and the few plants left in the United Kingdom are threatening to close, because, they claim, they can not afford the costs of complying with tough regulations on lead.

• The international trade in lead battery scrap often defies national laws regulating or prohibiting such trade, or exploits loopholes in these laws. For example, waste batteries are pouring into the Philippines despite a 1991 ruling that such imports violate a national ban on hazardous waste imports. Greenpeace estimates that less than 5% of the non-ferrous metal wastes (including lead acid batteries) leaving the United Kingdom are even reported to national authorities as required under European Community law.

• The most immediate concern raised by the battery scrap trade is its impact on workers. Many workers at battery recycling facilities in Asia and Latin America are suffering from severe lead poisoning. At most plants in Asia and Latin America visited by Greenpeace, workers had very little protection from lead contamination. (In the U.S., people working with lead must wear fully enclosed protective suits.) Many workers' teeth were blackened by years of breathing in lead. Workers at some of these plants have died from exposure to lead and suffered from high concentrations of lead in their blood.

• People living, and children attending school near battery recycling facilities, are also victimized by this toxic trade. 22 out of 36 children attending kindergarten downwind from a Taiwan battery smelter were found to have elevated levels of lead in their blood. Villagers living near battery importing plants in Indonesia, Thailand and the Philippines complain that ashes from the factory often fall in their wells and on their food, causing everyone to have a cough (many people cough up blood). Other common complaints of people living next to battery importers include burning eyes, nausea, noise pollution, and polluted drinking water.

• The toxic impact of the lead battery waste trade reaches beyond humans: in Mexico, cows died after drinking toxic runoff from a smoldering, towering pile of imported lead acid batteries from the U.S.

• Sample data collected and analyzed by Greenpeace found severe lead contamination of soil and river sediment in Indonesia; soil, river sediment and rice husks in the Philippines; and soil and stream sediment in Thailand. The levels of contamination found in soil taken near lead smelters in the Indonesia, the Philippines and Thailand are far higher than levels found in the former Yugoslavia and industrialised countries. The analysis of Greenpeace's samples provides further evidence of the extreme threat of lead poisoning that these battery recycling plants pose to people who eat lead-contaminated crops, and plants and fish from lead-contaminated streams.

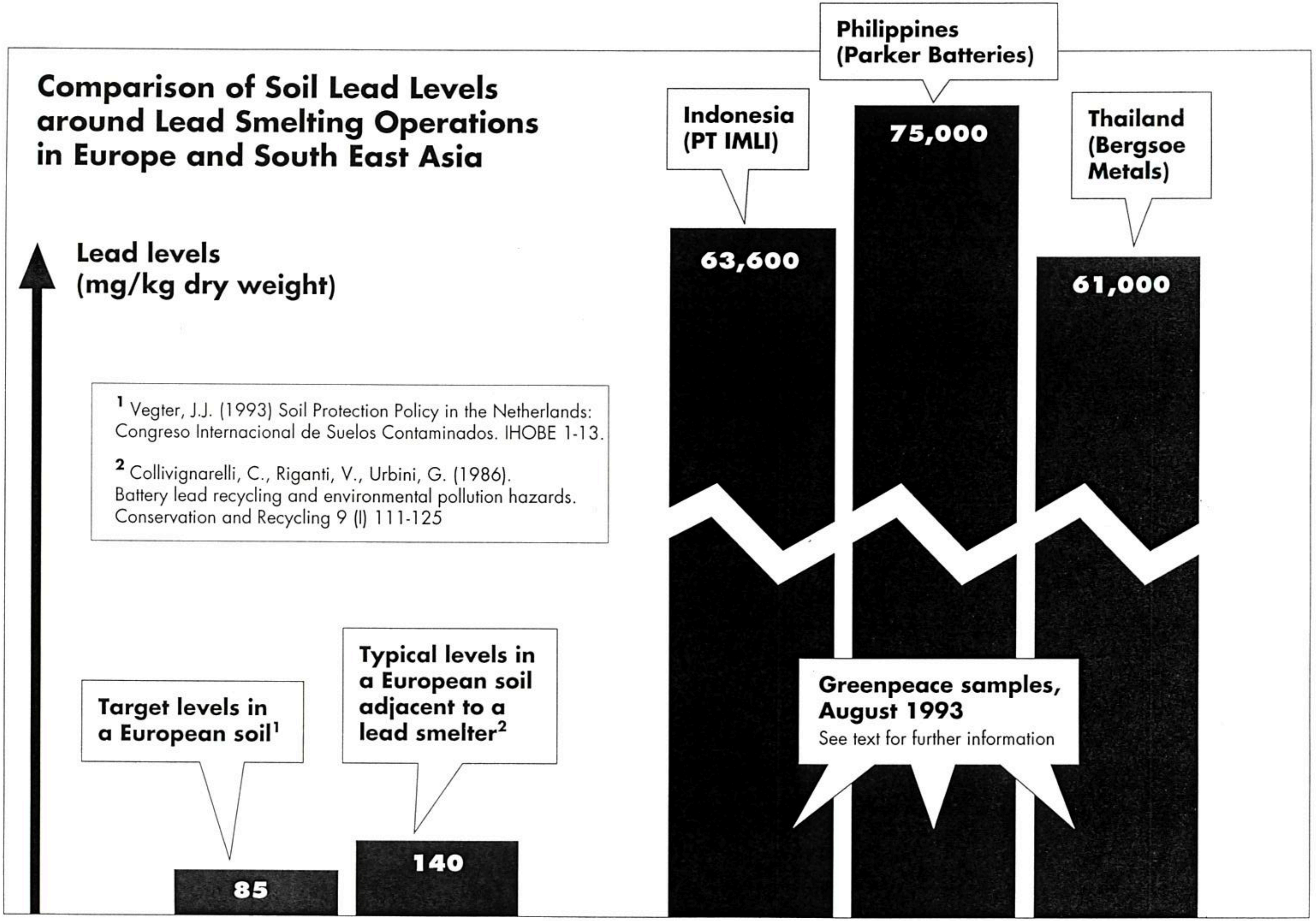
• Hair samples from local residents living around lead smelters in Indonesia and the Philippines showed levels of lead far in excess of previously known levels. The presence of such high levels of lead in hair indicates that people around these plants have been seriously contaminated by lead.

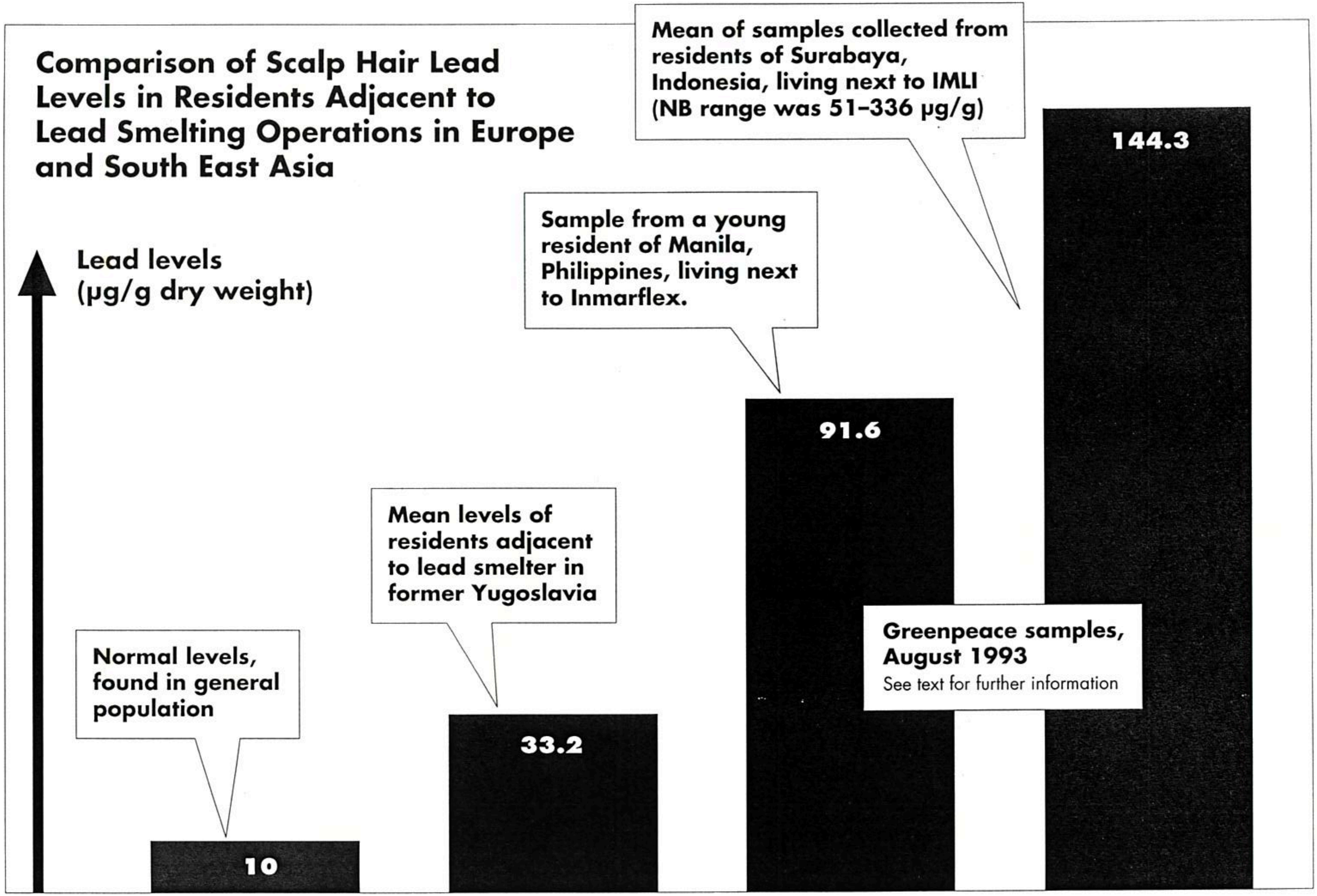
• Lead is the most obvious toxic substance processed and released at battery recycling plants. Greenpeace's investigations have found these plants to discharge other toxic contaminants which pose health and environmental dangers, including: arsenic, mercury, antimony, polyvinyl chloride (PVC), and sulphuric acid.

The lead battery industry has tried to characterize the trade in its wastes for recycling as an environmentally-positive alternative to disposal. This report demonstrates a constant flaw in this argument: whenever lead battery wastes leave industrialised countries, they severely damage people's health and contaminate the environment. By exporting the poisonous legacy of lead battery wastes, industry and consumers in rich Northern countries do not bear the true price of their toxic production and consumption. By allowing the continuation of business-as-usual, this toxic trade also discourages the development of clean alternatives to the old-fashioned lead-acid car battery.

Some Of The Lead Acid Battery Waste Importing Facilities Studied

Importing Country	Company	Main Exporters	Sample Data/ Enviro. Impacts	Health Impacts
Brazil	Tonolli do Brasil	UK, US	Lead, cadmium pollution of lake	Elevated lead in local children
Indonesia	Indo Era Multi Logam (imli	Aus, US, UK	Drinking water, polluted by lead	High lead in villagers blood
Mexico	Alco Pacific	US	Cows killed by toxic discharge	Neighbors report respiratory problems and sting ing eyes
Philippines	Philipp. Recyclers	Aus, NZ US,UK	Contamination of crops	Neighbours black effluent into river
Taiwan	ACME	J, US	Air emissions reach nearby schoolchildren	31 of 64 workers poisoned
Thailand	Bergsoe Metals	Aus, J	Toxic chlorine air emissions, heavy metals in stream sediments	Neighbors' eyes burn at night


Comparison of Soil Lead Levels around Lead Smelting Operations in Europe and South East Asia
Lead levels (mg/kg dry weight)
1 Vegter, J.J. (1993) Soil Protection Policy in the Netherlands: Congreso Internacional de Suelos Contaminados. IHOBE 1-13.
2 Collivignarelli, C., Riganti, V., Urbini, G. (1986). Battery lead recycling and environmental pollution hazards. Conservation and Recycling 9 (I) 111-125
Target levels in a European soil[1]
85
Typical levels in a European soil adjacent to a lead smelter[2]
140
Indonesia (PT IMLI)
63,600
Philippines (Parker Batteries)
75,000
Thailand (Bergsoe Metals)
61,000
Greenpeace samples, August 1993
See text for further information



Comparison of Scalp Hair Lead Levels in Residents Adjacent to Lead Smelting Operations in Europe and South East Asia
Lead levels (µg/g dry weight)
Normal levels, found in general population
10
Mean levels of residents adjacent to lead smelter in former Yugoslavia
33.2
Sample from a young resident of Manila, Philippines, living next to Inmarflex.
91.6
Mean of samples collected from residents of Surabaya, Indonesia, living next to IMLI (NB range was 51–336 µg/g)
144.3
Greenpeace samples, August 1993
See text for further information

Overview of the global lead battery trade 2

In most heavily industrialised countries, old car batteries are usually returned for recycling to car repair shops, recycling centres or scrap merchants. Batteries contain a high proportion of lead, a highly toxic heavy metal, in addition to sulphuric acid and various types of plastic, including PVC.

Battery recycling is therefore an inherently dangerous process, with the potential for a great deal of environmental and human health damage. Increasingly strict environmental standards in industrialised countries now require expensive pollution control equipment in secondary lead smelters and high health and safety standards for the workers. In the US, for example, workers are required to wear full-body protective gear to shield themselves from hazardous fumes and burning liquids.

However, in developing countries, such stringent standards are rarely applied, due to the cost. As a result, increasing quantities of waste lead batteries are being shipped from industrialised countries to developing countries to be recycled.

In 1993, researchers from the Greenpeace Toxic Trade Campaign travelled to ten lead acid battery recycling facilities in Indonesia, Malaysia, the Philippines and Thailand. Greenpeace found dangerous and dirty factories that were discharging acid into waterways, dumping residual wastes in the open, and poisoning workers, villagers and their families.

In Latin America, Mexico used to be the primary destination for waste batteries from the US; since the facility there closed, Brazil is increasingly being targetted for the export of lead acid batteries. Here also, there are incidences of worker poisoning and of environmental damage.

As individual countries act to ban or restrict the import of lead batteries, lead battery exports merely move to other developing countries, where there is less resistance. The indications are that as countries like Taiwan, Indonesia, and Thailand are tightening up their legislation, lead battery waste is now being diverted to countries lacking such legislation, like China and Brazil.

2.1 The exporters: quantities and policies

The principal OECD countries exporting lead battery waste are Australia, Canada, Japan, New Zealand, the U.K. and the USA. These countries' laws all encourage their industries to export hazardous wastes such as lead battery scrap.

Australia

In 1992, Australia exported over 17,000 tonnes of lead battery scrap to Hong Kong, Indonesia, Japan, New Zealand, Papua New Guinea, the Philippines, Taiwan and Thailand[1]. The main Australian companies involved in exporting batteries are: Non Ferral Pty Ltd; Minemet Ltd; (exports from Australia & Middle East); Simsmetal Ltd (exports from Australia); Aus Export Trading House (exports from Cyprus) and Colby Australia Imports Pty Ltd.

There is currently no requirement for companies exporting lead battery wastes to report this to the Australian authorities, so therefore there is no prior informed consent requested from the destination countries. Australia is resisting global efforts to ban such waste shipments under the auspices of the Basel Convention.

Canada

From 1990 to 1992, Canada exported over 5,000 tonnes of lead waste and scrap[2] to China, South Korea, Philippines, Thailand, Indonesia, Taiwan, Hong Kong and India[3]. Pacific Metals Inc of Vancouver was involved in attempting to ship waste batteries to China and the Philippines in 1991 and was denied access by the Chinese and Philippines Governments[4].

Canada operates a typical prior informed consent procedure. Any waste trader wanting to export lead battery waste (or any dangerous waste, according to the Dangerous Goods Transportation Act) needs to inform Environment Canada of the quantities, the type of waste, the mode of transport, the destination and the use of the waste once it arrives. Environment Canada then has to request authorisation from the country of destination.

Japan

Sources report that Japan exports 30,000 tonnes of lead-acid auto batteries to Southeast Asia each year. The main Japanese companies involved in shipping waste to the Philippines are: Metal Trading Services Co Ltd, Oceania Corp., and LGA Corporation. These companies shipped 350 tonnes of waste batteries to the Philippines from January 1992 to June 1993[5].

New Zealand

In 1991, New Zealand exported 336 tonnes of lead waste and scrap to Indonesia. This rose to 645 tonnes in 1992 to Indonesia and the Philippines and in 1993, 317 tonnes of lead waste was exported to the Philippines[6]. The main companies shipping waste from New Zealand to the Philippines are Warren Metals Limited and Aoteorea Ltd. From January 1992 to June 1993, these companies exported 500 tonnes of waste batteries[7].

USA

In the first nine months of 1993, the U.S. exported over 37,000 tonnes of lead scrap. More than 78% of these wastes went to Canada, which has relatively weak lead waste pollution control and liability regulations. Most of the remaining 8,000 tonnes of lead scrap were shipped to Brazil, Malaysia, Pakistan, South Korea, Hong Kong/China and India[8].

In 1992, the US exported about 60,000 tonnes of lead scrap, of which at least 2,000 tonnes went to Asia, including India, South Korea, China, Hong Kong, Pakistan, the Philippines and Malaysia[9]. The principal company involved in exporting US batteries to the Philippines, is Ramcar Batteries Inc. in California.

In 1990 and 1991, the U.S. exported 71,000 and 87,000 tonnes of lead scrap, respectively. Other major importing countries of U.S. lead scrap in the 1990s have included: Indonesia, Mexico, the Philippines, South Africa, Taiwan, Thailand and the U.K.[10] By comparison, the U.S. imports less than 400 tonnes of lead scrap each year.[11]

The USA is the largest generator of hazardous waste in the world, and has strongly resisted calls for a ban on all waste exports. Companies exporting hazardous waste from the USA have to obtain the prior consent of the importing country. However, a loophole in U.S. law allows used batteries to escape hazardous waste regulations if their posts are intact. Thus, most battery scrap is exported as a commodity, not as a hazardous waste.

UK

In 1992, the UK exported 578 tonnes of lead waste to non-OECD countries, including lead battery waste, to Indonesia, Pakistan, the Philippines, British Indian Ocean Territories, Bulgaria and South Korea. This rose to nearly 4,000 tonnes in the first 11 months of 1993; the major destinations were the Philippines, Indonesia, India and Brazil[12]. The main UK companies involved in exporting lead batteries are: A Cohen and Son of London, F J Church and Sons, Essex, G & P Batteries, Birmingham and R J Howards, Lancaster[13].

The UK has exported a total of 59,613 tonnes of lead waste and scrap to both OECD and non-OECD countries since 1988[14].

In past meetings of the Basel Convention, the UK has lobbied hard to keep the option of exporting wastes for "recycling" open. Waste trade to and from the UK is regulated under the EC Directive on Transfrontier Shipments of Hazardous wastes, which is soon to be replaced by a new European Union Regulation in May 1994. Some of the provisions of the first EC Directive have still not been properly implemented by UK authorities – in particular the regulations requiring companies to submit "uniform documents" when exporting non-ferrous metals wastes for recycling. Less than 5% of the 80,000 tonnes of waste exported by the UK is reported to the authorities as required[15]. There have been no "uniform documents" submitted for the export of any lead batteries. Even if there had been, this simplified procedure doesn't include any requirement to ask the importing country for prior informed consent.

The new EU regulation will incorporate the notorious "Red Amber Green" list devised by the OECD. Lead waste and scrap, which is the usual description given in customs declarations for lead battery waste, would be considered a "green" listed waste. Minimal controls on the export of such wastes would be applied. However, lead acid batteries (whole or crushed) are also included in the amber list, which requires the country exporting the waste to inform the country of destination. Despite this, the increasing amount of lead-acid battery waste being exported from the UK is not included in Department of Trade and Industry statistics for amber list waste exports. The UK Government says that developing countries will also be asked whether or not they would be willing to receive "green" list wastes, although there is no requirement in the new regulation for this to happen.

Lead battery waste is also classified as special waste by some local Waste Regulatory Authorities in the UK[16], but not by others, leading to the situation where a consignment of lead battery waste can be moved freely within the UK, until it passes through a county which considers it a special waste, where the company risks prosecution for not having the correct documentation.

2.2 The importers: quantities and policies

Asia is the primary destination for lead battery wastes from OECD countries. Asia's leading importing countries of lead scrap are Thailand, the Philippines, Indonesia, China/Hong Kong, India, and South Korea[17].

The Philippines is the only country in Asia that bans all hazardous waste imports. Indonesia, Taiwan and South Korea have tried to restrict lead battery imports; regardless, lead battery scrap is making its way into each of these countries.

Latin America – especially Brazil – is the second most popular destination for this dangerous trade.

A Asia

Indonesia

In Indonesia, Environment and Health Officials have been fighting to control lead acid battery processors since mid 1991. The Federal Environment Department closed one lead acid battery recycling factory in Surabaya in May 1991 and another in Bekasi in September 1992. In December 1992 the regional government of Cirebon ordered the closure of ten of the lead acid battery recycling factories because of the pollution they caused, and the lack of worker safety standards[18].

Presently, there are four operational waste battery recycling plants in Indonesia[19];

PT. Indo Era Multi Logam near Surabaya.
(processes 100% (IMLI) imported batteries)
PT. Non Ferindo Utama, Tangerang, near Jakarta
(processes 100% imported batteries)
PT. MuktomasNear Jakarta, (processes 50% imported batteries)

PT. Shun Thien Metal Indo.Semarang, Jawa Tengah, (processes 100% imported batteries.

The main exporters of lead battery waste to Indonesia are Australia, which exported more than 11,000 tonnes of waste battery scrap to Indonesia in 1992, and the UK, which exported nearly 1,000 tonnes in 1992 and 1993.

Indonesia, along with the Philippines, is one of the few countries in South East Asia which has banned some waste imports, notably plastic waste. It was this plastic waste import ban which led to 250 containers of lead acid batteries being temporarily impounded in various Indonesian ports[20]. However, new containers continue to be imported into the country, in particular from Australia, although shipments from the UK stopped after May 1993. The Indonesian waste import ban does not clearly ban imports of waste metals for recycling, and therefore this trade is continuing, despite the fact that Indonesian Environment and Health officials have been fighting to control waste battery processors since mid 1991.

The Philippines

The Philippines is increasingly being targetted for imports of lead acid batteries. This country imported over 6,000 tonnes of batteries in 1992; this increased to over 16,000 tonnes in the first six months of 1993, from countries including Australia, New Zealand, the US and the UK[21]. The vast majority of this was bound for a large lead smelter near Manila – Lead Smelters Inc., recently renamed as "Philippines Recyclers Inc." – (PRI).

Approximately 500 tonnes of lead acid batteries were also imported to another company, Asia Pacific Lead Smelters Inc. However, many other smaller "backyard" lead recyclers also end up processing imported waste, in the form of products and by-products from the main smelters.

Waste imports such as waste batteries are violating a national law banning such toxic waste imports. The Philippine Department of Environment and Natural Resources ruled in 1991 that "the importation of waste batteries which are considered as hazardous materials is not allowed" under Republic Act No. 6969[22].

Despite the above statement, and the fact that this law bans waste imports, a loophole appears to exist which allows the import of certain wastes such as batteries. This is currently being challenged in Parliament by Senator Mercado. Philippines Recyclers Inc., the main company importing waste batteries into the country, have an "interim importation clearance" issued by the Environment Management Board (EMB) of the Philippines[23], which allows them to import waste. In addition, PRI have a tax exempt status from the Finance Department, which is intended to encourage new industries.

Taiwan

In the late 1980's, Taiwan was one of the principal destinations for waste lead batteries. Two factories in particular, ACME and Thai Ping, highlight the problems faced by non-OECD countries. They started importing lead acid batteries from the US and Japan in 1987 and continued to do so until 1990. Environmental and human health problems first surfaced at the ACME facility (see Section 4.3).

In 1990, the Taiwan Environmental Protection Agency (EPA) decided to end all battery imports due to the extensive contamination[24]. "Don't import from the United States" said EPA Director, Eugene Chien, "it causes too many problems for us"[25].

Taiwan's Environmental Protection Agency has since replaced this ban with a new licensing procedure for lead waste importers. This procedure has dramatically limited, but not entirely stopped, lead scrap imports.[26] Export records from Australia indicate that Australian companies were still shipping lead-acid batteries to Taiwan, through May 1993.[27]

Thailand

Thailand imports about 57,000 tonnes of used batteries per year[28]. There are indications that Thailand is becoming a popular dumpsite for foreign battery wastes, especially from Australia: in 1992 Australia exported 166 tonnes of lead battery waste to Thailand; this increased to over 6,000 tonnes in the first nine months of 1993. Other countries which export used batteries to Thailand include Japan, Singapore, Kuwait and the European Community[29].

Seven secondary lead smelters in Thailand recycle imported used batteries, the largest of which is Bergsoe Metals, in Saraburi.

There is no law in Thailand which bans the import of any sort of waste, although the policy of the Ministry of Industry is not to accept imports of toxic waste, they have no means to enforce this policy[30]. The situation with the import of waste into Thailand is extremely difficult to control. Wastes, along with dangerous products, are often imported with no licence and stored indefinitely at the port of Bangkok, the location of the notorious Klong Tooey chemical fire, when a badly stored chemicals in a warehouse caught on fire on March 2, 1991 with devastating consequences.

Following the exposure of lead battery imports in 1993[31], it seems that Thailand is now also moving to ban the import of lead battery waste; the National Environment Board has been asked to consider a ban on the import of waste batteries[32].

B Latin America

Brazil

There are seven companies importing lead waste, including lead battery scrap, in Brazil;

Acumuladores Ajax Ltda
FAE S/A Ind. Com Metais
Italmagnesio Nordeste S/A
Metalurgica Bitury S/A
Microbat Ltda
Sulina de Metais S/A
Tonolli do Brasil Ind e Com de Chumbo Ltda.[33]

Of these companies, Tonolli, FAE and Microbat are known to have had problems with contamination of workers and of the environment. The largest of these companies is Microbat, also known as Microlite and part of the Saturnia Batteries Enterprise. Saturnia is considered the biggest producer of car batteries in Latin America; 70% of the material used to produce batteries is lead scrap and 30% is primary metal[34].

The biggest exporters of lead battery waste to Brazil are the USA and the UK. There are also a lot of shipments from Puerto Rico. One of the US companies involved is Lion Metals of New Jersey (shipping from Puerto Rico); one of the British companies involved is A Cohen & Son of London[35].

In 1990, Brazil's Federal Environmental Protection Agency (IBAMA) created the first Brazilian regulations to control waste imports. The legislation permitted the import of 32 different types of residues if the importing company could prove that it could treat the wastes in an "environmentally safe" way. This would mean obtaining a report from the relevant State Environmental Protection Agency stating that the company has not violated any environmental laws.

In 1992, after Brazil ratified the Basel Convention, new legislation was enacted which banned almost all types of waste imports. However, the legislation still included a loophole which allowed wastes containing "mainly metals" destined for recycling plants to be imported. The requirement for the wastes to be treated in an "environmentally safe" way remains. Lead battery waste from the UK and the USA is imported into Brazil through this loophole.

These laws are also not completely enforced; the Federal EPA does not have enough resources to inspect all the ports, and the State EPAs allow import licences to companies which have been fined for enviromental violations, provided that the last fine was not in the 6 months before the licence request.

Recent scandals involving the import of toxic wastes have led the Brazilian authorities to consider the possibility of a total ban in the near future. The major opposition to such a ban is expected to come from the lead battery reprocessing industry.

Mexico

Mexico was a major destination for U.S. lead battery waste exports from 1988 to 1991. The shipments stopped after the importing company, Alco Pacific, declared bankruptcy and closed in 1991.[36] Mexico prohibits hazardous waste imports for disposal, but allows them for recycling.

Economics of the battery waste trade

The main factors causing the lead battery waste trade are typical to all waste trade schemes: in industrial countries, the environmental and occupational health regulatory cost of operating lead battery recycling facilities is ever-increasing, and the prices offered for secondary lead are low. It is simply not profitable to operate secondary lead smelters in many industrial countries. Battery brokers are finding more profitable markets in places where workers are paid little, and environmental and workplace regulations are weak and/or unenforced.

3.1 Battery collection and recycling in industrial countries

In industrialised countries, the collection of used lead batteries is generally well organised. Countries such as Sweden, Germany and Italy operate adjustable levy systems, which are related to lead prices. A levy is imposed on new batteries and used to fund the collection and recycling of old batteries when the lead price is too low to make recycling economic[37].

In the United States, many states require retailers to accept used car batteries when consumers purchase new ones. Several U.S. states require a cash deposit on new battery purchases, which is refunded to the consumer after they return the used battery to the retailer.[38]

There is no levy system in the UK for the collection of used batteries, which are generally collected by car repair shops and scrap metal dealers.

This contrasts with the situation in many developing countries, where batteries are often dumped indiscriminately. Imports from industrialised countries are considered a more reliable source of secondary raw material for large secondary lead smelters than domestic waste batteries, which are not collected centrally.

Ironically, in the UK, the cost associated with new environmental regulations (such as the Duty of Care) has led to a drop in the percentage of batteries collected. The estimated recovery rate for used batteries in Britain is 85-95%[39]. However, this relatively high rate of return is vulnerable to fluctuations in the market price for lead, and there is evidence that increasing collection costs and falling lead prices are reducing the recycling rate[40]. The latest industry figures indicate that the percentage of used batteries which are collected and recycled in the UK has dropped from 90% to 70%[41].

3.2 Lead recycling industry flight from industrial countries

Lead batteries and lead battery smelters have been transferring out of industrial countries in recent years, as environmental regulations tightened and domestic lead prices dropped.

One of two major secondary lead smelters in the U.K., H J Enthoven in Derbyshire, recently spent £10 million on updating their smelter; 40% of this was invested in pollution control[42]. But few other companies in industrial countries are willing to make such investments.

The U.K. secondary lead industry faces a "critical situation," according to a recent issue of the Metal Bulletin. The U.K.'s Lead Development Association warned that "the current low lead price, combined with increasing associated environmental costs ... has made it less profitable" to operate secondary lead smelters. Industry officials in the U.K. are predicting that both lead smelters there will close within the next four years[43]. This is due to "the current low lead price, (which) combined with increasing associated environmental costs under waste management licensing and Duty of Care regulations at scrap years, has made it less profitable to collect lead acid batteries"[44].

In response to the low lead price, some of the batteries are being thrown away to avoid the costs of complying with regulations, (and to increase the scrap value of cars, which is determined by weight in the UK). But some of the remaining 30% of used batteries in the UK are being shipped to developing countries (over 4,000 tonnes in first 11 months of 1993).

The secondary lead industry has already shifted out of North America en masse. According to the Journal of Metals, by 1987, "the inability to economically install emission controls and purchase liability insurance forced closure of over half of the secondary lead smelters in North America"[45]. The U.S. Bureau of Mines also attributed the closures to the fact that "waste disposal is becoming a very significant expense and is often a difficult task to perform"[46].

The surviving lead battery smelters in North America are facing fates similar to those facing U.K. smelters. According to one metals journal, ominously, secondary lead "prices continued to drop in 1992 and in 1993 because of low demand and ever-bulging inventories"[47].

Recently, in the US and Canada, many secondary lead smelters have been running below capacity, again due to low lead prices and short supply of waste batteries[48]. The total capacity for secondary lead smelting in the US is 1,151,000 tonnes. In 1992 only 74% of this capacity was used (853,000 tonnes). The total amount of lead battery waste exported from the US was 60,000 tonnes in 1992.

The uncertain future of the industry has meant that RSR Corp, the USA's largest secondary producer is now reluctant to install new electrotechnology as planned. The low lead prices (17-20 cents/lb) combined with the cost of spent batteries (between 3.5-7 cents/lb) means that "there has been little room for secondary processors to manoeuvre once conversion costs are included[49]." The export of waste lead batteries to developing countries not only leads to greater environmental damage taking place in these countries, but is one of the factors stopping the investment in new "breakthrough" technologies in the US.

3.2 How developing countries pay more for battery waste

The incentive for the export of battery waste from the UK and other industrial countries is purely economic. Because of the low current lead price, UK smelters can only charge £50 per tonne, whereas smelters in the Philippines, for example, can offer £70 per tonne.

One economic factor which can not be ignored are special tax incentives from finance departments in developing countries Companies such as Philippines Recyclers Inc and Asia Pacific Lead Smelting Corporation in the Philippines, for example, have been given a tax exempt status in order to encourage trade (as a new industry) from the Department of Finance in the Philippines[50].

Much more significant economic factors driving the lead battery waste trade are the lower compliance costs demanded by developing countries, especially in environmental and occupational health protection.

According to the American Metal Market, "Scrap trade sources have said the growing importance of poorer countries as buyers in the international battery scrap market is a reflection of the difficulty some U.S. operators have had in assuring that they can comply with increasingly strict environmental regulations"[51].

The U.S. Bureau of Mines echoed this argument, reporting that "Foreign smelters can afford to bid a higher price for scrap because their capital, labor and environmental costs are lower than U.S. producers."[52]

The lack of investment in expensive pollution control equipment and in proper health and safety for workers in many plants in developing countries, means that these companies can afford to pay far more for lead battery waste. The losers are the environment, the health of local people and the workers in these plants. Ultimately, the costs of cleaning up and the impact on the health and livelihood of workers and local people will outweigh any "benefits" that such industries bring to developing countries.

3.4 Lead industry's recycling greenwash

Without the option of exporting waste, the lead-acid battery manufacturing industry would ultimately be forced to become clean, by eliminating the use of lead in batteries. The demise of lead smelting companies in industrial countries, after all, reflects industrial societies' desire to stop being contaminated by lead. But the flourishing international trade in lead-acid battery wastes is providing battery manufacturers with cheap and easy escape valves for their toxic wastes.

The lead-acid battery industry is using the cloak of "recycling" to hide the global toxic impact of their products' wastes, and to thus reduce the threat to their 'status quo' use of toxics in production processes.

On May 7, 1991, Battery Council International, a trade association representing the international lead battery industry, distributed a press releases proclaiming: "Consumers Need to Be Jump Started on the Importance of Recycling Lead Batteries." This press release opens with classic words of 'greenwash':

"Recyclable lead batteries work hard behind the scenes keeping heart surgeons operating when a storm knocks out electricity, starting cars on subzero winter mornings, and providing power for important U.S. military missions, including igniting the launch of Patriot Missiles in the recent Persian Gulf War . . . To protect our environment and to make the best use of this essential source of power, consumers need to recycle all lead batteries."

As long as the option of exporting such wastes stays open, the amount of lead battery waste produced will continue to increase and research into acceptable battery alternatives is unlikely to take place. For example, to date, research into alternatives such as zinc-air and lithium has not been given high priority.

4 The lead battery waste trade's devastating impact

Greenpeace researchers followed the toxic battery waste trade to numerous lead-acid battery recycling facilities in Indonesia, the Philippines and Thailand in 1993. This research followed similar investigations conducted by the Center for Investigative Reporting in Taiwan in 1990, and other researchers in Brazil and Mexico in recent years.

Pieced together, these investigations reveal that industrial countries are not shipping their batteries to environmentally sound recycling operations. In fact, automobile batteries from rich industrial countries are being burned in extremely dangerous and dirty Third World factories. These secondary lead smelters are discharging acid into waterways, dumping residual wastes outside property gates, and poisoning workers, villagers and their families.

The investigations reveal the "double standards" inherent in all types of toxic waste trade. These double standards are reflected in all of the lead waste recycling processes that can potentially harm people and the environment: including transportation, workplace and ambient air emissions, storage and handling of scrap batteries, and slag disposal.

For example, people working in lead recycling facilities in the U.S. are required to wear full-body protective gear to shield themselves from hazardous fumes and burning liquids. In one facility in the Philippines, Greenpeace witnessed factory workers pulling batteries apart with their bare hands. In Indonesia, villagers reported that lead ash from the factory falls in their food at night.

Here are the researchers' findings, country by country:

A Asia

4.1 Indonesia

In Indonesia, environment and health officials have been fighting to control lead acid battery processors since mid 1991. The Federal Environment Department closed one lead acid battery recycling factory in Surabaya in May 1991, and another in Bekasi in September 1992. The regional government of Cirebon ordered the closure of ten of lead acid battery recycling factories because of the pollution they caused, and the lack of worker safety standards in December 1992[53].

The largest lead battery waste importer, PT Indo Era Multi Logam (IMLI) is located south of Surabaya. When IMLI began operations in the late 1980s, villagers believed it was a wood processing plant. Instead, IMLI burns up to 60,000 tonnes of lead acid batteries at the plant each year. According to Government sources, nearly 100% of this is imported batteries.

Clouds of smoke and ash from the factory have been descending on the community since IMLI began operation. Waste water from the plant is discharged into local waterways, which are used by villagers to irrigate their rice fields. Local residents complain that ashes from the factory often fall in their wells and on their food, and that the effluent from the factory is draining into the local irrigation system. Many villagers complain of being sick, that everyone has a cough, and half of them cough blood.

In 1989, the local government office in Pasuruan ordered IMLI to temporarily cease production[54]. The reasons given were that the plant had started operations without any assessment of its impact on environment and human health[55]. Current operations were considered to be a pollution and health hazard to the community and the surrounding environment. Despite this order, IMLI continued production, until eventually, the villagers appealed to the Surabaya Legal Aid Board in 1989, who took up the case.

In April 1991, a newspaper article reported that villagers were still suffering from air and noise pollution from IMLI[56]. The pollution had effectively forced the local primary school to move to another location. In May 1991, IMLI proposed to expand its capacity[57], leading to an increase in imports, the bulk of which were coming from Australia and the United States at that time.

Air samples taken by Indonesian Government authorities in June 1991 found high concentrations of lead, ammonia, hydrogen sulphide and other acid gases, 100 metres south of the plant[58]. They also sampled effluent from the IMLI factory and determined it to be extremely acidic, with the capacity to destroy agricultural production and interfere with flora and fauna[59].

In September 1991, the Surabaya Legal Aid Board did an investigation of the conditions in and around IMLI, with a particular focus on the workers conditions[60]. It was found that workers at IMLI were not sufficiently protected from acid and lead fumes, with only minimal cloth face masks. The plastic battery cases were cleaned by hand, subjecting the workers to acid splashes and vapours.

IMLI also dumps its waste slag – a mixture of lead and plastic from the furnaces – outside its factory gates. Villagers collect the slag, take it home, and smelt it in works over open fires in their backyards. The lead spills onto the ground as it is poured off, while molten plastic floats to the top. The villagers then try to sell the extracted lead content of the slag, while exposing themselves even more to the foreign waste invasion. People throughout Java are practicing this crude method of recycling wastes from another country[61].

An Indonesian government report shows that a majority of the sample of workers studied have blood lead levels in the range of 40 to 80 micrograms per deciliter[62]. This elevated level puts them at high risk of developing kidney and nervous disorders.

The local government office (Pasuruan) was reported to be taking action to resolve the IMLI's pollution problems in August 1992[63], as industrial effluent had polluted the river systems and groundwater. Local residents use this water as drinking and domestic water. Water treatment facilities installed at the plant were not fully operational. It was reported that pollution problems, with noise, smoke, dust and odour, and at certain times, loud explosions, were still occurring.[64] The case was forwarded to the Provincial Government for action.

Greenpeace visited the plant in August 1993 to take samples and visible atmospheric pollution was still apparent. The results from samples taken by Greenpeace at IMLI are outlined in Section 7.1.

4.2 The Philippines

The largest lead smelter in the Philippines, Philippines Recycling Inc. (PRI), has an environmental compliance certificate to operate, which covers air and water pollution, from the Environment Management Board. In August 1993, Greenpeace filmed inside the PRI facility, where they found some efforts at pollution control inside the plant, and efforts to provide workers with face masks and gloves. Despite this, gross pollution in the surrounding rice fields and river is still evident. Often the discharge from the plant into the river runs black, and close neighbours suffer from smarting eyes and sore throats.

Pollution from lead battery imports into the Philippines does not end at PRI. Lead shipped to PRI find its way to numerous small battery recyclers, like Parker Batteries, in the back streets of Manila, and INMARFLEX. At Parkers, workers are in constant contact with lead, and work in rooms with no ventilation. In contrast, people working with lead in the USA would be protected by fully enclosed suits.

Greenpeace campaigners visiting Parker found it almost impossible to breathe in the plant, because of sulphuric acid fumes. Lead waste and sulphuric acid drains into open sewers in the surrounding slum area. Slags from the lead smelter are dumped on open ground next to the plant.

Contamination of the workers by lead is evident by looking at their teeth, which are blackened by years of breathing in lead. Official occupational health and safety studies have found that workers at both Parkers and PRI had "significantly higher levels of lead" in their blood compared to workers from other industries using lead[65].

At another secondary lead processor in Manila, INMARFLEX, the residents experienced severe health problems from living next to the smelter. Many had breathing problems, one girl was coughing up blood. The residents told Greenpeace that workers at the plant were brought in from the islands. When they became too sick to work, they were sent back. Workers also suffered from coughing up blood. Greenpeace samples from PRI, Parker and Inmarflex are outlined in Section 7.2.

The other main importer of lead batteries, Asia Pacific Lead Smelting Co., also known as Hercules, used to operate a plant in Manila, which is now closed. They have now opened a new plant in Pampanga. At their previous facility, batteries were broken up by hand, in cramped hot and dusty conditions. Workers wore little protection from the lead, which oozes from cracks in the machine and drips onto the floor. The conditions at the facility in Pampanga are unknown.

4.3 Taiwan

The San Francisco-based Center for Investigative Reporting (CIR) first looked at the lead battery trade while producing the hour-long waste trade documentary, "Global Dumping Ground," and a companion book, both of which were released in 1990. Their investigative trail led to Taiwan, where CIR researchers found two factories importing lead-acid batteries from the U.S.: ACME and Thai Ping.[66] These factories were already under investigation by the Taiwanese government for causing severe health and environmental problems, and eventually, the government of Taiwan ordered a ban on all lead-acid battery imports. Taiwan's Environmental Protection Agency has since replaced this ban with a new licensing procedure for lead waste importers. This procedure has dramatically limited, but not entirely stopped, lead scrap imports.[67] Export records from Australia indicate that Australian companies were still shipping lead-acid batteries to Taiwan, through May 1993.[68]

The investigations were triggered in 1987 when a sick ACME employee went to Dr. Jung-Der Wang complaining of faintness and weakness in his arms and legs. Dr. Wang, a Harvard-educated specialist in environment-related health problems, determined that the worker suffered from an extremely high level of lead in his blood – twice the limit for U.S. standards. Dr. Wang surmised that the worker had been poisoned on the job.

With the help of the Taiwan government, Dr. Wang launched an investigation into the extent of contamination and poisoning amongst ACME workers. He found that 31 of the 64 ACME workers suffered from lead poisoning, and some of them had blood lead levels three times higher than U.S. occupational health limits.

The pollution from ACME's lead smelter did not stop at the factory gates. Dr. Wang examined 36 children at a nearby school and found that 22 of them had elevated levels of lead in their blood. In addition, a Taiwanese newspaper reported that ACME had dumped thousands of tonnes of waste in a open field near the factory, and that the waste was threatening the water supply of the surrounding community.

As the ACME investigation progressed, citizens living near an even larger lead smelter, Thai Ping, became concerned about local lead emissions. Protesters gathered at the Thai Ping factory and smashed windows.

Like the ACME factory, Thai Ping was poisoning its workers. In April 1990, Dr. Michael Rabinowitz conducted an investigation into the health of Thai Ping workers. He found that they had blood lead levels high enough to be at risk of developing kidney and nerve problems. He also examined school children near the Thai Ping smelter and found that the children's teeth had twice the lead level of children living in the capital city of Taipei.

Dr. Rabinowitz warned that the "children can be expected to have impaired intelligence, slower physical growth and some behavioural disorders – trouble paying attention, hyperactivity."[69]

4.4 Thailand

In May 1986, the US subsidiary of a Danish company, Bergsoe Metal Corp., went bankrupt, and closed its lead battery recycling plant in St Helens, Oregon. According the Oregon Department of Environmental Quality, Bergsoe's facility poisoned air, groundwater and solid beyond the plant's property with lead and arsenic[70]. Bergsoe's US subsidiary then tried to operate as a waste battery broker, and unsuccessfully requested the governments of Pakistan, South Korea and Taiwan to import lead battery wastes[71]. Today, Bergsoe operates a lead battery recycling plant in Saraburi, Thailand.

In Saraburi, north of Bangkok, Thailand, an ornate Buddhist archway leads to a temple, and to Bergsoe's lead smelter processing imported waste. The company operates a so called "state of the art" lead processor using Swedish engineering. Scrap car batteries are imported from countries like Japan, the Middle East and Singapore. Other lead residues are imported from the US, Australia and Japan. Bergsoe smelts scrap batteries and lead residues, together with raw mineral concentrates[72].

Bergsoe Metals opened the factory in 1982, and received an award from pollution control from the Thai Department of Industrial Works (DIW) in 1988. It is now seeking permission from the DIW to expand the factory. Imported scrap batteries are broken up and smelted whole, along with their plastic casings. This leads to large amounts of chlorine being emitted (up to 9% in atmospheric emissions), in addition to the lead and other substances associated with battery smelting. Liquid residues run off from the plant into drains and residues from the smelting process are dumped openly at the back of the plant, where heavy metals can be seen leaching into the ground[73].

Local residents complain that the plant emits white smoke, mostly at night, which makes their eyes burn, and gives them nausea and a strange taste in their mouth. The factory has arranged health visits for them, have taken blood tests and given them medicine for when they feel ill, which does not have much effect.

According to Suchart Somkhunthod, a neighbor of the factory and an infrequent employee of Bergsoe when "huge containers come from overseas," the smoke emitted "smells bad and makes me feel nauseous."[74]

B Latin America

4.5 Brazil

Beginning in 1987, scores of workers at two lead battery importing and recycling plants in Brazil quit or were fired from their jobs after their health failed. They had worked at Tonolli and FAE S.A., two lead battery smelters located in Sao Jose dos Campos' Region, Sao Paulo State, Brazil. City public health officials announced in 1991 that the lead recycling companies were responsible for poisoning the workers with lead.

According to Dr. Ezio Zaghetto, a Sao Jose dos Campos public health official, "Our tests [of the worker's blood and urine] showed that working at Tonolli and FAE causes chronic lead intoxication"[75]. CETESB fined FAE in 1988 for numerous violations of occupational health and environmental regulations, including problems with the smelter itself[76].

According to CETESB (the State of Sao Paolo Environmental Protection Agency), neighbors of Tonolli believe that the plant frequently releases black dusts, which settles on nearby farmland, and may have killed cattle at the Sol da Mata farm in October 1988.

CETESB believes that these emissions of lead and cadmium may also be causing highly elevated levels of lead in the blood of children living nearby[77]. This study by CETESB showed the rural population around Tonolli had higher levels of lead in their blood than any previous study done in urban areas. The lead levels of Sol da Mata resident children in the range of 4 years old are 37,2 ug Pb/dL.

When compared to the levels observed in children of the same age range living in Cubatao, an urban, industrial area (5,02 to 18,51 ug Pb/dL), the levels of contamination are extremely worrying. Of those people living on the farm for more than 3 years, a higher concentration is observed in children and elderly people. The same study found elevated levels of lead and cadmium in lake water, fish and heavy contamination in lake sediments.

Despite these findings, Tonolli and FAE are still operating and are two of Brazil's largest lead battery waste importers.

Worker health & safety has also been a problem at Microlite, the largest of the battery smelters[78], and part of Saturnia Batteries Enterprise. An investigation by the Trade Union of Metal Workers[79] found that workers were exposed to dust, metal fumes and acids, where there was inappropriate ventilation. Much of the handling of dangerous substances is done manually; protective clothing for workers was provided, although sometimes this was inadequate. There was also inadequate storage of lead wastes, and no efficient pollution control equipment for acid gases. In 1991, 206 work accidents occurred, with the worst accidents in the smelter, maintenance and foundry areas. In 1992 one worker died after an accident when molten lead was spilled over him due to inadequate machinery.

The company has taken tests of the levels of lead in workers[80]. It was found that 15% of the exposed workers has concentrations of 40mg lead in their blood, with some cases of over 60mg lead; the Brazilian and WHO limits are 40mg. Workers also reported cases of varicose veins, dizziness, breathing difficulties, gastric problems, colic, headaches, and lead poisoning. High concentrations (more than 200 mg/m3) of lead in air were also found in almost all areas of the plant; a level of 100mg/m3 was set as the tolerance limit, with 300mg/m3 as the level above which there is a serious risk.

4.6 Mexico

In December 1993, Morris Kirk, the operator of a Mexican lead battery recycling company called Alco Pacific, was sentenced to 16 months in a California state prison, and fined $2.5 million for illegally transporting lead battery wastes from the United States to Mexico[81]. He had shipped the wastes across the border under the pretext of recycling. Mexican law allows hazardous waste imports for recycling but not for disposal.

Kirk's Alco Pacific smelter in Ojo de Agua, Mexico, imported hundreds of truckloads of automobile batteries between 1988 and 1991. It faced growing resistance from people living nearby. Alco Pacific's smelter closed in early 1991 and Kirk declared bankruptcy, leaving behind a massive pile of car battery wastes from the United States.

The 15,500 ton pile of waste batteries will be cleaned up by a corporate co-defendant in the case, RSR Industries of Dallas, Texas, which is one of the world's largest automobile battery recycling companies. RSR Industries allegedly supplied most of the batteries to Alco Pacific through its California-based subsidiary, Quemetco[82].

Car batteries were not the only toxic lead wastes from the U.S. planned to be "recycled" at the ill-fated Alco Pacific smelter: According to U.S. Environmental Protection Agency records, the transnational corporation, DuPont, unsuccessfully tried to ship millions of pounds of lead slag from its New Jersey plant to Alco Pacific in 1990[83].

A Greenpeace investigation of the Alco Pacifico plant in Tijuana in 1992 found that uncontrolled fires were burning in the lead battery waste pile. This investigation was documented in "Wasting the World," a Greenpeace Toxic Trade campaign video released during the December 1992 meeting of the Basel Convention[84].

David Eng, a district attorney for Los Angeles County, confirmed that numerous fires have been burning in Alco Pacific's toxic battery pile since the smelter closed in 1991. Eng also reported that cows at a nearby dairy farm have died after drinking lead-contaminated water flowing from the smoldering battery dump, and residents of the surrounding towns are suffering from skin and respiratory diseases[85].

5 The technology of lead acid battery recycling

5.1 Background

Lead has the highest recovery rate of any non-ferrous metal, with more than 50% of world demand met with recycled material. Over 60% of lead used in the OECD is consumed in lead acid batteries (see Table 1).

The history of recovery of lead from batteries in industrialised countries stems from small, privately-owned companies processing local waste, and the development of larger companies operating on a regional basis. Equipment was unsophisticated, and a unilateral approach to plant design was the rule. Prior to the 1960's, these operations were unrestricted by environmental and public health constraints, leading to occupational problems for workers and environmental contamination. During the mid 1960's technological improvements improved efficiency, and reduced occupational and environmental hazard to some degree. Increasing environmental pressures, coupled with poor market conditions and lack of government strategy with regard to battery recycling caused the industry to decline during the 1980's, with many companies ceasing to trade. Those that survive have adopted a policy of non-expansive consolidation[86].

Lead recycling operations in developing nations have incurred costs because of the increasing environmental stringency demanded of industry in the West. Low wages and lax environmental standards and/or practise mean that a high margin of profit can be returned on secondary lead recycling in South America and South-East Asia. Thus, industries have developed in many developing countries which resemble the lead recovery operations of the West sixty years ago, in some instances with considerably lower standards on worker protection and environmental impact.

5.2 Processing and recycling

Lead scrap is of three types: whole battery scrap, industrial scrap (such as drosses and skimmings) and other scrap (such as cable sheathing). In the U.S. in 1980, 71% of all scrap was obtained from used batteries[87], and it is likely that batteries form an even more predominant part of scrap today.

The environmental standards achieved by battery resmelters vary widely. Figure 1 shows the procedure adopted by a Milanese smelter, but this might be truncated or altered in other plants. For instance, the entire battery might be charged to the smelter[88] without prior removal of the casing. OECD countries would therefore require an afterburner on the smelter to combust hydrocarbons in the exhaust, and scrubbing apparatus to remove sulphur dioxide and hydrochloric acid. Such expensive equipment is not likely to be installed in lead smelters in non-OECD countries, and will certainly be absent from "cottage" smelters.

Hazards are associated with all stages of the recycling. Storage of spent batteries can give rise to lead oxide dusts and runoff of acids into groundwater. In OECD countries, the storage yard would have a concrete base and a storage tank to collect runoff, and a rain moisturizing system to prevent dust formation.

In OECD countries, batteries are handled by a closed cab, air-conditioned bulldozer, and then dumped directly into the crushing system. Separation of plastic and lead-bearing material is handled by flotation, producing: 1) Lead oxide in decanted slime. 2) Grid scraps of lead alloy containing antimony (1.5-6%), arsenic (0.15-0.2%) and tin. 3) Plastics, including PVC, polypropylene and rubber. 4) Liquid effluents, containing the battery acids and lead oxides.

Inputs

Final refining occurs in large "kettles", requiring considerable quantities of hygiene air to collect the fume and dust, so that very large filtration plants are needed to treat the volume of exhaust that arises.

Cable sheathing, weights, pipes and other high grade sources of scrap are fed straight into the smelter with no preparation, whilst lower grade scraps such as drosses and flue dusts from the smelting of lead and other non-ferrous metals are mixed with the charge before smelting.

As with copper smelting, the primary and secondary processes are not always distinct. All primary smelters reintroduce the residues from flue dust into the furnaces, and many (eg the Avonmouth plant in Bristol) import such materials from other plants. The advantages of economy of scale and the difficulties in locating new smelters are leading to calls for increased integration of primary and secondary plants, including battery recycling units[89].

Wastes

Atmospheric pollution in the working environment and outside the plant is probably the most significant threat to human health caused by lead smelting. Elemental lead and lead oxide particles occur in workplace dusts, which are generated particularly in the furnace and ingotting departments. In addition, high concentrations of air borne antimony can develop, especially during refining and ingotting. These dusts are theoretically collected in bag filters and venturi scrubbers before air is discharged to the environment, and are fed back into the process.

Significant sulphur dioxide emissions may also occur, especially if batteries are not crushed and separated before smelting. In addition, HCl fumes and products of incomplete combustion (PICs) may be produced.

Water used during the process becomes highly polluted, and must be treated before discharge. Water outflows arise from the following sources:

a) water used in the crushing and separation phases, which contains sulphuric acid as well as lead oxides and salts;
b) cooling waters for the ingot machine, contaminated with lead salts;
c) waters used in the fume wet-cleaning process, which will contain all compounds located in the fume;
d) waters used for yard irrigation, contaminated with leads and acids.

The waste water arising from these sources will require thorough neutralisation and flocculation/sedimentation of solids before discharge.

The two other principal waste products are plastics and rubber from battery cases and slags. Some of the plastic can be recycled, but the rubber and slags are landfilled, possibly on site[90].

5.3 Pollution-control technology relating to lead smelting

Emissions of lead and sulphur dioxide during pyrometallurgical processes are very difficult to control. However, expensive pollution abatement technologies can reduce human and environmental exposure. Of the £10 million recently spent by J H Enthoven & Sons on updating their secondary lead smelter in Derbyshire, UK, 40% was invested in pollution control[91].

The principle measures that are taken within conventional battery recycling plants in OECD countries to mitigate aerial pollution are:

a) Irrigation of the storage yard, to prevent high levels of lead dust forming during dry weather. Contaminated water treatment involves neutralising acidity and removing suspended material. This is achieved by the application of lime, and the flocculation and decantation of solids, respectively. The sludges produced are sometimes dried and re-inserted into the recycling process[92].
b) Mechanisation of all lead handling. In particular, the workers involved in breaking the used batteries before smelting are protected in plants like Enthoven & Sons in the UK, who use a crane, with a sealed and air conditioned cabin, to prevent contact with lead.

c) Air suction in all process departments, and the removal of particulates by bag filters. Careful design of the air extraction system is required to avoid the point furthest from the fan being starved of "pull". This problem can be mitigated by the inclusion of small booster fans[93].

Lead smelting operations vary between those fitted with the best available technology for pollution abatement, (as most plants in OECD countries do); those having some technology for pollution abatement, but is either archaic or capable only of primary filtration or removal (such as some of the plants in South East Asia, reviewed below); and those having no pollution abatement technology (such as "back street" or "home" smelters). Back street smelters comprise of small factories which rely on manual labour and crude technologies to break up and smelt lead battery waste. "Home" smelters consist smelting by local people, usually in or near their own homes; slags from large lead smelters are collected or bought by villagers, who burn it in order to recover the lead and sell it.

Likewise, health and safety can vary from complete protection from any contact with lead (see b above), to some protection, such as gloves and cloth face masks, to no protection whatsoever.

The reality of conditions in a selection of lead smelters in South East Asia is described in Section 4; the results of samples taken by Greenpeace in August 1993 are detailed in Section 7.

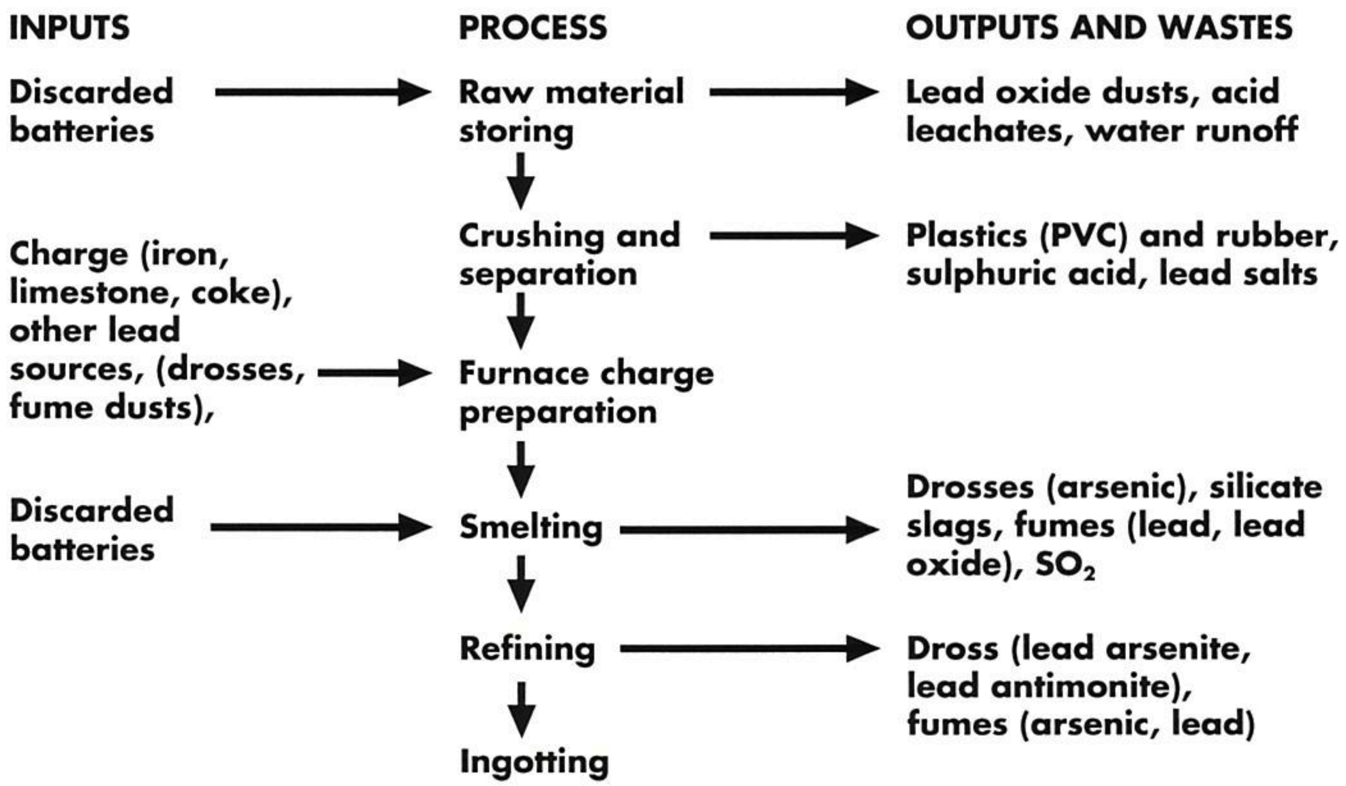
TABLE 1

The principal uses of lead in OECD countries and their potential for recycling (Wilson,1990).

USE	TONNES	% OF TOTAL	RECYCLABLE
Batteries	2,310,000	60.4	Yes
Cable sheathing	194,000	5.1	Yes
Rolled and extruded products	287,000	7.5	Yes
Shot/ammunition	88,000	2.3	No
Alloys	148,000	3.9	Yes
Pigments and compounds	521,000	13.6	No
Gasoline additives	110,000	2.9	No
Miscellaneous (eg weights, radiation uses)	165,000	4.3	Yes/No

FIGURE 1

Typical phases in the recycling of lead batteries and other lead waste (from Collivignarelli et al, 1986)



Potential environment and occupational hazard from lead

6

Lead is one of the most pervasive and toxic of all environmental contaminants, and some of the more extreme of its wide range of pernicious effects have been recognised for at least two thousand years. Metabolic, neurological and neuropsychological disorders can result from acute or chronic exposure. Interference with calcium metabolism and transport across nerve endings is believed to be the principle mode of toxic action in cases of neurological effect[94]. The mechanisms causing other lead related illness are generally less well understood, but some may be due to the lead binding to carboxyl groups in amino acids[95].

The classic neurological symptoms of exposure to high levels of lead are encephalopathy in children and peripheral neurotoxicity in adults[96]. The latter is characterised by the loss of muscle control at the extremities, causing foot and wrist drop. Motor nerve dysfunction has been measured at blood lead levels of 50-70 μg/dL[97].

Lead interferes with heamoglobin production, resulting in anaemia. This has been reported at blood levels of 60-80μg/dL[98]. It also causes irreversible damage to the nephrons of the kidney, leading to a gradual reduction in the efficiency of uric acid excretion. High blood levels during pregnancy are correlated with a higher frequency of stillbirths and miscarriages, and transplacental transport of lead can damage the central nervous system of the foetus[99]. There is no placental barrier to lead transport, and evidence suggests that foetal brain tissue is particularly sensitive to lead poisoning, so it is especially important for pregnant women to avoid exposure[100]. Paternal blood lead levels are related to congenital malformations in children, with levels commonly found in some work places possibly being inimical to spermatogenesis[101]. There is limited evidence that lead is also a carcinogen in humans, with cancers of the kidney being most strongly associated with exposure[102].

Organic and inorganic lead are less toxic to aquatic plants than mercury and copper[103], with acute/chronic effects generally appearing at media concentrations of 0.1-5 mg/L. Some terrestrial plants can also accumulate high concentrations of lead without apparent ill effect.

Acute effects of lead poisoning are usually reported in aquatic invertebrates at concentrations of 0.1- 10mg/L[104], although some species, including some polychaetes and isopods, are particularly resistant to lead intoxication.

Fish are more sensitive to lead than invertebrates, with Lethal Concentration (LC) 50 levels of between 0.5 - 10mg/L[105]. Sub-lethal effects, such as severe spinal deformities, have been recorded in media concentrations of less than 119μg/L.

7 Scientific survey of battery recycling in Asia

As described in Section 4 above, Greenpeace visited Indonesia, the Philippines, and Thailand in August 1993, to assess the status of the lead recycling industry. In addition to making field observations around (and inside some of) the factories, and conducting interviews with workers and local residents, samples were taken from soils, sediments, waste piles, and run-off. Scalp hair was collected from residents local to the factories. These samples were returned to the UK for analysis of heavy metal content.

7.1 Indonesia

Greenpeace visited PT IMLI located south of Surabaya, the largest secondary lead producer in Indonesia.

Samples were taken from the soil adjacent to the factory; from material dumped outside the factory, which included piles of ash/soil mixture, dross, and incinerator ash; and from sediment from a brook passing close to the plant.

All of the soil samples taken were contaminated with lead, varying in level from 112 mg/kg, to 304,900 mg/kg, with a mean value between five samples of 63 661 mg/kg. This represents severe contamination of the soil by lead, which can also be expected to enter the aquifer which serves wells and rice field irrigation systems. A mathematical guideline model has recently been produced by the international Society for Environmental Geochemistry and Health (SEGH), which can be used to predict population blood lead levels from soil levels, taking into account such factors as background blood level from sources other than soil, and the degree of certainty required in protecting the population[106]. The mean soil lead value in the soil around IMLI would be typically predicted by the model to cause a blood lead level of 85ug/dL. Since the current recommendation of the Centers for Disease Control (CDC) in the US is that levels should not be above 10ug/dL[107], and blood levels of above 80ug/dL are liable to cause severe lead poisoning symptoms (see 2.3), the local population is clearly at risk. One of the samples of soil taken from a middle school showed a level of 1890 mg/kg of lead. Although lower than the mean value (see above) children are more vulnerable to the toxicity of lead.

In addition to contamination by lead, the soils around IMLI demonstrated elevated levels of antimony, manganese, iron, and nickel, all of which represent toxic hazard.

The analysis of dumped ash, dross, and sediment revealed a similar concentration to that in soils. The ash was contaminated with high levels of lead, as well as manganese and copper. Samples from the piles of dross contained high levels of lead and iron. It is likely that significant quantities of lead reach local water and soils via leaching and wind-borne ash.

Further evidence of long term contamination of the local environment was the measurement of very high levels of lead in brook sediment (172,000 mg/kg). This poses a hazard to aquatic organisms, plants, and via consumption of these, to humans.

Direct evidence of prolonged and excessive exposure of local residents to lead as a result of IMLI's activities was obtained following analysis of scalp hair samples. Six individuals were tested, and found to have hair lead levels ranging from 51.2-336 ug/g (dry weight). Levels of toxic metals in hair are a well-established index of chronic exposure. Levels of lead in hair are normally below 10ug/g (dry weight), with influencing factors such as age, sex, and hair colour[108]. This value can rise sharply in individuals encountering prolonged exposure to lead; in the former Yugoslavia, lead smelter workers were found to have mean hair lead levels of 71.9 ug/g and local residents 33.2 ug/g[109]. These levels are vastly exceeded in the IMLI residents scalp hair tissue; these values compare to those obtained by Kopito, Byers, and Shwachman (1967) who reported the levels of lead in scalp hair in children suffering from lead intoxication.

There is some evidence that IMLI has improved in some areas of pollution control by installing primary effluent treatment facilities since Greenpeace visited in August 1993. Despite claims by the company about taking part in the "current modernisation and advancement of technological development", standards still fall well below those which would be required in OECD countries, in particular with regard to filtration of atmospheric emissions and protection of workers. The levels of lead measured in soils and sediments indicate that severe contamination by this toxic heavy metal has occurred over many years; some remediation of the local environment will be necessary. Such measures might include soil or sediment removal; soil containment; contaminant extraction; deep tilling, revegetation; or barrier construction. Clearly, those companies in industrialised countries which have profited out of exporting lead battery waste to IMLI should have some liability for this clean up.

A continuing problem emanating from the export of lead battery waste to IMLI and other large lead recycling operations in South East Asia is that this tends to spawn cottage industry smelting (see Section 5). Previously, low grade slag and dross was dumped outside the factory at IMLI for collection by local residents. Whilst the dross is no longer dumped, it is sold on to local villagers, who then propagate dangerous "backstreet" or even "home" smelting operations, as described above (5.3).

7.2 Philippines

Greenpeace visited three lead smelters in the Philippines; Philippines Recycling Inc. (PRI); Parker Batteries, a small battery recycler in Manila; and Imarflex, a medium-sized secondary lead producer in Manila.

7.2.1 Philippines Recycling Inc (PRI)

PRI is typical of a lead recovery operation in South East Asia, following the process scheme described in Figure 1, Section 2, with minimal implemetation of pollution-control technology, such as effluent treatment plants. Workers are also required to wear full face masks when visitors are present.

Samples were taken from around the plant; from sediment from below an effluent discharge pipe to a neighbouring river; from run-off to a swamp from the waste storage area below the plants lead smelter; and from rice husk ash from the rice field next to the lead smelter. Elevated levels of lead were detected in the samples (18,310, 33,240 mg/kg in the sediments, and 80 mg/kg in the burnt rice husks). In addition, elevated levels of manganese and copper were detected in all samples. The contamination of local crops as a result of lead smelting operations is evidenced by the high residual lead levels in the ash of rice husks. The potential hazard of lead poisoning via ingestion of such material is clear.

7.2.2 Parker Batteries

Greenpeace was able to gain access to the factory at the invitation of the owner. As described in Section A, the plant was typical of a cottage smelting operation with poor housekeeping, and no protection of workers from contact with lead. Samples taken from the solid waste found next to the lead smelter contained large amounts of lead. As a result of such waste being dumped around the factory, soil samples were demonstrated on analysis to contain high lead levels (75,000 mg/kg). This level could be expected to cause the human toxicological and environmental effects described in Section 2 above over a wide area of Manila.

7.2.3 Inmarflex

Inmarflex is a medium sized secondary lead processor, located in the outskirts of Manila, in a residential area. Little is known about the technology employed within the plant. Residents suffer severe effects from routine emissions (see Part I).

A sediment sample taken from a marshy area behind the plant contained massive levels of lead (191,300 mg/kg). All the effects described in 3.1, relating to hazard to the local population and biota are likely to prevail from this condition. Use of the SEGH model described in 3.1 suggests that residents near to this site would suffer lead poisoning, with blood lead levels in excess of 100 ug/dL.

Scalp hair samples taken from residents living adjacent to the Inmarflex plant confirmed that severe lead exposure was occurring, with levels of 91.6 ug/g detected in one seventeen year old. This individual was suffering from severe bronchial illness, probably as a result of lead poisoning. Health problems were noted to be rife throughout this village.

7.3 Thailand

As described in Section 5. Greenpeace visited Bergsoe Metals, a Danish-owned company in Saraburi, Thailand. Bergsoe is the largest secondary lead smelter in Thailand; the company uses Swedish technology consisting of a rotary kiln, after burner, cyclone and a baghouse filter. Water treatment consists of neutralisation with lime and sedimentation. Lead battery waste is charged whole into the smelter, together with cases, so emissions are likely to include by-products from burning plastics and rubber.

Samples were taken from a waste pile at the back of the plant (solid waste sample); from a drainage ditch downstream of plant run-off (sediment sample); and from another ditch 100 metres downstream of the plant (sediment sample).

Under analysis in the UK, all the samples were shown to contain high levels of lead. The solid waste contained 61,400 mg/kg; the sediment adjacent to the plant 2715 mg/kg; and even 100 metres from the plant sediment contained 645 mg/kg. All the samples were significantly contaminated with manganese.

As discussed in 3.1, current models suggest residents in the neighbourhood of the plant would suffer high blood levels in the region of 40-80 ug/dL.

7.4 Other toxic effects as a result of lead battery smelting

In addition to lead, many other highly toxic heavy metals were determined to be present in the Greenpeace samples, including arsenic, mercury, antimony, and cadmium. The results of all the samples taken are listed in Appendix 1.

Although the present sampling study was focussed at metals analysis, an acid effluent is produced as a result of recycling, even if sulphuric acid is drained from batteries prior to their shipment. Acid exposure to workers via fumes or direct contact is the result, along with degradation of the receiving aquatic environment due to pH effects[110].

In certain battery recycling operations, plastic casing is not removed prior to combustion, leading to the generation of chlorinated hydrocarbons, including highly toxic dioxins[111], if the plastic cases are made of PVC. In some instances, casings are simply dumped, causing persistent and potentially toxic effects via slow breakdown and leaching.

7.5 Discussion

The results of the sampling study currently undertaken in and around lead smelting industry in South East Asia indicate the scale of the occupational and environmental hazards encountered by local workers, residents and biota.

Samples taken by Greenpeace demonstrated that soil and sediment lead levels within and around the smelting operations were highly elevated. When such values are compared to typical levels of lead in soil around European lead smelting operations, and European target levels for acceptable lead concentrations in soil (Figure 2), it becomes clear that an extreme threat to public health and environment by lead poisoning is prevailing in Indonesia, Thailand, and the Philippines. Likewise, the results of hair samples show very high concentrations compared to typical levels from around lead smelters. This has occurred directly as a result of the export from OECD countries of lead batteries, which are being recycled using operations which are no longer acceptable in developed countries.

The toxicology and ecotoxicology of lead is now well established, with low target levels set for occupational and environmental exposure by most OECD countries. It is essential that such standards become applied to all nations. Countries currently exporting lead wastes for recycling should now be prevented from doing so, since it has been clearly demonstrated by the current investigation that the result of such trade activity in receiving communities is environmental degradation; life-threatening conditions for lead workers; and severe public health repercussions for innocent residents, and in particular for their children.

IMLI, Desa Gunung, Gangsir, Indonesia

Sample (mg/kg)

METAL	DROSS	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 5	ASH AND SOIL	INCINERATOR ASH	SEDIMENT
Arsenic	23	6	7	2	28	9	23	<0.1	21
Mercury	0.7	<0.1	0.1	0.2	<0.1	<0.1	0.6	0.3	<0.1
Antimony	140	50	50	50	100	50	60	50	90
Nickel	105	n/d	10	15	2490	10	25	35	560
Manganese	184	1240	970	1320	310	1200	55	400	620
Iron	40200	36400							
Chromium	54.4	7.02	5	5	20	5	5	55	90
Zinc	332	54.2	65	110	250	115	125	770	265
Copper	101	28.8	50	135	4875	40	170	415	3195
Cadmium	25.8	6.47	0.8	1.9	59	<0.5	9.4	3.0	51
Cobalt	6.53	18.3							
Lead	13200	112	2815	8590	304900	1890	23980	1770	172000
Titanium	159	784							

Philippines Recycling Inc, Philippines 2B

Sample (mg/kg)

METAL	ROCK SEDIMENT	ASH FROM BURNED RICE	RUN-OFF FROM WASTE STORAGE
Arsenic	150	<1	41
Mercury	0.1	0.1	0.1
Antimony	50	<50	<50
Nickel	85	<5	35
Manganese	1030	275	1660
Iron			
Chromium	25	10	20
Zinc	485	20	340
Copper	285	10	175
Cadmium	204	<0.5	25
Cobalt			
Lead	18310	80	33240
Titanium			

Parker, Manila, Philippines, 1C
Sample (mg/kg)

METAL	DROSS	SOIL	KLINKER SOLID WASTE	SOLID WASTE
Arsenic	1	36	11	<1
Mercury	0.2	0.3	0.2	<0.1
Antimony	140	70	80	1000
Nickel	40	10	29.1	33.3
Manganese	5	400	1910	0.29
Iron			25800	16.6
Chromium	<5	20	88	0.45
Zinc	<0.5	165	2210	0.43
Copper	210	230	190	29.3
Cadmium	<0.5	<0.5	41.3	n/d
Cobalt			11.6	0.29
Lead	605000	75000	50800	184000
Titanium			169	0.16

Inmarflex, Philippines, 2A
Sample (mg/kg)

METAL	SEDIMENT
Arsenic	31
Mercury	0.1
Antimony	70
Nickel	20
Manganese	195
Iron	
Chromium	50
Zinc	135
Copper	50
Cadmium	2.3
Cobalt	
Lead	191300
Titanium	

Bergsoe Met, Thailand 1
Sample (mg/kg)

KLINKER	SEDIMENT 1	SEDIMENT 2
210	3	6
0.2	0.2	<0.1
70	<50	<50
245	20	20
4570	485	750
60	40	45
115	125	80
535	40	25
61	29	0.5
61400	2715	645

References

1. Australian Bureau of Statistics, Commodity Export Statistics, 1990-93.
2. Note: Figures for "lead scrap" and "lead waste" exports often do not differentiate between lead-acid battery waste and many other kinds of lead waste, such as slags and ashes from lead smelters and lead cable scrap. Customs and waste export regulations in most industrial countries do not categorise these waste streams separately. Many industrialised countries do not regulate the export of these wastes at all.
3. Statistic Canada, customs declarations 1990-1992.
4. Environment Canada, Access to information request, lead waste exports 1991.
5. Documents on file with Greenpeace UK.
6. Statistics New Zealand, Lead Waste and Scrap, Overseas Trade 1991-1993.
7. Documents on file with Greenpeace UK.
8. American Metal Market, December 15, 1993; PIERS.
9. PIERS (Port Import Export Reporting Service) data, USA, 1992.
10. *Metal Statistics: 1993* (American Metal Market, 1993); Numerous issues of American Metal Market newspaper.
11. *Metal Statistics* 1993
12. UK Customs & Excise, trade statistics, 1992-93, compiled by Greenpeace UK.
13. Documents on file with Greenpeace UK and Greenpeace investigations.
14. UK Customs & Excise, trade statistics, 1992-93, compiled by Greenpeace UK.
15. Greenpeace UK correspondence with Waste Regulatory Authorities in the UK, 1993.
16. Recycling world, Issue 159, November 12th 1993, publ. by Scrap Market Ltd.
17. *The Waste Invasion of Asia*, a Greenpeace report published January 1994.
18. Jakarta Post articles and Indonesian government records.
19. BAPEDAL (Department of the Environment, Indonesia), document on the Effective Control in the Operation of Waste Batteries, on file with Greenpeace UK and Greenpeace Australia.
20. Materials Reclamation Weekly, June 19, 1993.
21. Documents on file with Greenpeace UK.
22. Delfin J Ganapin, Office of the Undersecretary for Environment and Reserach, Philippine Department of Environment and Natural Resources, letter to Paul Ch. Rabe, Director General, Office of American Affairs, Department of Foreign Affairs, Manila, 3rd April 1991.
23. Angie Brabante, Chief of Chemical Waste Management Department, Philippines, meeting with Anita Celdran, Green Forum, Philippines, August 1993.
24. Taiwan Evnrionmental Protection Agency, letter to Greenpeace, 1990.
25. Center for Investigative Reporting with Bill Moyers, Global *Dumping Ground: the International Traffic in Hazardous Waste* (Seven Locks Press, USA, 1990)
26. American Metal Market, October 19, 1992.
27. Australian Bureau of Statistics, Commodity Export Statistics, 1993.
28. The Nation, 25 November 1993, op.cit.
29. The Nation, Plan mooted to ban import of used batteries, 25th November 1993, article.
30. Prakarn Bunchuyedee, Pollution Control Department, meeting with Madeleine Cobbing, Greenpeace UK, August 1993.
31. Klomjit Chandrapanya, The Nation, Indecent Disposal, September 1993 (exact date).
32. The Nation, 25 November 1993, op.cit.
33. Trade Statistics, Brazilian Customs, 1991/92.
34. Eng. Norton de Assumpcao Martarello, "Relatorio sobre atividades desevolvidas na Empresa Saturnia Baterias - Microbat Ltda". October 1992.
35. Trade Statistics, Brazilian Customs, 1991/92.
36. American Metal Market newspaper.
37. Wilson, DN. 1990, Recycling of Lead. In Recycling of Metalliferous Materials, Institute for Mining and Metallurgy, London.
38. Battery Council International documents.
39. Department of Trade & Industry (UK), 1993. Batteries and accumulators containing certain dangerous substances - directive 91/157/EEC. Department of Trade and industry Consultation Paper.
40. Ibid.
41. Metal Bulletin, UK secondary Pb smelter's future threatened, 18 November 1993.
42. ENDS (1988) Enviromental Data Services, H J Enthoven and Sons; Moulding a Cleaner Image for Lead. Company Report 120, ENDS Report 160, May 1988, pp.11-13.
43. Metal Bulletin, UK secondary Pb smelter's future threatened, David Wilson of the Lead Development Association, 18 November 1993.
44. Metal Bulletin, UK secondary Pb smelter's future threatened, David Wilson of the Lead Development Association, 18 November 1993.
45. Taylor and Zunkel, "Environmental Challenges for the Lead-Zinc Industry," Journal of Metals, 40 (8), August 1988, pp. 27-30.
46. Smith and Daley, Domestic Secondary Lead Industry: Production and Regulatory Compliance Costs, Department of Interor (Bureau of Mines), Information Circular, 1987.
47. Adrian Gardner, "Working under leaden skies," MBM, December 1993.
48. Metal Bulletin Magazine, Working under leaden skies, December 1993.
49. Metal Bulletin Magazine, Working under leaden skies, December 1993.
50. Customs and Excise, Port of Manila, exemption certificate given by Department of Finance .. dates ...
51. American Metal Market, April 17, 1992.
52. Smith and Daley.
53. Jakarta Post articles and Indonesian government records.
54. Bupati Kepala Daerah Tingkat II Pasuruan letter no. 660.1/996/431.14/1989 dated 9.6.89.
55. Decree no. 29, 1986, Analysis on Environmental Impact (AMDAL) documents.
56. Memo, dated 12.4.91 pg. 1.
57. Article in Jawa Pos, dated 26.4.91 pg. 1.,
58. BTKL Lab report no. 57, samples taken by YL Sugiyanto of BTKL
59. BTKL Lab report no. 1540, samples taken by YL Sugiyanto of BTKL.
60. Surabaya Legal Aid Board, LBHS Index : AHA/R.06/ 1992., documents on file with Greenpeace Australia.

61. Simon Divecha, Greenpeace Australia, Investigations in Indonesia, 1993.
62 BAPEDAL (Department of the Environment, Indonesia), document on the effective control in the Operation of Waste Batteries, on file with Greenpeace (op.cit.)
63. Article in Surabaya Pos, dated 29.8.92 pg. 1.
64. Article in Kompas, dated 25.8.92 pg. 1.
65. Catro II, Felicidad T Castro, M.D., Chief, Health Control Division, OSHC, The Biological Levels of Lead in Selected Workers, 2nd National Occupational Safety and Health Congress, September 1991, Quezon City, Philippines.
66. Center for Investigative Reporting, *Global Dumping Ground.*
67. American Metal Market, October 19, 1992.
68. Australian Bureau of Statistics, Commodity Export Statistics, 1993.
69. Center for Investigative Reporting.
70. Brent Walth, "Blind Faith," Wilamette Week, September 24-30, 1987.
71. US EPA records.
72. Worapoj Mitravicharn, technical assistant manager, Bergsoe Metals, conversation with Klomjit Chandrapanya, The Nation, August 1993.
73. Madeleine Cobbing, Greenpeace UK, & Simon Troendle, Greenpeace International, investigation in Thailand, August 1993.
74. Klomjit Chandrapanya, "Indecent Disposal," FOCUS (Thailand), September 2, 1993
75. Michael Kepp, "Workers walk at Brazil units," American Metal Market, March 4, 1991.
76. "Fae leva multa depois de ser elogiada por alemaes," Vale do Paraiba, March 1988.
77. CETESB, report on environmental and public contamination by lead, at the farm "Sol da Mata," near Tonolli, March 6, 1989.
78. Eng. Norton de Assumpcao Martarello, "Relatorio sobre atividades desenvolvidas na Empresa Saturnia Baterias – Microbat Ltda", October 1992.
79. Eng. Norton de Assumpcao Martarello, "Relatorio sobre atividades desenvolvidas na Empresa Saturnia Baterias – Microbat Ltda", October 1992.
80. Eng. Norton de Assumpcao Martarello, "Relatorio sobre atividades desenvolvidas na Empresa Saturnia Baterias – Microbat Ltda", October 1992.
81. Los Angeles Times, December 16, 1993.
82. Andrea Ford, "Firm Agrees to Clean Up Tijuana Site," Los Angeles Times, June 16, 1993.
83. U.S. Environmental Protection Agency records.
84. Greenpeace International video, Wasting the World, December 1992, available from Greenpeace Communications, London.
85. Los Angeles Times, December 16, 1993.
86. Wilson DN, 1990. Recycling of lead. In Recycling of Metalliferous Materials, Institute for Mining and Metallurgy, London.
87. Kaplan RS and Ness H, 1987. Review article no. 13. Recycling of metals. Conservation and Recycling 10: 1-13. Kopito, L, Byers, RK, Shwachman, H, (1967). Lead in hair of children with chronic lead poisoning. N. Engl. J. Med. 276, 949 - 953.
88. Kaplan and Ness 1987 op. cit.
United Nations Environment Programme, 1984. Environmental aspects of selected non-ferrous metals industries; an overview. UNEP Industry and Environment Office, Paris.
89. Zunkel AD and Taylor JC, 1988. Integrated primary/secondary Pb smelting. Journal of Metals 40: 32-35.
90. Johnston P, Stringer R and Puckett J. 1992. When green is not: the OECD's "green" list as an instrument of hazardous waste de-regulation. Greenpeace International.
91. Shelley, 1990.
92. Collivignarelli C, Riganti V and Urbini G, 1986. Battery lead recycling and environmental pollution hazards. Conservation and Recycling 9: 111-125.
93. Shelley, 1990 op.cit.
94. Goldstein GW, 1990. Lead poisoning and brain cell function. Environmental Health Perspectives 89: 91-94.
Silbergeld EK, 1990. Toward the twenty-first century: Lessons from lead and lessons yet to learn. Environmental Health
Perspectives 86: 191-196.
95. Goyer RA, 1986. Toxic effects of metals. In Casarett and Doull's Toxicology. The Basic Science of Poisons. CD Klaassen, MO Amdur and J Doull (eds), Macmillan, London.
96. Goyer RA, 1986. op. cit.
97. Goyer 1986. op. cit.
98. World Health Organisation, 1983. Reports and Studies No. 22. Review of potentially harmful substances - cadmium, lead and tin. GESAMP, Geneva.
99. W.H.O., 1983 op.cit.
100. Goyer RA, 1990. Transplancental transport of lead. Environmental Health Perspectives 89: 101-105.
101. Sallmen M, Lindbohm M, Anttila A, Taskinen H and Hemminki K, 1992. Paternal occupational lead exposure and congenital
malformations. Journal of Epidemiology and Community Health 46: 519-522.
102. Goyer RA, 1986 op.cit.
103. Moore J and Ramamoorthy S. 1984. Heavy Metals in Natural Waters. Springer-Verlag, New York.
104. Moore J and Ramamoorthy S. 1984. op.cit.
105. Moore J and Ramamoorthy S, 1984 op.cit.
106. Wixson BG and Davies BE, 1994. Guidelines for lead in soil. Environ. Sci. Technol. 28, (1) 26-31.
107. U.S. Centers for Disease Control, 1994. Preventing Lead Poisoning in Young Children; U.S. Department of Health and Human Services: Atlanta, GA.
108. Schumacher, M., Domingo, JL, Llobet, JM, Corbella, J. (1991). Lead in children's hair, as related to exposure in Tarragona Province, Spain. Sci. Tot. Env. 104, 167 - 173.
109. Stankovic, M. (1977)
110. Collivignarelli C, Riganti V and Urbini G, 1986 op.cit.
111. Zunkel, AD, and Taylor, 1988 op.cit.