



Blacksmith Institute's The World's Worst Toxic Pollution Problems Report 2011

The Top Ten of the Toxic Twenty

ARTISANAL GOLD MINING MERCURY POLLUTION
INDUSTRIAL ESTATES LEAD POLLUTION
AGRICULTURAL PRODUCTION PESTICIDE POLLUTION
LEAD SMELTING LEAD POLLUTION
TANNERY OPERATIONS CHROMIUM POLLUTION
MINING AND ORE PROCESSING MERCURY POLLUTION
MINING AND ORE PROCESSING LEAD POLLUTION
LEAD-ACID BATTERY RECYCLING LEAD POLLUTION
NATURALLY OCCURRING ARSENIC IN GROUND WATER ARSENIC POLLUTION
PESTICIDE MANUFACTURING AND STORAGE PESTICIDE POLLUTION

Produced in collaboration with Green Cross Switzerland

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This report is available online at www.worstpolluted.org

Top Ten Toxic Pollution Problems

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Introduction

The World's Top Ten Toxic Pollution Problems

About the Report

The 2011 World's Worst Pollution Problems Report is a first attempt to quantify the human health impact of source industries and the specific toxic pollutants they create. This evaluation is based on data that the Blacksmith Institute and Green Cross Switzerland have collected on toxic hotspots around the world. Quantifying the global health impacts from these places is a relatively new area in environmental health research. Blacksmith Institute and Green Cross Switzerland believe such research is vital to show the true magnitude of the damage caused by toxic pollution from mining, industrial and agricultural activities to create awareness on the economic and social impact of pollution, and on the need to fund and implement clean up activities.

In 2008, the Blacksmith Institute and Green Cross Switzerland published a report titled, "The World's Worst Pollution Problems: The Top Ten of the Toxic Twenty." This report included an unranked list of ten of the most prevalent and dangerous pollution issues pulled from a list of twenty broader global pollution problems. The list of pollution issues was created based on the opinions and analysis of a team of experts from Blacksmith's Technical Advisory Board, and the criteria for selection included the number of people impacted, the toxicity of the key pollutant, and the ease with which the pollutant could be inhaled, ingested, or absorbed. Each issue was described in detail and the report provided information on key pollutants, sources, pathways of exposure, and health impacts. This list presented some of the most important and dangerous global pollution problems, and helped to bring international attention to the risks pollution poses to human health.

The 2011 report revisits the topic of the worst pollution problems but makes significant use of the volumes of data that Blacksmith and Green Cross Switzerland have collected on pollution hotspots



Solid waste from chemical manufacturing facilities

since 2008 thanks to support from various donors. In the intervening three years, Blacksmith has identified and assessed over 2,000 polluted sites and has collected data about concentrations of key pollutants, industrial sources, GPS coordinates, observed health effects, exposure pathways, photos, maps, and information about the potentially exposed population.

With this database of in-depth and on-the-ground research, the 2011 report is able to more accurately and directly isolate and identify the most severe and widespread pollution problems. The research used also includes scientific analyses of specific levels of pollution in relation to international health standards, which allows for a more detailed and quantifiable analysis of the health risks associated with pollution. Research and documentation of this scale has never been done before, and the information gathered, along with this report highlighting the worst problems, will serve as a tool to help prioritize future resource allocation and cleanup efforts. In addition, this research on

Top Ten Toxic Pollution Problems



Dyes used to color textiles

pollution hotspots throughout the world provides a unique opportunity to begin to quantify health burdens posed by exposure to toxic pollution.

Scope of the Report: How the List was Created

The goal of this report is to identify toxic pollutants that have the most significant known human health impacts and to begin to quantify the health burdens they create. Specifically, the report focuses on the human health impact caused by toxic metal and chemical pollution coming from mining and industrial and agricultural activities in low- and middle-income countries. The research focuses on local health effects of toxic pollution, near the source, as opposed to more widespread health impacts that arise from emissions to the atmosphere or contamination of larger water bodies.

Blacksmith Institute and Green Cross Switzerland recognize that the world faces many severe environmental challenges, including climate change; deterioration of ocean ecology; deforestation; desertification; fresh water scarcity; invasive species; and chemical contamination, to

name a few. All of these problems are interrelated in complex ways, and are, in part, caused by human activity. This report does not intend to deemphasize the impact of any of these environmental issues, or that of any other pollutants, but rather focuses on those pollutants that the organizations are able to track effectively through the industrial process and into pathways that cause exposure to humans.

Mining and industrial production is a large sector of the global economy, with data from 2006 showing industrial output contributing to 28.1% and 38.8% of GDP in low- and middle-income countries, respectively.¹ Though industrial growth has contributed to increases in jobs and has been important in the overall development of many countries, this sector is also responsible for significant environmental and health problems caused by industrial pollution. The World Water Assessment Programme of the United Nations Educational, Scientific and Cultural Organization (UNESCO) estimates that industry is responsible for the annual accumulation of 300 to 500 million tons of sludge, heavy metals, and other toxic wastes, and that 70% of untreated industrial waste in developing countries is dumped directly into water systems.²

1. "GDP: percent gdp from industry." World resources institute, earth trends: economics, business and the environment. Available at http://earthtrends.Wri.Org/searchable_db/index.Php?Theme=5&variable_id=215&action=select_countries.

2. "Water and Industry." World Water Assessment Programme, United Nations Educational, Scientific and Cultural Organization. Accessed September 6, 2011. Available at http://www.unesco.org/water/wwap/facts_figures/water_industry.shtml



<-- People sorting waste at a municipal dump site in India

--> Waste scraps outside of an informal tannery in India



The 2011 “top ten” and “toxic twenty” list is limited by several factors. First, and most importantly, the pollutants discussed within this report are those that are classified as “toxic” by the Blacksmith Institute Technical Advisory Board. These pollutants include, but are not limited to, heavy metals, radionuclides, poly-aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), fluorides, asbestos, cyanides, and persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) and some pesticides. The Technical Advisory Board evaluates pollutants that are not included in the list above on a case-by-case basis. The Board reviews the available environmental health literature on the biological effects of a given pollutant and comes to a consensus on whether it fits into the organization’s definition of toxic.

Blacksmith and Green Cross Switzerland are aware that this classification excludes many widespread pollution problems caused by mining, industrial and agricultural activities. For example, the scope of this analysis excludes bacterial contamination of water; discharge of non-toxic particulates to the atmosphere or receiving waters and resulting respiratory or water quality impacts; emission of carbon dioxide and other greenhouse gases; SO₂, NO_x, and acid discharges to the atmosphere or receiving waters; biological or chemical oxygen demand; and indoor air pollution, particularly on occupational health. The analysis also excludes oil contamination related to drilling and petroleum product transport, storage and

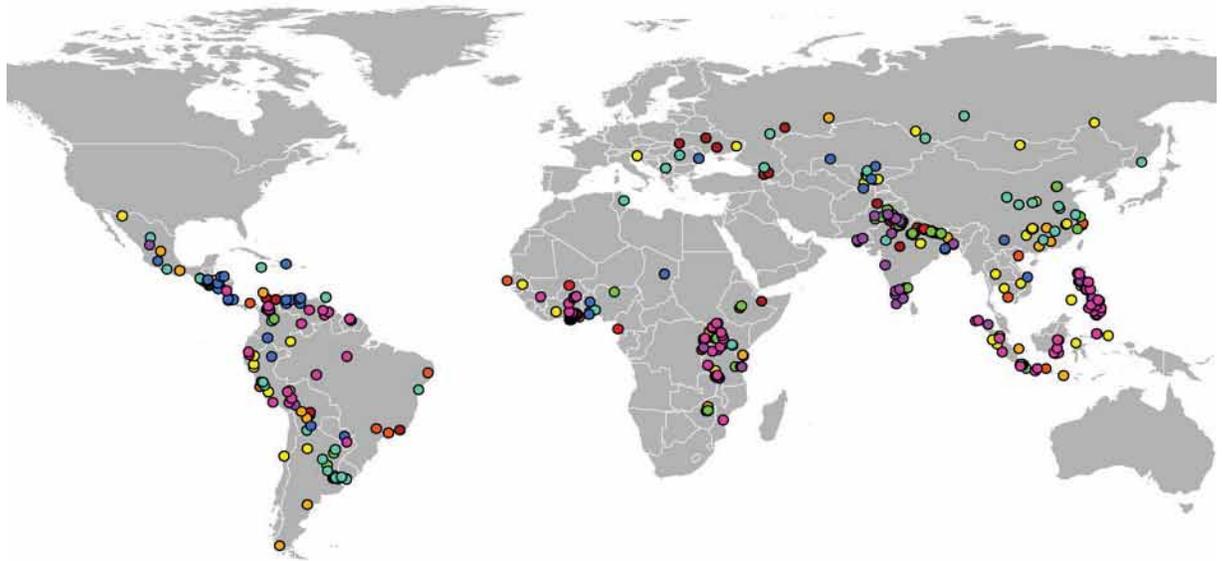
distribution, although a section is included at the end of the report discussing this issue. These issues are excluded from the report either because the pollutants have been deemed non-toxic by Blacksmith’s TAB, or the sites containing such pollutants cannot be identified and evaluated under current assessment protocols.

Blacksmith’s site identification and assessment program aims to evaluate sites that have a clear, fixed source of toxic pollution that can be targeted for remediation efforts. This scope excludes pollution problems where the source is unclear or distributed —such as automobile emissions, general urban air pollution, non-point source water pollution from urban or agricultural storm runoff, general household or commercial waste disposal, and oil or chemical spills from transport and distribution activities. Though these pollution problems impact millions of people, they generally fall outside of the scope of Blacksmith’s research and reports since it is very difficult to determine one key source of pollution and to effectively address these problems with targeted remediation programs.

Finally, the report generally does not assess contamination issues related to natural sources of pollution, with one notable exception: arsenic contamination of groundwater used as a source of drinking water. Naturally occurring arsenic in drinking water is included in the report because the pathways, impacts, and potential for remediation are similar to those of other toxic industrial pollutants.

Top Ten Toxic Pollution Problems

- Artisanal Gold Mining — Mercury Pollution
- Industrial Estates — Lead Pollution
- Agricultural Production — Pesticide Pollution
- Lead Smelting — Lead Pollution
- Tannery Operations — Chromium Pollution
- Mining and Ore Processing — Mercury Pollution
- Mining and Ore Processing — Lead Pollution
- Lead-Acid Battery Recycling — Lead Pollution
- Naturally Occurring Arsenic in Ground Water — Arsenic Pollution
- Pesticide Manufacturing and Storage — Pesticide Pollution



Contaminated Sites from Top Ten Pollution Problems

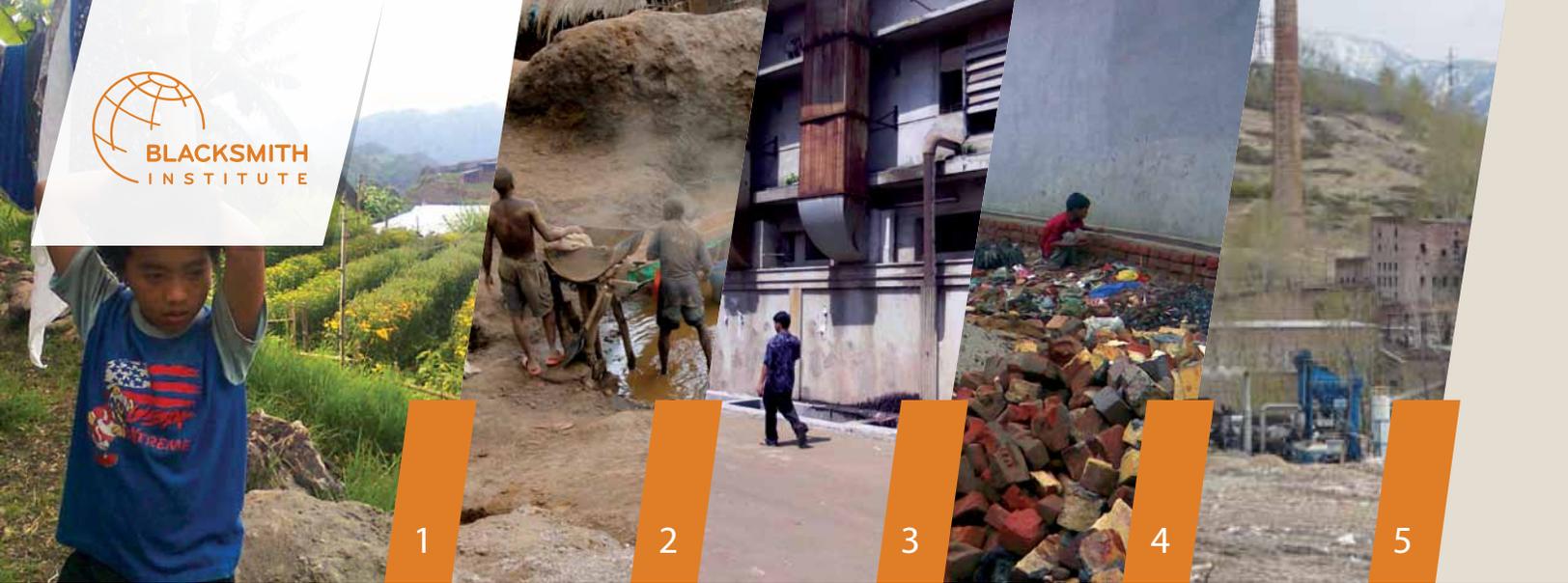
Identifying the Top Ten

The creation of the “top ten” and “toxic twenty” pollution problems was based on two factors: the estimated number of people affected by the pollutant and the number of sites identified globally where the pollutant exists in concentrations above health standards. Blacksmith is able to sort its data by population impacted and sites assessed, and both of these numbers were considered when identifying the pollution issues for this report. The ranking system for the 2011 report deviates from that of previous reports in several important ways. First, the evaluation now relies heavily on the data from Blacksmith’s ongoing efforts to identify and evaluate pollution hotspots, which allows for more thorough analysis of pollutants, pathways, and affected populations. Whereas previous reports relied on a nominating process carried out by experts and Blacksmith’s TAB, we now have primary data from extensive site assessments that can be used for estimating broader impacts. Second, the list of problems described in this report focuses on the coupling of a key pollutant and a specific industry that creates or releases the

pollutant. This coupling of activity and output is necessary to begin quantifying the particular health burdens associated with an industry and a pollutant in terms of disability-adjusted life years (described below). This measure as it applies to toxic pollution exposure is an important step towards understanding the hazards that pollution poses to human health on a global scale.

The industries and pollutants that were chosen also reflect the pollution issues that Blacksmith has collected the most information on to date. Blacksmith has more complete and developed data on pollution problems in certain regions of the world and has less data on others. As Blacksmith continues to collect data on pollution sites throughout the world, the scope of this analysis will be broadened, and we will be able to further and more thoroughly quantify disease burden associated with toxic pollution.

The data on which the report is based are preliminary, and Blacksmith’s efforts to identify and assess pollution hotspots are ongoing. The “top ten” pollution issues in this report are in order



of estimated populations at risk according to the information that Blacksmith has collected to date.

2011 Report in Comparison to 2008 Report

The list of the “top ten” and “toxic twenty” pollution problems for the 2011 report differs from the list in

the 2008 report based on two important factors: the focus of the report and the methods used for determining the lists. The focus of the 2011 report is specifically on toxic pollutants, and relies on a coupling of one source industry and one key pollutant in order to begin quantifying specific health burdens associated with these issues. The

The Top Ten Toxic Pollution Problems^(*)

Key Pollutant and Source Industry	Estimated Population at Risk
1. Artisanal Gold Mining Mercury Pollution	3,506,600
2. Industrial Estates Lead Pollution	2,981,200
3. Agricultural Production Pesticide Pollution (considering only local impact)	2,245,000
4. Lead Smelting Lead Pollution	1,988,800
5. Tannery Operations Chromium Pollution	1,848,100
6. Mining and Ore Processing Mercury Pollution	1,591,700
7. Mining and Ore Processing Lead Pollution	1,239,500
8. Lead-Acid Battery Recycling Lead Pollution	967,800
9. Naturally Occurring Arsenic in Ground Water Arsenic Pollution	750,700
10. Pesticide Manufacturing and Storage Pesticide Pollution	735,400

The Rest of the Toxic Twenty

11. Chemical Manufacturing Chromium Pollution
12. Chemical Manufacturing Mercury Pollution
13. Dye Industry Chromium Pollution
14. Industrial Estates Chromium Pollution
15. Industrial and Municipal Dump Sites Lead Pollution
16. Mining and Ore Processing Arsenic Pollution
17. Mining and Ore Processing Cadmium Pollution
18. Mining and Ore Processing Cyanide Pollution
19. Product Manufacturing Lead Pollution (especially from plating, electronics manufacture and battery manufacture)
20. Uranium Mining and Ore Processing - Radionuclide Pollution

Top Ten Toxic Pollution Problems



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2008 report listed more general pollution problems that in some cases were comprised of various sources and pollutants. The pollution problems identified for the 2008 report were established by the input of third party experts and the recommendations of Blacksmith's TAB based on extensive research

detailing pollutants, at risk populations, and potential health problems. The 2011 report is compiled based entirely on site assessment data that Blacksmith has collected during on-the-ground visits to locations with toxic pollution problems. Specific and detailed data has been collected on

2008 Report "Top Ten" List

2011 Report "Top Ten" List

1. Artisanal Gold Mining

Artisanal Gold Mining
Mercury Pollution

2. Contaminated Surface Water

Industrial Estates
Lead Pollution

3. Indoor Air Pollution

Agricultural Production
Pesticide Pollution (considering only local impact)

4. Industrial Mining Activities

Lead Smelting
Lead Pollution

5. Groundwater Contamination

Tannery Operations
Chromium Pollution

6. Metals Smelting and Processing

Mining and Ore Processing
Mercury Pollution

7. Radioactive Waste and Uranium Mining

Mining and Ore Processing
Lead Pollution

8. Untreated Sewage

Lead-Acid Battery Recycling
Lead Pollution

9. Urban Air Quality

Naturally Occurring Arsenic in Ground Water
Arsenic Pollution

10. Used Lead Acid Battery Recycling

Pesticide Manufacturing and Storage
Pesticide Pollution

Many of the pollution problems in the top ten and toxic twenty lists result from outdated or artisanal processes and economic activities.



A large mine with high levels of cyanide contamination

over 2,000 pollution sites throughout the world, and this data was used to determine the “top ten” and “toxic twenty” list based on estimated impacted populations and number of identified pollution sites. The pollution problems identified in the 2011 report, then, are much more specific and are solely based on Blacksmith assessment data.

Pollution and Global Health

The global health issues highlighted in this report are frequently underreported and underfunded. While many of these environmental health problems have been solved in high-income countries, low- and middle-income countries still face many challenges. The solutions to these problems are well understood, and Blacksmith Institute and Green Cross Switzerland have implemented many cleanup projects to address the types of problems described in the report. These projects are straightforward, economically efficient in providing public health benefits, and could quickly be scaled-up to tackle these issues on a global scale.

To understand the global threat that toxic pollution poses to human health, it is necessary to express the health risks in standardized measures that can, for example, compare the effects of lead against the effects of malaria or another prevalent global health problem. The Blacksmith database of polluted sites and Blacksmith Index are valuable tools for isolating specific sites and painting a broad picture of

pollution trends, but alone they do not quantify the total health impacts caused by these toxins.

Until recently, the health burden from diseases and other health risks was measured in number of deaths. Now, a more complex measure has been developed that calculates the burden a health problem poses based both on years of life lost and on years spent in poor health. This measurement, called a disability-adjusted life year (DALY), is equivalent to one year of “healthy” life lost. The sum of individual DALYs across larger populations expresses, in a general and standardized way, the gap that exists between ideal health standards and the current health of the population.³ The smaller the value of the DALYs, the less burden a disease has on society. These measures are very important for understanding disease burdens because they illustrate the large numbers of people who may live for many years with a disease that does not necessarily lead to death, but that causes varying levels of hardship and disability. Neurological disorders caused by pollution exposure, for example, are not necessarily fatal, but are incurable and can have tremendous impacts on quality of life. Thus, this measure, which allows for a quantification of both death and disability due to disease, is very important for understanding the true burden that pollution can have for global health.

The 2011 report represents the first attempt to quantify the health burdens posed by toxic pollution using this measure.

Sources of Toxic Pollution

While the primary aim of this report is to quantify the health impacts of pollution, it is also helpful to analyze the types of activities that commonly contribute to pollution problems. Understanding the common sources of toxic pollution allows policy-makers and local actors to design programs and policies to improve industrial practices and mitigate future problems.

After identifying and conducting preliminary assessments at over 2,000 polluted sites, Blacksmith Institute has found that abandoned, outdated and poorly regulated small and medium-scale economic activities create the majority of toxic hotspots, in terms of both number of places and people impacted. This runs contrary to popular sentiment that says it is the large, multi-national corporations that cause the greatest problems. While global enterprises do have accidents and cases of corporate malfeasance, their facilities are generally more modern and contain greater pollution controls than older, locally owned facilities and small-scale activities. This does not mean that high-income countries are not contributing significantly to the problem. Demand for commodities and consumer goods, driven largely

by the economies of high-income countries, has increased the severity of the impacts from mining, product manufacturing and recycling, among other economic activities.

The list of top sources varies slightly from the list of the top ten pollution problems. This is because the list of the top ten pollution problems counts only sites where a specific activity releases a specific pollutant. For example, mining and ore processing makes the top pollution problems list twice, once for mining operations that emit mercury, and again for mining operations that emit lead. Petrochemical industries and municipal/industrial waste disposal sites do not make the list of top pollution problems, but they do make the list of top sources. This is



Local workers remove soil contaminated with lead in a village in Northwest Nigeria

because these sources emit a variety of pollutants and no single pollutant shows up often enough to put the source and a specific pollutant in the top ten pollution problems list.

The data used to generate the list of top pollution sources captures only those industrial units known to Blacksmith that release severe toxins that jeopardize human health. The data do not represent industrial units that have safe practices. Each industry on the list can be pursued in a manner that is environmentally sound, and examples of responsible operations abound.

The data focus on industrial units where pollution is localized and can be measured in surrounding soil

and water. Industries that emit air pollutants that create regional or global impacts, such as poorly controlled coal-fired power plants, are only included to the extent that some of their activities result in toxic pollution of local soil and water.

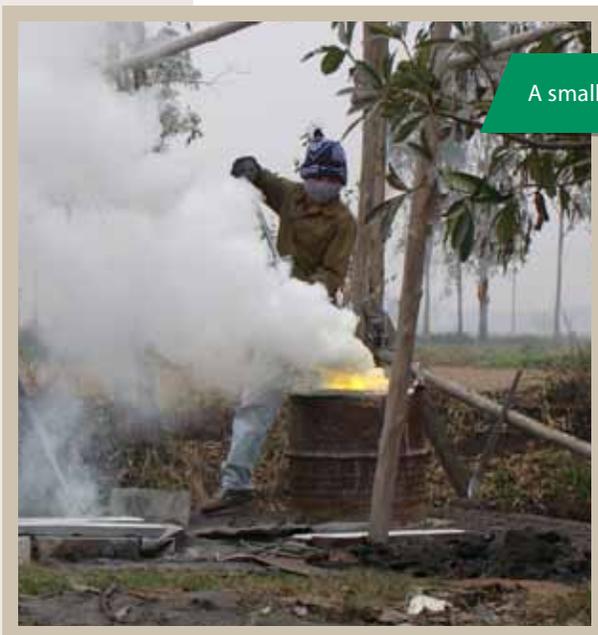
Occupational health impacts from the use of toxins in workplaces is not within the scope of Blacksmith's evaluations, so the number of people at risk due to workplace exposures to toxic pollutants is not included in the above numbers. Blacksmith acknowledges that there are likely many more contaminated sites than have currently been identified and assessed. For this reason, the numbers above represent a conservatively low estimate.

Top Ten Toxic Pollution Problems

Top Ten Sources of Toxic Pollution Hotspots

Source Activity	Estimated Global Population at Risk
Mining and Ore Processing	7,023,000
Metal Smelting	4,955,000
Chemical Manufacturing	4,787,900
Artisanal & Small-Scale Mining	4,233,400
Mixed Industrial Estates	3,862,800
Agricultural Production	3,274,400
Industrial/Municipal Waste Disposal	3,210,800
Heavy Industry (metal casting, rolling, stamping)	2,771,900
Petrochemical Industries	1,917,700
Tannery Operations	1,890,600

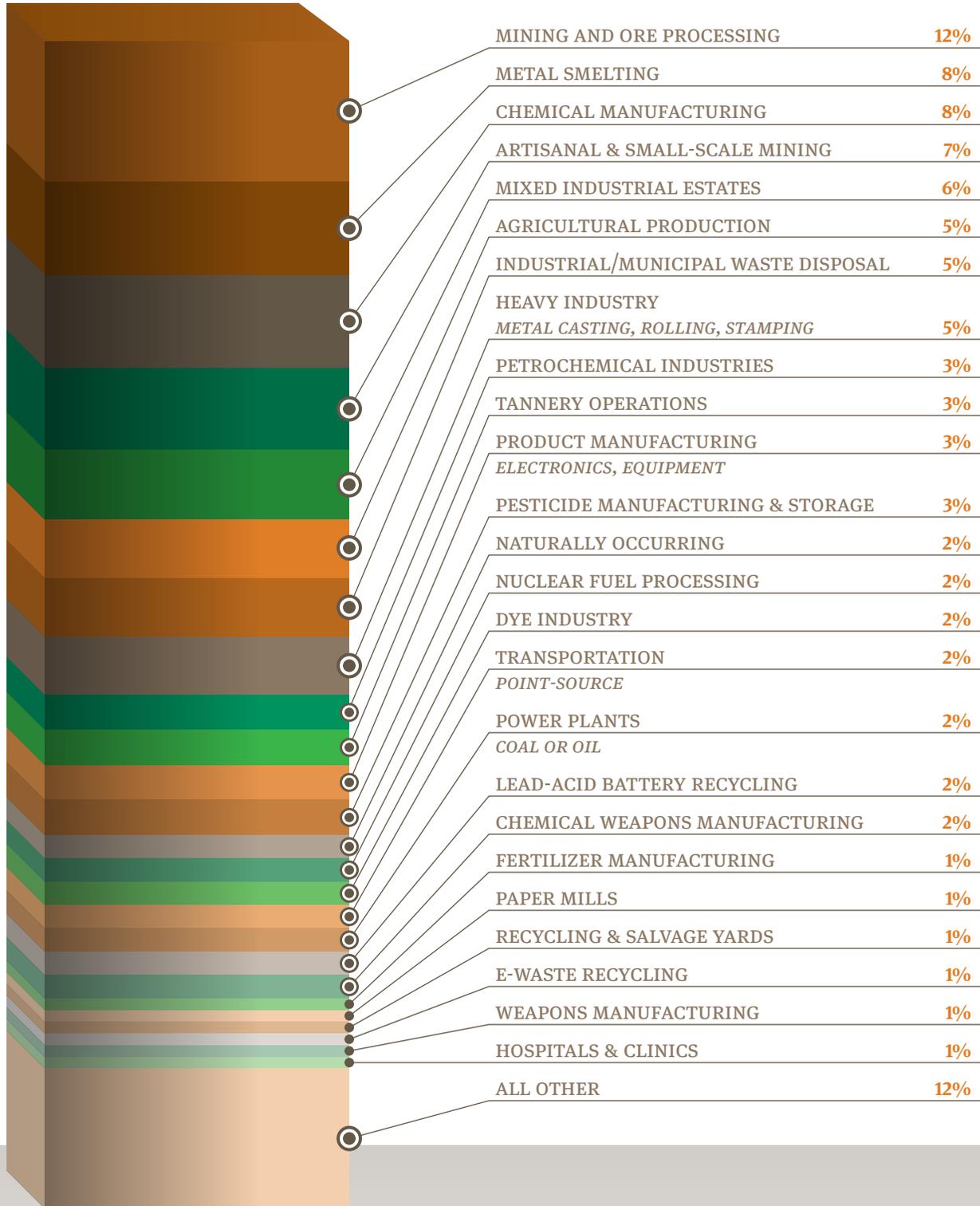
Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.



A small-scale metal smelter in Vietnam

With regard to agricultural production, the population at risk estimate relates only to local impacts related to storage and handling of pesticides. It does not include the health impacts to agricultural workers while working in the fields, which are considered an occupational exposure. For this reason, the number given above is likely a fraction of all health impacts from use of toxic substances in agriculture.

Blacksmith Institute has identified over 40 common sources of toxic pollution. The top 25 sources are shown in the chart below.



Top Ten Toxic Pollution Problems



A worker in a smelting facility for secondary lead

Quantifying the Global Burden Posed by Disease, Disability, and Death Associated With Toxic Pollution Exposure

Exposure to toxic chemicals throughout the world is an enormous and documented health concern. People of all ages and professions can be exposed to chemicals through soil, water, air, and food, and the impacts of chronic and acute poisonings have been well established for many of the most common and noxious toxins. Organizations such as the US Environmental Protection Agency (EPA) and World Health Organization (WHO) have established threshold exposure levels for many pollutants, but these levels are exceeded in countless locations throughout the world, where exposure can lead to debilitating health impacts.

There has been considerable research into the health effects caused by some toxins, but relatively little is known about the more general global disease burden posed by exposure to these chemicals and heavy metals. The global burden of disease is a tool developed by the WHO for measuring the amount of death and disability caused by a particular health problem. HIV/AIDS and malaria, for instance, account for high percentages of the total disease burden around the globe, and, combined, impact over 243 million people worldwide.⁴

The WHO has made limited initial progress in quantifying the disease burden posed by toxic exposure in both overall deaths and DALYs.

However, these efforts have been restricted by several factors, including the wide range of diseases caused by different toxins and different levels of exposure; a lack of strong dose–response studies that link levels of contaminants with clear health outcomes; the difficulty of isolating one cause for disease (for example, it can often be hard to discern whether pollution exposure is the sole cause for the development of a disease); and the difficulty of obtaining local and community-level data on pollution problems. According to existing WHO estimates, however, toxic chemical exposure throughout the world was responsible for 4.9 million deaths and 86 million DALYs in 2004.⁶ The large difference between deaths and DALYs illustrates the substantial amount of people who are living with disabilities caused by exposure to chemicals.

This report provides preliminary research and calculations that aim to address some of the gaps in previous global burden of disease quantifications. Blacksmith's on-the-ground capabilities and data on over 2,000 individual sites around the world where pollution poses a significant health problem allow for a unique and detailed analysis of disease burdens and global impacts caused by toxic pollution. This report and future work in this area, in contrast to other research on quantifying health impacts from toxic pollution, will be able to more thoroughly isolate burdens of disease based on pollutant, source industry, countries and regions, and various exposure pathways. Though the research is ongoing and is subject to many of the same limitations discussed above, the organization aims to eventually be able to quantify the disease burdens of every significant toxic pollutant that impacts human health. Though it will never be possible to analyze all toxics, which number in the hundreds of thousands, the ultimate goal of this work is to be able to more completely describe the enormous threat that toxic pollution poses to global health and to better illustrate the magnitude of the problem.

For each of the top ten pollution issues highlighted in this report, a DALY measure has been calculated for one site assessed by Blacksmith that suffers from this particular problem—for example, a used lead-acid

4. World Health Organization. "The Global Burden of Disease: 2004 Update." World Health Organization, 2008. Available at: http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index.html

5. Prüss-Ustün, Annette, et al. "Knowns and unknowns on burden of disease due to chemicals: a systematic review." *Environmental Health*, 10:9, 2011.

6. *ibid*

battery recycling site and lead pollution. The DALYs associated with each site are calculated using sample levels of the pollutant found in soil, water, or air, and the estimated population at risk of developing health problems that will lead to mortality or morbidity. The calculation for a DALY is: $DALY = YLL + YLD$, where YLL is Years of Life Lost (due to mortality) and YLD is Years Lost Due to Disability.⁷

Data and information from the WHO, the IRIS database of the US EPA, Health Canada, the US Agency for Toxic Substances and Disease Registry, the US Center for Disease Control, and various epidemiological studies were used to estimate disease incidence and severity associated with exposure to toxic pollutants. The specific studies that were used are Tseng, Wen-Ping 1977;⁸ Luippold, R.S., et al. 2003;⁹ Fewtrell, L.J., et al. 2004;¹⁰ Fawer, R.F., et al. 1983;¹¹ and Mandal, Badal Kumar, et al. 2011.¹² Information from the US Central Intelligence Agency and the US Census Bureau were used to determine country populations based on age groups. The WHO Global Burden of Disease 2004 Update was used to determine the disability weights associated with each disease.¹³ Disability weights are used as part of the YLD calculation for DALYs; the WHO has assigned weights between 0 and 1 to many different diseases, with 0 being the lowest disability level and 1 the highest. Cancer, for example, has a high disability weight, while measles has a lower weight. These weights help to distinguish more serious illnesses from less serious ones in order to properly determine the burden of living with a particular disease. The DALYs that are reported for each site represent both deaths and years lived with disability due to a disease caused by toxic pollution exposure.

It should be reiterated that the DALY calculations presented in this report are preliminary and are limited by a paucity of studies linking toxic pollution exposure to health problems and incidence rates. More complete and expansive epidemiological studies that clearly link levels of pollution in one specific pathway to verifiable health impacts will be necessary in order to calculate more robust DALY calculations in the future. Further research that is able to determine a linear relationship between increasing levels of contamination and more severe health outcomes (as opposed to one level of contamination associated with disease incidence) will also be necessary to properly quantify a more subtle and accurate burden of disease calculation. In addition, as Blacksmith continues to expand its research and site assessments of polluted places, our information on impacted populations and number of contaminated sites will improve greatly, which will allow for further accuracy in calculating diseased burdens caused by toxic pollution.

The calculations presented in this report, though preliminary and limited by the lack of information described above, were reviewed by members of the Blacksmith Technical Advisory Board and were established with recommendations from several Professors at the Mount Sinai School of Medicine and the City University of New York School of Public Health, both in New York. Blacksmith is also working with leading experts in the field of public health to prepare papers for a peer-review process. This project will likely be underway for years, and will continue to expand and improve, but this report is able to present initial estimates on the scale of the health impacts caused by toxic pollution. This first step is part of a larger, innovative undertaking to begin quantifying the consequences of toxic contamination throughout the world.

7. World Health Organization. "Health statistics and health information systems, Metrics: Disability-Adjusted Life Year (DALY)." Accessed October 7, 2011. Available at http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

8. Tseng, Wen-Ping. "Effects and Dose-Response Relationships of Skin Cancer and Blackfoot Disease with Arsenic." 1977. *Environmental Health Perspectives*, Vol. 19: 109-119.

9. Luippold, R.S., et al. "Lung cancer mortality among chromate production workers." 2003. *Occupational and Environmental Medicine*, Vol. 60: 451-457.

10. Fewtrell, L.J., et al. "Estimating the global burden of disease of mild mental retardation and cardiovascular diseases from environmental lead exposure." 2004. *Environmental Research*, Vol. 94: 120-133.

11. Fawer, R.F., et al. "Measurement of hand tremor induced by industrial exposure to metallic mercury." 1983. *British Journal of Industrial Medicine*, Vol. 40: 204-208.

12. Mandal, Badal Kumar, et al. "Speciation of Chromium in Soil and Sludge in the Surrounding Tannery Region, Ranipet, Tamil Nadu." 2011. *ISRN Toxicology*, Vol. 2011, Article ID 697980.

13. World Health Organization. "Global Burden of Disease 2004 Update: Disability Weights for Diseases and Conditions." Available at http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf

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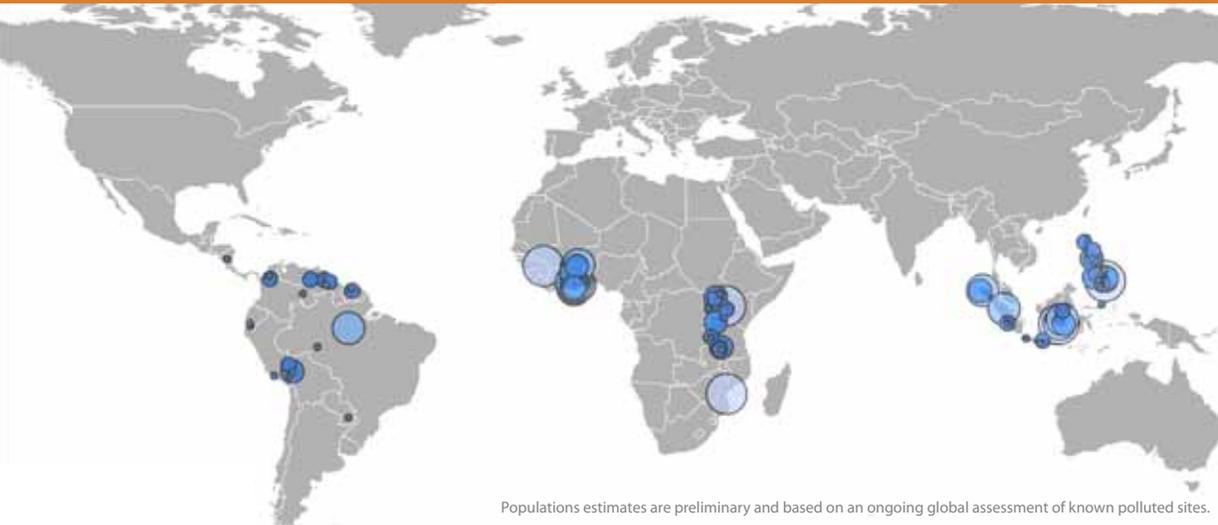
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THE TOP TEN WORST TOXIC POLLUTION PROBLEMS

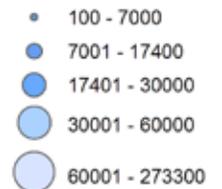
Artisanal Gold Mining Mercury Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 3.5 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Population at Risk



Mercury Pollution from Artisanal Gold Mining.

135 SITES

Description

Artisanal mining is the term for small-scale mining operations often conducted by hand and that consist of basic extraction and processing methods for obtaining minerals and metals, including gold. It is estimated that about 10 to 20 million people worldwide work in artisanal gold mining. Artisanal miners often use toxic materials to separate metals from the surrounding ore and silt. In artisanal gold mining, the most common separation process is known as mercury amalgamation. Due to a lack of awareness, as well as lack of environmental, health, and safety regulations in these small mining industries, miners are often exposed to dangerous levels of toxic materials. The mercury used in these mining activities can also be responsible for the contamination of water and soil, posing health risks for communities near and far, but also to the global population. About 1/3 of the global annual release of mercury into the environment is due to artisanal gold mining.

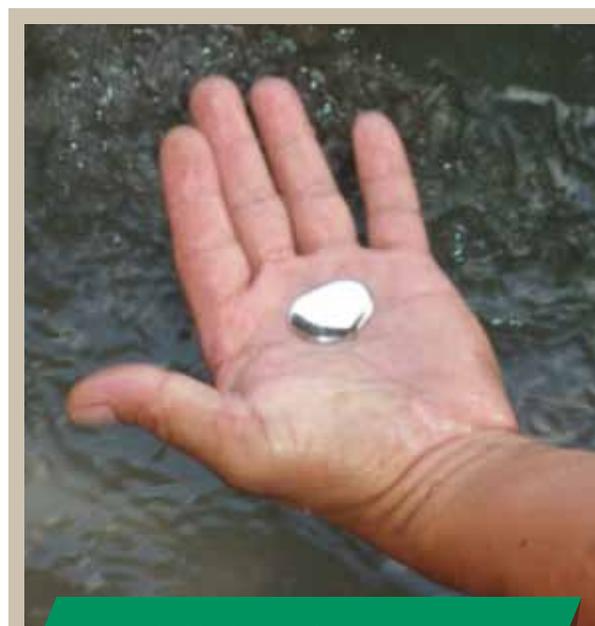
Industrial Process

The mercury amalgamation process commonly used in artisanal gold mining mixes elemental mercury with silt or ore dust that contain tiny pieces of gold. When the mercury is added to the silt, the mercury sticks to the gold, forming a solid mercury-gold amalgam. This amalgam is then removed from the remaining silt by washing with water (the amalgam is heavier than the silt). The separated amalgam is then heated, which vaporizes the mercury, leaving behind the gold. The heating process is often conducted inside homes, as the gold is valuable and processors want security and secrecy. As the mercury is vaporized, the miners and anyone else in the vicinity, including children, are at risk of inhaling mercury. Some mercury is also left in the silt (mine tailings) because of inefficient separation of the amalgam in washing or excess mercury use. This excess mercury often makes its way into surrounding waterways when mine tailings are disposed. This mercury in waterways is then absorbed by

Top Ten Toxic Pollution Problems



Mercury and gold flakes



A miner holds elemental mercury

various living organisms and is transformed into methylmercury, which is extremely hazardous to human health if digested.

Global Context

Artisanal mining is a source of income for people that frequently have few alternative options to earn a comparable wage. In addition to the local and global dangers posed by mercury exposure, many artisanal mines are also very poorly constructed and unstable, and the miners face potential shaft collapses and a high risk of injury. Despite the severe health hazards, artisanal gold mining is widespread, and its practice continues to increase as the price for gold rises. Between the summer of 2009 and the summer of 2011, the price of an ounce of gold approximately doubled. To date, Blacksmith has identified over 130 sites in low- and middle-income countries where artisanal mining has caused mercury contamination, with the majority of these activities taking place in Africa and Southeast Asia, with a concentration of sites in Ghana, the Philippines, and Indonesia.

Exposure Pathways

Artisanal gold mining leads to mercury exposure primarily through inhalation and ingestion.

Mercury vapors are released when mercury–gold amalgam is heated to separate the gold, allowing the vapors to be inhaled by miners and their families. Mercury vapor can also spread from the amalgamation-heating site through the air to distant communities. Excess liquid mercury used in the gold amalgamation process is often dumped with mine tailings and enters waterways. Mercury enters streams as inorganic mercury, where it is converted to the more toxic methylmercury by organisms. The methylmercury bio-accumulates in fish, moving up the food chain to species eaten by humans. Though mercury accumulation is most commonly associated with large, predatory fish, traces have also been found in birds, reptiles, and mammals, all of which can spread mercury to humans if consumed.

Inhaling mercury vapors from the amalgam heating process is the most direct pathway of exposure. Unlike mercury in the food chain that must accumulate over time, exposure to the vapors is immediate and can result in direct exposure to dangerous levels of mercury. A study of artisanal mining practices in Peru found that for every gram of gold produced using the amalgamation process, at least two grams of mercury were released into the air.¹⁴

Regions Most Impacted by Mercury Pollution from Artisanal Gold

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Africa	75	2,401,200
2. Southeast Asia	37	907,300
3. South America	19	195,000
4. Central America	1	3,100

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Health Effects

The health hazards that result from exposure to mercury depend on the level of exposure and the way in which the pollutant enters the body. Inhalation of mercury vapor is particularly hazardous for kidneys, the central nervous system, and the respiratory and cardiovascular systems.¹⁵ Inhalation of mercury vapor has also been found to cause neurobehavioral disorders, such as hand tremor and mental retardation. Exposure to other forms of mercury – and in particular the methylmercury that accumulates in fish – can also lead to problems with the kidneys, lungs, and central nervous system, in addition to arthritis, reproductive problems, loss of memory, psychosis, and in some cases, death. Children exposed to mercury contamination have a higher risk of developmental complications.

What is Being Done

Though the environmental and health problems associated with artisanal gold mining are numerous, there are relatively easy, effective, and inexpensive methods of reducing negative impacts. Blacksmith and Green Cross Switzerland, in conjunction with UNIDO's Global Mercury Project, have been working to introduce programs, technology, and training that will help artisanal miners reduce the

A child crushes gold ore in his kitchen



14. "Slum at the Summit." Earth Report. Television Trust for the Environment. Accessed on August 22, 2011.

Available at <http://www.tve.org/earthreport/archive/doc.cfm?aid=1623>

15. "Toxicological Profile for Mercury." U.S. Department of Health and Human Services. March, 1999.

Available at <http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=115&tid=24>



A worker pans for gold with mercury

Artisan mining is a source of income for people that frequently have few alternative options to earn a comparable wage.

amount of mercury to which that they are exposed. These efforts revolve around the introduction of a mercury retort device, which limits the amount of fugitive mercury emissions and also allows miners to recapture and reuse mercury. Retorts are built by local craftsmen using locally available materials. This technology is simple and economical, allowing the miners to save money while reducing health risks.

Though these programs can be very successful on a small scale, the effective implementation of retort technology relies heavily on proper training and education. To this end, Blacksmith, in partnership with local governments and NGOs, has implemented training programs in Mozambique, Senegal, Indonesia, and Cambodia that can be replicated on a larger scale.

Example — DALY Calculations

Our research process for calculating DALYs associated with pollutants from particular industries found that there is currently too little information on health impacts caused by exposure to mercury from artisanal gold mining. The data that Blacksmith has collected to date on samples from artisanal gold mining sites are also incomplete, and do not include enough information on samples of mercury in air, which is one of the more dangerous exposure routes for the toxin. Due to these limitations, we are unable to calculate a DALY estimate for mercury exposure from artisanal mining at this time. Blacksmith, however, is currently conducting projects in Africa that will help to fill some of the gaps in this research and data in the future.

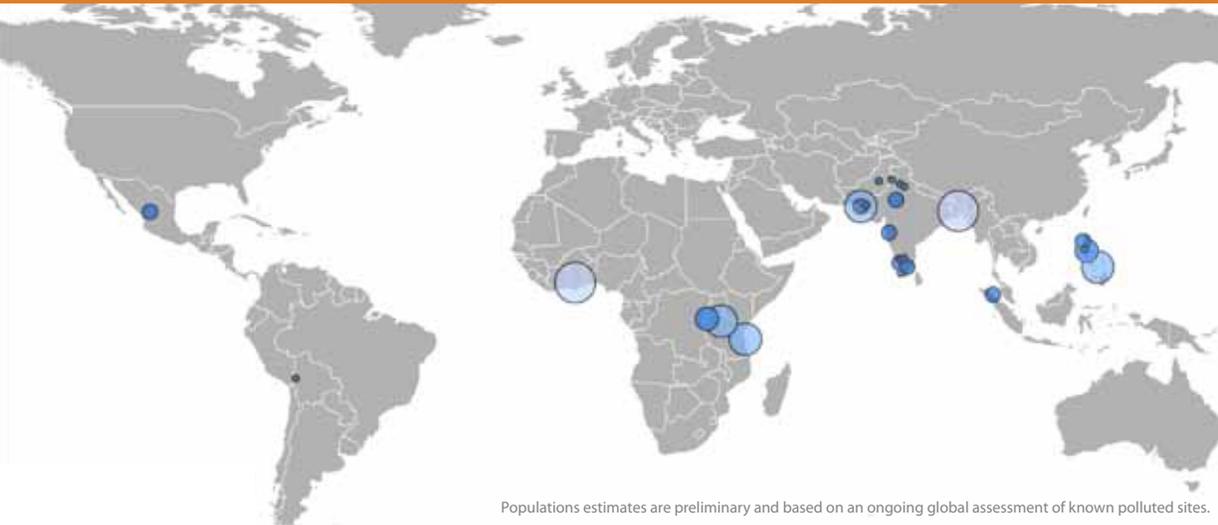


Children collecting water contaminated with mercury

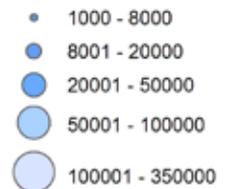
Industrial Estates

Lead Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 3 MILLION



Population at Risk



Lead Pollution from Industrial Estates.

29 SITES

Description

Industrial Estates are planned, zoned areas that are set aside for a variety of industries, offices, and production. These areas, also known as industrial parks, are frequently built outside of major population areas or residential neighborhoods and are easily accessible via roads, rail, and boat. Industrial estates are often governed by regulatory regimes that are set up to advance and encourage industry. Industrial parks contain a large variety of businesses ranging from food production to heavy metal smelting.

The Multilateral Investment Guarantee Agency of the World Bank recommends that industrial estates have effluent treatment centers, proper infrastructure for containing and disposing of toxic waste, emissions

standards, proper monitoring and reporting systems, and clear emergency preparedness plans.¹⁶ If the proper precautions are taken, industrial estates can reduce community and environmental impacts by isolating potentially hazardous processes in areas far away from residential neighborhoods and by ensuring safety and environmental standards for all of the industries in the zone.

Unfortunately, in many low- and middle-income countries, industrial estates have little to no waste treatment and disposal infrastructure, and they are often located near populated areas. In the case of an industrial estate that has no pollution control mechanisms, lead, which is often a main contaminant caused by industrial estates, can be released into surrounding air, soil, water, and food.

16. "Environmental Guidelines for Industrial Estates." Multilateral Investment Guarantee Agency, World Bank. Available at <http://www.miga.org/documents/IndustrialEstates.pdf>

Top Ten Toxic Pollution Problems



Wastewater from an industrial estate flowing in an open drain



Water polluted by industrial activity

Industrial Process

There are a large variety of industries within industrial estates that may be responsible for lead contamination. When industries are located in such close proximity, it is very hard to distinguish which one or ones, in particular, are responsible for pollution. In order to avoid placing blame on the wrong industry, industrial estates are clumped together as one industry group in the Blacksmith inventory, making the isolation of one single lead contamination-causing process impossible.

Typical industries that produce high amounts of lead and that may be found in industrial estates include lead-acid battery production and recycling (which accounts for more than two thirds of global lead use); lead smelting and casting; manufacturing of lead-glass and lead compounds; manufacturing of pigments, paint, and ceramic glazes; and recycling of e-waste that contains Cathode Ray Tubes.¹⁷

Global Context

The first industrial parks began to be constructed with the aim of creating a space where industry could be removed from population centers, where there was good access to transportation and infrastructure, but also where the number of industries in one area could create economies of scale for high-quality waste treatment and disposal infrastructures. In the past forty years, the number of industrial parks has grown rapidly, with one study from 1999 estimating over 12,000 worldwide.¹⁸ Almost every country in the world has some kind of industrial estate, with Vietnam and Sri Lanka estimated to each have 50 to 60 industrial areas, and India and China reaching hundreds of industrial clusters. Each industrial park is different in terms of the types of industries present and the size of the area, with some estates having room for hundreds of separate factories.

Most high-income countries have strict regulations and codes for their industrial estates, but in some

17. "Lead: When are you most at risk?" Health and Safety Executive. Accessed on August 30, 2011. Available at <http://www.hse.gov.uk/lead/mostatrisk.htm>

18. Falcke, Caj O., Ph.D. (1999) "Industrial Parks Principles and Practice." *Journal of Economic Cooperation Among Islamic Countries*, Vol. 20, No. 1: 1-10.

Regions Most Impacted by Lead Pollution from Industrial Estates

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Southeast Asia	12	1,132,900
2. South Asia	23	640,000
3. Africa	6	10,000
4. Central America	1	2,000

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Industrial parks can be less harmful when all the proper precautions are taken. Unfortunately, in many low- and middle-income countries, industrial estates have little to no waste treatment and disposal infrastructure, and are located near populated areas

low- and middle-income countries, little is done to protect surrounding communities from the waste and byproduct of these concentrated industries. South Asia and Africa, for example, have large-scale problems with lead contamination of groundwater systems by untreated effluent. The Blacksmith inventory has documented twenty-nine sites in these regions, and twelve in Southeast Asia, where industrial estates are releasing large amounts of lead contamination into the surrounding environment—which often means into an adjacent residential neighborhood. The inventory estimates that these sites alone impact close to 3 million people.

Exposure Pathways

Due to the diverse industries within industrial estates that may cause lead contamination, there are a number of different ways that toxins can enter the environment and can come into contact with people. Lead smelting and casting, and manufacturing of lead compounds—or other industries that require the heating of lead or objects containing lead—can release lead toxins into the air, where they can travel long distances and can contaminate soil, surface water, and food when they settle back to earth. Lead can remain in topsoil for many years, and can easily be spread as lead dust or tracked into homes or

neighborhoods on shoes and clothing. Lead in soil can also contaminate crops and livestock, and can easily make its way into surface and groundwater systems.

Other industries that use lead in their production processes, such as paint and lead-acid battery manufacturing, can contaminate the environment through untreated, toxic effluent that is sometimes released directly into nearby water systems or is dumped on the ground where contaminants can leach into soil and groundwater. Of the sites listed in the Blacksmith inventory, the most common pathway of lead poisoning due to industrial estates is through the contamination of drinking water for surrounding communities.

Health Effects

The health effects of exposure to lead can be both acute and chronic, and the problems caused by lead poisoning are particularly dangerous and severe for children. Acute lead poisoning can happen immediately and is often caused by inhaling large quantities of lead dust or fumes in the air. Chronic lead poisoning, however, occurs over longer periods of time and can result from very low-level, but constant, exposure to lead. Chronic poisoning is

Top Ten Toxic Pollution Problems



<-- Solid waste
outside of an
industrial estate

--> Untreated effluent
from industry is
dumped into a lake



far more common than acute exposure and can be caused by persistent inhaling or ingestion of lead, or, over much longer periods, can result in lead accumulation in the bones.

Health problems associated with lead poisoning can include reduced IQ, anemia, neurological damage, physical growth impairments, nerve disorders, pain and aching in muscles and bones, memory loss, kidney disorders, retardation, tiredness and headaches, and lead colic, which impacts the abdomen.¹⁹ Severe exposure to high concentrations of lead can lead to dire health risks, including seizures, delirium, coma, and in some cases, death.

Neurological damage is especially pronounced in children suffering from lead exposure, with even small amounts of lead poisoning capable of causing lifelong developmental and cognitive problems. Exposure to lead in utero can also cause birth defects.

What is Being Done

Due to the scale and variety of industries, addressing pollution problems from industrial estates can be a challenging task. The key interventions in this area involve working with local governments, NGOs, and industry leaders to improve the levels of control, treatment facilities, and health and safety management at the estates. Successful examples of these kinds of programs involve strong leadership from international companies to adhere

to global standards. In addition to leadership and effective management, industrial estates must also have the proper finances in order to upgrade to environmentally safe equipment. Proper enforcement of environmental and health standards, however, needs adequate political support, and buffering cooperation between government and industry can lead to improvements in these areas.

Example — DALY Calculations

The Malir River, which runs through Karachi in Pakistan, is contaminated with high levels of lead due to indiscriminate dumping of untreated wastewater from industrial activity. The water is used for a variety of purposes, including irrigation of crops. Samples of the river found 2,170 parts per billion of lead in the water, a level that is 100 times the health standard for irrigation water. Blacksmith estimates that 20,000 people living near the river are at risk of health problems caused by exposure to lead.

DALYs associated with adverse health impacts from lead exposure are estimated to be 479,186 for the estimated population of 20,000. Thus, the 20,000 affected people will have 56,407 years lost due to death, or impacted by disease or disability. This would come out to approximately 23.9 years lost or lived with a disability per person. This high number is possible due to the number of children who are potentially at risk of spending a significant portion of their lives living with irreversible disabilities caused by lead exposure.

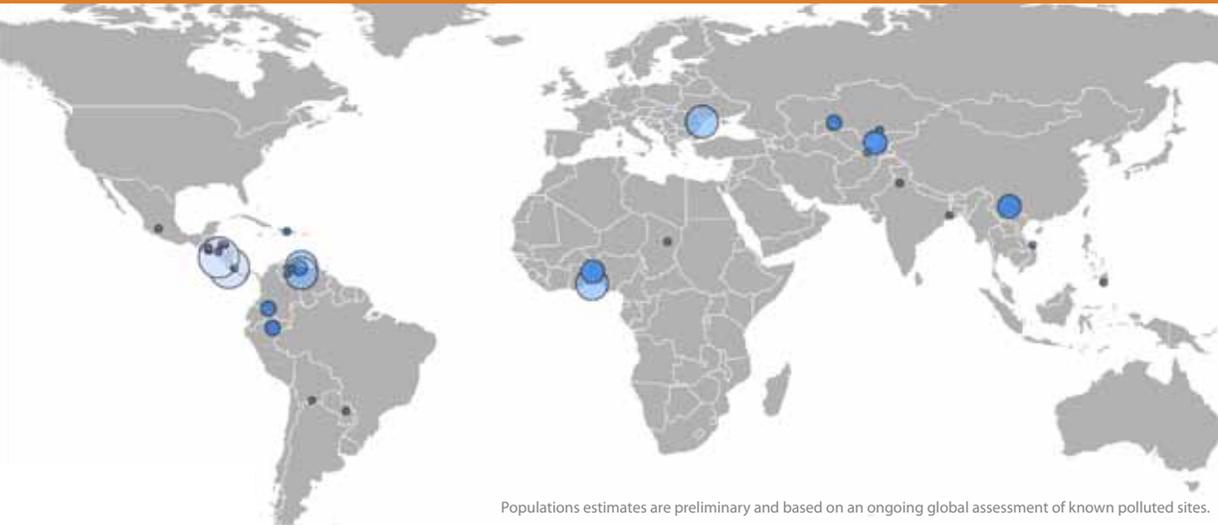
19. "New Basel guidelines to improve recycling of old batteries." United Nations Environment Programme. May 22, 2002. Available at <http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=248&ArticleID=3069&l=en>

Agricultural Production

Pesticide Pollution

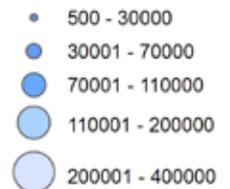
CONSIDERING ONLY
LOCAL IMPACT

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 2.2 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Population at Risk



Pesticide Pollution from Agricultural Production.

40 SITES

Description

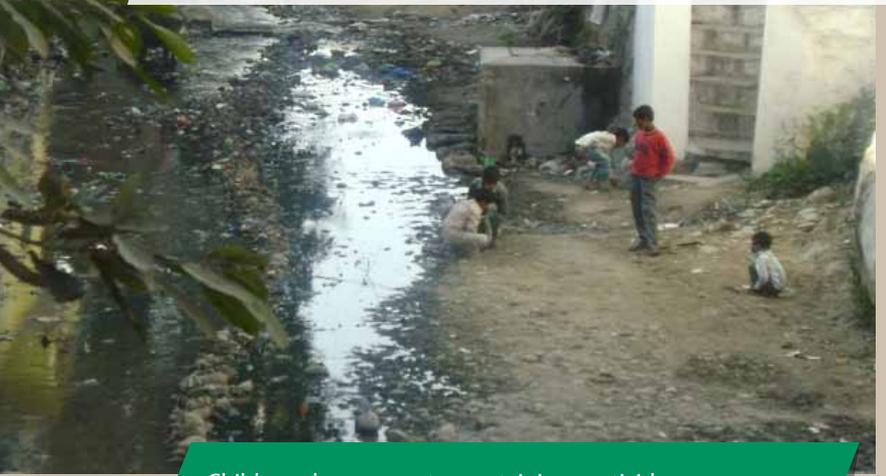
Agricultural production is one of the largest and most important economic activities in the world, particularly in low- and middle-income countries, where agriculture has a significant impact on GDP growth.²⁰ Some of the largest agricultural sectors throughout the world include the production of grain (rice, wheat, corn, etc.), coffee, beans (soy, lentil, etc.), potatoes, and tea. A major factor in agriculture over the last decades is the use of pesticides that protect crops from insects and pests that may be harmful to crop quality and yields. Agrochemicals, which include pesticides, herbicides, and fertilizers, have been widely used since the 1940s in many low- and middle-income countries. Unfortunately, many chemical pesticides, particularly those

containing chlorinated compounds, are often persistent in the environment and can be toxic to humans.²¹ These kinds of pesticides are dangerous to many different forms of life, and their impacts can spread far beyond their production and application point to even a global scale. Chemical pesticides can harm agricultural workers who do not wear the proper safety gear and can also be dangerous for nearby communities. Common pathways for human exposure include inhalation when pesticides are applied (particularly when applied through spraying), ingestion of contaminated foods, ingestion of contaminated soil (particularly children, who may not wash hands before eating after playing in dirt), and contamination of surface or groundwater and subsequent ingestion.

20. K. Aseno-Okyere, et al. "Advancing Agriculture in Developing Countries through Knowledge and Innovation." International Food Policy Institute, 2008. Available at: <http://www.ifpri.org/sites/default/files/publications/oc59.pdf>.

21. Pesticides only slowly decompose over decades or even centuries.

Top Ten Toxic Pollution Problems



Children play near water containing pesticides



Drinking water contaminated with pesticides

Industrial Process

The term “pesticide” describes a category of agrochemicals that are used to protect crops from certain bacteria, insects, and other potentially damaging organisms. Pesticides include insecticides, molluscicides, nematocides, fungicides, and herbicides and are intended to disrupt the ability of certain species to harm crop yields by paralyzing or killing them. Though pesticides have been instrumental in contributing to global agricultural growth, they are often harmful to more than just their target species. Organophosphates and organochlorine pesticides, for example, can cause damage to nervous systems by harming neurotransmitting enzymes and can be ingested by many different types of creatures.

Some organochlorine pesticides, including DDT, lindane, endosulfan, and chlordane, are so disruptive and dangerous that many countries have banned their use and have classified them as Highly Hazardous. Despite the risks associated with pesticide use, many forms of these chemicals are still widely used in low- and middle-income countries in a large variety of agricultural settings and have impacts far beyond the locations where they are sprayed. Studies have found that over 98 % of insecticides used in agricultural processes do not quickly degrade at the point of application and end up entering the larger environment, typically through rain and irrigation runoff, spray carry-over, or residue retention on food.²²

Global Context

The use of pesticides worldwide has grown exponentially over the past sixty years, with approximately 2.3 million tons of industrial pesticides now used annually. With this boom has come larger crop yields and more secure and reliable food sources for growing populations. Many low- and middle-income countries have even been able to produce enough food to sustain a large agricultural export economy, as well as to better feed their own population. These successes have led to a persistent demand for and use of pesticides, but the mass application of these agrochemicals has also impacted human health and environmental resources in a negative way. To reduce reliance on agrochemicals, the UN Food and Agriculture Organization (FAO) of the has launched in 2011 a new approach to agriculture called “Save and Grow.”²³

Many of the world’s agricultural processes take place in rural and economically disadvantaged areas where regulations are lacking and health standards are not enforced. For these reasons, pesticides are often improperly used and stored, and workers are often not fully aware of and protected from the dangers that pesticide exposure and contamination can cause. In addition, due to lax regulations, low cost, and the effectiveness of certain hazardous pesticides, sustained use of banned pesticides is an ongoing problem in many low-income rural areas.²⁴ Thus, agricultural workers and their families are more severely affected by dangerous pesticide

22. Miller, G.T. “Chapter 9.” *Sustaining the Earth*. 6th ed. Pacific Grove, California: Thompson Learning, Inc., (2004): 211-216.

23. See: <http://www.fao.org/ag/save-and-grow/>

Regions Most Impacted by Pesticide Pollution from Agricultural Production

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Central America	16	876,000
2. South America	13	594,800
3. Eastern Europe, Northern Eurasia & Central Asia	7	362,200
4. Africa	2	250,000

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

chemicals and contamination in these regions than in higher-income countries with tighter regulations.

Countries in South and Central America, where agricultural production is a widespread and year-round activity in many places, are badly impacted by health problems associated with pesticide contamination. One study found high levels of DDT in the breast milk of women who lived near spraying areas in Guatemala and El Salvador, with the highest levels found near cotton fields.²⁵

Pesticide contamination also impacts a large number of people in Central Asia and Eastern Europe. Blacksmith's ongoing global assessment of polluted sites estimates that over 2.2 million people are at risk from exposure to pesticides from agricultural production. This number, however, is likely significantly smaller than the actual impacted population, since Blacksmith has only performed site assessments for a limited number of locations affected by pesticide use. As Blacksmith continues to collect data and assess more sites around the world, this number will continue to grow.

Exposure Pathways

The most common ways that people are exposed to pesticides are through occupational dermal contact and inhalation, or ingestion of food or water containing the chemicals. A large number of agricultural workers in low- and middle-income

countries do not use protective masks, gloves, or suits while applying pesticides to crops, mostly due to the expense of this equipment. Toxins can be absorbed through the skin during handling of pesticides, can enter the body by touching plants or objects that have been sprayed, and can be inhaled during spraying processes if proper safety precautions are not taken.

Pesticides can also reach people who do not directly work in agriculture when large amounts are washed into streams, lakes, oceans, and ground water sources by rain or irrigation. The toxins can then be directly ingested through drinking water, or can accumulate in the tissues of a variety of aquatic life. Many of the most widely used pesticides have been classified as Persistent Organic Pollutants (POPs), meaning that they have long life-spans, do not biodegrade well, and have the ability to bio-accumulate in living tissue. When large amounts of pesticides build up in food sources, this contaminates the food chain for nearby communities.

Health Effects

Though there are many different kinds of pesticides, each with its own particular health impacts from a variety of chemicals, common health effects include skin irritations, respiratory and pulmonary problems, vision loss, damage to nervous and immune systems, birth defects, DNA damage, disruption of the hormonal system, many different

24. C. Wesseling, et al. "Agricultural Pesticide Use in Developing Countries: Health Effects and Research Needs." *International Journal of Health Services*, 27.2 (1997): 273-308.

25. de Campos, M. and Olszyna-Marzys, AE. (1979) "Contamination of human milk with chlorinated pesticides in Guatemala and in El Salvador." *Archives of Environmental Contamination and Toxicology*, Vol. 8, No. 1: 43-58.

Top Ten Toxic Pollution Problems



Skin problems caused by pesticide exposure

forms of cancer, and in some cases, death. A study of over 2,000 agricultural workers in Africa, Asia, and Latin America found that many workers suffered from acute pesticide poisoning and reported the following symptoms: chronic headaches, dizziness, convulsions, and nausea.²⁶

What is Being Done

The health problems associated with pesticide contamination and poisoning have been recognized on a global scale. In 2004, the Stockholm Convention on Persistent Organic Pollutants (POPs) entered into force, with the expressed aim of reducing and abolishing production of POPs, including toxic organochlorine-based pesticides.²⁷ The United Nations Food and Agriculture Organization (FAO) is working to introduce and implement more modern forms of agricultural production in order to minimize the amount of pesticides that are currently used on a global scale.

On a more local scale, educational programs that teach farmers about the risks pesticides pose to their health and the safety of their communities have been very successful. These programs are often implemented by local governments with international support. In some cases, retailers of certain pesticide products will offer safety classes in order to ensure the proper and responsible ways to use their products.

Other safety programs are offered to farmers by NGOs, such as "Plagbol" (Plaguicidas Bolivianas) in Bolivia, which provides a telephone advice service and training for the proper and safe use of pesticides.²⁸

Blacksmith has worked to support programs that develop a set of "best practices" for the application and use of pesticides and that help to implement strategies for reducing pesticide use and storage. Blacksmith also works in impacted areas to help raise funds for training and education programs that teach best practices and identify alternatives to pesticides. Green Cross Switzerland works closely with FAO, UNEP and WHO in the area of the Former Soviet Union and in West-Africa to raise awareness on the risks of old and obsolete pesticides, to find and safeguard old pesticides, to introduce better practices in future pesticides management, and to introduce (non-chemical) alternatives to DDT to control malaria in Central Asia and the Caucasus.

Example — DALY Calculations

The Hugli River in West Bengal, India, is an important source of water for people living near its banks, and the river is used for bathing, drinking, and cooking. This large river breaks off from the Ganges in northeastern India and empties into the Bay of Bengal. The Hugli, however, poses a risk to human health as it is contaminated with high levels of aldrin (an organochlorine) due to heavy pesticide use in the region. Water samples taken near Calcutta found 0.9 micrograms per liter of aldrin in the water – about 30 times the health standard. Blacksmith's assessment of a town on the banks of the Hugli estimated that 30,000 people were at risk of adverse health impacts from exposure to contaminated water.

DALYs associated with adverse health effects due to aldrin exposure at this site are estimated to be 475 for the estimated exposed population of 30,000. This means that the approximately 30,000 affected people will have a collective 475 years lost to death, or impacted by disease or disability. If spread equally across all impacted persons, this comes out to 0.02 years lost or lived with a disability per person.

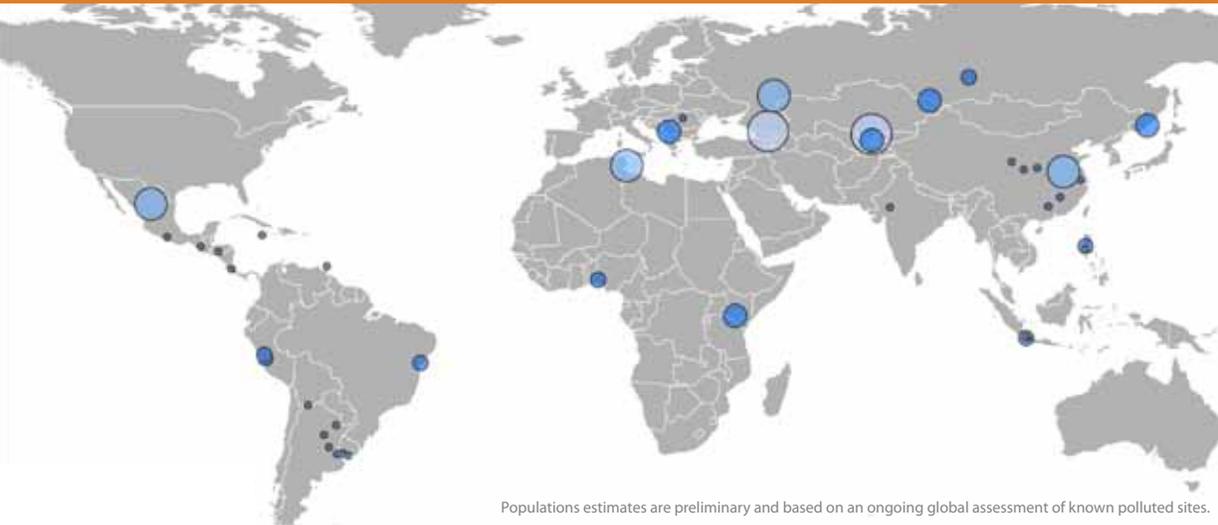
26. Pesticide Action Network International. "Communities in Peril: Global Report on Health Impacts of Pesticide Use in Agriculture." 2010. Available at: <http://www.pan-international.org/panint/files/PAN-Global-Report.pdf>.

27. "About the Convention." Stockholm Convention on Persistent Organic Pollutants. Available at <http://chm.pops.int/Convention/tabid/54/Default.aspx>

28. E. Jors. "Acute Pesticide Poisonings among Small-Scale Farmers in La Paz County, Bolivia." Department of International Health Institute of Public Health, University of Copenhagen, 2004. Available at: <http://plagbol.org.bo/files/tesis%20plagbol%20version%20completa%20en%20ingles.pdf>

Lead Smelting Lead Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 2 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Lead Pollution from Lead Smelters

53 SITES

Population at Risk



Description

Lead processing and smelting plants work with both primary and secondary lead. Primary lead is mined, separated from ore, and refined into various products, whereas secondary lead is recovered from used objects – such as used lead-acid batteries – for reuse in other products. Smelting is a key process in lead product production, and involves heating lead ore or recovered lead with chemical reducing agents. Both secondary and primary smelting processes can be responsible for releasing large amounts of lead contamination into the surrounding environment.

Industrial Process

Lead processing either requires the mining of new, primary lead, or the recycling of used products and

scrap metals. Both forms of lead must be melted using a smelting process in order to obtain pure and usable forms of the metal.

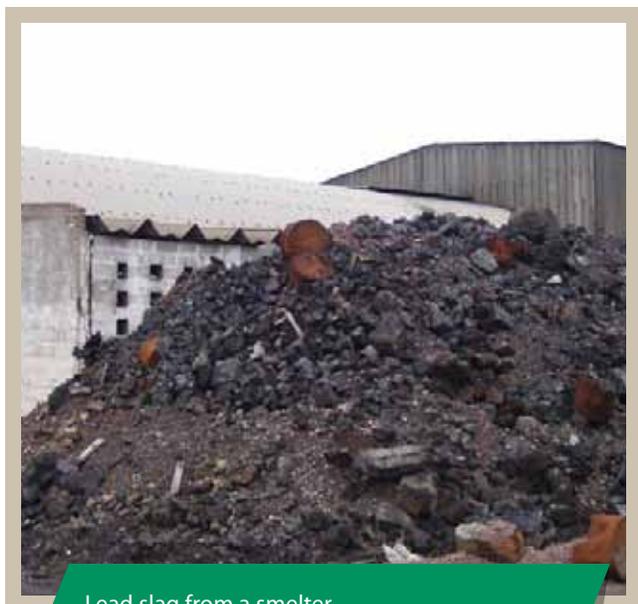
The primary smelting process involves separating lead from ore using heat and reducing or purifying agents such as coke and charcoal. Once the lead ore is mined, it must undergo several different processes in order to be turned into usable or metallurgical lead material: sintering, smelting, and refining. The sintering phase involves removing sulfur from the lead ore using a hot air combustion process. Once the sulfur is removed, the lead is sent into a smelter where it is heated at extremely high temperatures in order to isolate the pure lead from other metals and materials in the ore. Any remaining metals or other materials left after the smelting are removed during the refining process.²⁹ Lead dust and smoke can be

29. Primary Metals: Lead Processing." Illinois Sustainable Technology Center, Prairie Research Institute. Accessed on August 31, 2011. Available at http://www.istc.illinois.edu/info/library_docs/manuals/primmetals/chapter6.htm

Top Ten Toxic Pollution Problems



A large-scale lead smelter in southwestern Russia



Lead slag from a smelter

released during all of the above processes, and slag contaminated with lead particles may be left over after the smelting process.

Secondary smelting of lead is similar to primary smelting, but does not require the initial sintering process. Once lead is recovered from used materials

– with the majority coming from used lead-acid batteries – it is placed into a furnace where it is heated with coke or charcoal in order to isolate the lead from other compounds. Like primary lead smelting, the processing of secondary lead can also produce lead dust and toxic slag. If smelting plants and equipment are not properly constructed to minimize the release of pollutants, lead toxins can often enter the surrounding environment and contaminate soil, water, and food.

In addition, the mining process for extracting primary lead ore—if not performed with the necessary safety and environmental precautions—can create large piles of waste that contains lead toxins. If these piles are left out in the open, lead dust can be blown into surrounding areas, and lead can also leach into the ground and contaminate water systems.

Global Context

Lead is a very useful material found in many different products, with approximately six million tons used annually across the world.³⁰ Though much of this lead is recycled and reused, the US Geological Survey estimated that the world production of

30. Roberts, H. "Changing Patterns in Global Lead Supply and Demand." *Journal of Power Sources*, Vol. 116, No. 1-2 (2003): 23-31.

Regions Most Impacted by Lead Pollution from Lead Smelting

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Eastern Europe, Northern Eurasia & Central Asia	9	1,237,200
2. Africa	3	250,000
3. Central America	5	197,000
4. China	7	158,100

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

primary lead in 2009 was over 3.8 million metric tons.³¹ The extraction and smelting of lead can cause a large amount of toxic pollution, and emissions from lead smelting are a big contributor to global lead contamination.³² Lead smelting can also pollute the environment with large amounts of particulate matter, toxic effluents, and other various solid wastes.

Though lead smelting facilities exist all over the world, countries and cities where pollution may not be properly monitored by environmental and health regulations are more negatively impacted by health problems related to lead contamination. According to the Blacksmith inventory, countries in Eastern Europe, Northern Eurasia, and Central Asia are particularly at risk from lead smelting activities, with an estimated two million people impacted worldwide.

Exposure Pathways

The most common route of lead exposure caused by lead smelting is through inhalation or ingestion of lead dust, particles, or exhaust from the burning process.³³ Workers in the smelting factories are particularly at risk, as they can be exposed

to prolonged and direct inhalation of gaseous emissions and dust. Particles and ash containing lead can also be blown into nearby towns or onto agricultural fields, which can contaminate livestock and crops. Studies in China have found that certain crops, such as corn, are particularly susceptible to lead accumulation when grown in close proximity to smelters.³⁴ Dermal contact with soil contaminated with lead can also expose people to toxins.

In addition to toxic emissions, lead smelting produces wastewater, solid waste, and slag heaps that may be contaminated with heavy metal. Lead from these sources, as well as waste rock from lead ore mining, can often make its way into ground and surface water systems that are used for drinking, bathing, and cooking.

Health Effects

Please see health effects from lead on pages 20-21.

What is Being Done

Many modern and well-maintained lead smelting facilities have infrastructure in place that allow pollution levels to be controlled and monitored

31. Kelly, Thomas D., et al. "Historical Statistics for Mineral and Material Commodities in the United States: Lead." U.S. Geological Survey Data Series 140, Version 2010. Available at: <http://minerals.usgs.gov/ds/2005/140/#lead>

32. S. Dudka and D.C. Adriano. "Environmental Impacts of Metal ore Mining and Processing: A review." *Journal of Environmental Quality* 26.3, (1997): 590-602.

33. "Environmental, Health, and Safety Guidelines: Base Metal Smelting and Refining." International Finance Corporation. World Bank Group. April 30, 2007. Available at

[http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_SmeltingandRefining/\\$FILE/Final+++Smelting+and+Refining.pdf](http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_SmeltingandRefining/$FILE/Final+++Smelting+and+Refining.pdf)

34. Xiangyang Bi, et al. "Allocation and Source Attribution of Lead and Cadmium in Maize (*Zea mays* L.) impacted by smelting emissions." *Environmental Pollution* 157.3 (2009): 834-839.

Top Ten Toxic Pollution Problems

If smelting plants and equipment are not properly constructed to minimize the release of pollutants, lead can enter the surrounding environment and contaminate soil, water, and food.

Children play near a lead smelter in an area contaminated with high levels of lead



according to environmental and health standards. However, these kinds of operations can be quite expensive, which leads many smelting plants to forego important safety measures. This is particularly common in countries or areas where there is little to no government regulation of the industry. Thus, one of the most effective ways to reduce lead pollution from smelters is to work with governments, NGOs, and communities to update equipment and operations at the plants.

Several of the older lead smelters, some of which have been in operation for many decades, have created large areas of legacy pollution. Remediation efforts in these areas have to consist of both the removal and disposal of contaminated soil or material and to ensure that contaminated water and food are able to return to safe consumption levels.

Example – DALY Calculations

A city in northwestern India is home to a large smelter that is releasing lead toxins into the nearby environment. There are many lakes in this region, and lead has contaminated the drinking and bathing water for the nearby residents. Samples of water near the smelter found 430 parts per billion of lead, which is over 8 times the health standard. Blacksmith estimates that 3,000 people at this site are at risk of diseases caused by lead exposure.

DALYs associated with adverse health impacts from lead exposure at this site are estimated to be 47,917 for the estimated exposed population of 3,000. This means that the 3,000 affected people will have a collective 47,917 years lost to death, or impacted by disease or disability. This comes out to 16 years lost or lived with a disability per person.

Informal lead smelting in Indonesia



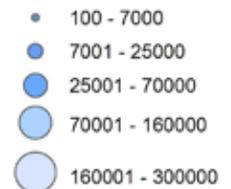
Tannery Operations Chromium Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 1.8 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Population at Risk



Chromium Pollution from Tanneries

95 SITES

Description

The leather manufacturing industry consists of several different processes, with one of the most important activities being the tanning of the raw hides. Tanning involves the processing of raw leather in order to make it more resilient and strong for use in a variety of different products. Tanning is a widespread, global industry that works with both light and heavy types of leather. Light leather is generally used for shoes and other soft products such as purses, and heavy leather is used for straps, belts, and in various machinery.

The tanning process itself is made up of three general phases: acquisition and pretreatment of raw animal hides; treatment of the hides with a tanning agent; and drying and shining the hides before

sending them to product manufacturers. Though these steps illustrate the general process, there are often many different processes that can be carried out at tanning facilities, and each may provide a variety of other services, such as bleaching, dyeing, finishing, and weaving of the hides.³⁵

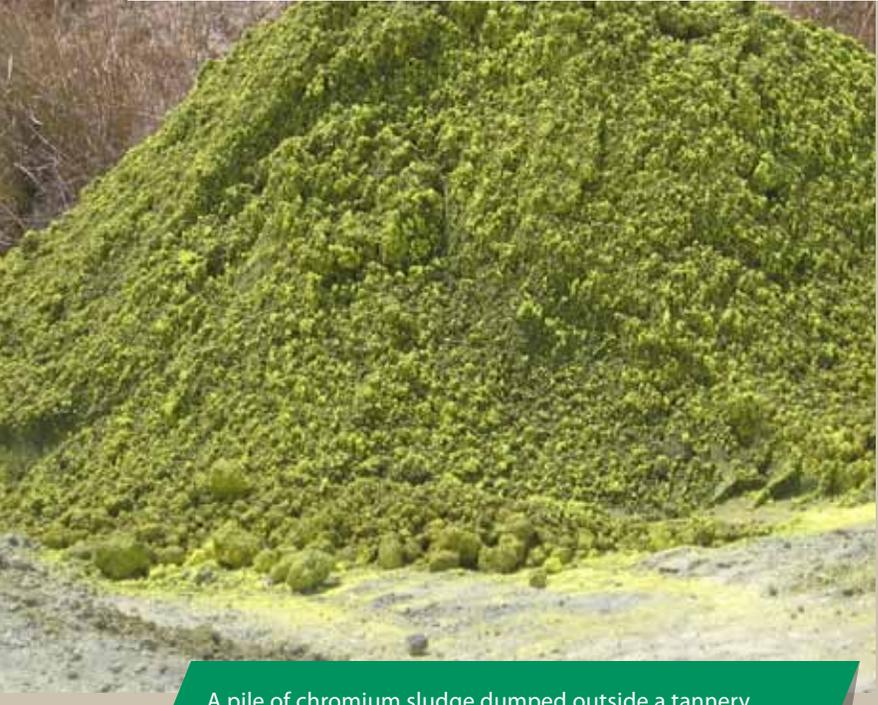
Industrial Process

The two main types of tanning are chrome tanning and vegetable tanning, with chrome tanning making up a large majority of the industry. Chromium compounds are applied to protect hides from decay and to make them more durable against moisture and aging.³⁶ Chromium interacts with fibers in the raw hide during a bathing process, after which the tanned hides are wrung and prepared for finishing.³⁷ Other materials that may also be used in the pretreatment

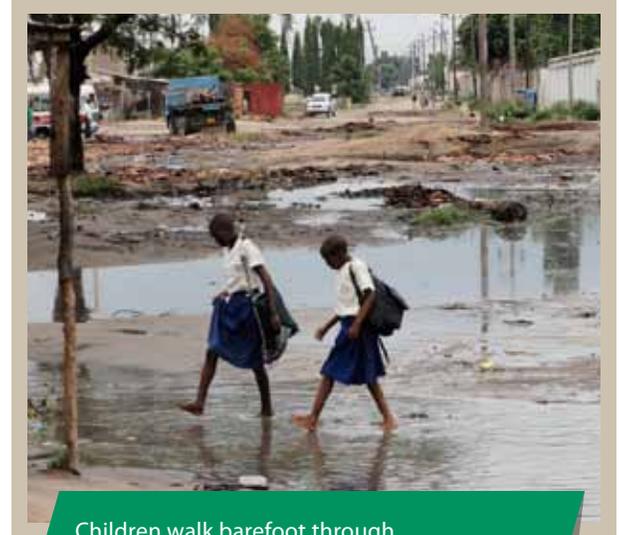
35. V.M. Correia; T. Stephenson, and S.J. Judd. "Characterisation of Textile Wastewaters – A Review." *Environmental Technology* 15.10 (1994): 917–929.

36. "Leather Tanning." U.S. Environmental Protection Agency, 1997. Available at <http://www.epa.gov/ttnchie1/ap42/ch09/final/c9s15.pdf>

Top Ten Toxic Pollution Problems



A pile of chromium sludge dumped outside a tannery



Children walk barefoot through tannery wastewater

and tanning processes include sulfuric acid, sodium chlorate, limestone, and limestone soda ash.

Due to the repeated processes of soaking raw hides and wringing them out, the tanning process creates large amounts of wastewater that may be contaminated with many different chemicals. Because there is wide variety in the chemicals used during the tanning process, wastewater from this industry can have very different chemical makeups. However, chromium contamination and high chemical oxygen demand are typical problems associated with tannery effluents, both of which can pose serious risks to the environment and human health.³⁸

In addition to creating potentially toxic wastewater, some tanneries also produce large amounts of solid waste that contain chromium, including: hide scraps, skins, and excess fats. Toxins from this waste can leach into nearby soil and water, placing nearby residents at risk of contamination.

Global Context

A large portion of the world's tanning industry operates in low- and middle-income countries, and the percentage of these countries contributing to light and heavy leather materials increased from 35 % to 56 % and 26 % to 56 %, respectively, between 1970 and 1995.³⁹ Many of these tannery sites are clustered together, creating heavily polluting industrial areas in many countries. In Hazaribagh, for example—a particularly large tanning region of Bangladesh that has over 200 separate tanneries—it is estimated that 7.7 million liters of wastewater and 88 million tons of solid waste are disposed of on a daily basis. These pollutants are responsible for the contamination of all nearby surface and groundwater systems with severely high levels of chromium.⁴⁰

37. *ibid.*

38. Z. Song, C.J. Williams, and R.G.J. Edyvean. "Sedimentation of Tannery Wastewater." *Water Research* 34.7 (2000): 2171–2176.

39. Jenkins, R., J. Barton and J. Hesselberg. "7. The Global Tanning Industry: a Commodity Chain Approach." *Environmental Regulation in the New Global Economy: The impact on industry and competitiveness*. Edward Elgar Publishing, 2004. 157-172.

40. Bhuiyan, M.A.H., et al. "Investigation of the Possible Sources of Heavy Metal Contamination in Lagoon and Canal Water in the Tannery Industrial Area in Dhaka, Bangladesh." *Environmental Monitoring and Assessment*, Vol. 175, No. 1-4 (2010): 633-649.

Regions Most Impacted by Chromium Pollution from Tannery Operations

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. South Asia	62	1,147,400
2. Central America	3	310,500
3. South America	11	205,000
4. Africa	9	143,000

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

According to the information collected in Blacksmith's inventory of sites, South Asia, and in particular India and Pakistan, has the highest number of tanning industries, with South America also at risk of large populations being exposed to chromium contamination.

Exposure Pathways

Chromium from leather tanning can make its way into air, soil, food, and water, and the most common forms of exposure are through inhalation of dust or fumes and ingestion of or contact with contaminated water. Workers in tanning facilities can inhale airborne chromium and can also be exposed by dermal contact from improper handling.

Wastewater and solid waste from tanning operations often find their way into surface water, where toxins are carried downstream and contaminate water used for bathing, cooking, swimming, and irrigation. Chromium waste can also seep into the soil and contaminate groundwater systems that provide drinking water for nearby communities. In addition, contamination in water can build up in aquatic animals, which are a common source of food.

Soil that is contaminated by chromium waste also poses a health hazard, since toxic dust can be inhaled by both people and livestock.⁴¹

Health Effects

Chromium commonly occurs in two forms. Trivalent chromium (chromium III) is a naturally occurring element that is relatively stable and innocuous, and can be found in plants, animals, and soil. Hexavalent chromium (chromium VI) is far more dangerous for humans, and is usually created by anthropogenic causes.

Hexavalent chromium is a toxic human carcinogen that can cause or increase the rates of certain cancers. Inhalation of chromium VI, which occurs most frequently among workers, has been found to cause cancer of the respiratory system. Inhalation of dust contaminated with chromium can also lead to eye damage, ulcerations, swelling, asthmatic bronchitis, and irritation to the throat and nose. More chronic exposure can sometimes cause sores to develop in the nose and can even lead to the formation of holes in the nasal septum.⁴²

Ingestion of chromium VI can cause stomach problems, such as ulcers, and can also be damaging for kidney and liver functions. Dermal contact causes a number of skin problems, including rashes, sores, and ulcers.

In addition, several studies have found evidence that chromium accumulation in the body can damage a person's ability to metabolize iron, which can lead to iron deficiency anemia.

41. A. Möller, H. W. Müller, A. Abdullah, G. Abdelgawad, and J. Utermann. "Urban Soil Pollution in Damascus, Syria: Concentrations and Patterns of Heavy Metals in the Soils of the Damascus Ghouta." *Geoderma* 124.1-2 (2005): 63-71.

42. "Health Effects of Hexavalent Chromium." OSHA Factsheet. Occupational Safety and Health Administration. U.S. Department of Labor. July 2006. Available at http://www.osha.gov/OshDoc/data_General_Facts/hexavalent_chromium.pdf

Top Ten Toxic Pollution Problems



<-- Tannery waste flows through an open canal in Dhaka, Bangladesh

--> A worker processes hides at a tannery



What is Being Done

Blacksmith Institute has successfully implemented programs to help clean up and alleviate the impacts of chromium on human health and has found several cost-effective and efficient ways to help address the problem. Because trivalent chromium is far less toxic than chromium VI, water that is contaminated with chromium VI can be treated with an electron donor that converts the pollutant to its less damaging, trivalent state. Other studies have found that bone charcoal, which is produced by burning animal bones, has the ability to remove chromium from water.⁴³

When soil and solid waste are contaminated with chromium, these areas and dumpsites can be effectively removed and disposed of in order to prevent further human contact with toxins. Other methods of removing chromium contamination from soil include vermiculture, which involves the use of worms to concentrate heavy metals in the soil. In addition, more recent studies have found that some forms of salt-tolerant bacteria may be able to decrease chromium contamination in soil.⁴⁴

Blacksmith Institute, in partnership with the Central Pollution Control Board of Kanpur, India, recently conducted a program that helped to reduce groundwater contamination caused by over 300 tanneries in the area. Tests conducted after the treatment showed that hexavalent chromium levels had become undetectable in some of the wells.

Additionally, a program in collaboration with local officials and NGOs in Gujarat, India, was able to move 60,000 tons of waste sludge from a tannery operation to a secure location. The remaining soil in the area was treated using vermiculture.

Example — DALY Calculations

A town in northern India on the banks of the Ganges River has approximately 400 small tannery operations that are contaminating the area with large amounts of hexavalent chromium. Because many of these tanneries are informal, they do not have proper waste treatment facilities, and effluent is openly dumped into the surrounding environment. Contaminated water from the river is used for a variety of purposes, particularly for irrigation. Soil in the area is also very contaminated with hexavalent chromium, which poses a dangerous health risk if dust from dry areas is inhaled. Blacksmith estimates that approximately 60,000 people are at risk of developing health problems from exposure to the toxic pollution. Samples in the area found 6,227.8 parts per million of hexavalent chromium in the soil.

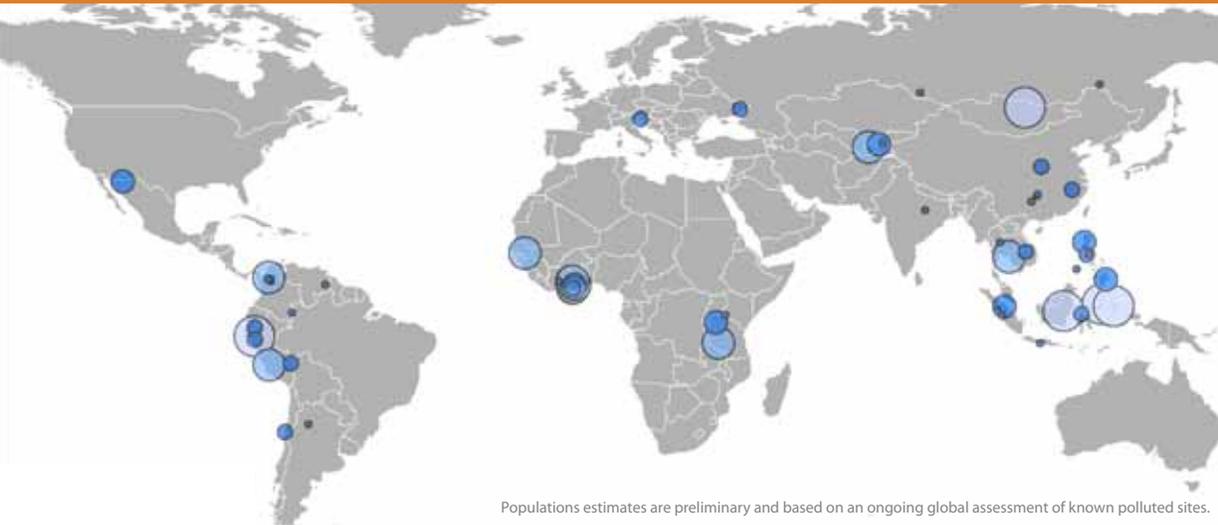
DALYs associated with health issues from hexavalent chromium exposure are estimated to be 167,066 for an exposed population of 60,000 people. Thus, the 60,000 affected people will have a collective 167,066 years lost to death, or impacted by disease or disability. This comes out to 2.8 years lost or lived with a disability per person.

43. S. Dahbi, et al. "Removal of Trivalent Chromium from Tannery Waste Waters Using Bone Charcoal." *Analytical and Bioanalytical Chemistry* 374.3 (2002): 540–546.

44. M. Megharaj, S. Avudainayagam, and R. Naidu. "Toxicity of Hexavalent Chromium and Its Reduction by Bacteria Isolated from Soil Contaminated with Tannery Waste." *Current Microbiology* 47.1 (2002): 51–54.

Mining and Ore Processing Mercury Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 1.6 MILLION

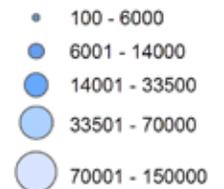


Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Mercury Pollution from Mining and Ore Processing

69 SITES

Population at Risk



Description

Mining and ore processing occurs throughout the world and consists of extracting minerals, metals, and gems from surrounding earth and ore. Industrial mines vary in size, with some being quite small operations and others very large. Many large-scale mines also have ore processing facilities where extracted ore is sent for crushing, washing, and various physical or chemical separation processes. Not all mined materials are dangerous, but many heavy metals and naturally radioactive materials that are removed from the earth can be very hazardous to human health.

In addition to active mines, there are a large number of inactive and abandoned mining sites throughout the world that still contain large levels of contaminants and pose dangers to local communities.

Industrial Process

Elemental mercury occurs naturally in the earth and is a liquid metal. Most mercury forms in a sulfide ore called cinnabar, but mercury is also frequently found in small amounts in other ores. A common method for separating mercury from cinnabar is to crush the ore and then heat it in a furnace in order to vaporize the mercury. This vapor is then condensed into liquid mercury form. If done improperly, mercury vapor, which is highly toxic, can escape into the atmosphere.

Waste rock and tailings from mercury mining, and other extraction processes where mercury is uncovered, can still contain small or large amounts of the toxic substance. Mercury that is not processed or claimed during mining and ore processing can make its way into the environment if the mining waste is not stored properly.

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Tailings pond from a large-scale gold mine



Mercury Mine Waste in Southwest Kyrgyzstan

Mercury is also extensively used in the gold mining process as an amalgam for separating gold from ore. When mercury is combined with gold silt, it causes a reaction that separates the gold from the ore. This amalgam is then heated in order to evaporate the mercury and leave the gold pieces. If done without the proper safety equipment, this process can release mercury vapor into the air and can also discharge various amounts of liquid mercury into the surrounding area.

Global Context

Mercury is uncovered and used in a number of mining processes. It is mined as a primary element for use in materials such as thermometers and fluorescent light bulbs, it can be commonly found in the ore of other mined materials, and it is frequently used in the gold mining process as an amalgam for the separation of gold from ore. Thus, mercury contamination is associated with a large variety of different mining and ore processing activities throughout the world. Due to its large health risk, international negotiations are ongoing to globally ban the use of mercury in the years to come (Mercury Convention).

Currently, the Blacksmith inventory estimates that over 1.5 million people are affected by mercury pollution from mining and ore processing, with most pollution problems of this nature occurring in Southeast Asia and Africa.

Regions Most Impacted by Mercury Pollution from Mining and Ore Processing

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Southeast Asia	16	566,200
2. Africa	16	462,000
3. South America	26	300,800
4. Eastern Europe, Northern Eurasia & Central Asia	8	195,300

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

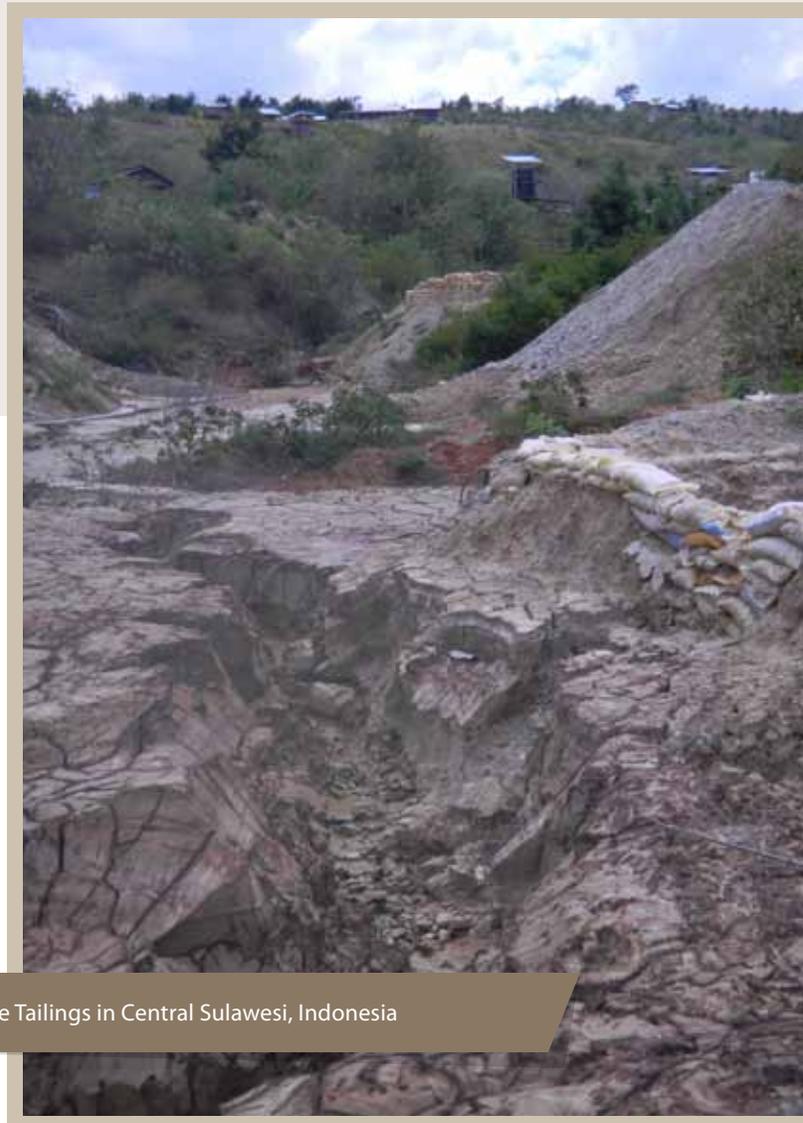
An important step in curbing the pollution created by mining and ore processing is to work with mines and governments to improve mining equipment and environmental regulation

Exposure Pathways

Waste rock and tailings that are created during the mining and ore refining process can release toxins into the environment if not stored or disposed of properly. In many cases, waste rock and tailings are left out in the open where they are exposed to the elements, and mercury can be washed into water systems by rainfall, or can leach into the soil. Mercury that is used as an amalgam in gold mining can also be released into the environment as vapor and elemental mercury. When mercury enters water systems, it can bioaccumulate in the bodies of aquatic animals, where it becomes organic, or methylmercury. When ingested, methylmercury can be very hazardous to human health.

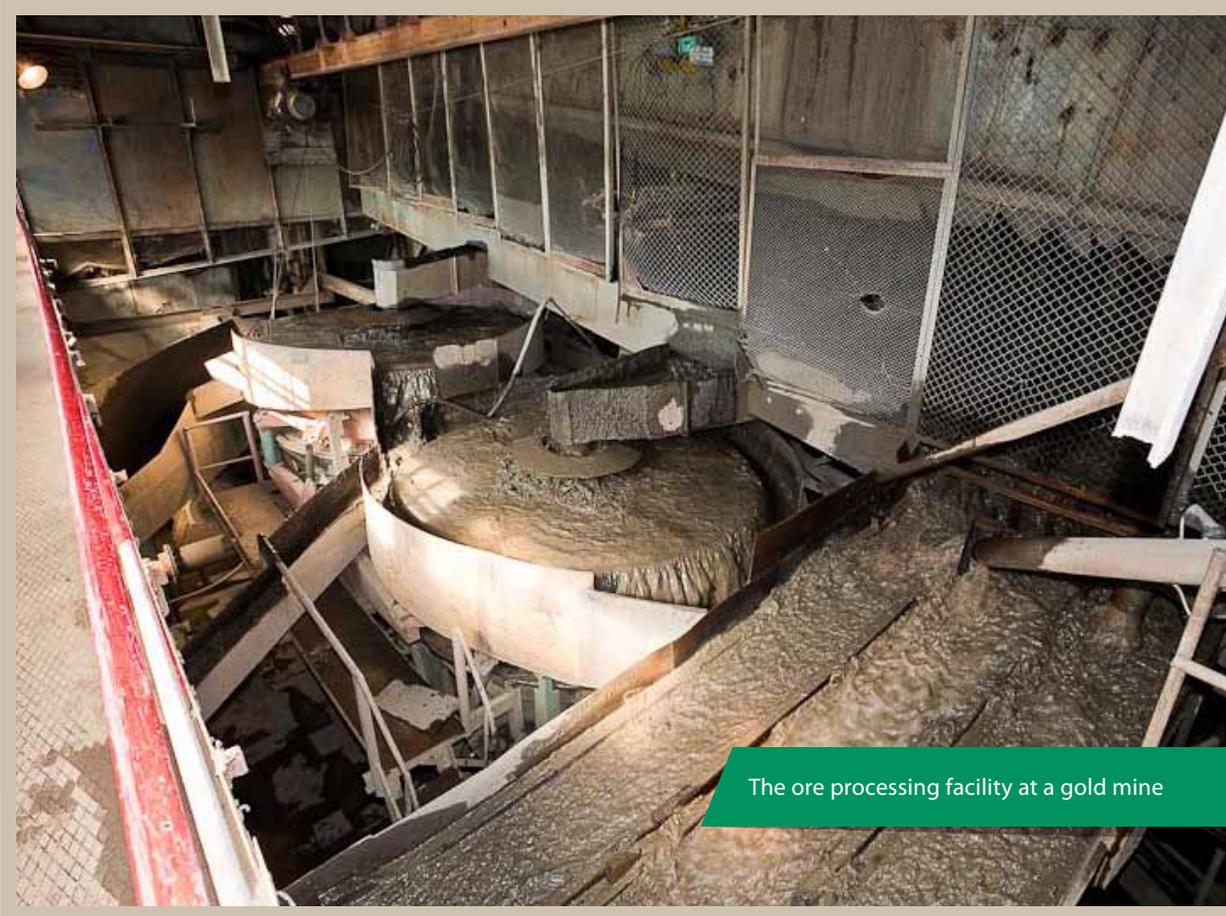
Health Effects

Please see health effects from mercury on page 24.



Mine Tailings in Central Sulawesi, Indonesia

Top Ten Toxic Pollution Problems



The ore processing facility at a gold mine

What is Being Done

An important step in curbing the pollution created by mining and ore processing is to work with mines and governments to improve mining equipment and environmental regulation. Many pollution problems occur due to a lack of set environmental and health standards, or, when laws do exist, weak enforcement and compliance procedures. However, if local governments and organizations put pressure on mines to decrease their emissions, this can be effective in terms of getting companies to institute new policies or set up new infrastructure, such as wastewater treatment facilities or more effective tailing storage areas.

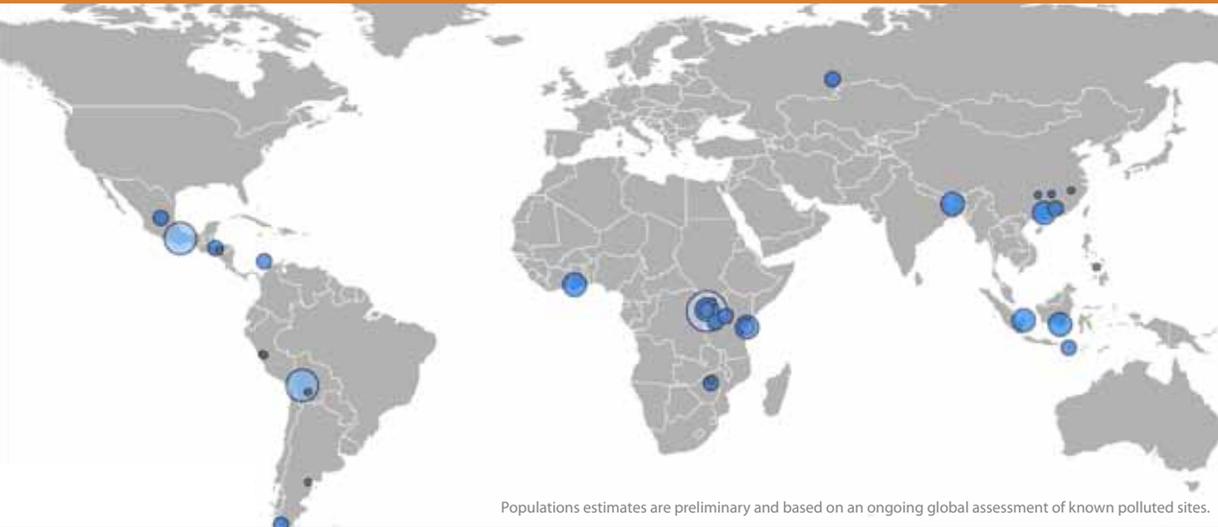
Example — DALY Calculations

A small town in the mountains of Chile has been the site of large-scale gold and copper mining since 1891. Air pollution in this region is so severe that the government classified the town as a “Saturated Zone” – indicating the dangers of breathing the air around the mine. Samples taken around the site found 100 micrograms per cubic meter of mercury in the air, which is 100 times higher than the WHO health standard. Blacksmith estimates that 20,000 people may be affected by this pollution.

DALYs associated with adverse health impacts from atmospheric mercury exposure at this site are estimated to be 716,950 for the estimated exposed population of 20,000. This means that the approximately 20,000 affected people will have a collective 716,950 years lost to death, or impacted by disease or disability. This comes out to 28.7 years lost or lived with a disability per person.

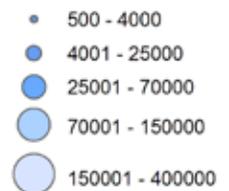
Mining and Ore Processing Lead Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 1.2 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Population at Risk



Lead Pollution from Mining and Ore Processing

33 SITES

Industrial Process

Mining can be an extremely destructive practice that often has very negative impacts on the surrounding environment. Because the material that is mined for is surrounded by other ore and rock, mining creates large amounts of mineral waste in the form of waste rock and tailings. Waste rock consists of all of the earth surrounding the ore that must be removed in order to access the desired minerals, metals, and gems. Tailings are the waste material from the ore processing phase, and often contain toxins left over from the ore separating process along with small amounts of heavy metals that were not fully removed.

Lead is almost always contained in sulfide ores as galena, or lead sulfide.⁴⁵ Waste rock material from mines that contain metal sulfides can lead to sulfuric

acid drainage when left out in the open air. Tailings also contain minerals and materials that can lead to dangerous runoff and water contamination when stored improperly. Some mine waste and tailing dump sites are structurally unsound and often overflow and break, allowing contaminants to spill out over the surrounding environment. In some cases, mines will have long pipes or waste canals that carry tailings to waterways for dumping.

Global Context

Lead is a heavy metal that occurs naturally in the earth's crust, and it is mined for use in a variety of materials including paint, ceramics glaze, batteries, and pipes. Lead also commonly exists in ore containing other frequently mined materials, such as iron, copper, silver, and zinc. Thus, there are many different mining operations worldwide that could

45. Brown, T.J., et al. "World Mineral Production 2003-2007." British Geological Survey, 2009. Available at: <http://nora.nerc.ac.uk/6251/>.

Top Ten Toxic Pollution Problems

A lead-zinc mining facility in China



potentially be responsible for releasing lead into the environment.

Miners in regions that lack environmental, health, and safety standards are often ill-equipped for their work, and some do not wear gloves, or even shoes while handling material that may contain toxins. Some mines are built in very close proximity to villages and towns, and children may play on the waste rock or tailings. To date, Blacksmith has identified 36 sites where lead contamination

from mining poses a serious health risk to over 1.2 million people, with populations in Africa and South America being the most impacted.

Exposure Pathways

Waste rock and tailings from mining and ore processing are not always stored or disposed of properly, and lead toxins in this material can leach into the soil and nearby water systems, impacting agriculture and water resources. In some cases,

Truck carrying mine waste containing lead and other heavy metals



Regions Most Impacted by Lead Pollution from Mining and Ore Processing

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. Africa	11	663,000
2. South America	8	179,700
3. Southeast Asia	4	129,300
4. Central America	4	122,500

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

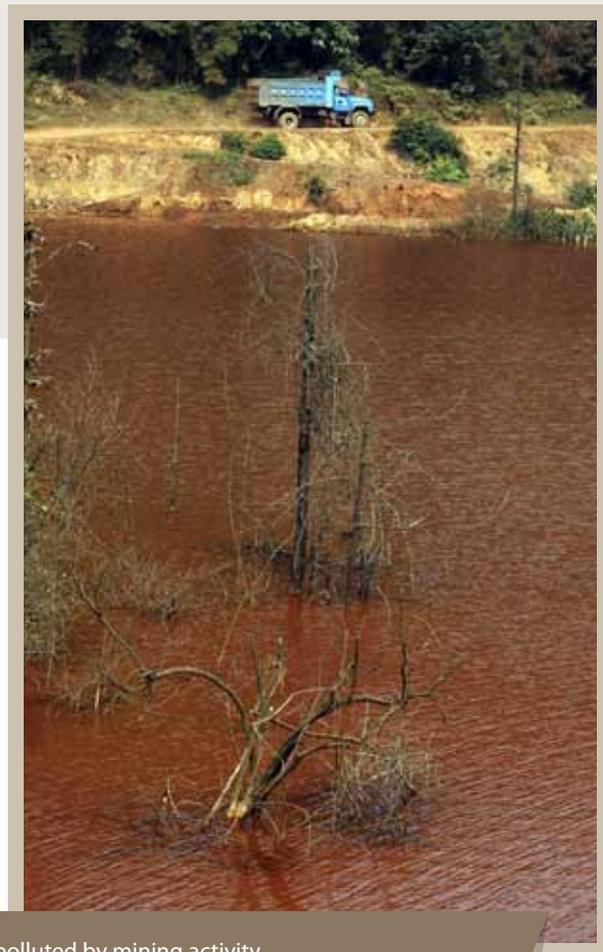
Lead contamination from mining poses a serious health risk to over 1.2 million people, particularly in Africa

waste and tailings are dumped out in the open and near residential areas where people may come into contact with contaminants, or children may play near or on toxic material. Because lead can be absorbed through dermal and mouth contact, this form of exposure can be particularly dangerous for children.

Miners are also at risk of exposure if they do not have protective equipment and frequently come into direct contact with ore containing lead. Miners can also inhale lead as dust during the mining and crushing processes.

Health Effects

Please see health effects from lead on pages 20-21.



A lake polluted by mining activity

Top Ten Toxic Pollution Problems



An abandoned mine with legacy lead pollution in Honduras

Miners in regions that lack environmental, health, and safety standards are often ill-equipped for their work, and some do not wear gloves, or even shoes, while handling material that may contain toxins

Example – DALY Calculations

A large mine on the island of Cebu in the Philippines was in operation from 1953 until 1994. When the mine closed, it left behind waste rock, tailings, open pits, and landfills that are leaching lead toxins into the environment. In 2006, mining operations re-commenced, and are also responsible for lead pollution in the area. Blacksmith samples found 18,194 parts per million of lead in river sediment. Blacksmith estimates that 3,500 people are impacted from disease caused by lead exposure.

DALYs associated with adverse health impacts from lead exposure at this site are estimated to be 74,624 for the estimated exposed population of 3,500. This means that the approximately 3,500 affected people will have a collective 74,624 years lost to death, or impacted by disease or disability. Distributed equally across the impacted population, this comes out to 21 years lost or lived with a disability per person.

Lead-Acid Battery Recycling Lead Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 1 MILLION



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Lead Pollution from Used Lead-Acid Battery Recycling.

69 SITES

10

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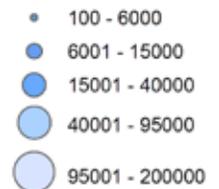
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Population at Risk



Description

Lead-acid batteries are rechargeable batteries that are widely found throughout the world and are commonly used in motor vehicles. These batteries are made up of lead plates and sulfuric acid that are contained within a plastic cover. The lead plates are perfect for use in batteries because of their ability to be recharged multiple times. After sustained use, the lead plates eventually weaken and are no longer able to store energy.⁴⁶ Used lead-acid batteries (ULABs) are either discarded or recycled. Because of the toxic materials within these used batteries, the

Basel Convention has included ULABs on its list of materials classified as "hazardous waste."⁴⁷

Industrial Process

Though the lead plates in a ULAB have been exhausted, this does not mean that the lead within the battery cannot be reused. In fact, most new lead-acid batteries contain up to 80% recycled, purified lead —making recycled lead a very valuable material.⁴⁸ Because of the success of recycled lead, the market for extracting and reselling used lead has grown substantially, particularly in low- and middle-

46. "Used Lead Acid Batteries: Factsheet." Department of the Environment and Heritage. Australian Government. August 2005. Available at: <http://www.environment.gov.au/settlements/chemicals/hazardous-waste/publications/lead-acid-fs.html>.

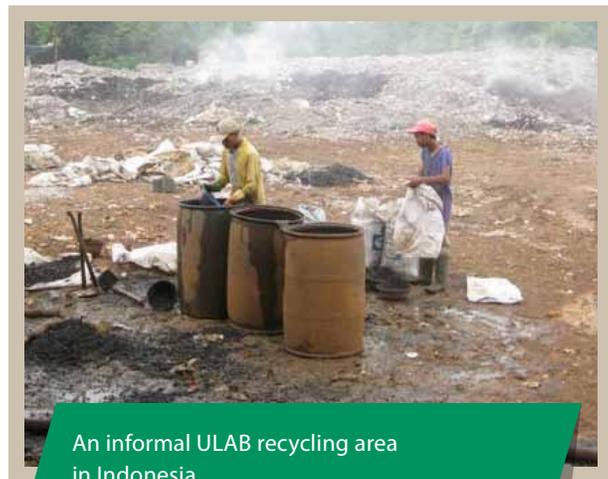
47. "The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal." Basel Convention. United Nations Environment Programme. Available at <http://www.basel.int/text/17Jun2010-conv-e.pdf>

48. "Batteris." U.S. Environmental Protection Agency. Accessed on August 25, 2011. Available at <http://www.epa.gov/osw/conservation/materials/battery.htm>

Top Ten Toxic Pollution Problems



Discarded lead-acid battery cases



An informal ULAB recycling area in Indonesia

income countries. Though high-income countries have developed safe and effective processes for the reclamation of lead from ULABs, the recycling process that occurs throughout much of the rest of the world is far less developed and regulated.

Unregulated recycling industries and informal methods of extracting lead —often conducted in homes or backyards— can lead to high levels of environmental lead contamination. These processes usually involve breaking the ULABs open by hand or with an axe, which can lead to direct dermal contact with lead and the improper release of battery acid into the surrounding soil. Pieces of the broken batteries are then left on the ground where they are exposed to the elements and can possibly spread toxins to people through dermal contact. Once the batteries are broken open, parts of the battery must be melted in order to recover the secondary lead. This process is frequently performed in homes and over informal kitchen stove flames. Lead-oxide, which accounts for 40 percent of the lead weight in each battery and is a particularly bio-available form of lead, is often improperly disposed of and left out in the open.

Global Context

On an annual basis, nearly 6 million tons of lead are used around the world, with over 4 million tons

used in lead-acid batteries. Substantial quantities of this lead consumption come from recycled materials and ULABs, which, when done properly, is a very effective industry in terms of reducing lead pollution and the need for mining of virgin ore material. Recycling of secondary lead, however, when done without proper regulations or safety measures, can be very dangerous and can lead to high levels of toxic exposure for both those directly involved and for surrounding communities.

Because of the growing market for secondary lead, many low- and middle-income countries have begun to buy ULABs in large quantities in order to recover and resell the material. Many of the ULABs originate in industrialized countries and are shipped long distance in order to be recycled.⁴⁹ Today, ULAB recycling processes occur in nearly every city in low- and middle-income countries, with many of the recycling and melting operations taking place in densely populated urban settings.

A large amount of the recycling processes in these countries, both small- and large-scale, is done with little knowledge of the health impacts these processes have. In many places, there are no environmental or health regulations that govern recycling, and lead is often released into the environment in very high quantities. Informal recycling is also disproportionately performed by

49. Trade and Environment. "A Teaching Case: The Basel Ban And Batteries."

Accessed October 14, 2011. Available at: http://www.commercialdiplomacy.org/case_study/case_batteries.htm.

Regions Most Impacted by Lead Pollution from ULAB Recycling

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. South America	15	322,800
2. South Asia	10	287,000
3. Africa	8	154,000
4. Southeast Asia	34	123,500

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

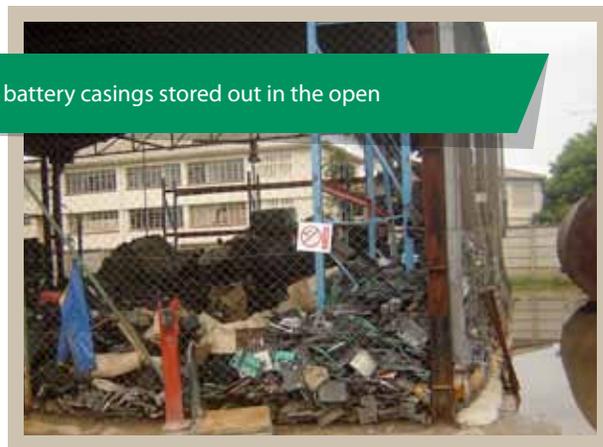
people living in conditions of poverty who may not have other viable means of income and who are often unaware of the dangers posed by these operations. Currently, the Blacksmith inventory estimates that almost 1 million people are affected by lead pollution from ULAB recycling, with the most severe problems observed in South America and South Asia.

Exposure Pathways

The informal recycling processes for ULABs can subject people to various forms of toxic exposure. The most frequent and common way that people are exposed to lead contamination is through lead particulates from the battery acid. During the breaking process, battery acid can easily leak into the soil or enter ground and surface water systems that are used for bathing and drinking. Lead toxins can also be inhaled during the melting of the lead plates, which allows the metal to enter into the respiratory and circulatory systems. Excess lead dust from this process can also be transported on clothing and can accumulate inside houses on bedding, furniture, and even food. Dry soil that is contaminated with lead particulates also poses the hazard of spreading lead dust throughout a community, where it can easily be inhaled or touched.

Young children are particularly at risk of lead exposure because of typical hand-to-mouth behavior. Because so many lead battery scraps are left out in the open, children often play in or around these dump sites and can inadvertently pick up stones or soil contaminated with lead, and even bring these objects back to their homes. The most frequent form of lead exposure for children is ingestion, as lead toxins can enter directly into

Broken battery casings stored out in the open



children's bodies through lead dust-covered hands, food, or toys that are either eaten or brought in contact with the mouth.

Health Effects

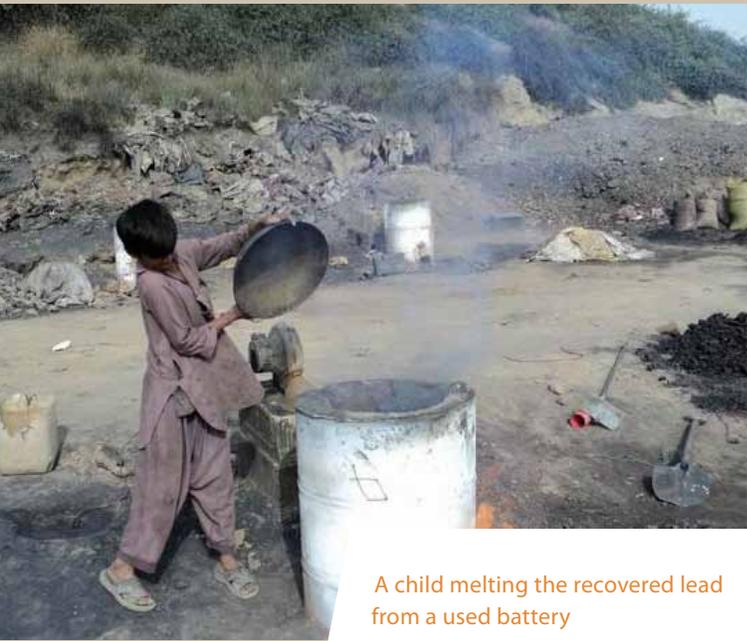
Please see health effects from lead on pages 20-21.

What is Being Done

Though the problems associated with informal ULAB recycling processes and lead poisoning are well documented and recognized under the Basel Convention Secretariat, these practices continue to occur on a very large scale throughout the developing world. Much of the informal ULAB recycling is very small-scale and difficult to regulate or control, but progress can be made through clean-up, outreach, policy, and education.

Blacksmith's Lead Poisoning and Car Batteries Project (formerly the Initiative for Responsible Battery Recycling) is currently in place in eight

Top Ten Toxic Pollution Problems



A child melting the recovered lead from a used battery



Burning used batteries to recover the lead

countries, including Senegal (with co-funding from Green Cross Switzerland), the Dominican Republic, India, and the Philippines. The Project aims to end widespread lead poisoning from the improper recycling of ULABs, and consists of several different strategies and programs, with the most important priority being the health of children in the surrounding communities. The multi-faceted system for mitigating and eliminating lead exposure and informal recycling consists of the following approaches: 1) the blood levels of children in recycling areas are monitored and treatment is provided to those with significantly high blood lead levels; 2) education and avoidance programs are implemented in communities surrounding recycling operations to inform community members of the dangers posed by improper ULAB recycling and to provide helpful advice on how to avoid exposure through inhalation, contact, and ingestion; 3) soil that is already contaminated with legacy lead particulates is either removed or is buried and covered with non-polluted top soil in order to avoid further toxic exposure; 4) programs and discussions take place with local governments and NGOs in order to implement sound policy for regulating and controlling problems associated with informal recycling and exposure; and 5) projects are undertaken with various community members and stakeholders to help create alternative economic opportunities.

Example – DALY Calculations

A small town outside of Manila in the Philippines contains a closed battery manufacturing plant and a ULAB recycling facility. Though the plant is guarded, scavengers still sneak in to recover material that may contain reusable lead. This practice, along with waste and toxic spillage from the other recycling facilities, has led to high levels of lead contamination in the area, and many people are growing their food in soil with high lead pollution. Blacksmith samples found 193,880 parts per million of lead in the soil, which is over 400 times the health standard. Blacksmith estimates that 15,000 people are at risk of exposure to lead in this area.

DALYs associated with adverse health impacts from lead exposure at this site are estimated to be 319,817 for the estimated exposed population of 15,000. In other words, the 15,000 affected people at this site will have a collective 319,817 years lost to death, or impacted by disease or disability. This comes out to 21 years lost or lived with a disability per person.

Naturally Occurring Arsenic in Ground Water

Arsenic Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 750,000



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Arsenic from Naturally Occurring Groundwater Sources

42 SITES

10

9

8

7

6

Population at Risk

- 3300 - 5600
- 5601 - 13000
- 13001 - 30500
- 30501 - 60000
- 60001 - 190000

Description

Arsenic is a semi-metallic element – although it is generally referred to as a heavy metal – that occurs naturally in the earth’s crust and has no discernible taste or odor. In its pure, elemental state, arsenic has a grey color and is relatively solid. When arsenic combines with other elements in the environment, it changes to a powder form that is either white or colorless and is very difficult to distinguish. This, along with its lack of smell and taste, makes arsenic compounds in water, air, or on food extremely hard to detect.

Traces of arsenic can be found in air, soil, water, and food. Though naturally occurring arsenic in the soil is usually only found in very low concentrations, some regions of the world contain arsenic-heavy deposits, which have been estimated to tremendously increase arsenic levels in the ground. These arsenic-rich areas

have frequently contaminated groundwater supplies, which are often the only source of drinking water for local communities.

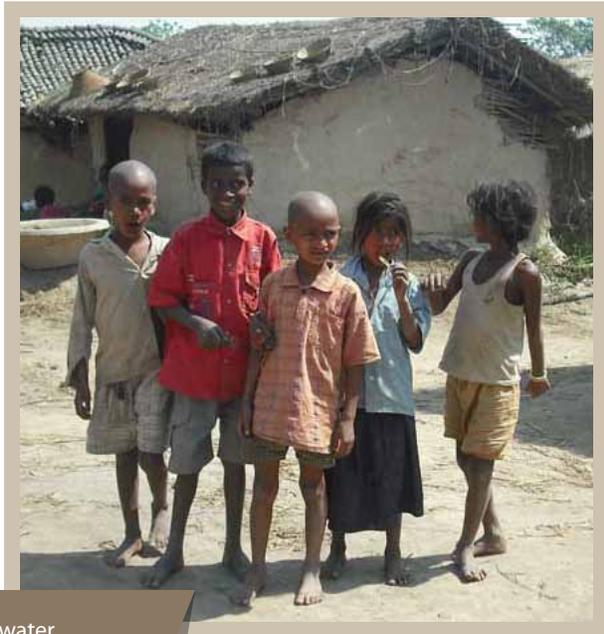
Industrial Process

Though there is no specific industrial process that creates this kind of arsenic pollution, the amount of arsenic that leaches from the earth’s crust into groundwater systems can be exasperated by human activity. In many parts of the world, groundwater systems are the only source of water for local communities, and this water is extracted from deep in the earth’s surface using pump wells. Water from these wells is used for a variety of purposes, including irrigation for agricultural fields. Over-pumping of water for agriculture has been blamed for pulling higher concentrations of natural arsenic into groundwater systems, which contaminates entire water sources.⁵⁰

Top Ten Toxic Pollution Problems



Children in a town with arsenic contaminated water



Global Context

The areas throughout the world that have the worst documented contamination of groundwater by arsenic are in South Asia, and the toxin poses a frequent problem in Nepal, India, and Bangladesh. According to a report by the WHO, "Bangladesh is grappling with the largest mass poisoning of a population in history" due to arsenic contamination in groundwater, with an estimated 35 to 77 million people at risk.⁵¹ Because arsenic contamination in Bangladesh has been the focus of many other agencies, including the WHO, Blacksmith has not completed site assessments for arsenic pollution in this country.

Exposure Pathways

The most common way that people are exposed to arsenic contamination is through ingestion. The arsenic-laden water is often directly used for drinking, but can also contaminate crops when it is used for irrigation purposes.

Women pumping water from a well contaminated with arsenic



50. "Arsenic Poisoning in India and Bangladesh." SOS – Arsenic.net. Last updated August 25, 2011. Available at <http://www.sos-arsenic.net/>
51. Smith, Allan H., et al. "Contamination of drinking-water by arsenic in Bangladesh: a public health emergency." *Bulletin of the World Health Organization*, 2000, 78 (9). Available at http://www.who.int/water_sanitation_health/dwq/arsenic/en/

Regions Most Impacted by Arsenic Pollution from Naturally Occurring Arsenic in Ground Water

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. South Asia	39	487,400
2. Central America	2	195,000
3. Africa	1	60,000
4. Southeast Asia	2	8,300

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

A child drinks from a well in Nepal contaminated with arsenic



Health Effects

Arsenic is known to be a dangerous toxin that can lead to death when large amounts are ingested. Small amounts of arsenic exposure over long periods of time can also lead to numerous health problems, including abnormal heart beat, damage to blood vessels and a decrease of red and white blood cells, nausea and vomiting, and clearly visible irritations of the skin. A common effect of arsenicosis, or arsenic poisoning, is dark patches of skin, corns, or warts on the body.⁵²

Arsenic is also a documented human carcinogen, and exposure over long periods has been found to cause cancer of the bladder, skin, lungs, kidney, and liver.⁵³

What is Being Done

Due to the significant and widespread human health problems posed by naturally occurring arsenic in drinking water, much international attention has been paid to this issue, particularly in Bangladesh. Most remediation programs have revolved around identifying and labeling wells with contaminated water, helping communities find safe alternatives for water sources (such as collecting rain water), and implementing low-cost water treatment systems.⁵⁴

52. "ToxFAQs For Arsenic." Department for Health and Human Services: Agency for Toxic Substances and Disease Registry. August 2007. Available at <http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=19&tid=3>

53. "Water-related diseases: Arsenicosis." World Health Organization: Water Sanitation and Health. Accessed on September 1, 2011. Available at http://www.who.int/water_sanitation_health/diseases/arsenicosis/en/

54. *ibid.*

Top Ten Toxic Pollution Problems



Children in a village impacted by arsenic in the drinking water

Though there is no specific industrial process that creates this kind of arsenic pollution, the amount of arsenic that leaches into ground water systems can be exasperated by human activity

Example — DALY Calculations

A township in the central region of Nepal has high levels of naturally occurring arsenic in the ground that is leaching into the area's groundwater system. Groundwater is the only source of drinking water in this area, and it is accessed by deep tube wells that bring the water to the surface. Samples of the drinking water in this area found 500 micrograms per liter of arsenic, which is 50 times the health standard. Blacksmith estimates that 8,000 people are at risk of arsenic poisoning in this area.

DALYs associated with health issues caused by arsenic exposure at this site are estimated to be 6,997 for an exposed population of 8,000. The 8,000 affected people will have a collective 6,997 years lost to death, or impacted by disease or disability. This represents 0.9 years lost or lived with a disability per person.

Pesticide Manufacturing and Storage

Pesticide Pollution

ESTIMATED POPULATION AT RISK AT ASSESSED SITES: 730,000



Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

Pesticide Pollution from Pesticide Manufacturing Facilities

33 SITES

10

9

8

7

Population at Risk

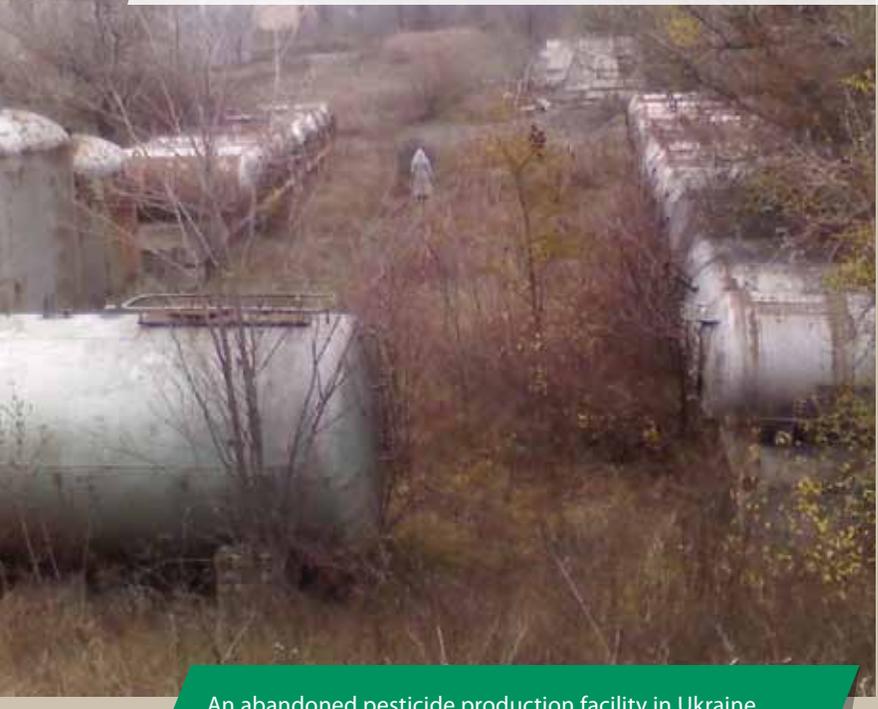
- 100 - 7000
- 7001 - 20000
- 20001 - 50000
- 50001 - 100000
- 100001 - 173400

Description

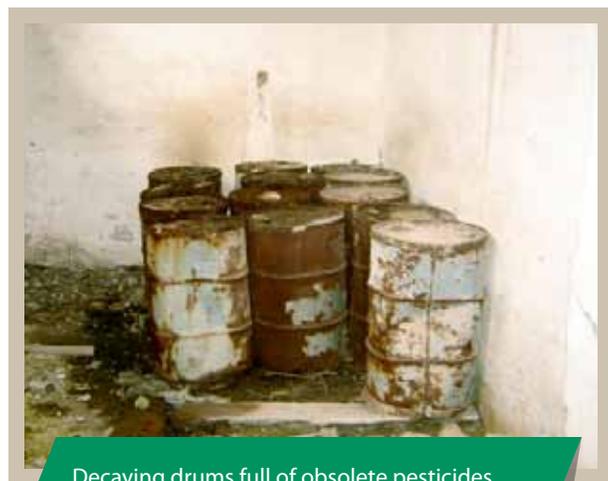
Pesticides are widely used in agricultural processes throughout the world in order to protect crops from pests, fungus, and bacteria, but many of these materials have been found to pose such a health hazard that they have been banned under the Stockholm Convention or are considered Highly Hazardous under the Basel Convention. However, though the international community has taken great lengths to protect people and the environment from particularly hazardous pesticides, many of these products continue to be produced, used, and stored. Some of the more noxious, banned pesticides that can still be found in high quantities in storage facilities are carbamates, persistent organic pollutants, organophosphates, and organochlorines—which include DDT and chlordane.

Many of the facilities that currently house large stockpiles of hazardous pesticides are very old or dilapidated and do not have proper infrastructures to support safe storage of the chemicals. In many of these facilities, old and deteriorating drums of toxins are stored in the open where they can leak into the surrounding environment. Because numerous pesticide storage areas were built many years ago, urban centers have since sprung up around them, leaving dangerous toxins in close proximity to residential neighborhoods. Other pesticides have been buried on site or in landfills, some of them to be excavated later on again and sold on black markets.

Top Ten Toxic Pollution Problems



An abandoned pesticide production facility in Ukraine



Decaying drums full of obsolete pesticides

Industrial Process

While a significant amount of toxic exposure to pesticides is due to improper storage, the pesticide manufacturing process itself can also release contaminants into surrounding areas.

Though there are thousands of different kinds of pesticides that can be manufactured, and thus many different production processes, the basic method of creating pesticides consists of a manufacturing step and a formulation step. The manufacturing process involves the creation of a chemical reaction between two or more compounds in order to create an active ingredient.⁵⁵ The formulation stage consists of mixing active ingredients with solvents and other materials in order to produce different forms of pesticides for various application purposes such as sprays or powders.⁵⁶ The processes that occur within each of these steps can potentially create toxic emissions, effluents, or solid wastes, especially if proper safety precautions are not taken.⁵⁷

Global Context

A large majority of storage facilities containing outdated, banned pesticides – many of which are abandoned – exist in low- and middle-income countries. In many places, these stocks of pesticides continue to be sold, despite being classified as hazardous and deemed illegal for use, and farmers frequently buy them due to their affordability and a lack of understanding about the health risks posed by these toxins. A 1996 study conducted by the Food and Agriculture Organization of the United Nations reported that approximately 15,000 to 20,000 tons of obsolete pesticides were still being stored in Africa.⁵⁸ This number is dwarfed again by estimates for the area of the Former Soviet Union, where numbers go into the hundreds of thousands of tons.⁵⁹ According to Blacksmith's research, the largest problems posed by pesticide storage and manufacturing are in India, Russia, Pakistan, and various countries in Central Asia, with affected populations approximating over 700,000 people. The main banned pesticide that is

55. "Pesticide Industry: A Profile – Draft Report." Research Triangle Institute. Prepared for U.S. Environmental Protection Agency, December 1993. Available at [http://www.epa.gov/ttnecas1/regdata/IPs/Agricultural%20Chemicals%20\(pesticides\)_IP.pdf](http://www.epa.gov/ttnecas1/regdata/IPs/Agricultural%20Chemicals%20(pesticides)_IP.pdf)

56. *ibid.*

57. "Environmental Guidelines for Pesticides Manufacturing." Multilateral Investment Guarantee Agency, World Bank. Available at <http://www.miga.org/documents/PesticidesManufacturing.pdf>

Regions Most Impacted by Pesticide Pollution from Pesticide Manufacturing and Storage

Country	Number of Sites in Blacksmith Database	Estimated Impacted Population
1. South Asia	16	279,300
2. South America	6	210,100
3. Eastern Europe, Northern Eurasia & Central Asia	6	131,000
4. Africa	6	115,000

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.



found in many of these places is DDT, but in terms of volume, lindane wastes will be the largest challenge in the future.

Exposure Pathways

The largest threat from pesticide manufacturing and storage is caused by old and improper storage containers and facilities that allow concentrated levels of toxins to leak into the environment. These leaks can carry toxins from the facilities directly into nearby soil and water that may be used for bathing,

drinking, or agriculture. Once toxins from pesticides enter the soil, they can also easily travel as dust on shoes or clothing and can be inhaled, touched, or ingested.

Some pesticides are persistent toxins and can have very long life spans once they enter the environment. Pesticides can also bio-accumulate in the tissue of animals. DDT in food is particularly hazardous and can build up in humans because of its solubility in body fat.

58. Wodagene, A. and H. van der Wulp. "Obsolete Pesticides in Developing Nations." Pesticides News, No. 32 (1996): 12-13.

59. See: <http://www.ihpa.info/how-to-be-involved/how-big-is-the-problem/>.

Top Ten Toxic Pollution Problems



Children play near a pesticide storage facility

A 1996 study conducted by the Food and Agriculture Organization of the United Nations reported that approximately 15,000 to 20,000 tons of obsolete pesticides were still being stored in Africa.

Health Effects

Though there are many different kinds of pesticides, each with different and varying levels of human health risk, pesticide storage poses a particular health problem due to the amounts of banned and dangerous pesticide stocks that still exist. DDT, for example, can lead to problems for kidneys, liver, intestines, the stomach, and the central nervous system, and can also cause cancer. If children or pregnant women are exposed, DDT may be responsible for reproductive and developmental problems.

What is Being Done

Significant international programs have been put in place to begin the reduction and clean up of pesticide stocks, with positive results. One multilateral effort, the Africa Stockpiles Programme, has been implemented in South Africa, Morocco, Nigeria, Tunisia, Mali, Tanzania, and Ethiopia.

Green Cross Switzerland works closely with FAO, UNEP and WHO in the area of the Former Soviet Union and in West-Africa to raise awareness on the risks of old and obsolete pesticides, find and safeguard old pesticides, introduce better practices in future pesticides management, and introduce (non-chemical) alternatives to DDT to control malaria in Central Asia and the Caucasus.

Example – DALY Calculations

A DDT factory in the northwest of Pakistan was closed in 1994 due to the banning of the pesticide. While the factory was in operation it produced up to 6,000 tons of DDT per year, and large stockpiles of the toxin are still stored at this abandoned facility. High levels of DDT can still be found in water and soil around the facility, and samples found 573 parts per million of DDT in soil, which is over 60 times the health standard. Blacksmith estimates that 40,000 people are at risk of health problems from DDT exposure in this area.

DALYs associated with health issues from DDT exposure are estimated to be 5,637 for an exposed population of 40,000 people. Thus, the 40,000 affected people will have a collective 5,637 years lost to death, or impacted by disease or disability. This comes out to 0.1 years lost or lived with a disability per person.

The Rest of The Toxic Twenty

Chemical Manufacturing Chromium Pollution

The chemical manufacturing sector is expansive and diverse, and is split into six different categories by the US Bureau of Labor Statistics: 1) basic chemicals, which include pigments and dyes, gases, and petrochemicals; 2) synthetic materials such as plastics; 3) agricultural chemicals such as fertilizers and pesticides; 4) painting products; 5) cleaning products, such as soaps and detergents; and 6) other chemicals, which include film products, ink toners, and explosives.⁶⁰ Another important sector of the chemical manufacturing industry is the production of pharmaceuticals. Chromium is employed in a variety of chemical processes – often as a catalyst for chemical reactions – and is frequently used for the manufacturing of chromic acid, synthetic dyes, pharmaceuticals and antiseptics, cleaning materials, and toners.⁶¹

Though the manufacturing of chemicals with chromium is varied, there are several general ways that pollutants can be released into the environment. The first is through wastewater, which can be generated while cleaning equipment, from chemical spills, and from cooling water used during heating procedures. This water often contains chromium, and when not treated or disposed of properly, can carry contaminants into local water supplies. Many chemical processes also require heating, which can release chromium vapor into the air. Chromium pollution created by chemical manufacturing, then, can reach people through



Yellow ground water containing chromium near a chemical manufacturing facility

residential and drinking water systems, and can also contaminate soil and food. Chemical manufacturing facilities in low- and middle-income countries, where environmental and health regulations may not be as stringent, may cause large amounts of chromium pollution through untreated effluent, with the largest problems, according to Blacksmith's data, occurring throughout South and Southeast Asia.

Please see health effects from chromium on page 32.

60. "Chemical Manufacturing, Except Drugs." United States Department of Labor, Bureau of Labor Statistics. Accessed September 15, 2011. Available at <http://www.bls.gov/oco/cg/cgs008.htm>.

61. "Best Management Practices, Chemical Manufacturing Sector: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride." XCG Consultants, Ltd., prepared for the Ministry of the Environment, Toronto, Ontario. March 6, 2007. Available at http://www.ene.gov.on.ca/environment/en/resources/STD01_076216.html

Top Ten Toxic Pollution Problems

A chemical manufacturing plant in China

Chemical Manufacturing Mercury Pollution

Mercury has been used in chemical manufacturing processes for many years, as it is a useful catalyst and reagent and can aid in the production of many different substances. Mercury is most commonly used in the manufacturing of pharmaceuticals, cleaning agents, dyes, explosives, and preservatives.⁶² Mercury is also used in a variety of devices at some chemical manufacturing facilities, such as thermometers. Mercury is also used in a variety of devices at some chemical manufacturing facilities, such as thermometers. Mercury can be released during chemical manufacturing much in the same ways as chromium—through effluent and emissions. If not properly treated or contained, wastewater from washing, spills, and cooling—in addition to breaking of thermometers or other products containing elemental mercury, like fluorescent light bulbs—can all lead to mercury contamination of ground and surface water systems. Mercury can also be released through emissions from chemical heating processes.

Mercury pollution from chemical manufacturing can be very dangerous for workers who may come into direct contact with liquid or vapor mercury, and the toxin can also enter drinking water systems, soil, and the food chain. Countries with poor infrastructure and effluent treatment facilities are particularly at risk from wastewater contamination, and Blacksmith estimates that mercury from chemical manufacturing impacts many people in Eastern Europe, Northern Eurasia, and Central Asia.

Please see health effects from mercury on page 16.

Dye Industry Chromium Pollution

The manufacturing and use of textile dyes is a varied and widespread industry that can either be very large in scale, or can occur in small and sometimes informal facilities. Most dyes get their color from the mixing of different compounds, many of which are toxic in nature. The most common colors associated with chromium use are yellows, oranges, greens, and reds, and these pigments are created by combining various chromium compounds with other elements.

Though there are many different processes that occur in the textile dyeing industry, a common operation will include pretreatment and bleaching of the material, dyeing in a wet bath, and post-dyeing with fixatives.⁶³ All of these processes create large volumes of wastewater that contain traces of heavy metals from the dyes. If this wastewater is not treated properly, or is dumped directly into nearby water systems, it can contaminate drinking and residential water with large amounts of chromium. Because many dyeing facilities throughout the world are small and sometimes family-run, it is prohibitively expensive to have proper effluent treatment equipment for every one. In countries where environmental and health standards are more relaxed, this can cause a large pollution problem when these smaller facilities dump toxins freely into water systems. Empty dye containers can also cause chromium contamination of water and soil when disposed of improperly.

Please see health effects from chromium on page 32.

62. *ibid.*

63. "Title III Section 313 Release Reporting Guidance: Estimating Chemical Releases from Textile Dyeing," United States Environmental Protection Agency. February 1988. Available at <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=10003B16.txt>

If wastewater from dyeing processes is not treated properly, or is dumped directly into nearby water systems, it can contaminate drinking and residential water with large amounts of chromium

Industrial Estates Chromium Pollution

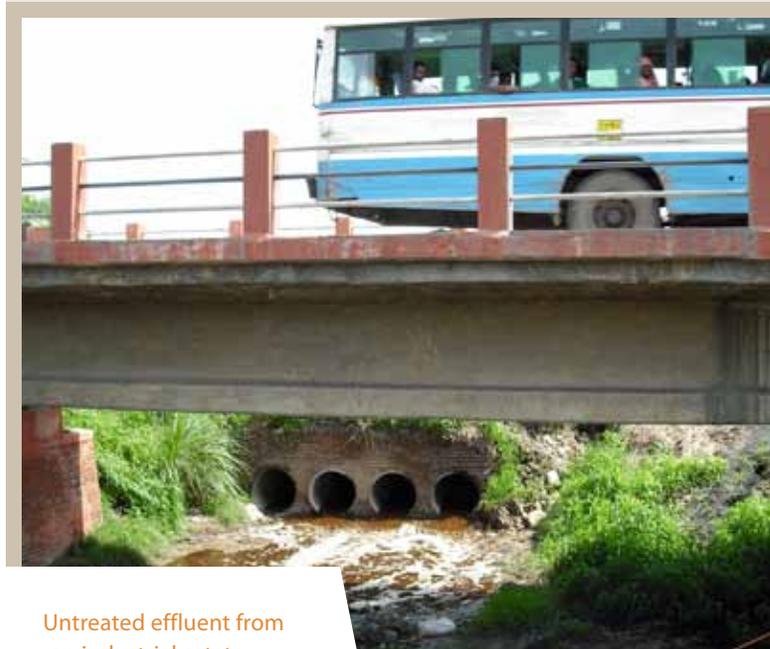
Industrial Estates are zoned areas that accommodate grouped industrial facilities. The industry in these planned areas is diverse and the amount of facilities can range from under ten to over one hundred. These areas exist all over the world, with almost 4,500 estimated to be in Asia. Though the industries within these zones can be very diverse, the most common industries that produce chromium contamination are metal processing (chromium coatings are used on a variety of metals to help prevent rust), stainless steel welding, chrome pigment and dye production, and leather tanning.

Due to the diverse processes and industries of each industrial estate, chromium pollution from these areas can contaminate water, soil, air, and food. The majority of chromium produced by industrial activities is in the more toxic, hexavalent form. Air pollution from industries that use chromium compounds, especially those that involve heating processes, can be very dangerous for both workers and nearby communities where airborne toxins may settle. Wastewater that is not treated properly can release chromium into water systems, and solid waste from frequent illegal dumping activities can leach contaminants into soil.

Please see health effects from chromium on page 32.



Workers at a dye facility in India



Untreated effluent from an industrial estate

Top Ten Toxic Pollution Problems

Industrial and Municipal Dump Sites Lead Pollution

Global production of solid waste, which includes both industrial and municipal garbage, accumulates every day at a staggering rate. Some of the biggest cities in the world, such as Dhaka, Lagos, and Manila, create 5 to 7,000 tons of solid waste every day, and a recent study found that Bangalore produces approximately 1,500 tons per day of municipal waste.⁶⁴ In low- and middle-income countries, many cities do not have government-run waste collection, and much of the waste is dumped in large and uncontained areas that are either in the middle of residential areas or right outside of them. Municipal waste can consist of a variety of different substances including food waste, electronics, paper and plastic packaging, glass, etc. Industrial waste is usually created in larger quantities and can contain extremely hazardous materials, such as heavy metals, volatile organic compounds, pesticides, and radionuclides. Lead contamination from dumpsites can come from a countless number of solid waste materials, such as electronics, batteries, paint, and medical supplies.

The garbage at these dumpsites often produces gas as the material decomposes and rots, and toxic substances can either leach into the soil and contaminate groundwater or can be carried into surface water systems by rain runoff. The amount of toxins released by dumpsites can be tremendously large, with one study finding lead levels in the soil of a former municipal and industrial waste area reaching 10,297 mg/kg – nearly 10 times above the health standard.⁶⁵ In addition to contaminants entering the environment, many people come into direct contact with lead toxins by scavenging and even sometimes living in the dumpsites. Large and uncontrolled dumpsites can potentially impact hundreds of thousands of people, with some of the largest problems existing in Tanzania, Kenya, Indonesia, and Pakistan.

Please see the health effects from lead on page 20.



People scavenge from waste at a large dump site in India

Mining and Ore Processing Arsenic Pollution

Arsenic is mined for use in a variety of different products, including batteries, insect control for livestock, and several types of pesticides. About 2,800 tons of arsenic were also used for the production of lewisite, a chemical weapon agent now destroyed a few years ago under the Chemical Weapons Convention. Nearly 90 % of mined arsenic is used in a compound known as copper chromated arsenate, which is a common wood preservative.⁶⁶ In addition, arsenic occurs frequently in the earth's crust, and is often present in the ore of other commonly mined metals, such as lead, copper, and gold. Arsenic, then, can easily be released into the environment through the mining and ore processing activities of these metals. Waste rock, tailings, and smelting processes at mines where arsenic is present in ore can release the toxin into the environment. One study of arsenic contamination near a gold mining site found that surface waters surrounding the mine had arsenic concentrations of 560 µg/L —50 times the standard for drinking water.⁶⁷

As arsenic is an element, it cannot be destroyed. It can easily spread from soil to air or water, and vice versa. Once the toxin is released from the earth's crust, it can bond with hydrogen and oxygen to become an organic compound, and most arsenic pollution will find its way into soil or water sediment where it can contaminate drinking water and agricultural products. Inhalation, ingestion, and dermal contact with arsenic can all pose human health risks.

Please see the health effects from arsenic on page 48.

64. Lakshmikantha, H. "Report on waste dump sites around Bangalore." *Waste Management*, Vol. 26, No. 6, 2006: 640-50.

65. Carr, Ramona, et al. "Identification and mapping of heavy metal pollution in soils of a sports ground in Galway City, Ireland, using a portable XRF analyzer and GIS." *Environmental Geochemistry and Health*, Vol. 30, No. 1, July 2007: 45-52.

66. "Public Health Statement: Arsenic." Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine. August 2007. Available at <http://www.atsdr.cdc.gov/pbs/pbs.asp?id=18&tid=3>

67. Eisler, R. "Arsenic hazards to humans, plants, and animals from gold mining." *Reviews of Environmental Contamination and Toxicology*, Vol. 180, 2004: 133-65.



A mine tailings pond contaminated with arsenic

Mining and Ore Processing Cadmium Pollution

Cadmium is a naturally occurring element in the earth's crust that commonly occurs as either an oxide, sulfide, or chloride compound and is used in a variety of different industries, including metal plating and for plastic, pigment, and battery production. Cadmium is almost never mined for directly, but rather is obtained as a by-product of the mining and smelting of zinc, copper, and lead ores.⁶⁸ Cadmium pollution can also be created by the mining of coal, as one study found that there were high levels of cadmium in blood ($>0.5 \mu\text{g}/\text{dL}$) in 85 % of children under the age of six who lived near a coal mine in Turkey.⁶⁹ Though cadmium can enter the environment in many different ways, smelting and ore processing of zinc is one of the leading anthropogenic causes of cadmium pollution.⁷⁰ Because cadmium is present in the ores of commonly mined elements, it can be transferred into the environment through waste rock and ore processing tailings. If mines contain smelters at their ore processing facilities, cadmium can also be released into the air during the heating of ore or can remain in the waste slag created by the smelting and refining process.

Once airborne, cadmium can travel easily as dust or vapor, and often contaminates soil and food when it settles back to the ground. The ingestion of food contaminated with cadmium is a fairly common route of exposure. Cadmium compounds in mining waste rock and tailings can leach into water and soil and contaminate drinking wells and water sources used for bathing and irrigation. Workers in the mines can be exposed to high levels of cadmium

dust and vapor when proper precautions are not taken. Cadmium is a very hazardous material that is a known human carcinogen. Inhalation and oral exposure to cadmium can cause chronic lung and kidney disorders, and in extreme cases, exposure may cause cancer.

Mining and Ore Processing Cyanide Pollution

Unlike the other common pollutants caused by mining and ore processing, cyanide is not formed in the earth's crust, but is instead created by various types of algae, bacteria, fungi, and plants.⁷¹ Cyanide contamination is commonly associated with the mining of metals, particularly gold, since it can bond with the desired metals and help isolate them from their ore. Cyanide use is normally part of the ore processing phase, and the most common methods are vat-leaching and heap-leaching. Vat-leaching consists of mixing crushed ore with a cyanide compound in a vat where it will form a new compound with the metal and can aid in isolating desired material from the unwanted waste rock. The typical amount of cyanide used in this process can range from 300 to 500 mg/L.⁷² For heap-leaching, mounds of crushed ore are either placed in large pits or, preferably, on impermeable material. Cyanide is then poured, dripped, or sprayed onto the mounds, and it forms compounds with the metals in the ore as it leaches through the pile. Though this practice is relatively cheap, it only yields about 50 to 75 % of the gold content from the ore.⁷³

Mining and ore processing activities that use cyanide can lead to toxic environmental contamination

68. "Cadmium Fact Sheet." Environmental Protection Agency. Accessed on September 21, 2011.

Available at <http://www.epa.gov/osw/hazard/wastemin/minimize/factshts/cadmium.pdf>

69. Yapici, Gulcin, et al. "Lead and cadmium exposure in children living around a coal-mining area in Yatagan, Turkey." *Toxicology and Industrial Health*, Vol. 22, No. 8, 2006: 357-362.

70. "Pollution Prevention and Abatement Handbook: Cadmium." International Finance Corporation, World Bank Group. July 1998.

Available at [http://www.ifc.org/ifcext/enviro.nsf/attachmentsbytitle/p_ppah_pguicadmium/\\$file/handbookcadmium.pdf](http://www.ifc.org/ifcext/enviro.nsf/attachmentsbytitle/p_ppah_pguicadmium/$file/handbookcadmium.pdf)

71. "Toxic Substances Portal: Cyanide." Agency for Toxic Substances and Disease Registry. Accessed on September 21, 2011.

Available at <http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=19>

72. "Use of Cyanide in the Gold Industry." International Cyanide Management Code for the Gold Mining Industry. Accessed on September 21, 2011.

Available at http://www.cyanidecode.org/cyanide_use.php

73. *ibid.*

Top Ten Toxic Pollution Problems



Tailings containing cadmium at a mine in the Philippines

Workers covered in oil from electronics manufacturing



through water and soil. The leaching processes, if done improperly or without the necessary oversight, can create large amounts of wastewater that often contains trace amounts of cyanide. The toxin can also remain in the tailings left behind from the ore processing, where it can leach into soil and groundwater systems, or can enter the air as dust. Cyanide is a highly toxic substance, and acute exposure can lead to heart and brain problems, and in some cases, can cause death.⁷⁴ Chronic exposure to cyanide through inhalation, ingestion, or dermal contact can cause problems with breathing, headaches, thyroid enlargement, chest pain, seizures, and skin irritation or sores.⁷⁵

Product Manufacturing

Lead Pollution (especially from plating, electronics manufacture and battery manufacture)

The product manufacturing industry – which includes hundreds of different manufacturing materials and processes – is a major part of the global economy and is responsible for many of the goods that people use on a daily basis. Lead is commonly used in many products due to its ability to protect against radiation and sound waves, its capacity to be recharged, and its resistance to water corrosion. Lead compounds are used for metal finishing and in the production of automobile parts, batteries, tires, and a wide range of electronic equipment, such as air conditioners, refrigerators,

televisions, and computers. Many of the production processes for these products require water use, heating, and chemical reactions, all of which can release lead into the environment.

Though lead contamination can occur during the processing of all of the aforementioned products, batteries are the main producer of toxic lead pollution. The manufacturing of batteries—which are predominantly used in cars but can also be used in other common products, such as computers—can release large amounts of lead dust and fumes into the air during plating and assembly processes, which can be harmful to workers and the surrounding environment if the dust is not properly contained. Wastewater from the cleaning and cooling processes during manufacturing can also carry lead into nearby water systems. The full life-cycle of a battery must also be considered, which would include the lead emissions of used battery recycling. A recent report estimated that the manufacturing and recycling of a projected one billion computer batteries in low- and middle-income countries through 2015 would create about 1.2 to 2.3 million tons of lead pollution —“between four and seven times the weight of the Empire State Building.”⁷⁶

Please see health effects from lead on page 20.

74. “Division of Toxicology and Environmental Medicine ToxFAQs: Cyanide.” Agency for Toxic Substances and Disease Registry. July 2006. Available at <http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=71&tid=19>

75. *ibid.*

76. Cherry, Christopher R. and Perry Gottesfeld. “Plans to distribute the next billion computers by 2015 creates lead pollution risk.” *Journal of Cleaner Production*, Vol. 17, 2009: 1620-1628.



A uranium mine in Ukraine

Uranium Mining and Ore Processing Radionuclide Pollution

Uranium, which is a radionuclide, is widely used as a source of fuel for nuclear power plants. Mining for this element occurs all throughout the world, and uranium is typically extracted through open-pit mining and in-situ leaching, which consists of injecting acid liquids or sodium bicarbonate into an ore deposit in order to bring valuable ore to the surface. Once the uranium ore is obtained, it must be ground into smaller pieces and combined with chemicals, such as sulfuric acid, in order to acquire pure uranium. The concentration of uranium in ore is very low, only accounting for 0.1 to 0.2 % of the ore content, which means that very large amounts of waste rock are created during the mining process. In addition, the processing of the ore leaves enormous amounts of toxic sludge that often contains radioactive materials, including left over uranium, thorium-232, and their decay product radium, which can contain as much as 85 % of the initial radioactivity of the ore.⁷⁷

Radionuclides are naturally occurring elements that are radioactive, meaning that they have atoms with

unstable nuclei. As elements or materials decay, they will emit radiation up to an end point in the decay process. Some materials decay quickly, but some, like uranium, can continue to be radioactive for millions of years. During the decay, different types of radioactivity with different health effects can be generated. Uranium mining in low- and middle-income countries is frequently lacking in oversight and regulatory practices, which can allow large amounts of toxic waste rock and tailings to contaminate the soil, air, water, and food of surrounding areas. People who live near these mines may also be exposed to radiation. Uranium radionuclides can cause damage to kidneys and to the genetic code, which can often impact fetal development. Other radionuclides, such as radon, can lead to leukemia and decreases in white blood cell counts. Several of the areas where uranium mining is conducted on the largest scale are in Central Asia, Namibia, Russia, and Niger, and two of the largest examples of the dangers of uranium mining and enrichment leading to radionuclide contamination are the Chernobyl site in Ukraine and the Fukushima nuclear power plant in Japan.

⁷⁷ P. Diehl. "Uranium Mining and Milling Wastes: An Introduction." WISE Uranium Project. Available at <http://www.wise-uranium.org/uwai.html>. August 15, 2004,

Top Ten Toxic Pollution Problems

A Note on Oil Production

Pollution from oil use and production is generally outside of the scope of Blacksmith's work, due to the globally pervasive nature of this industry and number of sites impacted by oil pollution. Basically, inclusion of this industry within Blacksmith's work would overwhelm our current resources and lead to poorer understanding of the impact of other industries. However, in view of the thousands of sites contaminated by the petrochemical industry, often in highly populated areas, and the many health impacts to which oil and petrochemical product exposure can lead, Blacksmith believes that, if the data existed, the petrochemical industry would be included as one of the top ten pollution problems. For this reason, it is important to discuss the dangers and health effects posed by this industry, as it likely impacts millions of people throughout the world.

The oil industry consists of many different processes, all of which have the potential to cause extreme environmental damage and health problems. The processes include drilling for crude oil, refining of oil and production of petrochemicals, and transportation of refined products, all of which can lead to harmful spills, leaks, and waste.

Once crude oil is extracted from the ground it must be chemically processed into commercial products. Oil refineries process crude material into over 2,500 products, including many different types of fuel, lubricants, asphalt, paraffin wax, tar, and petrochemicals.⁷⁸ Oil processing can be a fairly complicated procedure, with many operations that could potentially release large amounts of toxins and other pollutants into the environment. Volatile chemicals that are produced through the refining process can enter the atmosphere and can cause high levels of ambient air pollution. If done improperly or without appropriate equipment and oversight, the refining of oil can lead to spills of oil and wastewater that contaminate water systems and soil. Given the waste produced by oil refining – in general, processing one ton of crude oil can produce 3.5 to 5 cubic meters of wastewater and 3 to 5 kilograms of sludge and solid waste – proper



Saturated soil from an oil spill

containment and treatment of this material is very important to prevent widespread environmental damage.⁷⁹

Pollutants from oil refining and spills can contaminate the air, water, soil, and a large variety of food products. People who live near oil refineries or oil spill locations are at risk of inhaling or ingesting toxic materials, and those who are exposed are at risk of developing skin lesions, digestive and respiratory problems, and cancer. Several of the most harmful contaminants that people may be exposed to from oil pollution are volatile aromatic organic compounds such as xylene, benzene, and toluene. Volatile aliphatic compounds such as hexane and heptane are also key pollutants. Due to the demand for oil and its production on such a mass scale throughout the world, the oil production and refining industry poses a large risk to environmental and human health – especially when proper precautions and standards are not taken.

78. Gary, James H. and Glenn Handwerk. *Petroleum Refining: Technology and Economics*. 4th ed. New York: Marcel Dekker, Inc, 2001.

79. "Petrochemical Company." Lennetech: Water treatment and air purification. Available at <http://www.lennetech.com/petrochemical.htm>

Conclusion

Toxic pollution caused by mining and industrial processes throughout the world poses an enormous health risk to affected populations. Pollutants from these processes, as well as from some naturally occurring sources, such as arsenic in groundwater, are responsible for a significant amount of deaths and diseases every year, particularly in low- and middle-income countries. This report has developed estimates of health impacts from ten of the most prevalent types and sources of toxic pollution, in countries where Blacksmith's data show significant occurrence of these sources.

The report shows that, where studies on the health effects of toxics exist and basic assessment data from contaminated sites is collected, it is possible to quantify the level and severity of disease caused by toxic pollution. Using Blacksmith's site-specific data, this report has calculated DALYs associated with health impacts caused by exposure to a pollutant at one representative site for each of the top ten issues. On average, the sites studied in this report were calculated to cause 12.7 years of life lost to death or disability per person affected by the site. These DALYs are large, and illustrate the enormous disease burden of death and disability associated with toxic pollution exposure.

It is important to note key qualifications related to the health impact estimates:

These estimates are based only on acute effects from exposure through the primary pathway, typically ingestion or inhalation. The human health impact from exposure to toxins at levels above health standards is relatively well studied; however, relatively less is known about disease and other health impacts due to lower exposures or the cumulative impact from exposure pathways.

As stated earlier in the report, it is difficult to estimate the exposed population around a toxic contamination site. The calculations are based on the best available demographic data that site assessors could collect from local and national government records, aerial photographs, and personal observation.



Waste from a dyeing facility in India

DALY calculations are based on limited sampling of soil, water, or human biological indicators (e.g., blood or breath tests.) More testing would provide improved estimates of exposure of the impacted population.

Blacksmith's database of contaminated sites is the most comprehensive such database now existing for most low- and middle-income countries. However, Blacksmith is aware that there are many more sites in almost all such countries that have not been assessed.

Because of the above limitations, it is not possible to develop specific estimates of DALYs for specific toxic pollutants for an entire country, no less the world. However, in order to show the likely magnitude of health impacts of toxic pollution and be able to compare this health burden to other health burdens, a range of exposed populations has been estimated for five countries for various specific pollutants, related to the top ten toxic pollution causes discussed in this report. To develop the range, Blacksmith used information in our database about the total number of sites identified in a country with a specific toxic pollutant and the number of exposed people at those sites to estimate a potentially exposed population for the entire country.

The table below presents the results of our country-wide specific pollutant exposure estimating process. The table then contrasts the exposed population associated with the pollutants discussed in the top ten issues to the at-risk or exposed populations for other various diseases in the same country, based on WHO data. These comparisons illustrate that toxic pollution potentially causes just as large (if not larger) of a disease burden as other well known and documented health problems in low- and middle-income countries.

In view of the estimated health risk and burden caused by toxic pollution exposure worldwide, there is a clear need to address these problems. Significant

Top Ten Toxic Pollution Problems

Pollutants and Countries where DALYs and Estimated Populations at Risk were Calculated	Number of Sites Identified by Blacksmith	Estimated Population at Risk at Identified Sites	Estimated Total National Population at Risk ^I	WHO Estimate of National Population at Risk from Listed Disease ^{II}	Disease
Arsenic Pollution					
Nepal	47	596,400	1,138,800	55,400 ^{III,IV}	Tuberculosis
Chromium Pollution					
India	116	2,772,100	5,544,200	1,586,144 ^{V,VI}	Malaria
Lead Pollution					
India	82	1,398,000	2,796,000	1,586,144	Malaria
Pakistan	16	388,100	776,200	471,100 ^{VII,VIII}	Tuberculosis
Philippines	37	1,361,600	2,723,200	295,900 ^{IX,X}	Tuberculosis
Mercury Pollution					
Chile	1	14,000 ^{XI}	28,000	3,800 ^{XII,XIII}	Tuberculosis
Pesticide Pollution^{XIV}					
India	20	292,300	584,600	1,586,144	Malaria
Pakistan	3	60,000	120,000	471,100	Tuberculosis

Populations estimates are preliminary and based on an ongoing global assessment of known polluted sites.

I. Blacksmith estimates that our site assessments have captured approximately 50% of existing sites in each country. The total national population at risk is an estimate of the actual number of people at risk at all existing sites in the country, including those not yet identified and assessed by Blacksmith.

II. Because the populations at risk from pollution exposure include both deaths and incidence of disease, these numbers also illustrate the at risk population for other diseases using death and incidence rate. All estimates are based on WHO data from 2008, 2009 and 2010. Because the incidence rates only account for cases of a disease measured in one particular year, these numbers do not reflect repeat cases of a disease or cases that have not gone into remission. For this reason, the number of people at risk from these health problems at any given time is likely significantly larger.

III. World Health Organization. "TB Country Profile: Nepal." Accessed on October 17, 2011.

Available at: http://www.who.int/gho/countries/npl/country_profiles/en/index.html.

IV. World Health Organization. "Global Health Observatory Data Repository: Mortality and Burden of Disease: Disease and industry country estimates 2008: By sex." April, 2011. Available at: <http://apps.who.int/ghodata/?vid=10011>.

V. World Health Organization. "Malaria Country Profile: India." 2010. Available at: http://www.who.int/gho/countries/ind/country_profiles/en/index.html.

VI. World Health Organization. "Global Health Observatory Data Repository: Mortality and Burden of Disease".

resources are dedicated (appropriately) to addressing the health burden presented by diseases with similar or even lower health risks to those presented by toxic sites. However, resources to address toxic contamination are, in many countries, very limited. Clearly, countries with toxic contamination have the primary responsibility for remediating the sites and addressing the health impacts. However, there is also a need for the international community to help fund clean up efforts, provide technical support, and help with on-the-ground training to educate people about the dangers of toxins. Such support would be similar to help provided for various diseases and is needed due to the limited financial and technical resources in many low- or middle-income countries.

Blacksmith continues to identify and assess sites contaminated by toxic pollution in order to better understand the global scope of this issue and reduce the significant human health risks it causes.

Addressing the health impacts of toxic pollution in low- and middle-income countries is not an impossible undertaking. Though the number is large, there are a discreet number of sites, and remediation can often be done for a moderate cost. Blacksmith Institute and Green Cross Switzerland have demonstrated successful clean up and education projects in severely contaminated areas



A man with a used battery case as a water tank in Indonesia

that are both cost-effective and replicable. There are well-documented and researched solutions for many of the pollution problems discussed in this report. Given proper funding and resources, many of these solutions and programs can be implemented worldwide. Addressing pollution is not only a question of ethics, but is also far more cost-effective than the long-term social and economic costs of pollution. It is our intention to continue identifying and addressing these problems throughout the world and to show the benefits of preventative measures in order to ensure adequate and equal health for the world's population.

VII. World Health Organization. "TB Country Profile: Pakistan." Accessed on October 17, 2011.

Available at: http://www.who.int/gho/countries/pak/country_profiles/en/index.html.

VIII. World Health Organization. "Global Health Observatory Data Repository: Mortality and Burden of Disease: Disease and industry country estimates 2008: By sex." April, 2011. Available at: <http://apps.who.int/ghodata/?vid=10011>.

IX. World Health Organization. "TB Country Profile: Philippines." Accessed on October 17, 2011.

Available at: http://www.who.int/gho/countries/phl/country_profiles/en/index.html.

X. World Health Organization. "Global Health Observatory Data Repository: Mortality and Burden of Disease: Disease and industry country estimates 2008: By sex." April, 2011. Available at: <http://apps.who.int/ghodata/?vid=10011>.

XI. The estimated at risk population from exposure to mercury in Chile from Blacksmith research alone is quite low. To date, Blacksmith has only

assessed one mine site in Chile where mercury is the key pollutant, and this presents a large underrepresentation of Chileans who are likely impacted. The mercury contamination from the Blacksmith site is caused by a large copper and gold mine—both of which are very prevalent throughout Chile. A

rough and conservative estimate of the number of actual gold and copper mines in Chile is approximately 100

(<http://www.ame.com.au/Countries/Cu/Chile.htm>, and <http://www.ame.com.au/Countries/Au/Chile.htm>).

XII. World Health Organization. "Tuberculosis Profile: Chile." October 17, 2011.

Available at: https://extranet.who.int/sree/Reports?op=Replet&name=/WHO_HQ_Reports/G2/PROD/EXT/TBCountryProfile&ISO2=cl&outtype=pdf.

XIII. World Health Organization. "Global Health Observatory Data Repository: Mortality and Burden of Disease: Disease and industry country estimates 2008: By sex." April, 2011. Available at: <http://apps.who.int/ghodata/?vid=10011>.

XIV. It is very difficult to estimate the actual population that is at risk from exposure to pesticides in these countries (and in almost every case), as large

percentages of each country are involved in agricultural processes. Over 50% of the labor force in India works in agriculture, for example (CIA World Factbook: India. Available at: <https://www.cia.gov/library/publications/the-world-factbook/geos/in.html>).

Thus, the estimated impacted population from Blacksmith's site assessments under represents the actual numbers of people at risk.

APPENDIX



Blacksmith Institute & Green Cross Switzerland's Efforts to Identify and Address Pollution Problems

Introduction

The World's Worst Toxic Pollution Problems 2011 Report identifies the ten pollution sources that have the greatest impact on human health according to Blacksmith Institute's ongoing global assessment of polluted sites. The Report benefits from three years of work identifying, assessing and cataloging polluted sites around the world. To date, Blacksmith, with support by Green Cross Switzerland and other partner organizations, has collected data on over 2,200 sites where toxic pollution exists in levels above internationally accepted health standards. Blacksmith and Green Cross Switzerland use this database to conduct research on pollution trends and to prioritize remediation projects.

Background

In most high-income countries, severely polluted sites have already been identified and remediated through programs such as the US Environmental Protection Agency (EPA) Superfund Program. However, in many low- and middle-income countries, pollution hotspots are poorly documented, and sometimes are completely unknown to local and national governments. This shortage of information, often complicated by a lack of awareness, impedes coordinated remediation efforts. For this reason, the Blacksmith Institute, in partnership with Green Cross Switzerland and other bilateral and multilateral organizations, is working to identify and assess severely polluted sites throughout low- and moderate-income countries to allow for comprehensive and cost-effective remediation programs.

Goals

Blacksmith is able to identify polluted sites in target countries due to its unique, on-the-ground assessment capabilities. Teams of local field investigators, trained in collaboration with Blacksmith's regional coordinators, visit sites to determine pollution levels, document human health problems and assess the need for remediation. Using a standardized approach, investigators identify a primary pollutant, take samples to measure the concentration of the pollutant, identify the source of the pollutant, document the pathway from the source to the population, record GPS coordinates, estimate the number of people impacted by the pollution, interview local stakeholders, and record many other fields of data.

How Sites are Assessed

Blacksmith partners with the United Nations Industrial Development Organization (UNIDO) to conduct its site assessments, with financial support and other inputs from Green Cross Switzerland and a variety of other partner organizations. Blacksmith's process of evaluating polluted sites began in 2009 and, with anticipated funding from various agencies, is expected to continue through the foreseeable future.

Each site assessment is normally conducted by one of Blacksmith's trained field investigators. The investigator visits the site; observes and records physical conditions, collects samples of the pollutant(s) for analysis (samples are collected in several different locations, and the investigator reports the highest sample level found in the assessment); obtains readily available information about the site history, activities, hydrogeology,

Top Ten Toxic Pollution Problems

To date, the organization has collected data on over 2,200 sites where toxic pollution exist in levels above internationally accepted health standards.

and nearby populations; and conducts interviews with members of the community and various stakeholders. New field investigators must participate in a three-day training session in the country where the site is located. Staff from Blacksmith, along with other technical experts, helps the investigator to become acquainted with standard sampling procedures, the methods used to record site assessment data, and other evaluation practices. The last day of the training session requires the investigator to conduct a site assessment under the supervision of Blacksmith staff. Once trained, the investigators perform site assessments with the support of Blacksmith's regional coordinators, who are specialists in their fields and typically hold an advanced degree in a relevant discipline.

The investigators use a uniform method of collecting site assessment data by recording evaluation findings in a standardized Initial Site Assessment (ISA) document. An ISA includes information on a wide range of factors and descriptions about a site. For example, it requires information about a site's pollution concentrations relative to international standards, GPS coordinates of the specific point source location, an estimation of the number of people who are at risk for health problems, a detailed description of the site, an explanation of the industry or process that is responsible for the contamination, and an analysis of the pathway to human exposure.

Once an ISA is completed, it is submitted to Blacksmith's headquarters in New York where it is reviewed for quality and completeness by a team of researchers and technical advisors. A member of Blacksmith's Technical Advisory Board completes a final review of each ISA and makes suggestions for

cleanup efforts for the site, including estimated costs of remediation.

The Importance of Assessing Pollution Problems

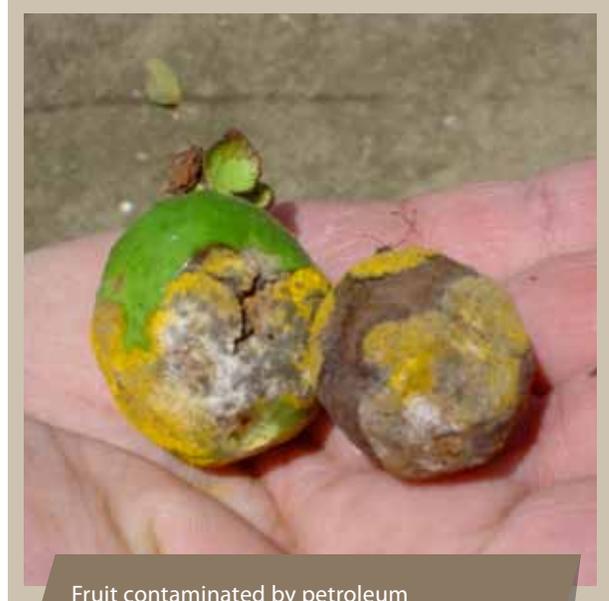
Most high-income countries have well-established environmental regulations intended to keep pollution at safe levels. Many of these countries have multiple federal laws to control pollution levels in air, water, and soil, apply the "polluter pays" principle, and some also have programs in place to identify and address legacy pollution problems caused by pre-regulation industrial processes. Low- and middle-income countries, however, often lack the infrastructure or regulation necessary to properly monitor, control, and address pollution problems that pose risks to human health.

This disparity in regulation and remediation resources (i.e. funds, but also experts available) between countries brings into focus the need for international action. However, targeted international efforts depend on comprehensive and systematic information on serious pollution problems and hotspots to prioritize efforts and define the best strategies to reduce health and environmental risks at these sites. The data that Blacksmith have collected on polluted sites throughout the world can be used as a tool to direct international efforts to those places where people are the most impacted by toxic pollution.

Blacksmith prioritizes pollution sites using an index model similar to the US Environmental Protection Agency's (EPA) Hazard Ranking System for Superfund Sites. Each site that is assessed receives an index score from 1 to 10, where 1 indicates a lower risk pollution problem and 10 a much higher



Children playing on mine waste contaminated with mercury



Fruit contaminated by petroleum pollution in Brazil

Low- and middle-income countries often lack the infrastructure or regulation necessary to properly monitor, control, and address pollution problems that pose risks to human health.

risk. Assessment sites receive a Blacksmith Index score based on several factors, including but not limited to: the likelihood of human exposure based on the pathway of the pollutant, the concentration levels of the pollutant in relation to international health standards, and an estimation of the number of people with the potential for exposure. This ranking system provides the necessary information for allocating resources and prioritizing remediation efforts to the worst polluted places and the populations with the most severe health risks.

The Scope of Blacksmith's Work

Blacksmith's site assessment work is restricted by the following criteria. Assessments only take place in low- to middle-income countries and in areas where there is a clear, point-source pollution problem that poses a definite risk to human health. Though the scope of Blacksmith's work excludes many documented and severe pollution and health problems – such as municipal waste and ambient air pollution – the assessment criteria are not meant to reduce the significance of these issues. The guidelines Blacksmith uses for its site assessment process allow the organization to direct attention towards issues that are causing severe health problems and that can be directly targeted and addressed.

Limitations Based on Geography

Blacksmith identifies low- and middle-income countries for site assessment based on World Bank gross national income projections, but some of these countries cannot be evaluated due to a lack of sites that fit the assessment criteria or because of operational obstacles such as government instability, government opposition to investigations by international NGOs, or violent conflicts. Since the evaluation process began in 2008, Blacksmith has conducted initial site investigations at over 2,000 sites in almost 100 low- to middle-income countries —numbers that will continue to grow.

Limitations Based on Pollution Source

Blacksmith's work is limited to sites with a clear, point source pollution problem. Point source pollution can be traced to one or a few specific and fixed locations, such as effluent from a factory or industrial estate. Pollution that cannot be traced back to a specific source, such as urban storm runoff contaminating drinking water, is not within the scope of Blacksmith's work. The assessment process focuses on point source pollution because these sites are more easily identifiable, can be directly evaluated, and can be targeted for effective remediation efforts.



Wastewater from a mix of product manufacturing facilities

Limitations Based on Pollutants

The scope of the site assessment process is limited to pollutants that the Blacksmith Technical Advisory Board has defined as “toxic.” A large portion of the sites that Blacksmith has evaluated suffer from contamination caused by heavy metals, radionuclides, dioxins, fluorides, asbestos, cyanide, poly-aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and persistent organic pollutants (POPs). Though this definition excludes many pollutants that are harmful to people and the environment, such as sewage and greenhouse gasses, this limitation is not meant to be interpreted as a value judgment between pollution categories. Rather, it is only a reflection of the information that exists in the Blacksmith inventory and of the work that Blacksmith has done up until this point.

Limitations Based on Health Impact

A very important criterion of the site assessment process is to determine the level of contamination relative to international standards. Samples of pollution from sites are evaluated in a laboratory and then compared to the maximum recommended levels for the pollutant outlined by the World Health Organization (WHO), the EPA, the European Commission, or another recognized source. Blacksmith’s work is limited to sites that have pollution concentrations that are above what is considered to be safe for humans.

Limitations Based on Risks to Human Health

Though Blacksmith’s evaluation of a site takes into account the impact of the pollutant(s) on the ecosystem and area wildlife, the most important concern, for the purposes of this report and Blacksmith and Green Cross Switzerland’s work, is the immediate human health risks caused by the contamination. In addition, while Blacksmith does not discount the fact that low levels of pollution (below maximum recommended exposure levels) and environmental destruction can pose health problems to a community, the evaluation process only targets areas that have the potential to cause severe and dangerous health problems for the local population.

The Blacksmith Index

The Blacksmith Index is the measure used to evaluate each site’s severity of contamination and health risks based on the information provided in the ISAs. Each site that is evaluated is given a score on a scale of 1 to 10, and the value that each site receives is used to help uniformly prioritize pollution problems across all of the ISAs. The index draws on the Source-Pathway-Response model of risk assessment, but Blacksmith calls its process the Pollution-Pathway-People model. The Index values are assigned by an algorithm that was created by



Old pesticide drums in a dump site

members of the Blacksmith TAB for the first report on the World's Worst Polluted Places in 2006. Since then, the index has been continually refined and updated.

Blacksmith Index Formula

BI = f [(Potential population at risk); (Severity of pollution); (Intensity of Exposure); (Allowance for severe and persistent toxins)]

Refinement of the Index

In 2010, Blacksmith undertook a reassessment of the index model in order to better reflect the large increase in the number of ISAs and to account for new information that had surfaced on some of the sites. The review of the formula involved a calibration process wherein a sample of sites was given an independent risk assessment by the TAB. These risk values were then compared to the values assigned by the Index, and the formulation was continuously adjusted until the rankings of the Index and the TAB were properly aligned. The new formula for the index uses the sum of the log of the population and the log of the pollutant severity, while the remaining two factors are unchanged. The new formula for the index allows for consistent rankings across all of the ISAs.

Application

A Blacksmith Index score is assigned to every site that is evaluated using the information submitted in

the standardized ISA form. To ensure consistency, an in-house researcher also reviews each site to confirm that the Index value properly reflects the information provided in the report. It is important to point out, however, that the Index measure is relative and not absolute. The purpose of the Index values is to help Blacksmith efficiently prioritize its cleanup and evaluation programs, and the scores are not meant to be interpreted as value judgments of the relative health problems of each individual site. A Blacksmith Index score is only assigned to sites that contain all the necessary information and that have been reviewed and approved by an in-house expert. Many of the sites in the database are still in the assessment process, and may be missing information or waiting for credible pollution samples. The number of approved sites in the database that have received a Blacksmith Index score is approximately 1,100 as of autumn 2011.

Conclusion

Blacksmith's assessment process is a groundbreaking effort to identify, evaluate, and document severe pollution problems around the world, developed with the support of like-minded partner organizations. The research from these evaluations will provide a much-needed resource to increase global awareness and comprehension of the severe health risks posed by toxic pollution. The refined Index model will also allow for a systematized way to assign priority to different sites and will allow international efforts to focus on the biggest global health problems caused by pollution.

About Blacksmith Institute

www.blacksmithinstitute.org

Blacksmith Institute (www.blacksmithinstitute.org) is an international not-for-profit organization dedicated to solving life-threatening pollution issues in the developing world. A global leader in this field, Blacksmith addresses a critical need to identify and clean up the world's worst polluted places. Blacksmith focuses on places where human health, especially that of women and children, is most at risk. Based in New York, Blacksmith works cooperatively in partnerships that include governments, the international community, NGOs and local agencies to design and implement innovative, low-cost solutions to save lives. Since 1999, Blacksmith has completed over 50 projects; Blacksmith is currently engaged in over 40 projects in 19 countries.

Since 2006, Blacksmith Institute's yearly reports have been instrumental in increasing public understanding of the health impacts posed by the world's worst polluted places, and in some cases, have compelled cleanup work at these sites. Previous reports have identified the top ten world's worst polluted places or pollution problems. Blacksmith reports have been issued jointly with Green Cross Switzerland since 2007. Read the reports at www.worstpolluted.org

About Green Cross Switzerland

Green Cross Switzerland facilitates overcoming consequential damages caused by industrial and military disasters and the clean-up of contaminated sites from the period of the Cold War. Central issues are the improvement of the living quality of people affected by chemical, radioactive and other types of contamination, as well as the promotion of a sustainable development in the spirit of co-operation instead of confrontation. This includes the involvement of all stakeholder groups affected by a problem.

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