THE WORLD'S WORST POLLUTION PROBLEMS:

THE TOP TEN OF THE TOXIC TWENTY

THE TOP TEN

(unranked and alphabetical)

1 Artisanal Gold Mining
2 Contaminated Surface Water
3 Groundwater Contamination
4 Indoor Air Pollution
5 Metals Smelting and Processing
6 Industrial Mining Activities
7 Radioactive Waste and Uranium Mining
8 Untreated Sewage
9 Urban Air Quality
10 Used Lead Acid Battery Recycling

BLACKSMITH INSTITUTE

GREEN CROSS

This document was prepared by the staff of Blacksmith Institute in partnership with Green Cross Switzerland with input and review from a number of experts and volunteers, to whom we are most grateful.

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This report is available online at www.worstpolluted.org

Table of Contents

INTRODUCTION TO THE TOP TEN OF THE TOXIC TWENTY

THE TOP TEN.
In 2006 and 2007, Blacksmith Institute and Green Cross Switzerland produced the first lists of the "World's Worst Polluted Places." Widely published and distributed, these lists included an unranked "Top Ten," as well as a more inclusive "Dirty Thirty" index of polluted places around the world, detailing the sources and effects of pollution at each.

They were compiled based on a variety of criteria. Foremost among these was the impact of pollution on human health.

Although the lists catalyzed widespread interest in the significant threat that environmental pollution poses to human health in the developing world, those sites named were only some of the more egregious examples of widespread problems.

To provide context and scale of these problems, Blacksmith Institute and Green Cross Switzerland have updated their work in this new report - "World's Worst Pollution Problems." Rather than focusing on just a few locations, this report gives an overview of the range of pollution threats humans face throughout the world.

With this report we hope to bring the attention of the international community to the enormous health risk posed by pollution every year in the developing world and to ways in which it might be tackled.

PROBLEMS ARE MORE THAN JUST A FEW SITES.
This year's Report sets out a range of pollution problems and for each gives a brief summary of the problem's source and scope. The list of problems is drawn primarily from the Blacksmith Institute database of polluted places, as well as from suggestions by relevant experts.

Blacksmith Institute's database contains about 600 sites nominated by individuals or groups, or identified by Blacksmith and other organizations in the field. These range from whole cities that are choking on air pollution, to complete rivers that are black and stinking, to small facilities that pose a toxic threat to a neighborhood, to villages whose water supply has turned orange and noxious. The emphasis in the database is – in line with Blacksmith Institute's mission - on legacy sites or clusters of polluters where there is no clear responsible party.

This year's report provides five lists drawn from a larger "Toxic Twenty" set of pollution challenges; problems that are repeatedly found both in health and pollution literature, and in Blacksmith Institute and Green Cross project work.

The "**Top Ten World's Worst Pollution Problems**" is a non-ranked set of global issues, which – in the overall judgment of a panel of expert advisors – represent ongoing activities and conditions that pose the greatest threat to human health. This judgment requires a balance between problems with widespread but moderate contamination levels, and problems that are smaller but much more toxic. There can always be debate about such judgments, but there is no denying that each of the Top Ten Worst Pollution Problems represents a worldwide threat to human health and development.

Each Pollution Problem has its own particular characteristics that separate it in some way from the others. Some of the problems, like heavy metals and persistent organic pollutants (POPs), remain for generations and continue to have a residual impact long after use. Others, like contaminated surface water, have a particularly damaging impact on the health of children. For this reason we have also created these subsidiary lists.

- The Top Four Least Addressed Pollution Problems;
- The Top Eight Pollution Problems Affecting Children;
- The Top Seven Pollution Problems in Africa; and
- The Top Four Pollution Problems Affecting Future Generations.

RANKING.

This year's ranking criteria is based on the system used in previous years to determine the Worlds Worst Polluted Places. It has been adjusted appropriately to account for the new direction of the report.

There are three primary factors taken into consideration when ranking the Top Ten and Toxic Twenty: Pollutant, Pathway and Population.

We first determine the severity or toxicity of the Pollutant. More innocuous contaminants receive a lower ranking, while more dangerous substances, say mercury or lead, garner a higher ranking.

Secondly, we evaluate the Pathway, or how the pollutant is transferred to the population. People absorb contaminants through direct inhalation, by drinking contaminated water, by inhaling airborne dust, by bathing in contaminated water, by eating contaminated foodstuffs, or through direct skin contact. The more direct, the less diluted and therefore more dangerous the pathway, the higher the ranking the problem receives.

Finally, we evaluate the Population. Here, population refers to the overall number affected by the pollutant globally. Those problems affecting the most people are ranked highest in this category.

Given the uncertainties in such assessments, the problems within the Top Ten list are NOT RANKED against each other and therefore are presented in alphabetical order.

POLLUTION IS A MAJOR FACTOR IN DISEASE.

Industrial wastes, air emissions, and legacy pollution affect over a billion people around the world, with millions poisoned and killed each year. People affected by pollution problems are much more likely to get sick from other diseases. Other people have reduced neurological development, damaged immune systems, and long-term health problems. Women and children are especially at risk. The World Heath Organization estimates that 25 percent of all deaths in the developing world are directly attributable to environmental factors.

A study, published in 2007 by a Cornell research group found even more alarming results. The team surveyed 120 relevant articles, covering population growth, pollution and disease and found that an astonishing 40 percent of deaths worldwide were caused by water, air and soil pollution[1].

CHILDREN ARE ESPECIALLY AFFECTED.

More than other leading causes of death, those tied to environmental factors have a disproportionate effect on children. Of the 2.2 million people killed by diarrhea in 1998, most were less than five years of age, and nearly two million were under 19[2]. Up to 90% of diarrheal infections are caused by environmental factors like contaminated water and inadequate sanitation. Similarly, acute respiratory infections, 60% of which can be linked to environmental factors, kill an estimated two million children under five every year[3].

Children are simply more susceptible to environmental risks than adults. Children are not just "small adults," but rather are physiologically different and more vulnerable than adults. By way of illustration, while children only make up 10% of the world's population, over 40% of the global burden of disease falls on them. Indeed, more than three million children under age five die annually from environmental factors[4]

THE DEATH TOLL IS NOT THE ONLY IMPACT OF POLLUTION.

The threat posed by pollution is not fully captured by its death toll. Pollution makes the lives of millions markedly more difficult. This happens through constant illness, neurological damage and shortened lifespan.

For instance, the presence of lead in children lowers I.Q. by an estimated 4-7 points for each increase of 10 μg/dL[5]. While the acuteness of the pollution varies from site to site, our database identifies populations around the globe with blood lead levels ranging from 50 -100 μg/dL, up to 10 times recommended levels.

WHAT IS BEING DONE.

Large steps have been taken by the global community to combat some of the worst threats to human health, such as Malaria and HIV/AIDS. These campaigns are impressive and important, and are producing real

1 Pimentel, D. et al. "Ecology of Increasing Diseases: Population Growth and Environmental Degradation." Human Ecology. 35.6 (2007): 653-668. http://www.news.cornell.edu/stories/Aug07/moreDiseases.sl.html
2 "Water-related Disease." Water Sanitation and Health. World Health Organization. Last Accessed September 30, 2008. Available at http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/
3 "Children's environmental health." Programmes and Projects. World Health Organization. Last Accessed September 30, 2008. Available at http://www.who.int/ceh/en/
4 ibid
5 "Lead Toxicity: What are the Physiologic Effects of Lead Exposure?" Case Studies in Environmental Medicine. Last Updated August 20, 2007. Available at http://www.atsdr.cdc.gov/csem/lead/pbphysiologic_effects2.html

results. Moreover, they are testament of the ability of wealthier nations to work together to relieve some of the worst suffering in poor countries.

While much attention has been paid to these pandemics, the relationship between human health and pollution seems to have been largely ignored. Indeed only a fraction of international aid is allocated to remediation of critical sites, despite the significant threat posed by pollution, and the proven efficacy of interventions. In other words, there is a great need to address critical environmental health threats that have had no attention in the global dialogue on poverty reduction.

COST EFFECTIVENESS OF DEALING WITH POLLUTION.

Relative to other public health interventions, pollution remediation can be very cost effective. Typically, in discussing these issues, effectiveness of interventions is measured using Disability Adjusted Life Years (DALY) or Quality Adjusted Life Years (QALY). These represent calculations of the years of "healthy life" lost due to the impacts of a particular disease or cause, in a specified area.

Given the DALY or QALY impact, and the total cost of a project, one can fairly accurately assess the cost effectiveness of a public health intervention.

In 2007, Blacksmith Institute used this methodology to compare some of its projects with other public health interventions. Among other findings, Blacksmith determined that its projects cost between $1 - $50 per year of life gained. This compared favorably to the $35 to $200 per year of life gained for World Bank estimates on interventions related to water supply, improved cooking stoves and malaria controls.

SCOPE OF THE REPORT.

This report presents a synopsis of twenty-one major pollution problems. In reality, there is considerable overlap, as illustrated in Table 1 below.

Some of the pollution problems faced by communities can be associated directly with specific pollutants - for example lead or mercury. In other cases, such as industrial estates, dealing with the problem must focus on the broader process or source because there is a variable cocktail of pollutants. In such cases, it is often difficult to disentangle the effects of the various contaminants, which may in fact work with each other to increase their impact on human health, exacerbating local health problems.

Additionally, accurate data about populations affected, amounts and types of pollution, or even about specific local health impacts are often lacking. Instead, the best estimates of experts are often the most credible source of information, and we have relied heavily in our assessment on our team of technical experts as we rank and grade these problems.

The presentation, therefore, by both pollutant and source is less than logically complete or final, as it reflects the messy reality of dealing with pollution problems worldwide.

ABOUT BLACKSMITH INSTITUTE. Blacksmith Institute designs and implements solutions for pollution related problems in the developing world. Since 1999, Blacksmith has been addressing the critical need to clean up dangerous and largely unknown polluted sites where human health is most affected by pollution. Blacksmith has completed over 50 projects and is currently engaged in over 40 projects in 16 countries.

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 sustainable development in the spirit of co-operation instead of confrontation. This includes the involvement of all stakeholder groups affected by a problem.

UNDERSTANDING POLLUTANTS AND SOURCES

	Agrotoxins	Arsenic	Cadmium	Chromium	Lead	Mercury	Particulates (airborne)	Pathogens	PCBs	Organic Chemicals	Radioactivity
Abandoned Mines		May be serious problem, depending on the ores that were mined	May be present as by-product of past mining	May be serious problem, depending on the ores that were mined	May be present as by-product of past mining	Mercury is used in processing of ore -may be dumped or abandoned on sites					Can occur depending on type of mine
Artisanal Mining						Many miners use mercury to recover gold					Can occur depending on type of mine
Coal Power Plants						Some plants emit mercury if the metal is in high concentrations in the coal used	Coal fired power plants can be major emitters of particulates				Fly ash from coal plants can contain large quantities of longlasting radioactivity
Garbage Dumps		Metals can occur in leachate	Metals can occur in leachate	Metals can occur in leachate	Metals can occur in leachate	Metals can occur in leachate	Dust and smoke are key problems with dumps	Medical and human waste in dumps provides sources of many pathogens		Industrial and hazardous materials can include many toxic chemicals	
Groundwater Contamination*	May occur in various concentrations	May occur in various concentrations	May occur in various concentrations	May occur in various concentrations				Some pathogens, depending on distance from pollution source	May occur in various concentrations		Possible
Indoor Air Pollution							Particulates are the major problem				Possible with radon
Industrial Estates		May occur in various concentrations	May occur in various concentrations	May occur in various concentrations		May occur in various concentrations	May occur in various concentrations		May occur in various concentrations	May occur in various concentrations	
Metals Smelting and Processing		Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores			Particulates from process can be a key issue			Some organics may be used in the processes	possible

*these are media rather than sources but they are the pathways for varied pollutants to impact people.

UNDERSTANDING POLLUTANTS AND SOURCES

	Agrotoxins	Arsenic	Cadmium	Chromium	Lead	Mercury	Particulates (airborne)	Pathogens	PCBs	Organic Chemicals	Radioactivity
Industrial Mning Activities		Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores	Likely to be significant, depending on specifics of ores	Dust can be an signifcant issue				Can occur depending on type of mine
Oil Refineries and Petrochemical Plants							Some volatile organics occur near industrial sources			Typical problem areas	
Old and Abandoned Chemical Weapons		Many early weapons are heavily based on arsenic								A wide range of highly toxic chemicals and their by-products are involved.	
Radioactive Waste and Uranium Mining							Particulates can be an significant pathway				Key problem
Surface Water Contamination*	Often get into surface water supplies. Long term effects are an area of concern.	Naturally occuring arsenic is a big problem in some groundwater systems		Can be a groundwater contaminant				Contaminaed drinking water is one of the major causes of infant diseases, in particular		Surface water used for drinking supply can contain significant levels of organics	
Untreated Sewage								Bacteria and viruses from human waste are a major problem		May contain high levels of organics if industrial wastes have been discharged to sewer	
Urban Air Quality					Problems with lead from gasoline now much reduced		Major issue			Some volatile organics occur near industrial sources	
Used Lead Acid Battery Recycling					Informal recycling is probably the major cause of lead poisoning in some urban areas						

*these are media rather than sources but they are the pathways for varied pollutants to impact people.

THE TOP TEN. (unranked and alphabetical)

There are three primary factors taken into consideration when ranking the Toxic Twenty and Top Ten: Pollutant, Pathway and Population. We first determine the severity of the pollutant. More innocuous contaminants receive a lower ranking, while those more dangerous substances, say mercury or lead, receive a higher ranking.

Secondly, we evaluate the Pathway, or how the Pollutant is transferred to the Population. People absorb contaminants through direct inhalation, by drinking contaminated water, by inhaling airborne dust, by bathing in contaminated water, by eating contaminated foodstuffs, or through direct skin contact. The more direct, less diluted and therefore more dangerous the pathway, the higher the ranking the problem receives.

Finally, we evaluate the Population. Here Population refers to the overall number affected by the Pollutant globally. Those affecting the most people are ranked highest in this category.

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THE REST OF THE TOXIC TWENTY

Abandoned Mines
Agrotoxins and POPs
Arsenic
Cadmium
Chromium
Coal Power Plants
Garbage Dumps
Industrial Estates
PCBs
Old and Abandoned Chemical Weapons
Oil Refineries and Petrochemical Plants

THE FOUR LEAST ADDRESSED POLLUTION PROBLEMS

The Top Four Least Addressed Pollution Problems provides an unranked summary of those least likely to be on public health policy radar. These might equally be called most "Unknown" or "Partially Ignored." Artisanal Gold Mining is included here, as is Used Lead Acid Battery Recycling. Both of these have far reaching effects – wherever there are cars, there are car batteries – yet there exist few international agencies and limited resources for dealing with them.

ARTISANAL GOLD MINING
CHROMIUM
OLD AND ABANDONED CHEMICAL WEAPONS
USED LEAD ACID BATTERY RECYCLING

THE TOP EIGHT POLLUTION PROBLEMS MOST AFFECTING CHILDREN

The Top Eight Pollution Problems Most Affecting Children importantly draws attention to those toxics that affect the most innocent. Children are simply more susceptible to environmental risks than adults. They are not just "small adults," but rather are physiologically different and more vulnerable than us. By way of illustration, while children only make up 10% of the world's population, over 40% of the global burden of disease falls on them. Indeed, more than three million children under age five die annually from environmental factors.

CONTAMINATED SURFACE WATER
GROUNDWATER CONTAMINATION
INDOOR AIR POLLUTION
METALS SMELTING AND PROCESSING
INDUSTRIAL MINING ACTIVITIES
UNTREATED SEWAGE
URBAN AIR QUALITY
USED LEAD ACID BATTERY RECYCLING

THE SEVEN WORST POLLUTION PROBLEMS IN AFRICA

Some of the Worst Pollution Problems are in many ways products of poverty. High levels of urbanization, lack of infrastructure and formal sector employment, and overstretched governments, present very dangerous conditions for human health. Nowhere is this better illustrated than Africa, which bears a disproportionate amount of the global burden of disease. The Seven Worst Pollution Problems in Africa highlights some of the problems making the economic development of the world's poorest continent that much more challenging.

ARTISANAL GOLD MINING
CONTAMINATED SURFACE WATER
INDOOR AIR POLLUTION
UNTREATED SEWAGE
ABANDONED MINES
OIL REFINERIES AND PETROOCHEMICAL PLANTS
RADIOACTIVE WASTE AND URANIUM MINING

THE FOUR POLLUTION PROBLEMS MOST AFFECTING FUTURE GENERATIONS

Some pollutants are particularly persistent, and more likely than others to affect future generations. While others will at the very least decrease in their severity over time, those in this category will not simply go away, and may in many cases, actually get worse. This can happen through "bioaccumulation" the process whereby pollutants increase in concentration and toxicity as they move up the food chain.

GROUNDWATER CONTAMINATION
OLD AND ABANDONED CHEMICAL WEAPONS
PCBs
RADIOACTIVE WASTE AND URANIUM MINING

THE TOP TEN

ARTISANAL GOLD MINING

Description

Artisanal and small-scale mining refers to mining activities that use rudimentary methods to extract and process minerals and metals on a small scale. Artisanal miners also frequently use toxic materials in their attempts to recover metals and gems. Such miners work in difficult and often very hazardous conditions and, in the absence of knowledge or any regulations or standards, toxic materials can be released into the environment, posing large health risks to the miners, their families and surrounding communities[1]. In this context, gold mining operations are particularly dangerous, as they often use the mercury amalgamation process to extract gold from ores.

Artisanal gold mining is one of the most significant sources of mercury release into the environment in the developing world, with at least a quarter of the world's total gold supply coming from such sources[2]. Artisanal gold miners combine mercury with gold-carrying silt to form a hardened amalgam that has picked up most of the gold metal from the silt. The amalgam is later heated with blow torches or over an open flame to evaporate the mercury, leaving small gold pieces. The gaseous mercury is inhaled by the miners and often by their immediate family, including their children. Mercury that is not inhaled during the burning process, settles into the surrounding environment or circulates globally for future deposition far from the site, where it is absorbed and processed by a variety of living organisms. This transforms elemental mercury into methylmercury. Methylmercury is one of the most dangerous neurotoxins that contaminate the food chain through bioaccumulation.

Context

Most artisanal gold miners are from socially and economically marginalized communities, and turn to mining in order to escape extreme poverty, unemployment and landlessness[3]. The dangers force miners to not only risk persecution by the government, but also mine shaft collapses, and toxic poisoning from the variety of chemicals unsafely used in processing. Despite the many dangers of this activity, artisanal mining operations continue to spread as the demand for metals increases and other livelihoods such as farming, are no longer economically viable.

UNIDO estimates that mercury amalgamation from this kind of gold mining results in the release of an estimated 1000 tons of mercury per year, which

1 Hilson, Gavin; Hilson, Christopher J.; and Pardie, Sandra. "Improving awareness of mercury pollution in small-scale gold mining communities: Challenges and ways forward in rural Ghana." November 13, 2006.

2 Veiga, M.M., et al. (2005). Pilot Project for the Reduction of Mercury Contamination Resulting From Artisanal Gold Mining Fields in the Manica District of Mozambique

3 Tschakert, Petra and Singha, Kamini. "Research on Smal-Scale Gold Mining in Ghana." Pennsylvania State University: Department of Geography. October 11, 2006. Available at http://www.geog.psu.edu/news/petra_ghana.html

constitutes about 30% of the world's anthropogenic mercury emissions. It is estimated that between 10 and 15 million artisanal and small scale gold miners worldwide, including 4.5 million women and 600,000 children[4]. According to UNIDO, as much as 95 percent of all mercury used in artisanal gold mining is released into the environment, constituting a danger on all fronts – economic, environmental and human health[5].

Exposure Pathways

Artisanal gold mining releases mercury into the environment in its metallic form during amalgamation and as mercury vapor during the burning process.

When metallic mercury is used to concentrate the gold, small amounts can be washed out along with the unwanted tailings or sediments. One study estimates that one or two grams of metallic mercury is lost for every gram of gold produced using the amalgamation process[6]. Once mercury is released into waterways, it enters the food chain through the digestion of bacteria and becomes the far more toxic – methylmercury. Methylmercury bioaccumulates in the food chain and is ingested by residents of downstream communities as they eat contaminated fish.

The most direct pathway however, is the inhalation of mercury vapors created during the burning process. An immediate toxic exposure, miners and their families are most affected by these noxious vapors. A study of artisanal gold mining in Peru concluded that for every gram of gold that is produced, at least two grams of mercury are emitted into the atmosphere[7].

Health Effects

Children that are exposed to mercury are particularly at risk for developmental problems. Exposure to mercury can cause kidney problems, arthritis, memory loss, miscarriages, psychotic reactions, respiratory failure, neurological damage and even death.

Some sites which have been noted as examples of the problem

I Trust My Legs Mine site, Ghana

Prey Meas Goldmines, Cambodia
Tambacounda Region, Senegal
Manica, Mozambique

What is Being Done

The Blacksmith Institute has initiated a series of appropriate technology demonstrations to limit mercury emissions associated with small-scale mining, involving the use of retort technology to reduce mercury vapors and enable recapture of mercury from the amalgam for reuse. These programs are carried out in conjunction with UNIDO's Global Mercury Project. Such programs can be very effective at the community level, although they are labor intensive to implement and challenging to replicate.

Mercury amalgamation results in 30% of the world's anthropogenic mercury releases, affecting up to 15 million miners, including 4.5 million women and 600,000 children

LIVING WITH MERCURY. LA RINCONADA, PERU

According to the BBC, in La Rinconada, Peru, between 2 and 3 tons of gold are produced each year through artisanal methods, releasing 4 to 6 tons of mercury into the air. This mercury settles on the roofs of homes and other structures. As there's no drinking water system in Rinconada, it is common practice for residents to collect melting snow from their roofs and use it for their personal consumption. In this way, mercury is ingested directly by the miners and their families[1].

1 http://news.bbc.co.uk/nolpda/ukfs_news/hi/newsid_4032000/4032911.stm

4 Veiga, M.M., Baker, R. (2004). Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small Scale Miners, Report to the Global Mercury Project: Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies

5 Veiga, M.M., et al. (2005). Pilot Project for the Reduction of Mercury Contamination Resulting From Artisanal Gold Mining Fields in the Manica District of Mozambique

6 Timmins, Kerry J. "Artisanal Gold Mining without Mercury Pollution." United Nations Industrial Development Organization. UNIDO. January 31, 2003. Available at http://www.natural-resources.org/minerals/cd/docs/unido/asm_mercury.pdf

7 "Slum at the Summit." Earth Report. Television Trust for the Environment. Accessed on September 15, 2008. Available at http://www.tve.org/earthreport/archive/doc.cfm?aid=1623

CONTAMINATED SURFACE WATER

Description
Every human needs about 20 liters of freshwater a day for basic survival (drinking and cooking) and an additional 50 to 150 liters for basic household use.[1] With growing populations and an overall increase in living standards, not only is the overall demand for freshwater pushing limits (one third of world now lives in areas of "water stress"[2]) but increasing pollution from urban, industrial and agricultural sources is making available resources either unusable or – if there is no alternative – dangerous to health. Almost 5 million deaths in the developing world annually are due to water related diseases, much of this being preventable with adequate supplies of safe water[3].

Context
Rural communities around the world traditionally take their water supply from rivers or from shallow dug wells. Growing concentrations of people combined with the increasing industrialization of land use have resulted in many major rivers becoming highly polluted. Sometimes the pollution levels even cause the rivers to become biologically dead and poisonous to drink. In areas where surface water is not readily available, groundwater is the primary water source and serves an estimated 20% of the global population who live in arid and semi-arid regions.[4] Underground aquifers are slower to show problems but now are increasingly affected by contamination that is extremely difficult to undo.

Treatment of contaminated drinking water is possible at an urban or a community scale, but it requires financial and human resources not often available. Even when provided, the quality after treatment is often still uncertain and remaining subtle pollutants in trace quantities can still pose health risks (such as the infamous "gender benders" which are believed to upset human hormone balance).

The efforts to reduce or prevent pollution of critical waters are numerous, but the scale of the challenges is enormous. River basins containing tens of millions of residents are almost unmanageable, given the weak capability and tools that are normally available and the low priority that is usually given to reducing pollution. This attitude is changing as the human and economic costs are recognized, but the timescale for major improvements is probably decades, at least in the larger systems.

1 Gleick, Peter H. "Basic Water Requirements for Human Activities: Meeting Basic Needs." Pacific Institute for Studies in Development, Environment, and Security. International Water Resources Association. Water International, 21 (1996) 83-92.
2 Kirby, Alex. "Water scarity: A looming crisis?" BBC. October 19, 2004. Available at http://news.bbc.co.uk/2/hi/science/nature/3747724.stm
3 Prüss-Üstün, Annette; Bos, Robert; Gore, Fiona; Bartram, Jamie. "Safer Water, Better Health: Costs, benefits and sustainability of interventions to protect and promote health." World Health Organization. 2008.

4 "Vital Water Graphics: Problems related to freshwater resources." United Nations Environment Programme. 2002. Available at http://www.unep.org/dewa/assessments/ecosystems/water/vitalwater/20.htm

Exposure Pathways

Key pollutants in the water systems are typically pathogens arising from human waste (bacteria and viruses), heavy metals and organic chemicals from industrial waste. Ingestion of pathogens through drinking contaminated water or with food prepared using contaminated water is the most common pathway. Eating fish from contaminated waters can be risky, since they can absorb and concentrate both pathogens and toxics such as heavy metals and persistent organics.

In addition, human health may be affected by crops that take up pollutants from contaminated water used for irrigation or from land flooded by polluted rivers.

Health Effects

Pathogens can cause a variety of gastro-intestinal diseases, which can be fatal to babies and to other vulnerable populations. WHO data shows water pollution is one of the greatest causes of mortality that can be linked to environmental factors. Boiling water can destroy most pathogens, however this requires fuel, a commodity often in short supply in poor households. (Some of these diseases may be related to poor hygiene rather than direct ingestion of contaminated water but this in turn is often a result of the lack of adequate amounts of clean water.)

Toxic contaminants in fish or other foods are less likely to cause acute poisoning but can have serious long-term effects, depending on the pollutants and the doses. Understandably, fishing communities along rivers are particularly at risk since they have a steady diet of the local fish over many years.

Some of the sites which have been noted as examples of the problem

Water quality problems are affecting virtually all of the developing world's major rivers. Northern India suffers immense flooding in its river systems but in the dry season, pollution problems dominate, especially in the upper reaches, including around New Delhi. In China, industrialization has created serious problems in rivers such as the Huai, where large sections of the river are acknowledged to be in the lowest possible water quality classification. Similar problems exist in many other urbanized waterways.

Even where the main stem of a river remains acceptable, serious problems are often seen in the smaller branches – usually local streams which have become urban drains (and dumps or "rubbish tips"). Unfortunately, these urban drains are also the main source of water for drinking and daily use for poor communities along their banks.

This problem will only worsen as competition for limited or degraded resources intensifies. Over the next few decades, up to two-thirds of the world's population will be affected by water scarcity.[5]

What is Being Done

India has a Ganga Action Plan, launched in the 1980's to reduce the pollution of the river Ganges, but measurable progress has been slow, despite the expenditure of hundreds of millions of rupees. In China, investment of billions of dollars over twenty years (along with closure or relocation of many industries) has produced a significant improvement in the Huangpu River in the centre of Shanghai, but increasing upstream loads from urbanization and industry are causing measurable deterioration even in the mighty Yangtze. These programs reflect the decades of effort and investment that are needed. The experience of the west on rivers such as the Rhine and the Thames has demonstrated that rehabilitation is eventually possible.

Better off communities can afford water treatment systems and wealthier people can take avoidance measures such as tankered or bottled water from safe sources, but the poor have limited options and need to look towards provisions of public water supplies. Unfortunately, many developing nations face their own public water challenges.

Where the problem is localized or can be linked clearly to a few specific sources or pollutants, smaller scale interventions can be effective, in terms both of achieving some improvement to water quality and also of starting a longer term process. However, large amounts of time and resources are typically needed.

5 Rijsberman, Frank R. "Water scarcity: Fact or fiction?" Agricultural Water Management. 80.1-3, (2006) 5-22.

INDOOR AIR POLLUTION

Description
Indoor Air Pollution (IAP) describes the adverse ambient air conditions inside households, schools, places of work and other indoor spaces. This can be caused by a range of sources, including stoves, smoking and machinery. Most IAP occurs in the developing world.

Context
The most significant cause of indoor air pollution in the developing world is the burning of coal or unprocessed biomass fuels for cooking, heating and light. More than 50% of the world's population gets their energy for cooking in this way. Almost all of these people live in poor countries.

Biomass fuels include wood, animal dung and crop residues. While high income nations have long since converted to petroleum products or electricity for cooking, most people in the developing world still rely heavily on this most basic form of energy production. In China, India and Sub Saharan Africa, it is estimated that more than 80% of urban households get their energy for cooking in this manner,[1] and more than 90% in rural areas.[2]

Biomass fuels are typically burned in rudimentary stoves. Importantly, few of these fully combust the fuel, therefore resulting in inefficient use of precious fuel and unnecessarily large air emissions.[3]

The high amount of emitted particulate coupled with usually poor ventilation produces indoor concentrations of toxic fumes which are a very real health risk to families. Those most affected are women, who do most of the cooking, as well as infants, who are often times strapped to the backs of their mothers.

Exposure Pathways
Indoor Air Pollution mostly affects health through inhalation, but can also affect the eyes through contact with smoke.

IAP happens largely in the household where cooking, sleeping, eating and other activities take place. Women and children are therefore most at risk.
The burning of biomass fuels adds to particulate. Particles with diameters of less than 10 microns (PM10) and particularly those less than 2.5 microns in diameter (PM2.5) are small enough to penetrate deeply into the lungs,.[4]

1 Smith, K.R. "Indoor air pollution in developing countries: recommendations for research." Indoor Air 2002: 12: 198-207.
2 Bruce, Nigel; Neufeld, Lynnette; Boy, Erick and West, Chris. "Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala" International Journal of Epidemiology. 1998: 27: 454-458

3 ibid
4 ibid

The US EPA recommends exposure standards based on a 24 hour average. In this time frame, it is recommended that average concentrations of PM10 should not exceed 150 ug/m3. In homes that cook with biomass fuels, concentrations are typically in the range of 300 to 3000 ug/m3, or up to 20 times higher than recommended levels. At times of cooking this number can reach as high 30,000 ug/m3 or 200 times the recommended level.

Health Risks
Indoor Air Pollution contributes to nearly 3 million deaths annually, and constitutes 4% of the global burden of disease.[5]

The largest health effects include:

•Acute Respiratory Infections (ARI). ARI accounts for 1/8 of the total disease burden in India, making it the largest single disease category[6]

•Chronic Obstructive Pulmonary Disease (COPD) COPD includes bronchitis, and accounts for 16% of female deaths in China.[7]

•Lung Cancer. Some two-thirds of women in China, India, and Mexico are non-smokers[8]

•Cataracts. Studies have found that women that use biomass fuels for cooking are as much as 2.4 times more likely to suffer from cataracts caused blindness.[9]

•Tuberculosis. Studies have found an adjusted risk of 2.7 for women that cook with wood in India.[10]

•Adverse Pregnancy Outcomes. In rural Guatemala babies born to women that cook with wood fuels were 63 g lighter than those born to women using gas and electric.[11]

Some sites which have been noted as examples of the problem
Because Indoor Air Pollution is so widespread, Blacksmith receives few nominations for specific sites. Biomass fuel use strongly correlates with per capita income, as this is what inhibit or encourages the transition to cleaner fuels and stoves. Therefore the area most worth highlighting here is Sub Saharan Africa, where per capita incomes remain lowest.

What is Being Done
Hundreds of campaigns have been implemented around the world to end the threat posed by IAP. Most of these have focused on the introduction of more fuel efficient stoves. However, these efforts need to be complemented by more comprehensive approaches to include improved ventilation, lifestyle changes, and host of other interventions ultimately resulting in a transition to cleaner burning fuels.

5 ibid
6 Smith, K.R. "Indoor air pollution in developing countries: recommendations for research." Indoor Air 2002: 12: 198-207.
7 ibid
8 Bruce, Nigel; Neufeld, Lynnette; Boy, Erick and West, Chris. "Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala" International Journal of Epidemiology. 1998: 27: 454-458

9 Smith, Kirk R. "National burden of disease in India from indoor air pollution" PNAS. November 2000. Vol 97. No. 24: 13286-13293.
10 ibid
11 Bruce, Nigel; Neufeld, Lynnette; Boy, Erick and West, Chris. "Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala" International Journal of Epidemiology. 1998: 27: 454-458

"Estimates of the global burden of disease suggest indoor air pollution is responsible for just under 4% of DALY lost meaning that its consequences are comparable with those of tobacco use and that they are only exceeded by those of malnutrition (16%), unsafe water and sanitation (9%) and unsafe sex (4%).[1]"

1 Bruce, Nigel; Perez-Padilla, Rogelio; and Albalak, Rachel. "Indoor air pollution in developing countries: a major environmental and public health challenge" Bulletin of the World Health Organization. World Health Organization. 2000, 78 (9): 1078-1092.

INDUSTRIAL MINING ACTIVITIES

Description
Industrial Mining Activities refers to mines that are currently engaged in mineral and metal extraction operations. The materials can range from common to precious, and from inert to hazardous. The mines themselves can be small or very large in size.

Context
The most common pollution problem for an active mine arises from the disposal of mineral wastes, mainly mine waste rock and tailings. Mine waste rock is the material removed to access or expose the valuable ore and is typically enriched in some constituents of the geochemistry of the ore. Tailings are the waste materials after the minerals are separated from the ore in a mineral processing plant.[1] They typically contain the valuable constituents in low concentrations, unrecovered by the process, and may also contain toxic residues of chemicals used in the separation process.

Mine waste rock often generates acid drainage when air and water come into contact with metal sulfide minerals, and the resulting sulfuric acid solutions contaminate surface water bodies and groundwater. The same phenomenon can also arise from tailings repositories, and both types of waste are sometimes deposited in structures that can suffer catastrophic failure. Rarely, mines will discharge the tailings into surrounding waterways, sometimes at high volumes. The high volume can negatively affect the agricultural and aquatic systems of the area, damaging farmland, and riverbeds. Accumulation of the tailings can cause riverbeds to become shallow, leading to overflowing and flooding.[2]

Exposure Pathways
Economic ore deposits contain many chemical elements in addition to those that are extracted for sale. Some of these are toxic, and they are often present at concentrations that pose risks to the environment and human health. These elements can occur in mineral waste repositories and in the exposed walls of excavations. They can be leached from both sources, transported by wind, or taken up by plants and animals in the human food chain. Physical agents such as asbestos and crystalline silica can also be windborne, and radioactive minerals pose their own set of risks. Substances emitted from or present at mine sites can enter the body in a variety of ways such as inhalation, absorption through dermal contact, or ingestion of contaminated food and water.

1 "Mine Tailings." Superfund Basic Research Program: The University of Arizona. 2008. http://superfund.pharmacy.arizona.edu/Mine_Tailings.php

2 Briones, Nicomedes D. "Mining Pollution: the Case of the Baguio Mining District, the Philippines." Environment and Policy Institute. East-West Center. Volume 11, Number 3: July 1987.

Health Effects
A number of health effects may result from active mine pollution depending on the specific substances present and their concentrations in air, soil, food or water. Unless a major accident occurs, the effects are often chronic in nature[3] and include irritation of eyes, throat, nose, skin; diseases of the digestive tract, respiratory system, blood circulation system, kidney, liver; a variety of cancers; nervous system damage; developmental problems; and birth defects.

Some sites which have been noted as examples of the problem
Guo'an Village, Guangxi, China
Santa Catarina, Brazil

What is Being Done
The aim of environmental regulation of mining operations by governments is to improve performance and to reduce emissions and the risks they pose to the environment and human health. Problems arise either when the law does not set strict enough limits on permitted emissions or where there is no effective enforcement of applicable laws, or both. In such cases companies may undertake voluntary emission reduction programs, often under pressure from civil society organizations. Such initiatives include installation of effective wastewater treatment, alternative waste disposal methods for mine tailings, etc.

3 Balkau, F. "Pollution Prevention and Abatement Guidelines for the Mining Industry." UNEP. 1994. Page 4.

GROUNDWATER CONTAMINATION

FRESH DRINKING WATER MAKES UP ONLY 6% OF THE TOTAL WATER ON EARTH AND ONLY 0.3% IS USEABLE FOR DRINKING

Description

Groundwater is water located beneath the surface in soil pore spaces and in permeable geological formations. Sources of groundwater include seepage from the land surface, such as rainwater, snowmelt and water also that permeates down from the bottom of some lakes and rivers.[1] Fossil groundwater is water that has been trapped in rock formations over geological time scales. Groundwater is a very important source of freshwater, making up 97 percent of the world's accessible freshwater reserves.[2] In addition, about two billion urban and rural people depend on groundwater for everyday needs.[3]

Context

Fresh drinking water makes up only 6% of the total water on Earth and 100% of the world's population relies on it. This includes the icecaps and glaciers and if these sources are subtracted from the total, only 0.3% of the water on Earth is useable for drinking, and the majority of that is groundwater.

Millions of people in the developing world rely heavily on groundwater, mostly through shallow dug wells. These can easily become polluted, primarily because of human activities. Such activities can be broadly categorized into four groups: municipal, industrial, agricultural, and individual sources.[4]

Municipal sources of groundwater contamination include open dumpsites, poorly constructed or maintained landfills, latrines and other waste sites. Each of these can contain a range of pathogens and toxins, including heavy metals, that can migrate downward and contaminate aquifers.

Industrial pollution of groundwater can come from dumping of wastewater or waste, from mining activities and from leakage or spillage from other industrial processes. Mining primarily affects groundwater through leaching of mine tailing piles.[5] Chemical manufacture and storage similarly present a threat through leakage.

Agricultural contamination comes primarily from overuse of pesticides and fertilizers that can later seep into groundwater sources.[6]

1 "What is Groundwater?" U.S. Geological Survey. U.S. Department of the Interior. Last Updated September 1, 2005. Available at http://pubs.usgs.gov/of/1993/ofr93-643/
2 The World Bank. "Water Resources Management: Groundwater" Accessed on September 15, 2008. Available at http://go.worldbank.org/6YTISD5KR0
3 ibid

4 "Sources of Groundwater pollution." Lenntech: water treatment and air purification. Available at http://www.lenntech.com/groundwater/pollution-sources.htm
5 "Sources of Groundwater pollution." Lenntech: water treatment and air purification. Available at http://www.lenntech.com/groundwater/pollution-sources.htm
6 "Groundwater pollution." Marquette County Community Information System. Available at http://www.mqtinfo.org/planningeduc0020.asp

Lastly, individuals can also cause groundwater contamination by improperly disposing of waste. Motor oil, detergents and cleaners can leak into water sources.

Importantly, groundwater can also be contaminated by naturally occurring sources. Soil and geologic formations containing high levels of heavy metals can leach those metals into groundwater. This can be aggravated by over-pumping wells, particularly for agriculture. This is the case in much of Bangladesh, where groundwater contains high levels of naturally occurring arsenic. One study indicated that a full one fifth of the population drinks water containing 5 times the arsenic level recommended by the WHO[7].

Groundwater pollution differs from surface water contamination in several important respects. Among them, it does not typically flow to a single outlet. It can affect people through wells dug in a contaminated aquifer, as it can flow into streams or lakes. Groundwater pollution also occurs on a different timescale than surface water contamination. Flow rates vary widely and can be as slow as 2 miles a year. Because of this, nonpoint source pollution can take years or even decades to appear in wells and just as long or even longer to dissipate or be converted..

These distinctions depend on topography, hydrology and the sources of groundwater recharge and have implications for limiting as well as remediating contamination[8].

7Pearce, Fred. "Arsenic in the Water." The Guardian. February 19, 1998. Available at: http://www.lifewater.ca/887805655-arsenic.htm

8 Harter, Thomas. "Groundwater Quality and Groundwater Pollution" ANR Publication 8084, Division of Agriculture and Natural Resources, University of California at Davis 2003. Available at http://groundwater.ucdavis.edu/Publications/Harter_FWQFS_8084.pdf

Exposure Pathways

Groundwater pollutants can enter the body directly through water supplies or by eating foods prepared with contaminated groundwater or grown in fields using contaminated sources. It may also affect humans when they are in direct contact with polluted waters.

Health Effects

Health effects from groundwater pollution depend on the specific pollutants in the water. Pollution from groundwater often causes diarrhea and stomach irritation, which can lead to more severe health effects. Accumulation of heavy metals and some organic pollutants can lead to cancer, reproductive abnormalities and other more severe health effects.

What is Being Done

Groundwater is very difficult to remediate, except in small defined areas and therefore the emphasis has to be on prevention. This is based on protection of sensitive aquifers, control of discharges and releases and provision of drainage and sanitation systems to avert pollution discharges. For small areas of highly polluted groundwater, it may be possible to pump out, treat, and recharge (which is expensive); to treat in-situ – for some contaminants; or to try to contain the pollution "plume", physically or chemically. However, there is continuing degradation of important groundwater aquifers in many countries, the serious impacts of which are only slowly being appreciated.

METALS SMELTING AND PROCESSING

Description

Metal processing plants and smelters are facilities that extract various metals from ore to create more refined metal products. Metals include copper, nickel, lead, zinc, silver, cobalt, gold, cadmium, etc. Smelting specifically involves heating the ore with a reducing agent such as coke, charcoal or other purifying agents. Primary smelting processes mine ore and concentrates, whereas secondary smelting processes recover scrap.

Context

Extractive metallurgical and smelting processes can be highly polluting activities. Some facilities that carry out metal and smelting processes are known to emit high quantities of air pollutants such as hydrogen fluoride, sulfur dioxide, oxides of nitrogen, offensive and noxious smoke fumes, vapors, gases, and other toxins. A variety of heavy metals: lead, arsenic, chromium, cadmium, nickel, copper, and zinc are also released by the facilities. In addition, pickling and other processes in metalworking use large volumes of sulfuric acid which may also be released. Estimates from a survey conclude that steel production alone accounts for 5 to 6 percent of worldwide, man-made CO_2 emissions.[1]

Metallurgical complexes primarily cause pollution through gaseous and particle release into the environment. Metals may be released as fine particles or volatile compounds, either via a chimney or as "fugitive" emissions from general operations. Organic vapors and sulfur oxides resulting from secondary smelting roasting operations and fuel combustion can cause smog, containing ozone, fine airborne particles, nitrogen oxides, sulfur dioxide and carbon monoxide.[2] In addition, some smelting processes can also produce large quantities of solid waste, known as slag, which usually contain significant amounts of contaminants.

Metal-bearing dust particles can travel far distances to pollute the soil and surface waterways. Highly alkaline smelter effluent and tailings also release acid to waterways from waste pits.[3]

Exposure Pathways

Humans typically become exposed to metal processing plant and smelter contaminants through inhalation

1 Beauman, Chris. "STEEL: Climate change poses stern challenge." The Financial Times. October 8, 2007. Available at http://us.ft.com/ftgateway/superpage.ft?news_id=fto100820070416397176

2 "Secondary smelting of nonferrous metals: Impacts, Risks and Regulations." National Center for Manufacturing Sciences: Environmental Roadmapping Initiative. Last Updated March 27, 2003. Available at ecm.ncms.org/ERI/new/IRRsecsmelt.htm

3 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

and ingestion.[4] Inhalation of pollutants occurs as a consequence of gaseous emissions and fine particulate matter (i.e. dust). Layers of dust can also settle onto nearby agricultural fields, causing crop intake of pollutants and later consumed by humans. Particulate matter emissions, sewage waters, and solid wastes also enter waterways used for drinking water.

Workers in metal processing plants and smelters generally have a higher risk of exposure to toxic pollutants since they can come into direct contact with the pollutants when working with substances containing metal processing and smelting waste.

Health Effects

Exposure to airborne pollutants from metal processing and smelting can lead to various acute and chronic diseases. Initial sudden exposure can lead to an irritation of the eyes, nose and throat. More serious and chronic effects are heart and lung problems, and even premature death.

Heavy metals also pose chronic health risks including bioaccumulation of toxic elements in organisms, which can result into birth defects, kidney and liver problems, gastrointestinal tract issues, joint pain, as well as nervous, respiratory and reproductive system damage. In La Oroya, Peru, a lead smelter operating since 1922 is blamed for the high levels of lead, a heavy metal, in the local children. A study from 2002 found that eighty percent of children tested in the area have blood lead levels two and three times greater than accepted levels.[5] The study also found that 73% of La Oroya's children between the ages of 6 months and six years had lead levels between 20 and 44 μg/dL, and 23% were found with levels higher than 45 μg/dL, which is almost quadruple the WHO limit of 10 μg/dL. [6]

4 ibid

5 Serrano, Fernando. "Environmental Contamination in the Homes of La Oroya and Concepcion and its Effects in the Health of Community Residents." Division of Environmental and Occupational Health. School of Public Health. Saint Louis University. February 2008. Available at http://www.upr-info.org/IMG/pdf/InternationalAssociationforEnvironmentalDefense_Peru_Joint_submission_Add_2_2008.pdf

Some of the sites which have been noted as examples of the problem

La Oroya, Peru
Elbassan, Albania
Tuticorin, Tamil Nadu, India
Rudnaya Valley, Russia
Zlanta, Romania

What is Being Done

Modern processing plants and smelters can be designed and operated to control releases to very low levels. However, such operations can be relatively costly and many plants, especially where regulations are not applied seriously, do not meet the standards. One key issue therefore is to improve the quality of operations. Older smelters (which can be many decades old) are often very poor in terms of emissions control and while some upgrading can be carried out, major improvements (such as upgraded sulfur recovery) can be very costly. The real opportunities for improvement come when processing plants are upgraded for economic and production reasons.

Old smelters also often have a legacy of a highly polluted surrounding area, where metal dust may have spread toxic pollutants over wide areas and years of acid releases can result in serious ecological damage. Remediation of such areas has to be focused on removing or curtailing the source of the problems and then tackling the key pathways that affect the local population, often water and contaminated food.

6 ibid

RADIOACTIVE WASTE AND URANIUM MINING

Description

Radioactive Materials and Wastes covers materials from a wide range of sources that emit radiation of different types, at levels that impact human health. Radioactive materials are used for power generation, military purposes, for treatment and analyses in the medical sector, for material control and treatment in industry, products of daily life and in scientific applications.

Radioactivity is the sign that matter is decaying in order to reach, according to the law of physics, a better energetical state. As materials decay, they emit radiation, eventually disintegrating entirely and becoming innocuous. For some materials, this process can happen in a fraction of a second. For others however, it can take as long as millions of years. There are four basic types of radioactivity that affect human health: Alpha, Beta and Gammy decay and Neutron radiation. Each poses a particular type of threat to human health[1].

Context

Radioactive waste is categorized broadly as high or low level waste. The former results primarily from fuel used in civilian or military reactors, and the latter from a range of processes including reactors, and industrial and commercial uses.

High-Level Waste typically refers to 'spent' fuel from a nuclear reactor. Most reactors are powered by uranium fuel rods, which is at the beginning only slightly radioactive. However, when the fuel rod is 'spent,' or used, it is both highly radioactive and thermally hot. Radioactive materials will reduce their activity with a so-called half-life time. The half-life time is the time required for reducing the activity to half of its initial value. Radioactive half-life times can span from fractions of a second to millions of years.

Radioactive materials cannot be treated, but only become harmless when they have finished their decay. Because this can take millennia, these materials must be stored appropriately. There are worldwide efforts to find ways that high-level wastes can be reliably sealed off from the biosphere for at least a million years in so-called final repositories. The issues surrounding the long term storage of high level waste are complex and often controversial. Given the levels of hazard involved, this matter is essentially a government responsibility.

Low-Level Waste includes material that has only a small decay activity or has become contaminated with or activated by nuclear materials. This can be clothing used in nuclear industry, medical materials, spent radiation sources or materials from inside of reactors.

Uranium Mining and Processing Wastes are a special category of (normally) low level wastes, which are of major concern because of the volumes of radiating materials concentrated in usually a small area, thus creating an overall hazard.

While uranium is mined around the world, some of the biggest producers are low-income countries. Indeed, of the ten largest producers of uranium, seven are in areas where industrial safety standards do not always correspond to the best industrial practices: Kazakhstan, Russia, Niger, Namibia, Uzbekistan, Ukraine and China[2].

Typically uranium concentrations can be as low as 0.1 to 0.2% in mined ore, meaning that well over 99% of what is mined is rejected after processing. Once mined, ore must be milled to produce useful uranium concentrate. Milling is the process of grinding the

1 "Backgrounder on Radioactive Waste" United States Nuclear Regulatory Commission. Last Updated April 12, 2007. Available at http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.html

2 "Uranium Mining" Information Papers. World Nuclear Association. Last Updated July 2008. Available at http://www.world-nuclear.org/info/inf23.html

ore and adding chemicals, usually sulfuric acid, to extract the uranium it contains. During milling, other constituents of the ore are released as well, including toxics like arsenic and lead. The byproduct of milling is a toxic sludge of tailings.

Because of the low concentration of uranium in ore, nearly as much sludge is produced as ore is mined. This leftover sludge contains a high amount of radioactivity – as much as 85% of the initial radioactivity of the ore. The tailings contain low-grade radioactivity but can be dangerous because of the very large quantities that are stored in rather small areas. Additionally, ground or surface water that is pumped away from the site during mining operations can also contain low levels of radiation and therefore contaminate local rivers and lakes.

Unless properly managed for long term stability and security, mining waste and milling tailings present a serious threat to human health, mostly through seepage and leaking of radioactive material. In this context, such mines have all the hazards of any poorly controlled hard rock mine, plus the special hazards of radioactivity. In the worst cases, mines have been developed in areas where seismic fault lines make tailings are particularly vulnerable to leakage[3]. And at some sites, tailings have been used in home construction.

Unfortunately, because so much uranium mining happens in the developing world and often under the control of agencies whose objectives are production rather than safety, large amounts of toxic tailings continue to pose a threat to humans daily.

Exposure Pathways

Exposure pathways are multiple. Contaminated water and food dusted with fine materials carried by the air can result in ingestion of Alpha and Beta particles, which are dangerous when taken into the body through food, water or air. Proximity to radioactive materials – not only loosely secured dumps but also roads or other structures built with mining wastes – can result in exposure to Gamma particles and neutron radiation.

Health Effects

Radioactivity impacts the human metabolism in a wide variety of ways. Its effects can be dramatic, attacking all body functions in cases of severe exposure but more commonly seen as causing a range of cancers from exposure over a period of time or impacting the genetic code, which can result in health problems transmitted to the following generations.

There is no 'safe' level of radiation exposure. High exposures can result in deathwithin hours to days to weeks. Individuals exposed to non-lethal doses may experience changes in blood chemistry, nausea, fatigue, vomiting or genetic modifications

Children are particularly vulnerable. Radiation has an effect on the cellular level. As children grow they divide more and more cells. There is therefore more opportunity for that process to be interfered with by radiation.

Fetuses exposed to radiation can result in smaller head or brain size, poorly formed eyes, abnormal or slow growth and mental retardation[4].

Some sites which have been noted as examples of the problem

Plutonium breeding and chemical processing facilities like Hanford Site, USA, or Mayak, Russia
Nuclear bomb test sites (worldwide)
Nuclear power plants and reprocessing facilities (worldwide)
Uranium mining tailings in e.g. Mailuu-Suu, Kyrgyzstan

What is Being Done

Some countries have well regulated industries and manage radioactive waste appropriately. In particular, there are regimes in place, nationally and internationally, for managing high-level radioactive wastes. However, in others, especially the poorer ones there is little appreciation of the scale of the hazards related to uranium mining and processing wastes and little or no industry or government effort to deal with the problem. The approaches to dealing with some mining wastes are similar to those required to contain and stabilize any mining waste, with the additional need for much increased effort to reduce or eliminate critical pathways such as use of contaminated water sources or food production on polluted soils. Given the very poor and remote areas where uranium mining is often located, the options for the local population may be very limited.

In these places, Green Cross Switzerland and Blacksmith Institute try to identify local partners and where possible implement projects to address some of the highest priority challenges.

3 Diehl, Peter. "Uranium Mining and Milling Wastes: An Introduction" World Information Service on Energy: WISE Uranium Project. Last Updated August 15, 2004. Available at http://www.wise-uranium.org/uwai.html

4 "Radiation Protection: Health Effects" Radition. U.S. Environmental Protection Agency. Last Updated August 28, 2008. Available at http://www.epa.gov/rpdweb00/understand/health_effects.html

UNTREATED SEWAGE

Description

Sewage refers to liquid wastes containing a mixture of human feces and wastewater from non-industrial human activities such as bathing, washing, and cleaning. In many poor areas of the world, sewage is dumped into local waterways, in the absence of practical alternatives. Untreated sewage poses a major risk to human health since it contains waterborne pathogens that can cause serious human illness. Untreated sewage also destroys aquatic ecosystems, threatening human livelihoods, when the associated biological oxygen demand and nutrient loading deplete oxygen in the water to levels too low to sustain life.

Context

The World Health Organization (WHO) estimates that 2.6 billion people lacked access to improved sanitation facilities in 2008, with the lowest coverage in sub-Saharan Africa (37%), Southern Asia (38%), and Eastern Asia (45%).[1] Improved sanitation facilities are those that eliminate human contact with fecal material and include flush or pit toilets/latrines and composting toilets.[2] Even where water based toilets are available, the wastes are far too often just discharged into drains and streams, in the absence of (expensive) collection and treatment systems. As a result, surface waters in many urban areas are highly contaminated with human waste. In areas with pit latrines, seepage into local groundwater is often a major problem, since many communities rely on shallow wells for drinking water.

Lack of access to improved sanitation disproportionately affects poor communities in urban and rural areas where resources for investments in collection and treatment infrastructure are scarce, although the challenge of maintaining existing systems to protect humans from waterborne disease outbreaks affects even the world's richest communities.

1 World Health Organization (WHO). 2008. "International Year of Sanitation 2008" Last accessed on September 16, 2008. Available at http://www.who.int/water_sanitation_health/hygiene/iys/about/en/index.html.

2 WHO and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation (JMP). 2008. Progress on Drinking Water and Sanitation: Special Focus on Sanitation. UNICEF, New York and WHO, Geneva, Last accessed September 16, 2008. Available at http://www.who.int/water_sanitation_health/monitoring/jmp2008.pdf.

Exposure Pathways

Sewage can be intentionally discharged to waterways through pipes or open defecation, or unintentionally during rainfall events. When humans use these waterways for drinking, bathing or washing, they are exposed to the associated pathogens, many of which can live for extended periods of time in aquatic environments. Humans then become ill by ingesting contaminated water, by getting it on/in skin, eyes or ears, or even from preparing foods with contaminated water. Sometimes humans can even become ill from inhaling contaminated water droplets.

Health Effects

Life-threatening human pathogens carried by sewage include cholera, typhoid and dysentery. Other diseases resulting from sewage contamination of water include schistosomiasis, hepatitis A, intestinal nematode infections, and numerous others. WHO estimates that 1.5 million preventable deaths per year result from unsafe water, inadequate sanitation or hygiene.[3] These deaths are mostly young children. Another 860,000 children less than five years old are estimated to die annually as a direct or indirect result of the underweight or malnutrition associated with repeated diarrheal or intestinal nematode infections .[4]

What is Being Done

Strides are being made on a global scale. The WHO estimated that 3.8 billion people had access to improved sanitation as of 2004, and has set a target of at least 75% global coverage by 2015. Meeting this ambitious target will be a challenge. However, a number of interventions have already proven effective in reducing the diarrheal disease burden resulting from inadequate sanitation.[5] These range from hand-washing and hygiene education, to toilet/latrine installation and point-of-use water treatment, to approaches comprised of multiple strategies.

3 Prüss-Üstün A, Bos R, Gore F, Bartram J. 2008. Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva: World Health Organization [Available: http://www.who.int/quantifying_ehimpacts/publications/saferwater/en/index.html, accessed 9/15/08].

4 Prüss-Üstün A, Bos R, Gore F, Bartram J. 2008. Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva: World Health Organization [Available: http://www.who.int/quantifying_ehimpacts/publications/saferwater/en/index.html, accessed 9/15/08].

5 Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colford JM Jr. 2005. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and metaanalysis. The Lancet Infectious Diseases, 5(1):42–52.

URBAN AIR QUALITY

Description
Airborne pollutants can be classified broadly into two categories: primary and secondary. Primary pollutants are those that are emitted into the atmosphere by sources such as fossil fuel combustion from power plants, vehicle engines and industrial production, by combustion of biomass for agricultural or land-clearing purposes, and by natural processes such as wind-blown dust, volcanic activity and biologic respiration. Secondary pollutants are formed within the atmosphere when primary pollutants react with sunlight, oxygen, water and other chemicals present in the air. Both primary and secondary pollutants may consist of chemical compounds in solid, liquid or vapor phases.

Outdoor air pollution in the context of public health is characterized by several major airborne pollutants. Particulate Matter (PM), Tropospheric Ozone (O3), Nitrogen Dioxide (NO2), and Sulfur Dioxide (SO2) are some of the most commonly monitored pollutants. Particulate matter in the atmosphere is mainly attributed to the combustion of fossil fuels, especially coal and diesel fuel, and is composed of tiny particles of solids and liquids including ash, carbon soot, mineral salts and oxides, heavy metals such as lead, and other organic compounds[1]. Particulate Matter is typically measured and characterized by particle size, as either PM10 (particle diameter ≤ 10 microns) or as PM2.5 (particle diameter ≤ 2.5 microns). The smaller particles are able to penetrate deeper into the lungs, disrupting the exchange of oxygen into the blood and causing inflammation.[1] NO2 and SO2 are chemicals produced by the combustion of fossil fuels and play a major role in generating photochemical smog, as well as creating acid rain. Ozone is a major component of photochemical smog, an air pollution phenomenon that forms when primary pollutants like NO2 and Carbon Monoxide (CO) react with sunlight to form a variety of secondary pollutants. Another important pollutant is lead (Pb) in countries where leaded gasoline is still in use. This can be a significant contribution to airborne pollution. Lead exposure poses serious health risks to any population, but children especially are at risk of significant neurological and developmental damage from prolonged exposure.

1 "Research Areas: Hazardous Components" Research Programs: Particulate Matter (PM) Health Effects. Environmental Protection Agency. Last Updated May 2, 2008. Available at http://www.epa.gov/NHEERL/research/pm/research_area05.html

Context
Outdoor air pollution and photochemical smog can occur in any environment where there are large and continuous emissions of primary air pollutants. However specifics of climate and geography play an important role in the persistence and severity of the pollution. In warm and sunny climates, air in the upper atmosphere can become warm enough to inhibit vertical air circulation and the dispersion of air pollutants, trapping smog in the lower atmosphere. Urban areas in topographic basins or valleys where surrounding hills or mountains inhibit air circulation are also prone to the build-up of persistent and high levels of photochemical smog.

The health impacts caused by outdoor air pollution have been widely recognized by both national governments and multilateral development organizations as a threat to urban populations, especially in developing countries. The WHO estimates that 865,000 deaths per year worldwide can be directly attributed to outdoor air pollution.[2] Most studies on the health effects of outdoor air pollution have focused on urban environments (>100,000 people) where the impact is considered to be most severe. People living in large urban areas, especially in developing countries, where the health risks of air pollution may be underappreciated and pollution controls lacking, are routinely exposed to concentrations of airborne pollutants that have been shown to cause negative health effects in both the short and long term.

Exposure Pathways
People are exposed to outdoor air pollution by breathing in pollutants, and by exposing eyes and skin while they are outdoors. Exposure is intensified by vigorous activity, as pollutants are drawn more deeply into the lungs during periods of physical exertion. People who live or work in close proximity to emission sources such as power plants, local industry or highways/major roadways are often exposed to higher concentrations of pollutants for longer periods of time, which elevates their risk of developing acute and/or chronic health problems. Long-term exposure to relatively low levels of pollutants can also cause serious health problems. Cities in developing countries often suffer heavily from outdoor air pollution, due to the heavy use of diesel fuel for transport vehicles, the predominance of coal for power generation, the proximity of urban populations to industrial facilities, and the lack of advanced emission controls for vehicles and industry.

Health Effects
Major health effects associated with outdoor air pollution are typically associated with chronic pulmonary and cardio-vascular stress from the fine particles and include increased mortality, respiratory and cardiovascular disease, lung cancer, asthma exacerbation, acute and chronic bronchitis, restrictions in activity and lost days of work. The health effects of outdoor air pollution fall disproportionately on infants, children and the elderly. People with pre-existing health conditions are also significantly affected. Studies indicate that chronic exposure to NO2 may impair lung development in children and cause structural changes in the lungs of adults. Exposure to ground-level ozone also causes burning and irritation of the eyes, nose and throat, and the drying out of mucous membranes, reducing the ability of the body to resist respiratory infections. Overall, health effects depend on many factors: the pollutant and its concentration in the air, the presence of multiple pollutants, temperature and humidity conditions, and the exposure period of a person to the pollutant, in both the short- and long-term.

What is Being Done
Although much progress has been made on reducing outdoor air pollution in developed countries, many cities in the these countries still frequently exhibit levels of pollutants that exceed recommended limits. The situation in developing countries is considerably worse. While the development of the catalytic converter for automobiles, the introduction of low-sulfur gasoline, and tough regulatory standards for tailpipe and power plant emissions have significantly reduced the emission of PM, NO2, and SO2 from fossil fuel combustion in developed countries, all of these changes required capital investments that many developing nations are not capable of making. For many cities in the developing world outdoor air pollution seems a monumental challenge, as there are few "quick fixes" and the costs of introducing advanced pollution control technologies can be steep.

Outdoor air pollution is a complex and multifaceted problem that requires an integrated approach to solving. Collaboration between urban planners, transportation engineers, energy and environmental policy makers and economists is critical to developing solutions that reduce

[2] Ostro, B. "Outdoor air pollution: assessing the environmental burden of disease at national and local levels." World Health Organization. 2004. Available at http://www.who.int/quantifying_ehimpacts/publications/ebd5/en/index.html
[3] "World Development Indicators 2007", World Bank. 2007. Available at siteresources.worldbank.org/DATASTATISTICS/Resources/table3_13.pdf

air pollution and its health impacts. Bangkok, Thailand is an excellent case study. Faced with rapid growth and urbanization in the 1990s, outdoor air pollution in Bangkok quickly rose to dangerously high levels. A multi-pronged strategy was instituted to combat the problem, including the introduction of emission reduction regulations, the elimination of leaded gasoline and the introduction of catalytic converters. In addition, other simple and cost-effective actions were taken: paving of road shoulders to reduce dust, public education and provision of free engine tune-ups. On a longer time-line, the city set to developing and expanding its mass transit systems. As a result of this integrated approach, Bangkok now has air quality that is better than American standards, and is approaching those of the E.U.

The phase-out of leaded gasoline is an important step, as it not only reduces the health impact of lead poisoning on the population, but also is necessary for the introduction of catalytic converters, which require unleaded fuel. Blacksmith Institute has conducted two successful projects to monitor and assist in the phase out of leaded gasoline in Senegal and in Tanzania.

Reducing the sulfur content of diesel fuels is also an important step in combating air pollution. Lowering sulfur dioxide emissions reduces both the health impacts of outdoor air pollution and the environmental and agricultural damage caused by acid rain. Reducing the sulfur content of diesel also permits the use of more advanced pollution controls systems that can further reduce PM and NO2 emissions. In many Asian cities, diesel vehicles are both the fastest growing segment of transportation and one of the largest contributors to outdoor air pollution. A measured and responsibly paced reduction of sulfur content in diesel fuels sold in these cities would provide significant benefits to the health of their populations.

Most Polluted World Cities by PM10 according to World Bank [3]

PM10 µg/m3 (2004)	City	Population (thousands)
169	Cairo, Egypt	11,128
150	Delhi, India	15,048
128	Kolkata, India	14,277
125	Tianjin, China	7,040
123	Chongqing, China	6,363
109	Kanpur, India	3,018
109	Lucknow, India	2,566
104	Jakarta, Indonesia	13,215
101	Shenyang, China	4,720
97	Zhengzhou, China	2,590

USED LEAD ACID BATTERY RECYCLING

Of the **8+ million tons** of lead produced worldwide every year, over 85% goes into lead acid batteries

Description

Lead acid batteries are rechargeable batteries made of lead plates situated in a 'bath' of sulfuric acid within a plastic casing. They are used in every country in world, and can commonly be recognized as "car batteries". The batteries can be charged many times, but after numerous cycles of recharging, lead plates eventually deteriorate causing the battery to lose its ability to hold stored energy for any period of time.[1] Once the lead acid battery ceases to be effective, it is unusable and deemed a used lead acid battery (ULAB), which is classified as a hazardous waste under the Basel Convention.[2]

Context

Recycled lead is a valuable commodity and for many people in the developing world the recovery of car and similar batteries (ULABs) can be a viable and profitable business. Therefore, the market for reclaiming secondary lead has been growing, especially in developing countries. Many developing countries have entered the business of buying ULABs in bulk in order to recycle them for lead recovery. These ULABs are often shipped over long distances for recycling, typically from the industrialized countries that produce, use, and then collect the spent batteries for reprocessing.[3] Currently ULAB recycling occurs in almost every city in the developing world, and even in some countries in rapid transition. ULAB recycling and smelting operations are often located in densely populated urban areas with few (if any) pollution controls. In many cases the local recycling operations are not managed in an environmentally sound manner and release lead contaminated waste into the local environment and eco systems in critical quantities.

As urban centers in the Global South become more populated the confluence of high unemployment rates, with increased car ownership, have led to a proliferation of informal ULAB reconditioning and recovery activities. These are often conducted by economically marginalized members of society, needing an additional source of income, but without any understanding of the risks involved. The informal process of recovering secondary lead from the ULABs includes breaking the batteries manually with an axe. In many cases, informal battery melting is a subsistence activity, and undertaken in homes (even in the kitchen), using archaic melting operations to recover and sell the secondary lead to the larger processers. Despite efforts by government agencies and the industry to bring safer and

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

2 "The Basel Convention at a Glance." Basel Convention. United Nations Environmental Programme. Available at http://www.basel.int/convention/bc_glance.pdf

3 "The Basel Ban And Batteries, A Teaching Case: The Basel Ban And Batteries" Available at http://www.commercialdiplomacy.org/case_study/case_batteries.htm

more efficient practices into this stage of the recycling process, ignorance of the risks of lead contamination combined with a lack of viable economic alternatives has led to the systemic poisoning of many poor populations throughout the developing world.

About 6 million tons of lead is used annually, on a worldwide basis, of which roughly three-quarters goes into the production of lead-acid batteries, which are used in automobiles, industry and a wide range of other applications. Much of this existing demand for lead is met through the recycling of secondary material[4] and in particular from lead recovered from Used Lead-Acid Batteries (ULAB). This high level of recycling is very effective in reducing the volumes of lead dumped in the environment and in minimizing the need for mining more ores. However, in many places, much of the recycling is done on an informal basis, in unhygienic and dangerous conditions and resulting in serious lead poisoning of the recyclers themselves and the neighboring communities.

Exposure Pathways

Throughout the informal recycling process, there are opportunities for exposure. Most often the battery acid, which contains lead particulates, is haphazardly dumped on the ground, waste pile or into the nearest water body. As the lead plates are melted, lead ash falls into the surrounding environment, collects on clothing, or is directly inhaled by people in close proximity.

Soil containing lead compounds can turn to dust and become airborne, enabling the lead compounds to be easily inhaled or ingested in a variety of ways. Lead can also leach into water supplies.

Children, in particular are often exposed to lead when playing on the waste furnace slag and handling rocks or dirt containing lead, while engaging in typical hand-to-mouth activity, as well as by bringing objects covered with lead dust back into the home. The most common route of exposure for children is ingestion, as lead dust often covers clothing, food, soil and toys.

Health Effects

Acute lead poisoning can occur when people are directly exposed to large amounts of lead through inhaling dust, fumes or vapors dispersed in the air.

However, chronic poisoning from absorbing low amounts of lead over long periods of time is a much more common and pervasive problem. Lead can enter the body through the lungs or the mouth, and over long periods can accumulate in the bones.

Health risks include impaired physical growth, kidney damage, retardation, and in extreme cases even death.

Lead poisoning can lead to tiredness, headache, aching bones and muscles, forgetfulness, loss of appetite and sleep disturbance. This is often followed by constipation and attacks of intense pain in the abdomen, called lead colic.[5] Extreme cases of lead poisoning, can cause convulsions, coma, delirium and possibly death.

Children are more susceptible to lead poisoning than adults and may suffer permanent neurological damage. Women that are pregnant and become exposed to lead can result in damage to the fetus and birth defects.

Some sites which have been noted as examples of the problem

Thiaroye Sur Mer, Dakar, Senegal
Bajos de Haina, Dominican Republic
Picnic Garden, Kolkata, India

What is Being Done

The challenges of ULABs are recognized by the industry and by the Basel Secretariat, who administers the relevant Convention. In some countries, the recycling systems have become formalized and are more or less well regulated. However, in many poorer countries, there is a large informal component alongside the established, larger recyclers. The Blacksmith Institute is currently trying to mitigate lead pollution from ULABs in seven countries around the world with a project entitled, "The Initiative for Responsible Battery Recycling". The project focuses on ending endemic exposure to lead from improper ULAB recycling through education, remediation of legacy contaminated soils, developing new responsible policies on appropriate management of ULAB, and either formalizing the ULAB collection or providing other sources of income for the informal sector operators.

4 Cahners Business Information 2001. Lead: Market Prices Won't Ignite. Purchasing 130:3, Reed Elsevier, Inc., Feb 8, 42-43.

5 "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

THE REST OF THE TOXIC TWENTY

ABANDONED MINES

Description

Abandoned mines are areas where operations to extract minerals and metals from the earth are now defunct. They are no longer active because they ceased to be valuable enterprises and so were permanently abandoned, or because they were shut down by the government due to environmental concerns. This is distinct from inactive mines, which have only closed temporarily due to financial or market reasons.[1] Abandoned mines exist in virtually every area where significant mining has been undertaken over past decades, and even centuries. They still pose major environmental, safety and health problems in many countries.

Context

Abandoned mines represent a legacy of outdated mining and mineral processing practices, and of inadequate mine closure[2]. The environmental impacts from abandoned mines include loss of productive land, degradation of waterways by sediment or salts, air pollution from contaminated dust; and, decrepit and dangerous structures including shafts and pits.[3] Particular problems often arise from the large quantities of waste rock which have been moved to allow access to the valuable ore. Unless these heaps have been properly contained and covered, they pose an ongoing threat of release of toxic materials and of landslides. A related, and sometimes greater problem is "tailings". Tailings are the finely ground waste rock that is produced by the initial ore processing that usually happens at or near a mine site. The tailings are often released as a mud-like slurry which can contaminate and clog rivers. Where the tailings are contained in a pond, behind a dam, the problem is temporarily resolved but abandoned tailings ponds are a major hazard, with risks of flooding and mud-slides.

Sites of abandoned mines sometimes still have the infrastructure and remnants of past mining operations. Derelict buildings, equipment or mine shafts pose public safety hazards, especially when children explore or play around the area of an old mine. Abandoned mines can also pollute the water through acid drainage, which occurs when rain or groundwater mixes with exposed metal sulfide minerals to create sulfuric acid and dissolved heavy metals which then acidify and contaminate local waterways.[4]

Ideally, all of the these hazards are resolved as part of a mine closure process but there many cases where this work has been incomplete or just ignored, mainly

1 "Abandoned Mines: Problems, Issues and Policy Challenges for Decision Makers" Summary Report. UNEP Division of Technology, Industry and Economics. Chilean Copper Commission. Santiago, Chile 18 June, 2001.
2 ibid
3 ibid

4 "Abandoned Mines' Role in Nonpoint Source Pollution." U.S. Environmental Protection Agency. Last updated July 23, 2008. Available at http://www.epa.gov/reg3wapd/nps/mining/mines.htm

for financial reasons. Unfortunately, the high cost of rehabilitation and lack of clearly assigned responsibility and standards, also undermine efforts for remediation of contamination. Occasionally the problems of abandoned mines are even complicated by cross contamination with other nearby industrial activities.

Abandoned mines present other economic issues. Communities that once depended on the mines for jobs and services are often still there, without alternative sources of employment.

Exposure Pathways

Abandoned mines can cause direct physical injury when people attempt to enter the sites. Hazardous materials, such as sharp objects, explosives and toxic gases or chemicals can be harmful. Deep shafts, shallow open cavities and piles of old mining waste located around the sites can also result in falls, collapses, or landslides. Toxic metals carried in the acid drainage from abandoned mine sites can exist in high concentrations and can often end up in local waterways and eventually in water supplies. Rain or wind erosion can also wash fine rock particles into waterways, often changing the ecology and affecting local food sources, as well as posing a direct threat to humans.

In arid climates or in dry seasons, fine tailings materials is easily carried by the wind and often results in a coating of dust over large areas, which may contain high concentrations of heavy metals. This dust may be inhaled directly or may be ingested through food crops or otherwise.

Health Effects

In the some cases, accidents at abandoned mines sites can result in death. Heavy metal poisoning from substances such as lead, cadmium and other metals can occur at hard rock mines. Chronic exposure to such pollutants from abandoned mine sites depend on the actual contaminants and their levels in the environment, but can lead to health problems such as diseases of the digestive tract, respiratory system, blood circulation system, kidney, liver; a variety of cancers; nervous system damage; developmental problems; birth defects; etc. Other health impacts from exposure to toxic solids, liquids and gases emitted from or present in abandoned mine areas may result in irritation of eyes, throat, nose, skin; nausea or dizziness.

Some sites which have been noted as examples of the problem

Meza Valley, Slovenia
San Antonio Oeste, Argentina
Lower Kilty, Thailand
Kabwe, Zambia

What is Being Done

There is a growing recognition of the hazards resulting from lack of proper closure or abandonment of mines and there are a number of efforts underway, inside and outside the mining industry. There are several initiatives that currently work to restore abandoned mine lands to acceptable conditions for the environment, human health and the wellbeing of neighboring communities. These include the Post Mining Alliance and the National Orphan and Abandoned Mines Initiative in Canada. However, because of the scale of the problems that exist at large abandoned mines, considerably more effort and resources are required to decommission these sites globally..

AGROTOXINS AND POPs

Description

Agrochemicals were initially developed to stimulate and improve agricultural output, through synthetic growth enhancers, and killing pests that damaged crops. However, such chemicals were often too effective, killing other organisms besides the intended pests, and polluting the environment. Now, the practice of intense pesticide and fertilizer application is recognized as hazardous to environmental and human health. Due to the serious negative impacts of some of these substances, they are often known as agrotoxins.

Agrotoxins are typically harmful pesticides including organochlorines and organophosphates such as Lindane, Dicofol, Heptachlor, endosulfan, Chlordane, Mirex, pentachlorophenol, toxaphene, DDT, etc. Other pesticides which are known to have serious health effects include glyphosate, methyl bromide, Metadof, Duron, Novafate and Novaquat.   In addition, overuse of some agricultural fertilizers can also release quantities of urea, nitrogen, phosphates, and heavy metals, which can have harmful effects at high levels.

Persistent Organic Pollutants (POPs) are chemicals that bioaccumulate in human and animal tissue and persist in the environment. POPs are used for range of purposes. Here we discuss their use as agrochemicals.

Context

The use of agrotoxins has skyrocketed since its introduction for agricultural purposes in the 1940s. Roughly 2.3 million tons (2.5 million imperial tons) of industrial pesticides are now used annually, a 50-fold increase since 1950. Out of the millions of tons of agrochemicals applied to soils every year, a significant portion ends up being washed away to the surrounding surface and ground waters, or absorbed by organisms which were not the original targets. At an extreme, one study found that over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their intended target species, including non-target species, air, water, bottom sediments, and food.[1] Since agrotoxins are also harmful to humans, their over-use poses a serious threat.

After recognizing the human health risks associated with agrochemicals, many older, more noxious agrotoxins, particularly organochlorines, are now banned in most developed countries. However, these older pesticides are highly effective in dealing with the target pests and are often the cheapest to produce. Therefore many developing countries are still using some of the more toxic agricultural chemical agents. For example, a study in 2003 estimated that about 36% of the pesticides restricted in use by the WHO have been used in the Tien Giang province of rural Vietnam.'

Chemical pesticides, especially those made of chlorinated compounds, can be highly toxic, persistent and may bio-accumulate. Fertilizers may also be hazardous to the environment and human health, especially where inorganic fertilizers, such as phosphate and micronutrient fertilizers, are blended locally with fillers such as recycled industrial wastes (e.g., steel mill flue dust, mine tailings), and therefore can contain the heavy metals.'

1 Miller GT (2004), Sustaining the Earth, 6th edition. Thompson Learning, Inc. Pacific Grove, California. Chapter 9, Pages 211-216.

Agrotoxins enter and pollute the environment in many ways. The most common way agrotoxins contaminate air, soil and crops is through its direct application on agricultural fields. Large volumes of agrochemicals are commonly applied in excess and indiscriminately to large areas of agricultural land.

Agrotoxins typically contaminate water through runoff from agricultural fields during routine watering, rain and wind. This impacts surface and groundwater quality, as well as possibly damaging fisheries and freshwater ecosystems. In addition, agricultural chemical runnoff has been credited with creating dead zones in parts of the ocean.

Exposure Pathways

Skin contact by handling pesticides or touching items treated with pesticides can result in dermal absorption of chemicals. Agrotoxins may also enter the body through inhalation, by breathing in dust or chemical spray. Poor handling and application of agricultural chemicals is a serious problem in many areas. Ingestion of agrotoxins usually occurs when consumed as a contaminant on food or in water. In 1993 to 1994, about 600 cases of pesticide poisoning from eating contaminated food were reported in Vietnam.[2]

Health Effects

The World Health Organization has found that one to five million farm workers are estimated to suffer pesticide poisoning every year and at least 20,000 die annually from exposure, many of them in developing countries.

The impacts of agrotoxins depend on the specific substance or chemical. In general, the effects can range from chronic head and stomach aches, loss of vision, skin problems, birth defects, damage to the central nervous system, immune system deficiencies, pulmonary diseases, respiratory difficulties, deformities, DNA damage, disruption of the hormonal system, cancer, and even death.

Some sites which have been noted as examples of the problem

Comunidad El Tololar, Nicaragua
Giang Province, Vietnam

What is Being Done

International efforts to eradicate toxic agrochemicals include the Stockholm Convention on Persistent Organic Pollutants, a legally binding agreement developed by the United Nations Environment Program.[3] The Stockholm convention seeks to reduce and eliminate the production of the most toxic organochlorine-based pesticides and other persistent organic pollutants.

Apart from such international efforts to eliminate the production and use of proscribed pesticides, educational programs for farmers have a significant role in teaching the value and effect of lower levels of agrochemical use on productivity and health. Such programs are typically run by governments, often with international support but in some cases they are offered to retailers by pesticide producers concerned with safe and responsible use of their product. In some cases, the lead is taken by local NGOs, such as "Plagbol" (Plaguicidas Bolivianas) an NGO in Bolivia and the Endangered Wildlife Trust's Poison Working Group in South Africa, which offers telephone advice and training programs for the appropriate use of pesticides.[4]

The Blacksmith Institute has supported programs to develop 'best practices' for pesticide use, and identify local reduction strategies. Green Cross Switzerland is involved in two large projects with UNEP, FAO, WHO and others to increase management capabilities in the former Soviet Union for inventorying, repackaging and destroying obsolete pesticides.

2 Nguyen, Huu Dung; Tran, Chi Thien; Nguyen, Van Hong; Nguyen, Thi Loc; Dang Van, Minh; Trinh, Dinh Thau; Huynh, Thi Le Nguyen; Nguyen, Tan Phong; and Thai Thanh Son. "Impact of Agro-Chemical Use on Productivity and Health." International Development and Research Center. May 15, 2003. www.idrc.ca/uploads/user-S/10536112540ACF122.pdf. Page 1

3 "About the Convention." Stockholm Convention on Persistent Organic Pollutants. http://chm.pops.int/

4 "Project Highlights: Poison Working Group." The Tony and Lisette Lewis Foundation. http://www.tllf.org.za/project_poisengroup.html

ARSENIC

Description

Arsenic is a naturally occurring, semi-metallic element that is odorless and tasteless. When combined with oxygen, chlorine, and sulfur, it forms inorganic arsenic compounds. In general, arsenic is considered a heavy metal, and can be very toxic to the environment and human health.[1]

Context

The toxicity of arsenic for humans is well documented and even famous as a method of poisoning used in fiction and in real life. Arsenic poisoned Napoleon, Francesco I de' Medici (the Grand Duke of Tuscany), George the III of Great Britain, and various impressionist painters that inadvertently ingested paints containing arsenic. However, both organic and inorganic forms of arsenic are frequently used for industrial and agricultural purposes. Organic arsenic compounds are typically used as pesticides while inorganic arsenic compounds are primarily used to preserve wood. Arsenic is also a common byproduct of copper smelting, mining and coal burning, and can also be released into the environment through the manufacturing of pesticides, burning fossil fuels, and cigarette smoke.[2] Water sources become tainted with arsenic through the dissolution of minerals and ores, industrial effluents, and atmospheric deposition.

Arsenic contamination of groundwater is becoming a common problem for many places in the developing world. While arsenic is a naturally occurring element in groundwater, higher concentrations of the element are being drawn into underground water supplies mainly due to over-pumping during agricultural irrigation.[3] Bangladesh is experiencing this problem with the number of people drinking arsenic-rich water having increased dramatically since the 1970s due to increased well drilling and population growth.[4] One estimate points to at least 100,000 cases of skin lesions, which occurred in Bangladesh due to increased arsenic exposure.[5] Studies found more than a fifth of the nation's contaminated drinking water to have 50 parts per billion of arsenic, which is significantly over the WHO's recommended limit of 10 ppb.[6]

Arsenic-contaminated food crops are a major problem in many developing countries straining their natural resources when attempting to boost agricultural crop production.[7] Using arsenic-rich waters to irrigate agricultural crops normally results in food uptake of the element and human ingestion of arsenic.[8] Young children and babies are particularly susceptible to arsenic poisoning from foods, such as rice due to lower tolerances to the element.[9]

Arsenic is also released into the environment and can impact human health during the process of copper smelting. Arsenic is a common by-product during the process and enters the environment as arsenic-laden dust.

Arsenic is also found in "pressure-treated" lumber, since it is used to treat lumber to make the wood

1 "Safety and Health Topics: Arsenic." U.S. Department of Labor: Occupational Safety and Health Administration. Last Updated June 16, 2008. Available at http://www.osha.gov/SLTC/arsenic/index.html

2 "ToxFAQs for Arsenic." Department of Health and Human Services: Agency for Toxic Substances and Disease Registry. August 2007. Available at http://www.atsdr.cdc.gov/tfacts2.html

3 "Arsenic Poisoning in India and Bangladesh" SOS – Arsenic.net. Last Updated September 15, 2008. Available at http://www.sos-arsenic.net/
4 ibid
5 ibid
6 Pearce, Fred. "Arsenic in the Water." The Guardian. February 19, 1998. Available at: http://www.lifewater.ca/887805655-arsenic.htm
7 Stone, Richard. "Arsenic and Paddy Rice: A Neglected Cancer Risk?" Science Magazine. July 11, 2008. Vol 321
8 libid
9 "Arsenic Poisoning in India and Bangladesh" SOS – Arsenic.net. Last Updated September 15, 2008. Available at http://www.sos-arsenic.net/

resistant to rotting, fungus and insects. The treated wood often releases arsenic and arsine gas into the environment, especially when burned.[10]

Exposure Pathways

The main way arsenic enters and harms the body is through ingestion. Arsenic can also enter the body by inhaling air containing arsenic dust, or absorbed through skin when in direct contact.

Sources of arsenic in drinking water can come from mining or industrial activities, leaching from old waste dumps, as well as from past use of arsenic-containing pesticides. It can also be naturally introduced into the water when minerals and ores dissolve into groundwater that flows through arsenic-rich rocks.

Health Effects

Ingesting large amounts of inorganic arsenic is the most common way humans die from arsenic poisoning. When small amounts of inorganic arsenic are ingested it can result in nausea, vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and also cause a 'pins and needles' sensation in the hands and feet.[11]

Arsenic is also a known carcinogen, and although cancers may not show up until years after the onset of arsenic exposure—various cases of skin, liver, bladder, and lung cancers are known to develop from chronic arsenic exposure. Damage to the central nervous system can also occur from chronic exposure. If small amounts of arsenic are consumed or breathed in over an extended period of time small 'corns' or 'warts' can develop on the palms, soles, and torso. It can also cause changes in skin pigmentation.[12] Inhaling airborne concentrations of inorganic arsenic can cause sore throats and irritate the lungs. Inorganic arsenic can also cause redness and swelling if contact with skin occurs.

10 "ToxFAQs for Arsenic." Department of Health and Human Services: Agency for Toxic Substances and Disease Registry. August 2007. Available at http://www.atsdr.cdc.gov/tfacts2.html
11 ibid
12 ibid

Some sites which have been noted as examples of the problem

Zimapán, Hidalgo, Mexico
Chandipur, Laxmipur, Bangladesh
Samta, Jessore, Bangladesh
Dhaka, Bangladesh
West Bengal, India

What is Being Done

Significant efforts are being made to help remediate the problem of arsenic-laden drinking water. The World Bank is leading "The Arsenic Mitigation–Water Supply Project" for Bangladesh to help identify arsenic-contaminated wells used for drinking water, and test groundwater quality.[13] Within Bangladesh, efforts have focused on labeling all the contaminated wells, providing alternatives for safe drinking water, and developing low cost treatment systems.

Environments severely polluted by near-by arsenic ore mines and processing plants have experienced some level of remediation and rehabilitation to prevent further contamination by arsenic.

13 "Projects – Bangladesh: Arsenic Mitigation Water Supply" The World Bank. Last Updated September 25, 2008. Available at http://web.worldbank.org/external/projects/main?pagePK=104231&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P050745

Living with Arsenic - Bangladesh

The contamination of groundwater by arsenic in Bangladesh is referred to as "the largest poisoning of a population in history" by the WHO.[1] Millions of people in the country are at risk of drinking arsenic contaminated well-water, as the wells provide water for 90 percent of the population.[2] Bangladesh has already experienced at least 100,000 cases of skin lesions, and an estimated 3,000 deaths a year due to arsenic.[3]

1 World Health Organization. Factsheet: Arsenic in drinking water. May 2001. http://www.who.int/mediacentre/factsheets/fs210/en/index.html
2 ibid
3 Smith, Allan H.; Lingas, Elena O.; Rahman, Mahfuzar. "Contamination of drinking-water by arsenic in Bangladesh: a public health emergency." Bulletin of the World Health Organization, 2000.

CADMIUM

Description

Cadmium is a natural element commonly found in all soil and rocks and typically extracted during the production of other metals such as zinc, lead or copper. About 75 percent of all cadmium in the world is used in batteries.[1] The other 25 percent of cadmium is used in many other products such as pigments, metal coatings, and plastics.[2] Cadmium does not corrode easily, and can be used in equipment for the control of nuclear fission.[3]

Context

Since cadmium is a by-product from mining, smelting, and refining zinc, lead or copper mineral ores, these industrial activities can release cadmium into the environment through waste streams.[4] Once in the environment, cadmium does not break down and binds strongly to soil particles. It is toxic at even low concentrations and will bioaccumulate in fish, plants and animals. Cadmium is a commonly found pollutant in groundwater and rivers.

Cadmium enters the environment in several ways. Primary sources of airborne cadmium come from fossil fuel combustion, burning of municipal waste, smelting or refining other metals, as well as through cigarette smoke.[5]

Waterways become polluted when cadmium is released via waste streams of factories that process cadmium and other metals. Cadmium can also pollute water and soil as a result of poor waste disposal, spills or leaks at hazardous waste sites.

In addition, cadmium can enter the food chain when agricultural fields are irrigated with contaminated water and when phosphate-based fertilizers or sewage sludge containing cadmium are used as nutrients during agricultural production in various countries.[6]

1 Commodity Research Bureau, Inc. The CRB Commodity Yearbook 2004. Hoboken: John Wiley & Sons, Inc, 2005. <http://libaccess.lib.mcmaster.ca/login?url=http://www.MCMU.eblib.com/EBLWeb/patron/?target=patron&extendedid=P_225817_0&userid=^u>.
2 "Chemical properties of Cadmium – Health effects of Cadmium – Environmental effects of Cadmium." Lenntech: water treatment and air purification.Available at http://www.lenntech.com/periodic-chart-elements/cd-en.htm
3 Agency for Toxic Substances and Disease Registry (ATSDR). "Toxicological Profile for Cadmium." Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. June 1999. Available at http://www.atsdr.cdc.gov/tfacts5.html
4 "Chemical properties of Cadmium – Health effects of Cadmium – Environmental effects of Cadmium." Lenntech: water treatment and air purification.Available at http://www.lenntech.com/periodic-chart-elements/cd-en.htm

5 U.S. Environmental Protection Agency. "Cadmium Compounds." Technology Transfer Network Air Toxics Web Site. Last Updated November 6, 2007. Available at http://www.epa.gov/ttn/atw/hlthef/cadmium.html
6 "Cadmium Exposure and Human Health." Cadmium. Available at http://www.cadmium.org/env_exp.html
-http://www.npi.gov.au/database/substance-info/profiles/17.html

Exposure Pathways
In general, cadmium enters the body through inhalation, ingestion, and absorption through the skin. Humans are typically exposed to cadmium mainly through drinking or eating contaminated foods, smoking cigarettes, breathing contaminated air near fossil fuel plants or processing facilities and through occupational exposure.[7]

Health Effects
Short term exposure to cadmium can cause effects to the lung, such as pulmonary irritation, chest tightness, cough and nausea.[8] Long term inhalation of cadmium can result in high concentrations in the kidneys, lungs, and blood and lead to kidney and lung disease.[9] Cadmium is also linked to an increased risk of lung cancer. Other health effects include diarrhea, stomach pains, vomiting, bone fracture, reproductive failure, central immune system damage, fatigue, and loss of smell.

Some sites which have been noted as examples of the problem
Copsa Mica, Romania
Plachimada, India
Mae Tao River Basin, Thailand

What is Being Done
In addition to efforts to reduce emissions from production facilities, a number of National Collection and Recycling Associations (NCRAs) have been created around the world to promote the collection and recycling of all batteries, both from the general public and from industrial consumers. Nickel-cadmium batteries are virtually 100% recyclable once they have been collected. Today, there are 9 major NiCd battery recycling plants located in the United States, Europe and Japan capable of recycling approximately 20,000 metric tons of industrial and consumer NiCd batteries and their manufacturing scraps. There is more than adequate capacity to recycle all NiCd batteries presently being collected. In addition, anti-smoking programs have been introduced in many countries, which, if effective, reduces cadmium exposure.

7 ibid
8 U.S. Environmental Protection Agency. "Cadmium Compounds." Technology Transfer Network Air Toxics Web Site. Last Updated November 6, 2007. Available at http://www.epa.gov/ttn/atw/hlthef/cadmium.html
9 ibid

CHROMIUM

Description

Chromium (Cr) is a metallic element whose principal ore is chromite. These are found mainly in Russia, South Africa, Albania, and Zimbabwe.[1] Chromium is produced when the chromite is smelted with aluminum or silicon.[2] The metal has a number of uses, including steel making, metal planning and tanning. Chromium in the environment can be found in several forms, of which the trivalent ion (chromium+3) and the hexavalent ion (chromium+6) are of most concern. The latter (hexavalent) is the most toxic form.

Context

Elemental chromium is primarily used as a component of steel and other alloys. Trivalent chromium is used to make other metals and alloys, but is also used in refractory bricks and other chemical compounds. Chromium compounds in both trivalent and hexavalent forms are used for chrome plating, dyes and pigments, leather tanning and wood preserving.[3]

Chromite mining, can release chromium compounds into the environment, particularly into water. Further processing of the ore, particularly for use in tanning, produces wastes that can be highly polluting if not properly managed.

Elemental chromium and hexavalent chromium are typically produced by industrial processes, while trivalent chromium can be naturally occurring as well as a by-product of industry.[4]

When chromium compounds are used for electroplating, a thin layer of chromium is coated onto another metal such as nickel or iron, using an electric charge. Electroplating operations tend to produce large amounts of wastewater containing heavy metals, including chromium.

The leather industry uses chromium compounds in the process of tanning animal hides and skins, both to preserve them and to produce a tough, supple texture that is resistant to biodegradation, and ready to be further dyed. The methods employed by tanneries often produce large amounts of residues that can be harmful to the environment, including chromium wastes, hair, salts, and fleshing residues. In small scale or uncontrolled tanneries, these residues and the wastewater from the process are sometimes dumped into the surrounding area. For reasons of logistics, tanneries

1 "Chromium Toxicity Exposure Pathways." Case Studies in Environmental Medicine. Department of Health and Human Services: Agency for Toxic Substances and Disease Registry. Last Updated July 6, 2000. Available at http://www.atsdr.cdc.gov/csem/chromium/exposure_pathways.html
2 "ATSDR – Toxicological Profile: Chromium" U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. September 2000. Available at http://www.atsdr.cdc.gov/toxprofiles/tp7.pdf
3 ibid
4 ibid

are often located in clusters, which can include large number of individual operations and which can have a serious cumulative impact on the environment.

Exposure Pathways

Chromium compounds are typically found near industrial sites that process or use chromium. Such compounds can pose a health threat if inhaled or ingested

Waterways can become polluted with chromium if leather tanning, electroplating, or textiles industries release large amounts of wastewater containing chromium into surface waters. Solid wastes containing chromium that are not properly disposed of may also leach chromium down into the groundwater.

Chromium compounds, particularly hexavalent chromium, can become airborne as dust, a fume, or mist through combustion processes and inhaled by workers as well as nearby residents.[5]

Dermal contact may occur through handling chromium directly or coming in contact with water containing chromium wastes.

Health Effects

Typically, health effects from chromium only occur at high levels of exposure. Health impacts resulting from acute and chronic exposure to high levels of chromium can affect the kidneys, skin, eyes, and the respiratory system, and cause a variety of health problems such as lung cancer, kidney dysfunction, respiratory irritation, bronchitis, asthma, and skin rashes.

Inhaling high levels of chromium dust can cause irritation to the nose and throat, such as runny nose, nosebleeds, sneezing, coughing, with prolonged exposure leading to the development of sores and even holes in the nasal septum.[6]

Ingesting large amounts of chromium can upset the stomach, cause kidney and liver damage, stomach ulcers and even death.

Skin contact with certain chromium compounds can also result in allergic skin reactions, ulcers or rashes, where the skin swells, becoming red and itchy.

Some sites which have been noted as examples of the problem

Hazaribagh, Bangladesh
Orissa, India
Ranipet, Tamil Nadil, India
Alpharama Tanneries, Athi River, Kenya
Meycauayan, Philippines
Mikocheni, Dar es Salaam, Tanzania

What is Being Done

A number of new technologies have been developed to treat chromium contamination of soil and water, such as enhanced extraction techniques, chemical reduction, and biological processes. Many of the current remediation efforts first focus on reducing chromium(VI) to chromium(III), mainly because chromium(III) is generally less toxic and less mobile. In Kanpur, India Blacksmith Institute partnered with the local NGO, Ecofriends and the Central Pollution Control Board to help clean up water contaminated with chromium sulfate from local tanneries. The trial program treated polluted water with certain chemicals to stabilize the chromium, and was successful in lowering chromium levels in the water.

5 "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

6 "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

COAL POWER PLANTS

photo credit: Andreas Haberman

Description

Coal-fired power plants are the leading source of electricity for the world, and is the primary source of electric power for many countries.[1] An estimated 4050 million tons of coal are consumed worldwide each year, and almost 40 percent of the world's electricity is supplied by coal.[2] As a result , coal plants are one of the biggest sources of air pollution for many areas of the world, releasing particulates, nitrogen oxides, sulfur dioxide, mercury and carbon dioxide into the atmosphere.[3] Because of its widespread, and inadequately regulated proliferation, this dependence on coal is a growing hazard to human health and the environment.

Context

Coal is an abundant and cheap source of energy. According to the OECD "World Energy Outlook, 2006", coal is the world's most abundant fossil fuel with global reserves at around 909 billion tons.[4] The construction of coal plants for mass power generation is also significantly cheaper than other types of power plants, and there are constant improvements in cost efficiency through new technologies and mining productivity. These factors have resulted in a dominance of coal in electric power generation throughout the world. Cheap energy is particularly desirable for developing countries, as they strive for rapid industrialization.[5] Therefore the problem of polluting coal plants is more severe in these areas of the world. For example, Poland uses coal for 94 percent of all its electricity, and China relies on coal to supply 77 percent of its total electricity.[6]

Exposure Pathways

Coal power plants release large amounts of pollutants into the atmosphere that affect people directly; settle as a fine particulate matter on soil and agricultural crops; react with moisture in the air to form acidic vapors; or end up in waterways. In addition, coal-fired power plants are the largest source of worldwide mercury and carbon dioxide emissions into the atmosphere.[7] Direct exposure to the air emissions (or by-products) is a key pathway for large numbers of people.

Pollution control equipment can achieve significant reductions in the volumes of particulates, but then these

1 U.S. Environmental Protection Agency, "EPA to Regulate Mercury and Other Air Toxics Emissions from Coal- and Oil-Fired Power Plants." December 14, 2000. Available at http://www.epa.gov/ttn/oarpg/t3/fact_sheets/fs_util.pdf
2 "Coal Facts." World Coal Institute 2007 Edition. October 2007. Available at http://www.worldcoal.org/assets_cm/files/PDF/fact_card07.pdf
3 Energy Information Administration, "Emissions of Greenhouse Gases in the United States 2004." December 2005. Report #: DOE/EIA-0573(2004)
4 Kunzemann, Thilo "Coal Energy Profile: Dirty Power" Energy Profiles. Allianz Knowledge. Available at http://knowledge.allianz.com/en/globalissues/energy_co2/energy_profiles/coal.html
5 Russell, James. "Coal Use Rises Dramatically Despite Impacts on Climate and Health." Worldwatch Institute. January 28, 2008. Available at http://www.worldwatch.org/node/5508
6 Wan Zhihong. "Coal price rise hits electricity producers." China Daily. December 19, 2007. Available at http://www.chinadaily.com.cn/bizchina/2007-12/19/content_6414959.htm
7 U.S. Environmental Protection Agency, "EPA to Regulate Mercury and Other Air Toxics Emissions from Coal- and Oil-Fired Power Plants." December 14, 2000. Available at http://www.epa.gov/ttn/oarpg/t3/fact_sheets/fs_util.pdf

systems result in very large quantities of very fine "fly ash" which has to be disposed in a sound manner. This ash is usually pumped as a slurry into large ponds, which can release the material as a "mud" or as dust, if not properly controlled.

Coal plant pollution is not only affects surrounding communities, but also can travel long distances and pollute from faraway. For example, coal particles from Chinese coal plants have been linked to increased mercury levels in the bass and trout caught in Oregon's Willamette River.[8]

Health Effects

Emissions from coal-fired plants, which are a key component of air pollution in some districts, can contribute to a wide range of health problems, including chronic and life-threatening diseases like asthma, respiratory infections, allergies and heart ailments. Fine particulate matter that becomes airborne is also harmful to human health and known to cause damage to the respiratory system or even reach the bloodstream to affect the cardiovascular system. The heavy metals in coal pollution also cause neurological damage and developmental problems.[9]

It has been projected that the sulfur dioxide produced in coal combustion has contributed to about 400,000 premature deaths for Chinese citizens each year.[10] A study conducted by Norway's Center for International Climate and Environmental Research concluded that pollution from a city in China's top coal-producing region of Taiyuan has increased death rates by 15 percent and chronic respiratory ailments by 40 to 50 percent.[11]

Some sites which have been noted as examples of the problem

Datong, China
Taiyuan, China

Coal plants – Chongqing, China
In Chongqing, China,

According to Scientific American: "There is no true horizon in this inland port city ... This "furnace" of China, as it's known, is akin to the entire Rust Belt of the U.S. crammed into a single community of 30-plus million people (twice the size of the New York City metropolitan region)—and its residents breathe air filled with so much lung-clogging soot that it would fail both U.S. and European Union (E.U.) safety standards.

"The choking smoke produced by all that coal burning insinuates itself into the lungs of Chinese men, women and children and costs China an estimated $100 billion in health costs associated with respiratory ills, according to the World Bank. Further, it can literally stunt the growth of the next generation in this city in the heartland of China, according to recent research from Frederica Perera of Columbia University and her colleagues.[1]"

1 http://www.sciam.com/article.cfm?id=can-coal-and-clean-air-coexist-china

What is Being Done

A variety of solutions are being implemented to address the issue of dirty coal plants. The most straightforward involve either improving coal power technologies to be less polluting, or promoting alternatives for energy sources in power generation. However the substitution of coal by other sources will happen slowly in key economies such as India and China, due to economic factors. Cleaner coal (better processed at the mining stage to improve quality) is a basic step. More efficient combustion systems reduce the volume of pollutants produced per unit of energy. Effective pollution control systems to reduce emissions are increasingly being required, especially in new plants. Many old, inefficient coal plants are getting shut down and a new generation of less polluting plants is emerging – at least in industrialized nations. Nevertheless, there remain many areas in developing countries where coal plants are a major source of pollution.

8 "Chinese coal plants cause health problems around the world." CNN. November 13, 2007. Available at http://www.cnn.com/2007/WORLD/asiapcf/11/13/pip.coal.ap/index.html
9 U.S. Environmental Protection Agency, "EPA to Regulate Mercury and Other Air Toxics Emissions from Coal- and Oil-Fired Power Plants." December 14, 2000. Available at http://www.epa.gov/ttn/oarpg/t3/fact_sheets/fs_util.pdf
10 Bradsher, Keith; Barboza, David. "Pollution from Chinese Coal Casts a Global Shadow." New York Times. June 11, 2006. Available at http://www.nytimes.com/2006/06/11/business/worldbusiness/11chinacoal.html?_r=1&scp=1&sq=china%20coal&st=cse&oref=slogin
11 "Chinese coal plants cause health problems around the world." CNN. November 13, 2007. Available at http://www.cnn.com/2007/WORLD/asiapcf/11/13/pip.coal.ap/index.html

GARBAGE DUMPS

Description

Across the planet each person on average, produces somewhere between 0.2 and 1 kilogram of solid waste (garbage) per day, depending on a wide range of factors, not counting industry and construction activities, which produce even larger quantities. Much of the solid waste in developing countries is dumped into piles of varying size. From mounds along roadways, to dumps acres wide, these areas are unlined, and completely exposed to the elements , leading to contamination of the surrounding environment as materials degrade.

Major cities such as Lagos, Manila or Dhaka, all with populations above 10 million, are producing 5-7,000 tons per day of solid waste, of which some portion (between 30 and 70%) is actually collected and taken to a recognized “dumping place”. Figures indicate that a city of 1 million people (there are about five hundred worldwide) produces approximately 500 tons per day, every day, not including industrial waste.

Context

As communities grow larger, denser and often economically better off, more goods are consumed and more material is thrown away. In every city there are groups of people who will take waste from households, either for a small fee or for the value of what can be scavenged. Despite these collection activities, most of the waste is dumped in drainage ditches or any patch of wasteland. Eventually, by varying circumstances, large dumps appear.

These dumps can be several hectares in size and 20 meters or more high. They typically burn and smoke (due to the gas released as the material rots), and seep large quantities of corrosive liquid (“leachate”), which pollutes both ground and surface water. Often these dumps are colonized by poor families that extract a modest living from scavenging activities on the dumpsite.

These dumps are generally noxious and although they mainly pose an acute health hazard to the residents, they also contaminate the local atmosphere, support various kinds of vermin, and can pollute local waterways to a dangerous degree. Dumps are often used as open toilets and fecal contamination of the land and nearby waterways is common. Actions to improve the conditions of dumps are needed, but the problems are often too massive for developing country governments to fully address at present.

Exposure Pathways

The most immediate impacts are on the “ragpickers” who live on or beside the dumps.[1] These are members of the lowest level of the working class, often women or children from impoverished rural areas. People living on a large dump may number in the hundreds, while people involved with the “informal recycling” industry in

1 da Silva et al. “World at work: Brazilian ragpickers.” Occup Environ Med. 2005; 62: 736-740

a large city, including those who collect from homes or pick up along streets, may number in the tens of thousands. These people are directly exposed to the general filth, including medical waste and human excreta, as well as sharp edges and toxic materials.

Most dumps are located in or close to densely populated areas, often slums, since very poor people also seek the uncontrolled wastelands as a place to camp and eventually build shanties. As a result, many thousands, are exposed daily to the dust, fumes and smoke from the dumps. Their water is usually contaminated by hazardous leachate and close interaction with dumping areas exposes them to pathogens and toxics.

In the worst cases, dumps pose a direct physical threat to nearby residents. Pockets of gas can explode and injure people and the slow but relentless expansion of dumps can physically displace people. In an infamous case in Manila, a landslide of a 15 meter high dump is estimated to have buried and killed about 200 people in the adjoining shanty town.[2]

Health Effects

Typical health issues reported for dump scavengers include a high prevalence of childhood respiratory illness and poor lung function for adults; symptoms such as headache, diarrhea, skin diseases and back pain; cuts and punctures from sharp materials; poor nutritional status and infection by intestinal protozoa and parasitic worms.

2 Mydans, Seth. "Before Manila's Garbage Hill Collasped: Living off Scavenging." New York Times. July 18, 2000. Available at http://query.nytimes.com/gst/fullpage.html?res=9803E2DA133BF93BA25754C0A9669C8B63&sec=&spon=&pagewanted=all

The health effects on those living in proximity to the dumps include respiratory problems and possible impacts from contaminated water, including local crops. Given the typically poor living conditions in communities bordering dumps, it is difficult to distinguish the specific contribution of the dump to overall poor health status.

Some sites which have been noted as examples of the problem

Every city in the world has to deal with large amounts of garbage. In the developed world, decades of effort and investment have managed to bring about the use of sanitary landfills, which dramatically reduce the impacts of waste disposal. Most developing countries however are struggling to cope with the impacts of the dumps due to their sizes and locations.

What is Being Done

Recycling is part of the effort to reduce the relentless generation of waste, however dealing with the old, existing dumps poses the greatest challenge. Solid waste management in any given city costs a great deal of money. Half of a developing city's budget may go to waste management – mainly in paying the sanitation workers – and still that is only slowly resolving one part of the dumping problem. A modern landfill can cost $5-10 per ton to build and operate, which represents about $1m annually for a small city – money often not available. Cleaning up old burning dumps, which can contain millions of tons of rotting waste, is a very slow and piecemeal business. At best, dumps can be contained, slowly covered and eventually turned into some form of useful open space.

INDUSTRIAL ESTATES

Description
Industrial estates, known under many other names, are large areas of land (often hundreds of hectares) which are designated for general or specific industrial activity.[1]

Context
There are nearly 10-12,000 industrial estates worldwide, with an estimated 4,500 or so in Asia. They can contain anything from a handful of firms up to several hundred, of all types from high tech to basic industrial production. When well run, the estate provides environmental services for all the firms, but in the worst cases they can represent a large collection of highly polluting sources. Serious air pollution, heavy contamination of waterways and illegal dumping of hazardous wastes are consequences of estates where industrial growth is put before environmental management.

Industrial estates often operate under special regulatory regimes, intended to attract and promote industry, sometimes with specific incentives for export activities. They can range from very modern "IT City" complexes to clusters of small ad medium enterprises in profitable but dirty sectors such as tanning or textiles. Many "estates" resemble small industrial cities with numerous problems.

Exposure Pathways
Multiple pathways are involved. Air pollution is typically a problem caused by individual plants, although centralized power production can reduce the overall emissions somewhat. Water pollution is usually an issue because of individual discharges to local waterways or into the ground, unless control of wastewater is at a high level. Even where central effluent treatment plants are installed, typical systems cannot cope with the mix of pollutants coming from the estate, particularly when the required industrial pre-treatment is inadequate. As a result, effluents going into the surrounding waterways are often variable or do not meet standards. Toxic waste is usually not managed in a safe and environmentally sound way, because of the costs, and so illegal dumping can threaten the health and livelihood of nearby communities.

Health Effects
The health effects of badly controlled estates include all the same impacts as any industrial complex, depending to some extent on the actual mix of industries involved. They include respiratory problems, various internal effects of contaminated water, dermal conditions and so on.[2] It is often a challenge to match the symptoms to the sources.

Some sites which have been noted as examples of the problem
Virtually every country in the world, except the most rural, has some form of industrial estate. Vietnam and Sri Lanka are two countries that have been estimated to have about 50-60 such estates. India and China have hundreds of industrial clusters, not all of which are formally estates. In Africa, Nigeria has industrial estates in all of the major states.

1 "Industrial Estates." Pollution Prevention and Abatement Handbook. World Bank Group. July 1998. Available at www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_indusestates_WB/$FILE/industrialestates_PPAH.pdf

2 Iqbal, Nasir. "Supreme Court takes up industrial pollution issue again. Dawn. September 9, 2007. Available at http://www.dawn.com/2007/09/09/nat7.htm

What is Being Done

The challenge is to upgrade the level of control and of environmental management in the worst of the estates. There are good examples in all countries. These are often where leadership is taken by international companies (local or foreign) who are trying to operate global standards. Unfortunately, since upgrading environmental performance requires effort and money, there are estates where low management charges are reflected in bad environmental performance. The key requirement is essentially enforcement of environmental requirements, since the process upgrading and control techniques are widely available

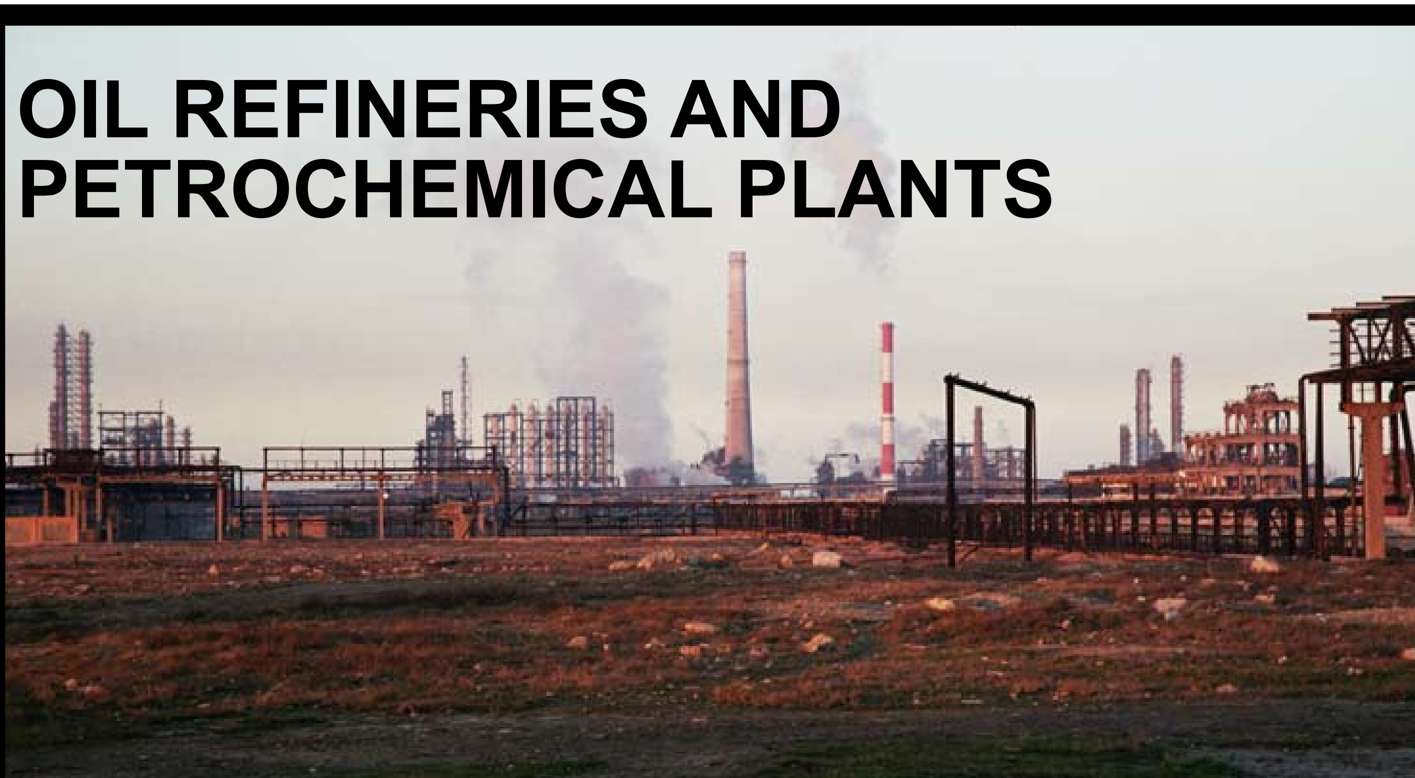
Progress in countries such as Thailand shows that improving industrial estate performance to acceptable levels, where the resources and the political will exist.

Industrial estates can bring advantages by reducing land use conflicts and of economies of scale in providing infrastructure. They can improve environmental management by providing cost-effective centralized facilities and – in the ultimate – evolve into "industrial ecosystems" with internal use of waste for feedstocks and high levels of recycling. However, in practice, centralized effluent treatment plants (CETPs) have a mixed record of performance and dealing with hazardous waste remains an issue in many developing countries.

In the end, estates need strong management and adequate finance.[3] Good enforcement of regulations is essential but this faces the typical problems of political support, especially since estates are often important sources of employment.

3 "Environmental Guidelines for Industrial Estates." Multilateral Investment Guarantee Agency. Pages 397-400. www.miga.org/documents/IndustrialEstates.pdf

OIL REFINERIES AND PETROCHEMICAL PLANTS



Description
An oil refinery is a major chemical processing plant that converts crude oil into commercial products such as fuels, lubricants, and feedstock for other downstream processes. [1] There are over 2,500 products that refineries produce including petrochemicals, asphalt, diesel fuel, fuel oils, gasoline, kerosene, liquefied petroleum gas, lubricating oils, paraffin wax, and tar.[2]

Context
The many and complicated processes and equipment, employed at oil refineries can allow the escape (or deliberate release) of various volatile chemicals into the atmosphere, resulting sometimes in high levels of air pollution emissions, and often a foul odor in communities surrounding the refinery.[3] Oil refineries also can cause pollution problems by releasing of inadequately treated wastewater to rivers, improperly managed spills infiltrating into groundwater, and consequences of industrial accidents. Typically, processing one ton of crude oil, refineries can produce up to 3.5 to 5 cubic meters of wastewater, and 3 to 5 tons of solid waste and sludge.[4]

1 "Refinery Plant: How it works." General Electric Oil and Gas. 2008. Available at: http://www.geoilandgas.com/businesses/ge_oilandgas/en/applications/refinery_plant.htm
2 Gary, James H.; Handwerk, Glenn E. Petroleum Refining: Technology and Economics. Fourth Edition. 2001.
3 "The Compilation of Air Pollutant Emission Factors, Volume I, Fifth Edition, AP 42" Chapter 5: Petroleum Industry: Petroleum Refining. U.S. Environmental Protection Agency. November 1997. Available at http://www.epa.gov/ttn/chief/ap42/ch05/final/c05s01.pdf
4 "Petrochemical Company" Lenntech: Water treatment and air purification. Available at http://www.lenntech.com/petrochemical.htm

The world consumes approximately 82 million barrels per day of refined petroleum products.[5] Raw or unprocessed ("crude") oil is not useful in its natural state and generally requires refining into a myriad of products for everyday use. Processing of crude oil for fuel results in losses to the environment and creates highly toxic wastes .

Exposure Pathways
Sources of exposure include air emissions, wastewater effluents, inappropriate disposal of waste products, the leaching of pollutants into waterways or failures in equipment causing spills or leaks.
Pollutants from oil refineries can enter the body in a variety of ways such as inhalation of vapors, absorption through dermal contact with spills or liquid wastes, or ingesting food and water contaminated by pollutants.

Health Effects
People living near oil refineries may suffer from respiratory problems and diseases such as cancer, skin lesions and harm to the digestive track due mainly to tainted water consumption. Exposure to crude oil may cause kidney failure, liver failure, altered blood chemistry, reproductive impairment, lung damage, and

5 "International Petroleum (Oil) Consumption Data." Energy Information Administration. Last Updated August 6, 2007. Available at http://www.eia.doe.gov/emeu/international/oilconsumption.html

nervous system damage in animals and wildlife.[6] The mixture of chemicals in crude oil and other oil products, such as benzene, xylene, and toluene are among the most prevalent organic pollutants. However, data linking the health impacts to identified sources does not often exist.

Some sites which have been noted as examples of the problem
Digboi, India
Haldia, India
Niger Delta

What is Being Done
Environmental standards and specific requirements which oil refineries and related petrochemical plants are required to follow exist in many countries. However, enforcement and compliance are often weak and concerns still exist that current control measures are often not enough. The avid environmental justice issues in many oil-producing developing countries indicate that stricter limits are needed.

Having an Oil Refinery in Your Neighborhood: Salamanca, Guanajuato, Mexico

According to media reports and some local NGOs, children in Salamanca, Guanajuato, Mexico, are advised to stay indoors. They cannot play outside because of fears that the toxic cloud of gases from the oil refinery will cause vomiting, dizziness, head and stomach aches or respiratory infections. The pollution in the air is considered incredibly dangerous by the local environmental group Fuerza Salmantina, and the government agency SEMERNAT labels Salamanca to be one of the 31 most polluted cities in Mexico. The pollution from Salamanca was also reported in a study by the state's Congress to make up 92.8 percent of total pollution generated in the 46 municipalities of the state.

Álvarez, Xóchitl. "Industrial Pollution Plagues Residents." El Universal. July 22, 2006. Last Accessed October 13, 2008. Available at http://www.eluniversal.com.mx/miami/19404.html

see also:
http://www.lajornadasanluis.com.mx/2005/08/09/pol1.php

6 "Toxic Tundra" Audubon: Defenders of Wildlife. 2002. Available at http://www.audubon.org/campaign/arctic_report/toxic_drilling.html

OLD AND ABANDONED CHEMICAL WEAPONS

Description
Chemical weapons are classified as arms that utilize toxic chemical substances to harm or kill an enemy during warfare. According to the international Chemical Weapons Convention, there are over 50 different chemicals that have been produced specifically for use as weapons during warfare (also known as chemical weapons agents or CWA)[1]. Most chemical weapons produced have either been used on the battlefields of WWI (more than hundred thousand metric tons), sea-dumped in one of the many oceans during the 50s and 60s (several hundred thousand metric tons) or are still stored in stockpiles worldwide (about 70'000 metric tons). These stockpiles are extremely dangerous if they would not be adequately maintained and guarded.

Context
Old and abandoned chemical weapons (OCW/ACW) stockpiles can be found in nearly every country that produced or stored chemical weapons or where chemical weapons were deployed during war. The most common methods of OCW disposal historically have been sea-dumping, burial or open-air incineration. During the large weapons destruction campaigns after WWII, hundreds of thousands of tons of OCW were transported to the nearest ocean port, loaded on boats and then dumped into the sea. Weapons not suitable for long distance transport were often buried (resulting in leaking of the shells after long term corrosion), burned in open pits or the chemical agent was poured into lakes. As a result, traces of un-destroyed chemical agent or products of its destruction (dioxines, furanes, arsenic, acids, etc.) are leaching today into the surrounding environment. Buried shells are often discovered by chance (e.g. during construction projects), the long term corrosion making identification of the contents difficult and the shells dangerous to handle.
While the destruction of military deployable chemical weapons is under way globally under the auspices of the Chemical Weapons Convention, OCW/ACW remain a difficult issue. A major challenge is that almost no archive data exists about the location of OCW/ACW sites and most findings are chance discoveries. The number of OCW/ACW sites is not well known. The locations of OCW/ACW types and sites has been as diverse as unexploded shells on WWI battlefields in Europe, shells sunk in Japanese ports, Japanese shells left in Northern China, or shells incinerated or buried in Russia and the U.S. Numbers can also vary from a few shells up to burial sites with thousands of shells. The U.S. Army has defined more than two hundred sites with OCW in the U.S. In Russia, experts estimate the existence of some dozens of OCW sites.

Exposure Pathways
Chemical weapon agents or reaction masses from open-pit burning or dumping are highly toxic. Besides direct exposure, the main risk is the migration of these substances into the ground and drinking waters, where they quickly bioaccumulate in the food chain.

1 http://www.opcw.org/html/db/cwc/eng/cwc_annex_on_chemicals.html

Health Effects

According to the Organization for the Prohibition of Chemical Weapons, chemical agents fall into four general categories:

Choking Agents such as chlorine, phosgene, diphosgene and chloropicrin, are absorbed through the lungs and cause the build up of fluids, which leads to choking and eventual death.

Blister Agents such as sulfur mustard, nitrogen mustard, and lewisite burn the skin, mucous membranes and eyes, causing large blisters on exposed skin. When inhaled as a vapor, these agents can burn the windpipe and lungs, leading to death.

Blood Agents such as hydrogen cyanide, cyanogen chloride and arsine, prevent blood and tissue cells from accepting oxygen, causing rapid organ failure.

Nerve Agents such as tabun, sarin, soman, and VX, cause paralysis of muscles (including the heart and diaphragm), seizures and loss of body control. This is the most deadly group of warfare agent, lethal doses can cause almost immediate death[2].

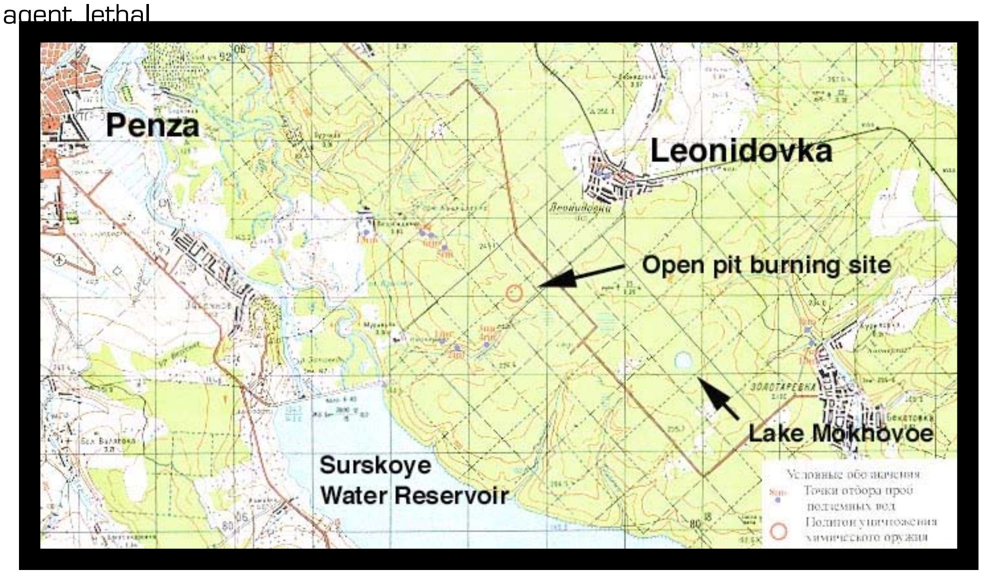
What is Being Done

The Chemical Weapons Convention (CWC) is an international treaty specifically aimed at eliminating military-deployable chemical weapons through prohibiting "the development, production, acquisition, stockpiling, transfer, and use of chemical weapons".[3] As of August 2008, there were 184 member states, and six countries with declared CW stockpiles, Green Cross Switzerland with its partner organizations Green Cross Russia and Global Green USA has been central in facilitating the timely and safe destruction of CWs in Russia and the U.S., which have been possessing together more than 90% of global CW stockpiles. In 2000, Green Cross Switzerland launched "Destroy Chemical Weapons Now," an international information campaign intended to raise awareness of the approximate 70,000 tons of toxic chemical weapons that still existed at that time throughout the world.[4] The organization has also encouraged international partnership toward global chemical disarmament, and effective implementation of the Chemical Weapons Convention. Starting 1997, Green Cross/Global Green has been building up a network of 12 local/regional public information and outreach offices in Russia and established an annual National Dialogue meeting which brings together all stakeholders Currently Green Cross is working with the Blacksmith Institute on the isolation of three open pit burning sites in Russia's Penza region, which threaten the drinking water supply of 600'000 people because of the migration of dioxines, furanes and arsenic released during the incineration process into Penza's drinking water reserve.

2 http://www.opcw.org

3 "Chemical Weapons Convention." Department for Disarmament Affairs. United Nations. Last accessed on September 22, 2008. Available at http://www.un.org/Depts/dda/WMD/cwc/

4 "Chemical Weapons Campaign" Available at http://www.greencross.ch/en/projects/chemicalweapons.html



A dead lake for drinking water?

The dumping of phosgene, diphosgen and picric acid in Lake Mokhovoe released approximately 740 tons of hydrochloric acid into the lake of 300'000m2. The water showed an extremely low pH-level of 1.5-2.5, killing every plant and animal in the lake. Even if the lake recovered a bit in the meantime, it remains decades after destruction at an unusually low pH-level of 4.2-4.8. As a result of the acidity of the water, there are still only few primitive life forms found in the lake today. This lake is closest to the only source of drinking water for the more than 500'000 inhabitants of Penza (Surskoe water reserve).

PCBs

Description

Polychlorinated biphenyls, also known as PCBs, are a group of man-made chemicals which are very resistant to decay and natural breakdown. PCBs typically exist as yellow, oily liquids or white, solid resins that do not burn or degrade easily.[1] In the past, PCBs were used in a variety of products, including coolants in electrical equipment, surface coatings, inks, dyes, adhesives, flame-retardants and even carbonless copy paper. However, as it became widely realized PCBs are persistent n the environment and hazardous to humans, production and use of PCBs has been banned in many countries.

Context

Although PCB production was banned, PCBs continue to pose human health risks. It is estimated that 30-70 percent of all PCBs produced remain in use and some production still goes on. Nearly 30 percent of all PCBs (about a thousand tons) are now located in landfills, in storage, or in the sediments of lakes, rivers, and estuaries.[2]

PCBs are released into the environment in many ways, including illegal or improper dumping of wastes from industries; leakage from electrical transformers containing PCBs; poorly maintained hazardous waste sites which contain PCBs; and waste incineration.

Once PCBs enter the environment, they do not readily break down and can be carried long distances in the air and waterways.[3] They tend to bioaccumulate and bioconcentrate in the fatty tissues of humans and animals.[4]

Exposure Pathways

PCBs are readily absorbed into the body and may persist in tissues for years after exposure.[5] Symptoms may be felt immediately, or they may be delayed for weeks or months..[6]

Skin absorption can also occur when directly handling PCBs, or if one is in an area where the chemicals were used, spilled, or dumped. PCBs can be ingested by eating fish and other seafood containing the chemicals, or drinking water contaminated by PCBs. Inhalation of PCB vapors is a possible exposure pathway as well.

1 "Polychlorinated Biphenyls (PCBs)" Wisconsin Department of Health Services. Last Updated December 1, 2004. Available at: http://dhs.wisconsin.gov/eh/chemfs/fs/PCB.htm
2 "Some Facts About PCBs." Clean Water Action Council of N.E. Wisconsin. Last Updated September 13, 1995. Available at http://www.wsn.org/cwac/pcbfacts.html
3 "Polychlorinated Biphenyls (PCBs): Basic Information." U.S. Environmental Protection Agency. Last Updated August 8, 2008. Available at http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/about.htm
4 Faroon, Obaid M.; Keith, L. Samuel; Smith-Simon, Cassandra; and De Rosa, Christopher T. "Polychlorinated biphenyls: Human health aspects." Agency for Toxic Substances and Disease Registry. World Health Organization. International Programme on Chemical Safety. 2003
5 "Polychlorinated Biphenyls (PCB) Facts." State of Missouri Department of Health and Senior Services. Substance Fact Sheets. Available at http://www.dhss.mo.gov/hsees/pcb.html
6 "Polychlorinated Biphenyls (PCB) Facts." State of Missouri Department of Health and Senior Services. Substance Fact Sheets. Available at http://www.dhss.mo.gov/hsees/pcb.html

PCBs tend to bind to soils, which fortunately can reduce the direct expose levels in many cases.

Health Effects
Since PCBs are chlorinated chemicals, they are soluble in fat and tend to accumulate in animal tissue, resulting in increased concentrations as they move higher through the food chain. High levels of PCBs which have built up in animal tissue eventually become toxic and cause health impacts. PCBs impair the function of the immune system, and may cause liver damage and digestive disturbance. They also have the potential to cause liver, skin, brain, and breast cancers.

Short-term exposure to PCBs may cause irritation to the skin, nose, throat, eyes and lungs. Long-term exposure to PCBs may cause a burning feeling in the eyes, nose and face; lung and throat irritation; nausea; dizziness; and chemical acne.[7]

Some sites which have been noted as examples of the problem
Site de Tombo, Conakry, Guinea
KPLC Transformer Facility, Nairobi, Kenya
Dandora Dumpsite, Kenya
Santo Andre, Sao Paulo, Brazil

What is Being Done
Many countries have severely restricted or banned the production of PCBs. The Stockholm Convention for Persistent Organic Pollutants is an international treaty targeting PCBs as one out of 12 toxic chemicals whose production should be banned.[8] The Blacksmith Institute is working to design treatment and storage plans for PCB pollution located in various countries.

7 "Polychlorinated Biphenyls (PCB) Facts." State of Missouri Department of Health and Senior Services. Substance Fact Sheets. Available at http://www.dhss.mo.gov/hsees/pcb.html
8 "Global clean-up of toxic PCBs." United Nations Environment Programme. June 10, 2004. Available at http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=399&ArticleID=4527&l=en

RANKING THE PROBLEMS AND TACKLING THEM

The pollution problems that have been discussed and summarised in the sections of this Report cover a wide range of pollutants, circumstances and impacts. In order to allow some comparison to be made between them and for a broad ranking to made of the importance of the problems, the same general approach to assessment has been applied as was used in the Top Ten report of 2007.

The fundamental criterion is the impacts on people, especially on vulnerable children.

The ranking approach applies a score to the three key parameters which control the eventual health impact of a pollution problem: the characteristics of the pollutant itself; he pathway by which it affects people; and the numbers of people who are impacted.

The approach is applied by the Technical Advisory Board which provides guidance to Blacksmith, drawing on the collective experience of many years dealing with the types of problems illustrated here.

To allow for easy comparison of the different problems discussed, a summary table has been prepared (Table 2).

	SITES IN BLACKSMITH DATABASE	ESTIMATED OCCURRENCE	LEVEL OF POLLUTION HAZARD	EXPOSURE PATHWAYS	NUMBERS OF PEOPLE AFFECTED	INTERVENTIONS AND FEASIBILITY	WHAT NEEDS TO BE DONE
Abandoned Mines	13	Limited, but can be common in traditional mining areas	High - metals mines in particular can disperse millions of tons of waste rock containing toxic heavy metals	Dust from mine waste, especially fine materials, can be ingested directly or though food as well as being breathed in. The surface and ground water may be routes by which people are affected	Typically thousands locally but many more where water catchments are impacted. Mining sites are often in remote mountain areas but in these areas the local and cumulative impacts can be very significant	May be able to protect communities at highest risk but usually need extensive moving of materials. Technically straightforward but costs at large sites can be in the millions of dollars	Keep a focus on communities impacted; intervene to cut pathways; stabilize and cover waste material to reduce exposures. Given the long history and large scale of many mining regions, government intervention is usually needed.
Agrotoxins and POPs	26	Very common because almost every large agricultural region uses pesticides and fungicides to control pest and improve yields. Manufacture of products is a related problem and out-of-date pesticides can be a particular challenge.	Moderate - many farm workers suffer acute poison each year; in areas where chemicals are over applied a range of chronic impacts are noted. Accumulation in the environment leads to legacy effects, as does waste from manufacture.	Skin contact or inhalation are risks for workers and local residents. The general population is exposed though accumulation in food or in water	WHO estimates that millions of field workers suffer some impact annually. The numbers exposed to chronic levels are probably similar. Over-use of Agrotoxins and agrochemicals in general is a worldwide problem.	Educating small farmers in proper use and reduced applications is difficult and not a priority for many governments. Better control of manufacture and formulation is feasible but requires will and resources.	The need to improve the quality and reduce the application of pesticides is increasingly accepted but will take long and sustained efforts to see progress. Banning of the worst toxins and replace my more effective options is a step forward. Control of manufacture and storage needs to be tightened, particularly in relation to out-of-date consignments. Needs to be an increase in national and regional management capabilities for inventorying, repackaging and destroying obsolete pesticides. Development of alternative disease control mechanisms to relieve reliance on pesticides.
Arsenic	14	Limited. Pollution typically either from mining and/or smelting or as residue from old chemical weapons or pesticides. Naturally occurring arsenic in groundwater recognized as a public health problem in some areas.	Pollution hazard is low. Arsenic is a traditional poison in high doses. Arsenic ingested in lesser amounts can cause both acute and chronic problems.	Main pathway is ingestion from water or food but also can be inhaled as dust or absorbed by contract through skin.	Those affected directly by polluted sites are in low numbers, except where river systems are polluted. Problems with arsenic in groundwater affect millions in Bangladesh and India. Problems being identified in other countries now.	Abandoned mines and processing areas need to be contained and/or cleaned. Very difficult to remove arsenic from water systems although simple systems have been developed for treating groundwater at point of use.	Mining and processing areas have to be identified so that contamination sources can be isolated from the environment. Sites polluted from other sources such as chemical weapons may be treated or simple isolated.

	SITES IN BLACKSMITH DATABASE	ESTIMATED OCCURRENCE	LEVEL OF POLLUTION HAZARD	EXPOSURE PATHWAYS	NUMBERS OF PEOPLE AFFECTED	INTERVENTIONS AND FEASIBILITY	WHAT NEEDS TO BE DONE
Artisanal Gold Mining	14	Common. Virtually every gold bearing area in developing countries has some form of artisanal mining activity and most use mercury.	High - large quantities of mercury are often used and much of it is dispersed into the environment during the process.	There are two main pathways. Mercury vapor is created when gold amalgam is heated. Mercury in water systems can be converted into bio-accumulating and toxin methyl mercury	There are informal gold mining communities in almost every large country in the developing world with often hundreds or thousands of people living and working in gold mining areas. In river systems such as the Amazon, millions are exposed to contaminated fish.	Mercury release can be significantly reduced by using simple retorts for gold recovery and by relatively simple changes in use of mercury in processing stages.	Interventions and improvements need to be brought to individual mining communities. A UN supported Global Mercury Program has had considerable success but much more needs to be done.
Cadmium	14	Limited. Typically occurs in mining and smelting wastes , in water and in air. Cigarettes are a source of airborne cadmium	Low. It is toxic but environmental concentrations are typically low. Likely to be associated with other heavy metals	Some airborne exposure, e.g. in mine tailings dust. Cadmium may enter food chain through uptake by crops.	In areas with mining waste issues, may be exposed populations with numbers in the hundreds. Likely to part of a suite of heavy metals.	Mining related problems addressed as part of broad tailings control, etc.	There are few, if any, measures that need to be taken specifically to address legacy pollution, outside of those related to mining.
Chromium		Limited. Particularly associated with mining of chromite ore and also with processing, especially for use in tanning	Moderate - hexavalent form is toxic and causes problems in drinking or irrigation water.	Drinking contaminated water or eating food which has been irrigated is a key route. Contact which high concentrations causes skin problems.	Typically hundreds directly affected by processing plants but can be very much larger numbers if water sources are polluted. There are many tannery clusters in developing countries, which often have chromium problems	Chrome dumps can be contained but this can be costly. Hexavalent chrome in groundwater can be converted to the less toxic form by injecting simple reagents but this is rarely economic, unless the problem is very limited	Dumps have to be removed, in order to prevent groundwater pollution. In mining areas, good practices can avoid release of chromium from the workings.
Coal Power Plants	6	Common. Coal fired power plants are common in many countries, especially in areas with coal resources. Levels of pollution control and of waste management are crucial.	Plants emit particulates, including traces of mercury that occur in the coal. The hazard lies in the huge quantities from a large plant. Materials trapped by the pollution control systems - fly ash - can cause serious dumping problems.	Poorly controlled air emissions can affect large areas, affecting people directly and contaminating soil. Ash ponds or dumps can release material which impacts water and land.	Power plants are one of the contributors to the air pollution problems that affect millions of people in some of the world's coal mining areas. Atmospheric transport of fine particles means that the effects can be identified across countries.	Modern plants with good air pollution control equipment are very much less of a problem than older plants. However, retro-fitting equipment can be very expensive. Fly ash continues to be a waste problem, despite efforts to reuse.	Dirty old plants need to be replace by modern cleaner ones. However, the demand for power means that old plants are not retired until they are completely obsolete.
Garbage Dumps	24	Very frequent. Every urban area has solid waste and unfortunately in most cases this gets dumped	Overall low - hazards are worst for those working on the dump and get less severe with distance away	People on the dumps are at risk from direct contact with sharp, contaminated and toxic materials. Neighbors suffer from smoke and dust blown from the dumps as well as from water contaminated by leachate.	May be hundreds living on a dump but tens of thousands in surrounding (often slum) areas. Virtually every urban area in the developing world has dumps which impact people and pollute the air and groundwater to a greater of lesser degree.	Closure of dumps is relatively straightforward in technical terms but is costly and involves social and institutional problems. The critical challenge is to develop managed landfills as an alternative, but finance is usually the sticking point.	Dumps are fundamentally a responsibility of local governments but these rarely have the financial resources and are politically unable to charge for waste management. Central governments can help and some mayors are successful but the long term solution probably has to wait until the cities are wealthier.
Groundwater Pollution	4	Very common. Shallow aquifers used for water supply, are impacted by pollution of water or ground above them. Latrines or septic tanks, as well as industrial waste, are causing increasing problems.	Moderate. Water traveling through the ground is eventually purified but shallow wells are frequently highly contaminated. Natural occurrence of arsenic in some areas has been a major health problem.	Mainly through drinking water from contaminated wells	Groundwater is a significant resource in almost all continents. Millions of people in many parts of the world rely on shallow wells (often called dug wells) for their water source but these are often contaminated.	Protection of groundwater requires dealing with the sources, for example by improved sanitation. In some cases, deeper or better constructed wells reduce the risk.	Managing groundwater is one of the big challenges in achieving safer water and sanitation. Small scale interventions can deal with some local problems but government policy and regulatory action are essential.

	SITES IN BLACKSMITH DATABASE	ESTIMATED OCCURRENCE	LEVEL OF POLLUTION HAZARD	EXPOSURE PATHWAYS	NUMBERS OF PEOPLE AFFECTED	INTERVENTIONS AND FEASIBILITY	WHAT NEEDS TO BE DONE
Indoor Air Pollution	1	Very widespread. Estimated that 80% of population in developing countries burn coal or biomass (dung, wood, waste etc) for cooking, heating and light. Most stoves are very inefficient and generate clouds of smoke and particulates.	Poor quality fuels releases large quantities of fine particulates which are a major factor in respiratory disease for adults and children. Inefficient stoves and lack of ventilation, which are the usual case, make the hazard much worst.	Inhalation is the key route although smoke and dust can also cause eye problems.	The total numbers exposed may be a billion. The critical number is the mothers and infants who spend hours over the fireplace and these may number hundreds of millions.	Until about the past decade, this problem was ignored - essentially because the victims are usually poor women. Cleaner fuels is a crucial step but development progress is the real answer. More efficient stoves, fuel switching, better ventilation etc can alleviate the problem.	Bringing change to millions of homes is a huge implementation challenge. Dealing with indoor air is increasingly on the agenda of development groups - both governmental and NGO. It is one aspect of the overall challenge of improving living conditions and in some cases needs to be addressed as a separate priority.
Industrial Estates	100	Common. Industrial estates/areas are common in almost all countries but very varied in content and in management. In principle have central waste and wastewater facilities but reality may differ.	Concentration of industry can lead to high loads of wastewater and of hazardous waste. Very wide range of toxics may be present and in worst cases are dumped in the environment.	Varied but most important is probably through contaminated water used for domestic use or for agriculture.	Industrial estates are common and often in heavily populated areas so many thousands can be impacted in severe cases. However, not all have problems.	Central facilities may need upgrading - costs to be carried by individual plants and pre-treatment and improved management enforced. Standards and facilities slowly improving in most areas.	Adequate regulation and enforcement need to be applied to problem systems. May require policy changes to remove exemptions or political support to balance industry/output focus.
Industrial Mining Activities	40	Frequent. Mining of metals and other minerals such as coal and stone occurs all round the world, although some areas are richer in mineral resources.	Most common problems arise from handling and disposal of the large quantities of waste rock and mill tailings. These can release unrecovered metals and also process chemicals.	Metals can be leached from the mine and transported in surface or round water; they can also be distributed by wind and in either case taken up directly or indirectly by people.	Mines are often in remote areas where the local communities bear the brunt of problems. Where tailing are released into waterways (by design or otherwise) many thousands may be affected.	Control of water releases and of waste rock and tailings is the first step. Treatment of effluents from process or from tailing ponds is possible and material dumps can be covered or otherwise contained.	Good practices have been developed and implemented by some mining companies but improved enforcement is often the key to reducing the impacts of mining activities. Unfortunately, this is easier said than done.
Metals Smelting and Processing	40	Common. Smelters and foundries are common in many urban industrial areas. The smaller and least sophisticated facilities are often the problem.	The hazard level depends largely on the metals being processed. Many ores can contain amounts of toxic heavy metals. Secondary smelting of lead can be a particular problem. Uncontrolled emissions of sulfur can cause acid rain problems.	Multiple possible pathways including inhalation of aerosols (e.g. of acids), particulates and dust; ingestion of metals as dust or through water; and ingestion through contaminated crops or other food.	Large smelters can impact local towns and affect thousands of people.	Technological fixes exist for particulates and dust; sulfur control is straightforward but costly. General "fugitive" emissions of dust need to be managed. Drainage systems prevent material washing into waterways.	Retrofitting smelters is a question of cost and political will. Remediation of impacted areas requires land forming and covering of waste heaps. Larger areas of low contamination need behavioral interventions to prevent ingestion of contamination.
Oil Refineries and Petrochemical Plants	14	Common. There are several hundred oil refineries worldwide, with a large number of countries having at least one.	The major issue is the release of a variety of petrochemicals into the atmosphere. There are also risks associated with effluents or spills which contaminate the ground and related water bodies.	Atmospheric releases can be from venting or fugitive emissions or even vapors from spills. In any case inhalation is a major pathway. Oil in water can cause various impacts if ingested.	Hundreds or thousands can potentially be impacted during operations. Once decommissioned, the main threat is from contaminated soil and water.	Control of releases is based on good quality facilities and on vigilant management. Spills need to be contained and contaminated land may have to be removed to a secure disposal site.	Operating practices are improving worldwide but there are often legacies of contamination and spills that need to be identified and remediated.
Old and Abandoned Chemical Weapons	3	Limited, but very little information. At least 200 identified in US and probably similar numbers in countries such as Russia and China. Sites can contain buried, highly corroded shells or highly toxic destruction products.	Sites are contaminated with traces of warfare chemicals or its destruction products like arsenic, dioxines or furanes.	Main pathway is contamination of water supply - either from dumping into water bodies or run-off and infiltration from contaminated land. Other pathway is inadvertant exposure of workers discovering the site.	Very variable but there are examples of water supply to hundred thousands being threatened. Mainly an issue in former chemical weapons possessor states, WWI battlefields, and some former colonies.	Land problems can be treated in various ways. Pollution of water sources is insidious and difficult to deal with	Identification is a critical issue: weapons sites were almost always secret and few records are available.

	SITES IN BLACKSMITH DATABASE	ESTIMATED OCCURRENCE	LEVEL OF POLLUTION HAZARD	EXPOSURE PATHWAYS	NUMBERS OF PEOPLE AFFECTED	INTERVENTIONS AND FEASIBILITY	WHAT NEEDS TO BE DONE
PCBs	9	Limited. PCB is most commonly found in cooling oil in electrical transformers.	Low - PCBs can have chronic effects but not acute	PCBs biaccumulate and pose a threat when contaminated animals, particularly fish, are consumed.	The numbers directly affected are limited. Likely to be in order of hundreds at any site.	There is a major international program underway to deal with stockpiles of POPs in Africa. Similar efforts are likely for other countries.	There is a need for identification of other dumps or stores that have not yet been recorded and for these stores to be made secure until they can be safely sent for final disposal.
Radioactive Waste and Uranium Mining	24	Very limited but unpredictable. Major sources of radioactivity are closely controlled but small sources (e.g. for medical purposes) may be dumped illegally.	High - High level radioactive waste, typically 'spent' uranium fuel, remains highly dangerous for long periods of time.	Exposure pathways are multiple. Radioactive materials can be inhaled or ingested, or individuals exposed to radiation. Exposure can cause cell and genetical damage.	The numbers directly affected are likely to be small. Excluding the population near Chernobyl, radioactivity mostly affects communities living near uranium mines and processing centers.	Better regulatory structures are needed to deal with ongoing contamination. Where legacy contamination exists approaches to contain and stabilize waste, and remove critical pathways are needed.	There is a need to inventory and prioritize the worst sites. Where there is an acute risk, the pathway to humans must be eliminated.
Surface Water Quality	19	Very frequent. In many areas, especially where population densities are high, the water sources are polluted. Water treatment is possible but in reality often very limited.	High - waterborne diseases are very common and can be fatal, especially to the very young and the weak.	Everybody drinks water but contaminated water used for cooking and washing can also lead to exposure.	The developing world is urbanizing rapidly and this problem is a challenge for governments everywhere. Figures from WHO indicate that about 7% of all deaths in Africa are from diarrheal diseases, and about 80% of these are children under 4 years.	Treatment of drinking water can improve the quality dramatically but there are many financial and technical challenges. Protection of the water sources is also part of the answer.	Despite decades of international efforts, progress remains slow in dealing with this fundamental problem.
Untreated Sewage	14	Uncontrolled sewage discharges are very frequent, occurring in almost all urban areas. Even in relatively developed cities, the extent of the formal system is limited and many areas are "served" by open sewers. In developing countries, 90-95% of sewage is dumped untreated into surface water.	Pathogens typically occur in extremely high numbers. Water from contaminated drains is often used as a supply for household use, posing very severe risks. Clothes washing and bathing in contaminated drains are also hazardous.	Ingestion, directly or via contaminated food or utensils, is the main route. Infection through direct contact with pathogens in water is also a risk.	A significant portion of all the low income dwellers in poorer cities and towns may rely on contaminated drains. The problems of uncontrolled sewage discharges have to be considered as an element of the water quality problem.	Many interventions have been tested and put into practice to reduce the problems of discharges of water borne sewage. High costs is a barrier to conventional systems and alternative approaches often face technical or social barriers.	There are ongoing international efforts to support local and national governments to deal with the pervasive problems of sewage discharges. In fact this is currently the International Year of Sanitation.
Urban Air Quality	31	Frequent. In urban areas with high levels of pollution, everybody is at risk. The ten polluted cities have a combined population of about 80 million people.	The acute impacts of high particulate or ozone levels are limited but extensive studies have shown that the chronic effects are increased deaths, due mainly to stressed hearts and respiratory problems.	The fundamental pathway is simply to breathe the polluted air.	With the developing world urbanizing and motorizing rapidly, the total numbers exposed are in the hundreds of millions, if not billions.	There are few "quick fixes". Industry is now (in most case) exceeded as a source by transport and controlling transport emissions requires technological, planning and behavioral changes.	Cities with serious problems need to address issues such as improved and more attractive public transport, controls on vehicle emissions and a host of other measures.
Used Lead-Acid Batteries	23	Common. Lead-Acid batteries are part of every car or truck and many boats and other machines. Although rechargeable, they eventually need to be replaced.	If properly managed, ULABs are not a problem. However, informal backyard operations can cause significant hazards by spreading lead dust.	The main problem is dust, which may be inhaled or may be ingested when food is contaminated.	At an enclosed site, hundreds of neighbors can be impacted At an open site, whole communities of perhaps several thousands may be affected.	Implementation of good practices is not complicated and not particularly expensive, if the operators are cooperative. Clean-up of lead contaminated areas requires removal of the lead sources and decontamination of the worst impacted areas.	The many small informal operations have to be identified and brought into the formal system (or closed), while surrounding areas need to be evaluated and then decontaminated.

CONCLUSION

CONCLUSION.
Pollution is a major factor in disease. Estimates of the global death toll where pollution is a significant factor range from 25% to an astonishing 40%. Most of these deaths occur in the developing world, where the rapid confluence of industrialization and urbanization puts millions directly in harms way. Moreover, those affected are disproportionately children. For instance, while children only make up 10% of the population, over 40% of the global burden of disease falls on them.

The death toll is not the only affect of pollution. Annually millions of lives are made markedly more difficult through constant illness, neurological impairment and lost life years. By way of example, the presence of lead in children lowers I.Q. by an estimated 4-7 points for each increase of 10 µg/dL[1]. While the acuteness of the pollution varies from site to site, our database identifies populations around the globe with blood lead levels ranging from 50 -100 µg/dL, up to 10 times recommended levels.

Despite this pollution pandemic, shockingly little is being done in response. With regard to international assistance and public health, large amounts of resources have been leveraged to combat some of the worst killers like HIV/AIDS, Malaria and TB. While much attention has been paid to these diseases, the relationship between human health and pollution seems to have been largely ignored. Indeed only a fraction of international aid is allocated to remediation of critical sites, despite the significant threat posed by pollution, and the proven efficacy of interventions. In other words, there is a great deal more to be done.

1 "Lead Toxicity: What are the Physiologic Effects of Lead Exposure?" Case Studies in Environmental Medicine. Last Updated August 20, 2007. Available at http://www.atsdr.cdc.gov/csem/lead/pbphysiologic_effects2.html

Combating the health threat posed by pollution can be done affordably and effectively. In 2007, Blacksmith Institute used a standard methodology to compare some of its projects with other public health interventions. Among other findings, Blacksmith determined that some of its projects cost between $1 - $50 per year of life gained. This compared favorably to the $35 to $200 per year of life gained for World Bank estimates on interventions related to water supply, improved cooking stoves and malaria controls.

To be clear, the Pollution Problems presented in this report are some of the biggest killers in the world – and many can be stopped effectively and affordably.

IMPACTS OF THE TOP TEN.
Some of pollution problems, although ubiquitous, are less acute than others. An estimated 80% of the world's households cook with unprocessed biomass fuels on rudimentary stoves in poorly ventilated kitchens. Indoor air pollution particularly affects women and children, resulting in, among other effects, increased incidence of acute respiratory illness.

Others, while still widespread, affect fewer people with more severity. Acute lead poisoning resulting from informal car battery recycling can kill very quickly at certain levels. More commonly, lead has debilitating effects on neurological development, resulting in lives made that much harder in some of the poorest countries in world.

Hence, in this year's report, Urban Air Pollution ranks alongside Used Lead Acid Battery Recycling and Artisanal Gold Mining. Readers are likely aware of the health threat posed by air pollution in some of the world's major cities, like Beijing or Mexico City. Those same readers, however, may not even be aware of Artisanal Gold Mining, let alone its pollution component. This only underscores the importance of ranking these problems in this way.

There are an estimated 10-15 million Artisanal Miners worldwide who mine for gold. These miners use mercury to form an amalgam with the gold contained in mined soil. That amalgam is later burned; evaporating the mercury while leaving behind gold. The evaporated mercury is extremely toxic if inhaled and then quickly condenses and finds its way into local water supplies, where it is either ingested directly by humans, or bio-accumulates in fish, which in turn are eaten by humans. An estimated one third of global mercury emissions come from these activities, yet the problem is largely unknown. This underscores the importance of this report; that global killers are often silently taking lives around the world. The goal of this report is to illuminate these preventable deaths for the international community.

CREATING SUBGROUPS.

The Toxic Twenty span a wide range of issues. Each pollution problem has its own set of particular characteristics that separates it in some way from the others. Some of the problems, like POPs, remain for generations and continue to have a residual impact long after use. Others, like contaminated surface water, have a particularly damaging impact on the health of children.

For this reason we have prepared the smaller lists from the Toxic Twenty. The first of these, "Top Four Least Addressed Pollution Problems," provides an unranked summary of those least likely to be on public health policy radar. These might equally be called most "Unknown" or "Ignored." Artisanal Gold Mining is included here, as is Used Lead Acid Battery Recycling. Both of these have far reaching effects – wherever there are cars, there are car batteries – yet there exist few international agencies and limited resources for dealing with them.

The second subgroup "The Top Eight Pollution Problems Affecting Children" importantly draws attention to those toxics that affect the most vulnerable populations.

Some of the worst pollution problems are in many ways products of poverty. High levels of urbanization, lack of infrastructure and formal sector employment, as well as overstretched governments, present very dangerous conditions for human health as people turn to informal - and often toxic – sources of income generation.

Nowhere is this better illustrated than Africa, which bears a hugely disproportionate amount of the global burden of disease. Our third subgroup "The Top Seven Pollution Problems in Africa" highlights some of the problems making the economic development of the world's poorest continent that much more challenging.

Lastly, we present "The Top Four Pollution Problems Affecting Future Generations." Some pollutants are particularly persistent, and more likely than others to affect future generations. While others will at the very least decrease in their severity over time, those in this category will not simply go away, and may in many cases, actually get worse. This can happen through "bioaccumulation" the process whereby pollutants increase in severity as they move up the food chain.

LOOKING FORWARD: WHAT CAN BE DONE.

Industrial wastes, air emissions, and legacy pollution affect over a billion people around the world, with millions poisoned and killed each year. Other people have reduced neurological development, damaged immune systems, and long-term health problems. Women and children are especially at risk.

Much of this can be fixed, affordably and effectively. There exist culturally and economically responsible interventions that have been proven to save lives. Many of these are developed at the local level with input from technical experts. Others adapt more complex technologies to be more appropriate for developing country environments. As a whole, many of these solutions are replicable, effective and affordable.

To implement these interventions, two responsibilities must be taken up by the international community. First, there must be a concerted global effort to identify comprehensively the polluted places where human health is at risk. Second, the resources necessary to support the remediation of these sites must be made available.

THE GLOBAL INVENTORY PROJECT.

A major challenge to the international community is to identify exactly where and how pollution affects people. To our knowledge, Blacksmith Institute's internal database of polluted places is the most comprehensive in the world. However, the 600 sites it contains just scratch the surface of what exists.

Partly to address this need, Blacksmith Institute has entered into a partnership with the European Commission and the United Nations Industrial Development Organization to develop a comprehensive inventory of polluted places. The Global Inventory Project will be the first of its kind. During the 18-

month project Blacksmith and partners will identify and assess more than 500 polluted places. The information collected will be made accessible to organizations and governments working to end the health threat of pollution.

THE HEALTH AND POLLUTION FUND.

A second major challenge is to leverage the funds necessary to remediate the many polluted places where health is at risk. In order to provide a vehicle to take up this challenge, the Health and Pollution Fund (HPF) was launched in principle in October 2007 by representatives from governmental agencies of the United States, Germany, China, Russia, Mozambique, Kenya, and the Philippines. Also part of the launch were representatives from the World Bank, the United Nations Industrial Development Organization, Green Cross Switzerland, Blacksmith Institute, as well as leading researchers from within the public health and pollution remediation fields. HPF is a planned $400 million fund which will be dedicated to combating toxic pollution in developing countries that has resulted from industrial, mining, and military operations.

The Fund will be directed toward cleaning up over 400 highly polluted locations worldwide that affect more than 100 million people - people who suffer from reduced life expectancies, increased cancer risks and severe neurological damage. Projects initiated by HPF will channel funds to local stakeholders, with technical support and oversight provided by a central Secretariat. The Fund is in development, in discussions with potential donors.

For more information on the Health and Pollution Fund, please visit www.HPFund.org

TECHNICAL ADVISORY BOARD MEMBERS

Technical Advisory Board Members
Listed in alphabetical order.

Margrit von Braun Ph.D. P.E.
Administrative Dean and Founder, Environmental Science Program, University of Idaho.

Dr. von Braun is Dean of the College of Graduate Studies and Professor of Chemical Engineering and Environmental Science at the University of Idaho. She received her BS in Engineering Science and Mechanics at the Georgia Institute of Technology in 1974, her MCE in Civil Engineering at the University of Idaho in 1980, and her Ph.D. in Civil/Environmental Engineering in 1989 at Washington State University. She was awarded the College of Engineering Outstanding Faculty Award in 1992. Dr. von Braun was a Kellogg National Leadership Fellow from 1993 to 1996. Her research areas include human health risk assessment, hazardous waste site characterization with a focus on sampling dust contaminated with heavy metals, and risk communication. She is establishing a network of international graduate students involved in assessing risks to community health from waste sites in the developing world.

Pat Breysse, M.D.
Director of the Division of Environmental Health Engineering Department of Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health

Pat Breysse is currently the Director of the ABET accredited Industrial Hygiene Program and is the Associate Director of the Center for Childhood Asthma in the Urban Environment. In this context, most of Dr. Breysse's research concentrates on exposure assessment with a resulting emphasis on public health problem solving particularly in the workplace. Exposure assessment research includes pollutant source characterization, exposure measurement and interpretation, development and use of biomarkers of exposure/dose/effect, and evaluating relationships between sources, exposures, doses and disease. Dr. Breysse's research contribution has included investigations of electron microscopic methods for asbestos analysis, and the development and evaluation of optical and electron microscopic analytical methods for synthetic vitreous fibers exposure assessments.

Timothy Brutus, M.Sc.
Risk Management Specialist for the New York City Department of Environmental Protection

Timothy Brutus is the Risk Management Program Manager for the New York City Department of Environmental Protection at the Downstate Reservoirs. The Risk Management Program for the Downstate Reservoirs assures consistent water quality and supply to New York City and surrounding boroughs while ensuring the operation,s staff safety by managing engineering and administrative controls at these facilities. Tim,s educational background includes a geochemistry and environmental engineering degrees, with specific expertise in metals geochemistry and technology development and application. Tim,s educational and employment background has been focused on arsenic geochemistry, investigating various sources of arsenic, both natural and anthropogenic in various media and explaining the complex geochemistry i nvolved. Prior to the work currently being carried out at NYC DEP, Tim has designed and applied technologies for various LNAPL and DNAPL contaminated sites, including soil vapor extraction, in-situ chemical oxidation, and air sparging applications. Tim is also a guest lecturer and contributor to other non-profit organizations.

Jack Caravanos, Ph.D., CIH, CSP
Director, MS/MPH program in Environmental and Occupational Health Sciences, Hunter College

Jack Caravanos is Professor at Hunter College of the City University of New York where he directs the MS and MPH program in Environmental and Occupational Health Sciences. He received his Master of Science from Polytechnic University in NYC and proceeded to earn his Doctorate in Public Health (Env Health) from Columbia University's School of Public Health in 1984. Dr. Caravanos holds certification in industrial hygiene (CIH) and industrial safety (CSP) and prides himself as being an "environmental health practitioner". He specializes in lead poisoning, mold contamination, asbestos and community environmental health risk.
Dr. Caravanos has extensive experience in variety of urban environmental and industrial health problems and is often called upon to assist in environmental health assessments (i.e. lead/zinc smelter in Mexico, health risks at the World Trade Center, ground water contamination in NJ and municipal landfill closures in Brooklyn). Presently he is on the technical advisory panel of the Citizens Advisory Committee for the Brooklyn-Queens Aquifer Feasibility Study (a NYC Department of Environmental Protection sponsored community action committee evaluating health risks associated with aquifer restoration).

Denny Dobbin, M.Sc.
President of the Society for Occupational and Environmental Health

Mr. Dobbin has over 40 years occupational hygiene experience as an officer in the US Public Health Service and as an independent.

His assignments included seventeen years with the: National Institute for Occupational Safety and Health, US Centers for Diseases Control and Prevention (and its predecessors) where he managed research programs and developed policy including a two year assignment with the U.S. Congress in the Office of Technology Assessment. He worked on toxic chemical issues at the U.S. Environmental Protection Agency. He managed a Superfund grant program for model hazardous waste worker and emergency responder training for ten years at the National Institute of Environmental Health Sciences, U.S. National Institutes of Health Since 1997 he has worked independently on occupational, environmental and public health policy issues for non-profit, labor and other non-governmental organizations.

He is the President of the Society for Occupational and Environmental Health, an international society and is past Chair of the Board of Directors of the Association of Occupational and Environmental Clinics. He is past Chair of the Occupational Health and Safety Section, American Public Health Association. He was the 1998 honoree for the OHS/APHA Alice Hamilton award for life-time achievement in occupational health. He is an elected fellow of the Collegium Ramazzini, an international occupational and environmental health honor society. Mr. Dobbin is a member of the American Conference of Governmental Industrial Hygienists where he served as recording secretary of the Physical Agents Threshold Limit Value committee and chaired the Computer and Nominating committees. He has participated in the American Academy of Industrial Hygiene, the National Public Health Policy Association and Society of Risk Assessment. He is a Certified Industrial Hygiene, (ret.)

He has a B.S. in Electrical Engineering from the University of Idaho, and a M.Sc. in Occupational Hygiene from the London School of Hygiene and Tropical Medicine, London, UK.

Josh Ginsberg, Ph.D.
Director of Asia Programs, Wildlife Conservation Society

As Director of Asia Programs at the Wildlife Conservation Society, Josh Ginsberg oversees 100 projects in 16 countries. He received a B.S. from Yale, and holds an M.A. and Ph.D. from Princeton. Dr. Ginsberg spent 17 years as a field biologist/conservationist working in Asia and Africa on a variety of wildlife issues. He has held faculty positions at Oxford University, University College London, is an Adjunct Professor at Columbia University, and is the author of over 40 reviewed papers and three books on wildlife conservation, ecology and evolution.

David J. Green
Owner and CEO of Phoenix Soil, LLC; United Retek of CT LLC; American Lamp Recycling, LLC; Green Globe, LLC; and Jayjet Transportation, LLC.

David Green received his M.ed in chemistry and has owned and operated hazardous waste remediation companies since 1979. His companies have conducted in-situ and ex-situ treatments of hazardous materials on over 16,700 sites in the US, China, UK, and central Europe. The technologies incorporated include, low temperature thermal desorption, solidification/stabilization and chemical treatment. Mr. Green serves as Chairman of the Local Emergancy Planning Commision and the Director of Operations for the Connecticut's Department of Homeland Security USAR Team.

David Hanrahan, M.Sc.
Director of Global Programs, Blacksmith Institute

David Hanrahan oversees the technical design and implementation for Blacksmith of over 40 projects in 14 countries. Prior to joining Blacksmith, Mr. Hanrahan worked at the World Bank for twelve years on a broad range of environmental operations and issues, across all the Bank's regions. During much of this time he was based in the central Environment Department where he held technical and managerial positions and participated in and led teams on analytical work and lending operations, including Acting Head of the department for a number of years.
Before joining the World Bank, he had twenty years of experience in international consultancy, during which time he also earned post-graduate degrees in policy analysis and in environmental economics. His professional career began in Britain in water resources for a major international engineering consultant. He then moved to Australia to build the local branch of that firm, where he helped to develop a broad and varied practice for public and private sector clients. He later returned to the UK and became Development Director for an environmental consultancy and subsequently Business Manager for a firm of applied economics consultants. In 1994 he was recruited by the World Bank to join its expanding Environment Department.

David Hunter, Sc.D.
Professor of Epidemiology and Nutrition, Harvard University School of Public Health

Dr. Hunter received an M.B.B.S. (Australian Medical Degree) from the University of Sydney. He continued his formal education at Harvard University, receiving his Sc.D. in 1988. Dr. Hunter is a Professor of Epidemiology and Nutrition, Harvard School of Public Health. Dr. Hunter is involved with several large, population-based cohort studies, including the Nurses' Health Study (I and II), Health Professionals Follow-up Study, and the Physicians' Health Study. Among the goals of these large cohort studies is to investigate gene-environment interactions, including the impact of lifestyle factors, on disease causation. Disease endpoints of interest for some of these cohorts include cardiovascular disease, diabetes, and osteoporosis. He is also involved in long running studies of nutritional influences on HIV progression in Tanzania.

Eric Johnson
Member of the Board of Trustees, Green Cross Switzerland

Eric Johnson has a broad perspective on the environment and chemical contamination. He began his career as an editor of Chemical Engineering and Chemical Week magazines. He then became involved in the selection, assessment and remediation of industrial sites. One of his major projects was the remediation and conversion of a former aluminum smelter to alternate land-use. Mr. Johnson was an early adopter of life-cycle assessment. That, combined with his experience in environmental impact assessment, led to his 1996 appointment as editor of Environmental Impact Assessment Review – a leading peer-reviewed journal in the field.

Mr. Johnson has analyzed numerous environmental issues that touch on the chemical industry including: alternative fuels, brominated flame retardants, CFCs and replacements, ecolabels (for detergents, furniture polishes, hairsprays and personal computers), GHG emissions and trading, plastics recycling, PVC and the chlorine-chain, REACH, socially-responsible investing, tri-butyl tins and TRI and environmental reporting. In 1994 he organized the first Responsible Care conference for plant managers in Europe. Currently his main work is in comparing the carbon footprints of various sources of energy. He has worked internationally, concentrating mainly on the US and Europe. Mr. Johnson is an active member of the Board of Green Cross Switzerland.

Donald E. Jones
Donald Jones is the founder of Quality Environmental Solutions, Inc. and was previously Director of the IT Corporation national program for clients with hydrocarbon-related environmental problems and development of environmental management programs. He has served as an elected Board of Health member and was appointed as Right-To-Know and Hazardous Waste

Coordinator in the State of Massachusetts. Mr. Jones currently serves on the Local Water Board, as technical consultant to the local Facilities Board and provides editorial review of technical papers and publications for the National Ground Water Association.

Mukesh Khare, Ph.D.
Professor, Environmental Engineering & Management, Department of Civil Engineering, Indian Institute of Technology Delhi, Former Atlantic LNG Chair (Professor) in Environmental Engineering, University of West Indies, St. Augustine Campus, Trinidad & Tobago.
Dr. Mukesh Khare is Professor in the Department of Civil Engineering at Indian Institute of Technology Delhi, India. Professor Khare received his PhD from the Faculty of Engineering (Specialized in Air Quality) from the University of Newcastle Upon Tyne, UK in 1989. He has published more than 45 refereed articles to date in professional journals, 30 articles in refereed conferences/seminars, and two books: Modelling Vehicular Exhaust Emissions, WIT Press, UK; Artificial Neural Networks in Vehicular Pollution Modelling, Springer, USA. Additionally, he has published nearly 20 technical reports on research/consultancies conducted for government agencies and private industries. Dr Khare continues to serve as peer reviewer for several government ministries grants programs and state programs and consultant/advisor to the Government of NCR Delhi. He is also serving as casual reviewer to many journals and publishing houses in and outside the country. Professor Khare is on the editorial board of International Journal of Environment and Waste Management and is guest editing one of its special issues on Urban Air Pollution, Control and Management.

Philip J. Landrigan, M.D., M.Sc.
Director, Center for Children's Health and the Environment, Chair, Department of Community and Preventive Medicine, and Director, Environmental and Occupational Medicine, Mount Sinai School of Medicine

Dr. Landrigan is a member of the Institute of Medicine of the National Academy of Sciences. He is Editor-in-Chief of the American Journal of Industrial Medicine and previously was Editor of Environmental Research. From 1988 to 1993, Dr. Landrigan chaired a National Academy of Sciences Committee whose final report—Pesticides in the Diets of Infants and Children—provided the principal intellectual foundation for the Food Quality Protection Act of 1996. From 1995 to 1997, Dr. Landrigan served on the Presidential Advisory Committee on Gulf War Veteran's Illnesses. From 1997 to 1998, Dr. Landrigan served as Senior Advisor on Children's Health to the Administrator of the U.S. Environmental Protection Agency. He was responsible at EPA for establishing a new Office of Children's Health Protection. From 1970 to 1985, Dr. Landrigan served as a commissioned officer in the United States Public Health Service. He served as an Epidemic Intelligence Service Officer and then as a Medical Epidemiologist with the Centers for Disease Control in Atlanta. In his years at the CDC, Dr. Landrigan participated in epidemiologic studies of measles and rubella; directed research and developed activities for the Global Smallpox Eradication Program; and established and directed the Environmental Hazards Branch of the Bureau of Epidemiology.

Dr. Landrigan obtained his medical degree from the Harvard Medical School in 1967. He interned at Cleveland Metropolitan General Hospital and completed a residency in Pediatrics at the Children's Hospital Medical Center in Boston. He obtained a Master of Science in occupational medicine and a Diploma of Industrial Health from the University of London.

Ian von Lindern Ph.D
CEO and Chairman, Terra Graphics Environmental Engineering, Inc.

Dr. Ian von Lindern received his B.S. in Chemical Engineering (1971) from Carnegie-Mellon University, Pittsburgh, PA; and his M.S. in Biometeorology and Atmospheric Studies (1973) and Ph.D. in Environmental Science and Engineering (1980) from Yale University, New Haven , CT. Dr. von Lindern has 30 years of environmental engineering and science experience in Idaho. He has directed over 30 major environmental investigations, involving solvent contamination of groundwater in the Southwest, an abandoned petroleum refinery, secondary smelters and battery processors, landfills, uranium mill tailings, and several major lead sites including: Dallas, TX; the Niagara and Riverdale Projects in Toronto, Canada; the Marjol Battery Site in Throop, PA; ASARCO/Tacoma, WA; East Helena and Butte/Anaconda in MT; Anzon Industries in Philadelphia, PA and the Rudnaya Pristan-Dalnegorsk Mining District, Russian Far East. Through TerraGraphics, Dr. von Lindern has worked continually for Idaho Department of Environmental Quality on various projects since the company's inception in 1984. He has been the lead Risk Assessor for the Bunker Hill Superfund Site in north Idaho, communicating associated risk issues at many public meetings in the community. In the last few years, Dr. von Lindern directed and completed the Union Pacific Railroad "Rails-to-Trails Risk Assessment;" the exhaustive Five-Year Review of the Populated Areas of the BHSS; the Human Health Risk Assessment for the Basin; and several other technical tasks. Dr. von Lindern has served as a U.S. EPA Science Advisory Board (SAB) Member on three occasions: the Review Subcommittee for Urban Soil Lead Abatement Demonstration Project, 1993; the Subcommittee Assessing the Consistency of Lead Health Regulations in U.S. EPA Programs, Special Report to the Administrator, 1992; and the Review Subcommittee Assessing the Use of the Biokinetic Model for Lead Absorption in Children at RCRA/CERCLA Sites, 1988. He also served on the U.S. EPA Clean Air Scientific Advisory

Ira May

Ira May has worked as a geologist with the U.S. Army Environmental Center for more than twenty years. He has extensive experience with the clean up of hazardous waste sites at army facilities throughout the United States. Mr. May serves as a reviewer for the Groundwater magazine, a publication of the National Ground Water Association and is Vice Chairman of the Long Term Monitoring Committee of the Geotechnical Institute, American Society of Civil Engineers.

Anne Riederer, Sc.D.

Co-Director, Global Environmental Health Program
Rollins School of Public Health, Emory University

Anne Riederer is a Research Assistant Professor in the Department of Environmental and Occupational Health and co-directs the Global Environmental Health Masters in Public Health Program. She received her B.S. in Neuroscience from Brown University in 1989, an M.S. in Foreign Service from Georgetown University in 1991, and an Sc.D. in Environmental Science and Engineering from Harvard School of Public Health in 2004. Her research focuses on assessing exposures of children and women of childbearing age to developmental neurotoxins, including pesticides, heavy metals, and other environmental contaminants. From 1998-2004, Dr. Riederer held a U.S. Superfund Basic Research Program Training Fellowship to study lead, mercury and PCB exposures at the former Clark Air Base, Philippines. From 1991-1998, she worked for Hagler Bailly Consulting on air, water and waste regulatory program development for the Philippines, Indonesia, Viet Nam, Mexico, Egypt for various bi- and multilateral development agencies. She directed the company's Manila, Philippines office from 1994-1998.

Stephan Robinson, Ph.D.

International Director a.i., Green Cross Water for Life and Peace Programme
Green Cross Switzerland and Green Cross International

Stephan Robinson holds a PhD in experimental nuclear physics from Basel University. In 1994, he joined Green Cross Switzerland where he served until spring 2008 as International Director of its Legacy of the Cold War Programme. The Programme addresses the full implementation of arms control and disarmament agreements; the safe and environmentally sound destruction of weapons arsenals; the conversion and clean-up of military facilities and lands; reduced environmental impacts of military practices; improvements in the areas of public health, education, and social infrastructure in regions affected by military legacies; stakeholder involvement on military-environmental issues; and the building of a civil society.

Since 1995, the facilitation of chemical weapons destruction in both Russia and the U.S. has been a focus point of the Legacy Programme, which includes the operation of a network of twleve local and regional public outreach offices, the organisation of a Russia National Dialogue on chemical weapons destruction, but also practical community projects aiming at improving emergency preparedness and the health infrastructure. Other activities include the clean-up of a major oil spill at a nuclear missile in the Baltic area; the scientific investigation of a site of former chemical weapons destruction (open pit burning site) in the Penza area; different risk assessments of military facilities; an inventory of the Soviet nuclear legacy; and epidemiological studies of public health impacts by chemical weapons storage. In that function, Stephan Robinson has been regularly in Eastern Europe for on-site visits of projects and for meetings with various groups of stakeholders from government officials to local citizens.

Since summer 2008, he serves as international dire tor ad interim of Green Cross International's Water Programme where he deals with issues like equitable access to transboundary waters to avoid future conflicts due to water shortage, or projects dealing with polluted water and obsolete pesticides.

Paul Roux

Paul Roux is the CEO/founder of Roux Associates, Inc., a successful environmental consulting firm that ranked among the top 200 Environmental Consulting Firms in the July 2004 Engineering News Records. He has over 30 years of experience as a hydrogeologist and serves on the Board of Registration at the American Institute of Hydrology.

Leona D. Samson, Ph.D.

Ellison American Cancer Society Research Professor; Director, Center for Environmental Health Sciences; Professor of Biological Engineering, Massachusetts Institute of Technology

Leona Samson received her Ph.D. in Molecular Biology from University College, London University, and received postdoctoral training in the United States at UCSF and UC Berkeley. After serving on the faculty of the Harvard School of Public Health for eighteen years, she joined the Massachusetts Institute of Technology in 2001 as a Professor of Biological Engineering and the Director of the Center for Environmental Health Sciences. Dr. Samson's research has focused on how cells, tissues and animals respond to environmental toxicants. Dr. Samson has been the recipient of numerous awards during her career, including the Burroughs Wellcome Toxicology Scholar Award (1993-98); the Charlotte Friend Women in Cancer Research Award (2000); the Environmental Mutagen Society Annual Award for Research Excellence (2001). In 2001, Dr. Samson was named the American Cancer Society Research Professor, one of the most prestigious awards given by the society. The ACS Professorship was subsequently underwritten by the Ellison Foundation of Massachusetts. In 2003, she was elected as a member of the Institute of Medicine of the National Academies of Science, and she will become the President of the Environmental Mutagen Society in 2004.

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