Blacksmith Institute's

World's Worst Polluted Places Report 2009

12 Cases of Cleanup and Success

Just a few small, bright spots among over a billion lives affected.

Produced in collaboration with Green Cross Switzerland

Remediation // Legislation // Innovation // Education

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.

Primary Authors
Meredith Block, MPA, David Hanrahan, MSc

Contributions
Cyrille Adam, EdM, Richard Fuller, Sasha Hoff, Stephan Robinson, PhD, Bhaskar Sen Gupta, PhD, Jennifer Spiegler, Budi Susilorini, Ellie Tang, MPA

Special Thanks To:
Jack Caravanos, Nathalie Gysi, Brian Wilson, Anne Reiderer, Ira May; the members of the Technical Advisory Board (see appendix for listing), Blacksmith Institute staff, Christina Bigler, Valodia Shevtsov, Don Feil, Michael Benedict, Wolfgang Schimpf, Magdalene Sim, Pam Zarella, Triplesmart and Gustavo Cejas.

For questions, comments and feedback, please contact Blacksmith Institute in New York City at the following address:
Blacksmith Institute 2014 Fifth Avenue New York, NY 10035
+1 (646) 742 0200 Info@blacksmithinstitute.org

Media inquires should be directed to Magdalene Sim in New York at mag@blacksmithinstitute.org

Media inquiries in Europe should be directed to Nathalie Gysi at Green Cross Switzerland:

Green Cross Switzerland Fabrikstrasse 17 8005 Zurich, Switzerland
+41 (0) 43 499 13 10 nathalie.gysi@greencross.ch

This report is available online at ***www.worstpolluted.org***

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BLACKSMITH INSTITUTE

Letter from Blacksmith Institute Founder

Dear Reader:

The scope of pollution in the developing world is starting now to come into focus. Our initiative to inventory polluted sites throughout the developing world has registered early indications that the scope is comparable in population and risk to human health to problems like malaria and HIV; in other words, a huge problem not on the international radar screen.

It's a solvable problem. Whereas our earlier reports focused on educating people about pollution's existence and impact, this year we want to celebrate successes. We do this to show that the problems can be tackled successfully even with limited funding, and through models, can be replicated around the world. Doing so would save innumerable lives, aid economic development, improve neighborhoods and increase general intelligence.

It is important, however, to note that these examples were hard to come by. The successes are few and far between. So don't think the problem is near licked. We are showing off solutions because we want people to know that the problem is finite and the solutions doable.

The solutions outlined here range in size and type. But there are common threads.

Remediation is the most obvious: getting in and removing soil polluted by heavy metals in the Rudnaya region in Russia or stockpiled pesticides that leach into local water supplies in Tanzania. But there is also the need for local ***education*** to inform people about these silent killers and how to take steps to protect themselves daily. ***Legislation*** has played an enormous role in reducing the toll of pollution globally. The elimination of lead in gasoline in much of the world is responsible for improving intelligence: more coordinated international efforts such as the Chemical Weapons Convention are clearly needed. Finally, there is a role for ***innovation***, some technological but also social. The Gyapa stoves project in Ghana, for instance, builds on a technological innovation –a new type of stove– with social innovations, including the creation of a sustainable business model to support broad distribution.

Here is a way for us to make a difference for hundreds of millions – measurably and effectively - in our lifetime.

Richard Fuller
President - Blacksmith Institute

Introduction

Toxic pollution is a health and economic catastrophe for children and adults –mostly the poorest of the poor– in the developing world. According to some estimates, the health of over one billion people around the globe is compromised by exposure to the pollution of air, water and soil. Other researchers estimate that exposure to pollution causes 40 percent of deaths annually [1]. In some of these toxic sites, ongoing industrial activities are to blame. Pressures on both workers and local economies conspire to create a no-win situation: workers whose livelihoods depend on the very industries that are killing and debilitating them and their families. In other places, pollution is the legacy of now-defunct operations, where it is no longer possible to assess cleanup costs to the parties responsible. Marginalized communities live on or next to these sites, which may affect their long-term health and economic viability, as neurological damage and other disabilities deepen the poverty trap.

This report marks the fourth annual edition of "Blacksmith Institute's World's Worst Polluted Places Report." Blacksmith initiated the report in 2006 to raise public awareness of the devastating toll of pollution on communities in developing countries. Members of Blacksmith's Technical Advisory Board – comprised of leading experts in environmental health and pollution remediation– defined specific health-related selection criteria and identified ten "worst-case" sites based on the best-available information. In subsequent years the report has been issued jointly by Blacksmith Institute and Green Cross Switzerland. In 2007 the report expanded to include another 20 sites, which provided a more complete assessment. The reports have been widely distributed and extensively reported, helping to increase understanding of the challenges posed in polluted places. This scrutiny also led to efforts by many of the worst cases to improve their performance. In several sites, Blacksmith Institute has been invited by the relevant authorities to review and even support remediation efforts.

Building on 2008 Top 10
World's Worst Pollution Problems Report

The listing of polluted sites, however, is inherently limiting. The selection of a finite number of sites obscures the reality that the problems themselves are widespread and that no comprehensive list of these is yet available, although Blacksmith Institute's database of polluted places continues to grow. In 2008 the focus of the report shifted to types of problems that occur over and over again, despite practical solutions, dubbing them the "World's Worst Pollution Problems." The report detailed the context and the causes of these ubiquitous messes and discussed what needed to be done to address them, based on accumulated experience. As the 2008 report indicates, some of these pollution problems, such as urban air pollution, are geographically diffuse, involve multiple pollutants and result from various sources including vehicle and industrial emissions. Others are due to pollution from a single activity or a single source, such as a mining operation.

[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

Top ten of the toxic twenty (2008)
available at: www.worstpolluted.org

Top 10 Pollution Problems

- Artisanal Gold Mining
- Contaminated Surface Water
- Indoor Air Pollution
- Industrial Mining Activities
- Groundwater Contamination
- Metals Smelting and Processing
- Radioactive Waste and Uranium Mining
- Untreated Sewage
- Urban Air Quality
- Used Lead Acid Battery Recycling

We have taken the 2008 list as a starting point this year, looking at cases where each of these problems is in some aspect addressed by a successful approach that can serve as a potential model for other solutions.

2009 Report - Why Focus on Progress?

The purpose of this year's report is to begin to create broad support in the international community for a global commitment to eliminate the health impacts of toxic pollution in developing countries. In the past 40 years in the United States, Western Europe and similarly industrialized countries, the field of environmental remediation, combined with a renewed focus on environmental health, has nearly ended many of the daily life-threatening issues that many in developing countries face. All across developing countries, environmental legislation, enforcement and even trained engineers in hazardous waste removal are just beginning to emerge. To support this progress, the current report presents two global initiatives and 10 site-specific programs where successful strategies and techniques have been deployed to remove the contaminating source that threatens communities or to mitigate their exposure to these toxics.

Tens of thousands of polluted sites contaminate local populations –as many as 500 million people are poisoned each day in the developing world.

Only a few of these problems have been fixed. But it's a start and worth recognizing.

About the 2009 Report

While the disparities between developed and developing world are relatively stark in most cases, two initiatives with worldwide impact are highlighted here as models of how the international community can work together to make meaningful progress on pollution and health.

• **Leaded Gas Phase-Out:** a global effort by governments, multilateral agencies and the private sector to eliminate lead in gasoline that causes neurological damage.

• **Chemical Weapons Convention:** an international treaty to eliminate chemicals used as agents of warfare.

These poisons represent a shared burden –a threat to the health and safety of the entire planet. Eliminating them represents a shared benefit.

The type of toxic exposures that are described in the following 10 examples are not global issues. Rather they are problems that plague developing countries by orders of magnitude greater than almost anything experienced today in developed ones –thus, our reason for focusing attention there.

These 10 programs, we consider to be examples of successful efforts in developing countries that are reducing the toll of pollution on human health:

• **Accra, Ghana:** the broad commercialization of innovative cooking stoves to reduce indoor air pollution that causes respiratory illnesses among women and children;

• **Candelaria, Chile:** comprehensive copper tailings disposal and water conservation treatment system;

• **Chernobyl-affected areas, Eastern Europe:** medical, psychological and educational interventions to improve the lives and livelihoods of those living in the zone of radiation contamination;

• **Delhi, India:** broad-based public policies to reduce the vehicle emissions that cause urban air pollution responsible for respiratory illnesses;

• **Haina, Dominican Republic:** removal of soil contaminated by the improper recycling of used car batteries to reduce lead levels in children's blood;

• **Kalimantan, Indonesia:** new techniques to reduce mercury poisoning from artisanal gold mining;

• **Old Korogwe, Tanzania:** removal of a stockpile of pesticides responsible for contaminating soil and a nearby river, poisoning the local residents;

• **Rudnaya Pristan Region, Russia:** removal of lead-contaminated soil in children's playgrounds in order to lower blood lead levels in children;

• **Shanghai, China:** 12-year program to clean up sewage in an urban waterway that supplies drinking water to millions;

• **West Bengal, India**: reduction in arsenic poisoning through removal of naturally occurring arsenic in well water.

This report aspires to benchmark the beginning of the end of the toxic legacy devastating the health of millions of people in developing countries. These examples are not a definitive or exclusive list, but rather guidance for the possibilities of the impact of this work on a global scale.

Scope of this Report

The current report presents 12 examples of areas where solutions or cleanups have either been completed or are currently underway. Some projects were chosen because they represent a technology or engineering innovation that has been successful in reducing pollution and improving health indicators. Other sites were chosen because they represent a problem that is found in many locations and showcases a successful strategy for implementing the cleanup on a widespread scale. There are a few examples where a policy or a social movement has been the turning point for dealing with a specific toxin, such as the leaded gasoline phase-out. In each case, it is important to recognize that this is not a ranking based on comparable criteria. Rather, sites were chosen to give us an idea of the way forward, to tackle one of the largest public health threats of our time. The examples are seemingly disparate because the issues are equally as different as they are deadly.

I. Limitations of the science

For developing countries, addressing pollution is a relatively new priority with little or no funding locally or internationally. As a result, many of these cleanups are currently in process, and quantifiable data about pollution levels or health outcomes was difficult to obtain for the purposes of this report. Other than the few Blacksmith projects mentioned, no direct sampling of environmental health indicators was conducted specifically for this report, although we have cited other researchers or government data where available. Blacksmith Institute reached out to implementing agencies, NGOs, and government institutions for data regarding these sites. Because the data for many of these projects was unavailable, Blacksmith relies on the experience and expertise of our Technical Advisory Board to extrapolate which programs have relevance and should be celebrated for their successful pollution-reduction outcomes. The Board is made up of a team of international environment and health experts - including faculty members from Johns Hopkins, Bloomberg School of Public Health, Mt. Sinai Medical Center, Emory University and City University of New York.

II. Basic assumptions about the focus on toxics

Despite the many differences, the one commonality in all of the chosen projects is the disastrous health effects of the pollutants they deal with. Toxic pollution is regarded as a major (and quickly emerging) factor in disease. Industrial wastes, harmful gas emissions and legacy pollution likely affect over a billion people around the world, with millions poisoned and killed each year. People affected by pollution problems are much more susceptible to contracting other diseases. Others have impaired 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 [2].

In all this, children are especially affected. More than other leading causes of death, those tied to environmental factors have a disproportionate effect on children. According to WHO, 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 age two. Up to 90 percent of intestinal infections are caused by environmental factors such as contaminated water and inadequate sanitation. Similarly, acute respiratory infections, 60 percent of which can be linked to environmental factors and other 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 physiologically different and more vulnerable than adults. In some cases they have higher exposures since they eat, drink and breathe more per kilogram of body weight than adults and tend to ingest dirt and dust through playing and crawling on the

[2] *Environment and Health in Developing Countries*. World Health Organization Health and Environmental Linkages Initiative. Last accessed Oct. 21, 2009. Available at http://www.who.int/heli/risks/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/

Measuring radioactivity, Russia

ground both in and out of doors. While children only make up 10 percent of the world's population, over 40 percent of the global burden of disease falls on them. Indeed, more than three million children under age five die annually from environmen-tal factors [4].

Despite these grave numbers, death is not the only toll of exposure to toxic pollutants. 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 cronic 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/dL5. While the exposure intensities of the pollution varies from site to site, Blacksmith Institute's database identifies populations around the globe with blood lead levels ranging from 50 -100 µg/dL [5], up to 10 times the WHO reference levels for protection against neurological damage.

III. Topics covered/not covered

The most frequently asked question over the past four years of publishing these reports has been, "Why does the report only focus on sites and problems affecting developing countries?" The answer is that these are areas where life expectancies are among the lowest levels and that similar conditions no longer exist in the U.S., Canada, Europe, Japan and Australia today. In these wealthier countries, there are sufficient legal, political, cultural and economic disincentives for polluters to allow their activities to affect human health on a massive scale. Over the past five decades, the matrix of environmental activism, class action lawsuits, Superfund-type financing, and watchdog agencies ensures that the most egregious crimes do not continue, and that, for the most part, people are compensated and relocated when they that do occur.

Unfortunately, many of these tactics do not work in developing countries that are trying to increase their industrialization and make themselves economically competitive for manufacturing and processing. Typically, these governments are unfairly forced to choose between increasing industrial development that destroys the environment or sticking to policies that decrease their economic gains to preserve a healthy and safe environment. The technology to make this difficult choice obsolete has been available in wealthier countries for decades. It is a travesty that technology transfers have not been more widely implemented to prevent the so-called "race-to-the-bottom" effect that destroys health and environment throughout the developing world.

Additionally, Ministries of the Environment are the most underfunded agencies in many of these countries, with minimal political or financial clout. Various UN agencies, however, have done a great deal in providing model legislation and policy support to these offices, however, even when a law is passed, it typically remains an unfunded mandate as local agencies struggle to find resources, staff and technical capacity to enforce these policies. As yet, there is no mechanism to provide Superfund-type financing to these deadly toxic sites that are currently inhabited throughout the developing world. This makes toxic tort and class action lawsuits almost impossible to resolve on behalf of victims.

[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

Tanzanian workers remove stockpiled DDT from shed. Credit: GTZ

Nomination of Sites

In an effort to showcase the best of international effort to address such problems, Blacksmith Institute chose to use this year's report as a platform to highlight the efforts of several organizations working in this field. As in previous years, a nomination could come from any organization or person, NGO or government agency with a success story to highlight. This year's call for nominations was addressed via a press release, front page pop-up on our website as well as numerous articles. International organizations, UN agencies, country governments and NGOs were contacted in hopes of pulling together a list of sites where innovative techniques or approaches were implemented.

Despite aggressive solicitation by Blacksmith staff to numerous organizations throughout the world, the selection was surprisingly limited comprising an initial pool of 45 sites. Research into many of these sites revealed less than optimal results: disputed outcomes, limited pilots, and a dearth of available information. Given that Blacksmith Institute currently possesses a database with over 1,000 polluted sites still awaiting cleanups, it is clear that this is still very much an emerging issue. As developing countries struggle to put in place many basic laws regarding environmental protection, industrial and economic development must remain a priority for ending the extreme poverty that many of these countries face. Yet, as the link between health and poverty grows closer with renewed understanding, it is evident that the effects of endemic pollution on emerging economies can last for decades. Pollutants that inhibit the potential neurological development of young children condemn societies to a cycle of lower mental capacity and persistent poverty. Increased cancers, incidences of progressive lung diseases and weakened immune systems result in an escalated disease burden.

Training Tanzanian workers to remove obsolete pesticides safely increases local capacity to implement cleanups. Pictured here: decontaminating the shed after cleanup.

Current State of Pollution Remediation Globally

Need for remediation

The first priority for pollution control authorities in many countries is to deal with major ongoing releases of toxic substances. This is a logical and reasonable approach, but many agencies struggle to implement even the basic stages for lack of human and financial resources. Beyond this, remediation also requires both a complex regulatory and institutional process as well as the existence of technical and practical skills that are often scarce. It is often expensive and faces institutional and political battles over who is going to pay. The "Polluter Pays" principle should obviously apply, but bankrupt companies or legal battles can often delay the implementation of an urgently needed cleanup. Toxic hotspots are critical issues for local communities (and often for people downstream) but often do not get the attention of national authorities since the impacts are localized. It takes time for regulatory authorities to move far enough in to the overall environmental agenda to be able to take on the challenges of remediation. However, a number of countries are now beginning to put resources into the cleanup – for example India, China and Mexico.

Many sites are, in practice, a complex mixture of ongoing pollution and legacy issues that makes dealing with the institutional and technical issues even more difficult.

A growing sector

The most difficult aspect of remediation is usually seen as putting in place the necessary financing. Regulatory systems normally put the onus on the owner of the site where the pollution originated, but many companies argue, with more or less justification, that they are either not responsible or cannot afford the costs of the needed cleanup. In cases where the original polluter can no longer be identified or tracked down (the so-called orphan sites), the complications become even more difficult.

Despite being criticized for the high legal costs associated with its early days, the US Superfund system provides a practical approach to these challenges. The government can proceed to deal with the most urgent and hazardous sites, using the resources provided in the Fund while working to identify the responsible parties and using legal proceedings and public pressure to recover the costs from them. In 2008, for example, Superfund secured commitments of close to $2B from private companies to reimburse the government and to provide funds to deal with specific sites.

While this approach does have challenges, the basic principle is worth careful attention by governments struggling to deal with a growing list of remediation problems: allowing governments to take action (subject to legal safeguards) and to recover costs from responsible parties could help to address some of the most urgent cases.

Most industrialized countries do have some form of legislation in place to deal with remediation of the worst-polluted sites, often in the context of controlling the sale or development of land. Major industrial plants were often established close to urban centers, which provided markets and convenient transportation for their products. Many of these plants (such as iron and steel, chemicals, oil and gas processing, metals processing) were established decades ago and have now moved away (often to developing countries) or closed. The resulting industrial wastelands have frequently been a blight on these communities except where the value of urban land rose to the point that redevelopment of the land became attractive.

The redevelopment of such "brownfield sites" is now a part of most urban planning frameworks, and a number of major schemes have been started where the high cost of the remediation work can be recovered from the land value and a new use. Both India and China are now supporting such schemes.

As a result, there is an increasing level of interest and growing expertise available for cleanups in large and valuable urban sites, often using the best of international technology.

Unfortunately, relatively few of the many polluted sites have the potential value which can justify the millions of dollars needed first to clean up large old industrial sites to the required standards for new urban uses and then relocate any settled families to safer settings.

The reality is that most of the abandoned toxic sites have no recovery value, at least in the foreseeable future, which would justify a commercial decision to invest in cleaning them up. Small sites, often in urban fringe or rural areas, are unlikely to see any interest from a commercial angle and limited support from the regulatory system, leaving them truly orphaned.

Challenges and innovation

The understanding and the technology for remediation of all types of pollution sites is well established in the industrialized world. More importantly, regulatory systems and commercial incentives both work in favor of continuing the process of remediation of the overall inventory of polluted sites.

The fundamental challenge for developing countries is to select, from the accumulated experience in the remediation sector, those lessons which are most relevant and applicable. This requires an understanding both of the wide range of techniques and technologies available and of the realities and constraints of applying them in a developing country context.

In situations in which Blacksmith Institute and other groups are working, there is usually very limited access to capital, energy and supplies such as chemicals. Local officials and technical staff, even though often energetic and knowledgeable, rarely have relevant experience and expertise.

What is available in many developing countries is labor and, in many cases, time. This leads in the direction of simple approaches to achieve the needed improvements. Such methods are, of course, not always the solution but can be very effective in many cases.

Basic physical measures

Some cases basically require the collection and removal of the contaminated materials. This is relatively simple but may still require the use of equipment that is not available or affordable locally, such as earthmoving equipment. In any such project, the final disposal of the contaminated material is always a concern, but in many cases an acceptable solution can be found.

In other cases, covering or "capping" contaminated material may be a good option. For example, in abandoned mining areas the materials contained in the "tailings dams" (fine residue from processing) may be left to dry out, and then they are often picked up in windy conditions to form clouds of toxic dust. Covering these areas with soil or other material can essentially eliminate the problems, but even simple operations such as this may be beyond the resources of poorer communities.

Bio-remediation

Bioremediation processes –which are many and varied– have significant potential in the context of remediation in developing countries. The use of additives to encourage the growth of microbes and to speed bio-degradation is a well-established technology. In situ treatment of contaminated land can speed up the natural regeneration processes, particularly where organic compounds are involved. The challenge often is the cost of specific engineered additives, and the solution is frequently the use of local substitutes. These may be considerably less effective than their high tech counterparts but can be a very small fraction of the cost. Diluted cow dung has been used very effectively in some cases. Molasses or other sugar byproducts can be used as a cheap substitute for electron donor compounds in certain applications.

Bioaccumulation

Bioaccumulation of heavy metals is a well known phenomenon. It is perhaps best known in the context of fish, where mercury in tuna and other predator species is the classic concern. However, it occurs with heavy metals, such as cadmium, in plants as well. In areas of high metal concentrations, such as mining regions, many food crops, such as rice and grains, may accumulate toxic metals and become unsafe to eat. Under certain circumstances, selection of appropriate crops or varieties can provide ways to address these problems.

Obviously, finding food crops that do not readily take up the contaminants is one possibility. The opposite approach also has value: using plants that have particularly high absorption of the metals can gradually remove the contamination from the soil (and of course these crops cannot be used for food).

Another, somewhat unusual application of bio-accumulation is the use of vermiculture (worms) to deal with sites contaminated with organics and metals. One successful project in India combined the removal (to a secure landfill) of a large quantity of dumped hazardous waste with a vermiculture treatment of the moderately contaminated surface that was left. The application, over several seasons, of a simple microbial accelerator together with introduction of a large community of specially-bred earthworms resulted in a major improvement in soil condition and fertility as well as large reductions in remaining heavy metal concentrations when the worms were harvested and removed.

Measuring milk in Kasli

Wetland systems

Wetland treatment systems are very well known: natural wetlands purify wastes (especially domestic waste) through a number of mechanisms. Various forms of artificial wetlands have been developed and can be very effective, especially for smaller flows. An emerging innovation that has significant potential is the use of designed wetlands to improve the quality of wastewater streams containing high levels of metals. These systems function by a mixture of biochemical mechanisms, which alter the solubility of metals, and physical (filtering) mechanisms that trap and hold the particles. The capacity and lifetime of such system is finite, but they may be a cost-effective way for dealing with run-off from polluted sites while

efforts are underway to remove the sources.

Monsoon seasons pose a particular challenge for wetlands and other bioremediation approaches in many tropical countries. Intense seasonal rains can cause havoc with systems designed for relatively stable conditions.

Transfer of technology

The lessons of 30 or more years of pollution clean-up in industrialized countries can and must be used to help tackle the present problems of polluted places in the developing world.

Efforts by Blacksmith Institute and others over the past decade have shown that the best approach is not to try to transfer sophisticated and costly technology. The most effective way is to first tap into the best expertise and latest science and then to work with local experts to develop straightforward and relevant applications of the lessons.

All of the approaches outlined above have been implemented in this way. The progress is sometimes erratic, but the gains have been substantial. Most importantly, they are sustainable, because the techniques and requirements have been adapted to the local conditions.

The “standards issue”

The old adage that “the best is the enemy of the good” is relevant to remediation projects. In many cases, especially those that are big, complicated and affect large numbers of people, the only practical approach is an incremental one. The most immediate solutions to the worst problems need to be implemented first, with an objective of reducing the risks to the local population as quickly and as far as possible. However, achieving international standards or WHO guidelines is rarely possible in one single bound, and a pragmatic approach of maximizing the initial intervention needs to be adopted. Such approaches can be at odds with long-term objectives or environmental standards sometimes resulting in objections to “unfinished” interventions.

This tension is particularly evident in situations where the pollution sources are closely linked with issues of local livelihoods. Such is the case in dealing with artisanal gold mining using mercury or informal lead recycling. Ideally, these activities need to be replaced with other economic activities that avoid the use of toxic metals, but the reality is that such changes will often take a long time. Immediate interventions which can reduce the current risks are an essential part of moving towards the ideal.

In systems where there is heavy reliance on central or external support, there is also often a reluctance to undertake a partial solution as this may reduce the opportunity for a future “windfall” of resources from outside. This attitude is never displayed by the communities actually suffering from the present pollution and has to be resisted.

Supporting capacity

The critical constraint is often neither the understanding of the issues nor the capacity to address them but the lack of confidence and support to start tackling seemingly unmanageable problems.

The simple answer is that the most critical intervention is to support the local community to find and implement their solutions, usually on a step-by-step basis. The core of Blacksmith Institute’s approach is to bring together a Stakeholder Group including all the concerned parties: those who are directly affected, those who are responsible for the pollution and those who are charged with finding solutions. Where the local problem is agreed to be serious and immediate, experience has shown that all these parties want to find a practical solution. The role of the outside support is first to help to identify and convene this Stakeholder Group (usually by backing a local “champion” and providing some resources to cover practical costs of meetings). The support is then used to make relevant skills and expertise available to the Group, usually by paying local experts and by providing focused inputs from relevant national or international experts.

The Stakeholder Group is charged with agreeing on a set of actions that can be implemented in the short term with the resources available as the first practical steps on the road to more comprehensive solutions. The mutual confidence and the experience gained from such actions provide the basis for developing and implementing long-term solutions. Again, experience has shown that this simple approach can lead, sometimes over a period of years, to finding comprehensive and practical answers.

Progress in Vapi, India

Vapi is an industrial estate in Gujarat, India, developed by Gujarat Industrial Development Corporation (GIDC) during 1967. Vapi was included as one of the Top 10 Worst Polluted Places in 2007 and has been removed from the list subsequent to improvements in pollution management. The estate, spread on 1140 hectares of land, accommodates a number of chemical industries including manufacturers of pesticide, pharmaceuticals, dyes and dye intermediates, paints, and a sizeable number of paper and pulp industries. Effluents from the area affect two rivers: the Damanganga and Kolak. These rivers flow almost parallel to the west, into the Arabian Sea, passing through Daman on the coast.

More recent information regarding pollution levels received from government authorities indicate that pollution levels in air and water are significantly improved from earlier data sets. Significant investments have been made, both in pollution control technologies for specific industries, and in common treatment plants. These show reduced pollution in Vapi. Air pollution in and around Vapi is now generally within government standards.

Groundwater in surrounding areas has also been sampled authoritatively, and shows significant improvement. Earlier statements regarding mercury levels in groundwater, and health effects in villages, have proven to be false. Drinking water in the town and surrounding villages is clean and well supplied, according to reliable test data. There are no significant health implications regarding drinking water according to a detailed health assessment conducted by Dr. Ratnam of PARIRAKSHANA. Significant effort has gone into stopping illegal dumping within the industrial estate, as it is not tolerated by the Vapi Industrial Association. Dumps outside of the estate still exist, and are being dealt with appropriately. There has also been improvement in roads and footpaths. All the open gutters are covered, and drainage from plant to the Common Effluent Treatment Plant (CETP) is well established. Flowering shrubs cover both sides of the roads. Tens of thousands of trees have been planted in and around Vapi.

The CETP continues to be upgraded and improve its performance, and new investments being tested should bring all tests to within government standards by the end of this year. Heavy metals are well managed; only chemical oxygen demand (COD) regularly exceeds government standards. The Industries Association has built a Center of Excellence to improve the quality of products, testing of the materials, and advising VIA members on reducing effluents and pollution.

Vapi is a good example of how industry has proactively worked to improve their environment. They are to be commended for these activities, and while more work still needs to be done, their commitment to work with government and NGO alike to solve common problems is one that should be replicated throughout India.

Several areas of additional improvement remain. These include: eliminating industrial effluent discharge/overflow into Bill Khadi and remediation from the industrial area; eco-friendly treatment of non-toxic waste from the paper industry and cessation of open land disposal; expediting the creation of an effluent disposal pipeline to an environmentally safe location in the Arabian Sea to avoid further water pollution problem in River Damanganga; remediation of illegal dumps in Vapi and surrounding areas; regular monitoring of the ground and surface water; and continuing to ensure the pollution level is within the prescribed standards of CPCB for all the sites.

Blacksmith Institute's

World's Worst Polluted Places Report 2009

Phasing Out Leaded Gasoline - Global •
Disarming and Destroying Chemical Weapons - Global •
Reducing Indoor Air Pollution - Accra, Ghana •
Managing Mine Tailings to Protect Scarce Water Supply - Candelaria, Chile •
Mitigating Nuclear Contamination - Chernobyl Affected Zone, Eastern Europe •
Improving Urban Air Quality - Delhi, India •
Removing Lead Waste - Haina, Dominican Republic •
Preventing Mercury Exposure - Kalimantan, Indonesia •
Mitigating Lead Exposures - Rudnaya River Valley, Russia •
Disposing of DDT - Old Korogwe, Tanzania •
Transforming an Urban Waterway - Shanghai, China •
Removing Arsenic - West Bengal, India •

12 Cases of Cleanup and Success

Site	Problem	Main Pollutant	Human Exposure Pathway	Outcomes and Outputs Rationale For Site Inclusion	Numbers affected worldwide by problem	Actual or Potential Numbers Affected by Intervention	Est Number of Children Affected*	Approaches				Potential for Translation to Other Locations	Project Partners
								Innovation	Remediation	Legislation	Education		
Global	Leaded Gas	Lead	Inhalation of lead particulates in airborne emissions from automobiles.	As of 2009 all but three countries will have either eliminated use of leaded gas or are moving in that direction. This is an example of a broad transformation of global health that has resulted in reducing the economic burden of low intelligence worldwide.	Global, future generations	All	All	Petroleum additives developed to replace lead in gasoline; catalytic converters developed to handle unleaded fuel.	Elimination of pollutant (lead)	Country-by-country bans; current gobal phase-out program administered by UNEP	Awareness of research confirming the damage to human intelligence from lead in gasoline as well as paint and other sources	Advanced economies will adopt measures because of popular demand and increasingly become internationally accepted standards.	UNEP for countries not yet phased out
Global	Chemical Weapons	Neurotoxins	Deliberate or accidental poisoning via inhalation or dermal contact	188 out of 195 countries have ratified convention banning weapons. All weapons stocks likely to be destroyed by 2021. Non-members exclueded from global chemicals trade, members subject to inspection.	Global, future generations	All	All	Multilateral agreement	Elimination of vast quantities of pollutant through drawdown of stockpiles in U.S. and Russia	Chemical Weapons Convention	Global awareness of the dangers and need to eliminate chemical weapons stocks	Treaties are complex and difficult to achieve but effective in bringing about coordinated action.	Organisation for the Prohibition of Chemical Weapons (OPCW); Green Cross/ Global Green
Accra, Ghana	Indoor Air Pollution	Particulates, CO_2	Inhalation	Included in 2008 Top 10. Use of stoves improves air quality by 40-45%; reduced childrens' mortality from respiratory illness by 25%	>Billion	Actual is approx. 400,000 in 2008	160,000	Sustainable business model	Reduction in indoor air pollutants caused by cooking fires fueled by biomass.		Marketing included program to drive awareness of IAP health issues and to teach cooking adaptations	Sustainable model and specific stove technology used can be tailored to local conditions.	International Relief, USAID, Shell Foundation
Candelaria, Chile	Mine Tailings Disposal/ Water Pollution	Heavy metals such as cyanide	Ingestion of contaminated groundwater.	Intervention enables treatment and recirculation of 80% of treatment waters and prevents contamination of groundwater.	Unknown	130,000	Approx. 57,000	A comprehensive tailings impoundment/cut-off-wall system prevents tailings leakage and filters water bound in tailings.			Industry groups support the adoption of best practices.	Cited as an industry good practice to be emulated by others.	The Compañia Contractual Minera Candelaria (CCM Candelaria), Freeport McMoRan Copper and Gold

* Data extrapolated from 2007 World Population Data Sheet. Population Reference Bureau, USAID 2007.

Site	Problem	Main Pollutant	Human Exposure Pathway	Outcomes and Outputs Rationale For Site Inclusion	Numbers affected worldwide by problem	Actual or Potential Numbers Affected by Intervention	Est Number of Children Affected*	Approaches				Potential for Translation to Other Locations	Project Partners
								Innovation	Remediation	Legislation	Education		
Chernobyl-Affected Zone, Eastern Europe	Radiation	Radioactive waste	Ingestion	Therapy camps responsible for 30 to 80% reduction in radionuclides measured; extensive education helps families mitigate impact of radiation.	5.5 Million in Chernobyl affected zone	1200 family club members	14,600 in therapy camps since 1996	Therapy camps; Family Clubs, Microcredit program			Training trainers; Family clubs teach about hazards and how to avoid them	Program could easily be expanded with additional funding.	Green Cross organizations in Belarus, Russia, Ukraine, and Switzerland; Swiss Agency for Dev and Co-operation
Delhi, India	Air Pollution	CO_2, SO_2, Particulates	Inhalation	Included in 2008 Top 10. SO_2 decrease 34.8%, PM by 7% upon introduction of CNG buses, Unfortunately, Delhi continues to battle air pollution related to its increasing population and expanding metropolitan perimeter. A rapid transit system is in progress.	>Billion	17 million**	5.6 million		Introduction of CNG buses; conversion of two-stroke engine vehicles; introduction of low sulphur diesel; introduction of metro	Court ordered remedy implementing environmental agency recommendations		Requires political commitment	India's Ministry of Environment & Forest, the Supreme Court of India, the Delhi Metro Rail Corp.
Haina, Domincan Republic	Used Lead Acid Battery Recycling	Lead	Ingestion	A Top 10 2008 Problem and a Top 10 2006 Worst Polluted site - pollutant, lead, completely eliminated by soil removal.	Est. 40 Million	30,000	9,900		Soil replacement		Awareness of hazards	Low cost and known technology.	Terra-Graphics, Blacksmith Institute
Kalimantan Indonesia	Artisanal Gold Mining	Mercury	Inhalation of airborne vapors	Intervention eliminates 80%-90% of evaporated mercury. Program is responsible for increasing knowledge of health issues among 70% of miners.	Est. 15 million worldwide, not including indirect effect of mercury in the environment	Approx. 10000 directly affected in Kalimantan	Approx. 4,400	Retort recaptures mercury used as an amalgam in gold processing; allows producer to continue economic activity and benefit from lower production costs			Campaigns to increase the awareness of hazards and provide training in use of retort	Simple technology can be implemented anywhere. The technology and approach can bring broad benefits to mining families as well as reducing the amount of mercury released into the environment.	Yayasan Tambuhak Sinta, UNDP, UNIDO

* Data extrapolated from 2007 World Population Data Sheet. Population Reference Bureau, USAID 2007.

Site	Problem	Main Pollutant	Human Exposure Pathway	Outcomes and Outputs Rationale For Site Inclusion	Numbers affected worldwide by problem	Actual or Potential Numbers Affected by Intervention	Est Number of Children Affected*	Approaches				Potential for Translation to Other Locations	Project Partners
								Innovation	Remediation	Legislation	Education		
Old Korogwe, Tanzania	Contaminated Surface Water	DDT	Ingestion	Intervention resulted in removal of 100 tons of toxic chemicals leaching into nearby waterway.	>Billion	10,000 in Old Korogwe; additional population affected downstream; one estimate is 3.5 Million in Tanzania (est 10K x 350 known stockpiles)	4,400 in Old Korogwe		Eliminate pollutant - 86 tons of DDT and 20 tons of DDT-contaminated construction material	Stockholm Convention of 2004 resulted in ban of DDT and other POPs		Exemplary international collaboration. In addition, training of local crews in hazardous waste handling techniques increases local capacity to implement similar programs	NEMC of Tanzania; GTZ, Africa Stockpile Program, et al.
Rudnaya River Valley, Russia	Metals Processing and Mining	Lead	Ingestion	Included in 2008 Top 10 problems and 2006 Top 10 Worst Polluted sites; pollutant eliminated from locations most frequented by children; pollutant release reduced by phaseout of ore smelting operations	Unknown	55,000	8,250		Soil replacement in children's play areas		Increased awareness led to shutdown of smelter	Low cost and known technology.	Far East Health Fund, et al.
Shanghai, China	Untreated Sewage	Water-borne pathogens	Ingestion	Project brought urban waterway up to national standards; flood controlled; removed "black and stink" condition; water fauna returning.	>Billion	13.4 Million (Shanghai population 2004)	2.68 million (20% of population is under 15 years old)		Removal of pollutant through wastewater treatment, aeration of waterway			The resources of fast-growing economies such as China's and India's should make possible large-scale efforts such as this; requires significant funding and political commitment.	Asian Development Bank; Suzhou Creek Rehabilitation Leader Group, et al.
West Bengal, India	Groundwater Pollution	Arsenic	Ingestion	Reduction of arsenic in groundwater to below detectable levels	est. 100 million in Ganges Delta and ASEAN countries have right geological conditions for in-situ treatment	30,000 in current program	9900 in current program; potentially 33 million in Ganges Delta and ASEAN	System to remove arsenic through in-situ technology using aeration; no chemical treatment	Long-term use may remove arsenic and iron from groundwater		Awareness campaigns to prepare affected population to expect change in the taste of water	Technology can easily be maintained by local electricians and plumbers, even illiterate ones with minimal training and manageable costs. Eliminates need for disposal of toxic wastes that characterize filtration systems	World Bank; University of Belfast, Ramakrishna Vivekananda Mission, et al.

* Data extrapolated from 2007 World Population Data Sheet. Population Reference Bureau, USAID 2007.
** per http://esa.un.org/unup/p2kodata.asp

1 Phasing Out Leaded Gasoline

Location

Global

Pollutant

Lead

Cause

The use of leaded gasoline to achieve higher octane ratings.

Health Impact

Lead poisoning causes central nervous system damage and impairs neurological development in children.

The global phase-out of leaded gas is nearing completion
Credit: Vagabondblogger

Output

Government agencies such as the U.S. EPA began to ban the use of leaded gasoline in the 70's; alternative fuels and other fossil fuel additives came into the market and became economically competitive at that time.

Outcome

As of February 2009, only eleven countries continue to use leaded gasoline, and among these, only three used leaded gas exclusively [1].

Implications

Elevated blood lead levels among children dropped from 88 percent in the pre-phase out years to around 1 percent in the post-phase out years [2].

Remaining Challenges

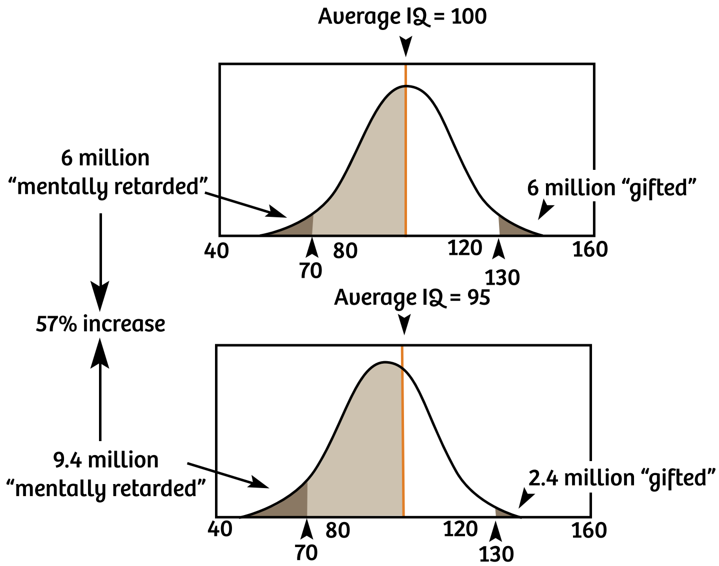
Leaded gasoline is generally cheaper than its unleaded alternative. Developing nations with a lower quality of living often require government subsidies to implement a phase-out program.

[1] ⇢ www.unep.org/pcfv/PDF/MapWorldLead-February2009.pdf

[2] *EPA Requires Phase-Out of Lead in All Grades of Gasoline.* 28 Nov. 1973. ⇢ http://www.epa.gov/history/topics/lead/03.htm.

BLACKSMITH INSTITUTE

Societal impact of 5-point loss in IQ score



Diminished IQ stunts economic development. This graph shows the social impact of a relatively small drop in average population IQ, which can be caused by the presence of a small concentration of heavy metals in the environment. In this example, the 5-point drop raises by 57% the number of individuals considered neurologically impaired, with stark implications for social and economic development.

Source: Mt. Sinai Children's Environmental Health Center.

Context

Arguably the first and the most important global environmental health improvement to date has been the phase out of lead in gasoline. The phase out not only represents a nearly worldwide shift in paradigm regarding a toxic substance, but is also an example of a public-private partnership that has immeasurably impacted future generations. Simultaneously, two critical factors led to the phase out - the manufacture of catalytic converters directly into cars and the emerging medical data of the time that revealed the disastrous effect of lead on childhood health and development.

Site Details

Although the use of lead additives to achieve higher octane ratings had steadily risen from about 1930 to 1970, the concern over vehicular emissions led car manufacturers to begin installing catalytic converters into cars, to reduce other airborne pollutants. It was quickly discovered that the build up of lead particulates blocked the flow of emissions to the catalytic converter, leading to the rise in manufacture of unleaded gasoline. At the same time, new medical data was presented regarding the permanent and debilitating effect of lead on human IQ.

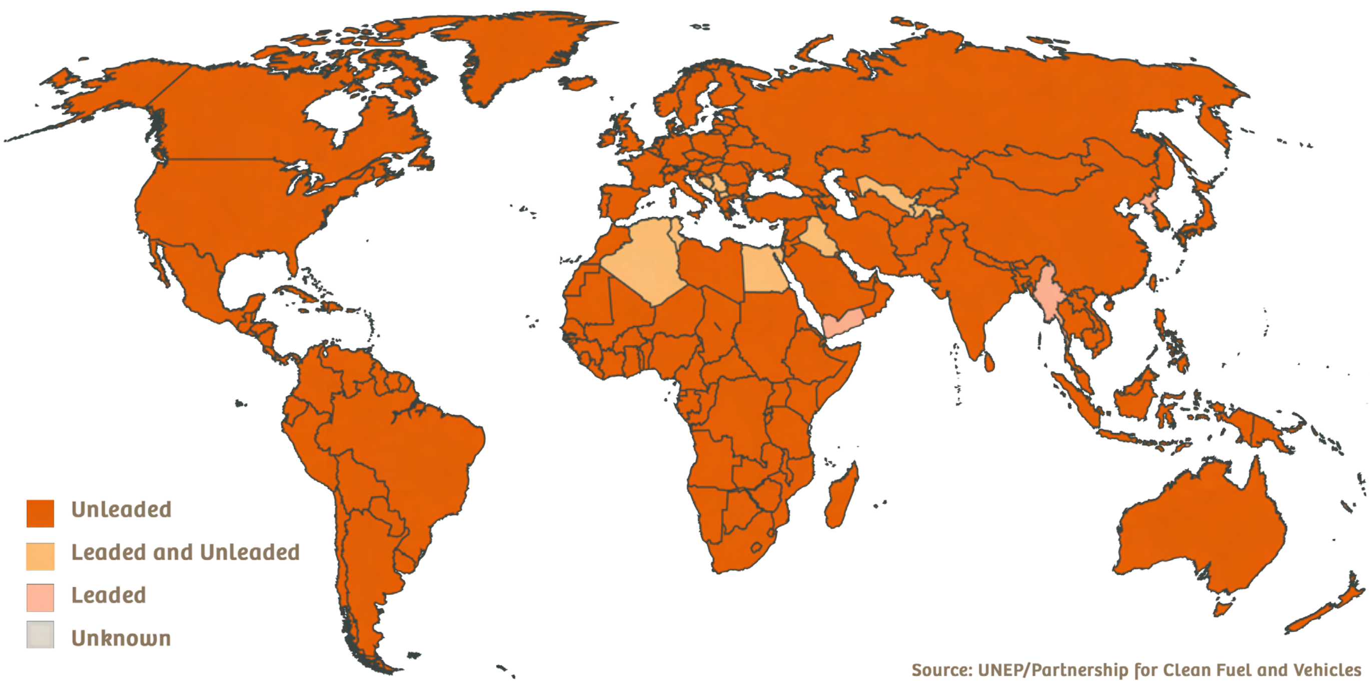
Despite the overwhelming medical evidence linking ambient lead concentrations to higher lead in blood and decreased IQ, the phase-out ultimately became dependent on two factors: the ability of refiners to produce gasoline with a higher octane rating and secondly widespread use of catalytic converters, which are incompatible with the use of lead.

Exposure Pathwayss

Lead poisoning could trigger hypertension and seizures among adults. Children exposed to lead for an extended time period may experience irreversible mental damage. Some of the exposure pathwayss include:

- Inhaling lead particulates in airborne emissions from automobiles
- Being exposed to airborne dust in lead-contaminated soil
- Ingesting dust through normal hand-to-mouth activity or walking or playing in bare feet
- Picking up dust-covered objects and taking them home

Leaded Gas Phase-Out Status, Feb. 2009



Source: UNEP/Partnership for Clean Fuel and Vehicles

- Drinking contaminated water – lead in groundwater and/or airborne dust entering water supplies

- Eating contaminated food –dust accumulating on locally grown fruits and vegetables

Health Impacts

Before the global phase out, exhaust fumes from vehicles using leaded gasoline typically accounted for 90 percent of airborne lead pollution.

Lead and lead compounds can adversely affect human health through either direct inhalation or ingestion of lead-contaminated soil, dust, or paint. Elevated lead levels can adversely affect mental development and performance, kidney function, and blood chemistry. This is particularly a risk for young children, due to the increased sensitivity of young tissues and organs to lead as well as to their greater chance of ingesting lead with soil and dust.

In children, it has been concluded that a 10 microgram per deciliter increase of lead in blood causes approximately a 2.5-point decrease in the IQ. Studies have pointed out that children who grew up in urban settings with higher traffic density tend to have higher blood level levels than their rural counterparts. A variety of statistical relationships between ambient lead concentrations and BLL and children's IQ suggest that a 1 mg/m3 increase in ambient airborne emissions can be connected to an approximately 1 IQ-point decrease in exposed children. The affected children are likely to have lower learning and social contact abilities.

Lead-related pollution also causes cardiovascular problems in adults even with low levels of exposure, as well as adverse reproductive effects for women. Additionally, in adults, high blood lead levels have been linked to elevated blood pressure causing hypertension, heart attacks and premature death.

Urban air pollution is a growing health issue in the developing world. Credit: Aaron May

One estimate of the relationship between ambient airborne lead levels and the cardiovascular impacts of lead in adults - including hypertension, heart attacks and premature deaths - concludes that a 1µg/m3 increase in ambient lead concentrations was estimated to cause 44,800 to 97,000 cases of hypertension per 1 million males between the ages of 20 and 70, 180-500 nonfatal heart attacks and 200-650 premature deaths per 1 million males between the ages of 40 and 59.

Intervention

Although levels of lead in gasoline steadily decreased since 1970s, the United States did not fully phase out leaded gasoline until 1996. Throughout North America and Europe, most leaded gasoline phase-out programs were completed on a policy level within roughly 10-15 years.

Although most of the political commitment came from governments concerned about the effects of lead on their populations, other factors that led to successful policy included, the presence, interests and political influence of domestic auto manufacturers, and oil refineries; the technical capabilities and competitive position of domestic oil refineries; the external factors such as regulations or neighboring countries and the effect of tourism; and country-specific factors such as the availability of alternative fuels or additives.

The US EPA first announced regulations to limit the amount of lead in gasoline in November 1973. The new regulations mandated that the lead content for all grades of gasoline be restricted to 1.7 grams per gallon by July 1, 1975. The new regulations were based on 'total pool averaging,' which allows refiners to average lead usage over all grades - leaded and unleaded - of gasoline produced. These regulations were prompted by two factors. First, the increased recognition of the negative health effects associated with lead exposure from gasoline, particularly for children in urban areas. Second, the introduction of catalytic converters in new cars beginning in 1975. After the phase-out, elevated blood lead levels decreased from 88 percent of children to approximately one percent in 2006.

With the exception of Germany, the leaded gas phase-out in the European Union occurred later than in the United States. Germany began to restrict gasoline lead levels in 1972. The widespread phase-out that began in the mid-1980s had a few common features. First, the lead content of gasoline was fixed at a maximum of 0.4 grams per liter in 1981. In 1985, the EU mandated that unleaded gasoline levels of 0.013 g Pb/l be available in all member countries. Additionally since 1986 member countries have imposed taxation policies favoring unleaded gas. One major differential was the introduction of catalytic converters. France, for example, resisted the introduction in order to protect the national car industry from incurring higher costs and increasing the price of cars. Generally, the introduction in individual countries occurred in the mid to late 80s but continued as late as 1996.

Since 2002 the Partnership for Clean Fuels and Vehicles, a project within the United Nations Environment Program, has been working to finish the leaded gas phase-out globally. As of February 2009, only eleven countries continue to use leaded gasoline, and among these, only three use leaded gas exclusively. Working region by region, they have succeeded in providing policy support to Sub-Saharan Africa, Asia and South America - nearly every country in each region has either completely eliminated, or is working towards eliminating, any and all concentrations of lead in their gasoline.

Remaining Challenges

One limitation for remaining countries to make the switch to unleaded gasoline is an insufficient or total lack of local supply. The Indonesian Government, for example, facilitated the switch through the import of higher-priced unleaded gasoline from abroad.

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⇢ http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=459&ArticleID=5097&l=en

Clean Air Initiative for Asian Cities *Phasing out Leaded Gasoline Economic Madness?*.
⇢ http://www.cleanairnet.org/caiasia/1412/article-71105.html

Other Source
⇢ http://www.rec.org/REC/Publications/LeadOut/cover.html

2 Disarming And Destroying Chemical Weapons

Location

Global

Pollutant

Chemicals including chlorine, sulfur mustard, hydrogen cyanide, and sarin

Cause

Chemical weapons

Population Affected

Global

Health Impact

Weaponized chemicals are designed for use in warfare to cause death.

Output

The Chemical Weapons Convention (CWC) was ratified by the United Nations General Assembly in 1992 and ultimately ratified by 188 countries, effectively curtailing nearly all production and use of chemical weapons worldwide. Since 1995 Green Cross/Global Green have actively supported destruction of chemical weapons stockpiles in Russia and the US through a network of public outreach offices and educational activities.

Outcome

Destruction programs are ongoing in the remaining four of the seven original possessor states, including the U.S. and the Russian Federation.

Implications

By 2021, all chemical weapons in the world will likely be destroyed. Regular inspections of chemical industry as foreseen in the CWC prevents clandestine reproduction of chemical weapons. Countries that are not members of the CWC are excluded from global chemical trade.

Remaining Challenges

Three primary challenges remain: the safe destruction of remaining stockpiles, the identification and disposal of improperly discarded chemicals, and the acceptance of the treaty among the few remaining countries outside of the treaty.

Chemical nuclear warheads at a Russian stockpile.

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, as mentioned in the 2008 World's Worst Polluted Places Report. The most common methods of OCW disposal historically have been ocean 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 over time in leaking of the shells due to long-term corrosion) or burned in open pits, or the chemical agent was poured into lakes. As a result, traces of undestroyed chemical agent or products of its destruction (dioxines, furanes, arsenic, acids, etc.) are leaching today at these sites 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 occurring 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 have 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 200 sites with OCW in the U.S. In Russia, experts estimate the existence of some dozens of OCW sites.

Site Details

Chemical weapons are classified as arms that use 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). Most chemical weapons produced have either been used on the battlefields of WWI (more than hundred thousand about 124,000 metric tons), dumped in one of the many oceans during the 50's and 60's (several hundred thousand metric tons) or were still stored in stockpiles worldwide up until the 1990s (about 70,000 metric tons). By summer 2009, roughly half of this amount has been destroyed. These remaining stockpiles are extremely dangerous if they are not adequately maintained and guarded.

Exposure Pathways

Chemical weapon agents or products of their unregulated destruction (open-air incineration, sea-dumping, burial) like dioxins and furan 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 water, where they quickly bioaccumulate in the food chain.

Health Impact

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, amounts the size of a small drop lethal doses can cause almost immediate death.

A Dead Lake For Drinking Water?

The dumping of phosgene, diphosgen and picric acid in Lake Mokhovoe in Russia's Penza region released approximately 740 tons of hydrochloric acid into the lake of 300'000m3. The water in the 1960s showed an extremely low pH-level of 1.5-2.5, killing every plant and animal in the lake. Although the lake has recovered a bit in the intervening decades, it remains at an unusually low pH-level of 4.2-4.8. As a result of the acidity of the water, there are still only a few primitive life forms found in the lake today. This lake is one of the only source of drinking water for the more than 650,000 inhabitants of Penza (Surskoe water reserve).

Intervention

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". As of August 2009, there were 188 member states (out of 195 countries), and four countries with declared Chemical Weapon (CW) stockpiles.

Green Cross Switzerland, with its partner organizations Green Cross Russia and Global Green USA, has been key in facilitating the timely and safe destruction of CWs in Russia and the U.S., which together possess more than 90 percent 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 throughout the world at that time. The organization has also encouraged an international partnership toward global chemical disarmament, and effective implementation of the Chemical Weapons Convention. Starting in 1997, Green Cross/Global Green has established a network of 12 local/regional public information and outreach offices in Russia and initiated an annual National Dialogue meeting which brings together all stakeholders. Since 2007, Green Cross has been working with Blacksmith Institute to isolate three open pit burning sites in Russia's Penza region that threaten the drinking water supply of 600,000 people through the migration of dioxines, furanes and arsenic released during the incineration process into Penza's drinking water reserve.

Implementing Organizations

Organisation for the Prohibition of Chemical Weapons, Green Cross Switzerland, Green Cross Russia, Global Green USA, and Blacksmith Institute

Remaining Challenges

Safe destruction of remaining chemical weapon stockpiles demands labor- and capital-intensive processes. Currently, there is no international inventory or exhaustive data on the quantity or location of these chemicals, causing a security issue around the world. In order to completely remove remaining weapons, the international political community must reach consensus and act upon this issue collectively.

Russian stockpile with chemical artillery shells. These weapons are inspected regularly. Chemical test kits help to rule out the presence of warfare agent vapour in air from leaking weapons. This stockpile is in the process of being destroyed since May 2009.

3 Reducing Indoor Air Pollution
Accra, Ghana

Location

Accra, Ghana, West Africa

Pollutant

Indoor Air Pollution (carbon dioxide, particulate matter).

Cause

Burning of biomass (wood, charcoal, dung, crop residue) for cooking

Health Impact

Cooking fumes lead to an estimated 1.5 to 2 million deaths worldwide according to a 2000 report [1].

Output

To address the health effects of indoor air pollution due to cooking with biomass, the Gyapa stoves project has created an innovative commercialization scheme for producing and distributing an improved cooking stove, coupled with a campaign to drive demand by raising awareness of the health risks posed by indoor air pollution and teaching women how to cook traditional foods with the new stoves. be relocated. These components include medical clinics, therapy camps, family clubs, and micro-lending programs.

Outcome

In 2008, 68,000 stoves were sold in Accra and Kumasi, potentially providing cleaner indoor air for approximately 400,000 people, including approximately 160,000 children. PM10 levels in the air decreased by 40 to 45 percent through use of the stoves [2].

Implications

Many projects have focused on improving the stove technology to reduce pollutants. Uniquely, this program, because of its innovative strategy toward creating a sustainable business model, has gone the next step in gaining widespread use by creating a self-sustaining market and supply chain. Project partners expect 100,000 additional stoves to be sold in 2009.

Remaining Challenges

The Gyapa stove confronts issues of pricing, manufacturing, and quality control.

Improved cooking stoves help homes in Ghana approach international standards for indoor air quality.
Credit: EnterpriseWorks/Vita

[1] **Ezzati, M., and Kemmer, D. M.** 2002.
http://ehp.niehs.nih.gov/members/2002/110p1057-1068ezzati/EHP110p1057PDF.PDF
[2] **Titiati, A.** Retrieved Sept. 15, 2009 from
http://www.pciaonline.org/files/Titiati_Commercialization_Stoves.pdf

Commercial distribution of improved stoves helps reduce respiratory illness due to cooking fires. Credit: EnterpriseWorks/VITA

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 percent of the world's population gets their energy for cooking in this way, with almost all of these people living in impoverished countries [3].

In the West African nation of Ghana, the majority of the population relies on biomass (wood, charcoal, dung and crop residue) for cooking, causing high concentrations of smoke and carbon dioxide in traditional homes. In 2000, the World Bank estimated that 95 percent of Ghanaian households used solid fuels to power stoves, a much higher portion than the 73.4 percent estimate for Africa's Northwestern quadrant [4]. Worldwide, the burning of solid fuels is thought to be the largest source of indoor air pollution, and 80 percent of global exposure to such pollution occurs in developing nations [5].

As noted in the 2008 World's Worst Polluted Places Report, 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 amounts of air emissions [6]. The high amount of emitted particulate coupled with usually poor ventilation produces indoor concentrations of toxic fumes, which pose families at health risks. 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.

Site Details

Rural Ghanaian homes are generally small and often consist of one or two rooms. They are generally poorly insulated and ventilated. Cooking may take place inside or outside the home over a traditional clay stove or an open fire, fueled by savannah wood or other biomass; this use of solid fuels increases indoor air pollution as wood smoke freely passes into living spaces or into other homes. The use of wood as cooking fuel not only harms the inhabitants' health, but is also recognized as a factor in deforestation, soil erosion, loss of soil fertility, and ecosystem imbalance [7].

Health Impact

The effects of indoor air pollution range from acute respiratory infections, chronic obstructive pulmonary disease, lung cancer and asthma, to nasopharyngeal and laryngeal cancer. It also contributes to cataracts, blindness, and perinatal risks such as stillbirth, low birth weight, prematurity and early infant death.

In 2000, between 1.5 and 2 million deaths worldwide were caused by indoor air pollution. This represents

[3] **World Health Organization**. 2009. *Indoor Air Pollution and Household Energy Directory of References*. Retrieved 2 Oct. 2009 ⇢ http://www.who.int/heli/risks/indoorair/indoorairdirectory/en/index.html

[4] **Smith K, Mehta S, Maeusezahl-Feuz M.** *Indoor air pollution from household use of solid fuels*. In: **Ezzati M, Lopez A, Roders A et al**. Comparative Quantification of Health Risks, Global and Regional Burden of Disease Attributable to Selected Major Risk Factors, Geneva, World Health Organization, 2004. pp. 1435-1494. ⇢ http://www.who.int/publications/cra/chapters/volume2/1435-1494.pdf

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[6] **Bruce, N., et al**. *Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala*" International Journal of Epidemiology. 1998: 27: 454-4583 ibid

[7] ⇢ http://www.ghanadistricts.com/districts/?r=7&_=126&sa=4604, retrieved October 22, 2009

4 to 5 percent of global mortality for that year [8]. Children under five, young girls and women are most severely affected: they spend most of their time at home near the stove, while husbands and elder children are at work or in school.

The US Environmental Protection Agency recommends the daily average concentration of smaller particulate matter (PM10, < 10 µm in diameter) be no more than 150 µg/m³. In comparison, homes in which solid fuel is used for cooking can reach concentration levels as high as 5,000 µg/m³. A child sitting directly next to a stove may breathe air containing up to 50,000 µg/m³ of noxious matter [9].

Exposure Pathways

Indoor Air Pollution mostly affects health through inhalation, but can also affect the eyes through contact with smoke. It happens largely in the household where cooking, sleeping, eating and other activities take place. Household members who help cook meals generally stand directly over the stove, inhaling smoke throughout the process, although anyone within the enclosed space is also affected. The burning of biomass fuels adds to airborne particulate levels. 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 [10].

Intervention

EnterpriseWorks Ghana, Shell Foundation and USAID have partnered since 2002 to find a solution to Ghana's indoor air pollution problem. Initially targeting the two main cities in the country, Accra and Kumasi, the Gyapa Charcoal and Wood Stoves project aimed to reduce smoke and particulate matter levels in urban and rural households by developing a sustainable supply chain for improved cook stoves and raise awareness of the health risks posed by indoor air pollution.

Gyapa stoves, named after the Ghanaian word for "good fire," are charcoal-burning stoves. They are a version of the Rocket stove design, but fitted with a ceramic liner to improve fuel efficiency. The project partners found that air quality improved 40 to 45%, and that children under five were 25% less likely to die from respiratory diseases [11]. An independent study comparing the traditional stove with the Gyapa stove found that average 24-hour PM2.5 concentrations decreased 52% from 65µg/m3 after introduction of the new stove to 320 µg/m3 in the 'after' phase ($p = 0.00$), and average 24-hour kitchen CO concentrations decreased 40% from 12.3 ppm to 7.4 ppm ($p = 0.01$). 24-hour average CO levels in households using the Gyapa stoves met, or nearly met, the World Health Organization (WHO) 8-hour Air Quality Guideline. Despite these advances, PM2.5 concentrations remained well above the WHO 24-hour guideline [12].

Many stove designs have been developed to replace traditional open cooking fires to reduce indoor air pollution, and these designs are still evolving. The important innovation of the current project is the partners' focus on developing an entrepreneurial, market-driven model to support the manufacture, distribution and use of the stoves. A network of local craftspeople and entrepreneurs profitably manufactures the metal stoves and ceramic liners and distributes them to retailers. Meanwhile demand is being driven by a public awareness campaign on the health effects of cooking fires. Care is also taken to instruct women on how to adjust their traditional cooking techniques to the new stove. EnterpriseWorks/VITA initially provided capital for suppliers to invest in the necessary materials and trained local metal workers and ceramicists to build the Gyapa. Partners also provided customer care, quality control and business advice.

[8] **Ezzati, M., and Kemmer, D. M.** 2002.

[9] Ibid.

[10] **Bruce, N., et al**. *Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala*" International Journal of Epidemiology. 1998: 27: 454.

[11] **Titiati.**

[12] **Pennise D, et al.** *Indoor air quality impacts of an improved wood stove in Ghana and an ethanol stove in Ethiopia*. Energy for Sustainable Development, 132, June 2009, p.

Sales for 2008 were 68,000 with 2009 sales projected at 100,000. Meanwhile the venture provides income to over 400 individuals.

Remaining Challenges

Indoor air pollution remains as a significant health risk in the developing world. In the Ghana case, the Gyapa stove confronts issues of pricing, manufacturing, and quality control. There is a high demand for skilled ceramicists and raw material in the manufacturing process, posing challenges in technology and investment transfers to the developing country. Moreover, implementing organizations also experience challenges in distributing the product on a large scale.

Implementing Organizations

EnterpriseWorks/VITA, USAID, Shell Foundation, US Environmental Protection Agency, JPMorgan/ClimateCare, Center for Entrepreneurship in International Health and Development (UC Berkeley), Aprovecho Research Center, Columbia University, Industrial Research Institute (CSIR Ghana), Ministry of Energy, Ghana.

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4 Managing Mine Tailings To Protect Scarce Water Supply
Candelaria, Chile

Location

Candelaria, Chile

Pollutant

Copper mine tailings

Procession in Copiapó
Credit: Kaworu Koneru

Cause

Open pit mining and mineral processing activities could contaminate limited water sources in the desert.

Health Impact

Tailing slurries with toxic components (such as cyanide) would contaminate groundwater from limited existing sources and cause nervous ad immune system damages.

Output

A tailing impoundment/cut-off wall system was constructed to dispose of tailings and conserve scarce water in the desert region. 80 percent of the water bound up in the tailings is treated and recirculated into the supply system.

Outcome

The multi-stage treatment process ensures trapping of tailings with toxic chemical content such as cyanide. The system, as a whole, collects around 365 million tons of tailings and treats the water content found in these materials.

Implications

Successful design and implementation of this comprehensive system serves as a prime example for tailings management in development countries, which is one of the most severe and underestimated environmental and health issues.

Remaining Challenges

Extract and treat the last 20 percent of water bound up in the tailings

A system in the Candelaria Mines is designed to protect groundwater supplies in this arid region.
Credit: Kaworu Koneru

Context

As mentioned in the 2008 Report, mine tailings are the waste materials after the minerals are separated from the ore in a mineral processing plant. "Typically, the original rock is crushed or ground to a particle size of less than 0.1 mm in order to release the valuable constituents."[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. Water is used as a binding agent in the impoundment process to extract the valuable mineral constituents. Supernatant water, once released into the environment, would change the current pH and heavy metal content of groundwater supply. Cyanide, which damages the brain and the heart, is commonly found in mine tailings. The U.S. EPA identified cyanide in at least 471 of the 1,662 National Priorities Listed sites for pollution remediation under Superfund.

Site Details

The Candelaria Copper Mine is located in the Sierra El Bronce mountain range in the Copiapó River valley approximately 20 km southwest of Copiapó in the Atacama region of Chile. At a 600-m elevation, this mine has an estimated life of 20 years. Although biodiversity is relatively low in this desert environment, its scarce water resources are integral to agricultural irrigation, urban residential and commercial, and industrial purposes. Mining is the most significant source of economic profit for the region, followed by agriculture and small-scale industry such as copper refinery.

Health Impact

The U.S. Center for Disease Control and Prevention (CDC) states shortness of breath, seizures, and loss of consciousness as the early indications of cyanide poisoning. Short-term exposure causes brain damage and coma. Miners exposed to high levels of heavy metals could experience breathing difficulties, chest pains, vomiting, headaches, and enlargement of thyroid glands.

Exposure Pathways

The United Nations Environmental Programme (UNEP) and the International Council on Metal and the Environment (ICME) report on tailings management cited exposure pathways include being in contact with tailings transported by wind and water erosion and consuming ground and surface water contaminated by toxins including cyanide, sulfates, or other dissolved metals.

[3] Copiapó Government Website. 2009.
http://www.copiapo.cl/Sitio/Default.asp

Intervention

The Candelaria project focused on proper disposal of tailings with impoundment technology as well as effluent leakage prevention. A baseline study was conducted to determine the content and extent of tailings Effluent with tailings content is trapped by spill collection systems and a temporary containment pond and re-circulated back to the processing facility for treatment. This facility thickens tailings to 50 percent solids content for easier disposal. A major component of the 450-hectare tailings disposal facility is the dam, which is constructed of waste material from the mine. The dam is divided into multiple stages to comprehensively trap and filter tailings from the water. This tailing impoundment/cut-off wall system was designed to contain more than 365 million tons of tailings combined and prevent storm surge with tailings content from entering the water treatment system. As a result, water pollution is prevented and through the recycling process, the quantity of limited ground and surface water supplies are preserved in this desert environment.

Implementing Organizations

The Compañia Contractual Minera Candelaria (CCM Candelaria)—a former joint venture of Phelps Dodge Corporation of the USA and Sumitomo Metal Corporation of Japan, currently owned by Freeport-McMoRan Copper & Gold, Inc.

Remaining Challenges

Treatment systems similar to the one installed at the Candelaria copper mine are able to extract and treat a majority of the water locked up in tailings. The remaining 20 percent of water bound up in tailings is generally difficult to remove. Additionally, design of the tailings disposal/water treatment structure must be able to confine the smaller particles of tailings, as leakage of these toxic materials could yield negative environmental and health impacts.

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5 Nuclear Contamination
Chernobyl-Affected Zone, Eastern Europe

Location

Chernobyl-Affected Areas of Ukraine, Belarus, Russia and Ukraine

Pollutant

Radioactive waste

Cause

Core meltdown at nuclear power plant (NPP) with following explosion and large-scale release of radioactive materials into the environment

Health Impact

The accident took lives of on-site workers and resulted in large-scale relocation of residents in the area. Exposure to radioactive particles caused the development of various types of cancers, genetic changes, and long-term psychological stress and illnesses among nearby residents. A 30-km zone around the former NPP is closed to the public and health-relevant nuclear contaminants will continue to pollute the environment for centuries.

Output

Green Cross Switzerland and its local partners in Chernobyl developed and implement a program with medical, psychological, and pedagogical components to improve living conditions of community members, in view that those cannot be relocated. These components include medical clinics, therapy camps, family clubs, and micro-lending programs.

Outcome

By 2008 there were 11 family clubs, with a total of over 1,200 members, distributed throughout Belarus, Russia, and the Ukraine. More than 14,600 children have participated in youth therapy camps. In these healthful and comforting surroundings, it is typical for their radionuclide levels to drop by 30 to 80 percent.

Implications

Therapy camps have proven to be a simple and low-tech mechanism to dramatically reduce the radiation load even in those exposed to a true nuclear catastrophe. This successful approach can now be reapplied at other regions of serious radioactive contamination. The emotional, medical, and financial consolation helps give local communities a sense of hope, which is essential both for fighting off radiation-spawned disease and also for regaining a sense of social normality.

Remaining Challenges

Implementing agencies such as Green Cross Switzerland cited challenges in funding programs and alleviating anxiety about public and environmental health in the affected area.

At the end of Therapy Camps, children's radionuclide levels are typically lowered by 30-to-80 percent.

Context

In the night of 25 to 26 April 1986, the explosion of Chernobyl's nuclear power plant's (NPP) fourth reactor, the greatest industrial disaster in the history of humankind, released one hundred times more radioactivity than the nuclear bombs dropped over Hiroshima and Nagasaki. Four workers were killed instantly. Four days later, the residents of nearby Pripyat were ordered to evacuate. The residents never returned, and the town remains uninhabited to this day. The NPP has been inactive since December 12, 2000, however, a core staff remains onsite to service and secure the facility. At the time of the accident, about seven million people lived in the contaminated territories, including three million children. About 350,400 people were resettled or left these areas. However, about 5.5 million people, including more than a million children, continue to live in the contaminated zones.

Radioactive materials cannot be treated, and only become harmless when they have finished their radioactive decay. Because, depending on the material, 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. Selected as one of the 2008 Top Ten Worst Pollution Problems, radioactive waste continues to threaten our world today. In the case of Chernobyl, relevant amounts of nuclear materials have been released into the environment which cannot be remediated.

Site Details

The Chernobyl area was chosen still in Soviet times as the site of the first NPP on Ukrainian soil. The Chernobyl NPP lies in northern Ukraine, about 7 km from the border with Belarus, while about 120 km to the south lies Kiev, the capital of Ukraine, with a population of about 3 million. Both countries border Poland to the west and Russia to the east.

In addition to the reactor's immediate surroundings –an area with a radius of about 30 km– other regions were contaminated, particularly in Belarus, Russia and Ukraine, but also as far as Sweden, Western Siberia, and Northern Italy. International estimates suggest that an area up to146,000 km2 extending into Belarus, Russia and Ukraine are contaminated with cesium-137 at levels exceeding 1 curie (Ci) or 3.7 x 1010 becquerel (Bq) per square kilometer (1 Bq corresponds to 1 radioactive decay per second). This is an area greater than that of the neighboring countries of

Youth from Belarus spend at least 4 weeks in camps which provide healthy air and food.

Latvia and Lithuania combined. Most of the contaminated territory lies in Belarus, since up to 70 percent of the total fallout was deposited there. Of the total area of Belarus, 22 percent was contaminated with more than 1 Ci/km² of cesium-137. In the case of Ukraine, 7.25 percent of the territory was affected, and in the enormous Russian Federation, still 0.6 percent.

Health Impact

The level of radioactive contamination measured does not in itself indicate how much radiation is absorbed by the people living in these areas. The authorities responsible for managing the disaster in the three most affected countries estimate that people living in an area contaminated with 1 to 5 Ci/km² absorb an average of less then 1.0 millisieverts (mSv) per year (millisieverts are the internationally recognized units used to measure the harmful effects of radiation on the human body, i.e., the biologically effective dose). Only when soil contamination is over 5 Ci/km² are people likely to absorb more than 1 to 5 mSv per year. As a comparison: within the European Union, 1 mSv per year is the dose limit specified for people living near a nuclear power station.

There are widely varying analyses of the long-term health impact by the Chernobyl disaster, mostly reflecting specific agendas. To date, no consensus was found between interest groups. However, people living in contaminated areas have not only an increased chance for developing different pathologies, but suffer also from psychological stress. Passivity and depression are commonly observed in the Chernobyl region.

Exposure Pathways

The main threat to health is the ingestion of radioactive particles through air, food and water. The most relevant pollutants from a public health perspective are iodine-131, cesium-137, strontium-90, uranium
and plutonium. Iodine-131 (a homologue of normal iodine) is readily absorbed by the thyroid gland in case of a lack of naturally occurring iodine, leading to thyroid cancers. Strontium-90 (a homologue of calcium) is readily built into bones, leading to bone cancer or leukemia. Cesium-137 (a homologue to potassium) is built into muscle and tissue, leading to diffuse irradiation of the entire body. Radiocesium does not as effectively accumulate in the body as radioiodine or radiostrontium. The incorporation of

plutonium or uranium might ultimately lead to lung cancer.

Intervention

As it will be impossible to resettle the millions of people living in areas affected by the Chernobyl disaster, the Green Cross interventions aim at improving the living conditions in the villages of Belarus, Ukraine, Russia and Moldova. Green Cross Switzerland, in collaboration with its local partners, has developed over the years a set of medical, psychological and pedagogical interventions:

- **Therapy camps:** With the aim to strengthen their immune system and mental state, children and youths from Belarus, Russia and the Ukraine spend at least four weeks in camps providing healthy air and food. Medical and psychological care strengthens their immune systems and helps them to develop a more positive life attitude. At the end of the camps, the levels of radionuclides measured in children are typically lowered by 30 to 80 percent. More than 14,600 children and youth have participated in therapy camps since 1996.

- **Health preservation:** Regular visits by medical staff to the villages help to prevent chronic illnesses, thus avoiding serious impediments in the long term, but also help to assess the long-term efficiency of the measures taken.

- **Training for trainers:** The training courses for prospective youth-group leaders aim at making youths responsible and knowledgeable so they can pass on their knowledge to others.

- **Family clubs:** Those are established in villages and serve as a focal point for the population to share problems, learn about how to deal with the contaminated environment (e.g. in food courses teaching how to grow and prepare foodstuff in order to considerably reduce the level of radioactive intake), and facilitate local initiatives. In 2008, 11 family clubs with a total of 1,200 members were active in Belarus, Russia and the Ukraine.

- **Micro-credit programs:** Support local initiatives through micro-financing, allowing people to build their own small businesses and contribute to the local economic development.

Implementing Organizations

Green Cross Switzerland, Green Cross Belarus, Green Cross Russia, Green Cross Ukraine, and Swiss Agency for Development and Cooperation

Remaining Challenges

Intervention plans must address the complexity of radioactive waste contamination. For instance, they must deal with the immediate needs to clean up sources of contamination and reduce long-term physical and psychological damages to public health. This often entails working with government agencies, public interest groups, and community members. Successful implementation of these programs requires environmental education for the public, active participation, and extensive funding.

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6 Improving Urban Air Quality
Delhi, India

Location

Delhi, India

Pollutant

Sulfur Dioxide, particulates, carbon monoxide and other components of urban air pollution.

Cause

Emissions from automobiles, power plants, as well as other local industrial and urban sources.

Health Impact

Long-term exposure to relatively low levels of pollutants can cause serious health problems, including cancer, respiratory and cardiovascular diseases, and asthma. The health effects of outdoor air pollution fall disproportionately on infants, children, and the elderly.

Delhi combats air pollution with a fleet of buses using compressed natural gas.
Credit: Deepak Gupta

Output

India's Ministry of Environment and Forests undertook extensive measures to reduce vehicle emissions in the late 1990s including the introduction of a fleet of buses powered by compressed natural gas, mandatory inspection and maintenance requirements, emission norms, more stringent clean fuel requirements, and a pollution tax [1]. More recently, a subway system was constructed and the highway network was rehauled to reduce congestion.

Outcome

From 1993 to 2000, ambient carbon monoxide (CO) decreased by almost half, and lead concentrations fell by 75 percent. Between 2000 and 2003, as buses were converted to CNG, sulfur dioxide levels (SO2) decreased by 34.8 percent, and particulate matter (PM10) levels, by 7 percent [2].

Implications

Use of alternative fuel vehicles can yield significant urban air quality improvements, however, early gains have been neutralized due to the increase in the number of personal vehicles and increased commuting distances. The completion of an extensive subway system should help to reduce this burden.

[1] **Ravindra, K. et al.** (2006) Assessment of Air Quality in Delhi After the Implementation of Compressed Natural Gas (CNG) as Fuel in Public Transport in Delhi, India. Environmental Monitoring and Assessment, 115, 405-417.

[2] **Chelani, A. B., & Devotta, S.** (2007). Air Quality Assessment in Delhi: Before and After CNG as Fuel. Environmental Monitoring and Assessment, 125, 257-263.

Context

In the last half-century, increasing migration and industrialization have caused a boom in the number and density of mega-cities worldwide. While in 1950 just 54 million people lived in cities with populations larger than 5 million, this number is expected to be more than ten times higher by 2015 [3]. Despite tremendous social and technological advances, this rapid growth has come with a heavy price: the confluence of overcrowding with the rise of personal automobile ownership has made air pollution common in these ever-larger urban centers.

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. People living in large urban areas, especially in developing countries, where the health risks of air pollution may be underestimated 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. Cited as one of the Top Ten Worst Pollution Problems in Blacksmith Institute's 2008 report, urban air pollution persists as a growing environmental health issue [4].

Site Details

India carries a large part of this heavy burden. In the National Capital Territory (NCT) of Delhi, urban population increased by 51.53 percent between 1991 and 2001 [5], and is expected to reach 21 million inhabitants by 2015, making Delhi the 5th largest city in the world [6]. In addition to the ecological and industrial problems this poses, Delhi's communities and government have had to face a dramatic increase in pollutants resulting from the surge in personalized vehicles. Historically the city has relied largely on small, 2 and 3-wheeled vehicles equipped with 2-stroke engines, which emitted more than 70 percent of hydrocarbons and 50 percent of carbon monoxide in Delhi's air. Overloaded, poorly maintained buses and diesel trucks are also traditional fixtures on the city streets. This combination led to a dramatic rise in pollution from total suspended particles (TSP), which reached a high of 450 $\mu g/m^3$ in 1996 [7].

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 Impact

Major health effects associated with outdoor air pollution are typically chronic pulmonary and cardiovascular 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

[3] **United Nations Population Division,** *World Urbanization Prospects: The 2001 Revision.*

[4] **Blacksmith Institute.** *Top 10 Worst Pollution Problems*, 2008.

[5] **United Nations Environment Program.** *CNG conversion: Learning from New Delhi.* Retrieved 10/05/09 from:
http://ekh.unep.org/?q=node/1737

[6] **United Nations Population Division,** *World Urbanization Prospects: The 2001 Revision.*

[7] **Chelani, A. B., & Devotta, S.**

disproportionately on infants, children and the elderly. People with pre-existing health conditions are also significantly affected. Studies indicate that chronic exposure to nitrogen dioxide (NO_2) 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. It is estimated that 7,500 Indians die every year from outdoor air pollution in Delhi alone. A significant reduction in vehicular pollution is key to saving those lives, as well as reducing soaring health care costs. To accomplish these goals, studies have established a target of reducing particulate matter (PM_{10}) by 142 $\mu g/m^3$ [8].

Efforts to improve air quality in Delhi face an uphill battle given a rapidly growing population and expanding metropolitan area.
Credit : Dave Morris

Intervention

Since the early 1990s, India's Ministry of Environment & Forests (MoEF) has undertaken a multi-pronged approach to solving Delhi's air pollution problem. Officials recognized early on that vehicles contributed almost two thirds of total pollution figures and initially focused their efforts on converting Delhi's public transportation fleet to cleaner fuels; the first Compressed Natural Gas (CNG) bus was launched on an experimental basis in 1998. Negotiations between the local and national governments and private contractors culminated in 2001 with the progressive conversion of city buses. Delhi now boasts the largest fleet of CNG-powered buses in the world, and has invested in a suitable network of CNG stations to cater for the demand. While buses account for less than 1% of vehicles on the road, they serve almost half of Delhi's travel needs [9].

CNG's success in Delhi relied on legal requirements forcing the local government, private operators and individuals to convert to cleaner fuels. Early on, India's Supreme Court and MoEF introduced emission norms, mandatory inspection and maintenance requirements, and gradually phased out older private vehicles. Through sales tax exemptions and other incentives, the Delhi government helped replace 47,000 older auto-rickshaws and conducted pollution testing on 2.4 million vehicles between 2002 and 2003 alone. Other fuel control measures were introduced: a ban on leaded gasoline, the introduction of EURO I and EURO II emission norms, controls on adulteration of fuel, control of their sulfur content, lowering of benzene content in petrol [10]. These measures

[8] **Ravindra, K. et al.**
[9] **Chelani, A. B., & Devotta, S.**
[10] Ibid.

eventually led to the wide-scale conversion to natural gas and in 2005 the Supreme Court began imposing a pollution tax on diesel buses that had not yet converted to CNG. The revenues generated allowed the city to invest in other pollution control measures throughout Delhi's agglomeration.

Following MoEF's recommendation, Delhi's government initiated an ambitious project to update its transportation infrastructure. The Delhi Metro Network, started in 1998, opened its doors to commuters in 2002 and has since been a model of speed and efficiency. With further expansion phases planned for the upcoming years, the network will reach 500 km of metro lines by the year 2020. The highway network has also been rehauled, notably with the construction of the brand new, 136 km-long Kundli-Manesar-Palwal (KMP) expressway. This ring road has been an important factor in helping decongestion within Delhi itself.

Results

The partnership's initiatives, and the government's stringent legal requirements in regard to the major outdoor air pollution contributors yielded good results. After peaking in 1996, vehicular pollution was curbed and levels of the major pollutants began decreasing: between 1998 and 2003, ambient carbon monoxide (CO) decreased by almost half [11]; from 1993 to 2000, lead concentrations fell by 75 percent; between 2000 and 2003, as buses were converted to CNG, sulfur dioxide levels (SO_2) decreased by 34.8 percent, and particulate matter (PM_{10}) levels, by 7 percent [12]. During the same period, however, monitors also observed a 13.7-percent increase in nitrogen dioxide (NO_2). This is explained by the dramatic rise in personal vehicles, but also by CNG's high burning temperatures, which help nitrogen from air react with the oxygen in the combustion chamber, thus resulting in higher NO_2 levels than traditional engines. These results are widely considered to show a significant success, even leading one expert to exclaim, "What took 30 years to accomplish, we have done in 5 years." [13] In 2003, Delhi received the Clean Cities International Award by the U.S. Department of Energy for its aggressive efforts in curbing pollution.

Implementing Organizations

India's Ministry of Environment & Forests (MoEF), the Supreme Court of India, the Delhi Metro Rail Corporation.

Remaining Challenges

Delhi's development as one of Asia's main industrial and financial hubs has caused an important increase in population, leading to an explosion in the number of personal vehicles: from less than a million in 1990 to almost 3 million in 2005 [14]. This rise will present a formidable challenge to Delhi stakeholders, as vehicular pollution contributes 67 percent of the total pollution in the city. [15] In addition, and despite a promising curb in overall vehicular pollution, the Central Pollution Control Board still considers most major pollutants to be above acceptable levels. The high levels of NO_2 emitted by CNG, as well as the many other pollutants caused by factors other than vehicles must also be addressed: studies showed that particulate matter (PM_{10}) levels began increasing again in 2003 [16]; this increase is related to small industries, domestic coal burning, thermal power plants and natural sources as well as vehicular pollution, but the trend demonstrates the challenges ahead for Delhi's population. Government agencies and individuals will need to continue re-assessing fast-changing demographics, technologies and industry in order to prevent a return to the catastrophic pollution levels of 1990's.

[11] **Ravindra, K. et al.**

[12] **Chelani, A. B., & Devotta, S.**

[13] United Nations Environment Program.

[14] **Narain, U., & Krupnick, A.** (2007) *The Impact of Delhi's CNG Program on Air Quality.* Resources for the Future Discussion Paper 07-06. Retrieved 10/05/09 from: http://ideas.repec.org/s/rff/dpaper.html - Discussion Papers

[15] Chelani, A. B., & Devotta, S.

[16] Ravindra, K. et al.

Outcomes of Delhi Air Quality Improvement Measures

Measures	1996	1998	2000	Outcomes
Emissions Norms of Vehicles	Emission norms made stringent as compared to 1991	Emission norms for catalytic converter fitted vehicle made stringent. Hot start replaced by Cold start test which gives less emissions	Euro-I equivalent norms for all types of vehicles except passenger vehicles which are EURO-II equivalent	GNG/LPG norms finalized
Fuel Quality Improvement	Fuel Quality Specification notified under EPA for the first time. Lead content (g/l) = 0.15 Diesel Sulphur = 0.5% Gasoline Benzene = 5.0%	• Diesel sulpher reduced to 0.25% • Gasoline benzene reduced to 3.0% • Gasoline lead phased out	• Diesel sulphur reduced to 0.05% • Gasoline benzene reduced to 1.0% * Gasoline sulphur with 0.05% maximum sulphur in all outlet. • Low smoke 2-T oil introduced	Diesel with 0.05% sulphur throughout retail outlets in metro area
Other Measures	Govt. vehicles to run CNG/ Catalytic Converter	• 15 years old commercial vehicles banned • Pre-mix 2T oil in retail outlets	• Buses more than 8 years phased out • Replacement of pre-1990 autos/taxis with vehicle on clean fuels • Conversion of post 1990 autos to CNG initiated • Fuel testing laboratory established	All taxis/autos and buses to run on CNG

Source: Auto Fuel Policy, 2002, cited in: United Nations Population Division, World Urbanization Prospects: The 2001 Revision

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7 Removing Lead Waste
Haina, Dominican Republic

Location

Bajos De Haina, Dominican Republic

Pollutant

Lead

Cause

Improper recycling of used lead acid (car) batteries

Health Impact

Lead furnace slag has contaminated Haina's soil, water and food supplies leaving the population of Haina with one of the highest levels of lead poisoning in the world. Health effects of lead poisoning include neurological damage, reduced I.Q., anemia, nerve disorders, loss of memory and concentration, infertility, increased blood pressure and chronic headaches and weakness [1]. Effects are particularly severe on children.

Output

A coalition including government, academics and NGOs came together to design and fund a cleanup project—the first of its kind in the country.

Outcome

Average blood lead levels among patients decreased significantly from 71 to 28 µg/dL The cleaned up site is slated to become a public park.

Implications

Improper treatment and disposal of chemicals lead to irreversible environmental and health impacts. International communities must pay attention to the full life-cycle of these toxic materials.

Remaining Challenges

Unfortunately, neurodevelopment damages that have occurred among the community's children in Haina may be permanent. Therefore, a significant amount of social support is needed to help impoverished families deal with these life-long disabilities.

[1] *World's Worst Polluted Places Report 2008*. **Blacksmith Institute.**

Local contractors in the Dominican Republic were hired and trained to manage hazardous materials cleanup

Context

Bajos De Haina has been referred to as the 'Dominican Chernobyl' due to its toxic pollution levels. A community near an abandoned lead smelter, over 90 percent of Haina's residents were found to have elevated blood lead levels. In 2000, the Dominican Secretary of Environment and Natural Resources identified Haina as a national hotspot of significant concern. According to the United Nations, the population of Haina is reported to have the highest level of lead contamination in the world.

Site Details

Paraiso de Dios is a community located in the municipality of Haina, 7 kilometers due west of the capital, Santo Domingo and just west of the bridge crossing the Haina River. The former MetaloXsa (Metales y Oxido, S.A.) Lead-acid Battery Recycling facility occupies approximately 45 hectares on a site located on the top of a hill with a view of the Rio Haina, which is about 300 meters to the south and drains directly into the Bay of Haina another 0.7 km downstream. Three sides of the site are bordered by homes with dirt floors. Across the street is a large vacant parcel of land with barbed wire restricting access. The site is flat with no intact buildings, roads or facilities. There are a few smaller dilapidated building shells and the remnants of a concrete rotary kiln support. Paraiso de Dios is very hilly. Rainwater runoff from this site travels east and south through a highly-populated residential neighborhood to the Haina River, and then drains into the Bay of Haina. Lead levels in soils throughout the community exceeded U.S. EPA limits for lead by over 10,000 times -some reaching 60 percent lead content.

Health Impact

The health effects of lead poisoning are both acute and chronic, and they are particularly severe on children. These effects include: neurological damage, reduced IQ, anemia, nerve disorders, muscle and joint pain, loss of memory and concentration, infertility, increased blood pressure and chronic headaches and weakness. Even small amounts of lead in children's bodies are associated with long-lasting neurological and cognitive impairments. At high concentrations lead poisoning can cause death. Further testing by Blacksmith Institute staff continued to show elevated blood lead levels in the community despite the end of smelting activities at the plant:

Date	# Patients	Average BLL Concentration
March 1997	116	71 µg/dl
August 1997	146	62 µg/dl
March 2007	31	31 µg/dl
March 2009	83	28 µg/dl

With these high levels of lead in the community, action needed to be taken to remove the contaminated material and educate the community on the health risks of lead.

World Health Organization limits are 10 µg/dl for lead in blood although current epidemiological evidence suggests there is no safe level of exposure to lead. According to most international standards, lead levels above 70 µg/dL in children are considered medical emergencies. Levels upwards of 100 µg/dl have been documented in children living adjacent to lead smelting facilities in the Dominican Republic as well as in other places around the world including Senegal and the Philippines.

Exposure Pathways

The defunct recycling facility's lead slag continued to contaminate Haina's soil, water, and food supplies. Empty battery casings, large piles of excavated lead slag, and other debris litter the facility. Pollution enters human bodies in the following ways:

- **Inhaling dust:** During dry months, soil causes airborne dust pollution that affects a large area. Automobile usage, construction activities, and other everyday activities further generate airborne dust, which enters the respiratory system as well as the bloodstream.

- **Absorbing dust through skin or mouth:** Soil easily generates dust that is ingested through normal childhood hand-to-mouth activity. In addition, barefoot children pick up dust-covered objects and bring them to their homes. Dust containing lead can build up on bedding, clothing, and cooking utensils.

- **Drinking contaminated water:** In time, lead can migrate and contaminate subsurface and surface water supplies. Airborne dust can also migrate and enter water supplies.

- **Eating contaminated food:** Contaminated soil generates dust that accumulates on locally grown fruits and vegetables. Dust can enter homes and settle on food items inside.

- **Playing on slag:** Children handling the abundant large and small "rocks" in the area can get lead oxide on their hands. This substance enters the body through direct ingestion or contaminated foodstuffs.

Intervention

Terragraphics Environmental Engineering, in partnership with Blacksmith Institute, designed an intervention for the site with an approximate timeline of two years.

In 2007, Blacksmith Institute led the formation of a stakeholder group, meeting with possible funders and conducting community outreach and education programs. The stakeholder group consisted of The Ministry of the Environment and Natural Resources, the Autonomous University of Santo Domingo, MetaloXsa, and the community, among others. The group met regularly to discuss project progress and build consensus on appropriate intervention and remediation activities. In the first year, Blacksmith Institute consistently held community education days to encourage community members to adopt appropriate safeguards to mitigate their lead exposure. Ongoing blood testing was also conducted.

Excavation of the site occurred from December 2008 through February 2009. Over 6000 cubic meters of principal threat materials were removed from the community and transported to an industrial site for storage in an environmentally sound, monitored pit for processing at a later date. In conjunction with the Ministry of Environment, local crews and contractors were hired and trained, building capacity within the Dominican Republic to perform a hazardous waste removal operation - the first of its kind for the country. In addition to removing waste from the formal industrial site, community walkways and backyards were also excavated and backfilled with clean sand and soil. The main pit, where a majority of the waste was stored, will become a park in late 2009. Blacksmith Institute will continue to monitor the blood lead levels of the children in the community.

Implementing Organizations

Ministry of Environment in the Dominican Republic, Blacksmith Institute, the Inter-American Development Bank, University of Santo Domingo, TerraGraphics Environmental Engineering, Inc., Hunter College, City University of New York.

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Used Lead Acid Batteries Are A Global Pollutant

Recycled lead is a valuable commodity for many people in the developing world, making the recovery of car batteries (known as used lead-acid batteries or ULAB) a viable and profitable business. However, in many developing countries and some in rapid transition, recycling of car batteries is done improperly and informally. Batteries are often broken open by hand, and the battery acid poured into the soil where it contaminates the groundwater and surrounding area. Weather-exposed broken batteries and casings are left to emit lead dust. Smelting operations are usually conducted in the open air, in densely populated urban areas, and often with few (if any) pollution controls. As a result, lead contaminated compounds are released into the local environment in critical quantities.

Improper recycling of used car batteries occurs in every city in the developing world as part of a complicated cycle where batteries are sold by major firms internationally, recovered in small-scale local operations, and often recycled back to the large manufacturers.

As urban centers in developing countries become more populated, the confluence of increased car ownership and high unemployment rates has led to a pandemic of informal used car battery collection and melting operations. In many cases, informal battery melting is a subsistence activity - done in homes and common areas. The lack of awareness of the dangers of lead combined with a lack of viable economic alternatives has led to the systemic poisoning of communities throughout the world.

In communities such as Haina where brain damage has already occurred among children, that disability is permanent and requires intensive social support for the families of those children.

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8 Preventing Mercury Exposure
Kalimantan, Indonesia

Location

Kalimantan, Indonesia.

Pollutant

Mercury

Cause

Artisanal and small-scale (ASM) gold mining and processing.

Health Impact

Emission of mercury damages human health, contaminates water supply, degrades land quality, and causes air pollution.

Output

Yayasan Tambuhak Sinta (YTS) has established a community-based participatory program to reduce mercury emissions includes the introduction of innovative retorts used to reduce mercury vapors and enable recapture of mercury from the gold-mercury amalgam created in the mining process.

Outcome

When YTS began work less than 20 percent of miners were aware of how serious mercury poisoning was and how it was contracted; today over 90 percent recognized the seriousness and impacts of this issue. Their large and efficient retort designs have proven capable of recapturing 80 to 90 percent of evaporated mercury, and are becoming more widespread as the more influential operators adopt their use. Throughout 2009, mercury emissions from this site have been reduced by 2,390 kg.

Implications

The Mt. Muro site is responsible for approximately 10 percent of global mercury emissions --success here will have significant benefits not just for local mining communities, but also for marine ecosystems and developing world children internationally. It sets an example that can be reused at other ASM sites throughout Indonesia and the entire developing world.

Remaining Challenges

Reducing the intensity and frequency of mercury mining could potentially hinder economic development in the region. Mining waste, such as tailings, is not managed and often ejected directly into forested areas or water bodies.

Context

UNIDO estimates that mercury amalgamation from this kind of gold mining results in the release of an estimated 1,000 tons of mercury per year, which constitutes about 30 percent 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 [1].

According to UNIDO, as much as 95 percent of all mercury used in artisanal gold mining is released into the environment, creating a danger on all fronts—economic, environmental and human health (2005). Covered by the 2008 World's Worst Polluted Places Report, ASM still threatens today's world environment and public health.

Site Details

Central Kalimantan is a natural resource-abundant region in Indonesia that consists of dense tropical forests and rivers. It is also the third largest province in Indonesia, with an area of 153,800 km². The region primarily produces raw materials including rattan, resin, and high-value timber. Due to its mineral deposits, it has experienced mercury contamination from small-scale mining activities for the last 20 years. 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. According to the Global Mercury Project, gold in this region is located beneath the primary or secondary forest. Artisanal gold miners therefore often seek new deposits following illegal logging in tropical forests [2]. Metal amalgam deposited in this region is burned with mercury to extract the more valuable gold components. A number of mercury contamination *hotspots* have been identified in Central Kalimantan, and YTS has been implemented a project that covers:

1. Upper Barito: Mt. Muro. The illegal small-scale mining activities take place within the boundary of a legal, government-granted mining concession of the highest national status (a Concession of Work). A field investigation conducted by YTS with Dr. Kevin Telmer of the Artisanal Gold Council and Budi Susilorini – Indonesia Country Coordinator for Blacksmith Institute – in April 2009, estimated that ASM in the region emits 50 to 100 tons of mercury per year to the environment. So, artisanal gold mining in this locality is responsible for 5 to 10 percent of the total global mercury emissions from the ASM sector. The miners consume large quantities of mercury mainly because the ores are rich in silver, and mercury amalgamates both gold and silver. Another reason is the miners practice whole ore amalgamation where more mercury is needed in this process rather than amalgamating a concentrate only. As a result, much of the mercury used is lost to the environment as tailings. To worsen the issue, miners in the Upper Barito region use cyanide as an agent to capture an additional 30 percent of gold from the amalgam.

2. Upper Kahayan: Kuala Kurun, Tewah and Tumbang Miri. Gold shops in urban environment have been identified as the major source of emissions in this region because the miners usually carry their gold to these towns, where amalgam is burned at the point-of-sale. There are sixteen gold shops that actively burn amalgam in the three towns of Kuala Kurun, Tewah and Tumbang Miri.

Health Impact

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 [3].

Exposure Pathways

Mercury is a persistent global contaminant, and it has dangerous effect to the human's vital organs. Mercury can enter the human body through various

[1] **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

[2] GEF/UNDP/UNIDO Global Mercury Project –Central Kalimantan, 2007

http://www.borneomercury.com/english/home.htm

[3] *World's Worst Polluted Places Report 2008*. **Blacksmith Institute.**

Kalimantan's gold mining community is involved in ongoing developing of retort technology.
Credit: Yayasan Tambuhak Sinta

pathways, including inhalation, ingestion, skin contact, as well as maternal mercury transfer. Once mercury is released into waterways, it becomes a more toxic form of methyl-mercury, which bioaccumulates in the food chain (e.g. high fat-content fish) through bacterial digestion.

Intervention

Having identified major sources of mercury emissions, YTS is currently implementing a community-based, participatory project to reduce the atmospheric mercury releases. The organization has done so by conducting a program of direct intervention, aimed at lowering the level of mercury consumed by gold-processors and subsequent emissions from burning mercury amalgam.

Improving local technologies provides an important entry-point into this community and allows the project to collaborate with the gold-processors to solve their problems. Improving the miners' ability to recover mercury and promoting mercury recycling reduces both mercury emissions and the demand for further mercury. Moreover, improvements in technology not only provide better economic returns due to efficient recovery; but also create safer surroundings for people to work in.

In Mt. Muro, the present focus is on designing, manufacturing, transporting, field-testing and distributing efficient and safe large-capacity retorts capable of burning from 10 to 30 kg of amalgam per session. When this retort is used on daily basis, a 20-percent increase in efficiency is expected compared to the current locally made retort used by the miners. One of the major operators who have tested the 30 kg capacity retort reported a recapture rate of 90 percent (estimated 80 – 100 kg per month) and a corresponding reduction in costs to miners. Additionally, YTS continues to distribute small-capacity Fauzi retorts for burning amalgam balls of less than 1 kg. In the Upper Kahayan River, the intervention activities focus on supplying water-box condensers to gold shops that are burning gold-mercury amalgam.

The additional reduction of mercury emissions that will be achieved in 2009, as a result of the use of the retort and water-box condenser YTS has distributed so far, is estimated at 2,390 kg of Hg (approximately USD 140,000 of value). The number is expected to increase as a result of further equipment distribution in the last quarter of 2009 and the beginning of 2010.

Implementing Organizations

Yayasan Tambuhak Sinta (YTS), United Nations Development Programme (UNDP), United Nations Industrial Development Organisation (UNIDO), Global Environment Facility, and Blacksmith Institute.

Remaining Challenges

In certain mining areas such as Galangan, mercury is often supplied to gold shops free of charge, giving individual miners no incentive to reduce the amount used and subsequent pollution levels. Cyanide used to extract additional gold content from amalgam is not regulated—there is no tailing and mining waste management in the region. As mining shifts further inland mercury contamination will spread due to the over-dredging of rivers and heavy deforestation. Artisanal and small-scale mining (ASM) generates a significant portion of economic profits in the Central Kalimantan region. The gross primary ASM economy in Indo Muro is USD 25 million per year.3 If the environmental conditions continue to worsen and sites were no longer available for mining, unemployment and social unrest are likely to occur.

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Yayasan Tambuhak Sinta, Project Quarterly Report: Quarter 1, Quarter 2 and Quarter 3, 2009

Yayasan Tambuhak Sinta, Summary on the Artisanal Gold Mining Project in Central Kalimantan, July 2009

9 Mitigating Lead Exposures
Rudnaya River Valley, Russia

Location

Rudnaya River Valley, Russia

Pollutant

Lead

Cause

Legacy smelting and processing of lead, active lead mining

Population Affected by Intervention

55,000

Health Impact

Nearly a century of mining and refining of lead has left the soils of this region contaminated with heavy metals and other toxic substances contributing to high levels of cancers as well as lead poisoning, which is particularly severe among children.

Output

An international consortium is engaged in a multi-faceted project to mitigate the health effects of lead. Activities include: studying contamination and sources of exposure, conducting outreach and education, medical monitoring of children and cleaning up playground areas.

Outcome

Between 2007 and 2009, pollution remediation was conducted in a total area of 16,400 square feet. 90 percent of the children residing in this area saw an average of 37-percent blood lead level decrease.

Implications

A multi-pronged international approach with an emphasis on community education is highly effective in minimizing harmful impacts of industrial processes.

Remaining Challenges

Extensive contamination would require large-scale remediation activities and possibly relocation of some inhabitants.

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Children play in fresh sand after heavily lead-contaminated soil has been removed.

Context

As covered in the 2008 Report, metals smelters and processing heavily impact environmental conditions and often cause chronic and acute illnesses. Severe pollution of the Rudnaya River Valley area from mining, refining, and smelting activities resulted in a high cancer rate among residents. The district capital Dalnegorsk is contaminated with boron, sulfur, and heavy metals including lead, cadmium, and zinc. The second biggest town in the valley is Rudnaya Pristan, which translates into "mining port" and is built around the lead smelter and the seaport, is one of the most lead contaminated sites in Russia. Mining technology has not seen much efficiency improvement since 1920s. Extremely poor hazardous waste management has put local residents at high risk of lead poisoning and cancer, which is regularly reported in the area.

Site Details

Dalnegorsk (population 50,000) and Rudnaya Pristan (population 5,000) are located in the Russian Far East about 500 km northeast of Vladivostok. Rudnaya River flows into the Sea of Japan in the north of Russia's Primorsky Krai or Maritime Region, a century old mining area. There are several other smaller towns in the valley that are also contaminated with heavy metals. Lead and zinc ore produced in the local mines is then processed at the refining factory in Dalnegorsk. The lead and zinc concentrate were transported in open cars to Rudnaya Pristan for smelting up until 2006. Today the concentrate is no longer smelted, only transported to the port of Rudnaya Pristan for shipping abroad. The mines, refining plant, smelter stack and the railroad were the main sources of heavy metals contamination of the area. The local population is very poor and used to growing most of its food in local gardens where soil is often contaminated with lead and cadmium far above the US EPA limits.

Health Impact

The impacts of lead are most severe on miners, smelter and refining plant workers, and children. For instance each of four consecutive directors of the smelter in the last 30 years died from cancer. Certainly, nearly all the children in Rudnaya Pristan are never completely healthy. The town has the highest rate respiratory diseases in the region and a number of other illnesses including neurological damage are reported. In Rudnaya Pristan about 50 percent of tested children had elevated blood lead levels even after the smelting of lead concentrate was stopped.

Rudnaya Pristan's lead smelter switched to battery recycling when the health hazards of smelting lead concentrate became apparent.

Testing shows that the health problems will persist as long as the town remains highly contaminated. In Dalnegorsk and other settlements of the valley the situation is a bit better – about 20 percent of children have elevated blood lead levels.

Exposure Pathways

In Dalnegorsk the most contaminated areas are near the refining plant, mines, and the railroad. In Rudnaya Pristan the most contaminated places are the central part of town near the smelter and the port area. The contaminants most harmful for human health are lead and cadmium that enter human bodies in the following ways:

• Inhaling dust: It is a problem during the dry summer and fall seasons. It poses most risk to children since they are exposed to the heaviest dust particles occurring at the level right above the ground.

• Playing with contaminated soil: Wherever children run and play, they are always on highly contaminated soil. Children living right across the street from the smelter are at the highest risk. It gets progressively cleaner as distance from the smelter increases; at five kilometers from the main smelter stack, the environment is nearly clean.

• Indoor dust: Lead particles are brought in houses with street dust and on shoes that walked on contaminated soil.

• Local contaminated crops: Children and adults eat fruit with contaminated dust. In addition, edible plants uptake lead and cadmium from the soil; unfortunately the local staple, potato, does this most effectively. Contamination varies with location, but it is a very important pathway of exposure.

• Air pollution: Emissions of heavy metals to the air were the most significant exposure pathway before lead concentrate smelting was stopped in 2005.

Intervention

Far Eastern Environmental Health Fund in partnership with Blacksmith Institute and TerraGraphics Environmental Engineering developed a plan to mitigate lead health risks in Rudnaya Pristan, Dalnegorsk, and other towns in Rudnaya River Valley. Early efforts started in 2004 focusing on several things such as studying contamination and sources of exposure, doing community outreach and education, and conducting medical monitoring of children. In 2007 the partnership was joined by the Green Cross Switzerland enabling the scope of the project to expand to include cleaning up playground areas.

Results

As the result of the project activities, the mining company switched in 2005 from smelting lead concentrate to the recycling of old lead batteries. This change drastically decreased the air pollution, which was the main source of lead poisoning in Rudnaya Pristan. In 2005-2006, the main railway was removed, except for the section between the mine and refinery in Dalnegorsk. This action eliminated the second most significant source of contamination. Meanwhile, specialists of the Far Eastern Environmental Health Fund conducted regular community outreach and worked to educate both children and their parents about lead health hazards. From 2005 blood lead monitoring was conducted every year. Through local medical personnel, each family with children with blood lead levels over 8 µg/dl received proper counseling and supplied with Detoxal 75, a biological food additive based on brown algae developed by Russian scientists for removing heavy metals from the human body. In 2007-2009 seven playgrounds –a total area 16,400 sq meters –were decontaminated.

Residences and playground are right next to the lead smelter.

The health results were dramatic. Among 40 children in Dalnagorsk, 36 of them (90 percent) saw blood lead levels decrease. Prior to the project, the average blood lead concentration of those 40 children was 13.9 µg/dl. After remediation of playgrounds, counseling families, and providing them basic treatment the average blood lead concentration became 8.8 µg/dl. Project partners consider such a significant (37 percent) drop as a first sign of success. Similarly in Rudnaya Pristan, although the sample was small, children at the highest risk demonstrated a reduction in blood lead levels an average of 23 percent in 2008 versus 2007.

Remaining Challenges

Although the risk of lead poisoning among children has been greatly reduced since 2005, it persists as long as the valley remains contaminated. The most significant progress has been achieved in Dalnegorsk where it is possible in the near future to come very close to solving the issue of lead poisoning. The major issue remains in Rudnaya Pristan, because of very high contamination of the area. To eliminate the problem there requires decontaminating dwelling areas near the smelter and port possibly including the relocation of some families from contaminated housing. Furthermore, contaminated agricultural lands remain a persistent, widespread and possibly insoluble problem.

Implementing Organizations

Far Eastern Environmental Health Fund, Blacksmith Institute, Green Cross Switzerland, Terragraphics Environmental Engineering

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10 Disposing of DDT
Old Korogwe, Tanzania

Location

Old Korogwe, Tanzania

Pollutant

Pesticides DDT and Thiodan

Cause

Unsecured stockpile of 100 tons leaching into soil and stream

Health Impact

DDT releases a strong odor and damages the nervous system of adult and children.

Output

At the request of the government of Tanzania and with support from the African Stockpile Program, the German Technical Cooperation (GTZ) safely removed pesticides from the site and transferred them to Germany for destruction in accordance with international waste transfer regulations. GTZ also trained local personnel in hazardous removal techniques, enhancing Tanzania's capacity to conduct future clean up operations.

Outcome

The GTZ-led operation successfully removed 86 tons of DDT and 20 tons of DDT-contaminated construction material from the dismantled store and shipped them to Germany for incineration while abiding by international safety regulations.

Implications

This operation provides a model for international governments and supranational organizations to cooperate in removing toxic chemical stockpiles in developing countries where resources and technology are often missing.

Remaining Challenges

Many developing countries experience similar issues of improper toxic storage and disposal, especially that of persistent organic pollutants (POPs). These cases are often unknown or unreported until years later, directly threatening public health and the surrounding environment.

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Context

The people of the town of Korogwe fetch their daily drinking water, do their washing, fish and go for a swim in the local river. Nearby is a rust-pitted shed containing a 100-ton stockpile of DDT. Every rain shower in this tropical zone flushed the poison into the river [1].

Site Details

Old Korogwe is a mountainous small town approximately 280 km north of the Tanzanian capital, Dar Es Salaam with a population of nearly 10,000. The Old Korogwe pesticide store was located on the site of a former sisal factory and had stored DDT and Thiodan since 1980s. The site was within 80 m of the Pangani River, the only source of drinking water supply in Old Korogwe, and important for the production of rice paddies. Cattle of nearby small farms grazed within proximity of the site. The Micro Credit Bank for Women of Tanzania, a site with frequented by women and children, is adjacent to the pesticide storehouse. Children in the neighborhood also used to play on the extensive site of the storehouse.

Health Impact

DDT is an insecticide that was used in 1940s, mainly as malaria-prevention agent. The production and use of DDT has been banned since the Stockholm Convention went into force in 2004. Once introduced into the human body, DDT accumulates in the system over the long term. According to the WTO, the effects of DDT and its metabolites include premature birth, an elevated risk of breast cancer and damage to the nervous system, liver, kidneys, and immune system of adults and children.

Exposure Pathways

Eating contaminated foods and direct ingestion.

Intervention

The GTZ-led operation successfully removed 86 tons of DDT and 20 tons of DDT-contaminated construction material from the dismantled store and shipped them to Germany for incineration while abiding by international safety regulations [2].

The GTZ Team started the operation by strategically planning the process with input and comments from its project partners. When the team arrived at the site, it prioritized briefing nearby communities on safety issues related to DDT exposure and disposal, in order to evacuate the area during the process. Significantly, the entire process was carried out in accordance with international waste transfer regulations, for example, using UN-approved equipment and procedures. GTZ commissioned a German commercial disposal company, Currenta GmbH, Leverkusen, with the on-site tasks of securing and disposing of chemicals. Currenta also planned the transboundary transfer of collected DDT between Germany and Tanzania. Following the removal of DDT from the site, the pesticide store was demolished. The collected toxic waste was shipped to Dormagen, Germany based on OECD safety standards.

GTZ also worked closely with the Tanzanian National Environment Management Council (NEMC), and trained three employees from the Council as chemical waste disposal specialists. As a result, the NEMC now has local expertise to handle future disposal initiatives in the country under the World Bank's Africa Stockpiles Program (ASP) [3].

Implementing Organizations

The National Environmental Management Council (NEMC) of Tanzania, German Technical Cooperation (GTZ), the African Stockpile Programme (ASP) of the World Bank and Food and Agriculture Organization (FAO), and Currenta GmbH, Leverkusen (German commercial disposal company).

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Working in the intermediate zone

Remaining Challenges

As of February 2008, there were still 350 stockpiles in Tanzania with an estimated 1,500 tons of obsolete pesticides yet to be cleaned up by the ASP [4]. Unreported toxic storage cases like the Old Korogwe pesticide store are common in developing countries, where knowledge level of harmful pollutants are relatively low. These cases are often unknown or unreported until years later, directly threatening public health and surrounding environment. Furthermore, cases in which local governing agencies and public interest groups are aware of a public health sometimes lack resources for remediation and disposal.

In May 2009, the UN and WHO announced a plan to support a global phase-out of DDT by 2020 [5].

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[4] **GTZ,** 2008.
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11 Transforming An Urban Waterway
Shanghai, China

Location

Shanghai, China

Pollutant

Residential and Industrial Waste.

Cause

Dumping of raw sewage in waterway, compounded by flooding.

Population Affected

13.4 million [1].

Health Impact

Untreated sewage spreads cholera, typhoid, and dysentery among urban populations and disproportionately affect children's health.

Output

The Shanghai Government and Asian Development Bank teamed up to design and implement a 12-year project which included sewage treatment, injection of oxygen into the waterway, and flood controls to bring water quality to acceptable levels for household use.

Outcome

The first phase of the project improved water quality from worst than the lowest class in the national standard to Class III. The second phase aims at maintaining water quality while incorporating sustainable urban design elements in the rehabilitation system.

Intervention

This rehabilitation project demonstrated success in restoring contaminated water bodies in an urban setting as well as generating additional benefits such as increased green space and higher property values in the area.

Remaining Challenges

Despite ongoing billion-dollar investments and relocation/shutdown of industrial facilities, upstream pollution loads continue to threaten the Yangtze River.

Suzhou Creek runs through the heart of Shanghai.
Credit: Le Niners

[1] Asian Development Bank (ADB) Project Completion Report: Suzhou Creek Rehabilitation Project (Loan 1692-PRC) In the People's Republic of China. Sep 2005.
http://www.adb.org/Documents/PCRs/PRC/pcr-prc-32121.pdf

Context

More recently known as the most polluted water body in Shanghai or the "black and stink", Suzhou Creek has been a historically important shipping and trading route in China since 1600s. Starting from 1920s, the Creek has observed severe pollution due to urban population growth, industrialization, raw sewage and other wastewater discharge, which directly damaged plant and aquatic species and caused algal bloom. As a source of irrigation and industrial water supply to Shanghai, poor water quality of the Creek also threatened health conditions of the 3 million residents in the area.

Site Details

Suzhou Creek is a 125-km waterway of which 54 km cuts through the city of Shanghai. The average depth is 2 to 4 meters at low tide and about 7 to 8 meters at high tide. Its upper reach receives water from Taihu, a large freshwater lake west of Shanghai that serves as a flood relief; the lower reach flows through downtown Shanghai and intersects with the Huangpu River before joining the Yangtze River. Suzhou Creek has an average net flow of 6 m3/s and 10 m3/s at the river mouth, of which 40 to 60 percent is contributed by the inflow of domestic and industrial wastewater along the banks. Pollution from human and industrial waste dumping over the past few decades led to visual pollution and release of a foul odor. Algal blooms became a common occurrence in the early summer. According to official sources in China, Suzhou Creek overall failed to meet Class V, the lowest of the national water quality standard. Out of the six branches of the Creek, Zhengru Port (Zhengrugang) was once recorded having water quality three to four times lower than Class V.

Health Impact

Sewage can carry potent human pathogens such as cholera, typhoid, and dysentery. Other diseases caused by sewage contamination of water include schistosomiasis, hepatitis A, and intestinal nematode infections, many of which can live in aquatic environments for extended periods of time. The World Health Organization estimates that 1.5 million preventable deaths per year result from unsafe water, inadequate sanitation or hygiene, with young children being the largest group of victims. Another 860,000 children under age 5 are estimated to die annually as a direct or indirect result of the underweight or malnutrition associated with repeated diarrheal or intestinal nematode infections.

Exposure Pathways

Underdevelopment of sewage treatment systems and unregulated dumping of refuse continued to contaminate Suzhou Creek. Industrial, commercial, and residential waste was once visible on the surface of the Creek. Pollution enters human bodies and damages health in the following ways:

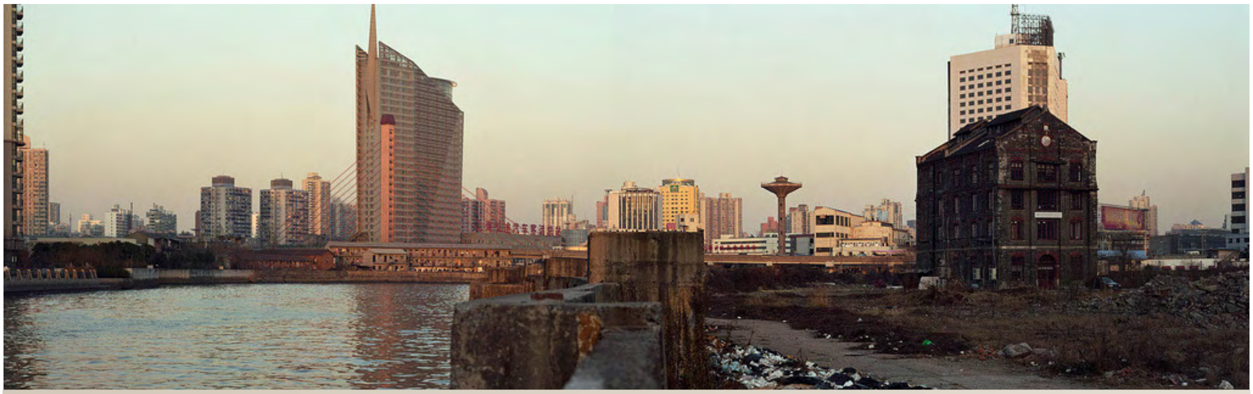
- **Preparing food with/Drinking contaminated water:** Untreated sewage can enter into drinking water pipes during rainfall events, directly reaching household water supplies.

- **Absorbing pollutants through skin, eyes or ears:** Humans are exposed to the pathogens in contaminated water from being in dermal contact, bathing, and washing.

Intervention

Suzhou Creek Rehabilitation Project

The Shanghai Municipal Government established the Suzhou Creek Rehabilitation Leader Group in the mid-1990s following the Central Government's intent of pollution remediation. Granted a USD 300 million loan by the Asian Development Bank (ADB) in 1999 to implement the first phase of the plan, the Leader Group has been orchestrating an intervention for the site with a timeline of 12 years. Suzhou Creek Rehabilitation Project has three main objectives: to improve water quality, strengthen water resources management, and improve flood control. The first phase of the plan, launched in 1998 and successfully completed in 2003, prioritized the reduction of sewage discharge into the river, the installation of a water lock between the Huangpu River and Suzhou



The Suzhou Creek Rehabilitation Project is a 12-year project to improve water quality and control flooding. Credit: kafka4prez

Creek, and the introduction of oxygen into the eutrophic water.

The Suzhou Creek Rehabilitation Leader Group works in concert with local construction companies to create a comprehensive water treatment solution for the area with environmental, health, and economic benefits. The Shanghai Fuxin Riverbed Treatment Co. Ltd focuses on the Zhengru Port, the most pollution area of the Creek, by diverting water flow into a treatment canal. The company applies a rigorous water treatment method by adding anaerobic bacteria into the black water to introduce oxygen. The bacteria-containing water then enters a silt pool 1m wide, 1.65 m deep and 60 m long, divided into six squares. By the time the black water entered the third square of the pool, the foul smell disappears and visibility increases. By the sixth pool, the water is clear to the bottom and healthy for fish to grow and has reached Class III of the national water standard, suggesting that it is clean enough for irrigation and as raw water for tap use.
The ongoing second phase commenced in 2003. Fully funded by the Shanghai Municipal Government, this phase aims to maintain and improve water quality of the Creek, to remedy water issues of the six tributaries, and to develop green spaces around Suzhou Creek. The Shanghai Suzhou Creek Rehabilitation Construction Company introduced the innovative design of Meng Qing Garden to serve as a landscaped recreational green space and functional wastewater treatment system which contains an equalization basin to store excessive rainwater in an underground storage tank and a base for environmental and water resources protection education. The second phase has a goal of restoring aquatic life by 2010. It is important to note that Suzhou Creek, which meets Taihu Lake, is an integral breeding ground for the Chinese Mitten Crab (also known as the big sluice crab), a seasonal delicacy in China that generates significant exports profit for the region.

Currently, the Rehabilitation Project has realized social, environmental, and economic benefits. Overall, the Suzhou Creek Rehabilitation Project relocated an estimate of 7,700 people but created job opportunities for 4,000 skilled and unskilled workers. It takes a comprehensive approach to tackle severe pollution issues of Suzhou Creek—a water body located in an urban setting and heavily connected with other major rivers in the region. Phase I of the Project treated immediate problems of Suzhou Creek by alleviating its odor and pathogens. Phase II further treats the contaminated water and integrates recreational elements into the design. Furthermore, the Shanghai Municipal Government proposed to construct biking/jogging trails, playgrounds, and parks along the Creek, in order to increase the environmental-friendly appeal of the city before the World Expo Shanghai in 2010. According to the ADB, property prices near Suzhou Creek have experienced double-digit since the implementation of the Rehabilitation Project. Excluding these figures, net economic benefits were estimated to be in excess of 4.1 billion RMB ($490 million) with a 22 percent rate of return.

Implementing Organizations

Asian Development Bank, Suzhou Creek Rehabilitation Leader Group, Shanghai Suzhou Creek Rehabilitation Construction Company, Shanghai Fuxin Riverbed Treatment Co. Ltd, CDM (construction contractors).

Remaining Challenges

Phase I of the Suzhou Creek Rehabilitation Project demonstrated success by dramatically improving the water quality standard from a few times worse than the lowest class to a level acceptable for everyday use. Phase II of the Project focuses on a broader regional scope including the Taihu Lake as well as the Yangtze River. Despite ongoing billion-dollar investments and relocation/shutdown of industrial facilities, upstream pollution loads continue to threaten the Yangtze River. Moreover, the Shanghai Municipal Government attempts to combine water treatment system components with its sustainable development plan due to limited and highly valuable urban space. In light of the Shanghai World Expo 2010, there are several proposals to expand green space along Suzhou Creek and increase pedestrian-friendliness in the downtown area. Phase II of the Project also aims at reviving water species that were wiped out by ongoing contamination and the devastating algal bloom in 2007.

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12 Arsenic Removal
West Bengal, India

With contributions from Dr. Bhaskar Sengupta, Queen's University Belfast

Location

West Bengal, India.

Pollutant

Arsenic

Cause

Naturally occurring in groundwater.

Population Affected

137 million worldwide; approximately 70 million in India and Bangladesh and 30 million in other ASEAN countries.

Health Impact

Health effects include skin lesions and cancer of the skin, lung, kidney, bladder and liver. Use of contaminated groundwater in irrigation is also responsible for transmission of arsenic through the food chain, accounting for nearly 50 percent of the total arsenic exposure in many regions of South Asia.

Output

Starting in 2006, a team of European and Indian scientists led by Queen's University Belfast (QUB) established a low-cost, chemical-free method of treating and pumping groundwater in the state of West Bengal in India to remove naturally occurring but deadly arsenic.

Outcome

Arsenic presence in waters from the treatment plants was reduced to barely detectable levels from levels 28 times above those acceptable to the U.S. EPA, effectively eliminating the carcinogenic substance from the water.

Implications

This technology could transform arsenic removal strategies from groundwater sources in the Ganges and Mekong Deltas and other areas where the naturally occurring arsenic is of arsenopyrite origin. This region covers the arsenic affected zones of Eastern India, Bangladesh, Cambodia, Vietnam and Thailand.

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Context

Arsenic (As) poisoning from drinking water has been called the worst natural disaster in the history of mankind. An estimate of 137 million people are affected in 70 countries by arsenic poisoning [1]. According to a report by the World Bank, more than 1,312 villages in West Bengal, India, near the Ganges River are detrimentally affected by arsenic contaminated groundwater [2]. A study done in 2000 showed that at least 10 million people living in West Bengal, including about 2.5 million children, were drinking arsenic contaminated ground water containing levels significantly above the limits set by the World Health Organization [3]. As a result, almost 3 million people in the region suffer from arsenic related diseases [4].

Site Details

In West Bengal most drinking water has been typically collected from open dug wells and ponds without any arsenic problem. However, due to pollution, this water became contaminated with heavy metals & bacteriological contaminations such as diarrhea, dysentery, typhoid, cholera and hepatitis. Since 1970s and 1980s shallow hand-pumps & wells (at depths less than 70 meters) were installed to provide clean drinking water. Arsenic was found in the ground water of West Bengal in the 1980s. An estimated 30 million people in the Ganges delta are drinking groundwater contaminated with arsenic [5]. In Kasimpore in West Bengal, site of the first water treatment plant implemented by the TIPOT Consortium (see Intervention), the arsenic concentration in groundwater, which was being used by the local population for drinking purposes ranged from 91 to 282 μg/L as compared with the WHO drinking water guideline value of 10 μg/L. Subsequently six plants for community water supply were set up in two districts of West Bengal with the World Bank grant and each plant has been supplying the drinking water of more than 500 people. Locations of the site are given in the project website, www.insituarsenic.org.

Arsenic is released to groundwater under naturally occurring aquifer conditions.

Health Impact

Arsenic is a potent carcinogen and is known to cause cancer of the skin, lung, kidney, bladder and liver.

Exposure Pathways

People are poisoned from drinking contaminated water. Use of contaminated groundwater in irrigation is also responsible for transmission of arsenic through food chain, accounting for nearly 50 percent of the total arsenic exposure in many regions of South Asia.

Intervention

Starting in 2006, a team of European and Indian scientists led by Queen's University Belfast (QUB) established a low cost chemical free method of arsenic removal (www.qub.ac.uk/tipot) in the state of West Bengal in India. The technology known as 'TIPOT' (for Technology for in-situ treatment of groundwater for potable and irrigation purposes) is based on subterranean arsenic removal (SAR) without the aid of any chemicals. The project was supported by the European Commission under Asia Pro Eco programme. Subsequently, Ramakrishna Vivekananda Mission (RKVM), one of the Indian partners of TIPOT Consortium, received a grant from the World Bank to set up six community water treatment plants in the state of West Bengal with the assistance of Queen's University Belfast.

The conventional technologies used in India for arsenic removal are based on 'pump and treat' method involving either adsorption or membrane processes. Such plants are expensive to run and have problems associated with waste disposal and maintenance. In contrast, 'TIPOT' process based on subterranean arsenic removal (SAR) or 'In-situ treatment' neither uses any chemicals, nor produces

[1] *Arsenic in Drinking Water Seen as a Threat* AP Online August 30, 2007

[2] Subterranean Arsenic Removal: Experiment to Delivery. World Bank Project Report: 2006-0880. Retrieved 2 Oct 2009
⇢ http://tiny.cc/Worldbankreport

[3], [4] Ibid.

[5] *Arsenic Plan Fails*, New Scientist, 31 July 2004.

any disposable waste. The installation is similar to a tube-well and all parts are easily available.

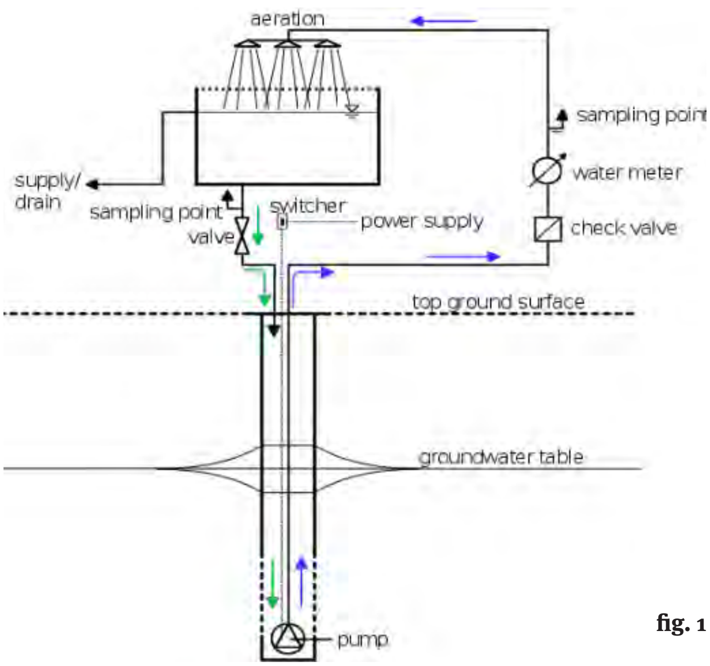

fig. 1

The in-situ method is cost-effective and, unlike filtration systems, eliminates the need for sludge handling. The arsenic which is trapped into the sand along with the iron flocs constitute an infinitesimal volume of the total volume being handled and hence pose very little environmental threat in its precipitated form. The whole mass remains down below unlike other processes where there is extra cost of sludge handling and messy disposal problem. The process is chemical free, simple and easy to handle. There is no restriction to the volume it can handle as long as proper time is allowed for the oxygen rich impregnated water to create the adequate oxidizing zone in the deep aquifer. It is also quite flexible with respect to the raw water quality as the efficient coefficient could be varied depending on the quality of the raw water. It involves low capital cost and minimum operating cost or expertise.

Credit: Ravakrishna Viuikananda Mission

Plant	Capacity	Initial Arsenic conc (mg/lt)	Final Arsenic conc (mg/lt)	Initial Iron conc (mg/lt)	Final Iron conc (mg/lt)
Merudandi, Basirhat	4000 lt	0.2820	BDL	3.3259	BDL
Naihati Purbapara, Basirhat	4000 lt	0.1750	BDL	1.5734	BDL
Tepul, Gobardanga	4000 lt	0.158	BDL	2.9356	0.101
Rangpur, Nilgunj	3000 lt	0.0916	BDL	3.4028	0.068
Ghetugachi, Chakdah	3000 lt	0.2065	BDL	2.077	BDL
Naserkul, Ranaghat	3000 lt	0.187	BDL	3.2248	0.077

fig. 2

Max Permissible Limit:
Iron: 1 mg/lt
Arsenic: 0.05 mg/lt (BIS); 0.01 mg/lt (USEPA/WHO)
Below Detectable Level (BDL) = below 0.002 mg/lt

At total of six in-situ treatment plants have so far been constructed in W. Bengal (fig. 2.)

This technology could transform the way arsenic will be removed from groundwater in South Asia and other parts of the world. TIPOT technology is appropriate for the Ganga and Mekong Delta where the arsenic is of arsenopyrite origin. This land mass covers the arsenic affected zones of Eastern India, Bangladesh, Cambodia, Vietnam and Thailand. An estimated 70 million people are affected in India and Bangladesh by arsenic exposure and another 30 million in other ASEAN countries.

Implementing Organizations

Queen's University Belfast and Ramakrishna Vivekananda Mission in association with National Metallurgical Laboratory of India, Institute of Environmental Management and Studies, India, Leiden University, Netherlands, Stuttgart University, Germany and Miguel Hernandez University, Spain.

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http://www.insituarsenic.org.

Conclusion

Blacksmith Institute's World Worst Polluted Places Report 2009

Conclusion

Children are more susceptible to environmental risk than adults.

It has proved much easier to report on polluted places and pollution problems than on successful clean ups. The problems are many; the success stories, few. In the 2008 report from this series, we tried to understand the dimension of the problems and to measure, as best we could, the worst of those problems based on the pollutants, pathways and population affected. In the current report, we looked at each of those worst problems and how aspects of these were being addressed with some degree of success. In some cases the successes are complete. In others they continue to be works in progress.

This report has looked at 12 examples of progress of environmental health and pollution mitigation in the developing world. What have we learned?

1. That progress is born of cooperation and collaboration. In each of our examples, the interventions are partnerships bringing together many organizations. Governments, citizens groups, businesses and industrial associations, multilateral agencies and other non-governmental organizations, consultants, academics all have to play active roles. In many cases there are good practices to be emulated, and we have tried here to provide some of those.

2. That approaches to address pollution in these regions come in a range that varies according to the nature of the problem, the means at hand, the

social organization of the affected population. The solutions are not monolithic, and they are not purely technological. Innovation, remediation, education and legislation are all at play.

3. That the solutions in some cases are quite straightforward: dig up contaminated earth or remove toxic stockpiles and dispose of them safely. This report gives examples from three continents: Bajos de Haina in the Dominican Republic, Old Korogwe in Tanzania, and Rudnaya Pristan in the Russian Far East. The problem is localized and the solution is complete.

4. That in some cases, the solutions rely on innovative approaches to seemingly intractable problems. In Kalimantan, Indonesia, the use of a new retort by artisanal gold miners enables them to continue their economic activity while preventing mercury poisoning among their families and preventing large quantities of mercury from entering the food chain. In Accra, Ghana, a program to introduce new stoves is preventing respiratory death and disease from indoor air pollution while creating a sustainable market for local entrepreneurs. And in West Bengal, India, a new system for treating arsenic in groundwater is designed to provide clean water to a village without creating toxic residue.

5. That some situations require solutions that are more complex, requiring extensive legislative and/or infrastructural changes. We offer here three examples. One is the clean up of a waterway in Shanghai, China that saw the installation of water treatment and flood control facilities, among other modifications. A second is ongoing measures by the authorities in Delhi, India to address the air quality problems through the adoption of compressed natural gas (CNG) and the addition of a municipal rapid transit system. The third example, from a copper mine in Chile, is the design and implementation of a system that prevents pollutants from the extraction process from entering the water treatment system.

6. That education is important –both as a motivator of action and as an aspect of the solution itself. In the Chernobyl- affected areas of Eastern Europe children and families can learn many techniques to reduce the health effects of radiation and improve the quality of their lives. Indonesian goldminers and Ghanaian cooks have to learn new techniques to adapt to their new equipment. Understanding the toxic origins of illness is a first step in eliminating it.

7. That action on a global scale is possible. Global treaties, such as the Chemicals Weapons and Stockholm Conventions provide platforms for the worldwide community to address serious threats to health and safety.

Moving Forward on Polluted Places

Removing contaminated soil, in many cases, offers a permanent solution.

The way to deal with individual polluted sites is well understood – providing local groups with the responsibility and resources to find short-term improvements and to identify longer-term practical solutions. The resources and technology to solve these problems has been used for decades in industrialized nations.

The major challenges are twofold: First, finding resources to finance more interventions; and secondly to scale up already effective approaches so that support and assistance can be brought to the thousands of communities that are struggling with toxic pollution problems and need immediate help. As it stands, there is no funding mechanism that specifically addresses these problems in developing countries.

It is to address these challenges that the Blacksmith Institute has brought together a range of key international stakeholders to initiate a Health and Pollution Fund (HPF). This fund will be the mechanism for making available a larger scale of technical and financial resources to address priority problems.

The HPF (www.gprfund.org) was launched in principle in October 2007 by representatives from governmental agencies of the United States, Germany, China, Russia, Mozambique, Kenya, the Philippines, the World Bank, the United Nations Industrial Development Organization, Green Cross Switzerland, Blacksmith Institute and leading researchers from within the public health and pollution remediation fields. A planned $400 million fund, HPF 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 efficiently channel funds to local stakeholders with technical support and oversight provided by a central international secretariat. Conference organizers are currently approaching donors in various country development agencies, multilateral development banks, and other international aid organizations along with high net-worth individuals to develop funding.

Appendix

Blacksmith Institute Technical Advisory Board

Maria del Rosario Alfario
Environmental Contamination Inspector, Costa Rica

Thomas G. Boivin
President, Hatfield Consultants

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

Dr. von Braun is the Dean of the College of Graduate Studies and has been on the University of Idaho faculty since 1980. She received her BS in Engineering Science and Mechanics at the Georgia Institute of Technology, her MCE in Civil Engineering at the University of Idaho, and her Ph.D. in Civil/Environmental Engineering 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.

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 Director of the Division of Environmental Health Engineering in the Department of Environmental Health Sciences at the Johns Hopkins Bloomberg School of Public Health. He is also the Director of the Center for Childhood Asthma in the Urban Environment. This is a large multi-investigator research program funded by the U.S. Environmental Protection Agency, and D. National Institute for Environmental Health Sciences. Dr. Breysse is an active researcher with over 120 peer-reviewed publications. His research focuses on air pollution and risk assessment. Dr. Breysse serves or has served on numerous government committees and panels including the U.S. National Toxicology Program, National Institute for Occupational Safety and Health, and National Academy of Sciences.

Grant S. Bruce
Vice-President, Hatfield Consultants

Tim Brutus
Risk Management Specialist
New York City Department of Environmental Protection

Mr. Brutus is currently the Risk Management Specialist for the New York City Department of Environmental Protection for the downstate reservoirs that bring all of the water into New York City. His previous experience is on complex multi-technology remediation projects with CH2M Hill, Inc. He has extensive site investigation experience including, but not limited to, indoor and outdoor air sampling, multiple groundwater and soil sampling techniques and technologies. He has aso contributed to other non-profit organizations restoring contaminated brownfields to their former use as wetlands and worked in analytical laboratories in New York and New Jersey.

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

Jack Caravanos is an Assistant 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 a 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
President, 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.

Mr. Dobbin 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 specialist the National Public Health Policy Association and Society of Risk Assessment. He is a Certified Industrial Hygiene Specialist (ret).

Mr. Dobbin holds 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.

Dr. Yu Yang Gong
Managing Director, ESD China Limited

Dr Gong is currently the Managing Director of ESD China Limited, and has served as the Vice President for the Louis Berger Group (USA), and Regional Manager for ERM China. He is a licensed Professional Engineer registered in the United States with over 20 years of diverse consulting and academic experience, primarily in the USA and China.

He has his B.Sc. and M. Sc. from Beijing University in China, and Ph.D. from Buffalo University in USA. He has both industrial and academic experience in the following areas: Soil and Groundwater Pollution Control Regulation and Policy Development, Contaminated Site Investigation (SI/RI); Risk Assessment (e.g., RBCA), Site Remediation, Solid/Hazardous Waste Management, Surface Water and Groundwater Quality Modeling, Contaminated Facility Decontamination, Waste Reduction and Reuse, and Asbestos/Lead Based Paint Abatement. His experience in hazardous waste and contaminated site regulation and policy development is best represented in his capacity serving as an international expert for World Bank, ADB and other international agencies (US TDA and Germany GTZ) and work in several developing and developed countries (USA, Israel, Sri Lanka, Japan, China etc).

Dr. Gong's experience in Contaminated Site Investigation and Remediation includes, Environment Site Assessment and Characterization (ESA, PA/SI/RI), Treatability/Pilot Study, FS, EE/CA, In-Situ and On-Site Remediation System Design and Costing, System Installation and O&M. He has 15 years hands on experience in technologies such as Incineration, Thermal Desorption, Chemical Oxidation & Reduction, SVE, Bioventing, Air Sparging, Bioslurping, Bioslurry, Soil Washing, Pump and Treat, Funnel and Gate (with treatment wall/barrier), Natural Attenuation, Institutional Control (such as capping); Excavation/dredging and Secured Landfill Disposal.

Dr Gong is a task member for the WEF book Hazardous Waste Treatment Process and has numerous publications/presentations in site investigation and remediation. His PhD thesis is on PCBs fate and transport. Currently he serves as a Technical Adviser for Ministry of Environmental Protection (MEP) for its POPs contaminated land cleanup program, participating PCB NIP review, contaminated facility decontamination guideline and POPs Contaminated Site Priority Action Plan preparations. He is also an invited technical advisor for the Guideline for Chongqing Contaminated Site Soil and Groundwater Investigation, Risk Assessment and Restoration. He serves in a similar capacity to Beijing City, Zhejiang and Jiangsu provinces.

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. David serves as Chairman of the Local Emergency Planning Commission and the Director of Operations for Connecticut's Department of Homeland Security USAR Team.

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

David Hanrahan oversees the technical design and implementation for Blacksmith of over 40 projects in 14 countries. Prior to joining Blacksmith, David 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.

Before joining the World Bank, he had twenty years of experience in international consultancy, during which time he also earned postgraduate 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.

Vasco Duke Hernandez
Head of Environmental Research, University of Panama

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. Robinson 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
Founder of Quality Environmental Solutions, Inc.

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
Professor, Department of Civil Engineering, Indian Institute of Technology Delhi, India
Former Atlantic LNG Chair Professor in Environmental Engineering, Faculty of Engineering, University of West Indies, St Augustine, Trinidad and Tobago
Fellow, Wessex Institute of Great Britain
Principal Member, International Sustainable Technological Association (ISTA), Arizona State University, USA
Principal Reviewer, Research Management Group, USA
Member Research Review Committee, National Research Foundation, Pretoria, South Africa
Consultant (Air Pollution), Government of Delhi, India

Prof. Mukesh Khare is serving as Professor in the Department of Civil Engineering at Indian Institute of Technology Delhi, India. Professor Khare received his PhD in Faculty of Engineering (Specialized in Air Quality) from the University of Newcastle Upon Tyne, UK in 1989. He has published to date more than 35 refereed research articles in professional journals, 40 articles in refereed conferences/seminars, 2 books: Modeling Vehicular Exhaust Emissions, WIT Press, UK; Artificial Neural Networks in Vehicular Pollution Modeling, Springer, USA; 03 contributed chapters in books/handbooks, published by WIT Press, and Elsevier, USA. Additionally, he has published about 20 technical reports on research/consultancies conducted for government agencies and private industries. Prof. Khare continues to serve as peer reviewer for several government ministries grants programs and state programs and consultant/advisor to the Government of Delhi, India. He is also serving as reviewer to many journals and publishing houses. Prof. Khare is in the editorial board of International Journal of Environment and Waste Management and Guest Editing one of its special issues on Urban Air Pollution, Control and Management.

Prof. Khare's research has focused on local scale urban air quality modeling targeting the predictions of episodes at urban roads/intersections, mainly arising out from undefined low-level/line sources. Current research areas include formulation of air quality models and their validation; indoor air quality in air-conditioned and naturally ventilated buildings and exposure assessment of related pollutants on indoor occupants. He has also worked extensively in the area of industrial wastewater treatment particularly application of Rotating Biological Contactor Systems to treat industrial and sewage wastes. Prof. Khare and his research group have carried out a number of on-site assessments of air pollutants and designed a number of effluent treatment plants to treat the corresponding wastes from various types of industries.

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 pediatrician and an international leader in public health and preventive medicine. Dr. Landrigan's pioneering research on the effects of lead poisoning in children led the US government to mandate removal of lead from gasoline and paint, actions that have produced a 90% decline in incidence of childhood lead poisoning over the past 25 years. His leadership of a National Academy of Sciences Committee on pesticides in children's diets generated widespread understanding that children are uniquely vulnerable to toxic chemicals in the environment. The findings of the NAS Committee secured passage of the Food Quality Protection Act in 1996, a major US federal pesticide law and the first environmental statute to contain specific protections for infants and children. Dr. Landrigan served as Senior Advisor to the US Environmental Protection Agency where he was instrumental in helping to establish the EPA's Office of Children's Health Protection. Dr. Landrigan has been a leader in developing the National Children's Study, the largest study of children's health and the environment ever launched in the United States.

BLACKSMITH INSTITUTE

Ian von Lindern, PhD
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

Bill Lorenz
Former Director, Environmental Resources Management, Young Leaders Programme Director, GIFT

Ira May
Geologist, U.S. Army Environmental Center

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, and Egypt for various bi- and multilateral development agencies. She directed the company's Manila, Philippines office from 1994-1998.

Dave Richards
Independent Environmental Adviser

David Richards works as an independent environmental adviser in the areas of environmental policy and strategy, external engagement and multi-stakeholder initiatives, and strategic environmental risk management. He spent 32 years in the mining industry, 19 of those at operating mines and advanced development projects. For 28 years he was an employee of Rio Tinto. His background is in economic geology and geochemistry, and since 1992 he has worked in corporate environmental policy development and assurance. He has been involved in several multi-stakeholder initiatives including the Mining, Minerals and Sustainable Development (MMSD) project (2000 – 2002), the IUCN-ICMM Dialogue (2002 – present), the Millennium Ecosystem Assessment (2004 – 2005), the Post Mining Alliance (2005 – present) and the Business & Biodiversity Offset Programme (BBOP) (2007 – present). He helped to develop geochemical Risk Assessment tools and has extensive experience in site-based strategic multi-disciplinary risk reviews.

Dr. Stephan Robinson
Director of the International Disarmament Program, Green Cross Switzerland

Stephan Robinson holds a PhD in experimental nuclear physics from Basel University. In 1994, he joined Green Cross Switzerland where he serves today 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 Programme, which includes the operation of a network of eleven local and regional public outreach offices, the organization of a Russian 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 site in the Baltic area; the scientific investigation of a site of former chemical weapons destruction (open pit burning site); different risk assessments of military facilities; an inventory of the Soviet nuclear legacy; and epidemiological studies of public health impacts by chemical weapons storage. Stephan Robinson is regularly in Eastern Europe for on-site visits of projects and for meetings with various groups of stakeholders from government officials to local citizens.

Paul Roux
Chairman, Roux Associates, Inc. (www.rouxinc.com)

Paul Roux received an M.A. in Geology from Queens College, City University of New York, and a B.S. in Engineering Science from C.W. Post College, Long Island University. He is a certified Professional Geologist and Hydro geologist, has served on the Editorial Board of Ground Water Monitoring and Remediation and currently serves on the Board of Registration of the American Institute of Hydrology.

Mr. Roux has over 35 years of experience with contaminated soil and groundwater remediation at industrial plants and landfills. He has worked at a number of the largest and most complex Superfund sites in the US, as well as major chemical and petroleum facilities. Roux Associates, which was founded in 1981, currently has more than 230 professional employees in five offices. The firm provides a broad range of consulting and project management services to solve complex environmental, health, and safety problems associated with air, water, land and interior pollution; hazardous materials; and toxic waste treatment and disposal. Roux Associates was twice named as one of America's 500 fastest-growing private companies by Inc. Magazine and, since 1996, has been listed as one of the Top 200 Environmental Consulting Firms by Engineering News Record.

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.

Brian Wilson
Program Manager
International Lead Management Center
MRSC - Member of the Royal Society of Chemistry

Brian Wilson is the Program Manager for the International Lead Management Center located in North Carolina, USA. He is responsible for the design and implementation of multi-stakeholder lead risk reduction programs. Before joining the ILMC he worked for 15 years with the oil industry followed by 18 years with MIM Holdings in the Metals Industry. He left the United Kingdom and MIM UK as the Group Personnel Manager in 1996 to join ILMC after a career that spanned smelter production, industrial relations and human resource management. Brian has worked with UNEP, UNCTAD and the Basel Secretariat on Lead Risk Reduction and Recycling projects in the Far East, Russia, Central and South America, the Caribbean and West Africa.

Jay Vandeven, MS.
Principal
ENVIRON International Corporation

Jay Vandeven is a Principal in the Arlington, VA office of ENVIRON International Corporation. ENVIRON is an international consultancy, providing chemical risk management services to public and private sector clients from a platform of more than 70 offices worldwide. He has been a consulting environmental engineer for twenty-five years, focusing on the sources, fate and transport, and remediation of chemical and radiological compounds in all environmental media. Mr. Vandeven has worked on some of the largest Superfund sites in the U.S. as well as contaminated sites in Eastern Europe. He routinely counsels clients on negotiations with regulatory authorities and represents clients in environmental disputes. Mr. Vandeven is also a member of the committee that administers the ENVIRON Foundation, an internally managed philanthropic initiative that provides financial assistance to projects worldwide that promote protection of human health and a sustainable global environment, particularly with respect to the impact of chemicals and society's use of the Earth's resources.

About Blacksmith Institute
www.blacksmithinstitute.org

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

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

About Green Cross Switzerland

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

Blacksmith Institute
2014 Fifth Avenue
New York, NY 10035 USA

www.blacksmithinstitute.org
info@blacksmithinstitute.org