THE WORLDS WORST 2013

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THE WORLDS WORST 2013: THE TOP TEN TOXIC THREATS

CLEANUP, PROGRESS, AND ONGOING CHALLENGES

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

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INTRODUCTION AND CONTEXT

This 2013 report is the eighth in an annual series of reports released by Green Cross Switzerland and Blacksmith Institute. Previous reports have highlighted some of the world's worst polluted places, presented examples of successful cleanup projects, and outlined the world's worst pollution problems. This year's report takes a look at the progress made in dealing with some of the world's worst polluted places and sets this against the ongoing identification of thousands more, less notorious, polluted places. This examination of industries, pollutants, and sites is based on data collected by Green Cross Switzerland and Blacksmith Institute and on industry information, public sources, and the scientific literature.

Flagging Polluted Places

The World's Worst Polluted Places reports in 2006 and 2007 brought problems of highly polluted places to international attention by listing about 40 notorious sites worldwide, selected by a panel of knowledgeable specialists. These listings, as explicitly acknowledged in the reports, were based on limited information and data. This was only to be expected, since pollution by its nature shuns the spotlight.

The lists covered a wide range of polluted places, ranging from industrial plants and mining facilities, through industrial estates and SME clusters, to areas of polluted air and water, and some major industrial disasters. The criteria used in identifying these sites included the size of the population affected (in particular if children were at higher risk); the potency of the toxicants involved; and clearly established pathways and impacts. These have not changed. However, the lists of sites that are now the focus of "polluted places" efforts have certainly evolved.

This Top Ten Toxic Threats report builds upon previous reports to highlight the progress of many contaminated sites and an increased understanding of the far-reaching effects of toxic pollution. The 2012 report utilized disability-adjusted life years (DALYs) to reveal that over 125 million people are at risk from toxic pollution in 49 low- and middle-income countries. That number has since been revised up to 200 million. The strikingly high number of people at risk established toxic pollution as a public health threat equivalent to more highly publicized public health problems such as malaria and tuberculosis. Even though toxic pollution remains a far less well-known problem, it is believed to have a similar impact on death and disability in developing countries as many well-known and well-funded diseases. This year's report demonstrates this increased understanding of the problem and how much progress has been made in the past several years. It also demonstrates how much further there is to go.

From Ten to Many

This year's report presents updates and progress made at the original 'worst polluted' sites, pulling together information from research and academic papers, news and media attention, and reports from in-country staff and investigators. More information has become available, some in response to the debates that the Top Ten lists generated. Real progress has been made in some cases, although not everywhere and often not enough. The findings show that much can be achieved through focused intervention and site remediation, but also that much more remains to be accomplished at some of these sites.

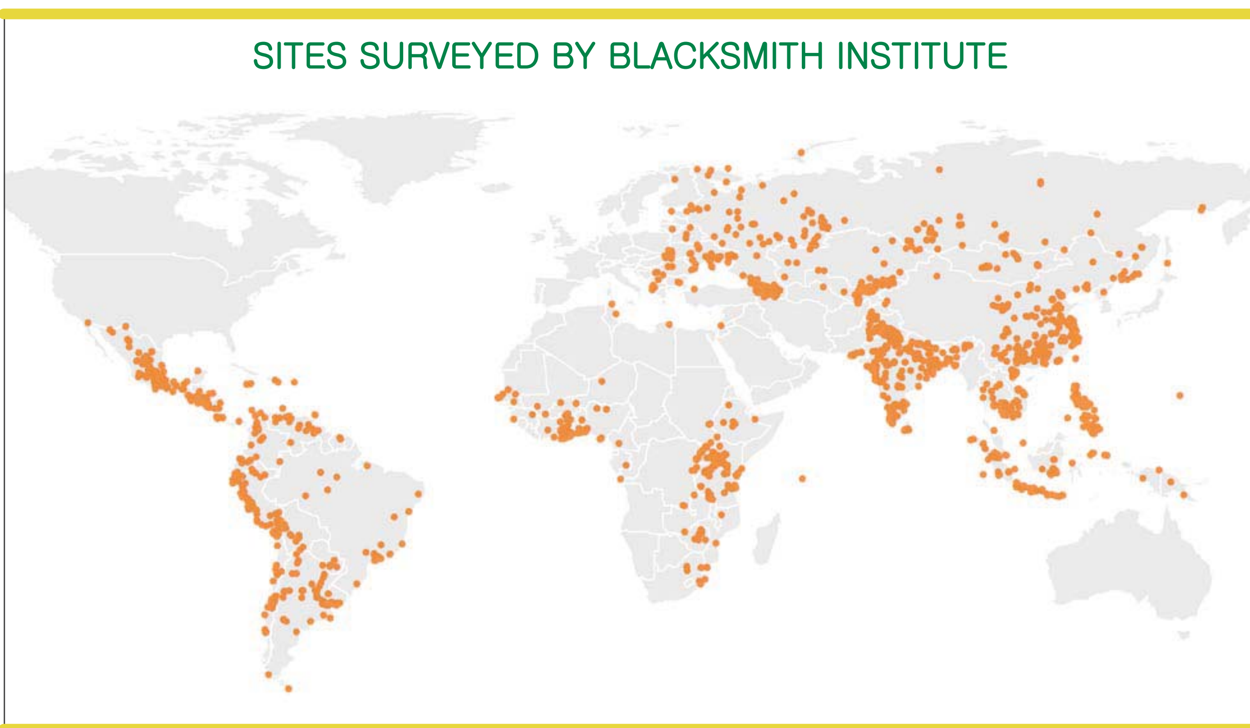
From a broad scope of problems identified in the initial reports, the work of Green Cross Switzerland and Blacksmith became more focused on mining, industrial and chemicals issues as critical areas for addressing contamination and remediation. Green Cross and Blacksmith also recognized that other important problems such as urban air pollution, dirty rivers, and industrial accidents are wider than just "polluted places" and require different approaches. The emphasis in interventions has been increasingly on a relatively small number of sectors that result in widely distributed but similar problems, rather than individual high profile hotspots. This shift has been guided by the large amount of data that has been gathered over recent years on nearly three thousand individual sites in more than 70 countries.

Disaster sites are no longer specifically identified in Green Cross and Blacksmith operations but, sadly, accidents continue to occur, with Fukushima a lesson against complacency in regard to our ability to design and manage successfully large and hazardous operations. Consequently, this years report also addresses the industries identified over recent years as the top polluters globally and provides illustrations of the level of disease burden attributable to toxic pollution at some typical sites.

Scope of the Problem

Green Cross Switzerland and Blacksmith currently estimate that more than 200 million people are at risk of exposure to toxic pollution globally. This estimate has increased substantially over the past several years, both because the scope of the exposure is increasing and because there is a better understanding of the problem.

In order to better understand the morbidity and mortality associated with toxic pollution, Green Cross Switzerland and Blacksmith quantified the public health burden in last years report by calculating the DALYs associated with the issues (the DALY being the recognized measure of the health burden, as established by the World Health Organization (WHO)). That report



Agbogbloshie Dumpsite, Ghana

then examined the burden that toxic pollutants can put on population health in the context of the contaminated sites that are the focus of Green Cross Switzerland and Blacksmith's work. The identification and investigation of polluted sites is an ongoing task, increasingly being picked up and shared by local agencies in the countries involved. Therefore discussion of geographic regions in this report is by no means complete since it only represents sites are have been identified and are under investigation to date.

Toxic Pollution and Human Health

The health effects of toxic pollution vary greatly in both the range and severity of disease and disability with which they are associated. The World Health Organization, in conjunction with the World Bank, estimates that 23% of deaths in the developing world are attributable to environmental factors, including pollution, and that environmental risk factors contribute to more than 80% of regularly reported diseases.[1] In fact, it is estimated that up to 37% of a country's total disease burden could be prevented by achieving environmental improvements alone.[2] It is currently estimated that nearly one-fifth of the cancer incidence globally can be blamed on environmental exposures.[3] This number is disproportionately higher in developing countries.[4] Again, a recent study of more than 3,000 toxic sites, funded by the World Bank, European Commission, and Asian Development Bank, shows that as many as 200 million people globally may be affected by toxic chemicals.[5]

Other notable health effects include both acute and chronic poisoning, cognitive impairment, organ damage, respiratory issues, diarrhea, and vomiting. Due to their smaller size, increased cellular surface area to volume ratio, and greater hand to mouth behavior, children are disproportionately affected by toxic pollutant exposure. The World Health Organization estimates that 33% of the global burden of disease for children is attributable to the environment.[6] Health effects in children from exposures *in utero* can range from premature birth and low birth weight to vision and cognitive impairment. Once again, children in developing countries are disproportionately affected, as malnourishment and inadequate access to resources leaves these children particularly vulnerable.[5]

The shortage of adequate resources in many low- and middle-income countries increases the severity of health impacts from toxic pollution while simultaneously marginalizing those who need help the most. An objective of the work of Blacksmith Institute and Green Cross Switzerland and one goal of this report is to enhance understanding and funding for this crucial area of public health.

Addressing the Identified Toxic Threats

The objectives of Green Cross Switzerland and Blacksmith are not just to identify and publicize toxic problems but, more importantly, to find and implement practical solutions. This requires, in the most urgent cases, beginning to put in place effective approaches even if the initial solutions are only a start on the long-term cleanup that is required.

One of the most important areas of progress since the initial *World's Worst* reports is the gradual emergence of a broad coalition of international organizations, public and private, who have recognized the scale and importance of the toxics agenda and who are cooperating to address it.

Current efforts include specific projects and related activities to deal with priority issues and sites, as well as technical and financial support to build the capacity of communities, governments, and industry groups to put in place better systems and cleaner processes. The good news is that the scale of the problem worldwide is slowly becoming better defined as more data is collected and as the underlying science is better understood. The work highlighted in the recent years on quantitative evaluation of health risks from polluted places continues to be expanded and refined.

Informal used lead acid battery processing is one of the world's worst pollution problems

The toxics agenda is becoming even more relevant to achieving international goals in areas such as maternal and child health, since the impacts may be significant at levels well below those at which clinical symptoms are seen. Unfortunately, the high health impacts estimated in previous reports may still be an underestimate of the damage caused by polluted places.

What Can Be Done?

Greater efforts need to be made to control pollution and waste, as it is markedly easier and more economical to prevent toxic pollution problems than to clean them up. This series of annual reports exists not only to identify the major sources of toxic pollutants but also to present and explore some of the simple and cost-effective solutions that exist to remediate them. For each industry listed in this report, available preventative actions and remediation solutions are discussed. These solutions are meant to display the varied options that exist to reduce the risk of toxic pollution exposure. By presenting these options, the report hopes to encourage governments and industries to practical action.

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1 The World Health Organization, 2013. Available at: http://www.who.int/gho/phe/en/

2 Pruss-Ustun A., S. Bonjour, and C. Corvalan. 2008. "The impact of the environment on health by country: a meta-synthesis. *Environmental Health* 25;7:7. doi: 10.1186/1476-069X-7-7.

3 Vineis, P. and W. Xun. "The emerging epidemic of environmental cancers in developing countries." Annals of Oncology 20: 205–212, 2009.

4 The World Health Organization, 2013. Available at: http://www.who.int/gho/phe/en/

5 Blacksmith Institute. 2013. "The Poisoned Poor". Available at: http://blacksmithinstitute.org/files/FileUpload/files/GAHPPoisonedPoorOnePager-1.pdf

6 The World Health Organization. 2011. "Summary of Principles for Evaluating Health Risks in Children Associated with Exposure to Chemical." Available at: http://www.who.int/ceh/health_risk_children.pdf

THE NEW TOP TEN

AGBOBLOSHIE, GHANA

CHERNOBYL, UKRAINE*

CITARUM RIVER, INDONESIA

DZERSHINSK, RUSSIA*

HAZARIBAGH, BANGLADESH

KABWE, ZAMBIA*

KALIMANTAN, INDONESIA

MATANZA RIACHUELO, ARGENTINA

NIGER RIVER DELTA, NIGERIA

NORILSK, RUSSIA*

*INCLUDED IN THE ORIGINAL 2006 TOP TEN LIST

TOP TEN MOST POLLUTED SITES WORLDWIDE

Background and Rationale

The 2006 and 2007 *World's Worst* reports highlighted some particularly notorious polluted sites around the world. These were chosen based on a version of the widely accepted Source-Pathway-Receptor model. Locations were included for review if a toxin from an industrial source was found in a human exposure pathway above international standards. Fundamentally, those sites with toxins most above the standard, in the most severe pathway, and affecting the most people were selected to comprise the Top Ten. This was based on very limited information available at the time, thus the selection was somewhat constrained.

In the intervening years the available knowledge in this area has increased considerably. Several countries, including Mexico and India, have begun conducting national inventories of contaminated sites. New environmental agencies have been formed, and national remediation programs are developing. Alongside these developments, Blacksmith Institute has conducted more than 3,000 initial risk assessments in 49 countries over the past 6 years, with site visits to well over 2,000 such sites, usually in the company of local authorities. The net result of these efforts is a much larger pool of information than was available in 2006 and 2007.

This newly available information presents different challenges in ranking sites. The 3,000 plus sites screened include disparate sources and pathways that are not immediately comparable. It is necessarily an imperfect science to try to rank, for instance, an area of tanneries releasing hexavalent chromium into a Nepalese river against an abandoned metals smelter in Argentina. Thus this year's report takes a different approach.

To draft this year's list, Blacksmith Institute and Green Cross Switzerland first looked back at previous *World's Worst* reports. Over the past several years, these reports have used a number of different approaches to defining the health risk posed by pollution. The 2008 report attempted to bring attention to the efforts by governments and other organizations to deal with toxic pollution, highlighting specific projects and success stories. From 2009 to 2011, polluting industries and individual toxins formed the focus, rather than specific sites. The top pollution sources were identified and prioritized based on the total number of people they place at risk. In 2012 this approach was further refined through the use of Disability Adjusted Life years (DALYs), the standard metric for measuring the burden of disease. DALYs much more accurately capture the health risk posed by pollutants and industries.

The 2013 World's Worst builds on these reports, using information and risk assessment data from the databases. Sites were chosen based upon the severity of their risk to health, identified by both site assessments and independent reports. Sites were also prioritized in terms of providing examples of similar sites around the world.

Some of the sites selected, such as Dzershinsk, Russia or Kabwe, Zambia, appeared in the original Top Ten lists. Limited progress has been made at these sites in view of the size of the problem. Other names on the list, such as Agbogbloshie, Ghana or Kalimantan, Indonesia, were selected less for the scale of their local health impact, and more as examples of specific pollution problems (e-waste and artisanal gold mining, respectively) which collectively place an enormous toll on human health.

Importantly, some broad criteria guide the selection of sites included in this report. Blacksmith Institute is focused on addressing point-source industrial pollution that poses a public health risk in low and middle-income countries. Accordingly, this report takes the same approach. The well-known issues of ambient urban air pollution or arsenic contaminated wells were not considered for inclusion.

Collectively, the 2013 list is a snapshot of some of the worst pollution problems in the world. The health of more than 200 million people is at risk daily from pollution issues like those found at the sites listed here. The goal of this report is illuminate this often overlooked public health threat rather than to be comprehensive.

Agbogbloshie Dumpsite, Ghana

Agbogbloshie, in Accra, Ghana, is the second largest e-waste processing area in West Africa. E-waste, or electronic waste, is a broad term referring to a range of electronics, including refrigerators, microwaves, and televisions. Because of the heterogeneous composition of these materials, recycling them safely is complex and can require a high level of skill.

Ghana annually imports around 215,000 tons of secondhand consumer electronics from abroad, primarily from Western Europe, and generates another 129,000 tons of e-waste every year.[1] Assuming growth continues in a linear manner, Ghana's e-waste imports will double by

1 Feldt, Torsten, Julius N. Fobil, Jurgen Wittsiepe, Michael Wilhelm, Holger Till, Alexander Zoufaly, Gerd Burchard, and Thomas Goen. 2013. High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana. *Science of the Total Environment* 466-467, 1 (January): 369-376.

Chernobyl, Ukraine

Agbogbloshie Dumpsite, Ghana

2020. Approximately half of these imports can be immediately utilized, or reconditioned and sold.[2] The remainder of the material is recycled, and valuable parts are salvaged.

A range of recovery activities takes place in Agbogbloshie, each presenting unique occupational and ecological risks. The primary activity of concern from a public health perspective is the burning of sheathed cables to recover the copper material inside. Styrofoam packaging is utilized as a fuel to burn the material in open areas. Cables can contain a range of heavy metals, including lead. To some extent, these metals can migrate through particulate in the smoke, while significant amounts are also left behind on area soils.

Agbogbloshie is a vibrant informal settlement with considerable overlap between industrial, commercial, and residential zones. Heavy metals released in the burning process easily migrate into homes, food markets and other public areas. Samples taken around the perimeter of Agbogbloshie, for instance, found a presence of lead levels as high as 18,125 ppm in soil.[3] The USEPA standard for lead in soil is 400 ppm. Another set of samples taken from five workers on the site found aluminum, copper, iron, and lead levels above ACGIH TLV guidelines. For instance, it was found that one volunteer had aluminum exposure levels of 17 mg/m^3 compared with the ACGIH TLV guideline of 1.0 mg/m^3.[4]

2 Amoyaw-Osei, O.O. Agyekum, J.A. Pwamang, E. Mueller, R. Fasko, M. Schleup. 2011. Ghana e-waste country assessment. *SBC E-Waste Africa Project.* Available at: http://www.ewasteguide.info/files/Amoyaw-Osei_2011_GreenAd-Empa.pdf#page=1&zoom=110.00000000000001,0,849

3 Caravanos, Jack, Edith Clark, Richard Fuller, and Calah Lambertson. 2011. Assessing Worker and Environmental Chemical Exposure Risks at an e-Waste Recycling and Disposal Site in Accra, Ghana. *Journal of Health and Pollution* 1, 1.

4 Caravanos, Jack, Edith Clark, Richard Fuller, and Calah Lambertson. 2011. Assessing Worker and Environmental Chemical Exposure Risks at an e-Waste Recycling and Disposal Site in Accra, Ghana. *Journal of Health and Pollution* 1, 1.

Hazaribagh is heavily contaminated with Hexavalant Chromium

A conservative estimate of the population at risk might fall in the area of 40,000 people.[5] However, a more in-depth assessment would be required to better capture the risk, which might affect as many as 250,000 people. Since 2008, Blacksmith Institute and its partner, Green Advocacy Ghana (GreenAd), have been piloting technologies to aid recyclers in replacing the burning process. Hand wire-stripping tools introduced in 2010 were met with a small-degree of success but burning remained the preferred method. Currently, project partners are working to mechanize the wire-stripping process through the creation of work stations outfitted with a variety of wire-stripping machines. These machines eliminate air pollution and centralize recycling to reduce wide-spread communal exposures. Comprehensive health and occupational safety trainings, implemented since 2008, have built the capacity of workers and community members for reducing the risk of heavy metal exposure.

Chernobyl, Ukraine

Chernobyl is internationally recognized as one of the worst nuclear disasters in history. On the evening of April 25, 1986, testing in the Chernobyl power plant 62 miles north of Kiev triggered a massive meltdown of the reactor's core releasing more than 100 times the radioactivity of the bombs dropped on Hiroshima and Nagasaki. Around 150,000 square kilometers of land was affected in the accident. To this day, the 19-mile exclusion zone around the plant remains almost entirely uninhabited. Within seven months, the reactor was buried in a concrete casing designed to absorb radiation and contain the remaining fuel. However the structure was only intended to be a temporary solution and designed to last no more

5 PeaceFM Online: Time up for Sodom and Gomorrah; September 4, 2009. Available at: http://news.peacefmonline.com/news/200909/25988.php

than 20-30 years.[6] Estimates put the number of people at risk in Ukraine, Russia, Moldova and Belarus at between 5 and 10 million, and officials believe the accident was responsible for some 4,000 cases of thyroid cancer.[7,8]

Radioactive contamination from the Chernobyl Power Plant spread over 40% of Europe and parts of Asia, North Africa, and North America immediately following the nuclear disaster. Nearly 400 million people resided in territories that were contaminated with radiation at a level higher than 4 kBq/m2.[9] Today, there are over a dozen artificial radionuclides such as cesium-137 that can be detected in the surface soil around the plant. They are all documented as being well above the recommended levels. Internal exposure from radionuclides deposited on the ground and ingestion of contaminated foods produced in contaminated areas remain the major pathways. As a result of prolonged low-dose exposure, an article published in *Environmental Health Perspectives* in 2012 concluded via a nested case-control study that there has been a significant increase in the risk of leukemia.[10]

Several other smaller interventions are currently ongoing. Green Cross Switzerland for instance has developed a series of medical, psychological and pedagogical programs. These include for instance “therapy camps” which provide temporary respites for the most affected individuals. They also include visits by medical staff to affected areas, “Train the Trainer” programs for youth, and micro-credit work to contribute to economic development.

6 The World Nuclear Association, 2013. Available at: http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Chernobyl-Accident/#.UmAqW-DPY-c

7 CNN: After Chernobyl, complexity surrounds local health problems; August 19, 2013. Avaialable at: http://www.cnn.com/2013/08/18/health/helping-chernobyl-children/

8 Nuclear Energy Institute: Chernobyl Accident and It’s Consequences; July, 2011. Available at: http://www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Chernobyl-Accident-and-Its-Consequences

9 Taira, Y et al. “Vertical Distribution and Estimated Doses from Artificial Radionuclides in Soil Samples around the Chernobyl Nuclear Power Plant and the Semipalatinsk Nuclear Testing Site.” *PLoS One* 8.2 (2013).

10 Zablotska, LB et al. “Radiation and the Risk of Chronic Lymphocytic and Other Leukemias among Chornobyl Cleanup Workers.” *Environmental Health Perspectives* 121.1 (2013): 59-65

Tailings in Kabwe continue to mined artisanally

Children monitor a lead remediation project in Nigeria

Citarum River Basin, Indonesia

The Citarum River Basin in Bandung, West Java, Indonesia covers an area of approximately 13,000 square kilometers, coming into contact with a population of 9 million people.[11]

The river provides as much as 80% of surface water to Jakarta's water supply authority, irrigates farms that supply 5% of Indonesia's rice, and is a source of water for upwards of 2,000 factories.[12]

Contaminants from both industrial and domestic sources are present in the Citarum River. Field investigations conducted by Blacksmith Institute, for instance found levels of lead at more than 1,000 times the USEPA standard in drinking water.

A 2013 APN Science bulletin found that aluminum, manganese, and iron concentrations in the river were 97 ppb, 195 ppb, and 194 ppb, respectively. These are all significantly higher than the world averages, which are 32 ppb, 34 ppb, and 66 ppb, respectively.[13] The concentrations are also well above the recommended levels of heavy metals in drinking water set by the EPA. Manganese in drinking water, for example, has a standard of 50 ppb to minimize adverse health effects.[14] Water in the Citarum River has concentrations of manganese that are nearly four times those recommended levels.

Importantly the Indonesian Government is taking considerable action on the issue. As an illustration the government has negotiated a 500 million dollar multi-tranche loan package with the Asian Development Bank to support efforts to rehabilitate the Citarum. This will be delivered in 500 million

11 UNESCO, Citarum River Basin water quality improvement through demonstration of innovative technologies and enhancing capacities at the community, river basin and national levels; November, 2012. Available at: http://www.switch-in-asia.org/Pilot%20sites/SWITCH%20-%20Citarum%20River%20concept%20note_NOV2012_EN.pdf

12 World Water Week in Stockholm, 2010; Page 31. Available at: http://www.worldwaterweek.org/documents/Resources/Synthesis/Abstract_Volume_2010.pdf

13 Asia-Pacific Network for Global Change Research, Issue 3, March 2013. Available at: http://abs.aseanbiodiversity.org/images/documents/APN%20Science%20Bulletin%20-%20March%202013.pdf#page=8

14 EPA: Secondary Drinking Water Regulations, 2013. Available at: http://water.epa.gov/drink/contaminants/secondarystandards.cfm

dollar installments over 15 years and is part of the governments 3.5 billion-dollar plan to restore the Citarum River Basin.

Dzerzhinsk, Russia

Throughout the Soviet period, Dzershinsk was one of Russia's principle sites of chemical manufacturing, including chemical weapons. Today, it is still a significant center of the Russian chemical industry. Between 1930 and 1998, an estimated 300,000 tons of chemical wastes were improperly landfilled in Dzershinsk and the surrounding areas. From this waste, around 190 identified chemicals were released into the groundwater. In 2007, water samples taken within the city showed levels of dioxins and phenol thousands of times above recommended levels. This prompted the Guinness Book of World Records to name Dzershinsk the most polluted city in the world later that year. Over the last several years, efforts have been undertaken to close down outdated facilities and remediate contaminated land.

High concentrations of toxic phenol in the air has led to residents of Dzershinsk suffering from increased levels of diseases and cancers of the eyes, lungs, and kidneys.[15] This has caused life expectancy in the city to plummet. A study from 2006 revealed that average life expectancy in Dzershinsk was 47 for women and just 42 for men.[16] Sulfur dioxide in the air also remains a big problem. A study published in 2013 found that 35% of those residents living adjacent to an industrial or mining area had experienced a chronic cough with sputum, compared to just 18% of those residents who did not (odds ratio: 2.16).[17] The city has a total population of nearly 245,000 people. The toxic emissions and pollutants from local industries are potentially affecting all of the local residents.

15 Environmental Disaster in Dzerzhinsk, 2011. Available at: http://survincity.com/2011/02/environmental-disaster-in-dzerzhinsk/
16 Environmental Disaster in Dzerzhinsk, 2011. Available at: http://survincity.com/2011/02/environmental-disaster-in-dzerzhinsk/
17 Nieminen, P et al. "Environmental Exposure as an Independent Risk Factor of Chronic Bronchitis in Northwest Russia." *International Journal of Circumpolar Health* 72 (2013).

A SPECIAL NOTE ON FUKUSHIMA

The Fukushima nuclear disaster that occurred in March 2011 was one of the worst the world has ever seen. The damage from a powerful tsunami in the region caused massive equipment failures leading to a partial meltdown of the plant and the release of radioactive materials into the surrounding environment. Despite a quick reaction to curtail the spread of radiation and minimize the damage, over 2 years have passed since the accident and radioactive materials are still seeping into the surrounding environment and the Pacific Ocean. In September 2013, estimates put the amount of polluted water dumped into the sea at just over 1,000 tons.[17] It is currently believed that the plume of radioactive cesium-137 released by the disaster could begin flowing into the U.S. coastal waters starting in early 2014. Additionally, a 2013 WHO report predicts that for populations living around the Fukushima nuclear power plant there is a 70% higher risk of developing thyroid cancer for girls exposed as infants, a 7% higher risk of leukemia in males exposed as infants, a 6% higher risk of breast cancer in females exposed as infants and a 4% higher risk, overall, of developing solid cancers for females.[18]

Green Cross Switzerland has a number of ongoing interventions at the site. These include "Therapy Camps" for children and adolescents. Here they receive medical and psychological care in a healthy and clean environment. Interventions also include those aimed at families to help them adopt simple practices to limit their exposure to dangerous radioactivity.

Hazaribagh, Bangladesh

There are 270 registered tanneries in Bangladesh, and around 90 percent are located in Hazaribagh on about 25 hectares of land. Most of these use old, outdated, and inefficient processing methods. Together, the tanneries employ around 8,000 to 12,000 people.[18] Every day, the tanneries collectively dump 22,000 cubic liters of toxic waste, including cancer-causing hexavalent chromium, into the Buriganga, Dhaka's main river and a key water supply.[19] The homes of tannery workers in Hazaribagh are built next to contaminated streams, ponds, and canals. Informal leather recyclers who burn scraps of leather to produce a number of consumer products also heavily pollute the air.[20]

Aside from the fact that hexavalent chromium is a well-known carcinogen, workers and local residents also face a number of less severe yet more common health problems every day. Skin and respiratory diseases, for instance, result from repeated exposure to hazardous chemicals when measuring and mixing them as part of the tanning process. Acid burns, rashes, aches, dizziness, and nausea are also common health problems faced by local residents.[21] The 2011 census lists the total population of the Hazaribagh sub-district at just over 185,000, though reliable data in relation to residents residing in the informal settlments is difficult to come by.[22]

18 Environmental Concerns regarding Hazaribagh Tannery area and Present Relocation Scenario (2011).
19 Human Rights Watch, 2012. Toxic Tanneries: The Health Repercussions of Bangladesh's Hazaribagh Leather. Available at: http://www.hrw.org/sites/default/files/reports/bangladesh-1012webwcover.pdf
20 "Material Damage. Toxic Tanneries Cause Lasting Harm." *Hazards Magazine* 2012: Issue 120. Web. <http://www.hazards.org/workingworld/materialdamage.htm>.
21 Human Rights Watch, 2012. Toxic Tanneries: The Health Repercussions of Bangladesh's Hazaribagh Leather. Available at: http://www.hrw.org/sites/default/files/reports/bangladesh-1012webwcover.pdf
22 Bangladesh Bureau of Statistics, "Household, Population, Sex Ratio and Literacy Rate," 2011, table C-01 http://www.bbs.gov.bd/PageWebMenuContent.aspx?MenuKey=439.

Kabwe, Zambia

Kabwe, the second largest city in Zambia, is located about 150 kilometers north of the nation's capital, Lusaka. A 2006 health study discovered that, on average, children's blood lead levels in Kabwe exceeded the recommended levels by five to ten times.[23] This was the result of contamination from lead mining in the area, which is situated around the Copperbelt. In 1902, rich deposits of lead were discovered, leading mining and smelting operations to run almost continuously for over 90 years without the government adequately addressing the potential dangers of lead. Smelting was largely unregulated throughout the 20th century in Kabwe, and these smelters released heavy metals in the form of dust particles, which settled on the ground in the surrounding areas.[24] While the mine is currently closed, artisanal activity at tailings piles continues.

The current CDC recommended level of lead in children's blood is 5 ug/dL. Levels in excess of 120 ug/dL can potentially be fatal. In some neighborhoods in Kabwe, blood concentrations of 200 ug/dL or more were recorded in children, and records show average blood levels of children tested ranged between 50 and 100 ug/dL.[25] Children who play in the soil and young men who artisanally mine the area are most at risk.

The Zambian government has made significant progress in dealing with the issue, particularly through a USD 26 million remediation program funded by World Bank and Nordic Development Fund from 2003 to 2011.[26, 27] Despite these efforts, the site still poses an acute health risk that will require further work.

23 Tembo, B., K. Sichilongo, and J. Cernak. "Distribution of Copper, Lead, Cadmium and Zinc Concentrations in Soils around Kabwe Town in Zambia." *Chemosphere* 63.3 (2006): 497-501.
24 IRIN: Kabwe, Africa's Most Toxic City; 2006. Available at: http://www.irinnews.org/report/61521/zambia-kabwe-africa-s-most-toxic-city
25 Nweke, Onyemaechi C., and William H. III Sanders. "Modern Environmental Health Hazards: A Public Health Issue of Increasing Significance in Africa." *Environmental Health Perspectives* (2009).
26 The World Bank: Copperbelt Environment Project Tackles the Lead and Uranium Danger in Zambia. Available at: http://go.worldbank.org/NQ5GAPHMA0
27 Berkeley Mineral Resources PLC: The Kabwe Mine; 2013. Available at: http://www.bmrplc.com/lead-and-zinc/kabwe-mine/

Kalimantan, Indonesia

Kalimantan is the Indonesian portion of the island of Borneo and is composed of five provinces. In two of those provinces, Central and South, Artisanal Small-scale Gold Mining (ASGM) forms the primary source of income for 43,000 people.[28] The vast majority of ASGM miners globally utilize mercury in the gold extraction process. The mercury forms an amalgam with gold concentrate and is burned off in rudimentary smelting. The United Nations Industrial Development Organization (UNIDO) estimates that more than 1,000 tons of mercury are released into the environment each year through this process, which constitutes about 30 percent of the anthropogenic mercury emissions.[29]

Mercury vapors can travel long distances in the atmosphere, and partly for this reason, have attracted considerable international attention. Importantly, however, the most acute health risks posed by ASGM sites are more local in nature. Many miners smelt within the home, releasing dangerous amounts of mercury vapor that are trapped inside. Additionally, mercury released during the amalgamation process (before smelting) is easily released into area waterways where it can accumulate in fish. One article published in the *Journal of Water and Environment Technology* in 2008 found a concentration of mercury in the Kahayan River of Central Kalimantan that was 2,260 ng/L. This is more than twice Indonesia's standard for total mercury in drinking water (1,000 ng/L).[30]

The Indonesian government is making progress on this issue. As a signatory to the recently adopted Minamata Convention on Mercury (10 October 2013), Indonesia has taken an important step with the international community to limit anthropogenic releases of mercury. Additionally, the Ministry of Environment has long supported the work of NGOs like Blacksmith Institute and Yayasan Tambuhak Sinta (YTS) in working with miners in a collaborative fashion to mitigate their releases and exposure.

Matanza-Riachuelo, Argentina

The Matanza-Riachuelo River Basin is more than 60 kilometers long and houses a number of SME clusters, including chemical manufacturers. It is estimated that 15,000 industries are actively releasing effluent into the river, which cuts through 14 municipalities in Buenos Aires.[31] Chemical manufacturers are responsible for more than a third of the pollution.

Pollutants in the Matanza River vary greatly. A study published in the Latin American *Journal of Sedimentology and Basin Analysis* in 2008 revealed that soil on the banks of the river contained levels of zinc, lead, copper, nickel, and total chromium that were all above recommended levels. Chromium, for example, had a mean value in soil of 1,141 ppm, which is significantly higher than the recommended level of 220 ppm.[32]

It's believed that 60% of the approximately 20,000 people who reside near the river basin live in territory deemed unsuitable for human habitation, with 6% living in the basin's most unsuitable conditions.[33] Environmental factors such as diarrheal diseases, respiratory diseases, and cancer are significant public health problems associated with the multiple industries in the basin. A 2013 article published in *Salud Colectiva* found that 80% of

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28 The Borneo Research Bulletin: Artisanal Gold Mining, Mercury and Sediment in Central Kalimantan, Indonesia; January 2012. Available at: http://www.highbeam.com/doc/1G1-336176554.html

29 Blacksmith Institute, 2010. Artisanal Gold Mining – Central Kalimantan. Available at: http://www.blacksmithinstitute.org/projects/display/165

30 Elvince, Rosana, Takanobu Inoue, Kouji Tsushima, Ryousuke Takayanagi, Ardianor, Untung Darung, Sulmin Gumiri, Salampak Dohong, Osamu Nagafuchi, Tomonori Kawakami, and Toshiro Yamada. "Assessment of Mercury Contamination in the Kahayan River, Central Kalimantan, Indonesia." *Journal of Water and Environment Technology* 6.2 (2008): 103-12.

31 1 World Water Week in Stockholm, 2010. Available at: http://www.worldwaterweek.org/documents/WWW_PDF/2010/thursday/T6/M_R_Basin_Argentina_vf_09se_10_rafaelli_carsen.pdf

32 1 Ronco, Alicia et al. "Screening of Sediment Pollution in Tributaries from the Southwestern Coast of the Río De La Plata Estuary." *Latin American Journal of Sedimentology and Basin Analysis* (2008).

33 Pietri, DD, P. Dietrich, P. Mayo, and A. Carcagno. "[Multicriteria Evaluation of Environmental Risk Exposure Using a Geographic Information System in Argentina]." *Revista Panamericana De Salud Publica* 30.4 (2011): 377-78.

water samples taken from wells near the Matanza-Riachuelo river basin were not safe for drinking due to contamination.[34] This issue is aggravated by inadequate infrastructure in the nearby informal settlements, where residents are left with few options for drinking water.[35]

Several important programs are making progress on the issue. Most significantly a billion dollar World Bank funded effort will focus on sanitation and industrial pollutant abatement.[36] Given the scale of the investment and the actors involved, considerable progress is anticipated.

34 Quality of Water for Human Consumption: The Health of the Population Residing in the Matanza-Riachuelo River Basin Area in Greater Buenos Aires].” *Salud Colectiva* 9.1 (2013): 53-63.
35 IRC International Water and Sanitation Centre, 2009. Available at: http://www.source.irc.nl/page/46738
36 World Bank, 2013. Available at: http://www.worldbank.org/projects/P105680/matanza-riachuelo-basin-mrb-sustainable-development-adaptable-lending-program?lang=en&tab=overview

Niger River Delta, Nigeria

The Niger River Delta is a densely populated region that extends over 70,000 km2 and makes up nearly 8% of Nigeria's land mass. It is heavily polluted by oil and hydrocarbons, as it has been the site of major petroleum operations since the late 1950s.[37] Between 1976 and 2001 there were nearly 7,000 incidents involving oil spills where most of the oil was never recovered.[38] As of 2012, some 2 million barrels (320,000 m3) of oil were being extracted from the delta every day.[39] Groundwater and soil

37 UNEP, 2011. Available at: http://www.unep.org/science/chief-scientist/Activities/DisastersandConflicts/OilPollutioninthe-NigerDeltaNigeria.aspx
38 Amnesty International. *Nigeria: Petroleum Pollution and Poverty in the Niger Delta". ". United Kingdom: Amnesty International Publications International Secretariat, 2009.*
39 Isumonah, V. Adelfemi (2013). "Armed Society in the Niger Delta". *Armed Forces & Society* 39 (2): 331–358.

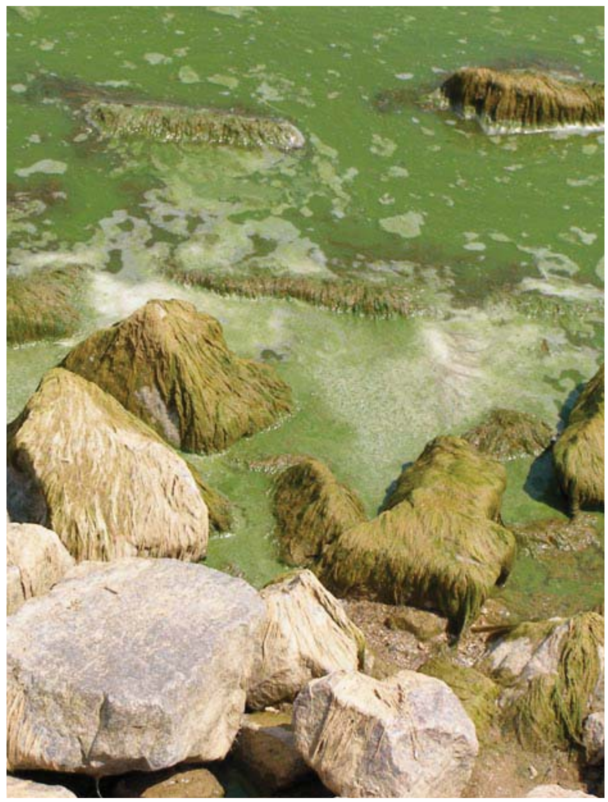
have been heavily polluted in the process, which has also devastated aquatic and agricultural communities.[40]

An average of 240,000 barrels of crude oil are spilled in the Niger delta every year due to mechanical failure, third party activity, and many unknown causes. The spills have not only contaminated the surface and ground water of the delta but also the ambient air and locally grown crops with hydrocarbons, including known carcinogens like polycyclic aromatic hydrocarbons (PAHs).[41] A 2011 report from UNEP concluded that soil and groundwater pollution levels exceeded national standards at two-thirds of reviewed locations in and around the Niger delta.[42] These spills have affected local population health in a number of ways. One article published in the *Nigerian Medical Journal* in 2013 estimated that the widespread pollution could lead to a 60% reduction in household food security and a 24% increase in the prevalence of childhood malnutrition. This is in addition to the fact that the crude oil is likely hemotoxic and can cause infertility and cancer.[43]

Norilsk, Russia

Norilsk is an industrial city founded in 1935. Mining and smelting operations began in the 1930s and Norilsk contained the world's largest heavy metals smelting complex as recently as the early 2000s. Nearly 500 tons each of copper and nickel oxides and two million tons of sulfur dioxide are released annually into the air.[44] Life expectancy for factory workers in Norilsk is 10 years below the Russian average.

While the exact number of people potentially affected by pollution in Norilsk is unknown, it's estimated that over 130,000 local residents are being exposed to particulates, sulfur dioxide, heavy metals, and phenols each day from air pollution.[45] Past studies have found elevated copper and nickel concentrations in soil nearly everywhere within a 60km radius of the city. This has led to increased levels of respiratory diseases and cancers of the lungs and digestive system. Children are especially vulnerable and become ill 1.5 times more frequently than children from surrounding districts.[46] While investments have recently been made in reducing environmental emissions, the surrounding area remains seriously contaminated.



40 The New York Times, 2010. Available at: http://www.nytimes.com/2010/06/17/world/africa/17nigeria.html
41 Ordinioha, B. "The Human Health Implications of Crude Oil Spills in the Niger Delta, Nigeria: An Interpretation of Published Studies." Nigerian Medical Journal 54.1 (2013).
42 UNEP, 2011. Available at: http://www.unep.org/science/chief-scientist/Activities/DisastersandConflicts/OilPollutioninthe-NigerDeltaNigeria.aspx
43 Ordinioha, B. "The Human Health Implications of Crude Oil Spills in the Niger Delta, Nigeria: An Interpretation of Published Studies." *Nigerian Medical Journal* 54.1 (2013).
44 EPA, 2007. Available at: http://www.epa.gov/wed/pages/publications/abstracts/archive2003/allen-gil03.htm
45 Norilsk Nickel Wrestles with an Old Polluter, 2010. Available at: http://www.tandfonline.com/doi/abs/10.1080/00139157.1996.9930998?journalCode=venv20#.UnLMZ-DPY-d
46 Geocurrents: Pollution Problems in Norilsk, 2012. Available at: http://www.geocurrents.info/place/russia-ukraine-and-caucasus/siberia/pollution-problems-in-norilsk

THE 2006 AND 2007 TOP TEN: WHERE ARE THEY NOW?

Limited Progress

Chernobyl, Ukraine
Kabwe, Zambia
Norilsk, Russia
Mailuu-Suu, Kyrgyzstan
Dzershinsk, Russia

Significant Progress

Linfen, China
Tianying, China
La Oroya, Peru
Sukinda, India
Ranipet, India
Sumgayit, Azerbaijan
Rudnaya Pristan, Russia

Success Story

Haina, Dominican Republic

In 2006 and 2007, the World's Worst reports compiled a Top Ten list with the assistance of the Blacksmith Technical Advisory Board (TAB). Sites were chosen by adopting a methodical approach to evaluating those locations where human health was most at risk and children's lives were especially threatened. In particular, those reports took into account 5 major criteria:

—Size of the affected population
—Severity of the toxin(s) involved
—Impact on children's health and development
—Evidence of a clear pathway of contamination
—Existing and reliable evidence of health impact

In total, the 2006 and 2007 reports prioritized 13 sites (most of the original sites showed up on the list a second time in 2007). While progress has been slow on a few of the sites due to a number of extenuating bureaucratic and political forces, there has been at least some form of progress made at almost all of these locations. Unfortunately, however, the problem has only been fully mitigated at one such site—Haina, Dominican Republic.

Linfen, China

A highly polluted industrial city that had serious problems with air quality, including both particulates and gases (such as sulfur dioxide)

Linfen is located in Shanxi Province, which alone provides nearly one third of the nations energy.[47] Strong demand over the past several decades has led to an increase in the number of coal mines in Linfen, many of which are unregulated. In 2003, emissions related to coal exploitation led to Linfen's as having 'China's worst air quality' in a report put out by the State Environmental Protection Administration (SEPA).

In 2006 and 2007 when previous lists were released, particulate matter resulting from the coal industry was taking a serious toll on the health of Linfen's inhabitants. Local clinics and health facilities were seeing an unusually high number of cases of bronchitis, pneumonia, and lung cancer in considerable excess of the national average.

Since 2007, Linfen has made strong progress in dealing with its pollution issues through well funded interventions. Within five years of this work starting, the average air quality health index (AQHI), a measure of particulate in air with 1 being the lowest and 10 being the most dangerous, has improved from 4.18 in 2006 to 1.69 in 2011.[48]

This was done by implementing a number of environmental and health-oriented programs. During the five-year period, a total of 1,056 small-scale factories and 746 middle scale factories closed. A monitoring system was also set up for the 99 key polluters in the area that closely watched and regulated the levels of pollution they emitted. Additionally, coal smoke pollution was greatly reduced during this time as 272 inefficient boilers were treated and 937 commercial stoves were replaced with cleaner burning fuels.

While exact figures are difficult to come by, Blacksmith estimates that perhaps 2 billion Renminbi (over 3.25

47 Global Institute for Tomorrow: Building a Brighter Future Promoting low-carbon development in Shanxi, China; September 2012. Available at: http://www.global-inst.com/downloads/programme_materials/past/2012_ORIX_GLP_Briefing_Note.pdf

48 Air Quality Index Information: http://www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=065BE995-

Children in Paraiso de Dios, Haina, Dominicant Republic

million USD) were spent on site cleanup work, with funding mainly coming from the municipal government.

Chernobyl, Ukraine

Notorious for the catastrophic release of radioactive materials and radiation after an accident at a Soviet-era power plant

Chernobyl is still recognized as one of the worst nuclear disasters in history. On the evening of April 25, 1986, testing in the Chernobyl power plant 62 miles north of Kiev triggered a massive meltdown of the reactor's core releasing more than 100 times the radioactivity of the bombs dropped on Hiroshima and Nagasaki. Around 150,000 square kilometers of land was affected in the accident. To this day, the 19-mile exclusion zone around the plant remains largely uninhabited.[49] Within seven months, the reactor was buried in a concrete casing designed to absorb radiation and contain the remaining fuel. However the structure was built to last no more than 20-30 years.

Radioactive contamination from the Chernobyl Power Plant spread over 40% of Europe and parts of Asia, North Africa, and North America immediately following the nuclear disaster. Nearly 400 million people resided in territories that were contaminated with a significant dose of radiation. Today, there are over a dozen artificial radionuclides such as cesium-137 that can be detected in the surface soil around the plant. As a result of prolonged low-dose exposure, an article published in *Environmental Health Perspectives* in 2012 concluded via a nested case-control study that there has been a significant increase in the risk of leukemia.[50]

It is estimated that the total number of people at risk in Ukraine, Russia, Moldova and Belarus could be as high as 10 million. In addition to increased rates of leukemia, thyroid cancer in children surrounding

49 ASME: Chernobyl 25 Years Later; April 2011. Available at: https://www.asme.org/engineering-topics/articles/nuclear/chernobyl-25-years-later

50 Zablotska, LB et al. "Radiation and the Risk of Chronic Lymphocytic and Other Leukemias among Chornobyl Cleanup Workers." *Environmental Health Perspectives* 121.1 (2013): 59-65

the area has also become a prominent associated health effect. In the past few years, some residents have begun returning to their old homes at their own risk in the areas surrounding Chernobyl, as levels of radiation have decreased and are no longer fatal.[51]

While progress has been slow, there have been a number of positive improvements at the site. A shelter implementation plan has been put into place with two major steps. First, the French construction company Novarka has been hired to build an arch-shaped steel structure to cover the existing containment structure. This updated cover is designed to last 100 years, and is due to be completed in 2015.[52] It will be a great improvement on the current structure, which has begun leaking in several areas. The second major step is the creation of a fuel storage facility, which is being built by the US firm Holtec. It will be housed in the exclusion zone for nuclear waste and will be able to accommodate 20,000 spent fuel assemblies. This second major step will likely be completed in late 2014 or early 2015.[53]

The European Bank for Reconstruction and Development has been the major stakeholder in this site improvement. They are investing over 2 billion USD on the new containment structure and over 275 million on the spent fuel storage facility. As previously stated, Holtec and Novarka also play key roles in the project design and development.

Several other smaller interventions are currently ongoing. Green Cross Switzerland for instance has developed a series of medical, psychological and pedagogical programs. These include for instance "therapy camps" which provide temporary respites for the most affected individuals. They also include visits by medical staff to affected areas, "Train the Trainer" programs for youth, and micro-credit work to contribute to economic development.

51 International Atomic Energy Agency. Available at: http://www.iaea.org/newscenter/features/chernobyl-15/cherno-faq.shtml
52 Nuclear Energy Insider: Novarka putting a new cap on Chernobyl; April 10, 2013. Available at: http://analysis.nuclearenergy-insider.com/decommissioning/novarka-putting-new-cap-chernobyl
53 European Bank for Reconstruction and Development: New Safe Confinement and Spent Fuel Storage Facility; January 2011. Available at: http://www.ebrd.com/downloads/research/factsheets/chernobyl25.pdf

Haina, Dominican Republic

High levels of lead contamination in local children as a result of releases from a battery recycling smelter and access to the abandoned facility

Paraiso de Dios, in Haina, the Dominican Republic, was the scene of an extreme lead poisoning incident in the 1990s. In March 1997, 116 children were surveyed, and again in August 1997, 146 children were surveyed. Mean blood lead concentrations were 71 µg/dL (range: 9–234 µg/dL) in March and 32 µg/dL (range: 6–130 µg/dL) in August. The study revealed that at least 28% of the children required immediate treatment and 5% showed lead levels >79 µg/dL who were at risk for severe neurologic sequelae at the time of the study. Residents reported that several children suffered seizures during the factory operational years.

Several organizations conducted a range of interventions at the site focused on reducing blood lead levels in children through community education and nutritional supplements. Most notably New York-based Friends of Lead Free Children working jointly with the Autonomous University of Santo Domingo (UASD) engaged in a number of activities through the early 2000s.

The site was initially brought to the attention of Blacksmith Institute in 2006 by the International Lead Management Center. At this time Blacksmith Institute began investigating the possibility of implementing remediation activities at the site. Meetings with the Ministry of Environment (MOE) and others revealed that a recalcitrant owner was unwilling to allow construction work. As an alternative, Blacksmith Institute conducted a broad community education campaign from 2006 to 2009 jointly with UASD, the municipal government of Haina and others. Blacksmith also continued pursuing the possibility of remediation activity at the site.

Blood testing in May 2009 revealed an average of 25 µg/dL (range 5->65 µg/dL) in those children tested. As no remediation work was conducted at the site before this time, this significant decline in Blood Lead Levels (BLLs) was most likely the result of the education measures undertaken.

In November 2009, MOE took ownership of the site through legal means. Blacksmith Institute and TerraGraphics Engineering mobilized very quickly to begin remediation work that December. MOE construction crews implemented a TG remediation design with TG staff supervising the activity. The key elements of the implemented plan included transporting high-level waste to an offsite facility which met strict regulatory standards, and entombing the rest of the material onsite. The area was then transformed into a park.

Following the onsite activity, UASD, Blacksmith and TerraGraphics carried out a remedial program in the community with Inter-American Development Bank funding. The key components of this work were the construction of Gabian basket walls to limit soil erosion, removal of highly contaminated waste, and covering of contaminated soils with a concrete layer. This work was implemented in August 2010. Blood tests taken in September of the same year found an average BLL of 12.6 µg/dL (range 4-46 µg/dL), or less than half that of studies before the remediation. It is anticipated that these levels are now below 5 ug/dL, though further sampling is required to confirm this assumption.

Children playing near in lead contaminated soil

La Oroya, Peru

Lead and other pollutants in the air and on the ground from decades of lead processing

Adults and children in La Oroya, Peru have been exposed to toxic emissions from a poly-metallic smelter since 1922. According to studies carried out by the Director General of Environmental Health in Peru, in 1999 around ninety nine percent of children living in La Oroya had blood lead levels that exceeded acceptable standards. Sulfur dioxide concentrations also exceeded the World Health Organization's standards by more than ten times. Vegetation in the area was being destroyed by acid rain from sulfur dioxide, and arsenic, cadmium, and a number of other heavy metals were accumulating in the environment at significantly high and unhealthy levels.

Following the 2006 and 2007 reports, the owner made significant progress in reducing emissions from the smelter itself. Investments in pollution controls were substantial, including water treatment plants, tailings management systems, and ambient air controls and monitoring. The final investment, that of a fully-contained smelter, was partially completed when the ownership of the facility changed.

The government of Peru has demonstrated a great desire to improve the site and the health of residents in the area. For instance, efforts have been made to deal with the legacy pollutants on the ground by paving roads in the region. This work will decrease dust and therefore inhalation of contaminated soil.

Sukinda, India

Poorly controlled waste and run-off from this chrome mining area was reported to be impacting workers and downstream communities

Sukinda is located in the State of Orissa, which

contains 97% of India's chromite ore deposits and one of the largest open cast chromite ore mines in the world. In 2007, twelve mines operated with inadequate environmental management plans, resulting in considerable pollution in the area. Perhaps as much as 30 million tons of waste rock were spread over the surrounding areas.[54]

When the 2007 report was published, approximately 70% of the surface water and 60% of the drinking water contained hexavalent chromium at more than double national and international standards.[55] The Brahmani River is the only water source for the residents and treatment facilities are extremely limited. The air and soils are also heavily impacted. The Orissa Voluntary Health Association (OVRA) reported before the 2007 report that 84.75% of deaths in the mining areas and 86.42% of deaths in the nearby industrial villages occurred due to chromite-mine related diseases.[56] The survey also determined that villages less than one kilometer from the sites were the most severely affected, with 24.47% of the inhabitants found to be suffering from pollution-induced diseases.[57]

The local pollution control authorities have been trying to find a way to upgrade the operations in Sukinda for several years. The Indian government has also recognized the need to do this and has visited the site in the past two years to discuss a proper plan of action. More than any country in the scope of this report, India has made significant

54 Joseph, Benny. "Natural Resources." *Environmental Studies*. New Delhi: Tata McGraw-Hill, 2009. 29-30.

55 Dhakate, R., V. Singh, and G. Hodlur. "Impact Assessment of Chromite Mining on Groundwater through Simulation Modeling Study in Sukinda Chromite Mining Area, Orissa, India." *Journal of Hazardous Materials* 160.2-3 (2008): 535-47.

56 Das, AP, and S. Singh. "Occupational Health Assessment of Chromite Toxicity among Indian Miners." *Indian Journal of Occupation Environmental Medicine* 15.1 (2011).

57 Das, AP, and S. Singh. "Occupational Health Assessment of Chromite Toxicity among Indian Miners." *Indian Journal of Occupation Environmental Medicine* 15.1 (2011).

Progress has been made at Rudnaya Pristan, but more action is required

progress in dealing with pollution issues on a national level (see *A Special Note on India* below). The authors are hopeful that Sukinda will be addressed as part of these new programs.

Rudnaya Pristan, Russia

A region recovering from decades of lead contamination

After 100 years of mining and smelting activities, the Rudnaya River Valley in the Russian Far East is contaminated with lead, cadmium, arsenic, zinc, copper, and other heavy metals. The small town of Rudnaya Pristan was one of the most heavily contaminated areas due to a lead smelter located in the town. Although the smelter closed in 2005, research conducted since the closure shows that dangerous levels of heavy metals, particularly lead, still exist in the town's soil, household dust and locally grown crops. Most critically, children in the town still have dangerous levels of lead in the their blood.

In 2005, local researchers, with assistance from Blacksmith Institute and Green Cross Switzerland, began monitoring the blood-lead levels of children in Rudnaya Pristan. The research revealed that among those children tested, 69% had levels of lead in their blood above the CDC recommended level.

Between 2006 and 2012, Rudnaya Pristan made limited but important progress in addressing local environmental health risks. After the site was named one of the world's worst polluted in 2006, researchers from the Far East Environmental Health Fund designed and implemented a project to begin reducing children's health risks from lead in Rudnaya Pristan. The project assessed the levels of contamination and types of risks, taught community members behaviors that reduce exposure to heavy metals, replaced heavily contaminated soils from playgrounds and other high-risk areas, and provided special counseling and medical treatment to families with children severely poisoned by lead.

One of the primary ways that children are exposed to lead is through inhalation of contaminated dust and ingestion of contaminated soil. Children play at ground level, with their hands, and thus take in more dirt and dust than adults. Because of this, a major component of the intervention was the cleanup of contaminated soil at playgrounds in Rudnaya Pristan. The playgrounds were located in the center of town, at kindergartens, schools, and a summer camp. The main cleanup method was to remove the top layer of contaminated soil, dispose of it safely and replace it with new clean soil. By the end of the project, 25,840 square meters of contaminated soil were removed and replaced with clean soil.

In 2012, researchers from the Far East Environmental Health Fund conducted another round of medical monitoring and found that, among those tested, the number of children with dangerous blood-lead levels had decreased from 69% to 44%.

Mailuu-Suu, Kyrgyzstan

Uranium mining waste threatens a town and imperils an entire region

The small town of Mailuu-Suu sits in the valley of the Mailuu-Suu River, just downstream from two million cubic meters of radioactive mining waste. From 1946-1968 the uranium plant in Mailuu-Suu produced and processed more than 10,000 tons of uranium ore.[58] The waste from this operation sits in twenty-three dumps that were left open to the elements near the banks of the river. This waste contaminates the town's drinking water with dangerous heavy metals and radioactive particles, and presents a broader risk to the entire Ferghana valley, one of the most fertile and densely populated areas in Central Asia.[59] Since appearing in the 2006 list of the World's Worst Polluted Places, several projects around Mailuu-Suu have reduced these risks, but more work is needed.

Both Mailuu-Suu and its twenty-three uranium mining waste dumps sit at the bottom of a narrow, seismically active valley. If a landslide either pushed some of the mining waste into the river, or blocked the river and caused water to back up and flood the waste dumps, the result would be devastating contamination of the downstream areas.[60] The Mailuu-Suu River is a tributary to the Syr-Darya River, which is a primary source of water for the Fergana valley–a dense population center spanning Kyrgyzstan, Tajikistan, and Uzbekistan.

The risks at Mailuu-Suu are not theoretical. In May of 2002, a large mudslide blocked the course of the Mailuu-Suu River and threatened to submerge

58 UNECE: Environmental Performance Review, Kyrgyzstan; 2000. Avaialable at: http://www.unece.org/fileadmin/DAM/env/epr/epr_studies/kyrgyzstan.pdf

59 Nasritdinov, Emil et al. "Environmental Migration: Case of Kyrgyzstan." *Environment, Forced Migration, and Social Vulnerability* (2010): 235-46.

60 Torgoev, Almazbek, and Hans-Balder Havenith. "Landslide Susceptibility, Hazard and Risk Mapping in Mailuu-Suu, Kyrgyzstan." *Landslide Science and Practice* 1 (2013).

Mailuu-Suu is heavily at risk from radionuclides a uranium waste site. In April of 2006, roughly 300,000 cubic meters of material fell into the Mailuu-Suu River near the uranium mine tailings. It is only a matter of time until the next event like these takes place.

Progress at Mailuu-Suu has been slow but steady over the last decade. To reduce threats posed by seismic activity, the World Bank provided assistance to improve infrastructure around the waste dumps and move some of the radioactive materials that posed the most significant risk. While important, this project addressed only those materials that presented the most immediate and severe risks.[61] The threat posed by landslides remains high.

Blacksmith Institute and Green Cross Switzerland have been working in Mailuu-Suu since 2008 to measure and reduce the daily health risks faced by residents. These are health risks that exist even without a catastrophic seismic event, simply due to the town's the proximity to the waste dumps. The ultimate goal of the project is to reduce human exposure to heavy metals and radionuclides among residents. The project has three primary components: environmental and medical monitoring, community education and water filtration.

Before designing a response to environmental health threats faced by residents, it is necessary to identify the risks and assess their relative severity. This project sampled air, meat, plants, water and soil around the town to see where residents might come into contact with dangerous materials and what types of activities would increase or decrease that exposure.

After identifying the types of risks present in the town, the project partners designed education programs for students, teachers, parents, medical professionals and municipal officials to educate them about activities that could increase or reduce health risks. Radio advertisements were created to remind residents about dangerous activities and areas, and to encourage risk-reducing behavior. Posters and signs were places around the region identifying hazardous areas and encouraging residents not to graze animals or allow children to play nearby.

In addition to monitoring and education, the project aimed to directly reduce exposure to dangerous particles among the town's most vulnerable residents–its children. Drinking water in Mailuu-Suu comes straight from the local river.[62] The river water is allowed to settle briefly in tanks and ponds before being piped into homes, but is not filtered or treated in any other way. When it comes out the tap, it is brown with silt. That silt contains the metals and radioactive particles that jeopardize the health of residents. To reduce the amount of dangerous particles consumed by children in Mailuu-Suu, project staff installed ten industrial water filters in schools and hospitals around town. Local residents were trained to operate the filters and to regularly replace the filtration cartridges. The town was provided with several years of replacement cartridges to ensure the filters continue to remove dangerous material until a long-term solution is found. Blacksmith Institute is currently evaluating options to install a permanent water treatment system.

Kabwe, Zambia

Widespread contamination from an abandoned lead smelter

Kabwe, the second largest city in Zambia, is located about 150 kilometers north of the nation's capital, Lusaka. A 2006 health study discovered that, on average, children's blood lead levels in Kabwe exceeded the recommended levels by five to ten times.[63] This was the result of contamination from lead mining in the area, which is situated around the Copperbelt. In 1902, rich deposits of lead were discovered, leading mining and smelting operations

61 The World Bank: 28,000 Inhabitants of Mailuu-Suu Valley in the Kyrgyz Republic to Benefit from Improved and Safer Access on the Road to Villages; 2011. Available at: http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22936608~pagePK:64257043~piPK:437376~theSitePK:4607,00.html

62 Uralbekov, B. M., B. Smodis, and M. Burkitbayev. "Uranium in Natural Waters Sampled within Former Uranium Mining Sites in Kazakhstan and Kyrgyzstan." *Journal of Radioanalytical and Nuclear Chemistry* 289.3 (2011): 805-10.

63 Tembo, B., K. Sichilongo, and J. Cernak. "Distribution of Copper, Lead, Cadmium and Zinc Concentrations in Soils around Kabwe Town in Zambia." *Chemosphere* 63.3 (2006): 497-501.

to run almost continuously for over 90 years without the government adequately addressing the potential dangers of lead. Smelting was largely unregulated throughout the 20th century in Kabwe, and these smelters released heavy metals in the form of dust particles, which settled on the ground in the surrounding areas.[64] While the mine is currently closed, artisanal activity at tailings piles continues.

The current CDC recommended level of lead in children's blood is 5 ug/dL. Levels in excess of 120 ug/dL can potentially be fatal. In some neighborhoods in Kabwe, blood concentrations of 200 ug/dL or more were recorded in children, and records show average blood levels of children tested ranged between 50 and 100 ug/dL.[65] Children who play in the soil and young men who artisanally mine the area are most at risk.

The Zambian government has made significant progress in dealing with the issue, particularly through a World Bank and Nordic Development Fund USD 26 million remediation program from 2003 to 2011.[66, 67] Despite these efforts, the site still poses an acute health risk that will require further work.

64 IRIN: Kabwe, Africa's Most Toxic City; 2006. Available at: http://www.irinnews.org/report/61521/zambia-kabwe-africa-s-most-toxic-city

65 Nweke, Onyemaechi C., and William H. III Sanders. "Modern Environmental Health Hazards: A Public Health Issue of Increasing Significance in Africa." *Environmental Health Perspectives* (2009).

66 The World Bank: Copperbelt Environment Project Tackles the Lead and Uranium Danger in Zambia. Available at: http://go.worldbank.org/NQ5GAPHMA0

67 Berkeley Mineral Resources PLC: The Kabwe Mine; 2013. Available at: http://www.bmrplc.com/lead-and-zinc/kabwe-mine/

Chromium can appear orange in water

Ranipet, India

Accumulated processing wastes led to chrome contamination of the groundwater supplies

Ranipet is located about 100 miles upstream from Chennai, the fourth largest city in India. A factory in Ranipet manufactures sodium chromate, chromium salts and basic chromium sulfate tanning powder used by local tannery operations in the leather tanning process. The Tamil Nadu Pollution Control Board (TN PCB) estimates that about 1,500,000 tons of solid wastes accumulated over two decades of plant operation.[68] The wastes were stacked in an open yard (three to five meters high and on 2 hectares of land) on the facility premises, making it very easy to contaminate water used for washing and irrigation.[69]

Contamination of soil and groundwater with wastewater was affecting residents of Ranipet in a residential colony about 1 kilometer from the factory. Three open wells, a dozen bore wells, and around twenty-five public hand pumps had been abandoned at the time the 2006 Top Ten report was written about the high chromium levels in the water. Farmers in the area also worried that they were harming local residents by irrigating their crops with contaminated water, even though other sources of water were not readily available. Many complained about foul

68 The Tamilnadu Pollution Control Board: Revised Action Plan for Critically Polluted Area, Ranipet; November 2010. Available at: http://cpcb.nic.in/divisionsofheadoffice/ess/Ranipet.pdf

69 Srinivasa, S. G., and PK Govil. "Distribution of Heavy Metals in Surface Water of Ranipet Industrial Area in Tamil Nadu, India." *Environmental Monitoring and Assessment* 136.1-3 (2008): 197-207.

smells in the area and of skin lesions resulting from dermal contact. This was substantiated in a 2008 article published in *Environmental Monitoring and Assessment.* The study found that the concentrations of several heavy metals in surface water were all well above the recommended level. Chromium, for example, was found to have an average concentration in surface water of 247 ug/L, more than five times the recommended level of 49 ug/L.[70]

More than any country in the scope of this report, India has made significant progress in dealing with pollution issues on a national level (see *A Special Note on India* below). The authors are hopeful that Ranipet will be addressed as part of these new programs.

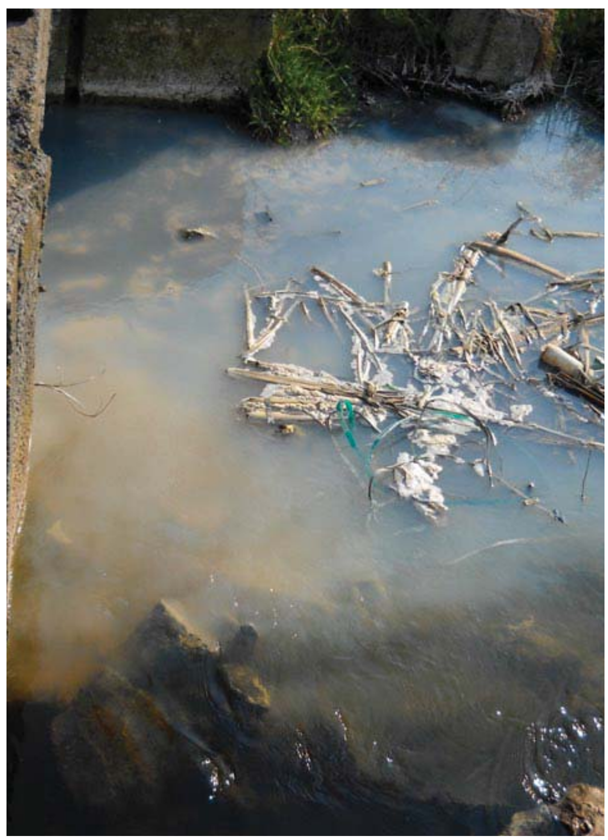
Sumgayit, Azerbaijan

An industrial city polluted by chemical production celebrates success and faces continued challenges in cleaning up its environment

Sumgayit was a major Soviet industrial center with more than 40 factories that produced metals and chemicals. During Soviet era, residents experienced elevated rates of illness compared to the rest of Azerbaijan. After gaining independence, the industrial activity in the city slowed and the extent of the pollution caught the attention of concerned locals and international organizations, including Blacksmith Institute. In 2006, Sumgayit was listed in Blacksmith Institute's *Top Ten Worst Polluted Places*.

Over the last decade, the municipal and national government have taken steps to reduce the impacts of the city's industrial legacy. Old factories that lacked adequate pollution controls have been closed, and are being replaced by modern facilities. A new water treatment station reduces the volume of contaminated water being released into the Caspian Sea. The national government built a hazardous waste storage facility, and has begun transferring contaminated materials that had been dumped haphazardly around the industrial complex into a secure facility. Thousands of trees have been planted around the city to try and remediate the soil.

Despite this progress, pollution problems remain. In 2012 and 2013, Blacksmith Institute tested soils at sites throughout Sumgayit as part of the organization's global Toxic Sites Identification Program. Results showed that many parts of the territory are still contaminated by heavy metals and organic pollutants that are known to impact human health. These pollutants exist near residential settlements, and likely cause adverse health impacts to some residents. The government and companies responsible for the territory acknowledge that more work is needed and are planning additional activities to reduce contamination and improve public health. Blacksmith Institute is now working directly with national government and private sector on several initiatives to improve environmental health in Sumgayit and throughout Azerbaijan.



70 Srinivasa, S. G., and PK Govil. "Distribution of Heavy Metals in Surface Water of Ranipet Industrial Area in Tamil Nadu, India." *Environmental Monitoring and Assessment* 136.1-3 (2008): 197-207.

Tianying, China

Large-scale metals processing had produced air and soil contamination well above international standards

Tianying in the Anhui province is one of the largest lead production bases in China, accounting for about half the country's total production. Antiquated and low-level technologies, illegal operations, and inadequate pollution control measures were causing severe lead poisoning at the time of the 2007 report. At the time the average lead concentrations in air and soil were 8.5 and 10 times the national standards, respectively. Additionally, local crops were contaminated with lead dust at a rate 24 times higher than the national standard.[71]

Residents, particularly children, were reported to suffer from lead poisoning and its related effects as a result of this contamination.[72] Health effects included decreased IQs, short attention spans, learning disabilities, hyperactivity, impaired physical growth, hearing and visual problems, stomachaches, colon problems, kidney malfunction, anemia, and brain damage. Pregnant women had also reported numerous cases of premature births and underdeveloped infants.

The catalyst for the improvements at Tianying has been the establishment of a government-sanctioned industrial park to consolidate and improve various informal-sector activities. While the exact number of people at risk from toxic pollution is currently unknown, it is believed to have decreased significantly from the estimated 140,000 people in 2007. There are now more than forty companies in the park, which was selected as one of the seven "urban mining" demonstration bases in the country by the National Development and Reform Commission (NDRC).[73]

The park includes a proper systematic recycling network, a regulated industrial chain, scale use of resources, and advanced and environmentally friendly technology and equipment. It also allows for the sharing of infrastructure, centralized treatment of effluents, and environmentally sound operation and management. Dismantling of industrial items is now restricted to a particular area where dust is properly collected as opposed to being released into the environment. Most importantly, the nearest village is now 1 km away, which is an important improvement from informal industries that were previously backyard operations in residential neighborhoods of Tianying.

There is still a lot of work that needs to be done in Tianying to ensure the collective health of members of the community. But the government has clearly demonstrated an interest in the issues, having spent in excess of USD 163 million to complete the industrial park.

Dzershinsk, Russia

Numerous Soviet-era chemical plants (including chemical weapons productions) have resulted in serious groundwater and other contamination

Throughout the Soviet period, Dzershinsk was one of Russia's principle sites of chemical manufacturing, including chemical weapons. Today, it is still a significant center of Russian chemical industry. For instance, the city was home to a leaded gasoline factors that produced a potent toxin named TEL. It is believed that between 1930 and 1998, around 300,000 tons of chemical wastes were improperly landfilled in Dzershinsk and the surrounding area. From this waste around 190 identified chemicals were being released in to the groundwater.

Roughly a quarter of the city's 300,000 residents

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71 Wu, Y., Q. Huang, G. Hu, Z. Wang, H. Li, R. Bao, H. Yan, C. Li, L. Wu, and F. He. "[Study on the Effects of Lead from Small Industry of Battery Recycling on Environment and Children's Health]." *Zhonghua Liu Xing Bing Xue Za Zhi* 23.3 (2002).

72 Faber, Daniel. "Chapter 4: The Unfair Trade-off." *Capitalizing on Environmental Injustice: The Polluter-industrial Complex in the Age of Globalization*. Lanham: Rowman & Littlefield, 2008. 203-04.

73 Cohen, Nevin. "Tianying, China." *Green Cities: An A-to-Z Guide*. Thousand Oaks: Sage Publications, 2011. 420-24.

Numerous air pollutants are released from large smokestacks in Russia

were still employed in factories that produce toxic chemicals at the time our 2007 report was published. In 2003, the death rate was reported to exceed the birth rate by 260%, and the city's annual death rate (17 per 1,000) is higher than Russia's national average (14 per 1,000). In a city of 300,000, that translates to about 900 extra deaths annually. The average life expectancy is reported to be 42 years for men and 47 for women.[74]

While there has not been any significant improvement in the physical environment at this site, there has been a lot of planning for proper treatment and site remediation. Work is ongoing to close down outdated facilities and restore contaminated land. The Russian government is preparing to allocate 100 billion rubles ($3.3 billion) to clean up pollution left over by Soviet-era industry, including the "white sea" in Dzerzhinsk.[75]

Norilsk, Russia

One of the world's largest heavy metals smelters was operating for decades with little pollution control

Norilsk is an industrial city founded in 1935 as a slave labor camp and is the second largest city (after Murmansk) above the Arctic Circle. Mining and smelting operations began in the 1930s and when the 2006 report was published Norilsk contained the world's largest heavy metals smelting complex, where nearly 500 tons each of copper and nickel

74 Environmental Disaster in Dzerzhinsk, 2011. Available at: http://survincity.com/2011/02/environmental-disaster-in-dzerzhinsk/

75 The Moscow Times: $3.3 Bln To Clean Up Soviet Pollution; January 23, 2013. Available at: http://www.themoscowtimes.com/news/article/33bln-to-clean-up-soviet-pollution/474437.html

oxides and two million tons of sulfur dioxide were released annually into the air.[76] The city had been accused of being one of the most polluted places in Russia, where the snow is black, the air tastes of sulfur, and the life expectancy for factory workers is 10 years below the Russian average.

Norilsk Nickel, the firm responsible for the pollution, is one of Russia's leading producers of non-ferrous and platinum-group metals. It controls one-third of the world's nickel deposits and accounts for a substantial portion of the country's total production of nickel, cobalt, platinum, and palladium. It also ranks first among Russian industrial enterprises in terms of air pollution.[77] Because the plants were constructed during the Soviet era, environmental standards and regulations are essentially nonexistent.

Local residents are severely affected by the air quality where copper and nickel exceed the maximum allowable concentrations. Children suffer from numerous respiratory diseases and an exceedingly high amount of ear, nose, and throat problems. Similarly, children living near the nickel plant were shown to become ill at a rate 1.5 times higher than children from further districts.[78] Mortality from respiratory diseases is considerably higher than the average in Russia, accounting for nearly 16% of all deaths among children. Premature births and late-term pregnancy complications are also frequent.

While there have not been any true remediation plans implemented in Norilsk at this point, the Russian government is certainly aware of the problem and how it is affecting the health of its citizens. Last year, president Vladimir Putin took a helicopter tour of the area to survey the site as an initial assessment. Over the coming months and years, officials will certainly look to address this problem with a proper site plan and remediation.

A Special Note on India

More than any country in the scope of Blacksmith and Green Cross' work, India has made laudable progress in dealing with pollution and human health. This has included both inventory and remediation work. Perhaps most notably the Indian government announced a 'Clean Energy Cess', or coal tax, on all coal mined in the country or imported from July 1, 2010 onward. This is part of India's National Clean Energy Fund (NCEF) and is intended for a range of environmental ends, including reducing India's carbon footprint and restoring contaminated areas. Given the size of the fund, up to USD 400 million, India is expected to make considerable progress over the next decade. As this work continues, Blacksmith and Green Cross will report on efforts being made.[79,80]

76 Allen-Gil, S.m, J. Ford, B.k Lasorsa, M. Monetti, T. Vlasova, and D.h Landers. "Heavy Metal Contamination in the Taimyr Peninsula, Siberian Arctic." *Science of The Total Environment* 301.1-3 (2003): 119-38.

77 Zhulidov, AV. "Long-term Changes of Heavy Metal and Sulphur Concentrations in Ecosystems of the Taymyr Peninsula (Russian Federation) North of the Norilsk Industrial Complex." *Environmental Monitoring and Assessment* 181.1-4 (2011).

78 Geocurrents: Pollution Problems in Norilsk, 2012. Available at: http://www.geocurrents.info/place/russia-ukraine-and-caucasus/siberia/pollution-problems-in-norilsk

79 Reuturs: India eyes millions in green funds from coal tax; February 26, 2010. Available at: http://www.reuters.com/article/2010/02/26/us-india-coal-climate-idUSTRE61P36D20100226

80 Bloomberg: India to Start Clean Energy Fund By Taxing Coal Use; February 26, 2010. Available at: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=awGQrKRFV_PQ

About Green Cross Switzerland

Green Cross Switzerland facilitates overcoming consequential damages caused by industrial and military disasters and the cleanup 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 cooperation instead of confrontation. This includes the involvement of all stakeholder groups affected by a problem.

About Blacksmith Institute

Blacksmith Institute is a New York based charity that works to mitigate exposurres at contaminated sites in low and medium income countries. To date, Blacksmith has carried out 50 such projects in 20 countries.

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