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the chemical engineer | issue 891 | september 2015

Dish the dirt

Remediation: helping people help themselves

Providing the nudge

The best way to help communities clean up toxic sites is to advise and encourage, say **Andrew McCartor**, **Bret Ericson** and **Sandra Gualtero**

Environmental pollution is the single largest cause of disease and death in developing countries, causing 8.9m deaths annually worldwide. By comparison, HIV/AIDS causes 1.5m deaths and malaria and tuberculosis fewer than 1m each. More than one death in seven is the consequence of environmental pollution. Despite the tremendous impacts on human health and the global economy, the effects of pollution continue to be undercounted, underreported and insufficiently addressed in national policies and international development agendas.

Pollution is strongly linked to poverty. The overwhelming majority of the disease burden from pollution – 94% – falls on residents of low- and middle-income countries. It disproportionally affects countries that are ill equipped to deal with the problem, and vulnerable populations that do not have the resources to protect themselves and recover. The disproportionate poisoning of the poor represents a global environmental injustice.

Pure Earth (formerly the Blacksmith Institute) has conducted more than 80 projects to help communities mitigate toxic exposures while also protecting livelihoods. This has proved manageable, cost-effective, and eminently do-able – by the communities themselves, following a nudge in the right direction. Let's look at a few cases.

(Left): The Sumgayit industrial area is a mix of abandoned and operational industries, and historically suffered from a mix of soil contaminants; (Right): An industrial effluent settling pond at Pure Earth's remediation site. The pond was occasionally emptied and the dried effluent piled on the adjacent beach.

PCB Beach: Sumgayit, Azerbaijan

Andrew McCartor

It's the first day of my first solo work trip. I'm in Azerbaijan to identify and clean up toxic hotspots. I have been here for less than 24 hours. My boss is calling from New York to check in, and I'm in jail.

"Drew, mate, how's it going out there? Seen anything interesting?" Indeed. I have seen children playing on a beach composed of dried effluent from a chemical plant that is highly contaminated with polychlorinated biphenyls (PCBs), benzene, and benzo[a] pyrene. I have seen men bagging this toxic 'sand' and selling it as construction material at the local market. And now, sitting next to me in our cell, I see a very nervous local colleague having a rough first day as our new national coordinator. I don't say any of this to my boss. "It's going…you know…peaks and valleys."

I work for a non-profit organisation that cleans up life-threatening toxic pollution in low- and middle-income countries. I am in Azerbaijan to design and implement a cleanup project at the aforementioned site, which I have come to call "PCB Beach".

Back in Azeri jail, my colleague and cellmate has a plan. He tells the police that he is a professor (true) of international law (false), and that under the Geneva Convention the police are required to call the American Consulate to explain my arrest. To this day, I don't know if that is true, but it doesn't matter, because the police don't know either. A minute later we are outside the station.

We were arrested for taking pictures of an abandoned industrial estate in the city of Sumgayit – the site of PCB Beach and a former hub of Soviet chemical production. For years, Pure Earth listed Sumgayit as one of the world's most-polluted places. After contributing to the city's infamy, it was incumbent upon us to help clean it up.

We spent the next year meeting with Azeri government officials, the owners of the project site, and other relevant actors. What emerged was a peculiar, but not uncommon picture. The local actors could contribute expertise, money, labour, heavy equipment, even free disposal of contaminated soil in a hazardous waste landfill. They had everything required to complete a cleanup project. So what were they waiting for? Sometimes people just need a nudge.

Between 2014 and 2015, we helped local partners in Azerbaijan move 600 m^3 of toxic material to a high-quality hazardous waste landfill, re-grade the land with an equal amount of clean soil/sand, and plant the site with native vegetation. We contributed technical assistance, a small portion of the project funding, and most critically, the nudge to act.

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(Left): A secondary metal smelter in Vietnam recycles scrap metal into ingots in an open furnace.

All photos courtesy of Pure Earth

Pure Earth conducted extensive soil sampling to assess contamination levels. We helped local partners in Azerbaijan move 600 m³ of toxic material to a high-quality hazardous waste landfill, re-grade the land with an equal amount of clean soil/sand, and plant the site with native vegetation.

toxic 'craft villages': Dong Mai, Vietnam

Bret Ericson

During the Vietnam War, a US bomber crashed near a rural North Vietnamese village. By chance, someone in the village had experience in smelting metals, and saw the plane's mangled aluminium parts as an opportunity. He dismantled it, carried the pieces home, and melted them down to create aluminium ingots for resale. One by one, his neighbours caught on and the village was transformed into a small-scale aluminium smelter. Years later, aluminium scrap collected in nearby Hanoi would arrive by the truckload, and return to Hanoi as ingots.

By the time I arrived in Vietnam, China's demand for raw commodities had helped transform hundreds of Vietnamese villages into horizontally-integrated metal recycling factories, each specialising in a particular metal or product. These villages are now misleadingly referred to as 'craft villages'.

Our interests in these villages are the potential human health risks, particularly risks to children. Backyard smelting presents such a variety of potential hazards that it can be difficult to identify, untangle and mitigate each one. Personal protective equipment is totally absent, as are emissions controls. Children play next to furnaces firing at 1,000°C. In this context, is it feasible to pull the entire village from the Victorian era into the modern industrial age? No.

Since 2008, we have worked with the Vietnamese government to assess nearly 100 metal recycling villages. Our team of local investigators takes photographs and environmental samples, conducts interviews, and uploads their investigations into a global database. We work with government colleagues to compare and prioritise the sites based on health risks. When resources are available, we implement a cleanup project at a priority site.

It was in this context that in 2013 we came to Dong Mai, a village 30 km from Hanoi, and the site of the most severe lead poisoning epidemic I have ever witnessed. Dong Mai, like the other villages, had processed metal for decades. Though in this case, the metal was lead, an acute neurotoxin. The lead comes from used automobile batteries, also known as used lead-acid batteries. The batteries are broken open by hand, the acid poured out on the ground, and the lead removed and smelted in open furnaces.

In 2006, the Vietnamese government acknowledged the risks in Dong Mai and invested hundreds of thousands of dollars to construct an industrial area 1 km from town. The majority of the smelters were relocated, reducing active emissions of lead in the village for the first time in decades. This act alone represented an important and astute step by Vietnamese government to improve public

The project paid for the cleanup of the 38 most contaminated residential yards. As of July 2015, an additional 67 yards had been remediated by local homeowners using the project's protocol, but without external support or funding.

A lead recycler pours molten lead into ingot moulds.

All photos courtesy of Pure Earth

(Clockwise, from left): Recycled lead cooling in ingot moulds outside of a furnace; A project partner describes project activities to a local woman from Dong Mai, Vietnam; A community awareness meeting in which project partners explain project goals and activities and seek community feedback.

health, and a model that other governments should follow.

Although the source of pollution had been relocated, vast amounts of lead dust had accumulated over the years in residential soils, and lead slag had been used as infill for housing. Residents wore their dust-laden work clothes home, hugging their children after a long day, and spreading lead dust throughout the home.

The results from our initial environmental and health screenings were dismal. Blood-lead levels in children were frequently above the detection limit of our field equipment (>60 µg/dL), more than ten times above the level of concern or reference level set by the US Centers for Disease Control and Prevention. Lead levels in soil averaged 3,000 ppm, more than seven times above the US EPA guideline of 400 ppm.

Within three months of our visit, we had raised nearly US$100,000 for a cleanup project. We used this money to support our Vietnamese NGO partner, the Centre for Environment and Community Development (CECoD), and our colleagues in government. The University of Washington School of Public Health and the International Lead Management Centre supported the effort with human resources and technical expertise. Within six months of identification and assessment, we began risk-reduction activities.

Community education was a key component, and began with showing the mayor a detailed map of lead contamination throughout the village to convey the severity of the problem. In the end, 99% of the population participated in a three-day workshop conveying the risks of the *status quo*, the project's activities, and the intended outcome. CECoD staff rented beds in a local home. They listened to residents' concerns and ideas. They ate dinner with them. The project became endemic, inseparable from daily life. Me and my organisation were not even a blip on the community's radar.

In addition to environmental assessments, health monitoring, and community education, the project reduced exposures to lead by cleaning lead dust from homes and capping contaminated soil in yards and roads with clean soil or cement. The project team also constructed a changing room with showers at the industrial site so lead workers could shower and change before coming home.

One of the most remarkable outcomes of the project was the degree to which the solutions were replicated within the community after the project formally ended. The project paid for the cleanup of the 38 most contaminated residential yards. As of July 2015, an additional 67 yards had been remediated by local homeowners using the project's protocol, but without external support or funding. The project staff cleaned the interiors of the same 38 homes to remove lead dust. As of today, the owners of each of the 300 homes in the community have done the same.

Eight months after the project's start, children's blood-lead levels are down 35% on average, and are expected to decline further. The project's success is due to the simplicity and affordability of the technical intervention; the experience and dedication of the local partners; and the support from Marilyn S Broad Foundation and others. Our value in these places is not to do it for them; it's to nudge.

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All photos courtesy of Pure Earth

(Clockwise, from left): Mexican ceramics made with lead-free glaze; A ceramics studio and kiln where traditional cookware is fired; Ceramics being swabbed to identify the presence of lead in glaze. The red indicates that lead is present.

poisoned by pottery: Morelos, Mexico

Sandra Gualtero

In June of 2015, I received a late-night email labelled "URGENT." It was from a nurse in the Mexican state of Morelos who was conducting screenings of lead levels in the blood of newborns as part of a pilot project. The nurse had just discovered a baby with a blood-lead concentration seven times above the level of concern or reference level set by the US Centers for Disease Control and Prevention. We sent our country coordinator along with medical staff to the family's home, where, predictably, they saw a kitchen full of beautiful Mexican glazed cookware.

We anticipated that the adoption of lead-free glaze would be quick and easy. We were wrong. Changing a centuries-old practice, even if the change seems logical and urgent, is hard.

When the average person pictures chemical pollution, they might conjure billowing smoke stacks or toxic green slime that turns turtles into mutant ninjas. Few would picture a woman sitting behind a pottery wheel making ceramics. In Mexico, however, that image is quite relevant to the country's pollution story. Today, tens of millions of Mexicans suffer from low-level lead poisoning from glazes used in traditional ceramic cooking pots. When the deep-lustered glaze touches acidic food (such as Mexican food), the lead in the glaze leaches into the meal, and ultimately into the blood of the person enjoying it. The baby (and mother) in Morelos had been poisoned by leaded pottery.

In July the journal *Annals of Global Health* published a study by Pure Earth, the Mexican Institute of Public Health and others regarding concentrations of lead in the blood of Mexican children. The study was a meta-analysis of all available data on blood-lead levels in Mexican populations dating back to the 1970s. It showed not only that millions of Mexicans experience lead poisoning, but that 15% of the Mexican population has likely experienced a decrement of five IQ points as a direct result. In other words, millions of Mexican children are not reaching their full intellectual potential because they are being slowly poisoned by their cookware.

Although leaded glazes have been officially banned in Mexico since 1993, lax enforcement allows potters to continue using the toxic glazes. Each day, countless Mexican children receive a dose of this potent neurotoxin, and if you have eaten in a home, restaurant or hotel in Mexico, you might have received your dose too.

We've been working with Mexican authorities and pottery producers to replace leaded glazes and clean up contaminated workshops since 2008. Lead-free glazes are now available that look and function just like the leaded ones and cost less. Given that a solution to this problem is available, simple and cheap, we anticipated that the adoption of lead-free glaze would be quick and easy. We were wrong. Changing a centuries-old practice, even if the change seems logical and urgent, is hard.

We encountered several hurdles regarding perceptions among potters. Some said their customers preferred leaded glazes, and simply would not buy alternatives. Many argued that their family

Pure Earth

Barro Aprobado

(Top): Project partners celebrating with ceramics makers who recently converted to lead-free glaze; (Below): Display at an event to showcase lead-free ceramics and introduce restaurants and hotels to the project and the benefits of going lead-free.

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had been using leaded glazes for generations without any negative impact.

Unfortunately, a lack of awareness of long-term health effects from chronic exposures to a neurotoxin like lead is common. In many such cases, the health effects do not become apparent until many years later, and a link between the exposure and the health effect is never established. It happens with mining communities using mercury, just as it happens to people informally recycling the lead from automobile batteries. In the case of chronic lead poisoning for instance, children grow to have difficulty in school, behavioural issues, speech delays, and so on, but parents just think "he is just not that smart", or "she has always been a troubled kid" without realising that the issue is related to exposure to toxic pollutants. The lack of childhood screening programmes such as those in the US for lead, contribute further to the lack of awareness.

By 2013, we realised our supply-side strategy of convincing potters to switch glazes was not working. With funding from the European Commission, we began a pilot project in the state of Morelos, and partnered with local health institutions to try a different approach. Instead of working with pottery producers, we began working with major pottery consumers – restaurants and hotels – and used market forces to drive demand for lead-free pottery. This strategy was branded "Barro Aprobado" ("approved clay") .

Convincing individual restaurants and hotels to switch to lead-free pots was easy, but the key to broader success was to get them to advertise publicly that their cookware was lead-free. This marketing set their food apart as a premium product, and created in the mind of the public a new division of food classes: with poison, and without poison. This was the nudge that got the ball rolling.

In addition to the lead-free advertising at restaurants and hotels, we helped the government establish lead testing of cookware during restaurant inspections, and a pilot childhood lead-screening programme at 13 hospitals in Morelos. Other states have since expressed an interest in the Morelos model, and we hope to expand the pilot programme to finally put an end to this problem nationally.

nudges work

After 16 years and more than 80 pollution cleanup projects, the following lessons have emerged from our work. Firstly, the overwhelming health burden from toxic pollution is born by residents of low- and middle-income countries. Secondly, many pollution problems that jeopardise public health have relatively simple, inexpensive solutions. Finally, with a little technical advice, modest funding and a nudge, local communities can greatly improve their environment and health. **tce**

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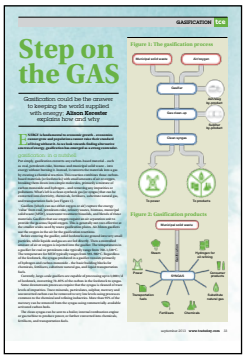
Chemical Engineering Matters

The topics discussed in this article refer to the following lines on the vistas of IChemE's technical strategy document *Chemical Engineering Matters*:

Health and wellbeing
Lines 1, 11–13, 15, 17, 18-19, 21, 27, 28

Visit **www.icheme.org/vistas2** to discover where this article and your own activities fit into the myriad of grand challenges facing chemical engineers



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