Cost Effectiveness and Health Impact of Remediation Of Highly Polluted Sites in the Developing World

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SUMMARY

Legacy pollution issues abound in the poorer countries and cause significant damage to local populations. According to WHO and the World Bank, up to one billion people are affected by pollution related issues. We examined four locations where pollution had been causing health problems, and where the pollutants have now (or will soon) been cleaned-up with Blacksmith Institute intervention. We then estimated the resulting health impact and cost benefits using established epidemiological data and methodologies.

The projects ranged in cost between $1 and $50 per year of life gained. These estimates compare favourably to $35 to $200 per year of life gained for World Bank estimates on interventions related to water supply, improved cooking stoves, and malaria controls. In other words, remediating highly polluted sites is one of the most cost effective methods to improve life expectancy in the developing world.

Extrapolating further, costs per life saved ranged between $42 and $500.

The health benefits gained by the local population are substantial, indicating that remediation of these sites is extremely cost effective. Millions of lives could be saved with further investments in this area. In addition to increasing life expectancy, these investments reduce health expenses for the local community. The low cost of this kind of intervention, along with its enormous health impact, justifies strong support for a concerted effort to deal with this issue globally.

INTRODUCTION

Pollution is endemic in many parts of the developing world, where a lack of regulations and enforcement have left legacies of pollution in many dense urban centers. These problems affect upward of one billion people, and result in an increased burden of disease, reduced quality of life, and reduced life expectancy. Active facilities provide continuous sources of pollutants to water and air. Even when shut down or re-configured to reduce emissions, old facilities often leave behind a legacy of toxic materials that continue to poison local populations.

Industrial and mining pollution imposes a particularly heavy burden on health, especially children's health. Heavy metals such as lead, mercury, chromium and cadmium cause developmental problems such as mental retardation, as well as various cancers and other diseases. Radionuclides are well known for their long-term negative health effects. Industrial chemicals such as solvents and PCBs also have been well studied with regard to their toxicity and impact on human health.

In developed countries such as the US and Europe, most of the worst problem sites have been dealt with through legislation and regulations such as the Superfund Program in the U.S., especially those that are affecting human health. But little work has been done in developing countries as these problems are not well understood locally and take a back seat to other governmental priorities such as education and primary health services. However, many clean-up initiatives can be accomplished with minimal amounts of money and can achieve substantial results in short time periods. It is often possible to clean up the worst aspects of a particular polluted site with inexpensive and effective technologies, and mitigate much of the health risk to quite a large population as a result.

REVIEW PROCESS

Blacksmith's strategy is based on developing low cost, efficient and practical solutions to priority problems impacting the health of the population, particularly children. This strategy is based on the concept that initial cleanup efforts at uncontrolled sites can produce large improvements at modest cost. This is a practical approach to making the maximum possible use of limited resources.

Herein we undertake a review of the effectiveness of our approach, using the methodologies developed by the World Health Organisation (WHO) and major health and regulatory agencies worldwide.

To determine the cost effectiveness of these kinds of clean-up initiatives, we reviewed four projects undertaken by Blacksmith Institute and other partners (including the World Bank and Asian Development Bank) to remediate toxic pollution legacy sites in various developing countries around the world. Remediation activities have either been completed, or been costed and planned for completion in each of these projects.

Because Blacksmith's project work focuses on implementation rather than study (and because studies can be expensive and take funds away from solutions), direct health effects were not measured in any of these projects. Instead, in order to project expected health effects, we researched peer-reviewed studies of similar problem sites, and projected these health results onto each particular site. In this way we can assess an expected health impact from the project, and give an assessment of the cost effectiveness of this type of work. Realizing the various shortfalls in this methodology, we firmly acknowledge that the results of this process are intended to be indicative only - to give an order-of-magnitude assessment of cost effectiveness - and that a great deal of detailed risk assessment and epidemiological work would be required to more accurately quantify these kind of results.

COST EFFECTIVENESS METHODOLOGIES

The essence of the approach lies in the concepts of DALY (disability adjusted life years) and QALY (quality adjusted life years), both of which calculate the years of "healthy life" lost due to the impacts of a particular cause or disease, in a specified area. Once this measure of health impact has been estimated, the benefits and cost-effectiveness of different interventions and projects can readily be evaluated.

The methodology has been developed and refined by WHO as part of their "Burden of Disease" program and is widely accepted by both the health sector and the regulatory agencies (such as USEPA) as a basis for making decisions on investments in disease prevention and pollution control. The approach is widely used to estimate the economic impacts of air pollution (for example by the World Bank) although its application to water and soil contamination is more complex.

DALY information is estimated from literature from other site studies which determined DALYs associated with changes in pollution. Literature was reviewed to estimate a rough DALY impact from a particular site problem. It is assumed that once the remediation has been completed, this DALY Impact has been mitigated.

A QALY[1] is a comparable measure to a DALY. It is the arithmetic product of both life expectancy and a measure of the quality of the remaining life-years. A QALY assigns specific weights on time in different health states. A year of perfect health is assigned the number 1, a year of life spent in less than perfect health is assigned a number less than one and 0 signifies death.

Calculations for our cost-effectiveness study are as follow:

Cost per Person = Project Cost/Affected Population

Cost per DALY(QALY) = Cost per Person/ DALY(QALY) Impact.

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[1] Harvard Medical Communications

To provide a simpler metric for the general population, we calculate "Blacksmith Lives Saved" from DALYs by assuming a flat population spectrum. Acknowledging many shortfalls, this metric is really a simplistic qualitative response to a much more complex issue. Nevertheless, it has value in its motivational capacity.

"Blacksmith Lives Saved" = DALY or QALY Impact/Local Life Expectancy x Affected Population

Cost per "Blacksmith Life Saved" = Project Cost /"Blacksmith Lives Saved"

Given the constraints on further studies, we have adopted this simplified approach based on transferring results from other studies and sites to those where Blacksmith has interventions.

OVERALL EFFECTIVENESS OF BLACKSMITH INTERVENTIONS

The estimates provided here should be put into context of other interventions aimed at reducing health impacts. Figures from the World Bank[2] for a range of pollution related interventions such as better water supply, improved cooking stoves, and malaria control range from $35 to $200 per DALY. Estimates from the Disease Control Priorities Project[3] for improvements that reduce illness associated with water pollution range from $47 to over $4,000 per DALY.

In relation to this range of other interventions aimed at public health, this preliminary analysis shows that Blacksmith projects are at least as cost effective, while targeting a poor and vulnerable population, especially children, who are not addressed by any of the large international health programs.

[2] See Listorti and Doumani 2001
[3] Supported by World Bank, WHO, Gates Foundation and others. See www.dcp2.org.

The Case Studies

KABWE – ZAMBIA

Kabwe, the second largest city in Zambia with a population of 300,000, is located about 130km north of the nation's capital, Lusaka. In 1902, rich deposits of lead were discovered in the mine and smelter located in the center of the town. Ore veins with lead concentrations as high as 20 percent have been mined deep into the earth and a smelting operation was set up to process the ore. Mining and smelting operations were running almost continuously up until 1994 with no emissions controls. The mine and smelter is no longer operating but has left a city with poison and toxicity from deadly concentrations of lead in the soil and water.

In Kabwe, blood concentrations of 300 micrograms/deciliter have been recorded in children and records show average blood levels of children range between 25 and 80 mcg/dl. Levels in excess of 10 mcg/dl are considered cause for concern with the US Centers for Disease Control. Effects are particularly severe during the early development of children's neurodevelopmental system, equivalent to the first 2-3 years, causing several specific brain dysfunctions, in particular neurodevelopment impairment, learning disabilities, attention, motor coordination, visuospatial and language disorders, and anaemia.

A Taiwanese study found that children delivered by female workers exposed to lead-batteries had a significant loss in quality-adjusted life years QALYs. The study estimated that of 38 babies delivered in one year, 19 babies would be born with blood lead levels over 30 µg/dl and 17 would be born with blood lead levels between 10 and 29 µg/dl. The study found that a program to reduce blood lead levels to 5, 10, and 15 µb/dl in female lead-exposed workers from levels as high would save each baby – 4.46, 3.34, and 2.42 QALYs respectively (Chuang).[4]

Mean blood lead level for children age 0-7 in Kabwe is 33.5 µg/dl The outcome of this project will be to reduce lead levels throughout the population to an average of 20 µb/dl. Extrapolating from Chuang's data, we roughly average a QALY effect of 3 per child in Kabwe.

Kabwe's affected population of 300,000 includes about 100,000 affected children. The remediation work underway is expected to cost $15 million.

> Cost per person = $50 per capita, or $150 per child.
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> Cost per QALY is thus calculated at between $15 (capita) and $50 (child).
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> With an average life expectancy in Zambia of just 31, then:
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> "Blacksmith Lives Saved" = 30,000

[4] Chuang, Kun-Yu Chao, Jung-Der Wang, 2005

and cost per “Blacksmith Life Saved” = $500

MUSLYUMOVA, RUSSIA

In the Southern Urals, the Mayak plutonium facility has been making weapons since 1949. Muslyumova is located 30 km downstream on the banks of the River Techa. Unregulated discharges have occurred sporadically from 1949-1956, with a very large release in the early 1960’s massively contaminating the riverbanks, and the village. It was found that 70% of the population (4,500 people) developed leukaemia.

The riverbank and sediment still showed very high levels of radioactivity, and Blacksmith funded a local partner to dig and remove these soils, and replace with clean soils. The radioactive soils were deposited in a safer place away from human contact, and covered again with clean soil.

The test area site shows a vast improvement from 199 micro roentgens per minute (measure of radioactivity) before remediation to 12 micro roentgens per minute after remediation.

Muslyomova’s affected population is about 4,500, with about 1,000 using the riverbanks regularly. A study considering the DALY impact of various cancers[5] found that the average years of life lost due to leukaemia to be 19.9. The remediation work cost just $15,000.

Cost per person = $15 per capita.

Cost per DALY is thus calculated at just $0.75

With an average life expectancy in Russia being 56.7 then:

“Blacksmith Lives Saved” = 350

and cost per “Blacksmith Life Saved” = $42

KANPUR - INDIA

Hexavalent chromium is highly carcinogenic, and is used in the tannery industry to preserve leather hides. Kanpur is a center of the tanning industry in India, and certain neighbourhoods are contaminated with the toxin to very high levels. A 1997 study conducted by the Central Pollution Control Board on the groundwater quality in Kanpur revealed Cr VI levels of 6.2 mg/l; the Indian government places the limit at .05 mg/l. The trial program, partnered with the Central Pollution Control Board, involved injecting chemicals into the groundwater that react with the toxic hexavalent version of chromium, thus enabling it to bind to the rock and

[5] Crettaz, 59

keep from contaminating water. The trial was successful, with levels of hexavalent chromium in some of the test wells dropping to non-detectable levels. Now, this process needs to be undertaken throughout the entire site, a project that is in the planning stages.

The population of Kanpur is 3 million people, with the pilot program affecting a population of about 3,000. The pilot program Noraiakheda, Kanpur cost $45,000. The cost of full-scale remediation is $680,000 for the entire region.

Chromium is a Group 1 carcinogen causing lung and tracheal cancers, and data for its exposure is generally from occupational health information. Estimations for DALY impact from drinking of contaminated water over a protracted period from a study by Crettaz[4] indicate that 9 DALYs are lost from high levels of exposure to hexavalent chromium. As the actual exposure levels are unknown, an expectation of a minimum of 5 DALYs is not unreasonable. Considering the trial project alone,

> Cost per person = $15 per capita.
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> Cost per DALY = $3
>
> With an average life expectancy in India of 51, then:
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> "Blacksmith Lives Saved" = 300
>
> and cost per "Blacksmith Life Saved" = $150

POPOV ISLAND, RUSSIA

One of the most popular tourist areas of Vladivostok, Popov Island had mercury contamination over 40 times EPA limits (2 ppb) in 80 ppb. Hundreds of broken thermometers had been thrown into the water tank, and the mercury had leached and contaminated the supply pipes throughout the town. Blacksmith funded a joint program with local authorities to replace contaminated piping and tanks, and now the water supply is free from detectable mercury.

The population of the town is 2500 people, and the total remediation costs were $15,000.

Mercury is a neurotoxin that affects learning and development, and in its methyl mercury form is highly toxic. Estimations for DALY impact from drinking of contaminated water over a protracted period from Crettaz[4] indicate 11 DALY's for methyl mercury, and 1 DALY for non-carcinogenic effects. Given that overall

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[4] Crettaz, Pierre
[4] Crettaz, Pierre

effects have not been assessed, an expectation of a minimum of 1 DALYs is not unreasonable. Considering the trial project alone,

Cost per person = $6 per capita.

Cost per DALY = $6

With an average life expectancy in Russia of 56.7, then:

"Blacksmith Lives Saved" = 45

and cost per "Blacksmith Life Saved" = $300

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