CLEANING UP THE TOXIC MESS

Blacksmith Institute and Eco Friends, an American and an Indian environmental group, work with local governments and neighborhoods to clean up groundwater poisoned by toxic industrial waste in projects that may offer solutions for other polluted places.

By DINESH C. SHARMA

For Chanda Devi and her family, getting clean, pure water in their house is a distant dream. The family has no access to piped water in their Nauraiakheda slum in Kanpur's Panki industrial area. They depend on water from deep underground. Two years ago, Devi got a 45-meter borehole well dug at her house and installed a motor to pump out the water. But all that the family got for its investment was an orange-yellow, sometimes greenish, cocktail of deadly chemicals.

"If we bathe with this water or use it for washing utensils and clothes, we get sick," says Devi. "Rashes appear on our legs and hands. And if somebody mistakenly drinks this water, he or she will start vomiting immediately. Look at the irony. Factories across the road get clean water from the Ganges and we have to consume water polluted by them."

Thirty thousand people in Nauraiakheda and several thousand more in other parts of the northern industrial city of Kanpur are victims of one of the worst cases of groundwater pollution in India. In 1997 the Central Pollution Control Board reported that groundwater in several places was contaminated with mercury, lead, arsenic, cadmium, many pesticides and hexavalent chromium, whose atoms can unite with up to six other atom groups to form new substances and can cause cancer in humans. The source of all these toxins: Kanpur's numerous tanneries, which use chemicals containing chromium and other heavy metals to tan leather.

The alarming level of groundwater contamination in Devi's neighborhood is a result of years of pollution by factories making basic chrome sulfate, a chemical used in tanning. They dumped their toxic sludge in the open. It leached into the ground and finally reached the groundwater, sometimes 100 meters below. Some industries even injected untreated effluents into the ground. These units have either closed down or shifted operations elsewhere, leaving behind a toxic trail. Nauraiakheda is a classic example of this legacy of pollution.

In 2003, government officials found a plume of hexavalent chromium in the water supply of Nauraiakheda, flowing from the site of a closed chemical manufacturing unit where toxic sludge had been dumped a decade ago. The concentration of the chemical was 16.3 milligrams per liter—1,630 times the limit set by the World Health Organization. Both the WHO and the U.S. Environmental Protection Agency say that when people ingest large amounts of hexavalent chromium, the chemical can cause kidney and liver damage, while skin contact can lead to ulcers. It has also been linked to higher incidence of lung cancer.

However, there is a glimmer of hope for Kanpur's pollution victims and perhaps others affected by groundwater pollution, if a project to clean up groundwater in Nauraiakheda succeeds. A consortium of Indian research institutions and the pollution board are spearheading this effort, initiated by the New York-based, nonprofit Blacksmith Institute. Of the $70,000 budget for three years, Blacksmith is providing about $45,000.

In 2003, Blacksmith Institute extended its new Polluted Places initiative to India under the aegis of a grant supported by the U.S. Asia Environmental Partnership, which also helped Blacksmith to identify local partners and project sites, including the hexavalent chromium site in Kanpur. The Polluted Places program is designed to locate and clean up the dirtiest and most dangerously polluted sites overlooked by the rest of the world. It defines a "polluted place" as one where pollutants sourced primarily from that point are causing substantial and preventable health problems.

Above: A handpump draws yellow-green water in the Shiv Nagar slum in the Panki industrial belt of Kanpur.

Right: Effluents containing toxins show up as neon blue and green as they are released into an open drain from a tannery in the Nauraiakheda area of Kanpur.

Right: Supposedly treated tannery effluents produce foam as they are released through an irrigation canal in Jajmau near Kanpur.

Photographs by DINESH C. SHARMA

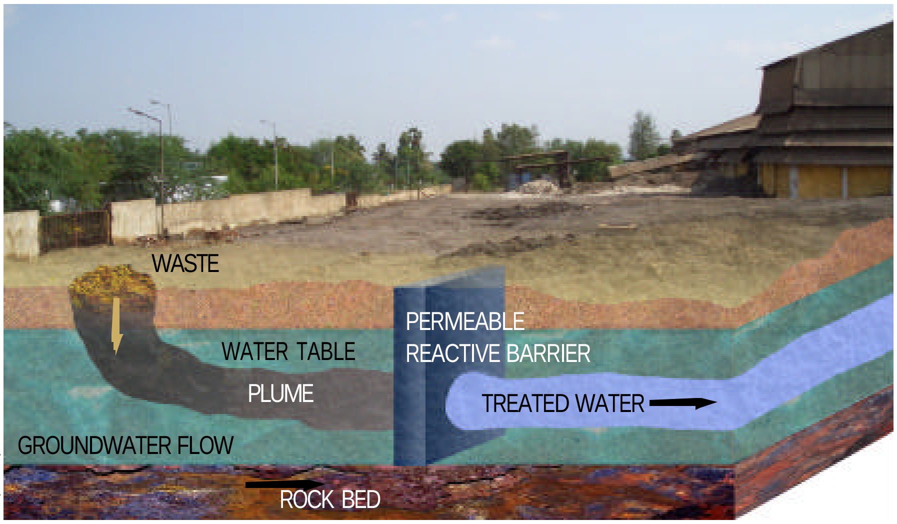
Blacksmith has more than 40 projects in about a dozen countries. Selections are made through a process in which communities, local government and voluntary bodies and others nominate a site for clean-up action support. The site must have substantial health problems due to pollution, lack of local clean-up efforts, community interest and capacity to make the clean-up feasible, and a reasonable hope of success. After Blacksmith experts and local coordinators evaluate the sites, the institute launches the projects with the help of local governments and volunteer groups. Blacksmith provides financial, strategic and technical support to organizations and institutions.

In Kanpur, Blacksmith first started working with a local volunteer organization, Eco Friends, after its chairman, Richard Fuller, and another expert, Peter Hosking, visited the city's polluted areas in January 2004. It identified Nauraiakheda and Jajmau for a project with Eco Friends. The idea was to create community awareness on groundwater contamination. While the problem in Nauraiakheda was a result of the direct activity of industries, the problem in Jajmau was different, although the pollution load was equally bad.

Jajmau's 350 tanneries are clustered on the banks of the Ganges. In an unusual project, government agencies in the 1990s proposed that treated effluents from the tanneries could be used for farming. The tanneries were supposed to pre-treat their waste to remove chromium and other toxins and then send it to a common plant for final treatment. Finally, this water was to be mixed with treated sewage and released for irrigation through a canal. Farmers of 20 villages downstream use the irrigation water. The project flopped because industries sent nearly untreated waste to the common treatment plant, so the "treated water" for irrigation still contained chromium, heavy metals and other contaminants, as detected in a series of studies. These chemicals have also leached into groundwater.

As part of the Jajmau project, Eco Friends organized meetings and workshops in villages to educate farmers about their groundwater and its disastrous impact. The idea was to sensitize and empower local communities so that they could demand clean water. At the same time, they wrote to national, state and local government authorities. The issue was raised at review meetings of the Ganga Action Support Project and also with the Supreme Court Monitoring Committee on Hazardous Waste. Residents of Jajmau villages signed petitions to local administrators demanding clean drinking water and action against the polluting industries.

"When we started working in the two areas, we found that communities were quite ignorant about the hidden threat of groundwater contamination," says Rakesh K. Jaiswal, executive



Graphic by SHARAD SOVANI Source: Powell & Associates

PERMEABLE REACTIVE BARRIER

A relatively new clean-up method being considered for the vast polluted area around Nauraiakheda, involves inserting columns or sheets of iron into the ground to first block the plume of polluted effluent, then cause the hexavalent chromium to oxidize into a less harmful form before it oozes through the barrier to reach the groundwater.

secretary of Eco Friends. "Now they are aware about the problem but feel helpless. Due to a continued supply of sewage and effluent waters to agricultural fields, people in villages around Jajmau are virtually drinking chemicals and slow poison in the form of groundwater."

After working for a year with Eco Friends, Blacksmith realized that the problem in Kanpur was grave and that an action-oriented project was required to demonstrate that groundwater could be cleaned. It got in touch with the pollution board, and soon a remediation project was conceived. Meanwhile, as a follow-up to its 1997 study, the board monitored the groundwater in Nauraiakheda through a network of four test holes to spot chromium pollutants at various levels and determine its concentration and chemical state.

The objective of the three-year project is to reverse chromium pollution and prepare a model for scientific investigation and assessment of this technique for use elsewhere in India.

In the first year, groundwater data was collected from 126 locations in the study area. Experts monitored the concentration of heavy metals and other pollutants and 22 pollution indicators at each location. They measured the pre-monsoon water levels at 12 places and made an inventory of how each house uses groundwater. Historical rainfall data for the area was collected from the Indian Meteorological Department and from satellite images provided by the National Remote Sensing Agency in Hyderabad.

"All this will give us a validated idea of movement of underground water, pollutants and its inter-relationship with the host environment," says Rajiv Kumar Singh, a scientist at the pollution board's northern zone office in Lucknow.

The study area has three zones of groundwater, the middle one being the most polluted. Using groundwater modeling software called Visual Modflow, originally developed by the U.S. Geological Survey, the polluted area has been demarcated and migration pathways of underground pollutants have been plotted. One of the collaborating institutions, the National Geophysical Research Institute at Hyderabad, is developing a mathematical model that will be able to predict direction and rate of the pollution plume, Singh says.

In the second phase of the project, different options for cleaning up the underground mess are being evaluated. A conventional way to clean up contaminated soil is to excavate and treat it. Similarly, polluted groundwater can be pumped up and treated. But in Nauraiakheda the extent of pollution is vast, and the area is inhabited by a large number of people. Yet another option is to use rainwater harvesting techniques to dilute pollutants in the groundwater. Though cost effective, this technique may take several years to produce results.

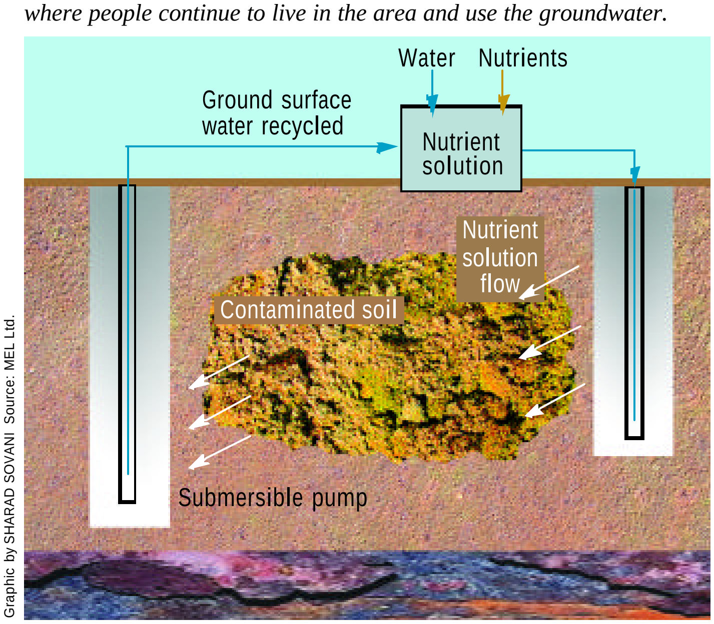
Another option being considered is a relatively new method known as "permeable reactive barrier." In this method, iron columns or sheet piles are placed vertically to isolate the pollution plume. When pollutants travel, they come in contact with iron and get oxidized into less harmful forms. In Nauraiakheda, if such barriers are put in place, hexavalent chromium would react with iron and be reduced to less harmful trivalent chromium.

Bioremediation is yet another method of cleaning up underground pollution. It uses naturally occurring microorganisms with unique biological characteristics, appetites, and metabolisms for waste cleanup.

"Bioremediation is one of the options we are likely to try out. It seems most appropriate for conditions here," says Singh, from the pollution board. "This method can produce results quickly,

BIOREMEDIATION

Naturally occurring microorganisms consume toxic waste, react with it to reduce its toxicity, or stimulate the growth of other toxin-eating microbes in the soil. This method can produce rapid improvement where people continue to live in the area and use the groundwater.



Graphic by SHARAD SOVANI Source: MEL Ltd.

given the fact that people continue to live in affected areas and use groundwater there."

A sufficiently high concentration of the appropriate microbes can achieve in weeks or months what would normally take nature years to do. This can be done in two ways—either more microbes are introduced directly into the polluted area or substances are added that will stimulate rapid growth of existing microbes in the soil. In Nauraiakheda, the second option is proposed—injecting bio-stimulants that could make existing microflora create conditions under which hexavalent chromium will change its chemical state.

Bioremediation has been shown to work in many sites in the United States and elsewhere, as opposed to more traditional methods such as "pump and treat," which is not sustainable, according to Rajesh Srivastava, associate professor in the civil engineering department at the Indian Institute of Technology in Kanpur. Srivastava got his doctorate from the University of Arizona in 1992 and later worked on waste management sites in the United States. One such site at a U.S. Air Force base in Tucson involved the use of chemical agents that act on the surface to clean up soil and groundwater contaminated with trichloroethylene, a solvent used in cleaning mechanical parts of fighter jets. IIT-Kanpur is part of the research team involved in the Kanpur project.

Blacksmith has short-listed two firms for the Kanpur cleanup—GZA GeoEnvironmental Inc. based in Norwood, Massachusetts, and the Japanese firm EcoCycle Corporation. It is also asking the Asian Development Bank to fund the remediation. EcoCycle has a specific bio-stimulant for sites of chromium pollution—the "electron donor compound." The compound is based on food or food-grade products and is thus free from synthetic chemicals. The company says this product can stimulate a local microbial consortium that can change hexavalent chromium to trivalent chromium, which gets precipitated. This method can produce results within weeks.

"Bacteria in the soil here have become inert over the years," explains Singh. "They need to be activated. Bio-stimulants can do this job."

However, other experts have sounded a note of caution. Says Banwari Lal, a scientist at the Energy and Resources Institute in New Delhi, "Such broad spectrum nutrients are not appropriate for reduction of hexavalent chromium to trivalent chromium because they stimulate oxidizing microbes along with reducing microbes. So, chromium three will be reoxidized instantly to chromium six (hexavalent)." Moreover, he says, without full knowledge of indigenous microbe populations and species it is extremely unlikely that off-the-shelf products will work.

Lal suggests another route for bioremediation of hexavalent chromium. He says specific nutrients should be designed after identifying indigenous microbes that could reduce the chemical. Then, select, fast-multiplying microbes may be grown in the laboratory. Such species can also suppress oxidizing microbes and other inefficient chromate reducers. If required, an immobilizing agent may be added to trivalent chromium to prevent its reoxidation into the hexavalent form. All this can help convert hexavalent chromium to trivalent chromium and help it stay in that state.

There are other concerns as well. Any remediation method may not be sustainable if the source of pollution continues. And this is the biggest worry in Kanpur. Factories located just across the road from residential areas of Nauraiakheda continue to release hazardous effluents into open drains. Sludge is still being dumped in the open at several places, including the backyards of the factories themselves. Unless regulatory agencies and local administrations take urgent steps to stop this onslaught on the environment, the Nauraiakheda project may prove to be an exercise in futility. □

A technician from Blacksmith collects toxic water from a discharge point in Ankleshwar industrial belt, Gujarat.

Courtesy Blacksmith Institute

Polluted Places in India

Bhopals and Chernobyls that the world has never heard of—this is how Blacksmith describes sites in its Polluted Places program. In the past two years, more than 100 sites from India have been nominated for cleanup, but only a handful have been selected for further evaluation and considered for remedial projects. One such project was to clean up a polluted stretch of the Wah-Umkrah River in Shillong in northeast India. It was carried out by a local group called North East Education and Development Society (NEEDS). The second project is now going on at Kanpur.

Blacksmith is also evaluating other sites for support, in Vapi, Ankleshwar, Vadodara, Nandesari (Gujarat), Ranipet, Kodaikanal, Palar (Tamil Nadu), Tangra, Howrah, Durgapur, Aruputo, Picnic Gardens (West Bengal), and sites in Delhi, Kerala, Karnataka, Andhra Pradesh, Haryana, Maharashtra and Orissa.

"We have an established methodology of identifying and researching toxic sites where human health and livelihood are being substantially affected by pollution," says Promila Sharma, India coordinator of the Polluted Places program. Once such a site is identified, a Blacksmith team conducts an initial assessment and, if intervention is needed, they design an action plan involving local government and community organizations that the institute will support. "We want to collaborate with local governments, research institutes, educational bodies and not just NGOs," says Sharma. The institute would like to support organizations that can carry out actual remediation work, she says.

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