The G-filter: A simple high-tech solution to India's water pollution

By **Vineeth Venugopal**

As Abdul Rajak Khan kneads the clay for his Gravity Filter, the sights and sounds of the village are all around him. Loose brown soil drifts from the ground, floating over unplastered red brick buildings. Copper bangles clatter as women pound hard mud with a bat, breaking it down into powder the consistency of dust.

The village culture is even represented in the way Khan says, "Mitti achchi hai." *The soil is good.* It has salts, which give it strength, and whiteness that has come to define pottery from Jodhpur.

Like most cities in the Indian state of Rajasthan, Jodhpur is a dense panoply of palaces and forts set in the stark landscape of the Thar Desert. The dry season lasts the whole year with meager rains supplying most of the water for nearly a million people, in addition to livestock. Much of this water also happens to be polluted with heavy metals, fecal matter, and bacteria such as *Escherichia coli*.

The G-filter that Khan is preparing is a homemade solution that promises clean, affordable drinking water to the Indian rural community. From the outside, it looks like any other garden variety flower pot, a wheatish brown frustum that fits inside another bucket. On a good day, the G-filter can produce up to a liter of pure water every hour that is then collected through a tap attached to the outer vessel.

While ceramic filters are common all over the world, the G-filter is made by local Indian potters through indigenous technology using only locally sourced raw materials. In Jodhpur, a scientific effort to study and standardize the filter was led by Professor Anand Plappally and his graduate students Sandeep Gupta, Raj Kumar Satankar, and Amrita Kaurwar (who has since graduated), and from the nearby Indian Institute of Technology (IIT) Jodhpur.

"In India, there is a potter in every village. Our goal is to help them create effective water filters using techniques that they are familiar with," Plappally tells me over the phone. "We don't need to teach them much about the traditional manufacturing process—they have been doing it for years." Instead, the research team helps them in selecting suitable raw materials, fine-tuning specific processing parameters, and in final product testing. The wares are shaped using a locally manufactured molding press. "The potter sells his products in the nearby market, thus avoiding transport costs. Not only does the overall health improve but also the economy," Plappally says.

Kaurwar, who led much of the materials studies in graduate school, says, "What differentiates the G-filter from other ceramic filters is that it is made in open earth kilns within potter households from raw materials that are locally available at Jodhpur. This includes sawdust from the local carpenter's shop, salty clays, oxidizing matter from *bajri* [saltpeter], and marble dust."

Left: A potter at Tindivanum in Tamil Nadu on June 10–11, 2017. Right: A field-made G-filter.

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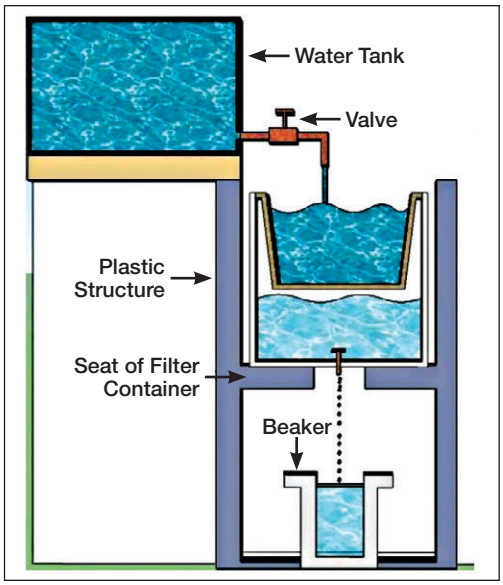

Left: Schematic of microbial filtration setup. From Gupta et al., *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, **13** (1), 53 (Spring 2018). Right: Ruparam Prajapat with a G-filter machine at Bhopalgarh in Rajasthan state.

Marble is one of Rajasthan's major exports. The white marble used to construct the iconic Taj Mahal was quarried from Makrana, a mere 150 miles from Jodhpur.

"The salts decrease the temperature at which the filter needs to be baked, reducing the fuel bill. The burnt calcium carbonates help in killing harmful bacteria such as *E. Coli,* and is effective to a lesser extent in removing heavy metals such as arsenic. The filtered water has no traceable amount of pathogens and is the best option that most villages currently have," Kaurwar says.

Kaurwar now lives in Pune, a large city in the western state of Maharashtra, where she moved with her husband and son after she obtained her PhD degree in March 2019. Oddly, the "village" is here too: It is in the indistinct clamor of the street vendors whose voices unceremoniously cut into our phone conversation. India and its villages are deeply intertwined, like a crab and its shell. They share similar destinies and sorrows, what is home and shelter is also what limits mobility and growth.

Most of the water in the country is severely polluted with microbial growth many times above what would be considered scandalous in the Western world. The Ganges River in the north carries upward of 9 billion liters of industrial waste and sewage every day. Most of the rivers are clogged with plastic, chemicals, and feces. Potable drinking water is fast becoming not just an urgent civic concern but also a major political issue. The southern city of Chennai, one of the major metropolitan cities of the country, is facing the worst water shortage in its history as of this writing and 7 million residents are pointing fingers at local politicians.

The lesser rivers, cities, and villages are no exception. Bacteria such as *E. coli* that causes diarrhea and even death are widespread. Now that she is the mother of a four-month-old, the quality of drinking water is very much on Kaurwar's mind as she explains how the G-filter works. "The pores of the filter are between 10 nanometers and 1 micrometer. These pores are too small for the bacteria to get through." Interestingly, without the marble dust, the *E. coli* filtration rate is 99.99%. With marble, this increases to 99.999%. At this rate, the bacteria are virtually untraceable.

Much of Kaurwar's work has been to detail the scientific nature of the filters and to quantify the filtration parameters. She has established, among other things, that the filter works best at an ambient temperature of 35°C, even though the drop off on either side is minimal. She has studied the role of other additives such as iron in the ceramic body. Iron was seen to improve the removal of arsenic.

A major part of their work has been to measure how effective the filter is in removing microbes. This was done through the setup shown in the schematic (above). Ambient water is spiked with a known strain of *E. coli* and is allowed to pass through the filter. The number of cells pre- and post-filtration is carefully measured and calculated, which yields the rates mentioned earlier.

Due to their efforts, the G-filter is taking a life of its own and is becoming popular not just in Rajasthan but also in faraway states such as Bihar, Kerala, and Tamil Nadu. This is in no small part due to the work of NGOs, non-governmental organizations, such as Rupayan Sansthan, Enactus IIT Madras, and the S M Sehgal Foundation that have come forward to promote the product.

The potter can sell fully functional filters with clay storage containers priced at around 600 Indian rupees or roughly USD$10. A typical filter can last up to a year with occasional cleaning. The NGOs take no part of the profit. They teach the technique to local potters and help standardize their wares. The potters sell them wherever they like.

The research group working on the G-filter has more than 10 publications in journals and books, with more in progress.

But the real reward, Plappally and Kaurwar assure me, is in the villages across India where their work will translate to good health, prosperity and happiness. □

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