Water Quality in Sand Dams

Why was it important to study water quality at sand dams?

Sand dams are a way to provide water for communities in dry areas where farmers might otherwise need to walk long distances for basic water needs. In Ukambani, a semi-arid area of eastern Kenya, the resident Kamba people integrate sand dam construction and management within the context of their traditional community activities. Organizations and community groups work together to build a concrete dam across a seasonal river or stream, which fills with sand during storm events. Sand in the dams hold water in its pore spaces, which can provide a water source into the dry season. Most commonly, users dig a simple scoop hole, which fills with water percolating out of the adjacent sand. Estimates are that up to 5000 dams have been built in the area, beginning in colonial times (early 1900's).

A typical sand dam in Ukambani during the dry season. Water is held in the pore space of the sand behind the dam. Some seepage has occured in this dam, forming a pool below the dam. Often such pools are also used as water sources.

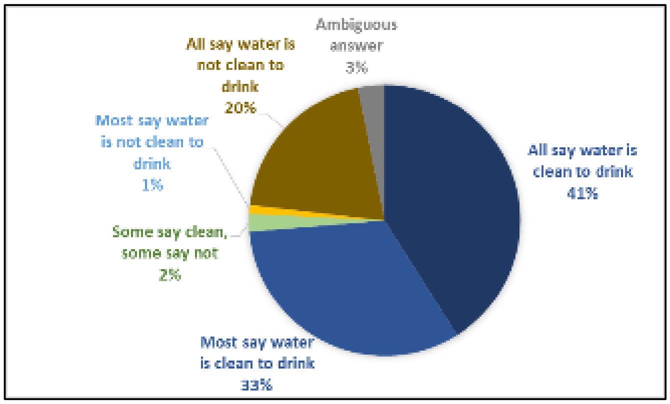
Typical scene at a scoop hole. A woman draws water into jerry cans used to transport the water. Livestock such as the donkey are common, and the dam surface is covered with manure piles (here the dark spots on the sand surface).

Undeniably there are potential benefits from sand dams, although there are some questions about how many dams are fully functional, how benefits compare to the cost of the dam, and how well the potential benefits have really been used (questions which are part of our larger study). For instance, women and children who are responsible for fetching water often speak of the time-saving benefit of not walking as far, freeing them for other activities. Because water "filters" out of the sand, users and organizations alike have assumed that water is cleaned by this process, and thus users benefit from water which has been filtered of pathogens. This assumption is understandable, as sand filtration is a known method of water purification. However, water purification by the sand is a largely untested assumption in the case of sand dams, and there are reasons to think that water collected at the dams may be more contaminated than has been assumed.

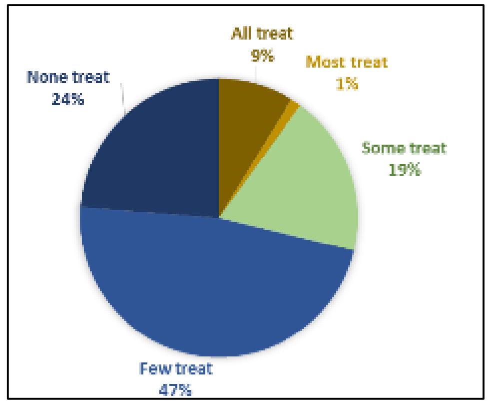
This study measured bacteria levels in water at sand dam sites, with the intent of determining whether there is a significant health risk to the users as currently practiced. The study was undertaken between MCC and its two "sand dam" partners, Utooni Development Organization (UDO) and Sahelian Solutions (SASOL), with the gracious donation of bacterial testing supplies from Dr. Jonathan Roth of Micrology Labs (Goshen, Indiana, USA).

What do users think about the quality of the water they use?

As part of the study, we interviewed sand dam communities on their perceptions of water quality, and their current drinking water practices. Nearly three-quarters of communities essentially believed that water from sand dams was clean to drink, and consequently do not treat their water.



Interviewees answers about how sand dam users perceive water cleanliness. Individuals or groups reported on their understanding of how that community of sand dam users perceive the water.



Interviewees answers about whether sand dam users treat their water before drinking.

"Seeing is believing", as the saying goes. Most commonly, the assumption of water purity was based on its appearance – the water was clear, so why should there be worry of contamination? In situations where users did not believe water was clean, they again often based this judgment on appearance (although more reasons also came into play).

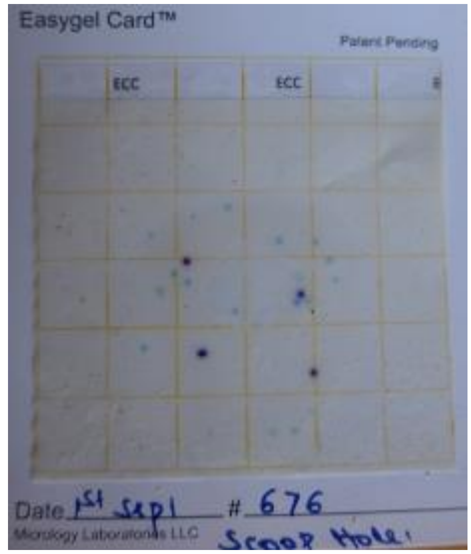
Clear water from a pump well on a sand dam. Users often report clear water such as this means the water is clean water drinking.

UDO staff testing water from scoop hole. Women and children who were collecting water were curious about the activity.

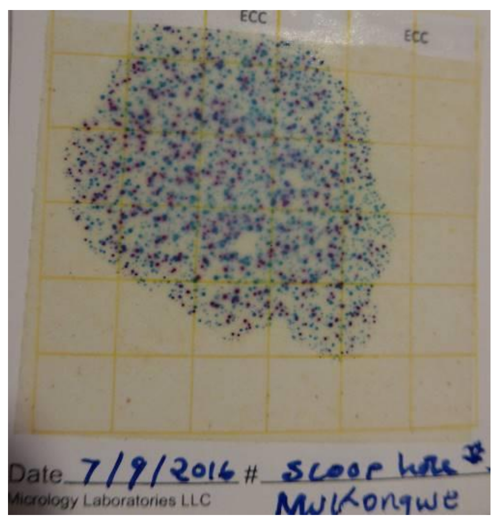
We visited nearly 100 separate dam communities, and in all cases where there was water present and tested, the interest of community members was piqued by seeing us testing the water. Users dropped their activities and gathered around to watch and ask about the testing. Although we could not tell them the results at the time (the test takes 1-2 days), it was encouraging to see users interested in the question of water cleanliness – this bodes well for any future engagement with communities on drinking water issues.

What were the results?

In all tests shown, the fecal coliforms (as *E. coli*) are the purple dots (colonies), and general coliforms are blue dots. In general, the health standards (such as those by the World Health Organization) have a standard of "no fecal coliforms per 100 ml of water". In practice, a scale of risk levels is often used. A common scale, which we follow in this study, is to consider any value above 100 fecal coliforms per 100 ml to be at the "high to very high risk" level. Since we tested only 0.5 ml (in duplicate), the presence of any fecal coliforms present on the card implies the sample is in the high to very high risk category.

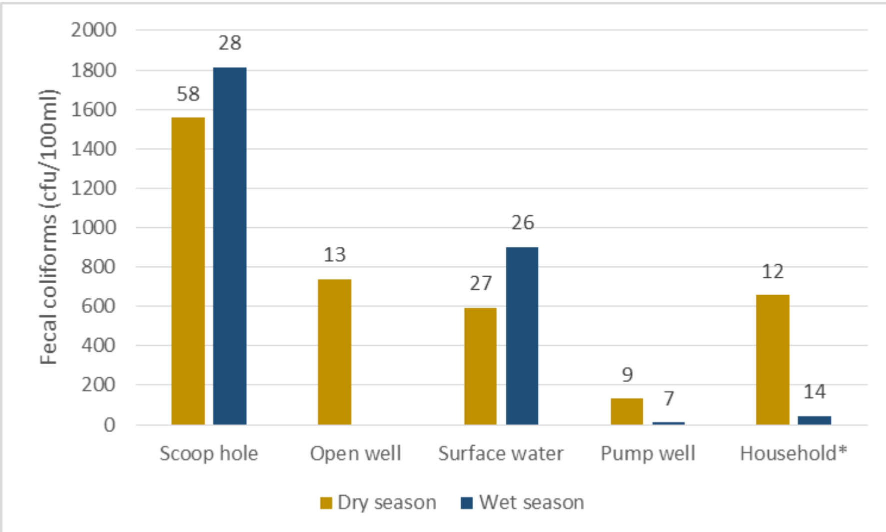


Example of scoop hole with relatively lower fecal coliform count, around 800 per 100 ml.



Example of a very high bacterial level at a scoop hole. We estimate nearly 100,000 fecal coliform per 100 ml (1000 times higher than the high risk level of 100 per 100 ml)

Since scoop holes are the most common way to access water in sand dams, the status of scoop hole contamination was the most fundamental question. The study found scoop holes have consistently high levels of fecal coliforms (as *E. coli*), the most common indicator of pathogen health risks in drinking water. General coliforms, a larger class of bacteria which is generally not in itself disease-causing, but which can give an indication of whether water is generally contaminated, were also at high levels. In 87% of scoop holes, fecal coliforms were present, and all scoop holes had general coliforms.



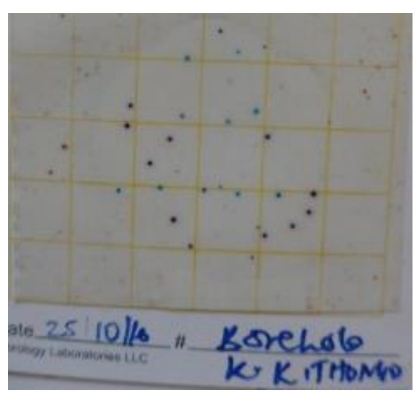
*Geometric mean and standard deviation of fecal coliform in various water sources, by season. "High to very high risk" is 100 cfu/100ml. *Household is taken from users' homesteads; it is water from scoop holes or wells in the dry season, and roof rainwater in the wet season.*

Are there strategies to harvest water from sand dams in a way that lowers the health risk?

Perhaps there is clean water at the dams, but the current practices are not harvesting the water in a clean manner. If so, perhaps a change in behavior at the water source could substantially reduce health risks. We did several initial tests to investigate this.

First, perhaps water from sealed, deeper water sources is clean. Pump wells were present at a few dam sites and were tested. Pump wells were cleaner, with 75% clear of fecal coliforms. However, having 25% of pump wells containing fecal coliforms indicates a continued need for treatment before drinking. This seems consistent with what we know about pump wells – their mere presence does not insure clean water, as contaminated can find its way to the source.

Borehole (pump well) that serves several hundred people in a drier area. Notice many donkeys; the area around the borehole was completely covered with dry manure from livestock, presenting an obvious risk for contamination.

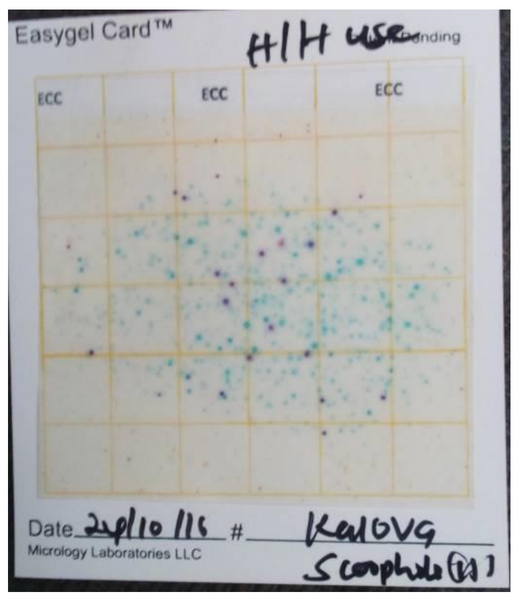


Unsurprisingly, the water sample from this borehole in fact did show many fecal coliforms.

Another pump well, also with livestock present. Livestock drink from the pool upstream from the pump well.

No fecal or general coliforms were found from this pump well. Out of several hundred samples, this was one of the few samples that was entirely clear of bacteria.

Second, users often scoop out the water from holes first, let water percolate back in, and then harvest the water. Users feel this is more clean, since the water then looks better. Tests from 12 scoop holes in the wet season indicated that clear water from scoop holes first did not lower the concentration of fecal coliforms. Neither were deep scoop holes free of bacteria, even though water presumably filters for longer through the sand.

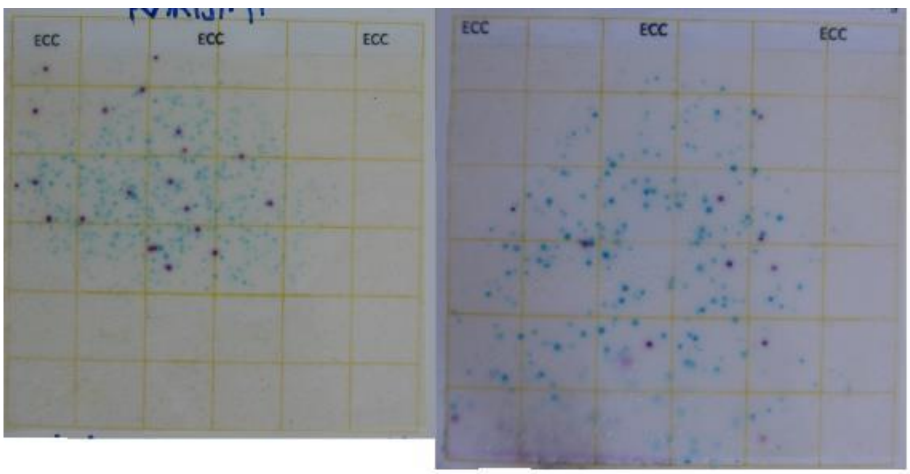


A deep scoop hole (at left) was dug in a dry area where water was particular scarce. Bacteria levels were still high at this site - either the "deep water" is not effectively filtered in the sand, or the water is recontaminated at the hole.

Many communities had what might be considered semi-protected water sources – permanent open wells that were deeper than scoop holes and often fenced off, and so potentially more clean. While there might be benefits to this arrangement (such as reduced effort of re-digging scoop holes), water cleanliness did not appear to be one of them. These sources did not show any indication of being cleaner than scoop holes.

Typical open well at a sand dam.

A filter system; the wife bought this because she wanted water cleaned, but her husband did not like the taste of chlorine. This was the only instance of filtration observed in the study.



Water from both the open well source (left) and after "filtration" (right) had high levels of fecal coliforms. The filtration unit was likely only for particles; the wife in this family was not made aware that it would not clean the water of bacteria.

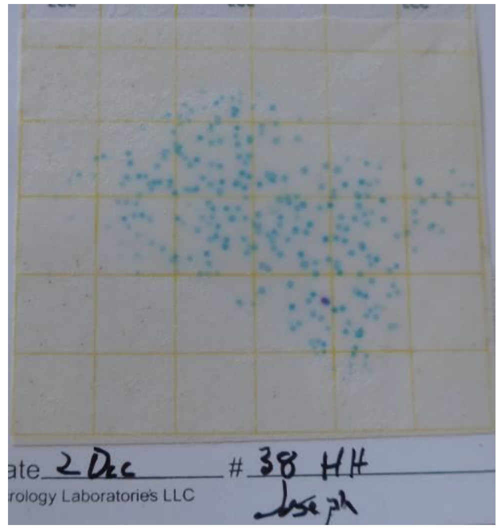
Finally, water collected from roof rainwater could be a cleaner source of drinking water. The vast majority of residents in the area do collect water from the roof during the wet season. Fecal coliforms were present in 25% of rainwater samples (taken from storage containers used to collect the rainwater), although general coliforms were abundant. Roof rainwater is therefore on par with pump well water – cleaner than other sources, but not reliably clear of fecal coliforms.

Examples of bacterial tests at 4 types of water sources, results are from the specific sources shown. Cards show fecal coliforms as purple dots (general coliforms as blue dots).

What can or will be done?

In several cases we returned to show results to users. Here, UDO and MCC staff discuss water test results with a homeowner. Showing the homeowner a picture of the water test allowed him to easily understand the implications, and motivated him to say that he should start treating water.

Talking with homeowner about testing results. During the wet season, they drink untreated water collected from the roof (blue barrel in background). In the dry season, they use a nearby scoop hole.



Collected roof water had many general colifiorms, one fecal coliform (in 0.5 ml)

Both UDO and SASOL are increasing their engagement with WaSH (water, sanitation and hygiene) issues in the communities, and MCC is working with them in how best to increase their efforts in getting communities to reduce the health risks associated with contaminated water.

In summary, this collaborative study between MCC, UDO, SASOL and Micrology Labs identified a previously under-recognized issue. Having firm evidence of the situation with water contamination has moved the issue beyond how we thought about the issue previously, which was based solely on untested assumptions. This has motivated these organizations to seek ways to help communities understand and mitigate these health risks.