Membrane-based Sanitation Technologies: An Innovation Worth Getting Excited About

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Having worked for 25 years in sanitation, I have developed a healthy cynicism for anything which people claim to be a marvelous breakthrough innovation. There have been many interesting contenders including ecological latrines, struvite extraction systems, new pit empting devices and biological based shit digesting systems, all of which have their merits, but all of which come with a host of drawbacks.

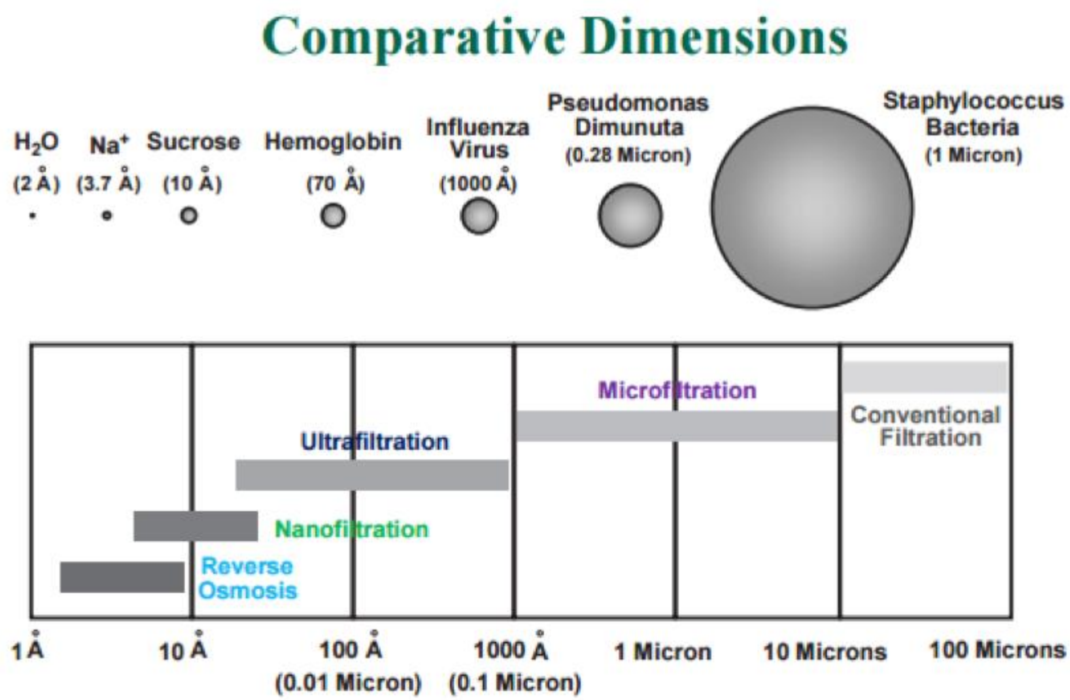
The same cannot be said for the latest ‘pit life extender’ and compact mobile treatment unit, which are beginning to look like true breakthrough innovations. They are being developed and prototyped by the Water For People program in India and its partners, WASH institute and Population Services International (PSI), with funding from the Bill and Melinda Gates Foundation. Together they have developed technical innovations which offer safe, simple, cost effective solutions for households and institutions whose pit latrine fills up too rapidly, or for a replacement of traditional vacuum tankers which generally become uneconomical and unaffordable when operating a long way from a disposal site.

The germ of both ideas lies with the research undertaken by Water for People and Mott McDonalds into the physical characteristics of pit sludge. Anecdotal observation of pit emptying showed that the vast majority of waste removed from pits was thin and watery, but it was not until use of the newly developed 'ball penetrometer', which takes profiles of the sheer strength of the sludge within the pit, that the true extent of the problem was realized; pits are filling up with water, not dense sludge. This turned our thinking on its head and made us focus on better managing the water within a pit and to stop focusing on the relatively small volumes of thick sludge.

Water is the devil in the sanitation value chain. It is only really needed to flush excrement the short distance from the bowl to the pit, but after this, it becomes nothing but a hindrance. It makes pits fill up too quickly, transport costly and the need for large expensive and unwanted treatment plants whose primary purpose is to separate out water from the solids. Improving water management within the pit would have a huge impact on every subsequent part of the value chain. The question is how do you do it?

Some basic research led to Cranfield University in the UK and discussions over the work they were doing with microfiltration using membranes. For the uninitiated, microfiltration is a type of physical filtration process where a contaminated fluid is passed through a special pore-sized membrane separate microorganisms and suspended particles from liquid. The filters used in the microfiltration process are specially designed to prevent particles such as, sediment, algae, protozoa or bacteria from passing through.

There are four categories of membrane, micro membranes, ultra-filtration membranes, nano- membranes and reverse osmosis membranes. They are engineered non-woven fabrics whose pore size is carefully controlled and used as a method for restricting what passes through them. Micro membranes have a pore size from about 0.1 µm whilst ultrafiltration membranes have a pore size of 0.03 µm (1µm is one millionth of a meter or one thousandth of a millimeter – so they are pretty small), these are the two membranes which present the greatest interest for dewatering sludge or pit contents. The following diagrams give an idea about the membranes filtration capacities.



In taking forward these ideas, Water for People agreed with the WASH Institute (WASHI) in India, to experiment with the concept and see what was technically possible. Whilst membranes are widely used and accepted in the water industry, they have never been used for an on-site sanitation application. It started by testing a series of membranes wrapped around plastic slotted screens inserted into septic tanks and quickly found that the use of a single, one shot, membrane was impractical due to the high organic matter of the waste and biofouling of the membrane.

By December 2015 comparisons of a sand filter, a 800µm cloth filter and a porous concrete filter, as a first stage roughing filter that separated the liquid from the highly contaminated sludge, were made. The sand filter clogged, the porous concrete gave poor results and the cloth filter worked the best. In the second stage experiments, activated carbon filters and sand filters were used to remove the odours and in the third stage 5µm filters, UV filters and batch chlorination, were tested to remove coliforms. The chlorination results were good, but required a long settling time and the process is ‘fail to danger’, that is households would not buy the chlorine and be happy to discharge highly contaminated effluent. The UV filter gave the best result, but added significantly to the costs. Experiments were also carried out using aeration to increase treatment around the cloth filter.

Although the experimental design and testing work was still continuing, there was a growing confidence that with the prototypes created it was possible to filter effluent straight from the pit, treat it, and then discharge it into a nearby drainage channels. The prototypes water discharge quality complied with Indian wastewater discharge standards and had a discharge rate of 1.2 liters per minute. At an estimated cost of $60, it was thought that the production of an affordable, commercially viable device was attainable.

By April 2016 the design had been further refined and improved. The whole system is housed in a box measuring 45cm x 23cm x 30cm and uses a fabric filter, a 800µm membrane filter, an activated carbon filter, and a reverse osmosis filter and is driven by two small pumps. The discharge results were impressive with BOD of 9 milligrams per liter mg/l and coliform count of 110 per 100 milliliters. This enables discharge directly into a water body or used for irrigation. All filters eventually clog and this usually results in the flow rate declining to a point where it is unacceptably low. This occurred within the household filter after seven months, at which point they were replace with a new filter costing Rps 150 ($2.20).

A new technology without ideas for its practical application is worthless. The possible options for the membrane and filtration process are initially thought to be

1. As a ‘pit life extender’ bought and managed by the household or institution.
2. Micro tanker with a longer travelling range than tradition vacuum tanker based services
3. Replacement for existing vacuum tankers as they would be cheaper to purchase and operate and not require access to a treatment plant
4. As the basis for a pay-as-you-go business model in high density urban areas
5. For use in service contracts with public institutions, schools, hospitals, and large blocks of flats which all produce large quantities of waste water and the need regular routine servicing.
6. As a water conserving device for toilets in water stressed areas. They enable the reuse of the water for flushing
7. As part of a low cost compact sewage treatment plant, particular in small towns which currently lack any form of treatment plant

Good progress has also been made with developing a mobile treatment unit that uses this technology. Larger capacity filters and a buffer tank have been mounted on the back of a pick-up which currently allows a discharge rate of 500 liters per hour with a relatively easy upgrade to 1000 liters per hour. A centrifuge has been incorporated, which takes the sludge from the bottom of the buffer tank and spins it to reduce its volume and moisture content to such levels that they can be safely stored in a maize sack. The real advantage of the mobile treatment unit is that it removes the need for a centralized treatment plant since the dry sludge can be treated and made safe in relatively simple drying beds or by converting it into solid fuel briquettes. The operation costs should be relatively low as the filters can be backwashed or replaced at a low cost. Sanitation for small towns with no treatment plants, for which there are 1000's throughout India and Africa, now becomes affordable, private sector enabled, and technically achievable. It means an end to the indiscriminate dumping of millions of gallons of highly pathogenic waste into ditches and rivers and at last we have an innovation that can have a huge impact on health.

It is still in the early days for both these technologies. The next step is to test them in real life conditions with potential customers to gain more accurate information about their longer term performance and operating costs. After this, the plan is to commercialize the product using some form of open access platform, developing new business models and work out how to introduce the product to Africa and Latin America.

Water For People is working with WASH Institute, and PSI in this technology development, and is grateful for the support of the Bill and Melinda Gates Foundation (BMGF)

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