First published in tce www.tcetoday.com
News & views from the process industries, published monthly by the Institution of Chemical Engineers

Potters for peace, filters for life

Wendy Laursen reports on successful humanitarian and engineering collaborations for securing clean water supplies for all

LEADERS from 189 countries met in New York in 2000 to reaffirm their commitment to the principles of human dignity and equity.

One of the specific Millennium Goals outlined at the time was to reduce by half the proportion of people without access to safe drinking water by 2015. Subsequently, in 2003, the years 2005 to 2015 were proclaimed as the International Decade for Action, "Water for Life".

Individuals and organisations around the world are working to achieve this goal but there is still the potential for those with science, engineering, marketing or communications expertise to save millions of lives.

Water-related diseases such as diarrhoea, cholera, trachoma, hepatitis and intestinal worms afflict millions of people worldwide. Approximately 1.8m people die each year from diarrhoeal diseases alone. This equates to about 5000 deaths a day or one death every 15 seconds, 90% of which are children under the age of five.

Many pathogens excreted by humans and animals can cause diarrhoea when they are ingested via faeces-contaminated drinking water. These pathogens, and other contaminants, can be physically removed by filtering, adsorption or sedimentation and they can be neutralised by chemical, heat or UV treatment. Safe transport, storage and handling are necessary to prevent recontamination.

Use of water filters in the home

A UN evaluation of the costs and benefits of water and sanitation improvements at a global level estimated that improved access to safe water can reduce diarrhoea morbidity by as much as 25% and can significantly reduce the incidence of many other diseases. Halving the proportion of people without sustainable access to an improved water supply such as a borehole, protected spring or collected rainwater would cost approximately $1.78b/y. The disinfection of household water and the provision of safe storage would cost an additional $2b. Productivity gains and savings in healthcare costs would bring economic benefits of up to $60 for every $1 invested.

The World Health Organisation (WHO) has established a collaborative network of UN agencies, development agencies, non-government organisations, research and professional associations and private industry to promote improved point-of-use water management. United by a common mission and strategic plan involving advocacy, communication, research and implementation, the stakeholders retain the flexibility and creativity they need to operate successfully under the varied conditions found throughout the world.

As an example of their research and communication role, WHO released a publication, *Fluoride in drinking water*, in 2006 containing details of the latest scientific evidence on the occurrence of fluoride, its health effects, and methods for analysing and reducing excess levels. Excessive fluoride can cause dental and skeletal problems and occurs in elevated levels in water in Turkey, Iraq, Iran, Afghanistan, India, Thailand, China and the rift valley in Africa. Over one million cases of skeletal fluorosis in China are attributable to drinking water. Some relatively inexpensive ways of removing excess fluoride from water include the use of crushed clay pots, bone charcoal and activated alumina.

UNICEF has developed a range of strategies to help meet the millennium goals related to water and sanitation. It operates in 91 countries and is the largest single agency working in the sector. It has developed a decade strategy that focuses on young child survival and gender inequality. UNICEF aims to ensure that all schools have adequate and child-friendly water and sanitation facilities and has implemented hygiene education programmes.

The need to fetch water can have a major impact on the welfare of women and girls, who are typically burdened with the task. Disease can mean that children are too sick to attend school or too unwell to concentrate when there. Older girls which have entered puberty may be deterred from attending school if the facilities are inadequate or non-existent.

UNICEF worked in Pakistan after the earthquake in 2005 that killed more than 70,000 people and ruined infrastructure and water schemes. To reduce the risk of diarrhoea, typhoid, cholera and other infections, it distributed Nerox Filters throughout relief camps and educated families, not accustomed to treating water, about their use.

Nerox Filters are gravity-fed devices for personal or family use and their unique membrane is 100% effective against bacteria. The concentration of heavy metals and pesticides can be reduced significantly and the filter has no moving parts and needs no electricity.

Senior advisor in water management Oluwafemi Odediran believes that health education and hygiene promotion are central to the success of household solutions. Behavioural change interventions require a long-term programme and continually changing social and economic circumstances mean that ongoing monitoring of water quality is also required.

Odediran believes that there is a role for further research into the provision of simple and practical solutions for the treatment of arsenic and fluoride in naturally occurring water, especially in sub-Sahara Africa. Household solutions for microbial contamination in Asia are also needed.

Doctoral student Joe Brown of the University of Carolina, US, is developing a ceramic water filter that uses goethite, an iron oxyhydroxide that is commonly found in tropical soils. Mixing this into the clay means that the filters are effective against viruses that are too small to be trapped

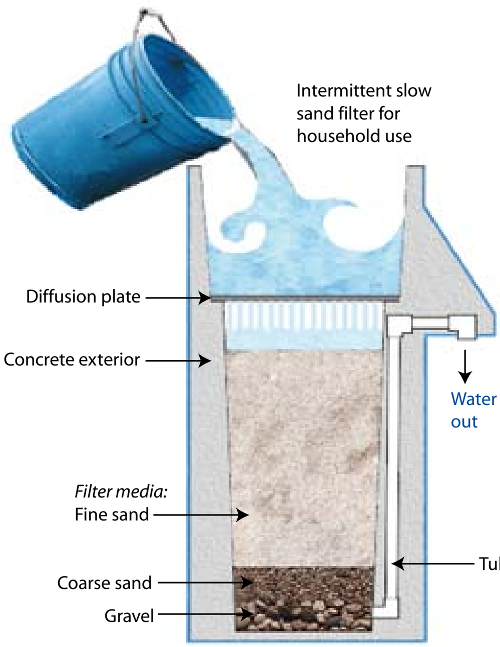
SODIS – simple, cheap, and demonstrating significant health benefits

by ordinary ceramic filters. Goethite effectively creates a positive charge when mixed with clay in the right proportions and this inactivates viruses as they pass through the filter. Brown is working with Potters for Peace to implement the technology in Cambodia where diarrheal illnesses are a major killer.

Potters for Peace and Potters Without Borders help setup workshops in developing nations that can produce ceramic water filters. They provide training and technical support, working with a variety of organisations to set up the facilities, which they help to become economically viable as quickly as possible. Efficient production practices and low cost products are critical to the ongoing success of the local businesses they help to establish.

Burt Cohen, on the board of both organisations, has established a research facility in Canada where he works with engineers to develop and test point-of-use systems that are effective, affordable and transportable. They operate under an open-source policy so their experience and research can be shared.

Principle of the Biosand filter



According to Cohen, the need for affordable water filtering exists in many countries and can result from lack of infrastructure, natural disasters or because of changing patterns of economic development. Sometimes the traditional inhabitants of an area are marginalised as people that are more affluent or large manufacturing corporations secure water resources for their own use.

Potters Without Borders uses ceramic filter technology that was previously too expensive for many communities. It has produced a low-cost press and optimised many aspects of the processing to maximise production success. The filters are micro-porous ceramics that strain bacteria from the water passing through them. A colloidal silver coating is fired onto the filters and this neutralises the organisms to prevent contamination of the filter with repeated use.

Potters Without Borders and Potters for Peace are active in research that will improve the processing and production of their filters. They are working with engineers from Seattle University, US, to identify suitable burnout materials that are locally available in different parts of the world and are determining optimal particle sizes for these materials. Another research partnership with Gonzaga University, US, is looking at further improvements to the production equipment. Further collaborations are being sought to help improve the efficiency and economy of their systems and to gain a better understanding of the factors affecting flow rates. They are also planning to develop smaller filters that are easier and cheaper to transport to remote areas.

Cohen believes the ongoing adoption of filters in many communities is strongly dependent on strengthening communication between manufacturers and end-users. Sometimes distance, cultural practices and lack of medical knowledge can hamper attempts to convey the importance of filter use. He cites an example where aid workers have had difficulty in conveying the concept of diarrhoea to people who rarely experience a solid stool.

The development of sustainable systems that can operate successfully within the marketplace is also the goal of the international, nonprofits organisation PATH. With the help of a $17m grant from the Bill & Melinda Gates Foundation, it is adapting and developing a commercial market for household water treatment and storage systems.

Its commercial model will be trialled initially in India where the mix of urban and rural communities provides a broad testing ground. The organisation will be adapting a range of filters and chemical products to make them more usable, shippable and affordable and will develop marketing strategies to support health messages and increase motivation.

Some of the technologies PATH is adapting include powders that combine the flocculant iron sulphate with the disinfectant chlorine or hypochlorite solution produced locally from salt water. It is are also working with other organisations to implement ceramic filters, nano-coated paper filters, Biosand filters and SODIS, a solar disinfection technology. It has avoided reverse osmosis and distillation options, as they are relatively complex and expensive.

Safe Water Project director, Glenn Austin, believes marketing will be important to communicate a range of product and financing choices. Austin believes there is tremendous potential for finding and developing additional surface treatments for ceramic filters to extend their effectiveness with low incremental costs. He says that currently contaminants such as viruses, protozoa, industrial chemicals, arsenic and fluoride are difficult to remove. Any help in extending treatment effectiveness to these additional contaminants at very low cost could literally save millions of lives.

SODIS is one of the technologies WHO recommends and PATH is implementing. Developed by the Swiss Federal Institute for Aquatic Science and Research (EAWAG), SODIS is a solar disinfection treatment where contaminated water is put into transparent plastic or glass bottles and exposed to sunlight for six hours.

Ultraviolet radiation (wavelength 320–400 nm) destroys diarrhoea-causing pathogens and if temperatures rise above 45 °C, temperature acts synergistically.

Currently approximately 2m people in more than 20 countries use SODIS for the daily treatment of drinking water. The health impacts of SODIS have been documented in several scientific studies that have shown a 30–50% reduction in the incidence of diarrhoea. The method is low-cost and most communities in the world have a ready supply of PET bottles.

In the last five years, the SODIS project has received a number of humanitarian awards for their work around the world and SODIS is successfully promoted in South America by the Fundación SODIS. An estimated 60m people in South America do not have access to an improved water supply. Now over 300,000 people there are using SODIS on a regular basis. The implementation of the technique has been combined with training programmes

and, in some cases, implemented initially in schools, as a way of educating and engaging communities.

EAWAG research has shown that PET bottles are preferable to PVC bottles because they contain fewer softeners. Although some reactions occur in the plastic they are produced on the outer surface of the bottles and have not been observed to migrate into the water.

Project director Martin Wegelin at EAWAG believes that research into titanium coating processes would be extremely beneficial. TiO_2 is known to accelerate solar oxidation but generally, this catalyst is used as a suspension. It would be advantageous if it could be used to coat the inner half side surface of PET bottles or alternatively applied to plastic pieces that could be put into the bottles. If the coating process was simple enough for production in local workshops, it would provide an additional income to local communities and add value to empty PET bottles.

Biosand filters are an adaptation of slow sand filters being implemented around the world by the Canadian humanitarian organisation the Centre for Affordable Water and Sanitation Technology. The filters are comparatively small and easy to use in the home because they can be run intermittently. They consist of a diffusion plate, biofilm layer, sand media and then a gravel layer all housed in a concrete box. Biosand filters have been shown to remove over 90% of faecal coliform, 100% of protozoa and parasitic worms, over 95% of zinc, copper, cadmium and lead and 76–91% of arsenic.

The Vestergaard Frandsen Group of Switzerland has produced the LifeStraw as a practical response to the Millenium Development Goals and the urgent need for safe drinking water worldwide. LifeStraw is a personal water purification tool that can be hung around the neck. The filter contains a patented disinfecting resin that kills bacteria on contact. Textile pre-filters remove particles up to 15 µm and active carbon filters remove parasites. It has no moving parts, no replaceable parts and is powered by sucking. It can remove microbes from up to 700 l of water; approximately one year of drinking water for an adult and two years for a child.

LifeStraw was distributed during the tribal conflicts in Northern Uganda and in Pakistan after the 2005 earthquake. LifeStraw is currently only available to humanitarian organisations but in the next few years, it will also be available on the retail market.

Arsenic is a water contaminant in many countries, but in Bangladesh, it has been called one of the largest mass poisonings in human history. It is expected to cause 10% of all future adult deaths among the nation's population of 130m. Arsenic is released into groundwater from rocks and soils and the shallow tube wells used in Bangladesh have dangerously high concentrations which can damage the skin and circulatory system resulting in cancer and death.

Ashok Gadgil of Lawrence Berkeley National Laboratory, US, is developing a cheap and effective way of filtering arsenic from water using coal ash. His idea is to coat the ash with ferric hydroxide, a compound that reacts with arsenic, and to fill teabag-sized pouches with the powder for point-of-use filtering. Coal ash is composed of particles less than 10 µm in diameter and has been heated to 800 °C so it is sterile and free of volatile compounds.

Gadgil has already developed a water purification system that kills bacteria with UV light that is used in Mexico and the Philippines. He hopes his coal ash filter will be cheaper than other filters already in use in Bangladesh which use pulverised brick.

Chemist Abul Hussam of George Mason University, US, is also tackling the problem of arsenic in Bangladesh. His filter involves passing water through two containers that contain river sand, pieces of iron and wood charcoal. Hussam won the $1m 2007 Grainger Challenge Prize for Sustainability administered by the National Academy of Engineering in the US. Hussam plans to give 5% of the money to the university, 25% will be used to develop smaller filters, and the remainder of the money will be used to increase production of the filters in Bangladesh.

New Zealander Russell Kelly has developed a filter system that uses iodine technology developed for NASA. The filter is a four-step process. Polluted water passes through a carbon-based filter, and then a 0.2 µm ceramic filter that has an iodine resin embedded in it. This filters out cysts and bacteria and kills viruses. The water then goes through a third filter which contains an iodine scavenging resin and then finally through another carbon-based filter.

The design is easily maintained and incorporates safeguards to ensure the filters will not operate if they need servicing. Kelly has developed four models. A gravity survival bag acts as a first response device in civil emergencies. It is gravity fed and can purify 12 l/h of water. One filter cartridge can produce clean water for ten people for 60 days.

The pedal-powered design is suited to communities with no electricity and consists of five separate filtration units which include pre-filtration, ceramics and resins. This model could sustain 3000 people in an emergency or be used by a community of 1–2000 people. Other models can be solar or battery powered and can be scaled up as required for larger communities.

The Lifestraw offers safe drinking water for up to 1–2 years

Kelly has obtained international patents and trademarks for the filter processes and is currently setting up a charitable trust so the technology can be used to support Red Cross, Oxfam and other organisations.

Many more people are working towards the Millennium Goals. The UN Millennium Campaign informs, inspires and encourages people's involvement and action, helping them to hold their governments to account for their Millennium promises. Visit www.millenniumcampaign.org/site/pp.asp?c=grKVL2NLE&b=138312 for more information. **tce**

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