GDM Technology for Household Water Disinfection

The Gravity-driven Membrane (GDM) technology reveals a high implementation potential for efficient, robust, durable, low cost, and virtually maintenance-free household water filters. A project was recently launched in Kenya to establish filter efficiency in the field and develop a market-based approach for their sustainable use. Maryna Peter-Varbanets[1], Rick Johnston[1], Regula Meierhofer[1], Wouter Pronk[2]

Household water filters

Household water treatment and safe storage (HWTS) systems have been associated with marked drinking water quality improvement and disease reduction. However, time-consuming operation and maintenance, aesthetic concerns, limited effectiveness, high costs of existing technologies, and lack of consideration of consumer preferences have limited the scale-up of HWTS systems.

Some studies on consumer preferences and efficiency of HWTS systems reveal that consumers favour filters rather than other HWTS technologies for their potential durability and ease of use [1]. Ceramic pot or candle filters, with a limited long-term efficiency, are the most widespread and marketed filters in developing countries. Aside from ceramic filtration, the choice of available HWTS filters is rather limited. Some filters are available for middle-income populations in emerging markets (i. e. Tata-Swatch, PureIt in India). However, since these filters require regular replacement of cartridges, they are associated with high operating costs. The potential of alternative filtration technologies should therefore be considered for HWTS applications.

Ultrafiltration

Ultrafiltration (UF) has proved very effective in removing particles, colloids and microorganisms from the water. Conventional, large-scale ultrafiltration systems require pumps and control equipment for operation, backflushing and cleaning. Decentralised systems, designed in a similar manner, are usually complex and expensive. Only few gravity-driven ultrafiltration systems for decentralised application are currently available (e. g. SkyJuice for community water supply and LifeStraw Family for household water treatment). Yet, they also require regular manual chemical cleaning (Skyjuice) or manual backflushing (Lifestraw).

GDM disinfection technology

With the gravity-driven membrane (GDM) disinfection technology, developed at Eawag, ultrafiltration operates for more than 24 months at a stable membrane flux of 4–10 $L.h^{-1}m^{-2}$ without backflushing, chemical cleaning or external energy supply. The transmembrane pressure of about 20–65 cm of the water column can be easily achieved in household systems. Natural water without pre- or post-treatment can be used as a feed. This phenomenon of a stable membrane flux was first documented in our previous study [2].

A layer of retained particles, colloids and microorganisms rapidly develops on the surface of the new membrane and leads to an initial decline in flux. However, after about one week, channels and cavities form in the fouling layer, allowing passage of water through the layer and resulting in stabilisation of the flux. These channels are caused by biological processes occurring within the accumulated organic matter and by microorganisms.

GDM systems can be operated with turbid water (up to 100 NTU) or high organic matter content (including diluted wastewater with a TOC of about 12 mg/L). Membranes used in GDM systems entirely remove protozoa and bacteria, and preliminary data shows 99.99 % retention of viruses. Membranes of even smaller pore sizes and intermittently operating filters will increase filter flow rate. This novel approach of operating UF systems at stable flux conditions allows development of a robust, maintenance-free and user-friendly household water treatment system.

Photo 1: Prototype of the GDM filter.

GDM disinfection of household water in Kenya

A new project was launched at Eawag in July 2010 with the aim to develop a novel household water treatment system based on the GDM disinfection technology. Assessment of the 40 GDM filter prototypes, using different raw water qualities, started in Kenya in May 2011. The first phase of the project will focuses on a technical evaluation of the prototypes with user feedback on filter design and operation. Field testing will be conducted in partnership with the Kenya Water for Health Organisation (KWAHO).

Production costs of a household GDM system are estimated at about 30 Euro. Assuming a system lifetime of several years, the annual costs for water treatment using a GDM system will be within reach of an average slum dweller. For sustainable implementation of the system, this project also includes an evaluation of potential sales distribution mechanisms, supply chains, long-term support, and development of marketing strategies. Interventions are planned to create demand, including commercial marketing, behavioural change through household promotion and ongoing interventions to maintain new behaviour.

[1] Albert, J. et al. (2010): End-user preferences for and performance of competing POU water treatment technologies among the rural poor of Kenya. Environ. Sci. Technol. 44, 4426–4432.

[2] Peter-Varbanets et al. (2010): Stabilization of flux during dead-end ultra-low pressure ultrafiltration, Water Res. 44, 3607–3616.

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