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Researchers investigate high-rate filters for water treatment

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Source: Antoine Antonio/Bloomberg News

DRINKING WATER TREATMENT
A group of researchers is currently investigating the potential of upgrading existing South African drinking water filtration plants

A group of researchers is currently investigating the potential of upgrading existing South African water filtration plants to use high-rate filters.

Effective filtration at drinking water treatment plants is important as it reduces the risk of outbreaks of certain waterborne diseases in drinking water supplies.

Water management and bulk water supply company, Umgeni Water, in consultation with researchers at other institutions, is carrying out the research. The project is being funded by the Water Research Commission (WRC), in an effort to ensure more efficient drinking water production, because of the threat of a lack of sufficient water in South Africa, along with water quality and availability issues becoming more acute.

So far, the researchers have conducted pilot plant trials at two different sites to assess the impact of filtration rate and influent conditions on filter performance. "We have also conducted surveys at plants around the country to assess current operating practices and identify barriers and opportunities for uprating their filters," says Pollution Research Group researcher and consultant on the Umgeni Water research project, **Barbara Brouckaert**.

Final pilot plant trials for the project, which was started in 2002,

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are under way and the report is expected to be finished this year.

"In conventional water treatment for drinking water production, the bulk of the pathogens in the raw water is actually removed by sedimentation and filtration. The final disinfection step is supposed to kill off whatever is left and is more efficient the cleaner the water is, since dirt particles consume some of the disinfectant and help to shield the microbes," says Brouckaert.

She explains that conventional filters that function between 2 m/h and 10 m/h, and high-rate filters that function at 10 m/h and higher, are both depth filtration processes, meaning that influent particles penetrate the filter bed and are not simply strained out on the surface.

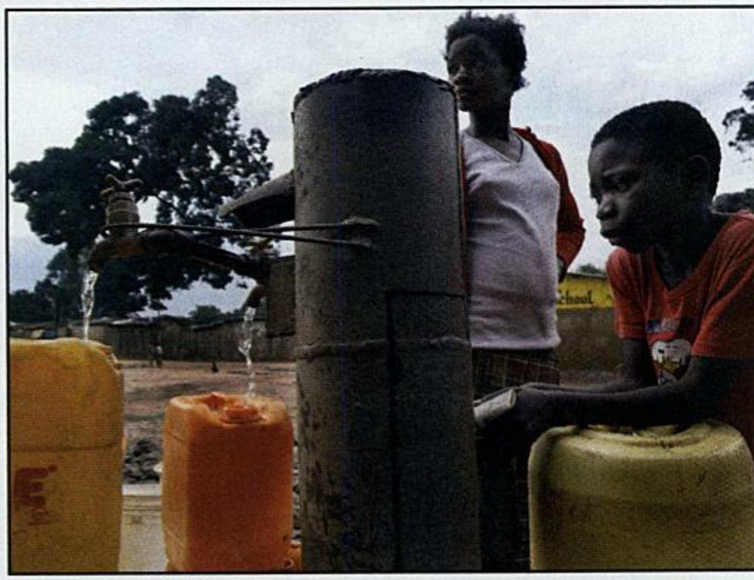
Both filter types also require adequate chemical treatment with coagulants, called flocculants, to effectively remove turbidity from water.

"International experience has shown that appropriately designed and optimally controlled filters can be operated up to 25 m/h and, in some cases, higher, without deterioration in filtrate quality, provided that there is adequate pretreatment," she comments.

She adds that most plants are not operated at such high rates and that standards vary from country to country.

In South Africa, conventional gravity filters, where the filter bed is usually located inside an open concrete box, tend to be operated at rates below 5 m/h, which is in line with the recommendation given by the Department of Water Affairs and Forestry's (Dwaf's) Technical Guidelines for the Development of Water and Sanitation Infrastructure. However, pressure filters and other package plant-type filters, which are widely used in small treatment plants, are often operated at higher rates.

Brouckaert notes that a primary barrier to upgrading filters is often existing plant hydraulics. If a plant was built between 20 and 50 years ago and was designed to operate at conservative filtration rates, it may require substantial civil works to increase the amount of flow that can physically be put through the filters.



Source: Jean-Claude Coutausse/Bloomberg News

INCREASED RISK
Areas with poor sewage treatment are also likely to offer ineffective drinking water, posing a double risk to consumers

High-rate filtration is not a suitable option for the majority of small rural plants in South Africa.

In contrast, large urban treatment plants with advanced instrumentation and highly skilled operators are often found to be operating at very conservative rates, while smaller plants with few technical resources and minimally trained operators are being pushed to operate at higher rates to reduce capital costs.

Brouckaert explains that although high-rate filters are not generally used in South Africa, there is one high-rate plant operational and, since the design of high-rate filters is not substantially different from conventional rapid filters, the expertise does exist in South Africa.

Brouckaert explains that the filtration process of conventional filters and high-rate filters is essentially the same, and that the main difference is in the size and type of filter media and chemical pre-treatment used.

"Coagulation, with the traditional inorganic coagulants, ferric chloride or aluminium sulphate (alum), alone, is considered adequate for rates up to 10 m/h but cationic polymer filter aids are added for higher rates," says Brouckaert.

Coarser media sizes are required at higher rates to prevent excessive pressure loss during the filtration process. This, in turn, requires a deeper filter bed to ensure adequate turbidity removal. Alternatively, dual media filters, which have a layer of coarse anthracite over finer sand, are popular in the US.

Brouckaert says, "There are a few dual-media filters in South Africa, mainly in package plants, but they are not common. However, we find that most filters are already using coarser sand sizes than in the US, and an increasing number are using polymeric blends instead of alum and ferric."

She further explains that the other important difference between conventional and high-rate filtration is the level of monitoring and control required.

"Tight monitoring and control are always necessary to ensure the production of safe, good-quality water. However, the higher the rate, the less time the operator has to react to adverse events. Therefore, high-rate filtration is not recommended for plants without 24-7 monitoring and control – preferably continuous online control – and without skilled operators and maintenance personnel," says Brouckaert.

The use of high-rate filters could be advantageous as plant capacity is increased without building new filters, which would save money and space.

However, there may be additional costs associated with increased instrumentation, monitoring equipment and pumping requirements, depending on the situation at each plant.

Meanwhile, water pollution was highlighted in February, following a report in the *Sunday Times* that South Africa was facing a water contamination crisis.

The newspaper quoted a report released by the National Nuclear Regulator, which highlighted several problems with South African water-treatment plants and other infrastructure managed by Dwaf.

The report stated that 43% of dams managed by Dwaf need urgent repair, and that immediate action is needed at 30% of municipal water-treatment works to prevent outbreaks of waterborne diseases.

The report also stated that ageing infrastructure needs to be replaced at a number of water-treatment works. Sewage spills into water sources and wastewater from mining operations seeping into groundwater systems were also cause for concern.

Minister of Water Affairs and Forestry **Lindiwe Hendricks** responded in a statement that, while the newspaper report had raised a number of concerns, it had not outlined any of the measures taken by Dwaf to tackle these issues.

"South Africa still maintains one of the best quality tap water in the world; and Dwaf monitors and works closely with the municipalities that supply the water to households to ensure clean drinking water," commented Hendricks.

She further noted that Dwaf has completed a comprehensive assessment of what needs to be done about the dams under its management, and that a budget of more than R1,2-billion has been allocated to manage the infrastructure maintenance needs of the dams.

Hendricks said, "The issues contained in the report by the National Nuclear Regulator are of concern to us and we have publicly stated we are addressing them."

While assuring the public that South Africa does not have a water crisis, she explained that South Africa remains a water-scarce country and that water pollution and acid mine drainage were of

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great concern to Dwaf.

Water conservation and the effective treatment of water for drinking purposes also remain a priority for the department, as effective water-treatment processes are necessary to ensure that drinking water supplied to the public is safe.

Filtration is one of the key aspects in the wastewater-treatment process as well as the treatment of drinking water.

Raw water is abstracted from the source, for example, a river or dam, and is then treated using different treatment processes. The amount and type of treatment varies according to the water source.

Water abstracted from a river or dam generally contains suspended materials and contaminants. Water suppliers at treatment plants add coagulant chemicals to the water so that the dirt forms clumps and settles at the bottom.

The water is then filtered to capture smaller contaminants. To finish off the process, chlorine and other disinfectants are added to eliminate germs and bacteria.

Brouckaert explains that the drinking water treatment infrastructure is in a similar situation to the municipal wastewater-treatment works in South Africa and that the problems with drinking water treatment, sewage treatment and dams are all related.

"Sewage spills increase the risk of waterborne diseases in two ways. People can be infected by direct contact with drinking untreated water, or if the spill occurs upstream of the raw water abstraction point for a drinking water treatment plant, then there is an increased risk of pathogens breaking through into the treated water," she comments.

Further, she says that the same municipalities which are struggling with their sewage treatment are usually also having problems with their drinking water treatment.

"So areas with poor sewage treatment are also likely to have ineffective drinking water treatment, posing a double risk to consumers. Sewage spills also cause other environmental problems, such as eutrophication, algal blooms, toxicity and increased organic levels in the raw water, which all make potable water production more difficult," says Brouckaert.

Water research, education and development research group the Pollution Research Group, which is part of the University of KwaZulu-Natal, says that granular media filtration is an important part of most drinking water treatment facilities, as filtration is usually the final, or sometimes even the only, particle-removal step in the drinking water treatment process.

Brouckaert notes that these types of filters are also sometimes used as the final particle-removal step in wastewater treatment.

The group says that filter performance depends on the design and operation of the filter, physicochemical pretreatment and the efficiency of the cleaning of the media between filter runs.

Filtration is also critical in safeguarding the microbial quality of water, and reduces the demand for disinfectants used in the treatment processes. The process is important as it reduces the risks of outbreaks of waterborne diseases.

Brouckaert explains that if filtration is inadequate, there is an increased risk that pathogens in the raw water may break through into the finished water. These pathogens include shigella, hepatitis A, salmonella, typhoid, cholera and gastroenteritis, which result from a variety of bacteria and viruses.

"Two organisms are of particular concern, however, namely giardia and cryptosporidum. These are pathogenic protozoa, which form resistant spores against which chlorine disinfection is not very effective. Giardiosis and cryptosporidiosis can be fatal in those with weakened immune systems, including young children, the elderly and HIV/Aids sufferers. Therefore, it is particularly important that these organisms are removed prior to the disinfection step," says Brouckaert.

Further, with appropriate pretreatment, filters can be effective in removing iron, manganese and organics. Organics are of particular concern as they can form carcinogenic byproducts when they react with disinfectants.