POINT-OF-USE WATER TREATMENT TECHNOLOGIES: A VIABLE ALTERNATIVE FOR THE PROVISION OF SAFE DRINKING WATER TO UNSERVED AND UNDERSERVED COMMUNITIES?

1. BACKGROUND

South Africa does not have abundant fresh water resources. In fact, it is regarded as the 30th most water-scarce country in the world, and is facing various challenges with regard to its water resources, ranging from availability and management to equitable use. Despite the challenges, the country has thus far achieved significant success in harnessing this limited resource in support of a strong economy and a vibrant society. This has been achieved through effective water-resource planning, infrastructure development and concerted efforts towards service delivery.

In South Africa, access to water (like health care, food, and social security) is a right set out in the Constitution of the Republic of South Africa, 1996. The 1997 White Paper on Water Policy was developed with the aim of managing the quantity, quality and reliability of the nation's water resources to achieve optimum long-term and environmentally sustainable social and economic benefits.

The National Water Act, 1998 (Act No. 36 of 1998), was enacted to ensure that the nation's water resources are protected, used, developed, conserved and managed and controlled in ways that take into account, among other things, the promotion of equitable access to water, as well as providing for the growing demand for water. Government's contribution includes funding for and regulation of water service provision, as well as giving direction to institutions providing water services.

Water services provision in local government is regulated through the Water Services Act, 1997 (Act No. 108 of 1997), in terms of which every water services authority has a duty to all consumers or potential consumers in its areas of jurisdiction to progressively ensure efficient, affordable, economical and sustainable access to water services.

Water service authorities have made investments to ensure the provision of safe drinking water to citizens. However, there are still challenges with the reliability of water systems installed to supply safe drinking water, more especially in the rural parts of South Africa. According to Statistics South Africa's Census 2011, only 9,2% of the population had access to safe drinking water. The Institute of Poverty, Land and Agrarian Studies, in partnership with the Water Research Commission, reports that the water service delivery issues behind social protests include no access or inadequate access to water from existing infrastructure; the poor quality of water from existing infrastructure; a lack of water supply infrastructure; the poor operation and maintenance of infrastructure; old water reticulation networks that have deteriorated; water shortages or intermittent supplies; water cut-offs, restrictions and/or disconnections; high tariffs and/or privatisation; inaccurate water billing; poor governance or corruption; the marginalisation of certain groups within municipal areas; and the politicisation of water service issues.

2. ACCELERATING SUSTAINABLE WATER SERVICE DELIVERY

Access to clean drinking water is still a problem in the majority of South Africa's rural communities, which rely on springs (protected or unprotected) and rivers for drinking water. Service providers battle with financial and technical resources to provide piped water to sparsely settled communities, which are at times located on difficult terrain. Even in situations where there is water infrastructure in place, some communities still do not have access to reliable water services. In other words, access to a tap does not translate into access to clean drinking water, or even water of any quality. Quantity is also a problem, experienced throughout the Southern African Development Community. It is acknowledged that installing a pipe or infrastructure in a village or community does not necessarily mean that the community or village will have water in the next five years (Rademeyer, 2013).

The fundamental responsibility of public water supply is to provide each consumer with safe drinking water that is adequate in quantity and acceptable in quality (Momba, et al., 2006). Science is breaking new frontiers in fighting diseases and lowering the cost of water purification (National Development Plan). The Department of Science and Technology (DST) and the Council for Scientific and Industrial Research (CSIR) are undertaking the Accelerating Sustainable Water Service Delivery (ASWSD) initiative with the objective of using science, technology and innovation to accelerate the provision of safe drinking water to unserved or underserved rural communities in the Eastern Cape, Limpopo and Mpumalanga. ASWSD I was implemented in the Amathole and OR Tambo District Municipalities in the Eastern Cape in 2008, and ASWSD II is being implemented in Mpumalanga and Limpopo from 2010.

Point-of-use (PoU) and household water treatment and safe storage (HWTS) technologies were part of the intervention packages in both phases. These are water treatment, handling and storage technologies that are employed at the household where the water is to be used. The intervention in Amathole District Municipality (Eastern Cape) provided ceramic water purification filters to households. In Phase II, AmaDrums were provided to project beneficiaries in Ehlanzeni District Municipality (Mpumalanga). The water purification systems include a range of technologies, including filters, chemicals, boiling, and chlorination with tablets or solutions, solar disinfection, and chlorination with flocculation. These interventions have over the years gained global prominence as evidence of their effectiveness in improving water quality and associated health outcomes has accumulated. They have emerged as a way of empowering communities without access to safe water to improve water quality by treating it in the home.

There are about 2 million diarrhoeal deaths related to unsafe water, sanitation, and hygiene every year across the globe, the vast majority children under five. More than one billion people lack access to an improved source of drinking water (World Health Organisation).

Ceramic water filters are both inexpensive and effective, and are widely used all over the world, with varying degrees of success. They rely on the small pore size of ceramic material to filter dirt, debris and bacteria out of the water. The AmaDrum is a South African technology developed by the CSIR. It employs chlorination with flocculation and some sand filtration to treat 50-litre batches of water at household level. In both projects (ASWSDI and II), the technologies allowed households to store the treated water safely, and to collect the water safely and hygienically through a tap. Safe storage after the collection or treatment of water is an integral part of HWTS and a common challenge (Wright, et al., 2004) Jagals – SA study.

Other means of providing safe drinking water to communities as alternative to pipes and taps should be explored. In other areas, individual households opt for treatment options based on indigenous knowledge systems. Such options should also be explored and, where feasible, formalised. This policy brief presents evidence for the potential and scope of PoUs in South Africa as a viable option for the delivery of safe drinking water to the unserved or underserviced communities. The options presented are based on lessons learnt from previous studies and current initiatives funded by the DST.

3. Ceramic household filter pilot in the Amathole District Municipality

After a situational assessment was conducted in Amathole in the Eastern Cape, it was discovered that many communities depend on springs and ponds for drinking water. The DST partnered with the CSIR and the Human Sciences Research Council (HSRC) to undertake the ASWSD initiative in the Eastern Cape. Communal water stations were designed, developed and installed at the river so that the community could continue to use their traditional paths for fetching drinking water. The project also provided beneficiary households in the selected villages with ceramic purification filters to treat the water collected from the springs and the river, as a back-up measure in case of the breakdown of the communal water stations. Ceramic purification filters were identified as more effective than the communal water stations, and as having the potential to become widely and sustainably used for improving household water quality.

The selection of ceramic filtration as the household-based intervention for the project was based on the cost-effectiveness of the technology, as well as the consideration that it put households in control of their drinking water treatment. The type of ceramic water filter selected (made by Potters for Peace in Kenya) was based on cost, potential acceptability and the sustainability of the intervention in a rural South African setting. While the original intention of the project was to develop filters in South Africa, they were ultimately imported from Kenya in the interests of cost-effectiveness, and to enable the project to be completed within the planned time frame.

The ceramic filters were provided to the beneficiary communities, who were trained in the use and maintenance of the filters. However, Amathole District Municipality, a water service authority, indicated that water from one of the filters had been analysed by the Amatola Water Board and found to be unacceptable for drinking purposes, as it did not meet the South African National Standard (SANS) 241 for drinking water, as enforced by the Department of Water and Sanitation (DWS). SANS 241 regulates the microbiological, physical, aesthetic and chemical determinants of water. After the initial distribution of filters, an investigation was then conducted by the CSIR, with assistance from the HSRC and the members of the village task teams, to assess the use of the filters by the beneficiaries and the quality of the water filtered in the households.

Some of the findings from the investigation are as follows:

- All the beneficiary households were pleased to have the filters. They were also all of the opinion that other households would benefit from having the filters.

- The information sheet/poster provided by the CSIR and the HSRC was not used as extensively as planned. Half the households with filters did not have it close to the filter to remind them of the necessary steps to take in the use and cleaning of the filter.

- All the beneficiaries were trained in the correct use and cleaning of the filter, and were also part of the hygiene promotion activities during the implementation of the project. However, it was clear from the investigation that the filters were not cleaned correctly. Although most households cleaned the filters inside their houses, either on the floor or on a table, they used raw or dirty water. The majority of the households took care to place the cleaned filter on a clean area. This indicated that the concept of washing the filter had been accepted but, while the actions were performed correctly, the shortage of clean water available meant that dirty water was used to clean the filters. The average income level of the households appeared to be low, so it was unlikely that there was money available to spend on household disinfectants or any other chemical purification method. Boiling water would also use up scarce resources (paraffin or wood).

- The results of the chemical and microbial analysis conducted by the Amatola Water Board indicated that the ceramic filters were successful in reducing contamination at household level.

- Eighteen of the 29 filters investigated showed a 95-100% reduction in *E. coli* counts, meeting the DWS microbial requirements and standards. However, only 10 households had an *E. coli* count of zero in their filtered water, which is a World Health Organization requirement for safe drinking water.

- The filtered water from the ceramic filters meets the SANS 241 standards in terms of pH and conductivity, thus also meeting the DWS chemical requirements.

- There was more use of the water filters than of the communal water stations in the beneficiary communities.

4. AmaDrum in Thambonkulu Village, Ehlanzeni District Municipality, Mpumalanga

ASWSD II is providing AmaDrums to some 330 households in Thambonkulu Village. The village is in Nkomazi Local Municipality, which is both the water service provider and the water service authority for Thambonkulu. The decision to provide AmaDrums was informed by an extensive situational assessment conducted by the CSIR. There are boreholes in the area, as well as infrastructure for water reticulation. However, the infrastructure had not been working for more than a year at the time of assessment, forcing the community to rely on three unprotected wells. A community survey indicated that 62% of the households ranked the wells as their main source of water. However, the water level in the wells decreased significantly in winter, requiring community members to wait several hours for the level to rise again after other members had drawn water. Furthermore, some of the community members interviewed indicated that they collected water from wells and used it for all domestic purposes, including drinking and cooking, with no prior treatment. The water from the wells was found to be contaminated with nitrates and *E. coli*, and thus not safe for drinking.

The community also relies heavily on rainwater harvesting in households tanks (holding approximately 100 litres). The households have many water containers to harvest water during the rainy season or when municipal tankers provide water.

An initial pilot project showed high levels of acceptance of the AmaDrum technology by the Thambonkulu community. The 30 households that received the technology in the first phase of the pilot in Thambonkulu were assessed in terms of their ability to operate and maintain the technology independently a year after the project was implemented. The assessment demonstrated that the majority of AmaDrum users understood the basics of the operation and maintenance of the AmaDrum, and the treatment process, but there were some users who failed to understand the technology. A corrective retraining programme was therefore developed to address the knowledge gaps identified. This was followed by field assessments to monitor improvements in user behaviour and evaluate the performance of the AmaDrum in terms of water quality.

The AmaDrum appears to be a technology acceptable to household users, and one that they would recommend to others. Some households have taken the initiative of teaching other community members how to operate the technology. All households were able to assemble the drum, treat the water and generally maintain the unit after the corrective re-training. There was a significant change in user's knowledge of the treatment process as the proportion of households that was adding the incorrect dose of the purifying chemical decreased, from 55% before the retraining to 13% afterwards.

These changes in users' handling and understanding of the technology positively influenced its performance in the field. The water quality assessment results demonstrated significant improvements in the quality of the water after treatment using the AmaDrum technology. The treated water meets most of the standards set out in the SANS 241 guidelines. The microbiological parameters in a large proportion (above 85%) of treated water samples collected from the households were within limits. The users' health and hygiene behaviour contributed to non-compliance with SANS 241 limits in terms of *E. coli*. The key chemical parameters of the treated water were also within the SANS 241 limits, except for nitrates and residual chlorine. The level of chlorine in 30% of the tested samples was above the set limits, but the levels detected, while making the water taste bitter, did not pose an immediate risk.

5. CHALLENGES

One of the criticisms of the PoU products to date is the failure of the projects that piloted the use of the products to scale up beyond a limited or project-based application, to achieve long-term adoption beyond the public health initiative promoting their use, or to generate significant levels of use in a non-subsidised environment (Harris, 2005).

A review of the acceptance and long-term adoption of PoU technologies revealed a number of interacting factors. It identified compatibility with existing social and cultural norms and practices, the time required for the water treatment process, the convenience afforded by the technology, and the taste and visual appeal of the treated water, as key to the acceptability of a technology. Once an intervention has been accepted owing to its inherent properties, long-term adoption depended on another set of factors, such as cost, availability, perceived effectiveness, motivation, need for water treatment, as well as knowledge and self-confidence to take charge (Maposa, 2007). The review was based on the limited field evidence available at the time.

The interaction of these factors is illustrated in the case of the AmaDrum. In the early 2000s, the CSIR, the Department of Health, the Eastern Cape Development Corporation and Technology for Women in Business[1] undertook the AmaDrum project. The project was aimed at addressing the need to stop cholera outbreaks and other water-related diseases by ensuring a supply of clean drinking water. The science behind the proposed solution was tried, tested and found to be successful. The intended beneficiaries included various affected communities and the small, women-owned enterprise contracted to manufacture and distribute the AmaDrum in the Eastern Cape – ostensibly a win-win situation. However, it was found that the communities viewed the drums as an interim measure for use during the cholera outbreak, and not as a product for permanent use. Furthermore, some members of the community wanted running tap water, not PoU technologies, and thus rejected the technologies. Thus, in spite of their promise, the piloted products have so far failed to attain widespread adoption within the communities in which they were expected to be the most effective.

6. CONCLUSION

The following conclusions can be made on the basis of what was learnt from the implementation of the ASWSD I and II projects:

6.1 Water service providers in South Africa have invested a lot towards the provision of safe drinking water to South Africans in both urban and rural communities.

6.2 Providing safe drinking water requires an intervention that takes the situational context of each village or municipality into consideration. Supplying taps and pipes does not always mean that drinking water is

[1] A Department of Trade and Industry initiative that helps female entrepreneurs to apply science and technology-based business solutions to grow their businesses.

available. Some rural communities still relies on unsafe water sources even when there is infrastructure. (DST Policy Brief: Water service delivery: Is it pumps and pipes or reliable access to water?)

6.3 Some rural communities still rely heavily on springs and ponds for drinking water. In most cases drinking water is collected from unsafe surface sources outside the home and is then held in household containers. The drinking water may be contaminated at the source or during storage. Water fetched from taps may also be contaminated while being stored in household containers.

6.4 PoU systems have been received well by some South African communities. User training, and water and hygiene education, are important for the successful deployment, acceptance and long-term sustainability of PoU interventions.

6.5 PoU interventions can lead to dramatic improvements in drinking water quality, which is known to lead to reductions in diarrhoeal disease.

6.6 The legislation and policy environment is not conducive to the nationwide implementation of PoU projects.

6.7 There is little support from entrepreneurs for PoU devices, even if they have been tried, tested and found to be suitable for a particular community.

7. RECOMMENDATIONS

Based on all of the above, the following recommendations are made:

7.1 Any intervention in a system should be preceded by a diagnostic phase to determine the best possible intervention in a particular context; PoU or HWTS systems should be considered as alternatives to the traditional piped water where necessary. Water service authorities should consider investing in some point-of-use water treatment devices projects (a literature review and scan of water service delivery projects indicates that there is low investment into PoU by the authorities, so projects are not upscaled after the research phase).

7.2 PoU devices should be commercialised beyond the project interventions to benefit from standardisation and economies of scale. Beneficiaries of the devices should be able to purchase the devices if the need arise.

7.3 Interventions to provide safe drinking water should consider the situational context of each village or municipality into consideration. The provision of taps and pipes does not always result in the availability of drinking water (DST policy brief on water service delivery, 2014).

7.4 Water and hygiene education should be conducted even after the implementation of the project. This education initiative should be supplemented by operational and maintenance support from the authorities.

7.5 Water should be allocated so that it provides maximum benefit to all, whether directly or indirectly (National Water Resource Strategy, 2013), to ensure equity in access to the benefits of water resources. This is to be achieved by emphasising associated opportunities, for example reviewing infrastructure, investing in human capabilities, stimulating innovation, redressing historical technological inequalities, and increasing participation in the governance and management of water.

7.6 Relevant tools and indicators should be harmonised to assist in the monitoring and evaluation of PoU uptake, which is necessary in order to develop effective mechanisms to encourage and sustain the correct use of PoU.

7.7 Water services policy should be revised to incorporate and encourage the use of PoU, although not necessarily at the expense of the piped systems.

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