CHALLENGING THE "APARTHEIDS" OF KNOWLEDGE

in Higher Education through Social Innovation

Joana Bezerra, Craig Paterson & Sharli Paphitis (Eds)

Chapter 4

A community-based water monitoring programme in Makhanda/Grahamstown using the improved hydrogen sulphide test kit

Thandiswa Nqowana,
Sharli Paphitis, Roman Tandlich
and Sukhmani Mantel

COMMUNITY ENGAGEMENT, ENVIRONMENTAL
HEALTH AND BIOTECHNOLOGY
RESEARCH GROUP, FACULTY OF PHARMACY

t.nqowana@ru.ac.za

1. Introduction

HEIs have been largely focused on a prejudicial system that focuses on the idea of there being a correct way of generating and interpreting knowledge about the world (Altbach *et al.*, 2009). Most of these institutions follow strict disciplinary approaches, despite decades of attempts to encourage transdisciplinarity (Davies, 2016). Davies describes the legitimacy and value of knowledge as being dependent on the lay and expert knowledge (Davies, 2016). According to Miller *et al.*, (2008), a concept that has the ability to breach this gap is epistemological pluralism. Epistemological pluralism suggests that there may be several ways of generating knowledge and that accommodating this plurality can lead to a more successful, integrated generation of knowledge (Miller *et al.*, 2008). This

approach is particularly useful in the study and management of social–ecological systems.

The legitimacy of knowledge has been known to be affected by the stereotypes associated with particular persons based on unconscious or implicit biases (Fricker, 2007). These prejudicial stereotypes, as Fricker describes, give rise to epistemic injustice within society (Fricker, 2007; Glass & Newman, 2015). Injustices that are epistemic in nature seek to discredit people of various groups as 'knowers', either in the eyes of society or the academy (Fricker, 2007). In the pursuit of correcting this injustice, community engagement over the past two decades has been used worldwide in HE institutes to promote epistemic justice. Community-Based Participatory Research (CBPR) engages the multiple stakeholders, including the researchers, the public and community providers, who affect and are affected by local challenges (Israel *et al.*, 1998). Each partner of the CBPR contributes unique strengths and knowledge, with the aim of improving the health and wellbeing of community members concerned (Israel *et al.*, 1998). CBPR begins with a research topic of importance to the community and aims to combine knowledge with taking actions, including social innovation, to solve the problem at hand.

Rhodes University is one of the HEIs in South Africa that has been applying CBPR in different disciplines of the university. The application of CBPR at this university, although applied by a small sector of the academic departments, has been aimed at including the community of Makhanda (a small town in the Eastern Cape under the Makana Local municipality) in solving various problems faced by the town in innovative ways with the local community as agents in the process (Makana revision draft, 2017). One of the major problems faced by Makhanda has been its microbial water quality, which is lower than what is recommended by the Department of Water Affairs (DWA) (DWAf, 1996). Typically, water quality is determined by comparing the physical, biological and chemical characteristics of a water sample with water quality guidelines or standards. These standards are usually based on scientifically assessed and acceptable levels of toxicity to either humans or aquatic organisms (Luyt *et al.*, 2012).

Access to clean water across Makhanda has increased since 2004; however, the increasing demand for water is concerning as it may lead to more frequent drought conditions (DWA, 2016; Ashbolt, Grabow & Snozzi, 2001). Droughts are due to insufficient rain or an increase in the population of an area that has insufficient infrastructure (Tempelhoff, Gouws & Botha, 2009). For example, the drought in Makhanda, which started around February of 2008, is considered severe. This drought has led to the declaration of Makhanda as a water disaster area. This has

left citizens of Makhanda in a difficult position where there is a shortage of water, and when the water is available, the water quality is questionable. In this context, community-based water quality monitoring programmes are important as they equip the community with tools and knowledge of how to treat the water if the water is contaminated and consequently put their minds to rest. These programmes can include the community in the knowledge-building process, creating awareness about the danger of consuming contaminated water. For example, running workshops about the dangers of consuming poor quality water and getting the community involved in monitoring and purifying their water can help prevent outbreaks of diseases or illness.

Over the last couple of years, the Environmental Health and Biotechnology Research (EHBR) group at Rhodes University has been involved in studies of water quality monitoring and treatment strategies of tap and rainwater in Makhanda, as well as disaster management strategies. The purpose of introducing new ways of monitoring water quality to the community is to increase awareness and understanding about water quality in the community to avoid outbreaks of waterborne diseases. In geographically isolated areas such as Makhanda, alternative water monitoring tests can be used to ascertain the microbial water quality, introducing a socially innovative way to address local challenges (Tandlich, Luyt & Ngqwala, 2014). One such test is the improved hydrogen sulphide (H₂S) test kit, which has been used for monitoring microbial water quality in Makhanda for several years (Tandlich *et al.*, 2014; Luyt *et al.*, 2012). In previous studies conducted by the EHBR group at Rhodes University, it was shown that the test kit was 64% as reliable as standard indicator microorganism tests when the indicator microorganism concentration is around the regulatory detection limit for drinking water quality (Luyt *et al.*, 2012). Rates of false positive for the Colilert-derived concentrations have been reported to range from 7.4% to 36.4%. At the same time, rates of false negative results vary from 3.5% to 12.5%; and the Colilert medium has been reported to provide for cultivation of only 56.8% of relevant strains. Identification of unknown sources of faecal contamination is not currently feasible. Based on literature review, calibration of the antibiotic-resistance spectra of *Escherichia coli* or the bifidobacterial tracking ratio should be investigated locally for potential implementation into the existing monitoring system. The current system could be too costly to implement in certain areas of South Africa where the modified H₂S. Therefore, the improved testing protocol involves the use of five test kits per sampling site. In the analysis of the results yielded from the five-test-kit protocol, the water sample is considered positive

for faecal coliforms if all five test kits turn black within 72 hours of incubation at room temperatures. Water samples are considered negative if all five test kits are negative after 72 hours of incubation. Reliability of the test kit results using this modified protocol is 99.4% compared to the original testing protocol which gave a reliability score of 64% (Nhokodi *et al.*, 2016).

2. Community-based participatory research (CBPR)

In 2014, Tandlich *et al.* worked on the introduction of the H₂S test kit to a small part of the community of Makhanda for monitoring of rainwater (Tandlich *et al.*, 2014). This study led to the improved method of using the H₂S test kit used by Nhokodi *et al.* in 2016 to monitor tap water in the Eastern part of Makhanda and rainwater at Rhodes University (Nhokodi *et al.*, 2016). The results from these studies led to the development of the current extensive transdisciplinary research between the community engagement division and EHBR, where the H₂S test kit is to be introduced to a larger community basis of Makhanda using the public schooling system.

2.1 Engagement with a community partner

In 2014, the EHBR group conducted a study using a community-based monitoring and treatment programme which was based on the introduction of the H₂S test to the community (Tandlich *et al.*, 2014). A pamphlet about the sources of faecal contamination and the treatment of rainwater tanks was drafted to inform the community. Volunteers were recruited through collaboration with the non-governmental organisation Kowie Catchment Campaign (KCC)(Tandlich *et al.*, 2014). The recruitment of the volunteers with rainwater tanks was completed through contact with the KCC chairperson (Tandlich *et al.*, 2014). It was stipulated that forming a partnership with members from KCC would allow easier access to sampling sites and aid the authors in gathering information about health threats related to rainwater in Makhanda, since the authors and the KCC members had previously held discussions about microbial-related issues in water (Tandlich *et al.*, 2014). A total of eight volunteers from the KCC took part in the study, which supplied the authors with eight sampling sites. The method of engagement used in the study involved an initial meeting, where the principles of the H₂S test kit and sampling procedure using one H₂S test kit was demonstrated to the volunteers by the authors (Tandlich *et al.*, 2014). Occasional visits to the volunteers' households were also planned by the authors, with the aim of acquiring feedback from the volunteers on the use of the test kits and their experiences with

their rainwater. These occasional visits would also afford the authors the chance to advise the volunteers on observed problems during the monitoring of the rainwater (Tandlich *et al.*, 2014). Four out of the eight rainwater tanks were positive for faecal contamination on one or two occasions. The owners of these four tanks were advised by the authors on how to dose bleach into the rainwater tank according to the pamphlets provided to the volunteers. According to one-on-one interviews with the volunteers, they found the H₂S test kit easy to use.

The overall monitoring programme delivered the desired results, even though only 87.5% of the original volunteers completed the sampling. The programme could reach only seven volunteers out of total of 80 390 people in the Makhanda population. This means that not even one percent of the population was reached by the civic engagement programme launched in the study. The water quality results from the study were also not released to the public; instead, they were written in a thesis, which was printed out and displayed at the Rhodes University Library. Analysing the impact the study had on raising awareness about water quality, it can be concluded that even though it involved scientific engagement with community members, a big gap between the water quality knowledge of the community versus that of the university remained.

2.2 *Civic engagement and environmental sustainability in student projects*

In 2016, the EHBR group conducted a civic engagement and environmental sustainability project through teaching and learning (Nhokodi *et al.*, 2016). In this CBPR strategy, the research group did not involve a community partner as it did on the previous occasion. Instead, teaching and learning strategies in an academic course were used to conduct water quality monitoring. The researchers in this water monitoring project were a Bachelor of Pharmacy student and a student enrolled for Honours in Biotechnology (Nhokodi *et al.*, 2016). Both students' projects were focused on the monitoring of microbial quality of rainwater at Rhodes University campus and the Makhanda Local Municipal bulk drinking water supply. The main aims of these two projects were to use sound scientific strategies to develop a water monitoring approach where the results could be communicated easily to the Makhanda public and could benefit them (Nhokodi *et al.*, 2016)

Nhokodi *et al.*, (2016) sampled three rainwater tanks at the Rhodes University campus. The tanks were situated in various parts of campus. Permission for sampling of all rainwater tanks was obtained from the relevant Rhodes University officials (Infrastructure Division) and the results of the analyses were provided to

them (Nhokodi *et al.*, 2016). Another section of the study by (Nhokodi *et al.*, 2016) involved the sampling of municipal drinking water taps in Makhanda by Nqowana. This author chose all three sampling sites based on her scientific understanding of public health and water microbiology. She also chose the sites based on her knowledge and understanding of the water supply in the area and her concerns about possible implications of inferior microbial drinking water in her community (Nhokodi *et al.*, 2016). The author sampled all the sites herself, without involving any volunteering bodies from the community. This researcher's initiatives demonstrated a combination of scientific expertise and civic engagement, where she could introduce the H₂S test kit through interaction with the community. This interaction was prompted by the curiosity of the community when they saw the researcher sampling the communal tap (Nhokodi *et al.*, 2016). The analysis of the water using conventional methods showed that there was bacterial contamination in the water that could not be detected by these methods, therefore the author proceeded to conduct more tests on the water (Nqowana, Dube & Tandlich, 2017). These tests showed that the water in Makhanda might contain bacteria that is introduced into the water via the water distribution system (Nqowana, Dube & Tandlich, 2017).

This form of community engagement could involve a few community members, making them aware of the existence of the water quality testing kit but was not able to engage a large section of the community. This led to a partnership between the EHBR researchers with the Community Engagement Division at Rhodes University, with the vision of formulating a carefully planned CBPR water monitoring programme. The collaboration of these researchers:

- established a community-based programme with Grade 9 students at three Makhanda high schools to determine the quality of water in Makhanda through the community-based programme using the H₂S test kit;
- closed the knowledge-gap about water quality in the community using communication tools written in English, IsiXhosa and Afrikaans; and
- resulted in the distribution of water quality results acquired from the community-based programme using communication channels.

The implementation of these aims and objectives has given rise to a successful and efficient science engagement programme that can be adapted and used by local municipalities across South Africa to raise awareness about any issue at hand. The community-based programme has also lead to access to a broad

spectrum of sampling sites around Makhanda, which gives an accurate representation of the water quality across Makhanda.

3. Methods

The project development process of water quality monitoring in Makhanda was investigated and described as set out below.

3.1 *Training of volunteers and Grade 9 learners*

During the process of volunteer recruitment, six volunteers were recruited from Rhodes University's third-year Pharmacy class. Each volunteer facilitated at an introductory workshop session for the three schools. There was one introductory workshop per school, and this meant that two volunteers needed to facilitate at one workshop each. The six volunteers were trained in a lab at the Rhodes University Pharmacy Department to demonstrate the use of the H₂S test kit to the Grade 9 learners. They were also educated on the safety precautions of the kit and were asked to impart this knowledge to the Grade 9 learners.

3.2 *Piloting of manuals, surveys and workshop material*

The PowerPoint presentation on the manuals, surveys and workshop was piloted to five randomly selected Grade 9 learners from a different school to those in the study, with the aim of seeing if the material is clear and understandable. The pilot study allowed for the capturing of the time it takes to answer the surveys and could determine whether the questions on the surveys were capturing what was required.

3.3 *Preparation of the H₂S sampling kits*

A modified version of the Venkobachar *et al.*, (1994) H₂S water testing kit was used. This contained peptone (40 g), dipotassium hydrogen phosphate (3 g), ferric ammonium citrate (1.5 g); sodium thiosulphate anhydrous (2 g); Teepol (2 mL), L-cysteine (25 mg); distilled water (100 mL) (Venkobachar *et al.*, 1994). It was modified by the addition of deoxycholate (0.5% w/v) (Sobsey & Pfaender, 2002; Luyt *et al.*, 2011a). Deoxycholate has been suggested to inhibit non-faecal bacterial growth, decreasing false positive result occurrence (Sobsey & Pfaender, 2002).

The kit's preparation method was modified from Genthe and Franck's method (1999). The medium was mixed with a magnetic stirrer for 30 minutes and then left to stand for 15 minutes, forming a coffee brown solution. A one millilitre aliquot of the medium was absorbed into a 5 x 10 cm piece of filter

paper which had been folded and placed into a sterile urine jar (Spellbound Labs, Port Elizabeth, South Africa). The jars with the filter paper were placed into the UFE 700 oven (Memmert, Schwabach, Germany) overnight at 54°C . The sterility of the sterilised kits was checked periodically with 20 mL of sterile deionised water and incubation to identify positive a H₂S result due to contamination.

3.4 *Sampling procedure*

During the introductory workshop, the H₂S sampling procedure was explained to the learners verbally, while also referring to the distributed manuals which were available in English, IsiXhosa and Afrikaans. Each Grade 9 learner then received 30 H₂S test kits to collect water samples on a weekly basis for three weeks. Each learner used five kits for control purposes by adding deionised water, while the other five kits were used for sampling the source of water they use at their homes, making it a total of 10 kits per sampling occasion. Each learner conducted on-site sampling by sampling the source of water they use at their residence, be it tap or rain water. The H₂S water testing kits had approximately 20 mL of sampling water placed aseptically into the bottles. These were sealed and hand shaken to suspend the media, before being incubated at room temperature (18 – 25°C) for 72 hours. Samples were checked for the presence of a black precipitate, which was recorded as a positive result, every 12 hours. Tests remaining the initial yellow colour or which turned grey without going black within the 72 hour time limit were recorded as negative.

3.5 *Detection of faecal coliforms*

The method used in this study to assess faecal coliform concentrations was the membrane filtration method (m-FC) (MERCK) described in *Standard Methods* (APHA 1995). This method was used as a control in the study of the H₂S test kit vs conventional means of testing for presence of faecal contamination and also to calculate the correspondence rate (C_r). The correspondence was calculated with the following formula:

$$C_r = \frac{\text{(total number of corresponding H2S and mFC results)}}{\text{(total number of campured results)}} \times 100$$

100 mL of each water sample were filtered through a 0.45 µm pore membrane (Metricel Membrane Disc filters, Spellbound, Port Elizabeth, South Africa) and the filter was transferred to the medium slowly to avoid air bubble formation using sterile technique. Each sample was analysed in triplicate for independent

sampling results. The agar was incubated at 44.5°C for 24 hours and the results were captured in the form of colony forming units (CFU)/100 ml.

4. Results and discussion

4.1 *Water quality monitoring, traffic light system and GIS mapping analysis*

In Makhanda, water from the dams is treated in the treatment plants and then released into the pipe distribution system. But the condition of the water at the tap depends on the condition of the pipes, as well as factors like the concentration of the residual chlorine (Heibati, *et al.*, 2017). Brown coloured water from particles and sediment in the distribution system due to pipe breaks has increased an already sceptical Makhanda population's mistrust of the safety of its water (Richards & Daniel, 2008). Makhanda's community is very water conscious due to newspaper reports (Maher, 2006; Naketi, 2009; MacGregor, 2010; Mini, 2010; Mmango, 2010; Mngcambe, 2010) about unsafe drinking water and other reports around town. So many people are left wondering if the water is indeed safe. Thus, the aim of this project was to identify the microbial condition of tap water through science engagement using the H₂S water testing kit and identifying water quality problem areas using GIS mapping. The use of GIS maps to pinpoint where drinking water is not of satisfactory microbial quality helps identify the extent of the problem as well as the size of the area affected.

Science workshops were run at three Makhanda high schools namely, School 1, School 2 and School 3. Each Grade 9 learner received 10 H₂S test kits to collect water samples on a weekly basis for a duration of three weeks. Of the 10 H₂S kits that were distributed to each learner, five kits were used for control purposes by adding sterile deionised water, while the other five were used for sampling the source of water they use at their homes. Each learner conducted on-site testing by sampling the source of water they use at their residence and recorded the results on a supplied booklet. The results from each learner were transcribed and translated into a newly developed traffic light system as shown in **Table 1**. The traffic light system was developed with the aim of using it to communicate the results obtained from the H₂S kits in a manner that can be understood by the public. This traffic light system works on the basis that green stands for clean and safe water to drink, Yellow is a warning that the water might contain faecal contamination and may need further treatment i.e. boiling the water, and red suggests that the water is not safe to drink (Nhokodi *et al.*, 2016).

Table 1: Interpretation of number of positive H2S Kits using Traffic light system.

No. of kits positive	Colour representation	Interpretation of water quality
0	Green	Safe to drink
1-4	Yellow	Water requires further treatment (boiling) before consumption
5	Red	Do not drink! Report to councillor/Municipality

Adapted from Nhokodi *et al.*, (2016)

Table 1 was used to translate the water quality results from the learners. The data was first arranged according to the area of residence for each learner so that common area water quality results could be combined into one area, even if the learners were not from the same school. The water quality results for each area were then analysed and converted into their respective traffic light colour based on the number of positive H₂S water testing kits in that area for each week. The representative percentage for each traffic light colour at each area was then calculated and used as a point on a GIS map to depict the water quality at that area. For example, from the 90 learners who took part in the study, there were seven learners who came from a street called Daniels Street (Daniels Street is situated in Joza Location, Makhanda East). The number of positive kits from Daniels Street for the three weeks of sampling ranged from 1 – 4, meaning that on the traffic light system they were represented by a yellow colour. Therefore, Daniels Street had 100% yellow representation on the traffic light system. This 100% yellow representation meant that the water from Daniels Street required further boiling before use. This analysis was done for all the areas and a GIS map was created, as seen in Figures 1 and 2. The GIS maps were drawn for all Makhanda sampling points, **Figure 1** shows the sampling points according to GPS coordinates on the street layout of Makhanda, while **Figure 2** shows an enlarged region from **Figure 1** and the microbial water quality for each region.

Figure 1: GIS map of Grahamstown showing the sites of water sampling. The map was generated using ArcGIS 10.3 software with input information about the location of GPS sample points. A 90 m Digital Elevation Model (DEM) was obtained from the Shuttle Radar Topography Mission (SRTM) was used as the background.

The use of GIS also allows the identification of the different areas and levels which may be affected. Results from the different sampling rounds varied due to changing conditions of the water quality, which is the result of treatment efficiency and the number of pipe breaks within the area sampled.

Figure 2: GIS map of Grahamstown showing section B4, B5 and B6 from Figure 1. This region is Joza Location, Extension 4 and 5 as well as Sani Street. The water quality results are represented using the Traffic light system, with each colour representing: ● - 0 kits positive, ● - 1- 4 kits positive, ● - 5 kits positive. The percentage for each traffic light colour at each point represents the number of occurrences for that water quality at that area and is used as a point on the GIS map to depict the water quality at that area for the 3 weeks of sampling.

Results in **Figure 2** above show varying microbial water quality, with Daniels Street and Zondani Street having 100% of the colour yellow on the traffic light system. This meant that the water at Zondani Street and Daniels Street needed to be treated further by boiling before consumption. As can be seen in **Figure 2**,

Vellem Street and Sani Street had similar water quality (approximately 38% being safe to drink (green) and approximately 62% requiring further treatment before use (yellow). On the other hand, Extension 4 (Ext 4), Extension 5 (Ext 5) and Ncame Street had 78%, 88% and 67% respectively of water quality that was safe to drink (green) within the three weeks of sampling, while the remaining percentage for Ext 4, Ext 5 and Ncame Street showed the colour yellow on the traffic light system, which means that the water requires further treatment before use. Goba Street had 100% green which suggests that the water quality was good, while Wakashe Street had a mixture of good and bad water quality. In Wakashe, week 1 and 2 both had 5 H₂S water testing kits that were positive, showing a red colour on the traffic light system. This means that the water during those 2 weeks had to be reported to the local officials as it was not safe to drink. Further engagement with learners from Wakashe Street showed that there was concern about brown water due to a pipe break in that street, and through the engagement with the learners they were made aware that officials were working on the pipe.

Figure 3: GIS map of Grahamstown showing section A5 – A8 from Figure 1|. This region is Extension 6, 7, Transit Camp, Lingelihle. The water quality results are represented using the Traffic light system, with each colour representing: ● - 0 kits positive, ● - 1- 4 kits positive, ● - 5 kits positive. The percentage for each traffic light colour at each point represents the number of occurrences for that water quality at that area and is used as a point on the GIS map to depict the water quality at that area for the 3 weeks of sampling.

Figure 3 also had a mixed water quality results, ranging from 100% green in Lingelihle (A7), to points of red colour in Extension 6 (Ext 6). The water quality in Ext 6 varied greatly within the three weeks of sampling, which could be the result of many reasons. There was no pipe burst in the area, but the poor water quality could have been caused by issues with treatment during those three weeks of sampling. Transit Camp and Ext 7 had similar water quality over the three weeks of sampling, with approximately 56% and 51 % of the water quality results showing an yellow colour of the traffic light system respectively. The

yellow colour representation of these samples on the traffic light system meant that the water required further treatment as there were 1 – 4 H₂S water testing kits positive in those cases.

Figure 4: GIS map of Grahamstown showing section A4 and A5 from Figure 1. This region is Extension 8 and 9. The water quality results are represented using the Traffic light system, with each colour representing: ● - 0 kits positive, ● - 1- 4 kits positive, ● - 5 kits positive. The percentage for each traffic light colour at each point represents the number of occurrences for that water quality at that area and is used as a point on the GIS map to depict the water quality at that area for the 3 weeks of sampling.

In **Figure 4** above, Extension 10 (Ext 10) and a street in Extension 9 (Ext 9) called Ncelu Street showed the colour green on the traffic light system. Msenge Street, a street in Ext 9, had 67% of its water samples represented by green in the traffic light system, which means that the water was safe to drink, while Ncede and Nomyayi Street, also in Ext 9, only had 20% and 33% respectively of its samples labelled as green on the traffic light system. Ext 8, however, had occasions where the water that was sampled resulted in five positive H₂S water testing kits and was represented by red on the traffic light system.

Most of the areas in **Figure 5** had the representation of green in the traffic light system, excluding Victoria Road and Vukani. In fact, Victoria Road had 17% of its water samples as red.

Figure 5: GIS map of Grahamstown showing section B1, B2, B3, B4, C1, C2 and C4 from Figure 1. The water quality results are represented using the Traffic light system, with each colour representing: ● - 0 kits positive, ● - 1- 4 kits positive, ● - 5 kits positive. The percentage for each traffic light colour at each point represents the number of occurrences for that water quality at that area and is used as a point on the GIS map to depict the water quality at that area for the 3 weeks of sampling.

Water quality seemed to deteriorate significantly after pipe breaks or treatment failure. The most surprising results were for samples collected in Makhanda East, where water quality seemed to be better in some parts than others. Makhanda East is left without water more frequently and for longer periods of time than the rest of Makhanda. Positive H₂S water testing kit results were correlated with pipe breaks in the area and, on resampling, were negative, which means that the pipe breaks were fixed. This is a distinct contrast to the situation arising from the lack of chlorination in 2018, May. This has also been reported in other countries (Allen *et al.*, 2004). Pipe breaks can lead to an increased likelihood of diarrhoeal diseases (Nygård *et al.*, 2007). Using Faecal Coliform (FC) concentration as an indicator of treatment failure and distribution network issues is well-established (Carter *et al.*, 2000; Sartory, 2004; Chowdhury, 2012). A good correlation between the modified H₂S water testing kit and FC concentration values shows that it is a good alert system even under chlorinated water conditions. This is not surprising as the original H₂S water testing kit was used for tap water tests amongst others (Genthe & Jagals, 2003). Opportunistic samplings were run in middle income houses in Makhanda for three weeks and all produced positive results on week 1 with the H₂S water testing kit and FC (Luyt *et al.*, 2011a). This

was due to lack of chlorination of the Makhanda water, as was published in the local Grocott's newspaper by Sue Maclannan:

A notice dated Monday 21 May from the directorate of engineering and Infrastructure Services and signed by acting municipal manager Ted Pillay is headed 'Public notice: Water quality'. It warns residents of Makhaanda and Alicedale of a high concentration of *E. coli* – a bacterium found in the faeces of animals and humans – in municipal water.

'The municipality therefore request the residents, as a precautionary measure to ... boil the water before drinking,' the notice, issued Monday afternoon, reads. However, the high turbidity in water, while it may cause stains on clothing, does not pose a health hazard, the notice says. The problem is the result of Makana running out of supplies of the correct chemicals – a problem managers said was caused by supply chain delays (Grocotts' mail, 2014).

4.2 *Learners as citizen scientists*

The question of reliability arises from including school learners as volunteers in a water quality monitoring programme, or as citizen scientists. The Water Watch Group in America showed that volunteers can do many simple tests as reliably as experts if they are properly trained. Volunteers, such as the learners that were involved in this water quality monitoring project, provide man power which is often in short supply. Although their skills and equipment constraints limit the variety of tests they can do, they can access a large number of sites, providing more data for decision-making. The data indicates that the learners were successfully able to monitor the microbial water quality for their homes for a period of three weeks using the kit. Based on the GIS maps supplied above, the learners were also successful at recording and understanding the water results that came from the water quality monitoring programme.

As result of the water quality monitoring by the learners and their involvement in broader training and education components as part of the project, the learners gained better understanding of the term 'water conservation' and why it is important. We are unable to go into details about this broader educational and engagement project (which included workshops and poster designing competitions at the schools) in this chapter – that would provide material for another chapter in itself – but will briefly discuss some of the learnings from the qualitative studies undertaken to evaluate these aspects of the project. Through the science engagement, learners were able to understand more about water quality and learned about the risks associated with consuming water contaminated with faecal coliforms like *E. coli*. There was wide agreement amongst

learners on the risks associated with consuming water of poor quality and its links to illness/disease. The qualitative evaluations showed that before the learners were exposed to the kit, their method of water quality monitoring included appearance of the water, taste of the water and reporting it to someone who has access to testing materials. After the learners were exposed to the H₂S water testing kit, they were more accustomed to using the kit or reporting the water to the lab. After the engagement with the learners, more learners acquired some form of agency where they decided to boil the water first before reporting it to municipality. During the time of the engagement, the learners were having more conversations about water, specifically about water quality, with their families, and the learners got the chance to learn more about the H₂S kit and also tell their community about the kit during their presentations. Learner attitudes towards science as a subject and a career changed significantly from the time they were introduced to the programme to after they completed their individual projects of monitoring water at their homes.

5. Conclusion

The large-scale citizen-driven science project described in this chapter would not have been possible without challenging the boundaries of the traditional knowledge creation paradigm or the epistemic prejudices which underly it. While those traditionally deemed to be non-specialised scientists have frequently been excluded from participation in research in the role of scientist, citizen science projects assume epistemic credibility in citizens and include them as collaborators in the knowledge-making project. Learners were trusted as knowers and co-investigators in the research, as well as in coming to understand and address their own community challenges. Learners were allowed to take up active roles as scientists, thereby the testing of water quality in Makhanda were placed in the hands of the community. The learners collected and tested water samples from a large geographic area which allowed for the thorough microbial quality analysis of Makhanda water in a broad area. Through involving learners and their families in the project, science was presented as accessible. The application of science in the daily lives of community members and participants transformed these people, who are more in tune with their space and resources, into agents of change in their communities. The community-based water quality monitoring programme described in this article can be used as a template from which to draft an efficient tool for establishing involvement of citizens in science at a community level and narrowing the knowledge-gap about water quality and water treatment options. As a result, the outbreak of

waterborne diseases at the local government level, not only in Makhanda, but also in South Africa as a whole, can be prevented.

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