Assessing Wetland Health Using a Newly Developed Land Cover Citizen Science Tool for Use by Local People Who Are Not Wetland Specialists

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Abstract

More than half of the wetlands in South Africa have been degraded or lost due to economic activities, urban developments and poor wetland management. Reversing the trend would require the participation of a wide range of actors in addition to scientists. A case has been made for a citizen science approach in order to empower the public with skills and knowledge that would enable them to understand environmental issues without depending on specialists. However, the wetland health assessment tools used in South Africa are highly technical, rendering them largely inaccessible to non-specialists. Recently, Kotze (2015) developed a tool which seeks to address this gap by involving the wider community in monitoring the health of wetlands in South Africa. The aim of the present study was to test the extent to which the new wetland health tool can be used by local people to better understand their surrounding wetlands. The study's findings indicated that the tool enabled non-specialists to generate information about wetlands that was not significantly different from that produced by specialists.

Keywords: Environmental education, citizen science, public engagement, environmental management, wetland assessment tools.

Introduction

Since the 1960s, there has been growing interest in educating the public about the environment. Environmental education and education for sustainable development have both become prominent in recent years (McKeown, Hopkins, Rizi & Chrystalbridge, 2002). Whereas environmental education focuses on a public that is environmentally literate (Ehrlich, 2011), education for sustainable development also aims to empower the public to participate in decision-making (Hopkins & McKeown, 2002). Both approaches are designed to ensure the well-being of society and the environment, and require behaviour change among members of the public towards better environmental management (Kopnina, 2013). Studies (e.g. Stevenson, Peterson, Bondell, Mertig & Moore, 2013) have shown that environmental education and education for sustainable development can result in the desired behaviour change and in better environmental outcomes.

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In the southern Africa context, education for sustainable development has not replaced environmental education, but aspects thereof have been incorporated in environmental education processes as being relevant to the socioecological context (Lotz-Sisitka, 2004). Environmental education is not only critical for the school curriculum, but can also address community concerns by exploring and implementing solutions to environmental problems through practical actions (Hungerford, Volk, Ramsey & Bluhm, 1994). As most of the population in southern Africa resides in rural areas, natural resources are important for their livelihoods. Environmental education in the region therefore needs to have a strong focus on enabling people to sustain livelihoods and on reducing poverty.

Since environmental education and education for sustainable development are both informed by many different disciplines, the knowledge passed on to learners as well as the general public has been broad and extensive (McKeown *et al.*, 2002). This is important, as it allows the public to be well informed regarding environmental management and contributes to their resilience to environmental shocks (climate change and related natural disasters), which, along with population growth, can result in declining natural, social and economic assets (Telfer & Sharpley, 2015).

For effective environmental management and better environmental outcomes at the local level, several studies (e.g. Hochachka, Fink, Hutchinson, Sheldon, Wong & Kelling, 2012) have highlighted the need for the public to be able to gather their own information and make sense of it without depending on environmental specialists. Citizen science, which refers to research in which local volunteers and/or stakeholders play a prominent role as participants in promoting sustainability, has become a popular approach (Silvertown, Buesching, Jacobson & Rebelo, 2013). Citizen science combines environmental research with environmental education and observation (Dickson, Shirk, Bonter, Bonney, Crain, Martin & Purcell, 2012). Scientific information which would otherwise be too complex for non-specialists to understand may then be simplified, thereby empowering a wide range of locals (the elderly, the youth, the non-educated, women, and others) to participate in local programmes (Merenlender, Crall, Drill, Prysby & Ballard, 2016).

The benefits of citizen science include employment creation through skills passed on to volunteers, as well as broader and increased participation in, and understanding of, environmental policies and science projects (Conrad & Hilchey, 2011; see, also, Dickinson *et al.*, 2012). A recent study by Ballard, Dixon and Harris (2017) demonstrated that involving local people in information gathering for the purpose of conservation initiatives capacitates them for future conservation efforts. The tools developed can enable communities to act; hence people must be able to understand them with minimal input from the specialists, and must be able to produce reliable data (Thornhill, Ho, Zhang, Li, Ho, Miguel-Chinchilla & Loiselle, 2017). Citizen science is an approach to environmental education that allows the public to be on par with the specialists with regard to the data collected (Ghilardi-Lopes, 2015).

The use of citizen science in enabling environmental education has been increasing in developed countries such as the United States of America (USA) and the United Kingdom (UK) (Sullivan *et al.*, 2014). According to Sullivan *et al.*, (2014), it is also slowly being adopted in the rest of the world, including South Africa.

A few caveats concerning the citizen science approach in environmental management have been highlighted in the literature, with the poor quality of data being the principal challenge. Data collected by volunteers who lack the requisite skills are likely to be fraught with measurement errors. In addition, local volunteers may prefer certain sites more than others, resulting in selection bias (Cooper, Dickinson, Phillips & Bonney, 2007). In most cases, citizen science requires coordination of a high number of volunteers, which brings with it logistical challenges. The volunteer participants in citizen science programmes usually do not start with an understanding of the objectives of the programmes, thus requiring the specialists to clearly explain and define these objectives (Silvertown *et al.*, 2013). Although these negative aspects of citizen science have been noted, the consensus is still that it is an empowering approach that can lead to better environmental management, and to better wetland management, if it is implemented appropriately.

Wetland Health Assessments

A wetland is defined as 'land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil' (DWAF, 1998:9; SANBI, 2013). Wetland health is defined as the difference between the wetland's current structure and function, and the wetland's natural structure and function (Ollis, Ewart-Smith, Day, Job, Macfarlane, Snaddon & Mbona, 2015). Wetlands are a crucial ecosystem, as they are irreplaceable. They perform many ecosystem functions and services. These functions are the processes that take place within a wetland, such as water storage, water purification, the transformation of nutrients, and supporting the growth of living matter and wetland plants. These processes work together to maintain the wetland. Wetlands are involved in recharging groundwater, in the attenuation of flood peaks and in erosion control. They are also widely used for recreation purposes and food security. Wetlands supply rivers with water during the dry season, help in reducing desertification, combat droughts, and reduce flooding (Russi *et al.*, 2013; SANBI, 2013).

More than half of the wetlands in South Africa have already been degraded or lost (Jogo & Hassan, 2010; Nel, Colvin, Le Maitre, Nobula, Smith & Haines, 2013). Even though wetlands cover only 2.4% of South Africa's land, their destruction has a ripple effect far beyond the land which they cover (SANBI, 2013). According to Nel *et al.* (2013), our wetlands are threatened by a number of practices, such as large-scale crop cultivation, and especially mono-cropping. Wetlands can also become contaminated with soil and fertiliser runoff as a result of poor land management in crop agriculture. Poorly managed plantations of pine and wattle also lead to the degradation of wetlands; as a source of alien vegetation, they use more water than natural vegetation, thus reducing the amount of water available in the aquatic systems.

Wetland management plays a crucial role in conservation and the wise use of wetlands (Farrier & Tucker, 2000). One of the major challenges for wetland management is that a vast amount of data over a large spatial area is required to clearly understand the state of wetlands (Bonney, Cooper, Dickinson, Kelling, Phillips, Rosenberg & Shirk, 2009; Thornhill *et al.*, 2017).

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Environmental managers and practitioners are always looking for ways in which wetlands could be better understood and better protected (Allison, 2012). Many people do not value wetlands as much as they should owing to a lack of understanding of the importance of their ecosystem functions and their value to society (Lambert, 2003). One way of both educating people and involving them in the management of wetlands is citizen science (Ballard *et al.*, 2017). In line with the citizen science approach, Kotze (2015) has developed a rapid health assessment tool for wetlands. This tool seeks to empower participants to assess and monitor the state of local wetlands.

Previously, there were two main wetland assessment tools in South Africa, the WET-Health assessment tool and the Wetland Index of Habitat Integrity (IHI) assessment tool. These tools examine the different characteristics of wetlands, but neither of them promotes the participation of locals, as people who are not wetland specialists find the tools difficult to understand (Kotze, 2015). The new method seeks to examine all the ecological factors that affect wetlands, but in a simplified format based on WET-Health and Wetland IHI. This is a rapid-assessment tool that combines aspects of WET-Health and Wetland IHI and then focuses on land cover types/ disturbance units in wetlands and their upslope catchments. This tool was specifically designed for the citizen scientist. The ecological units that are assessed using WET-Health and the Wetland IHI have been simplified and assigned values that can easily be understood by the citizen scientist. The simplified values mean that citizen scientists do not have to know the four components that are being assessed, namely hydrology, geomorphology, water quality and vegetation.

New wetland monitoring tool

The newly developed wetland health tool is aimed at enabling people who are not wetland specialists to conduct assessments and determine wetland health. This tool or method assesses ecological conditions based on four components: hydrology, geomorphology, water quality and vegetation. The water quality component examines the physical, chemical and biological characteristics of water that are controlled or influenced by substances either dissolved or suspended in the water (Kotze, 2015). The tool works by determining the extent of land cover types present within the wetland and its catchment area. This is based on a comprehensive list of land cover types, with pre-assigned intensity scores based on expert judgement, peer review and scientific literature. The fact that these impacts have all been pre-assigned by an expert is a key difference between this tool and the other two used in South Africa (i.e. WET-Health and Wetland IHI).

The newly developed tool uses a scoresheet in an Excel spreadsheet which determines the health of the wetland using land cover type impacts. Once the impact is determined, the tool works out the Present Ecological State (PES) category of the wetland. This PES category ranges from A to F, with A being 'No impact on wetland integrity (health)', and B being 'Modification of wetland integrity is small'. C is used when modification of wetland integrity is clearly identifiable but limited. D is employed when approximately 50% of wetland integrity has been lost. E is assigned when more than 50% of wetland integrity has been lost. Finally, PES category F is used when the ecosystem processes of wetland health have almost been destroyed, or have in fact been totally destroyed and the wetland can no longer provide ecosystem services and value.

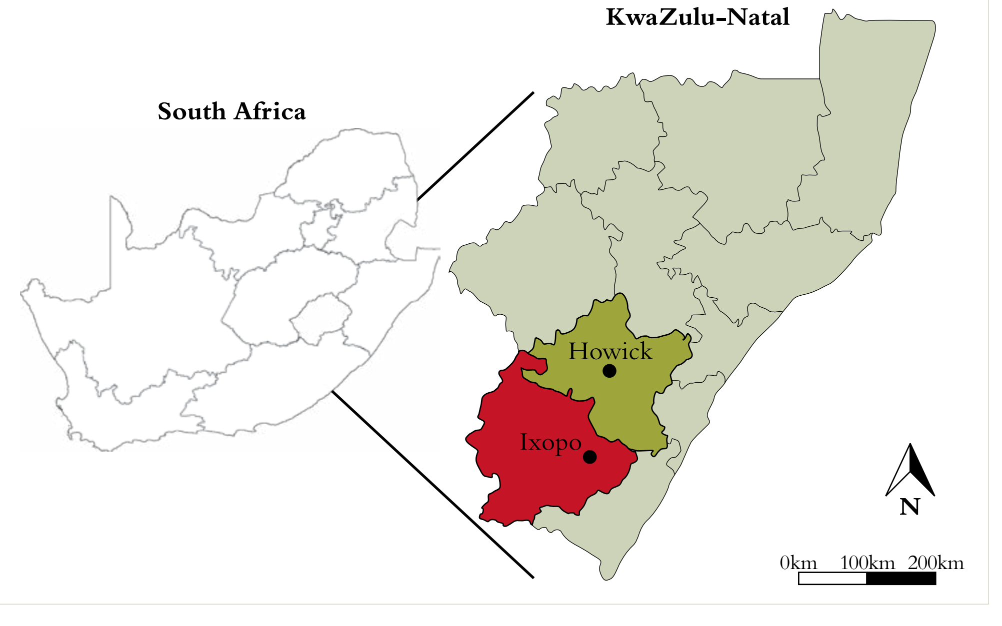
The present study was aimed at testing the extent to which the newly developed citizen science wetland health tool can be easily and effectively used by local people who are not wetland specialists in order to better understand their surrounding wetlands. The accessibility of the tool to non-specialists would make it an important element of environmental education that could: engage all citizens, regardless of their socio-economic and demographic characteristics; allow one to move beyond awareness and enable people to make informed decisions on environmental issues; and facilitate changes in the ways in which people view and act concerning the environment (Wals, Brody, Dillon & Stevenson, 2014). The study therefore seeks to ascertain whether the new citizen science tool addresses some of these pertinent aspects of environmental education, as well as whether any changes need to be made to the tool to improve accessibility and usefulness.

Methodology

Study area

Two wetlands were studied (see Figure 1): Siphumelele wetland at Howick and the Ixopo Golf Course wetland at Ixopo. The sites were chosen because they had most of the disturbance units that could be identified using the tool. Before the assessments were made regarding these wetlands, participants were trained in one-day workshop sessions, which introduced them to the tool. The two wetlands were assessed over a day each, since this is a rapid wetland assessment tool. A total of 56 participants took part. Ten participants carried out the assessment at Siphumelele wetland, and the other 46 assessed the Ixopo Golf Course wetland. The participants were

Figure 1. The study areas at Ixopo and Howick, KwaZulu-Natal, South Africa



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from different backgrounds and were purposively selected to represent the various groups of people who would be potential users of this tool, including: landowners, government officials, field technicians, environmental practitioners, wetland practitioners, educators, people who had completed only secondary education, university students, people from non-governmental organisations and conservancy forums, and other interested and affected parties. Wetland specialists also conducted the assessment in order to act as controls.

Data generation

The present study was conducted using mixed methods, as it was important, from both a qualitative and quantitative point of view, to understand participants' views on the tool that was being tested. The qualitative and the quantitative approaches were used for triangulation purposes (Creswell, 2013). Table 1 summarises the study objectives, the data collected, the data-collection tools, and the analysis methods that were applied in the study. A scoresheet was assigned to participants to fill in independently, and the results of participants were then compared. Focus-group discussions and questionnaires probed the perceptions of the participants after using the tool.

Table 1. Summary of the study objectives, data collected, the data-collection tools and the analysis methods

Research objectives	Data to be collected	Data-collection tool	Data analysis
To test whether the participants could use the tool	How easy it was to collect data, give scores accordingly and interpret data correctly	Questionnaire; scoresheet	Descriptive statistics
To identify factors that might affect the variability of the scores	Gender; level of education and experience; scores	Scoresheet; questionnaire	Analysis of variance
To determine perceptions regarding use of the tool	Views of participants	Questionnaire; key-informant interviews; focus-group discussions	Content analysis

The procedures followed in conducting the present study were based on a mixed-methodology triangulation design as described by Creswell and Clark (2007). The purpose of the design was to interpret the findings of the quantitative method using the qualitative findings.

A workshop was held with participants prior to them testing the tool. In the workshop, the participants were given an introduction to, and background information on, wetlands. They were then introduced to the newly developed tool. A trial run on how to use the tool was done. Clarity regarding the maps used as part of the tool and the field exercise was provided. After the workshop, the participants had to go into the field and apply the tool on their own. On conclusion of the field exercise, the participants submitted their independent assessments for comparison. They were then asked to complete the questionnaire by reflecting on the experience.

The instruments that were used to collect data in this study were: the land cover-based tool/scoresheet; the questionnaire; the scoresheet that the participants had to use in the field; the focus-group discussion guide; and the key-informant guide for post-session feedback. The tool/scoresheet was used to assess the wetlands and collect the quantitative scores. The scoresheets were analysed for missing data to investigate the extent to which the participants had understood how the tool works. The questionnaire was used to collect both quantitative and qualitative data. The questionnaire included demographic information of participants (such as gender, education level, type of qualification and job, and their organisations) as well as Likert scale-type questions to rate the level of satisfaction in using the tool.

The quantitative data were collected using the newly developed tool and a questionnaire. After assessing the wetland using the tool, the participants completed a questionnaire. The total number of assessors who began participating in the assessment of the two wetlands was 60 participants, but only 56 managed to participate throughout the study.

The qualitative methods were used to assist in generating rich, detailed data that left the participants' perspectives intact. Focus-group discussions were held to ascertain the participants' views on the tool after using it to assess the wetlands. This helped in identifying the gaps in the tool as well as the understanding of the participants. The groups were separated according to age, namely mainly young adults (16–35) and adults (above 35 years). A total of five focus-group discussions were held at the Golf Course wetland in Ixopo, with the 50 participants divided into groups of ten. Three of the five groups comprised young adults, and the remainder consisted of adults. Only one focus-group discussion was held in Siphumelele. The focus-group discussions had a time limit of 30 minutes each. The discussions were recorded on paper.

The limitations of the study were that the participants and stakeholder groups were confined only to those who had at least completed secondary-school education. Moreover, only two wetlands could be tested, thus limiting the types of wetland and range of wetland health which could be included in the study. Only valley bottom wetlands were studied, as these were the only ones accessible at the time of the study. Wetlands are classified into five different types, namely channelled valley bottom, unchannelled valley bottom, floodplain, hillslope seepage and pan wetlands (DWAF, 2007).

Data analysis

The quantitative analysis for this study focused on a quantitative comparison of the independently assessed condition scores for the wetlands by different participants. The comparisons were made with regard to the participant's scores and these scores were then compared with an expert's score (indicated as a control in tables and graphs). For the questionnaire analysis, information from the questionnaires was captured in an Excel template that had been created. The captured data were then transferred to the SPSS (Statistical Package for Social Sciences) where a few data manipulations and analyses were carried out. The qualitative analysis was conducted in order to guide interpretation of the results from the quantitative analysis, and to determine whether participants could use the tool. This included visually comparing participant's scoresheets with those of the experts.

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Results and Discussion

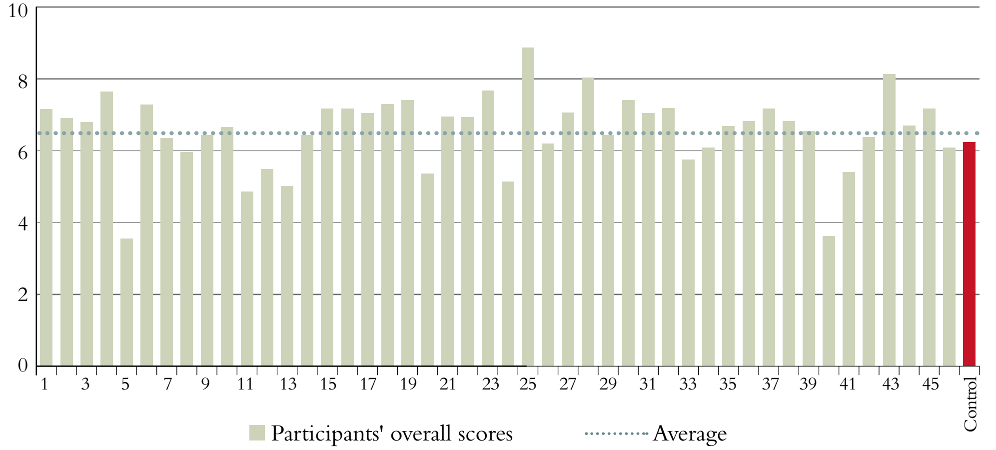
The Siphumelele wetland was assessed by ten participants. All the participants were compared with Participant 2 (control), who is a specialist on wetlands and has over 20 years' experience in working with wetlands. The overall results (indicated in Figure 2 and Figure 3) in this case are the combination of the results from the assessment of the impact on the wetland of land cover types present within the wetland, and an assessment of the impact on the wetland of land cover types present within the wetland's upslope catchment. The overall score is calculated by using a weighted score of combined impact scores derived from the scores for 'Hydrology', 'Geomorphology', 'Water quality' and 'Vegetation'. This score is weighted as 3:2:2:2, as recommended by Macfarlane, Kotze, Ellery, Walters, Koopman, Goodman and Goge (2009) (Kotze, 2015).

Figure 2. Overall scores combining land cover type impact on wetland and land cover type impact on catchment for the Siphumelele wetland

Figure 2 indicates that the control's overall score was 6.4 for the Siphumelele wetland, and that the scores of the other participants assessing this wetland ranged from 5.0 to 7.9. This translates into an overall PES of D and E, meaning that at least 50% of this wetland is modified. The significance of the variance, using Levene's Variance Comparison, was only 0.59, meaning that the scores were *not significantly different* between the specialist (control) and the non-specialists. For instance, Participant 6 had exactly the same overall scores as the control, even though it was the first time that this participant was using any wetland health assessment tool.

In the Ixopo Golf Course wetland health assessment, Participant 5 from the Siphumelele assessment was used as the control owing to this participant being part of both assessments and having had experience in working on wetlands. Figure 3 shows the overall scores that the participants arrived at for the second wetland. Of the 46 participants assessing the Ixopo Golf Course wetland, 37 arrived at the same PES category (E) as an overall result, which was the same category as that for the control's results. The remaining nine participants arrived at D category overall results.

Figure 3: Overall scores combining land cover type impact on wetland and land cover type impact on catchment for the Ixopo Golf Course wetland



For this wetland, the variance when using Levene's Test of Significance was 0.51. This indicates that there was equal variance between those participants who had experience with using other wetland health assessment tools and those who had none.

The variation in the overall scores at both wetlands was mainly due to the difference in the identification of land cover types by the different participants in both the wetland and the catchment.

These results show that the participants' scores did not vary much from those of the control, which implies that most of the participants understood what was required of them and could use the tool on their own. Furthermore, utilising this tool did not require previous experience in working with wetland tools. This also means that participants using this tool could produce quality data, as they were able to arrive at results that were statistically comparable with the control's results. This tool could also enable communities to act in the interest of protecting wetlands, as participants now understand the impact each land cover type has on a wetland and can identify and categorise the different land covers. In addition, minimal training was needed by the specialists in order for the citizen scientists to understand the impact each land cover type has on a wetland.

In the questionnaire, the participants were asked if they would ever use this tool again. The majority (84%) indicated that they would use the tool in future (see Table 2). Participants who were not sure whether they would use the tool again explained that they were mainly employed to deal with administration. The perception of 70% of the participants after utilising the tool was mostly that it was easy to use. Only 20% of the participants had difficulties in using the tool, with 10% of the participants indicating that they were not sure whether it was easy or difficult to use the tool. Based on the overall perception of the participants, as well as the data (scores) obtained, one could say that it is not difficult to use this tool. The majority of participants who utilised this tool (88%) thought it would help them to better understand wetlands.

Table 2 summarises the demographic data in respect of the participants in both the Siphumelele and Ixopo Golf Course wetland assessments, including their prior experience and their perceptions concerning use of the tool.

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Table 2. Summary of the participants' demographic data, their experience in wetlands assessment and their perceptions concerning the new tool [n = 56] – Siphumelele and Ixopo Golf Course wetlands

Variable	Indicator	Percentage (%)
Education level	Secondary	46
	Undergraduate	39
	Postgraduate	15
Gender	Female	59
	Male	41
Occupation	Environmental services	56
	Other	44
Experience in working with wetlands	Less than a year	52
	1 year to 2 years	34
	3 years and more	14
Use of wetland tools	Have not used wetland tool before	79
	Have used wetland tool before	21
Level of expertise perception with regard to wetlands	Participants with experience with wetlands	70
	Participants without experience with wetlands	30
Likelihood of using tool in the future	Likely	84
	Not sure	12
	Unlikely	4
Ease of using the tool	Easy	79
	Difficult	21
Improvement of understanding	Likely	88
	Not sure	7
	Unlikely	5

Conclusion and Recommendations

It is indeed possible to develop tools for citizen science that can be utilised for both environmental education and for environmental monitoring and management. This study showed that the wetland health assessment tool developed by Kotze (2015) is practical and suitable both for creating awareness and greater understanding of wetlands, and for supporting citizen-based monitoring of wetlands. It can be used by people who are not wetland specialists. It is evident that citizens can actively participate in scientific wetland research once they have been exposed to the subject and given suitable tools. In this way, more wetlands can be assessed and monitored than can be done by scientists on their own.

It is recommended that this tool be adopted and used by people with different levels of education in order to enhance the understanding of wetlands and wetland health, and to broaden the base of people contributing to wetland monitoring and research around South Africa. It is also recommended that other citizen science tools be tested and developed to assist in better environmental management. Of course, it is always important to test tools carefully and to proceed with caution when drawing conclusions from the results.

Notes on the Contributors

Nondumiso Dumakude is studying towards a masters in Environmental Science at the University of Free State, South Africa. She is also an environmental officer working with schoolchildren and the community to better manage their environment.

Dr Mark Graham is an aquatic ecologist with over 30 years' experience in terrestrial and aquatic ecosystem functioning and management. He is currently the director at GroundTruth in South Africa, a biomonitoring services and environmental consultancy.

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