Exploring the use and disposal of water around Constructed Wetlands in Setswetla.

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A research project submitted in partial fulfilment of the requirements for the degree of Master of Art by Coursework and Research Report (Organisational Psychology) in the Faculty of Humanities, University of Witwatersrand, Johannesburg, 31st March 2022.

Declaration

I declare that this research project is my own, unaided work. It has not been submitted before for any other degree or examination at this or any other university.

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31st March 2022.

Abstract

Background: Setswetla is a low-income, unplanned settlement located in Alexandra, Johannesburg. The community is characterised by an absence of sanitary services for effective disposal and recycling of greywater. As such, embedded water pathways in the street have provided channels for the eventual disposal of this greywater into the Jukskei River. Consequently, this results in surroundings plagued by high concentrations of *E. coli* and other harmful substances, which present a number of health risks to the community members.

Aim: Taking initiative from recommendations posited by a 2020 consultancy report, two redesigned constructed wetlands (CWs) were erected within the community to combat the problem of greywater disposal, treatment, and removal. Constructed wetlands have emerged as nature-based, low-cost technologies for greywater treatment because they imitate the natural filtration process of naturally occurring wetlands. Therefore, the aim of this study was to investigate whether the redesigned constructed wetlands supported the community members' wastewater disposal behaviour as well as if they were being used appropriately.

Method: Through direct observation, the activities of the community members in relation to their use and disposal of water around the re-designed constructed wetlands were studied. *The work sampling technique approach* and *time-and-motion approach* were utilised to determine the frequency in occurrences of the activities under study as well as the time spent going through the different activities. Behavioural themes gleaned from these observations were then quantified through a content analysis. Furthermore, short-structured interviews were conducted to enquire into the possible reasons for the observed behavioural trends of the community members. Thematic content analysis was used to analyse this data.

Results: The results suggested that the constructed wetlands were being utilised appropriately by the majority of the community members and they supported their water disposal behaviours. Additionally, it was found that they assisted to combat the problem of greywater disposal.

Key words: Greywater, Constructed wetlands, Environmental risk, Greywater treatment, Informal Settlements, Greywater disposal, Green Ergonomics

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CONTENTS

Introduction

Over the years, the ruinous activities of humans emanating from industrial waste and deforestation among many others have arguably led to the jeopardization of multiple environmental systems essential for the continued sustenance of life (Kalantzis, Thatcher & Sheridan, 2016). A great deal of human behaviour as well as the intricacies of our culture and economies influence our climate including the severity and regularity of adverse events (Hārtel & Pearman, 2010). Consequently, the destructive change in our weather systems presents a pressing concern that threatens all. *Green ergonomics* has emanated as one of the responses to climate change and a way of ensuring environmental sustainability (Thatcher, 2013). It is "conceptualised to specifically describe ergonomics with a pro-nature emphasis as well as focus on the bi-directional connections between human systems and nature in order to enable the wellbeing and effectiveness of human and natural systems" (Thatcher, 2013, p. 389).

Constructed wetland (CW) technology is an established multi-purpose, natural, low-cost technological option that is engineered and designed for wastewater treatment and water management (Chong-Bang, Wang, Lui, Zhu, Ge, Chang, Chang & Ge, 2010; Yongjun, Lui, Zhang, Hu & An, 2010). Research has shown that wetland systems are capable of achieving high treatment proficiencies concerning both inorganic and organic nutrients as well as remove pathogens if managed properly and utilized efficiently (Mthembu, Odinga, Swalaha & Bux, 2013). Likewise, as garnered from the numerous applications of constructed wetlands worldwide, they have been shown to have long lasting environmental and economic advantages (Stefanakis, 2019).

This research forms part of an ongoing exploration into the use and disposal of water around constructed wetlands in Setswetla, an unplanned settlement in Johannesburg. The community is plagued by the inappropriate disposal of wastewater—herein referred to as greywater—because it just gets dumped on the ground and this constitutes an environmental pollution problem which is a detrimental hazard to the well-being of the community members as well as the sanitary upkeep of their surroundings (Shaik & Ahammed, 2020).

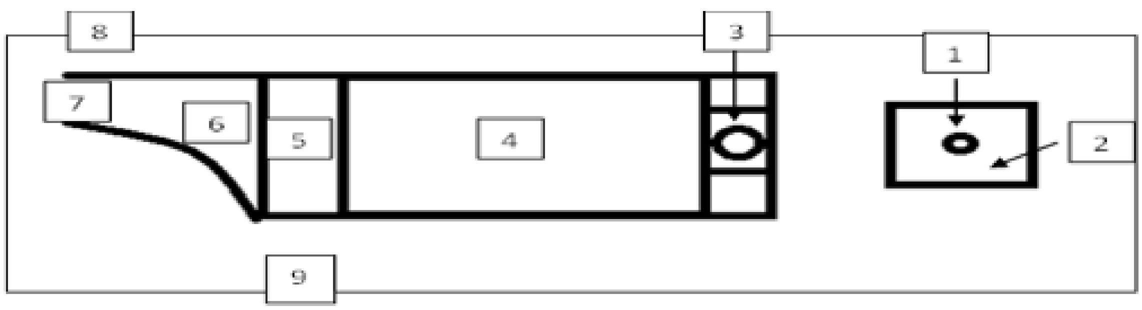
Two constructed wetlands were built in 2020 to combat this issue and in that same year, their use had been evaluated. Data gleaned from a consultancy report provided in December 2020 revealed that due to a number of design problems, the constructed wetlands were not being utilised in a manner that would encourage the necessary flow and filtration rate needed for wastewater purification (Todd, Davy & Ryan, 2021). Hence, as part of the plan to address these concerns redesigned constructed wetlands were implemented in April 2021, taking into consideration the recommendations put forth by last year's consultancy report. This study, using a task analysis, which included structural observation, aimed to investigate whether the redesigned constructed wetlands supported the community members' wastewater disposal behaviour. The study also looked at whether the redesigned constructed wetlands were being used appropriately.

Rationale

Water insufficiency is a South African reality. The country is characterised by semi-arid conditions and an average rainfall of 450mm/year, which is well beneath the world average of about 860mm/year (Otieno & Ochieng, 2004). Johannesburg, the economic core of the country, stands testament to the effects of this limited natural resource on the individuals inhabiting the area. For one, a lack of access to safe and secure sources of water, especially in many informal settlements and townships, poses serious health risks to the occupants. These dense, unplanned habitats significantly overload the available infrastructure to the extent that the water pressure is lowered, and the sewers become susceptible to frequent blockage and overflow (Greater Johannesburg Metropolitan Council, 2000). Additionally, mismanagement of water delivery networks and the exhaustion of the available water sources by continuous pollution have further exacerbated this problem (Otieno et al., 2004). Setswetla is a low-income, unplanned settlement located in Alexandra, Johannesburg on the banks of the Jukskei River (Leonard & Dladla, 2020). The community is characterised by a high population with many occupants residing in shacks or self-constructed dwellings. Access to water and electricity is available to most residents through standing, community-shared taps, scattered within the settlement and electrical connections from Municipality-installed transmission towers. However, there is little to no sanitation in the area where greywater can be disposed of effectively. Consequently, embedded water pathways in the street have provided channels for the eventual disposal of this greywater into the Jukskei River. This water contaminates the river and the community's surroundings with high concentrations of *E. coli* and other harmful substances that present a number of health risks to the inhabitants of Setswetla.

At present, there is a growing need for sustainable practices aimed at preserving the environment and protecting human and ecological health (Thatcher & Yeow, 2016). In South Africa, it is of particular importance to investigate alternate *green technologies* to substitute current available water recycling strategies given the problem of water scarcity (Melissa, 2005). Research by the South African Department of Water Affairs found that despite the 850 municipal treatment plants available in the country less than 50% of the assessed 499 wastewater treatment systems met the regulatory international and national water quality standard for wastewater treatment (Mthembu et al., 2013). The execution of inexpensive, easy-to-implement greywater technologies has therefore emerged as a possible solution to avoid water losses and to recycle greywater (Kalbar, Karmakar & Asolekar, 2012). A Constructed Wetland (CW) is an old technology, created to "exploit natural processes in order to remove pollutants from municipal, industrial wastewater or from mine drainage" (Mthembu, 2013, p. 4543; Stefanakis, Akratos & Tsihrintzis, 2011). These natural processes include soil, gravel, microbial activities, and vegetation to treat contaminated water (Vymazal, 2005). Additionally, the relationship and interaction between the microbes and vegetation contribute to the effective performance of the constructed wetland system (Vymazal, 2005).

In an attempt to develop interventions to reduce the concentration of harmful substances and *E. coli* in the greywater in Setswetla, two constructed wetlands—*top wetland* and *side wetland*—where erected within the informal settlement in February to March 2020 and based on observations from the consultancy report it was found that there was minimal usage of these sites (Todd et al., 2021). For the *top wetland*, the broken tap presented a significant issue and likely influenced usage. Additionally, it was constructed in such a way that a brick edging (as illustrated in Figure 1, numbers refer to the elements of Figure 1) enclosed the municipal ***tap*** (1) thereby leaving little space within the ***tap area*** (2) to conduct washing and other related activities (Todd et al., 2021). Consequently, the residents would usually perform these activities removed from the constructed wetland site and dispose of their greywater in places other than into the ***wetland inlet*** (3) (Todd et al., 2021). This inlet was connected to the ***wetland*** (4) for the direct deposit of disposed grey water. The main part of the wetland contained plants, gravel, and other materials for the filtration of greywater (Todd et al., 2021). The ***wetland end*** (5) followed immediately after the wetland and this made way for the ***wetland exit area*** (6) and then the ***stream*** (7). Figure 1 and 2 present an apt depiction of top wetlands' schematic.



Top wetland Schematic

Figure 1

Top wetland

Figure 2

Regarding the *side wetland* in Figure 3, it was located next to a ***waste stream*** (5) that runs down the side through the community and eventually down to the Jukskei River. It had a ***tap*** (1) with brick surrounding, right of the ***disposal area*** (2). Furthermore, similar to the top wetland, it had a ***wetland inlet*** (3), which led into the plants of the ***wetland*** (4) for filtration. In line with the minimal usage of the wetland sites as noted in the consultancy report, it was found that the nearby waste stream was used as a disposal site for greywater as opposed to the *side wetlands'* inlet (Todd et al., 2021). According to interviews with users, it was understood that it was easier to simply dispose of water into the *waste stream* than to lift containers to the inlet of the constructed wetland (Todd et al., 2021). Generally, it seemed that residents would not lift containers because they can be quite heavy, and will simply upend the water next to the tap or into the waste stream (Todd et al., 2021). This habitual behaviour is not unreasonable, as the residents would usually perform their activities, be it washing or the collection of water, in a stooped posture (Todd et al., 2021). Therefore, lifting 20L and 40L tubs and containers to dispose of water into the constructed wetland inlet as opposed to just upending them by the base of the tap appears to not be feasible behaviour (Todd et al., 2021).

Side Wetland Schematic Side Wetland

Figure 3

Double taps, a non-constructed wetland site illustrated in Figure 4, contained two taps, ***one higher in the street*** (1) with a ***second further down (3)***. The Municipality with concrete bases and bricks surrounding provided both taps. The drain from both taps empty to just below the second tap and this has resulted in a ***natural wetland*** (5) at the bottom of the site (Todd et al., 2021). Both taps have ***activity areas*** next to the tap area (2 & 4). While not formalized areas, this is where users performed activities such as washing, following interaction with the tap. *Double taps* was the most used area and showed great potential as a constructed wetland site. The majority of users at this site disposed of their water at the base of the tap, which flowed into a drain and emptied onto the street (Todd et al., 2021). Furthermore, the general structure of the tap, cemented based and brick surroundings provides a potential blueprint for the inlet to the constructed wetland.

Double taps

Double taps Schematic

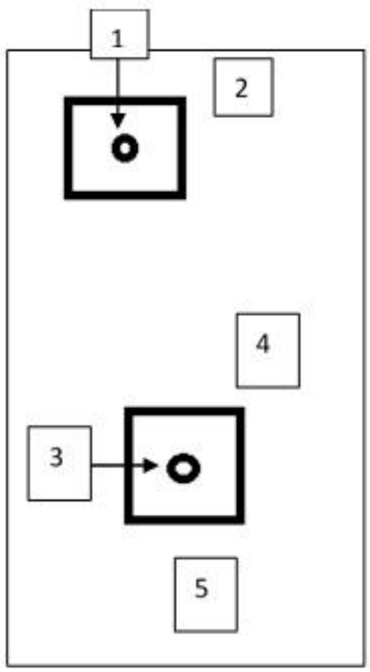


Figure 4

At *top wetland* all use involved the disposal of water (2.6%), with the most popular time being between 12 – 2 pm. The most commonly used container was the 20L and given that activity involved disposal, all observations were of very short duration (Todd et al., 2021). Greywater was disposed of at this site, either in or around the constructed wetlands. However, water was not disposed of at the tap and Todd et al. (2021) reported that this was most likely the case due to the broken tap at the site. For *side wetland,* the majority of the activities (10.4%) occurred earlier in the day, between 8-10am and 10-12am (Todd et al., 2021). The site was used for collection and disposal and for washing on one occasion. The most commonly used container was 20L with the activities not lasting longer than 5 minutes (Todd et al., 2021). Stooped postures were common and observed for nearly half of the activities, due to the low height of the tap. Greywater disposal occurred at the tap or at the nearby stream, but not in the wetland. As stated previously, users of this site commented on the fact that while the stream exists it is easier to simply dispose of water into it than to lift heavy containers to the inlet area of wetland (Todd et al., 2021). Consequently, the entrance or inlet to both wetlands was recommended to be at the same level as the base of each tap area (Todd et al., 2021).

Figure 5: Side wetlands user, demonstrating the alternate use of the wetland. Furthermore, shows the degradation of the tap area due to immediate disposal at the base.

Double taps was the most popular site with the majority of usage (66.3%) occurring earlier in the day, between 8 and 12 am. Similar to other sites, the most commonly used container was the 20L with handle, while the 40L tub was used for washing (Todd et al., 2021). Collection and disposal were short duration activities, while washing resulted in users spending extended periods at the site (over 15 minutes). Furthermore, washing resulted in stooped postures in all but one of the observations, due to the need for the participant to interact with washing on the floor (Todd et al., 2021). Disposal typically occurred at the tap, with water running into the accompanying drain and down into the informal wetland area. Interestingly, most people used the edge of the tap area to stand on so that their feet did not get wet (Todd et al., 2021).

Based off the shortcomings of the constructed wetlands, it was argued by the consultancy report that in general the current wetland design for *top wetland* and *side wetland* could be improved (Todd et al., 2021). As such, redesigned constructed wetlands were installed in April 2021. This report thus presents an evaluation on whether or not they were effective in reducing the presence of greywater, if they were used appropriately and whether they supported the community members' disposal behaviours. Incorporating the approach of participatory ergonomics into the creation of the constructed wetlands ensures community inclusion (Górny, 2014), which in turn triggers a ripple effect of enlightenment on the *green technology* of a constructed wetland among the community members. This also supports the continued sustainability of the project. In the end, this sustainability is sure to aid in certain areas of community development, concerning water re-use and reduced greywater problems that plague the settlement of Setswetla.

Chapter 1: Literature Review

This chapter presents a comprehensive literature review on the theoretical models pertaining to a better understanding of the system of a constructed wetland (CW) and its relevance to environmental sustainability and human health. It begins by situating the study in the overarching theories of human factors ergonomics (HFE) and the triple bottom line approach (TBL). Then it progresses to define the concepts of green ergonomics, green infrastructure and nature-based solutions. Context is provided through a closer inspection of the concept of informal settlements, its definition and why the inadequate disposal of greywater would be problematic in such areas. The proposed solution was found in the construction of constructed wetland systems before concluding with the proposed research questions.

1.1 Human Factors Ergonomics (HFE) and Triple Bottom Line Approach (TBL)

There is no better concept to encapsulate the essence of a constructed wetland in highlighting the mutual relationship between human health and environmental sustainability than that of *green ergonomics*, a branch born out of ergonomics (Thatcher, 2013). Human factors and ergonomics (HFE) is defined by the International Ergonomics Association as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" (2009). In optimising system performance and human well-being, machines, jobs, tasks, systems, and processes have to be designed in a usable, efficient, healthy, safe, and effective manner (Dul & Weerdmeester, 2008). Moreover, as argued by Moray (1995), lifestyle support systems are to be fashioned in such a way that the crucial behaviours required to lessen the gravity of global problems are elicited. Since we exist in an era where our behaviours, actions, and products have major influences on the sustainability of our fast-deteriorating natural resources, environment, and planet (Kuhlman & Farrington, 2010), HFE is required to play an important role in the reduction of these negative impacts (Thatcher, 2013). However, very little HFE research has directly addressed the ecological issues that still plague our world today, despite persuasive appeals to incorporate pro-environmental considerations into ergonomic interventions (Thatcher et al., 2016). Steimle and Zink (2006) posited the concept of *sustainable development and human factors, which* has sparked a renewed interest in tackling these issues within the ergonomics community. This led to the formation of the International Ergonomics Association Technical Committee on *human factors sustainable development*, and the formation of a special interest group on *green ergonomics* within the Institute for Ergonomics and Human Factors (IEHF) among many other developments (Zink, 2008; Hanson, 2010).

The phrase *sustainable development and human factors* is conceptualised as the "paths of human progress that meet the needs and aspirations of the present generation without compromising the ability of the future generation to meet their needs" (Brundlandt, 2013, p. 29). Over the years, it has come to be understood as the complex balancing of economic, social, and natural capital known as the Triple Bottom Line (TBL) approach (Elkington, 1998). The connection between these three forms of capital assumes that destitution often aggravates the negative effect on the environment due to an over-utilization of scarce resources (Thatcher, 2013). From a TBL perspective, economic and social upliftment are proposed as possible solutions to assist in the reduction of these environmental impacts (Thatcher, 2013). Steimle and Zink (2006) argued that a focus on human elements (primarily social capital) within the larger system needed to be merged into the study of sustainable development and human factors. This school of thought gained its inspiration from Docherty's notion of *sustainable work systems* to emphasise the link between sustainable development and human factors (Docherty, Forslin & Shani, 2002). According to Docherty et al. (2002), work that allows sufficient recreation opportunities and meets the psychological, physiological, and physical limits of human functioning is sustainable. In a similar vein, Dyllick and Hockerts' (2002) model of *sustainable corporations* demonstrates how human factors can promote sustainable development. Interventions, they argue, should be concerned with the designing of efficient systems (eco-efficiency) that ensure the health and safety of the humans in the system (socio-efficiency) as well as guarantee the usability of the systems by people (socio-effectiveness) (Thatcher, 2013). Scott (2008) takes the scope of application further by urging ergonomists to consider utilising the implementation of ergonomic interventions as an upliftment of whole communities.

1.2 Green Ergonomics

Green ergonomics refers to "ergonomics interventions that have a pro-nature focus, specifically ergonomics that focuses on human affinity with the natural world" (Thatcher, 2013, p. 391). It views the planet as a closed system that operates in such a way that disruptions to one part of the system inevitably have consequences for other parts of the system (Thatcher, 2013). Green ergonomics, therefore, acknowledges the two-way relationship with human's influence on the health of their natural environmental and in turn, the influence of their natural environment on their health and well-being (Thatcher, 2013). It is also important to note that while green ergonomics calls for this balance by stressing the importance of natural systems, the approach also includes the needs of humans and their economic and societal developmental needs (Thatcher, 2013). In essence, the development of human systems that integrate fully in a sustainable way with the natural environments is the main theme of green ergonomics (Thatcher, 2013). To achieve this aim, firstly, green ergonomics considers how *conservation*, *preservation* and *restoration* of natural capital can be enabled by human systems (Thatcher, 2013). Nature provides ecosystem services, which fulfil life-sustaining operations including regulating services (water decomposition, water purification etc.), provisioning services (minerals, food, energy etc.), habitat services (crop pollination, seed dispersal, drought mitigation etc.) and cultural services (aesthetic beauty, inspiration, serenity etc.) (Daily, 1999). The continued degradation of our natural environment would affect the smooth running of these ecosystem services, which will in turn have significant negative psychological and physical implications for humans (Thatcher, 2013). In this regard, "green ergonomics involves reducing the impact of human systems on these ecosystem services through ergonomics design that aims to avoid or diminish natural (and by implication, humanitarian) crises” (Thatcher, 2013, p. 392).

Secondly, green ergonomics considers how the connections between humans and nature might *facilitate human wellbeing and effectiveness* (Thatcher, 2013). Wilson (1984) introduced the concept of *biophilia*, which states that humans have an inherent affinity to connecting with nature. This manifests itself in the feeling of curiosity and wonderment, stemming from childhood development, about the natural world around us (Louv, 2005). Similarly, *ecopsychology* looks at enabling health and well-being through connecting with the health of the planet. Building on these psychological concepts, green ergonomics investigates “the ways to incorporate the restorative and creative properties of nature into the design and evaluation of workplace, homes and places of play” (Thatcher, 2013, p. 392). This would involve pro-nature ergonomics considerations at the design, productive, utilisation, recycling, and disposal stages of a system formation (Wenzel, Hauschild & Alting, 1997). Additionally, the aim of these designs is to facilitate systematic behavioural change (Thatcher, 2013).

1.3 Green Infrastructure and Nature-Based Solutions

Green infrastructure (GI) “is a modern approach to deal with issues that mainly arise in the urban environment” (Stefanakis, 2019, p. 1). More so, it is viewed as an ecological substitute to traditional grey infrastructure (Stefanakis, 2019, p. 1). Similarly, nature-based solutions focus on the utilisation and implementation of natural process and sustainable practices to tackle socio-environmental challenges (Capodaglio, Bolognesi & Cecconet, 2021). Nature based processes for wastewater treatment include vegetated drainage ditches, constructed wetlands, and natural buffer zones among many others (Capodaglio et al., 2021). Wetland systems, through a sequence of chemical, physical, and biological processes are able to eliminate various pollutants and therefore alter and improve water quality (Stefanakis, Akratos & Tsihrintzis, 2014). They have been found to offer a wide range of ecological and economic benefits and this has led to the utilization of their natural purification capability for different applications, specifically for wastewater treatment (Stefanakis et al., 2014). In so doing, the *constructed wetland* system was invented “to replicate the various naturally occurring processes of a wetland under controlled conditions for a beneficial purpose” (Stefanakis, 2019, p. 3). Their characteristic features are designed in such a way that integration or adoption into a built environment is made easier for landscape architects, urban planners, and engineers (Stefanakis, 2019). Regarding wastewater treatment, constructed wetlands are established as a sustainable treatment method that possesses high treatment capacity and much like the tenets of green ergonomics their whole essence is aimed at recognizing the two-way connections between nature and human systems in order to enable the efficacy of both sides of the spectrum (Masi, Rizzo & Regelsberger, 2018; Thatcher, 2013).

1.4 Informal Settlements

All over the world, housing is of upmost importance irrespective of an individuals' socioeconomic status, race, or skin colour (Marutiulle & Ijeoma, 2017). It is a basic amenity of humankind recognised as a universal right and afforded for in more than a hundred worldwide constitutions including in chapter 2, section 26 of the South African constitution (Ademiluyi, 2010). However, the global housing crisis disrupts the accomplishment of this vision set forth by the South African constitution and numerous international legislative acts. According to the statistics computed from the global survey performed by the United Nations (2005), it was estimated that about 100 million individuals were homeless worldwide and as many as a billion people were inadequately housed. In South Africa alone, "informal settlements have grown from an estimated 300 in 1994 to 2,700 in 2020" (Kumar & Shika, 2021).

In Johannesburg, informal settlements have formed an essential part of its inception—dating back to the transition from apartheid—and to some extents have shaped its growth as they are often replaced by formal development although the informal settlements ultimately re-emerge somewhere else (Huchzermeyer, Karam & Maina, 2014). Informal settlements are referred to as "residential areas that do not comply with local authority requirements for conventional (formal) townships" (Human settlement development, 2005, p. 10). Typically, they are situated on land that has not been authorised for residential use and are characterised by inadequate infrastructure, unsuitable living environments, overpopulation, poor access to education and health facilities and substandard dwellings (Human settlement development, 2005). In compliance with these characteristics, Setswetla fits the archetypal definition of an informal settlement. The community is overpopulated with most of its residents occupying self-constructed dwellings or shacks. There is little to no sanitation in the area where greywater can be disposed of effectively and as such, the surrounding environment is contaminated with high concentrations of *E. coli* and other harmful substances that present a number of health risks to the community's inhabitants.

1.5 Wastewater: Greywater

Greywater (GW) refers to the by-product water resulting from home-use, business-use, or as part of an industrial process (Shaikh et al., 2020). In the literature, it is generally divided into light greywater (LGW) and dark greywater (DGW) based on the concentration of contaminants in their individual sources (Shaikh et al., 2020). LGW includes wastewater derived from bathtubs, bath, hand basins, and bathroom sinks, while wastewater from rinsing, dishwashers and laundry washing constitute DGW (Shaikh et al., 2020). Bathroom GW refers to GW from sinks, showers, and bathtubs (Shaikh et al., 2020). Its chemical constituents include toothpaste lint, traces of urine, body fats, hair, skin, and body care products (Shaikh et al., 2020). Kitchen GW denotes wastewater from dishwashers as well as the kitchen and contains chemical toxins such as detergents, food residue, vegetable matter, fats and oil, tea, and raw meat washing (Shaik et al., 2020). This type of DGW favours the growth of microbial activity because of the presence of food particles and organic matter (Shaik et al., 2020). Laundry GW contains chemicals from oils, detergent, clothing fibres, solvents, and bleaches (Shaik et al., 2020).

A recurring theme among these differing variations of GW is the fact that they all contain hazardous chemical components that require efficient sanitary services to either recycle the GW safely or dispose of it effectively. Informal settlements, like Setswetla, unfortunately lack these services and as such are left to contend with the harmful exposure to these pollutants. For one, the GW in Setswetla contains high concentrations of *E. coli*, which has been found to cause terrible stomach cramps, meningitis, bloody diarrhoea, urinary tract infections, and vomiting (Hammerum & Heuer, 2009). Secondly, the eventual deposition of this GW (as well as a whole host of other compounding issues) into the Jukskei River has created a breeding ground for life-threatening diseases, mosquito infestation, microbial activity, environmental pollution, and a reduction in the quality of life of the community members. In Setswetla (and other informal settlements) there is also the problem of greywater and blackwater (sewage) becoming mixed because there are also insufficient blackwater treatment facilities. Therefore, sewerage pipes (if they exist) become blocked and overflow from overuse or sewage accumulates in the environment because there are insufficient facilities to cope with the population demands.

The Solution: Redesigned Constructed Wetlands

Sanquist (2008) and Sanquist et al. (2010) in their reviews, highlighted a number of interesting possibilities concerning the role of HFE in protecting the environment. They focused mainly on energy as the natural resource of interest; however, it is easy to see how HFE might be applied to environmental protection aimed at conserving, restoring, and preserving other natural resources such as biodiversity, water, or air quality (Thatcher, 2013). Not all HFE studies of feedback systems have yielded positive reports, for example, Flemming and Jamieson (2009) found a negative correlation between an ecological interface and the anticipated reduction in energy or water wastage. Similarly, the consultancy report from last year showed that the constructed wetlands, the ecological interface in this instance, had no effect on combating the greywater problem in Setswetla or on the reduction of harmful substances in the greywater (Todd, et al., 2021).

Follow-up, it has been argued, is required to understand how best to design systems that influence behavioural change and encourage pro-environmental behaviours (Thatcher, 2013). Here, green ergonomics would be well-placed to contribute as other strategies include presenting energy usage patterns to users (Hanson, 2010), enriching our understanding of the dynamics behind sustained behavioural change, keeping eco-efficiency in conscious awareness (Amel et al., 2009), and training interventions (Thatcher, 2013). Keeping this in mind, one can see how the recommendations for redesigning the constructed wetlands, which are the focus of this study, considered some of these strategies to enhance more user-system relations needed for behavioural change with regards to the people’s disposal techniques. For one, the new constructed wetlands were designed to provide a range of options including support for water-based activities (a raised washing area) to reduce the need for the habitual stooped posture employed by the community members when performing water-related activities at the tap. The implementation of multi-use water collection and cleaning activities support a more upright posture. Additionally, the raised nature of the wetlands has the added benefit of protecting the community against water surges from storm water or overflowing sewers. The taps at *top wetland* and *side wetland* were enclosed within a concrete tap area that harboured a wetland inlet. This wetland inlet led straight into the wetland for purification by the plants. Unlike the first design of the constructed wetlands where the wetland inlet was a separate entity and the community members had to lift their buckets to dispose of greywater. This design ensured that disposal of greywater was much easier for the community members as they would just need to tip their buckets over to access the wetland inlet. Carden, Armitage, Sichone and Winter's (2007) findings back up this reasoning since in both rural and urban settlements, individuals were found to manage their greywater disposal simply by disposing of it on the ground. This *ease of access* of the wetland inlet to the community members is exactly how the re-designed constructed wetland aimed to support the community members' *on-site* disposal technique. Furthermore, a side gutter was added to the design of *top wetland* to direct greywater away from the residents and towards the connecting waste stream at *side wetland* for the eventual disposal of this water into the Jukskei River. *Side wetland* was also moved closer to the waste stream as illustrated in the picture below (Figure 6 and Figure 7) because as found by the consultancy report, the residents used this stream as a site for wastewater disposal (Todd et al., 2021).

Top wetland *Side wetland*

Figure 6

Top Wetland Schematic

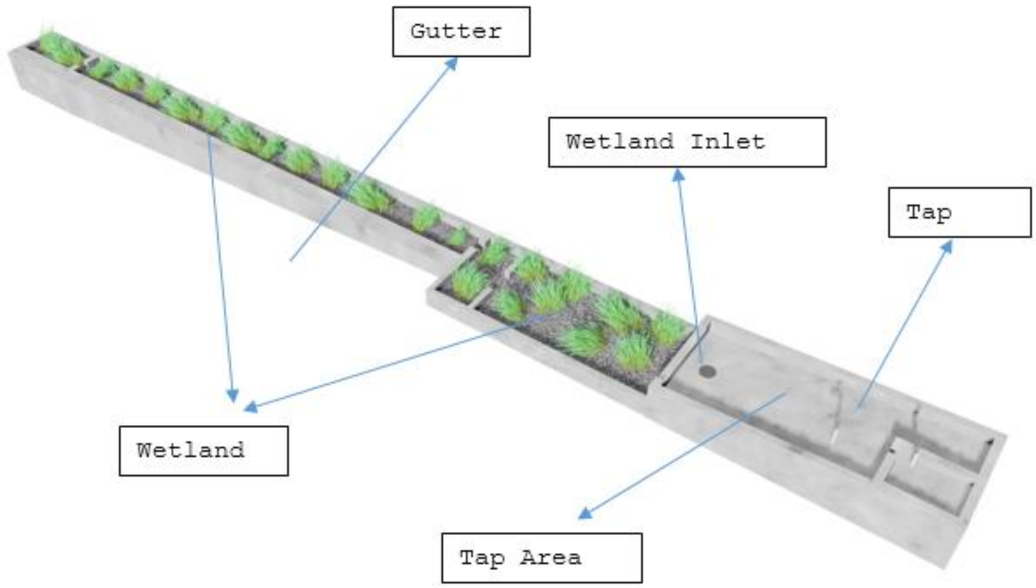


Figure 7

Side Wetland Schematic

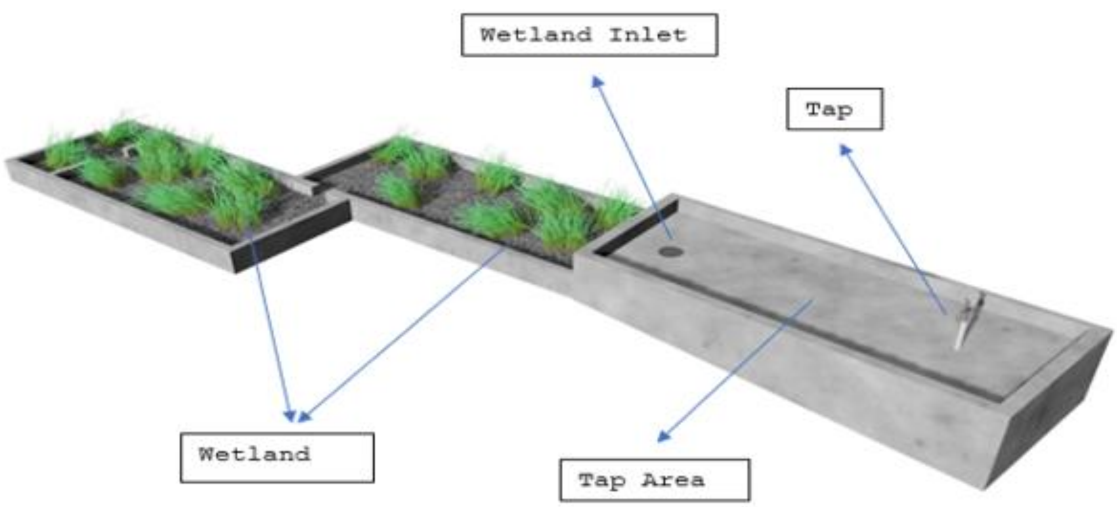


Figure 8

According to community members, there were internal political issues around the usage of the taps, as the *top wetland* tap was broken (Todd, et al., 2021). To combat this, the community members were included in the site selection using a participatory HFE approach. Carden et al. (2007, p. 433) in their site surveys on the use and disposal of greywater in non-sewered areas of South Africa found that "many interviewees were conscious of potable water scarcity and indicated a willingness to conserve water if the authorities showed them how this could be done." Thus, as part of the programme the community residents were involved to encourage others to use the constructed wetlands, and to engage the community as a whole. Regarding the quantity and quality of generated greywater in informal settlements, Carden et al. (2007) also noted that the socio-economic circumstances of each household influenced the amount of water used, how often laundry activities occurred, and the types of detergents used with an assumption that 75% of the water consumed in informal settlements ends up as greywater. Additionally, a recommendation regarding the underground piping system, *gravity sewer*, was put forth to be the preferred option for greywater disposal as opposed to ponds or wetlands (Carden et al., 2007). This is because wetlands were viewed as less practical options in high-density settlements owing to the lack of space and other associated health risks (Carden et al., 2007).

The main theme of incorporating these recommendations into the newly re-designed constructed wetlands is so that disposal of water into the inlet is much easier for the community members. As stated previously, the consultancy report stated there was minimal usage of the constructed wetland sites with *top wetland* being the least used out of the two. A vital aspect of the reports' analysis was water usage in relation to the wetland sites and three different activities were observed namely collection, washing and disposal. *Collection* referred to bringing containers to the tap and filling them (Todd et al., 2021). This collected water was then removed from the site, presumably for household activities. *Washing* referred to attending the taps to wash items, either dishes, buckets or clothing (Todd et al., 2021). Finally, *disposal* referred to the observation of activities that result in greywater either being brought from home to the tap area to be discarded or the disposal of greywater from the activities at the tap area (Todd et al., 2021).

1.6 Research Questions

Thus, the questions this research intends to answer are in threefold:

1. Are the re-designed constructed wetlands being used and if they are, how are they used?
2. What are the water-related activities that occur around the taps and near the constructed wetlands?
3. Do the re-designed constructed wetlands support the appropriate water disposal behaviours of the community members?

Data relating to the demographics of the participants, their activities in relation to the taps, their task breakdown and disposal techniques and location are to be garnered through direct observation to answer the questions, listed above. More detail on these aspects of data collection is explained in the method section.

Chapter 2: Methods

2.1 Research Design

This research was mixed methods in nature, employing the use of both quantitative and qualitative methods to collect data. It was situated within the positivist paradigm and took the form of a descriptive study. Here, the prospective research employing this design is solely interested in "providing an accurate portrayal or account of characteristics of particular individuals, situations or groups" (Dulock, 1993, p. 154). Furthermore, the research is a "means of discovering new meaning, describing what exists, determining the frequency with which something occurs, and/or categorizing information" (Dulock, 1993, p. 154). In relation to this study, the researcher focused on capturing and recording, through direct observation, the activities of the community members in relation to their use and disposal of water around the re-designed constructed wetlands. In achieving this aim, the work sampling technique approach and time-and-motion approach were utilised to determine the frequency in occurrences of the activities under study as well as the time spent going through the different motions of these activities (Barnes, 1968; Sittig, 1993). Behavioural themes gleaned from these observations were then quantified through a content analysis. Furthermore, short-structured interviews were conducted to enquire into the possible reasons for the observed behavioural trends of the community members.

2.2 Sample and Sampling

The data were collected through direct observation of the residents of Setswetla utilising an observation sheet (see Appendix A). In the previous study the majority of people observed were ***young adults***. However, this study took it a step further and distinguished two groups of people who might have had problems lifting full buckets to the disposal point. These two groups were ***children*** and ***older adults***. As such, children were defined as individuals below the legal age of majority in South Africa (5–17-year-olds). Young adults were referred to, as individuals above the legal age of South Africa (18–49-year-olds), and old adults were referred to as individuals in their early fifties or older. This form of observational research manifested itself structurally in that this study observed naturally occurring behaviour focused on certain set of behaviours (water collection, washing and disposal) relating particularly to the constructed wetlands. Observations occurred at the sites of *top wetland*, *back wetland*, and *no wetland*. *Top wetland* had 180 observations, *back wetland* 65 observations, and *no wetland* 265 observations. Thirteen short structured interviews occurred at *top wetland*, four interviews occurred at *back wetland* and three interviews occurred at *no wetland*. The reason behind the large differences between the numbers of interviews conducted at *top wetland* as opposed to the ones conducted at *back wetland* and *no wetland* is because they were many more people present at *top wetland*.

The researchers became active members of the community under investigation in what is referred to as *participant observation* (Jhangiani, Chiang, Cuttler, & Leighton, 2017). Here, the data collected originated from structured interviews, photographs, and notes based on interactions and observations. Furthermore, the form of participant observation was *undisguised* as the true identity of the researchers were disclosed to the community (Jhangiani et al., 2017). This afforded the researchers a much better position to understand the viewpoint and experiences of the individuals that were being studied.

2.3 Procedure

The *work sampling technique approach*, originally developed by Trippett (1953), was employed to measure the "working time of a person (or machine) or to establish a time standard for a specific activity (i.e., to identify the number of minutes required to perform a certain task)" (Sittig, 1993, p. 538). This method is a statistically based technique utilized for analysing work performance through direct observation (Barnes, 1968; Blay, Duffield, Gallagher & Roche, 2014). In essence, it is a technique for determining the frequency in occurrences of a certain activity (or a group of processes) with the help of statistical sampling and random observations (Barnes, 1968). This study followed a number of steps put forth by Sittig (1993) to efficiently execute the designing of a work sampling study, namely:

2.3.1 The research objective was identified:

In the case of this research, the study aimed to answer the set of questions highlighted in the *research question* section.

2.3.2 The study site was identified and approval obtained from the necessary authorities:

The study site in this case was the township of Setswetla (specifically an area known as Silvertown) and the study participants were its community members who used the taps at each of the sites. The community is led by a community leadership forum where all administrative decisions concerning the settlement are made with the knowledge of its residents. Required approval was received from the community leadership forum as well as the Silvertown community's informal leader, Ma Ellen Chauke, and official written permission was received from the Ward Councillor (Appendix D). The community leadership forum were regularly briefed on the developmental areas of the study concerning the re-designing of the constructed wetlands, the new implementation of tap areas, and their input on how the constructed wetlands could be erected in such a way that it might be embedded as part of the community members' activities given what happens around them and where water flows. Furthermore, when certain developments in the study directly affected the community members, like in the instance where the probable extension of a constructed wetland would affect a person's residence, approval was received directly from that community member.

2.3.3 The work categories were identified and carefully defined:

This was done so as not to leave any doubt in the mind of the observer how each and every activity would be observed and categorized (Sittig, 1993). In this case, established time and motion criteria identifying the activities—relating to the tap area and constructed wetlands—to be observed were formulated. These work categories included *water collection*, *washing,* and *disposal*. The time and motion criterion, extended from the original one used for the consultancy report as well as in discussion with the data collection team, (Appendix B) gives a detailed outline of these categories. *Water collection* referred to bringing containers to the tap and then filling it. *Washing* referred to attending the tap to wash items be it dishes, buckets or clothing, and *disposal* referred to the greywater that was either being brought from the home to the tap area to be discarded or the disposal of water from the activities at the tap area.

Regarding the breakdown of these behavioural categories, *water collection* scrutinised the ***largeness of the containers*** used for water collection, the ***number of these containers,*** and ***whether they were filled to the brim or not*** to create an understanding of the behaviour. *Washing* looked at the activities of ***laundering*** (washing clothes), ***rinsing of buckets***, ***washing of hands,*** and other actions (brushing of teeth and washing of cars). Likewise, *disposal* highlighted the amount of greywater disposed by the community members and the types of this water, namely: "***clean water***", ***washing water***, ***cleaning water***, ***wastewater*** including ***vegetable matter*** and ***any other***. ***Clean water*** refers to water resulting from the rinsing of bucket or a tap that was left to run as the individual disposed of water. ***Washing water*** refers to the water resulting from a washing activity. ***Cleaning water*** refers to water resulting from home chores like mopping of a dirty floor, dishwashing and so on. ***Wastewater*** including vegetable matter refers to water resulting from kitchen duties like meat washing and food residue. ***Any other water*** refers to urine or bathwater. In identifying the categories of urine and bathwater, the containers used to dispose them were particularly helpful as the former was usually brought out in a portable potty and the latter in a bucket.

2.3.4 A data entry form was created:

Once the categories have been described, an easy-to-use observation entry form was developed by the group of researchers involved in this study. Appendix A provides a framework of the data-recording sheet that was employed.

2.3.5 Appropriate observers were identified:

It was planned that certain individuals, who are residents of Setswetla, would be recruited to assist in the observations of the activities under study. Appointment of observers occurred via the researcher and in some cases by recommendations from the community. The observers from the community were three in total together with three researchers (postgraduate students) making ***six observers***. They were trained in the system of observational recording, relating to the schematic drawings of the constructed wetlands and their corresponding labels, what behaviours were to be observed, and how to record these observations onto the sheet in a coherent manner. This training occurred on the 6 September 2021 (Monday) over a period of a few hours—commencing in the afternoon—and subsequent practice was initiated to familiarise both the researcher and observers with the recording sheet.

Important key elements that were kept in mind when deciding who should collect the data included: 1) that they had an understanding of the activities being observed 2) that they could understand the English language and had sufficient literacy skills to use the data recording sheet, and 3) that they could perform the observations without affecting the study (Sittig, 1993).

2.3.6 A pilot study was conducted:

The pilot study in this case was the half day spent practising the data collection process with the appointed observers. The reason for this step is so that the definitions of the work categories were tested, and one was provided with a rough estimate of the percentages of time participants spend in each category (Sittig, 1993). As such, a few changes were made to the data-recording sheet including an expansion of the amount of water disposed and the containers used for washing from a limited quantity of 10L (small), 20L (medium) and 40L (large) to accommodate the quantities of <5L, 5L, 10L, 20L, 30L and 40L. Furthermore, a better picture of the way in which the constructed wetlands were being utilized by the community members was obtained and this helped in writing-up an accurate classification of these behaviours. These included: sitting on the constructed wetlands, using them as pathways, disposing of water in the gutter and not the wetland inlet, disposing of water in the wetland inlet, disposal of water in the wetland and any other behaviours that emerged during observations.

2.3.7 The work sampling study was designed:

One of the most important elements of the study was to decide whether the observations would be made randomly or at fixed intervals (Sittig, 1993). The underlying work activities under study lacked any apparent, prominent regularity or pattern. In essence, they occurred at random. However, the 2020 consultancy report showed that observation occurred between the times of 07h00-16h00. Usage of the taps and constructed wetlands were likely to have continued even after observation but taking into account that it was unsafe to be observing the community members activities after dark, observation stopped at 16h00. Thus, a fixed sampling interval from 07h00 to 16h00 was implemented in this study. This fixed interval applied to the observations that occurred on 7 September 2021 (Tuesday) to 10 September 2021 (Friday) which were all weekdays. On 11 September, (Saturday) observations began at 07h00 and ended at 15h00, on Sunday (12 September) they began at 08h00 and ended at 12h00. On Monday (13 September), they began at 12h00 and ended at 18h00. This day was the only exception to the fixed sampling rule, the reasoning behind this change was to observe how the arrival of the community residents— who had left their homes early to go to work or school— influenced the duration, and number of the water-related activities performed at the taps and constructed wetlands. At times, activity at the taps and constructed wetlands were slow during the afternoons of weekdays (7 to 10 September) and so it was thought that this was due to the absence of most residents who had gone to either work or school. In total, observations commenced over a period of seven days. At each site, there were a total of two observers and as the days went along each pair of observers rotated between the sites. Lunch breaks at 12h00 as well as rest breaks (every hour) were alternated between the observers so that when three observers (from each site) went for breaks, three would remain and vice versa.

This research incorporated the use of a *time-and-motion approach* together with the *work sampling technique* to evaluate the time spent in going through the different motions of the job or series of jobs (Sittig, 1993). On the one hand, the *time component* of the approach was first put forth by Frederick Taylor aimed at reducing time wastage for maximum efficiency (Price, 1989). On the other hand, the *motion component* was conceptualised by Lillian Gilbreth to evaluate movements and how work methods could be improved (Price, 1989). Here, the time-and-motion study aimed to identify the frequency of use of each site (where the constructed wetlands were erected), time of day and duration of constructed wetland usage, the demographics of user, and the activity breakdown. Taking inspiration from the 2020 consultancy report, this study employed the established time and motion criteria (Appendix B), agreed upon with the data collection team, to observe the community members in relation to their activities concerning the tap area and constructed wetlands.

Lastly, follow-up interviews were conducted to get an explanation for why certain behavioural trends were performed by the community members and whether the constructed wetlands were effective in combating the greywater problem. The first batch of short structured interviews occurred on 12 September 2021 (Sunday) and were conducted by the researcher. There were two interviews in total and lasted a duration of five minutes each. Questions relating to whether they made use of the constructed wetlands, their water-related behaviours performed in relation to the constructed wetlands and their perceptions regarding the effectiveness of the redesigned constructed wetlands (in contrast to the original design) in combating greywater were asked. Noting that two interviews were not representative of the community and were essentially just the opinions of two individuals, questioned very briefly, eighteen more interviews were conducted. The second batch of short structured interviews occurred on 5 March 2022 (Saturday) and were conducted by the researcher. They lasted a duration of five minutes each and followed the set of questions asked in the first batch of interviews with the inclusion of the community members suggestions in combating the perceived shortcomings of the re-designed constructed wetlands. Once saturation was reached (responses were being repeated and the same themes kept emerging) and a valid, robust understanding of the behavioural trends was developed, the interviews ceased. A random sample of community members who utilised the taps and interacted with the re-designed constructed wetlands were thus invited to take part in the face-to-face interviews.

2.4 Data Preparation

The first stage of the data analyses was to prepare the data. Here, the aim was to convert the raw data into something meaningful and readable. For one, the data sheets were circulated among the observers via email so that each observer had a complete set of the observation sheets. Then the information was transcribed into an excel spreadsheet before the variables in the study were coded appropriately. For instance: the gender differentiation between male and female, age group, the different activity types in relation to the constructed wetland site use and so on. The compiled data set yielded a total of 510 observations and 20 interviews.

2.5 Data Analysis

The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 27.

Descriptive statistics were run to summarize the data and to find patterns (Coe & Sacco, 2017). It was particularly helpful in understanding the characteristics of the sample in terms of their age, gender, water collection behaviours, constructed wetland utilisation, and water disposal practices. Frequencies were run for the categorical variables of age group, gender, water collection, washing, disposal, constructed wetland utilisation, size of the containers used for water collection, number of containers used for water collection, fullness of the containers, containers used for washing, amount of water disposed and the type of water disposed.

Furthermore, *Quantitative Content Analysis* (QCA) was utilized to analyse the systematically categorized and recorded data. QCA is defined as “a research technique for the systematic, objective, and quantitative description of the manifest content of communication” (Berelson, 1952, p. 18). It is widely utilised in the branch of communication; however, it can also be employed in a range of other branches featuring attributes of audio, textual, and visual material (Rourke & Anderson, 2004). Here, QCA was employed so that the relevant behavioural themes, under scrutiny, could be identified and their trends described (Coe & Sacco, 2017). Central to the technique of QCA “is the process of coding, which involves following a set of instructions about what features to look for in a text and then making the designated notation when that feature appears” (Coe et al., 2017, p. 1). To conduct a successful QCA, one would require careful attention to the unitization of the text for analysis, the choosing of a suitable group of units to analyse, reliability and the utilisation of a coding system that aptly represents the phenomena under study (Coe et al., 2017).

- Research question one assessed whether the re-designed constructed wetlands were being used and if they were, how they were being used. Quantitative Content Analysis was used to identify the relevant behavioural themes and describe the trends in order to answer this question.
- Research question two assessed the water-related activities that occurred around the taps and the constructed wetlands. The same procedure as question one was conducted to answer this question as well. Additionally, an indication of the length of time for each activity was tabulated as per the requirements of a time and motion study.

- Research question three assessed whether the redesigned constructed wetlands supported the appropriate water disposal and collection behaviours of the community members. The observational data produced some trends to this effect as well as the interview data.
- In evaluating the interview data, *Thematic Content Analysis* (TCA) was employed. TCA is a descriptive exhibition of qualitative data (Vaismoradi, Turunen, & Bondas, 2013). In this case, the qualitative data takes the form of interview transcripts collated from research participants. Here, the aim was to identify, analyse, and interpret the common behavioural themes in the interview text to create an understanding of why certain behaviours were exhibited towards the re-designed constructed wetlands by the community members. As well as, if these re-designed constructed wetlands supported these highlighted water collection and disposal behaviours and assisted in reducing the presence of greywater in the community. In so doing the third research question was answered.
- The steps followed to conduct the TCA as put forth by Braun and Clarke (2006) included:
  - ✓ **Familiarization:** Here the general overview of the data was understood.
  - ✓ **Coding:** Here the text (usually sentences or phrases) was highlighted with shorthand labels or codes.
  - ✓ **Generating themes:** Next, patterns were identified and conceptualised as themes.
  - ✓ **Reviewing themes:** Here the themes were reviewed to make sure that they were correct representations of the data under view.
  - ✓ **Defining and naming themes:** Here the themes were named and defined appropriately.
  - ✓ **Writing up:** Finally, the analysis was written up.

2.6 Ethical Considerations

Ethical clearance was obtained from the School of Human and Community Development internal review process overseen by the Human Research Ethics Committee at the University of Witwatersrand (ethics protocol number: MAORG/21/02). Participant information sheets were distributed to potential participants to serve as an introduction to the researcher and to enlighten them on the purpose of the study, their rights, what will be done with the collated data and who to contact if they have any complaints (Appendix E and F). The anonymity and confidentiality of the participants was protected. No identifying data that could be linked back to a person, including name or home address, was recorded during the observations. In the case of interviews with the community members, their names were simply not asked and pseudonyms (such as Person 1, Person 2 and so on) were utilised in the final report to protect their anonymity. Relevant COVID-19 protocols including the wearing of face masks, adhering to the social distancing rules, and regular sanitization were observed at all times during the observations and face-to-face interviews. Only the relevant components relating to the participants' disposal behaviours and activity around the taps were recorded in order to respect the privacy of community members.

Chapter 3: Results

This chapter presents the results of the analyses. At first, frequencies were calculated for the categorical variables of age group, gender, water collection, washing, disposal, constructed wetland utilisation, size of the container used for water collection, number of containers used for water collection, fullness of the containers, containers used for washing, amount of water disposed and the type of water disposed. These results for the whole sample can be found in Table 3.1. Quantitative Content analysis (QCA) was run to analyse the compiled observation sheets written up in an excel sheet to answer research questions one and two. Additionally, an indication of the length of time for each activity was recorded. These results can be found in Table 3.2, Table 3.3 and Table 3.4 respectively. Lastly, thematic content analysis (TCA) was conducted on the interviews to determine if the redesigned constructed wetlands supported the community members highlighted water collection and disposal behaviours as well as assisted to minimise the presence of greywater in the community. This answers research question three, the results of which can be found in Table 3.5.

Table 3.1

This table presents the frequencies for the variables of age group, gender, water collection, washing, disposal, constructed wetland utilisation, size of the container used for water collection, number of containers used for water collection, fullness of the containers, containers used for washing, amount of water disposed and the type of water disposed:

Age Group		
	Frequency	Percent
Child	100	19.6
Old Adult	109	21.4
Young Adult	301	59
Total Observations	510	100
Gender		
Female	361	70.8
Male	149	29.2
Water Collection		
Yes	308	60.4
No	202	39.6
Washing		
Washing laundry	83	42.6
Rinse	95	48.7
Washed hands	13	6.7
Other (washing a car with a hose pipe, washing meat or fruits, rinsing off a	4	2.1

mop and using their palms to drink water straight from the tap)		
Disposal		
At tap	251	75.4
In constructed wetland	16	4.8
At outlet	15	4.5
Outside constructed wetland	51	15.3
Use of constructed wetlands		
Sitting on the constructed wetland	6	3.5
Using the constructed wetland as a pathway	4	2.3
Disposal of greywater in the gutter and not the inlet	35	20.5
Disposal of greywater at inlet	94	54.9
Disposal of greywater in the wetland	1	0.6
Any other behavior e.g., standing on them	31	18.1
Size of container for water collection		
<5L	11	3.4
5L	12	3.7
10L	53	16.4
20L	238	73.5
30L	1	0.3
40L	9	2.8
Number of containers for water collection?		
One	300	92.9
Two	21	6.5
Three	2	0.6

Filled to the brim/partially filled		
Filled	224	72.7
Partially Filled	84	27.3
Containers used for washing		
<5L	2	2.4
5L	1	1.2
10L	8	9.8
20L	42	51.2
30L	2	2.4
40L	27	32.9
Amount of water disposed		
5L	6	1.8
<10L	181	53.1
10L	9	2.6
20L	124	36.4
40L	21	6.2
Type of water disposed		
Clean water	103	30.1
Washing water	112	32.7
Cleaning water	56	16.4
Wastewater	63	18.4
Any	8	2.3

From this table, it is shown that the sample contained a total of 510 observations. In this sample, young adults make up more than half of the observations at 59%, old adults make up 21.4 % and children make up 19.6%. Regarding the gender composition of the sample, the sample is quite under-representative in that females constitute 70.8%, while males constitute 29.2% of the sample. Moving on to the water-related activities that occurred around the taps, most of the community residents ***collected water*** in their buckets (60.4%), 48.7% ***rinsed*** their buckets before collecting water, and 75.4% of them ***disposed*** of greywater at the tap. Regarding the utilization of the constructed wetlands sites (***top wetland*** and ***back wetland***) most of the community members ***disposed of greywater at the inlet*** (54.9%). When collecting water 73.5% of the community members used 20L buckets, 92.9% used one containers when collecting this water and most times the buckets were filled to the brim (72.7%). When washing 51.2% used 20L buckets, most of the resident's disposed greywater that amounted to <10L (53.1%), followed by greywater that amounted to 20L (36.4%), and the type of water that got disposed the most was washing water (32.7%).

Table 3.2

This table presents the results of the Quantitative Content Analysis performed on the data collected on the constructed wetland systems of *top wetland* and *back wetland*. Additionally, the activities that occurred at *no wetland* were tabulated to create a comparison group between the community members' wetland behaviour and their non-wetland behaviours:

Use of Constructed Wetlands			
CATEGORIES:	CODES:	FREQUENCY:	PERCENT:
Sitting on them	1	6	3.5
Using it as a pathway	2	4	2.3
Disposing of greywater in the gutter and not the inlet	3	35	20.5
Disposing of greywater at the inlet	4	94	54.9
Disposal of greywater directly onto the wetland	5	1	0.6
Any other observed behavior e.g., standing on them	6	31	18.1
Water collection site used the most			
CATEGORIES:	CODES:	FREQUENCY:	PERCENT:
Top Wetland	1	180	35.3%
Side Wetland	2	65	12.7%
No wetland	3	265	52.0%
Activities at each constructed wetland	**Frequency**		
	Top Wetland (1)		*Back Wetland* (2)
Sitting on them (1)	4 (2.3%)		2(1.2%)
Using it as a pathway (2)	3 (1.8%)		1 (0.6%)

Disposing of greywater in the gutter and not the inlet (3)	21 (12.3%)	14 (8.2%)
Disposing of greywater at the inlet (4)	63 (36.9%)	31 (18.1%)
Disposal of greywater onto the wetland (5)	1 (0.6%)	0
Any other observed behavior e.g., standing on them (6)	26 (15.2%)	5 (2.9%)

Activity by gender	**Frequency**	
	Male	Female
Sitting on them (1)	1 (0.6%)	5 (2.9%)
Using it as a pathway (2)	0	4 (2.3%)
Disposing of greywater in the gutter and not the inlet (3)	8 (4.7%)	27 (15.8%)
Disposing of greywater at the inlet (4)	28 (16.4%)	66 (38.6%)
Disposal of greywater onto the constructed wetland (5)	0	1 (0.6%)
Any other observed behavior e.g., standing on them (6)	8 (4.7%)	23 (13.5%)

Use of *no wetland*			
CATEGORIES:	CODES:	FREQUENCY:	PERCENT:
Disposal of greywater into the floor drain	1	129	48.7%
Disposal of water onto the street	2	18	6.8%
Stooping to wash, collect and dispose greywater	3	106	40%

Standing on the edge of the tap to prevent feet from getting wet	4	12	4.5%

Research question one assessed whether the re-designed constructed wetlands were being used and if they were how they were being used. From this table, it is shown that indeed the constructed wetlands were being utilised by the community members. Six different categories conceptualised these behaviours namely: ***sitting on the constructed wetlands***, ***using them as pathways***, ***disposing of water in the constructed wetland output and not the inlet***, ***disposing of water in the inlet***, ***disposal of water in constructed wetland***, and ***other observed behaviours*** like standing on them. The results from the quantitative content analysis show that the majority of the behaviours (54.9%) being exhibited by the observed community members was the ***disposal of water into the constructed wetland inlet***. The *top wetland* was the site where the majority of this behaviour occurred (36.9%), as illustrated in Figure 9, and females (38.6%) were found to exhibit this behaviour pattern more than males (16.4%). As stated in the methods chapter, this kind of behaviour is concurrent with the appropriate use of a constructed wetland as they were designed.

Moving onto the behaviour pattern of ***disposal of water into the gutter and not the inlet***, the results show that 20.5% of the observed community members performed this behaviour, making it the second most performed behaviour pattern, occurring chiefly at the *top wetland* (12.3%) As opposed to the beneficial effects ***disposing of water into the constructed wetland inlet*** has on the purification process of the constructed wetland, ***disposing of water in the gutter*** negates the process in that the water that flows through the gutter does not get cleaned. However, the gutter does help in channelling the greywater on a course to eventual disposal in the river, thereby, reducing the chances of stagnant greywater polluting the community's environment. The category of ***any other behaviour*** classified behaviours such as standing on the constructed wetlands and leaning on the taps. Here, only 18.1% of the observed community members exhibited these behaviours and most of the times it was at the *top wetland* (15.2%) and by females (13.5%). 3.5% of the sample ***sat on the elevated side-walks of the constructed wetlands*** as depicted in Figure 9, 2.3% used these same elevated side-walks as ***pathways*** (see Figure 10) and 0.6% ***disposed of water in the constructed wetland*** itself. These behaviours were performed mostly at *top wetland*, respectively, with ***disposal of water directly into the constructed wetland*** occurring only at *top wetland*.

Sitting on the CW *Disposal into the CW inlet*

Figure 9: Top Wetland

Using the CW as a pathway

Figure 10: Top Wetland

Regarding non-wetland behaviours at the site of *no wetland*, it was found that the categories of ***disposal of greywater into floor drain***, ***disposal of greywater onto the street***, ***stooping to wash laundry*** and ***standing on the edge of the tap to prevent feet from getting wet*** conceptualised these behaviours. The results from the quantitative content analysis show that the majority of the behaviours (48.7%) being exhibited by the observed community members was the ***disposal of***

greywater into the floor drain. 40% of the community members ***stooped when washing, collecting and disposing greywater*** as illustrated in Figure 11, 6.8% ***disposed of water onto to the street*** and 4.5% ***stood at the edge of the tap to prevent their feet from getting wet*** as shown in Figure 12. It is also important to note that an absence of stooping at the wetland sites (*top wetland* and *back wetland*) is as a result of the raised washing area which supports a more upright posture as illustrated in Figure 13.

Figure 11: Man stooping to dispose greywater into the drain

Figure 12: Woman standing on edge of the tap

Figure 13: More upright posture at side wetland

Table 3.3

This table presents the results of the Quantitative Content Analysis performed on the data collected across the tap areas of *top wetland*, *side wetland*, and *no wetland*. Here, the water-related activities that occurred around the tap areas are presented to answer the second research question.

Water-related activities occurring at *top wetland* and *side wetland*						
	Yes	No				
1) Water collection	308 (60.4%)	202 (39.6%)				
	<5L	5L	10L	20L	30L	40L
Size of container	5 (2%)	5 (2%)	31 (12.7%)	101 (41.2%)	0	8 (3.3%)
	One	Two	Three			
Number of containers	142 (57.9%)	8 (3.3%)				
	Filled	Partially Filled				
Filled to the brim/partially filled	99 (40.4%)	50 (20.4%)				
Water-related activities occurring at *no wetland*	Quantitative Content Analysis					
	<5L	5L	10L	20L	30L	40L
Size of container	6 (2.3%)	7 (2.6%)	22 (8.3%)	137 (51.7%)	1 (0.4%)	1 (0.4%)
	One	Two	Three			

Number of containers	158 (60%)	13 (4.9%)	2 (0.8%)			
	Filled	Partially Filled				
Filled to the brim/partially filled	136 (51.3%)	34 (12.8%)				
Washing at *top wetland* and *side wetland*	Quantitative Content Analysis					
	Washing laundry	Rinse bucket	Washed hands		Other (teeth brushing, fruit rinse, washing car with hosepipes)	
2) Washing	41 (16.7%)	32 (13.1%)	10 (4.1%)		2 (0.8%)	
	<5L	5L	10L	20L	30L	40L
Containers used:	0	0	6 (2.4%)	25 (10.2%)	1 (0.4%)	9 (3.7%)

Washing at *no wetland*	Quantitative Content Analysis					
	Washing laundry	Rinse bucket		Washed hands		Other (teeth brushing, fruit rinse, washing car with hosepipes)
Washing	42 (15.8%)	63 (23.8%)		3 (1.1%)		2 (0.8%)
	<5L	5L	10L	20L	30L	40L

Containers used:	2 (0.8%)	1 (0.4%)	2 (0.8%)	17 (6.4%)	1 (0.4%)	18 (6.8%)
3) Disposal at *top wetland* and *side wetland*	At tap	In wetland		At outlet		Outside wetland (gutter, stream)
	104 (42.4%)	13 (5.3%)		3 (1.2%)		40 (16.3%)
	<5L	5L	10L	20L	30L	40L
Amount of water disposed	1 (0.4%)	77 (31.4%)	4 (1.6%)	73 (29.8%)	8 (3.3%)	0
Types of water that gets disposed	"Clean" (Fresh water)	Washing	Cleaning	Wastewater	Any (Bath water and urine)	
	35(14.3%)	52 (21.2%)	31 (12.7%)	39 (15.9%)	7 (2.9%)	
Disposal at *no wetland*	At floor drain			Onto the street		
	129 (87.8%)			18 (12.2%)		
	<5L	5L	10L	20L	30L	40L
Amount of water disposed	5 (1.9%)	104 (39.2%)	5 (1.9%)	51 (19.2%)	13 (4.9%)	0
Types of water that gets disposed	"Clean" (Fresh water)	Washing	Cleaning	Wastewater	Any (Bath water and urine)	

	68 (25.7%)	60 (22.6%)	25 (9.4%)	24 (9.1%)	1 (0.4%)

Research question two assessed the water-related activities that occurred around the taps and constructed wetlands. From this table, it is shown that the water-related activities performed by the observed community members fell under the categories of ***water collection***, ***washing,*** and ***disposal***. At the tap sites (*top wetland*, *back wetland* and *no wetland*) 60.4% of the community members were found to collect water every time they went to make use of the taps. At *top wetland* and *back wetland* 41.2% of them utilised ***20L buckets*** when they collected water, used ***one container*** (57.9%), and most of the time it was ***filled to the brim*** (40.4%). Similarly, at ***no wetland*** the most used container was the ***20L buckets*** (51.7%). However, more ***40L tubs*** were used at the constructed wetlands (3.3%) than at ***no wetland*** (0.4%) and one ***30L bucket*** was used at *no wetland* but none was used at the wetland sites. Most community members used ***one container*** (60%) when collecting water at *no wetland* as well with the only difference being that some individuals used ***three containers*** (0.8%). Just like at the wetlands most of the times the containers at *no wetland* were ***filled to the brim*** (51.3%).

In relation to washing, 16.7% of the community members were found to ***wash laundry*** at *top wetland* and *back wetland*, 13.1% ***rinsed their buckets*** first before collecting water, 4.1% came to the taps solely to ***wash their hands*** and 0.8% of people performed ***other*** washing related activities like teeth brushing, fruit rinse, and washing their cars with hosepipes (see Figure 14). Similarly, to the results found in the ***water collection category*** regarding the size of the container, most of the containers used for washing were ***20L buckets*** (10.2%), followed by ***40L tubs*** (3.7%), then ***10L buckets*** (2.4%) and least of all ***30L buckets*** (0.4%). At *no wetland*, however, most community members ***rinsed their buckets*** first before collecting water (23.8%), 15.8% ***washed their laundry***, 1.1% ***washed their hands*** and 0.8% performed ***other*** washing related activities. Most of the containers used for washing at *no wetland* were ***40L tubs*** (6.8%), followed by ***20L buckets*** (6.4%), then the same amount of ***10L buckets*** and ***<5L buckets*** were used (0.8%). The same goes for ***30L buckets*** and ***5L buckets*** (0.4%).

Figure 14: Man washing his car with a hosepipe at top wetland

Regarding disposal behaviours at *top wetland* and *side wetland*, most of the observed community members were found to dispose of their water (clean, washing, cleaning, wastewater or any other liquid) ***at the tap*** (42.4%), 16.3% ***outside the wetland*** (stream, gutter), 5.3% ***in the wetland*** and 1.2% at the ***constructed wetland outlet***. Most times the amount of water disposed was ***5L*** (31.4%), closely followed by ***20L*** (29.8%), then ***30L*** (3.3%) and lastly ***10L*** (1.6%) and ***<5L*** (0.4%). Most community members disposed of ***washing water*** (21.2%), then ***wastewater*** including vegetable matter (15.9%), ***"clean" water*** resulting from rinsing their buckets (14.3%) and ***cleaning water*** (12.7%) came third and fourth, respectively and least of all was ***any*** other type of water in the form of bathwater and urine (2.9%).

Disposal at *no wetland* occurred either ***into the floor drain*** or ***onto the street*** and it was found that most of the observed community members would dispose of their water (clean, washing, cleaning, wastewater or any other liquid) into the former (87.8%) and 12.2% disposed of water into the latter. Just like at the constructed wetlands (*top wetland* and *back wetland*) most times the amount of water disposed was ***5L*** (39.2%) closely followed by ***20L*** (19.2%), then ***30L*** (4.9%) and lastly ***10L*** (1.9%) and ***<5L*** (1.9%). However, in the case of the types of water that got disposed, most community members disposed of ***"clean" water*** (25.7%), then ***washing water*** (22.6%), ***cleaning water*** (9.4%) and ***wastewater*** (9.1%) came third and fourth, respectively and least of all was any other type of water in the form of bathwater and urine (0.4%).

Table 3.4

This table presents an indication of the length of time for each water-related activity as well as the time of day they occurred the most.

Time of day when water-related activities occurred the most:	Water collection	Washing	Disposal
07:00-08:00	12(3.9%)	6(3.1%)	15(4.5%)
08:01-09:00	35(11.4%)	26(13.3%)	41(12.3%)
09:01-10:00	58(18.8%)	35(17.9%)	48(14.4%)
10:01-11:00	57(18.5%)	36(18.5%)	54(16.2%)
11:01-12:00	36(11.7%)	21(10.8%)	40(12%)
12:01-13:00	21(6.8%)	19(9.7%)	32(9.6%)
13:01-14:00	27(8.8%)	17(8.7%)	31(9.3%)
14:01-15:00	30(9.7%)	21(10.8%)	42(12.6%)
15:01-16:00	17(5.5%)	10(5.1%)	18(5.4%)
16:01-17:00	9(2.9%)	3(1.5%)	8(2.4%)
17:01-18:00	6(1.9%)	1(0.5%)	4(1.2%)
Duration of each water-related activity:	Water collection	Washing	Disposal
<5 min	250(81%)	108(55.4%)	300(90%)
5-15 min	58(18.8%)	4(2.1%)	33(10%)
15-30 min	0	83(42.6%)	0

Most of the sample performed the activity of water collection between the times of ***09:01-10:00*** (18.8%) while washing (18.5%) and disposal were performed the most between the times of ***10:01-11:00*** (16.2%). Relating to the duration, most of the observed sample spent ***less than five minutes*** on each water-related activity with only the activity of ***washing*** occurring for ***15-30mins*** on some occasions (42.6%).

Table 3.5

This table presents the results from the Thematic Content Analysis (TCA) that was performed on the interview data.

Theme: Acknowledgment of use of constructed wetlands
• *Top Wetland* (Top wetland was perceived by the interviewees to be perfect, a 100 percent right in their words save for the stagnant water in the constructed wetland) • *Side Wetland* (Side wetland had the most complaints) • *No wetland* N(No wetland was okay besides the fact that sometimes it had water and other times it didn't)
Theme: Shortcomings of constructed wetlands
• *Stagnant water in top wetland* (causes an eyesore to the people, creates a breeding ground for mosquitoes, emits a foul smell that nauseates the people thus discouraging them from eating outside and the children play with the water which is extremely unhealthy for them) • *Blockage of drain at side wetland* (Caused by soil and dirt through the overflow of the waste stream into the constructed wetland during periods of flood or heavy rainfall) • *Absence of gutter at side wetland* (Causes a mess, bad smell, flourish of waste stream that is messy and flooding when the waste stream overflows and pours over the constructed wetland) • *Leakage at side wetland* (Side wetland raised walls are leaking and this defeats its purpose. The disposed water in the wetland flows through the cracks and forms a puddle of stagnant water around the constructed wetland. This causes a mess and does more harm than good to the environment)
Theme: Reasoning behind use of constructed wetlands
• *Proximity* (Nearness of the constructed wetland) • *Availability of tap* (When one tap is occupied and the other is not) • *Availability of water* (The tap has water) • *Ease of use of constructed wetland* (Easy to upend bucket to mouth of drain to dispose water, reduce stooped position for ease of washing)

Theme: Perceived benefits of the constructed wetlands • *Flooding Prevention* (The top wetland raised concrete walls ensures this) • *Pollution Prevention* (The top wetland inlet and wetland ensure that greywater is disposed of effectively. As opposed to being disposed of on the street and polluting the environment) • *Directing dirty water away from residents* (The top wetland gutter ensures this)
Theme: Suggestions to improve the constructed wetlands • *Lower the effluent level* to reduce the presence of stagnant water at the surface of the constructed wetland • *Unblock the inlet at side wetland* • *Construct a gutter like that of top wetland at side wetland* • *Removable strainer/grid on the inlet*
Theme: Reasoning behind disposal behaviour • *Conformity* (Greywater is disposed of in the waste stream at side wetland because this is what is observed and deemed acceptable by an unsaid rule within the community) • *Proximity* (Greywater is disposed in certain places—wetland inlet, gutter and waste stream—because it is near)

In conducting this TCA six themes were generated namely: *acknowledgment of use of the constructed wetlands*, *the shortcomings of the constructed wetlands*, *reasoning behind use of constructed wetlands*, *perceived benefits of the constructed wetlands*, *suggestions to improve the constructed wetlands* and *reasoning behind disposal behaviour*.

Acknowledgement of use looked at whether the interviewees utilised the constructed wetland sites (*top wetland* and *side wetland*) and it was found that they did. *Top wetland* was perceived by the interviewees to be perfect, a 'hundred percent right' in their words, save for the stagnant water in the constructed wetland. *Side wetland* had the most complaints with relation to the waste stream beside it, the inlet blockage, and the walls leakage. *No wetland* had the least complaints besides the fact that sometimes it had water and other times it did not.

> **Person 6:** They've done a good job here [pointing to top wetland]. Here, they've done a good job because the water was going to that passage and there to Gogo Margret.
>
> **Person 11:** I think what they did at top wetland, I'd give it a 100 percent.

The ***shortcomings of the constructed wetlands*** highlighted the interviewees' thoughts on the inadequacies of the constructed wetlands. For one, the *stagnant greywater* (see Figure 15) in the top wetland was a cause of concern to the interviewees who claimed that it was particularly dangerous to children who had a higher chance of playing with it or worse falling into the dirty water when they crossed over it to get to their homes. This stagnant greywater was characterised by a mixture of vegetable waste, food particles, food wrappers and soap detergent. Furthermore, it was an eyesore that provided a breeding ground for mosquitoes and emitted a foul smell that nauseated the people and discouraged them from eating outside.

Ayomide: How has the CW helped with the dirty water?

Person 1: Mara, it is not right.

Ayomide: Why do you say that?

Person 1: Because with one mistake the children enter into the wetland that has dirty water.

Ayomide: Ok so how has this stagnant water affected you?

Person 3: We can't eat out here even during the day.

Figure 15: Stagnant water at top wetland

The *blockage of the inlet* at back wetland (see Figure 16) was another flaw that overshadowed whatever benefits the constructed wetland once had. Due to the blockage, the tap area was now prone to overflowing and this caused large puddles of stagnate greywater around the constructed wetland. This problem is even more exacerbated by the fact that the *side wetland walls are leaking* and counteracting the greywater recycling function of the constructed wetland.

Ayomide: So, it hasn't helped in any way with the dirty water?

Person 5: It doesn't help anymore.

Ayomide: Before it used to help?

Person 5: Yeah, it used to help but it was leaking somewhere here (points to the side of the wetland wall) but they came and tried to patch it again but you see there its leaking there (lower on the back wetland wall).

Lastly, *the absence of a gutter*—like that at top wetland—at back wetland allows for flooding and environmental pollution (see Figure 16). The waste stream beside the side wetland and the blocked drain at the tap area encouraged the disposal of greywater in the waste stream. Consequently, the unsanitary and unhealthy waste stream flourished. Additionally, the people complained bitterly of the waste stream next to the back wetland and the *absence of a gutter* with interviewees stating that:

Person 6: "I love this pump [referring to side wetland tap]. There's only one thing I don't like and it's ***this mess***. I've told your boss. I've told your boss [research supervisor] this mess he must try and fix it up other way round…This is not healthy for everybody. Older, young, it's not healthy for everybody."

Person 5: The only thing that maybe they can come and ***do is to unblock it*** and after that make something for the water to flow that side (down the community into the river). Maybe build a wall so that water can flow away.

Ayomide: You know the thing by the tap there (referring to top wetland) like the stream.

Person 5: Yeah.

Ayomide: So, if they can do something like that here...

Person 5: Yeah, it's gonna work. I think like that one (top wetland) is perfect. If maybe they can do something like that to go this way. Because the only thing the water wants is a way to go. That's the only way because otherwise it's a problem.

The topography of Setswetla is characterised by a downhill slope leading into the Jukskei River and so it was understood from the interview texts that during periods of heavy rainfall, a flood of greywater and storm water would flow into the entryway of the community. The raised walls of the constructed wetland and gutter at *top wetland* helped to divert water away from the residents living behind it to the waste stream at *side wetland* which overflows, blocks the tap drain with soil and flows into the homes of people living close to the wetland. It was argued by the interviewees that had there been a well-constructed gutter replacing the unsanitary waste stream then it would have helped to continue the direction of the greywater, kick-started by the gutter at *top wetland*, out of the community and into the Jukskei River.

Blockage at side wetland

Absence of gutter at side wetland

Figure 16: Back Wetland

The ***reasoning behind the use of the constructed wetlands*** looked into the factors that fuelled the use of the constructed wetlands and it was found that proximity, availability of tap, availability of water and ease of use of the constructed wetland were responsible for this. *Proximity* defined how close the constructed wetlands were to the community members for efficient greywater disposal, washing and water collection. This particular theme was one that emerged multiple times within the interview data. It soon became apparent to the researcher that the closeness of a site utilised for water-related activities to the people of Setswetla was of importance. In understanding the reasoning behind this, one interviewee stated that:

> **Person 17**: Yeah, because you know normally, you would want water anytime of the day or night so you wouldn't want to just go out and walk all the way somewhere. So, that is why it is important for it to be close by.

Availability of tap defines the tap site that is available at the time that it is required for the water-related activities that occur around the taps. From the interviews, it was found that the taps in the community were not enough for the magnitude of people that resided within the community and as such, traffic (especially during the weekends) was bound to happen at the tap sites. For this reason when a tap site was occupied, a less occupied tap site was sought out to conduct water-related activities.

> **Ayomide**: Okay but do you make use of this tap. This one [points to top wetland].
>
> **Person 18**: Oh, now and then. Yeah, when it is full, that side [referring to side wetland], I'll come this side.

Availability of water defines the availability of water at a tap site. It was understood from the interviews that most times *no wetland* was devoid of water and this was what fuelled residents to make use of *top wetland* because it always had water. Lastly, *ease of use of the constructed wetland* looked at the characteristics of the constructed wetland that makes performing water-related activities much easier and accessible.

> **Person 10**: No complaints we are happy. Even now if I'm washing, I can carry the baby and wash nicely. By that time, I was bending too much but now I can carry my small one and manage. So, it is easy.

The ***perceived benefits of the constructed wetlands*** provided insight into what the interviewees thought of the constructed wetland and how it had helped them. Three codes emerged from the interviews regarding these perceived benefits and they included ***flooding prevention, pollution prevention, and the direction of dirty water away from the community residents***. Prior to the construction of the newly designed constructed wetlands, the community suffered from harsh flooding which most times entered into the homes of its residents as stated by the interviewees. The raised walls of the *top wetland* have since helped to divert storm water away from the community members living behind the constructed wetland. In this way, *top wetland* (specifically) has helped to prevent flooding from storm water. Earlier on in the report, it had been noted that due to an absence of an effective sanitary system, embedded water pathways in the street had created a harbour for stagnant greywater, which was extremely unhealthy for the community. Since, the erection of the constructed wetlands, the interviewees have stated that the constructed wetlands have *prevented this pollution*.

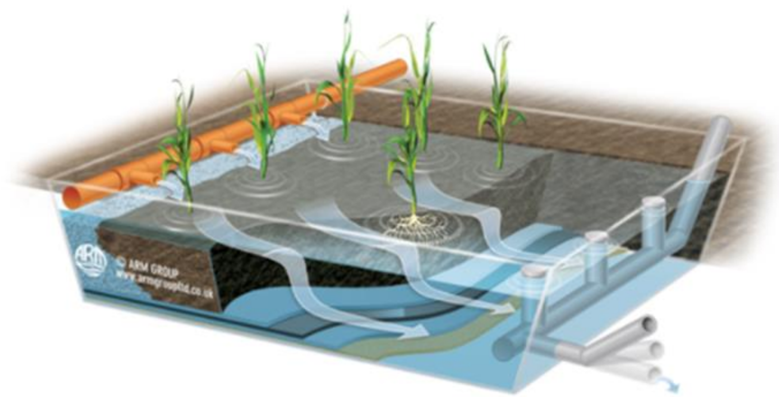
> **Person 17**: Yes, and then another thing is that it keeps the environment clean because usually it was muddy. This place was muddy and I'll see muddy papers and all that shit.

In relation to the *constructed wetland's gutter/stream directing dirty water away from the community residents*, one of the interviewees aptly described this as the stream creating a path for greywater to be disposed of in an area further away from the community.

> **Person 19**: For now, you can see, like it stopped many things like the dirty water was coming to my doorstep. It's not healthy for us. But since now the water has a direction exactly where the water is going to.

Suggestions to improve the constructed wetlands highlighted the interviewees opinions on what could be done to improve the current state of the constructed wetlands (*top wetland* and *side wetland*). These included to lower the effluent level of the constructed wetlands, unblock the inlet at back wetland, construct a gutter like that of top wetland at back wetland and to place a removable strain/grid on the inlet. At the moment, the constructed wetlands employ a horizontal surface flow (see Figure 17 and 18) system where the effluent level is maintained above the surface (Global Wetland Technology, 2022). In simpler terms, once the greywater flows through the inlet it is deposited above the soil for easy distribution (Global Wetland Technology, 2022). In this case, however, the deposited greywater ends up being stagnate because the design of the constructed wetland restricts the continuous flow of this greywater into a surface weir, for instance, placed at the end of the bed to collect the purified effluent. It was thus suggested by the interviewees that:

> **Person 3**: A proper drainage. Like a hole should be dug to allow the flow of dirty water in rather than this stagnant water.

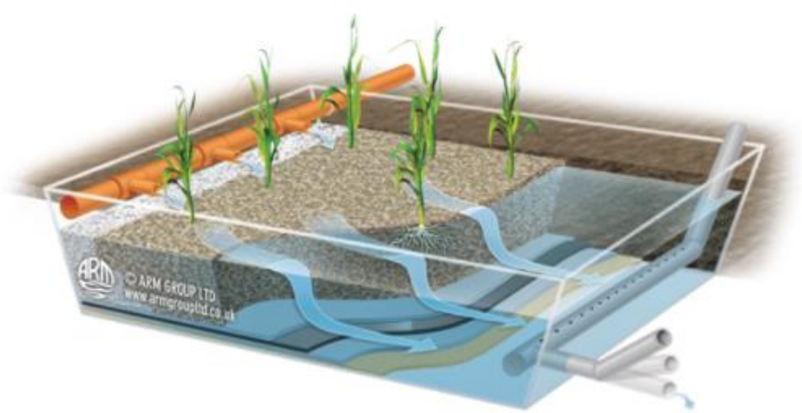


Horizontal Surface Flow Constructed Wetland

Figure 17

Figure 18

Seeing as a hole dug into the constructed wetland to combat the stagnant wastewater problem would only defeat its purifying purpose, it was thought that lowering the effluent level of the constructed wetland in a horizontal subsurface flow system (see Figure 19) would capture the ideas of the interviewees aptly (Global Wetland Technology, 2022). Here, the effluent level in the constructed wetland would be maintained just below the bed surface to guarantee full contact of the waste with the micro-organisms (Global Wetland Technology, 2022). This system is also utilised when the contaminates are soluble—like the detergents used when washing laundry—and are removed through microbial action—like the wastewater including vegetable matter disposal and cleaning water (Global Wetland Technology, 2022).



Horizontal Subsurface Flow Constructed Wetland

Figure 19

Regarding the *unblocking of the inlet at side wetland*, it was stated by the interviewees that for back wetland to be restored to its former glory the inlet had to be unblocked. Likening this to the reasoning behind the erection of the constructed wetlands in the first place, it only makes sense that the inlets have to remain unblocked, as they are the only source for greywater flow into the wetlands. As stated earlier, one of the reasons for this blockage is due to the overflowing of the waste stream beside the *side wetland* in periods of high rainfall. Consequently, it was also suggested by the interviews for the *waste stream to be replaced by a gutter*. Just like at top wetland, it was argued that a gutter at *side wetland* would help to direct greywater out of the community and into the Jukskei River.

> **Person 8:** <u>They need to build a gutter for the water to just flow easily</u> because right now there's no gutter and the water becomes blocked by soil and stuff and cannot run down. So, we need a gutter for the water to flow easily.

Lastly, it was suggested that a *removable strain/grid be placed on the inlets* so that non-biodegradable substances like plastic wrappers and papers can be prevented from entering into the wetland. Rather they would remain on the strain and this could be removed and disposed of properly.

> **Ayomide**: Okay, so how has this structure helped you?
>
> **Person 15:** Its right but there needs to be a strain on the drain so that when we pour water with the food it can float on the surface and then we can remove the dirt and put it back so that the only water that will go down will be dirty water and not food, not papers and stuff.

The ***reasoning behind the interviewers' disposal behaviours*** highlighted the factors that fuelled their exhibited disposal behaviours. It was found that proximity and conformity played an important role. *Proximity*, just as in the reasoning behind the use of the constructed wetlands, defined how close a disposal site was to an individual and *conformity* referred to the learned behaviours regarding the observed disposal behaviours that one is exposed to. As such, one's disposal behaviours could be influenced by what is being observed and this particularly rang true for the interviewees.

> **Ayomide:** If you have dirty water, where do you dispose it?
>
> **Person 4:** Inside the waste stream.
>
> **Ayomide:** Why there?
>
> **Person 4**: I just saw people pour everything here.
>
> **Ayomide**: Okay, so because people poured it in the waste stream and you just followed suite?
>
> **Person 4:** Yes.

Chapter 4: Discussion

This chapter presents a discussion of the results. It begins by exploring how each of the research questions presented in this study had been answered and what this information suggests about the redesign of the constructed wetlands. It highlights the visible changes in behaviours between wetland use and non-wetland use. Then it progresses to comparing this study to the 2020 consultancy report to determine whether they have been any notable differences between the early design of the constructed wetlands and the redesigned one. Additionally, it was compared to other studies on wastewater disposal in informal settlements to give insights into how similar or different they are from each other. The limitations of the study were expanded upon and directions for future research were advised.

4.1 How the research questions in this study were explored

4.1.1 Research question one:

Research question one assessed whether the re-designed constructed wetlands were being used and if they were how they were being used. The results from the quantitative content analysis showed that the constructed wetlands (*top wetland* and *side wetland*) were been utilised by the community members. Their behavioural patterns included ***sitting on the constructed wetlands***, ***using them as pathways***, ***disposing of water in the constructed wetland output and not in the inlet***, ***disposing of water in the inlet***, ***disposal of water in wetland*** and ***other observed behaviours (standing on them)***. Additionally, the study's findings showed that the majority of the behaviours exhibited by the observed community members was the ***disposal of water into the constructed wetland inlet***. The redesigned constructed wetlands were constructed in such a way that the inlet was built within the tap area for easier flow of disposed greywater into the constructed wetland when the community members attended to the taps to wash their clothes, collect water, or dispose of greywater. Constructed wetlands have been dubbed a practical nature-based solution to the problem of greywater due to their ability to recycle and remove contaminants from disposed greywater (Capodaglio et al., 2021). The general concept here is that the micro-organisms and plants act as a purification system allowing for the breakdown of toxins and nutrients present in the greywater (Capodaglio et al., 2021). Simply put, to optimise the potential of the constructed wetland's purification abilities, wastewater would have to be disposed into the inlet and then flow via the underground pipe into the wetland for filtration. Essentially, this behaviour exhibited by the majority of the observed community members was consistent with the appropriate use of constructed wetlands and in many ways assists to reduce the presence of the problematic greywater plaguing the community.

Regarding non-wetland behaviour at *no wetland*, it was found the observed community members exhibited the behaviours of ***disposal of greywater into floor drain***, ***disposal of greywater onto the street***, ***stooping to wash laundry*** and ***standing on the edge of the tap to prevent feet from getting wet***. The most exhibited behaviour was that of ***disposal of greywater into the floor drain*** and while the drain has no recycling purpose like the wetlands, it nevertheless assists in the effective disposal of greywater. This way the presence of the embedded street pathways of stagnant greywater are reduced. Carden et al. (2007) stated that many of the interviewees in non-sewered settlements in South Africa were aware of the issue of water scarcity and were willing to conserve water if educated on how to go about it. Thus, it is safe to say that through the constructed wetland initiative the community members have been enlightened on alternative forms of reducing the presence of the problematic greywater in the community. As such, they are less likely to just dispose greywater onto the street but rather into the floor drain just as they would the inlet at the constructed wetlands. Similarly, Todd et al. (2021) found that disposal at *no wetland* typically occurred at the tap, with water running into the accompanying drain or down into the open ground. Seeing as the tap area harboured the drain and the disposal behaviour of the community members was that of tipping over the contents of their buckets to dispose of greywater (be it on the street or into the wetland inlet), it is only feasible that most of the observed individuals at no wetland disposed of greywater into the floor drain. It was also found that a minority of observed community members ***disposed of greywater onto the street*** and not into the floor drain. Cele and Pharoah (2012, p. 139) provide a plausible reasoning behind this behaviour in stating that "in many cases informal settlements have inadequate waste disposal and sanitation infrastructure and services, but dumping occurs even where these are available, suggesting that people's behaviour is influenced by factors other than access to services". Thus, while the constructed wetlands or floor drain may exist it is understood that certain individuals would still dump/dispose of their water onto to the street or *on-site* (Carden et al., 2007). Consequently, this exhibited behaviour should not necessarily be utilised as a yardstick to determine the effectiveness of the constructed wetland but should be understood as a habitual disposal behaviour of the community members that can be quite difficult to change. However, its exhibition across the community can be reduced as illustrated by the findings of this study.

4.1.2 Research question two:

Research question two assessed the water-related activities that occurred around the taps. It was found that that these activities fell under the categories of ***water collection***, ***washing,*** and ***disposal***. The majority of the community members at the tap sites of *top wetland*, *side wetland* and *no wetland* were found to ***collect water*** every time they attended to the taps. Their choice of container for water collection was the ***20L bucket*** which most times was ***filled to the brim***. More ***40L tubs*** were utilised at no wetland as well as ***30L buckets***. In relation to ***washing***, the observed community members performed the acts of *rinsing their buckets before water collection*, *washing of their clothes*, *blankets* or *carpets*, *rinsing their hands*, *brushing their teeth*, and *washing their cars with a hosepipe*. Unlike the absence of any washing activity occurring at *top wetland* and only one washing activity occurring at *back wetland* in the consultancy report (Todd et al., 2021), this study found the majority of observed community members performing the activity of ***washing laundry***. At *no wetland* ***rinsing of the bucket before water collection*** was performed the most. Similarly in Todd et al. (2021), the observed community members were found to ***collect water*** (47.7%) the most at *no wetland*. The second most exhibited behaviour at *no wetland* was ***laundry washing*** and going by the findings of Todd et al. (2021) one can understand why majority of the observed community members in this study disposed of ***greywater into the floor drain***. It was stated that *no wetland* was commonly used for ***washing***, resulting in the generation of greywater, which was disposed of at the area (Todd et al., 2021). Similarly, to the results found in the water collection category regarding the size of the container, most of the containers used for washing at *top wetland* and *side wetland* were the ***20L bucket***. At *no wetland*, however, the ***40L tubs*** were used for washing the most.

Regarding ***disposal*** behaviours, most of the observed community members were found to dispose of their wastewater (clean, washing, cleaning, wastewater or any other liquid) ***at the tap*** of the constructed wetlands. ***Clean water*** refers to water resulting from the rinsing of bucket or a tap that was left to run as the individual disposed of water. ***Cleaning water*** refers to water resulting from home chores like mopping of a dirty floor, dishwashing and so on. Carden et al. (2007) in their study found that for non-sewered areas of South Africa, the common as well as acceptable method for greywater management was for individuals to dispose of it *on-site*. In this case, meaning the ground (Carden et al., 2007). It was understood that while they could trek long distances to collect water for household and other uses, they seldom walked far for greywater disposal and as such it was advised that greywater intakes are situated close to where the water is being utilised (Carden et al., 2007). Likening this finding to the residents of Setswetla, one can understand why the majority of the observed community members disposed of their greywater at the tap. The tap appears to be the part of the constructed wetland that residents interacted with the most. It is the one tool that churns out the needed resource (water) for water collection and washing which occurs chiefly *on-site* as well as one of the major sources (apart from direct disposal into the wetland) that ensures the flow of greywater into the constructed wetland. In the case, that greywater was not disposed at the tap; it was disposed ***outside the constructed wetland*** (stream, gutter). This behaviour is consistent with the findings in Carden et al. (2007) highlighted above, the only difference being that this disposal does not lead to the development of stagnant water but the direction of greywater away from the community. In this respect, the redesigned constructed wetland had been built to support the disposal behaviours of the community members. Together with this information, the results found that most times the amount of water disposed at *top wetland* and *side wetland* was ***5L***. Lastly, the observed community members were found to dispose of ***washing water*** the most at the wetland sites.

Comparing behaviour at the constructed wetlands (*top wetland* and *side wetland*) with behaviour at *no wetland*, it was observed that community members at this site *collected* water at the tap as well and *disposed* of their greywater into the ***floor drain or places removed from the tap***. These instances included, disposal of greywater on the ground as found in Carden et al. (2007) or in the embedded greywater pathways on the street. Similar to Todd et al. (2021), when laundry, buckets or plates were washed at *no wetland* an excessive stooped posture (a trunk angle over 90 degrees from the vertical) was employed. As opposed to the raised washing area of the constructed wetland which assisted to elevate this posture, *no wetland* lacked such structure and as such the individuals who used this site for water collection, washing, or disposal had to stoop. In this regard, the constructed wetland changed how the observed community members performed their water-related tasks. Additionally, the results found that most times the amount of water disposed at *no wetland* was ***5L*** and this can be linked to the fact that most of the observed community members were found to ***rinse their buckets first before collecting water***. This act only produced a small amount of “clean” water disposal.

Most of the sample performed the activity of water collection between the times of 09:01-10:00 while washing and disposal were performed the most between the times of 10:01-11:00. In the consultancy report, it was noted that at *top wetland*, all use involved the disposal of water, with the most popular time being between 12-2pm (Todd et al., 2021). At *side wetland*, the majority of the activities (water collection, washing and disposal) occurred earlier in the day, between 8-10 and 10-12am (Todd et al., 2021). This finding is consistent with what was found in this study and the same can be said for activities occurring the most between 8-12am at *no wetland* (Todd et al., 2021). Relating to the duration, the observed sample spent ***less than five minutes*** on each water-related activity with only the activity of ***washing*** occurring for ***15-30mins*** on some occasions.

4.1.3 Research question three:

Research question three assessed whether the redesigned constructed wetlands supported the appropriate water disposal and collection behaviours of the community members and helped to minimise the presence of greywater. Six themes were generated to answer this question namely *acknowledgment of use of the constructed wetlands, the shortcomings of the constructed wetlands, reasoning behind use of constructed wetlands, perceived benefits of the constructed wetlands, suggestions to improving the constructed wetlands and reasoning behind disposal behaviour.*

Acknowledgement of use looked at whether the interviewees utilised the constructed wetland sites (***top wetland***, ***side wetland***, and ***no wetland***) and it was found that they did. This was of importance because the community of Setswetla is not only exclusive to its residents. It is possible for new residents (or outsiders who are friends or family members of the community members) who have no knowledge of the constructed wetlands to be interviewed as this was randomized. Therefore, in order to be sure that they engaged with the constructed wetlands, there was thus a need for an acknowledgement of use. *Top wetland* was perceived by the interviewees to be perfect, a ‘hundred percent right’ in their words save for the stagnant water in the constructed wetland. *Side Wetland* had the most complaints with relation to the waste stream beside it, the inlet blockage and the walls leakage. *No wetland* had no problems besides the fact that sometimes it had water availability and other times it did not.

The ***shortcomings of the constructed wetlands*** highlighted the interviewees' thoughts on the areas where the constructed wetlands were lacking. The codes of stagnant water in top wetland, blockage of the inlet at back wetland, absence of a gutter at the back wetland, and leakage at back wetland conceptualised these thoughts. The *stagnant water in the top wetland* was a cause of concern to the interviewees who claimed that it was particularly dangerous to children who could fall into the wetland when crossing over it to get to their homes. Furthermore, it was an eyesore, which provided a breeding ground for mosquitoes, and emitted a foul smell that nauseated the people. The *blockage of the inlet* at the ***side wetland*** overshadowed whatever benefits the constructed wetland once had because due to the blockage, the residents explained that the tap area was now prone to overflowing. This caused large puddles of stagnant greywater around the constructed wetland. This shortcoming is even more exacerbated by the fact that the *back wetland walls were leaking* and counteracting the greywater recycling function of the constructed wetland. Lastly, *the absence of a gutter*—like that at top wetland—at side wetland allows for flooding and environmental pollution.

The ***reasoning behind the use of the constructed wetlands*** looked into the factors that fuelled the use of the constructed wetlands and it was found that proximity, availability of tap, availability of water, and ease of use of the constructed wetland were responsible for this. *Proximity* defined how close the constructed wetlands were to the community members for efficient greywater disposal, washing and water collection. As highlighted in Carden et al. (2007) it was advised that greywater intakes be situated close to where the water is being used as proximity was an important element for greywater disposal in informal settlements. *Availability of tap* defines the tap site that is available at the time that it is required for the water-related activities that occur around the taps. *Availability of water* defines the availability of water at a tap site and *ease of use of the constructed wetland* looks at the characteristics of the constructed wetland that makes performing water-related activities much easier and accessible. A lot of praise was attributed to the design of top wetland with many interviewees stating that its' redesign was a *hundred percent*. However, one point of appreciation that cut across the constructed wetlands (*top wetland and side wetland*) was the fact it was now much easier to dispose of water into the inlet of the constructed wetland. Taking inspiration from the recommendations put forth by Todd et al. (2021) in the consultancy report, the re-designed constructed wetlands had veered away from the separation of the constructed wetland inlet from the tap area and had instead merged them for easy access. The feedback from the interviewees demonstrates that indeed this aim was accomplished. Additionally, the interviewees perceived the raised washing area to be helpful in alleviating their stooped posture and in allowing for washing to occur even with a baby strapped to their back.

The ***perceived benefits of the constructed wetlands*** provided insight into what the interviewees thought of the constructed wetlands and how it had helped them. Three codes emerged from the interviews regarding these perceived benefits and they included ***flooding prevention, pollution prevention, and the direction of dirty water away from the community residents.*** Prior to the construction of the newly designed constructed wetlands, the community suffered from harsh flooding which most times entered into the homes of its residents, as stated by the interviewees. The raised walls of the *top wetland* have since helped to divert flood away from the community members living behind the constructed wetland. In this way, *top wetland* (specifically) has helped to prevent flooding. Earlier on in the report, it had been noted that due to an absence of an effective sanitary system, embedded water pathways in the street had formed a harbour for stagnant greywater, which was extremely unhealthy for the community. Since, the construction of the constructed wetlands, the interviewees stated that the constructed wetlands have prevented this pollution. Babatunde, Zhao, O'Neill and O'Sullivan (2008) claim that constructed wetlands act as purification areas for effluent discharged by the community and in so doing control environmental pollution. Correspondingly, the interviewees acknowledged the presence of drains in the tap area to be effective in the sanitary disposal of greywater. They eliminate the flow of greywater onto the street and stop the creation of muddy puddles around the taps. In relation to the *top wetlands' gutter* directing wastewater away from the community residents, one of the interviewees aptly described this as the stream creating a path for greywater to be disposed of in an area further away from the community. Earlier on in the report, a recommendation put forth by Carden et al. (2007) regarding the view that wetlands were not viable in high-density settlements because of lack of space, health risks and other safety considerations had been noted. The ***perceived benefits of the constructed wetlands*** in preventing flooding, pollution and reducing the presence of greywater in the populous community of Setswetla discredits this recommendation in showcasing the ability of wetlands to in fact be viable sources of alternate greywater management techniques.

Suggestions to improve the constructed wetlands highlighted the interviewees' opinions on what could be done to improve the current state of the constructed wetlands (*top wetland* and *side wetland*). These included to lower the effluent level of the constructed wetlands, unblock the drainage at the back wetland, construct a gutter like that of the top wetland at the back wetland and to place a removable strainer/grid on the inlet. At the moment, the constructed wetlands employ a horizontal surface flow system where the effluent level is maintained above the surface (Global Wetland Technology, 2022). In other words, once the greywater flows through the inlet it is deposited above the gravel for easy distribution across the surface (Global Wetland Technology, 2022). This deposition causes the creation of stagnant wastewater in the constructed wetland which is dangerous to the health of the community members and constitutes environmental pollution. To combat this problem, it was thus proposed that the *effluent level of the constructed wetlands should be lowered* in a horizontal subsurface flow system. Here, the effluent level is maintained below the soil surface to ensure full contact with the microorganisms responsible for the recycling of wastewater (Global Wetland Technology, 2022).

Regarding the *unblocking of the inlet at side wetland*, it was stated by the interviewees that for the back wetland to be restored to its former glory the inlet had to be unblocked. Likening this to the reasoning behind the erection of the constructed wetlands in the first place, it only makes sense that the inlets have to remain unblocked, as they are the only source for greywater flow into the wetlands. As stated earlier, one of the reasons for this blockage is due to the overflowing of the waste stream beside the *back wetland* in periods of high rainfall and sewage overspill. The sewage has been depositing effluent and raising the level of the waste stream so when it rains it overflows. Consequently, it was also suggested by the interviewees for the *waste stream to be replaced by a gutter*. Just like at top wetland, it was argued that a gutter at the *side wetland* would help to direct greywater out of the community and into the Jukskei River. Lastly, it was suggested that a *removable strain/grid be placed on the inlets* so that non-biodegradable substances like plastic wrappers and papers can be prevented from entering into the wetland. Rather they would remain on the strain/grid and this could be removed and disposed of properly.

As stated earlier, the *proximity* of a site used for water-related activities including disposal was understood to be of importance to the people of Setswetla. Regardless of the fact that individuals in informal settlements were willing to walk long distances to get water, they were not as willing to walk far to dispose of it and thus the common form of disposal was *on-site* (Carden et al., 2007). According to Cele et al. (2021), a reasoning behind this form of disposal and the need for disposal sites to be in close proximity to residents in informal settlements lies in the concept of *time*. Women (or children) were usually tasked with the chore of disposal and they reported that oftentimes they had a range of other household tasks to undertake and could not afford to waste time walking hundreds of meters away to dispose of waste (Cele et al., 2021). This argument when likened to this study sheds some light on some of the reasons behind the over-representation of females in the sample as well as the inhabitants need for the tap sites to be located close to them.

Apart from *proximity* playing a role in the interviewees' disposal behaviours, it was also found that certain individuals disposed in certain places because others did the same. *Conformity* in this sense refers to the learned behaviours regarding the observed disposal behaviours that one is exposed to. This response is similar to the findings in Cele et al. (2021) study into waste-disposal behaviours in the informal settlement of Kayamandi. Here, the respondents stated that they were reluctant to act against those who disposed waste inappropriately because they feared creating conflict with other community members (Cele et al., 2021). This was especially taxing when the individuals where older than they were, as it would be perceived as a sign of disrespect (Cele et al., 2021). Instead, it was easier to adopt and comply with the prevailing practices in the community than to challenge them (Cele et al., 2021).

4.2 Comparisons with the Consultancy Report

In the consultancy report, it was stated that the *top wetland* was the least used site during analysis (Todd et al., 2021). The most likely cause was the broken tap at the site (Todd et al., 2021). However, since the restoration of the sites' tap, it was found in this study to be the most used constructed wetland site with 180 observations and the majority being young adult females (76.7%). Additionally, the interview data shows that the *top wetland* re-design was perceived to be perfect and better than the *side wetland*. This could stand for another reason why it was the most used wetland. Just like the consultancy report which found *no wetland* to be the most popular site, this study also found it to be the most used site in relation to ***water collection***, ***washing*** and "on-site" ***disposal*** with 265 observations and the majority of its users being female. In the same respect, the potential site for wetland construction was much busier than the sites that already had a constructed wetland in place (Todd et al., 2021).

Concerning the re-design of the constructed wetlands, improvements in the exhibited behaviours of the community members were noted. For one, there was no reason for residents to lift containers to dispose of greywater into the constructed wetland inlet. The new constructed wetlands had made disposal easier in that the inlet to both wetlands (*top wetland* and *side wetland*) were constructed to be at the same level as the base of each tap. Linking to this was the fact that the majority of the observed community members were found to dispose of their greywater at the tap area leading to the constructed wetland inlet shows that their disposal behaviour of upending their container at the site of water-related activity was supported. Secondly, the stooped posture—a trunk angle over 90 degrees from the vertical—that was employed by community members when washing or disposing of greywater at *no wetland* was somewhat elevated at the constructed wetland sites (*top wetland* and *side wetland*) due to the raised concrete platform of the tap area. The raised washing area supported a more upright posture that allowed for community members to wash, collect or dispose of water without much strain on the back.

4.3 Limitations of the study

One limitation of the study would be with regards to the fact that *side wetland* had the least observations. Unlike *top wetland*, which was located directly at the mouth of the community and visible to all residents, the *side wetland* was constructed within the community and thus hidden from view. On one occasion a suspected inebriated male had "flashed" the observers (who were females) and had posed a threat to their safety. Furthermore, a corner adjacent to the constructed wetland housed a vicious dog that could be unruly from time to time and for these reasons, data collection had to cease—in those moments—to ensure the safety of the data collectors. It is thought that had the same amount of time spent observing *top wetland* been spent observing the *side wetland*, a true representation of the most used wetland would have been achieved.

Another limitation lies in the length and time frame of the data collection of the study. As stated previously, observations commenced from 07 September to 13 September with the weekdays (7-10 September) adhering to the fixed time interval of 07h00-16h00, observations during the weekends (11-12 September) starting at 08h00-12h00 and observations on Monday (13 September) starting at 12h00-18h00. It is understood that each week of the year varies depending on a number of differing factors and as such, one week is not enough to acquire a holistic view of the disposal and water-related activities of the community members around the constructed wetlands. Moving on to the time frame employed in this study, persons who utilised the taps early in the morning or late in the evenings where not observed on some days. It can be argued that due to safety reasons observations could not commence earlier that 07h00 or later than 18h00, however, highlighting this flaw just goes to show the possibility of other water-related or disposal behaviours emerging at the times that observations had ceased.

Earlier on in the report, it was stated that the observers had employed the form of participant observation that was *undisguised* in nature. Here, the true identity of the researchers were disclosed to the community and this could have inadvertently changed the behaviours of the community members. They were well aware of the reason behind the observations as well as the fact that the object of observation was their behaviour in relation to the constructed wetlands. As such, they may have changed their behaviours to suit an appropriate outcome. Additionally, it is possible that the observers could have missed important observations or divergent behaviours from the ones stated in this study. This could have happened as a result of the observers introducing bias into the research by unconsciously wanting to tailor the observations solely to the activities highlighted in the observation sheets and disregarding the ones that were not highlighted. In spite of these limitations, the results obtained from the study inform the literature on disposal behaviours, constructed wetlands and their incorporation into an informal settlement in South Africa. As well as how it might be embedded as part of community life given the water-related activities that occur around the taps and the flow of water disposal.

4.4 Recommendations for future research

Though this study focused on the disposal behaviours around the constructed wetlands, the fact still stands that constructed wetlands as nature-based solutions assist to recycle greywater (Capodaglio et al., 2021). In the long run the successful recycling of water through the wetland mechanism would assist tremendously to reduce the environmental pollution within the community of Seswetla as well as the people’s exposure to its offending sensory smell. The recycling abilities of the constructed wetlands while acknowledged were not, however, shown to be successful in this study and it would be recommended for future research to explore this aspect. Additionally, the water-related activities observed were all in relation to the constructed wetlands (*top wetland* and *side wetland*) and *no wetland*. It would have been useful to observe these behaviours removed from these sites (*top wetland*, *side wetland* and *no wetland*) to perceive how they differ from what is already known or how they are similar. In Carden et al. (2007) it was found that residents in poorly draining soils had devised set of ways to deal with the issue of greywater. For one, they all agreed to carry all their greywater to nearby storm water canals or better still, dump it down storm water access chambers to prevent stagnant water around shacks and restrict breeding grounds for mosquitoes (Carden et al., 2007). It would have been particularly informative to observe the disposal behaviours of community members who lived further down in the settlement and not close to the sites of observations (*top wetland*, *side wetland* and *no wetland*). Since, *proximity* was found to act as an important aspect to the disposal behaviours of the community members, different disposal behaviours were sure to emerge in how the community members living further away from the wetland site disposed of their greywater. Taking inspiration from Cele and Pharaoh’s (2021) study, it is proposed that the methodology of *focus groups* interviews, analysed thematically be incorporated in future research into the disposal behaviours of individuals living further from wetland sites. Here, the “focus groups were utilised to capture the viewpoints from a range of different locations within informal Kayamandi by purposively sampling respondents living both close to and relatively far from municipal waste disposal sites" (Cele et al., 2021, p.144). A discussion guide was also used to explore the residents' typical waste disposal behaviours and the factors that influenced these behaviours (Cele et al., 2021).

In a similar vein, another round of observation—this time longer—is recommended for future research at not only the tap sites (*top wetland*, *side wetland* and *no wetland*) but also at the disposal sites further away from them. Similar water activities highlighted in this study (***water collection***, ***washing*** and ***disposal***) would be observed with the inclusion of the certain activities that emerged at the disposal sites further away from the wetland sites. Furthermore, it would be recommended that the ***suggestions to improve the constructed wetlands*** (lowering the effluent level, unblocking the drainage at the wetland, constructing a gutter like that of the top wetland at the back wetland and placing a removable strainer/grid on the inlet) be incorporated into the future redesign of the constructed wetlands for more efficiency in reducing the presence of greywater in the community.

4.5 Conclusion

In conclusion, this study has explored the use and disposal of water around constructed wetlands in Setswetla. Direct observation, the work sampling technique approach, time-and-motion approach together with short-structured interviews were employed to collect data to answer the research questions set forth in this study. It was found that the constructed wetlands were being utilised in the manner in which they had been engineered for effective greywater disposal. Additionally, the re-designed wetlands had changed the community members' behaviours for the better. This was especially with regards to a more upright posture, ease in collecting and disposal of water as well as a more conscious effort in recycling greywater. The limitations of the study were highlighted and recommendations were put forth in a bid to enhance the effectiveness of the constructed wetlands further. All in all, this report has presented an additional informative piece on the literature informing the erection of alternative recycling mechanisms in informal settlements in South Africa. As well as the community members disposal and water-related behaviours.

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Appendix A: Observation Sheet

Date:	
Site/Area of observation: Top (1) Side (2) No (3)	
Time of day that these activities occur and duration: 1. 08:00-10:00 2. 10:00-12:00 3. 12:00-14:00 4. 14:00-16:00	
Demographic: 1. **Age Group:** Child (0) Young Adult (1) Adult (3) 2. **Gender:** Female (1) Male (2)	
Water-related activities that occur around the taps: 1. **Water collection:** Yes (1) No (2) 2. **Washing:** Wash (1) Rinse (2) Washed hands (3) Other (4) 3. **Disposal:** At tap (1) In wetland (2) At outlet (3) Outside wetland (4) (Stream, side gutter).	
How are the CW's being used? 1. Sitting on them (1) 2. Using it as a pathways (2) 3. Disposing of greywater in the **gutter** and not the **inlet** (3) 4. Disposing of greywater at the inlet (4)	

5. Disposal of greywater in the wetland (5) 6. Any other observed behavior (6)	

Water collection
1. How large is the container?
   <5L (1)
   5L (2)
   10L (3)
   20L (4)
   30L (5)
   40L (6)
2. How many containers were used?
   One (1)
   Two (2)
   Three (3)
3. Was it filled to the brim or partially filled?
   Filled (1)
   Partially Filled (2)	

Washing Containers used: 1. <5L (1) 2. 5L (2) 3. 10L (3) 4. 20L (4) 5. 30L (5) 6. 40L (6)	
Disposal Amount of water disposed: 1. <5L (Small) (1) 2. 5L (2) 3. 10L (Medium) (3) 4. 20L (4) 5. 30L (5) 6. 40L(large) (6)	
Types of water that gets disposed **1.** “clean” water (1) **2.** washing water (2) 3. cleaning water (3) **4.** wastewater including vegetable matter (4) 5. Any (5)	
Other Observations	

Appendix B: Time and Motion Criteria

Demographic	**Activity type in relation to site use**	**Task breakdown**	**Utilized disposal technique**
Background details (Gender, age group)	Water collection: Refers to bringing containers to the tap and then filling it.	e.g., Water collection description: How large is the container? How many containers were used? Was it filled to the brim or partially filled?	e.g., Upend the container around the tap area (which could possibly run into the street)
Time of day and duration of activity	Washing: refers to attending the tap to wash items be it dishes, buckets or clothing.	e.g., Tap usage.	e.g., Dispose greywater into the nearby stream
	Disposal: refers to the grey water that is either being brought from the home to the tap area to be discarded or the disposal of water from the activities at the tap area.	e.g., Body posture description: Standing or stooped?	e.g., Dispose water into constructed wetland inlet.

Appendix C: Ethics Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE: **PROTOCOL NUMBER: MAORG/21/02**

PROJECT TITLE: Exploring the use and disposal of water around Constructed Wetlands in Setswetla.

INVESTIGATOR Eyitayo-Ajayi Ayomide (1482382)

SCHOOL/DEPARTMENT OF INVESTIGATOR SHCD/Psychology

DATE CONSIDERED 20 June 2021

DECISION OF THE COMMITTEE Approved unconditionally

RISK LEVEL Low Risk

EXPIRY DATE 31 December 2023

ISSUE DATE OF CERTIFICATE 26 June 2021 **CHAIRPERSON** ____________________
(Dr Colleen Bernstein)

cc: Prof. Andrew Thatcher (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and ONE COPY returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

____
Signature

Date ______/______/______

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix D: Ward Councillor Permission

CITY OF JOHANNESBURG
METROPOLITAN MUNICIPALITY
OFFICE OF THE SPEAKER

Tel: (011) 582 1590
Fax: (011) 582 1588
Cell: 083 398 8804

City of Johannesburg
Region. E
Ward 109

OFFICE OF THE COUNCILLOR LIAQUAD EBRAHIM

22nd January 2020

To whom it may concern

RE: ACKNOWELDGEMENT LETTER

This letter serves to confirm that I, Ward 109, Councillor Liaquad hereby acknowledges that **URBWAT PROJECT,** will be conducting research on greywater treatment solutions in an urban informal settlement. The research will be conducted in Setswetla Informal Settlement, Ward 109, Alexandra.

I therefore grant permission to **URBWA**T team to conduct their study in Setswetla Informal Settlement. Please contact me should you have any further cause for concern.

Thanking you in anticipation,

Kind regards

....

Councillor Liaquad Ebrahim
Ward 109

City of Joburg
Office of the Speaker
2020 -01- 22
Ward Governance
REGION E

Appendix E: Participant information Sheet (Observations)

Participant Information Sheet (Ethnographic Observations).

Dear Sir / Madam,

My name is Ayomide Eyitayo-Ajayi, and I am a Masters student in Organizational Psychology at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the use and disposal of water around the re-designed Constructed Wetlands (CW's) in Setswetla under the supervision of Prof. Andrew Thatcher. The aim of this research project is to find out if the CWs are being used appropriately and if they support your wastewater disposal behaviour.

As part of this project, I would like to invite you to take part in an ethnographic observation. This activity will involve the researcher capturing and recording, through direct observation, your activities in relation to your use and disposal of water around the re-designed CW's. The activities that are under this study include, water collection, washing, and the disposal of water in, around and removed from the CW's. Observations will take place from the times of 07h00-16h00 during certain days of the week and recruited community members will assist with the observations on the days that the researcher is not present. With your permission, I would like to record this observation using a pre-generated data entry form. Additionally, I would also like to take certain pictures in support of the different observed activities. The recordings and pictures will be stored in a password-protected computer and only my supervisor and I will have access to this information. However, the pictures will form part of the final reporting and in this case, pictures that do not show any visible, traceable parts of your faces will be used.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or refuse to be observed or have your picture taken if you are uncomfortable. The observation will be completely confidential and anonymous as no identifying information, including your name, will be recorded during the observations, and the information you give to me will be held securely on a password-protected computer and not disclosed to anyone else. I will be using the gender differentiations (male and female) and age classification (young adult, middle age etc.) to represent your participation in my final research report. The pictures will also be taken in such a way that eliminates any facial recognition, whatsoever.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. The data collected from this research project will be stored in a password-protected computer and will be kept for a year. With your permission, the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

Researcher: Ayomide Eyitayo-Ajayi, 1482382@students.wits.ac.za
Supervisor: Prof Andrew Thatcher, Andrew.Thatcher@wits.ac.za

Appendix F: Participant information Sheet (Interviews)

Participant Information Sheet (Interviews).

Dear Sir / Madam,

My name is Ayomide Eyitayo-Ajayi, and I am a Masters student in Organizational Psychology at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the use and disposal of water around the re-designed Constructed Wetlands (CW's) in Setswetla under the supervision of Prof. Andrew Thatcher. The aim of this research project is to find out if the CW's are being used appropriately and if they support your wastewater disposal behaviour.

As part of this project, I would like to invite you to take part in an interview. This activity will involve a series of structured questions that I will ask you to answer regarding certain behaviours that were performed in relation to the CW's. The interview will take around 5 minutes. With your permission, I would also like to audio record this face-to-face interview using a digital device. This recording will be stored in password-protected computer and only my supervisor and I will have access to this recording. Furthermore, it may be stored for future secondary analysis.

There will be no personal costs to you if you participate in this project. You will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely on a password-protected computer and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. The data collected from this research project will be stored in a password-protected computer and will be kept for a year. With your permission, the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,
Ayomide Eyitayo-Ajayi

Researcher:
Ayomide Eyitayo-Ajayi, 1482382@students.wits.ac.za

Supervisor:
Prof Andrew Thatcher, Andrew.Thatcher@wits.ac.za, 0117174533