HOUSEHOLDS' KNOWLEDGE, PERCEPTION, AND BEHAVIOURAL INTENTION OF THE EFFECTS OF WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY.

BY

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DECLARATION

I, Sebashe Tshegofatso (student number: 224104990) declare that **"Households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality"** is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of a complete reference list. In addition, this study has not been presented or submitted previously for any degree or at any university.

[redacted] 09 August 2024

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Signature Date

Ms Sebashe Tshegofatso

DEDICATION

I dedicate this study to my lovely parents who loved, supported and nurtured me in every part of my academic journey and personal life. Sebashe Francinah (Mom) and Sebashe Setimela (Dad), you are the best.

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ABSTRACT

Improper waste disposal in water is a growing problem that has received little attention in Southern Africa. Deterioration of water quality presents burgeoning threat to human beings and all living organisms. Lack of knowledge and awareness; negative attitude and perception; poor waste practices and negative behavioural intention influence the current waste management activities. This study investigated households' knowledge, perception, and behavioural intention of the effects of waste disposal on water quality. A systematic sampling technique was adopted to collect data using questionnaires. A total of 384 questionnaires were administered in four villages and analysed using SPSS version 29.0 and Excel. T-test was used to compare mean values and standard deviation of all variables. In addition, Principal Component Analysis (PCA) and probit regression analysis were utilized to determine households' knowledge, perception, and behavioural intention towards waste disposal in water. Water quality assessment and MiniSASS were used to compare with the perceived environmental, health, and social risks.

Most (66.6%) of respondents were females and 62.9% were unemployed. The majority (89.0%) of respondents revealed that they were not currently paying for waste disposal services and 83.8% revealed that the municipality never collected their waste. About (96.6%) of respondents were not satisfied with the current municipal waste removal system. Almost (99.0%) of the respondents generated all classes of waste and 77.0% of respondents disposed of their waste in water bodies. Nearly, 86% of respondents were aware that accumulation of disposed waste in rivers causes health risks and 94% of respondents were not knowledgeable nor aware that the municipality and government render public support in the form of awareness campaigns.

The findings of the study also revealed that 74% of respondents had a positive attitude on disposing of waste in water bodies creates jobs for municipal workers or EPWP and 72% had a negative attitude on the willingness to travel to the landfill site to dispose of waste. On behavioural intention, about (86%) of respondents were in favour of transporting waste to the disposal location is cumbersome and most of the respondents (54.3%) were not in favour of 'to deal' with waste in future, I am willing to get in touch with organizations, municipality, and government officials. Furthermore, the results of probit regression analysis revealed that households' knowledge and awareness was influenced by education level; gender and employment status, households' attitude was influenced by income level; monthly waste disposal payment, municipal collection services and satisfactory level, and the perceived risks were influenced by households' knowledge. Moreover, the results of PCA revealed four factors that were extracted based on the responses of households which included disposal methods; campaign factors; community pressure and water quality.

The majority (73%) of respondents perceived that aquatic organisms cannot survive with less dissolved oxygen. Most (93%) of respondents perceived that high chemical oxygen demand (COD) leads to cancer-related diseases. The results also revealed that 76% of respondents perceived that children drown in polluted river due to poor turbidity. Water quality parameters (pH; nitrates; phosphorus; Electrical Conductivity (EC); COD; water temperature; turbidity; Total Suspended Solids (TSS) and Dissolved Oxygen (DO)) had potential health risks and did not fall within the permissible limits of WHO. Based on MiniSASS results, the most abundant taxa during dry season were Oligochates as they successfully inhabit polluted water.

It is therefore recommended that regular monitoring of river water quality should be conducted across all villages; environmental awareness and health education should be intensified in Ba-Phalaborwa Local Municipality; extension of waste collection services in rural areas; establishment of collection points with lockable and labelled containers according to waste type; recycling should be encouraged and promoted; waste sorting and separation at the source should be implemented prior to disposal; provision of storage containers (Skip bins); establishment of local recycling infrastructures in villages and, developing and strengthening of regulations and by laws on water quality.

Keywords: Knowledge; Attitude; Perception; Behavioural Intention; Waste disposal and Water quality.

ACRONYMS

BOD	Biological Oxygen Demand
CDW	Construction and Demolition Waste
CFA	Confirmatory Factor Analysis
COD	Chemical Oxygen Demand
COJ	City of Johannesburg
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and the Environment
DO	Dissolved Oxygen
DoH	Department of Health
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPS	Global Positioning System
HSSREC	Humanities and Social Sciences Research Ethics Committee
IDP	Integrated Development Plan
IWMP	Integrated Waste Management Plan
KAP	Knowledge, Attitude and Practices
LEDET	Limpopo Department of Economic Development, Environment and Tourism
MDM	Mopani District Municipality
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management

NEMA	National Environmental Management Acts of 107 of 1998
NEMA: WA	National Environmental Management: Waste Act 59 of 2008
NIMBY	Not In My Backyard
NWA	National Water Act
NWM	National Waste Management
NWMS	National Waste Management Strategy
PCA	Principal Component Analysis
PPP	Polluter Pays Principles
QGIS	Quantum Geographic Information System
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
SEM	Structural Equation Modelling
SPSS	Statistical Package for Social Sciences
SEMAs	Specific Environmental Management Acts
SWM	Solid Waste Management
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TSS	Total Suspended Solid
WEF	World Economic Forum
WSA	Water Services Act
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
WEE	Waste-to-Energy
WHO	World Health Organization

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Sebashe, T., Ngidi, S.C.M, & Oladele, O.I. (2024). Health risks of waste disposal in water – scientific data versus households' perception; evidence from peri-urban areas of Limpopo Province, South Africa. *Sustainable Water Resources Management.*

CHAPTER ONE: INTRODUCTION.

1.1. Background of the study.

One of the biggest sources of environmental damage is widely known as illegal dumping (Yi *et al.,* 2020). Illegal dumping or indiscriminate dumping is also known as fly tipping (or fly dumping); open dumping or midnight dumping (Niyobuhungiro & Schenck, 2022). According to a common definition used by many scholars (Bangani *et al*., 2023; Yi *et al*., 2020 & Yuan *et al*., 2023), illegal dumping alludes to the disposal of waste in a restricted area and individuals with no license, dumping waste on sites contrary to properly disposing at a landfill site or using an authorised rubbish dump. Waste is often abandoned in vacant; unoccupied or open area; forests; water bodies; sidewalks; fence lines; creeks and streets (Aslam, 2022; Jourbert, 2021; Shammi *et al*., 2023; United States Environmental Protection Agency, 2020; & Brandt, 2017). This is done to avoid the time and effort imperative for lawful dumping (Tomita *et al*., 2020).

Waste is classified into different categories such as electronic waste; radioactive waste; industrial waste; construction waste; commercial waste; waste tyres; general household waste; medical waste; garden waste and many more (Ambrin *et al*., 2018; DEA, 2023 & Nwachukwu *et al*., 2018). In addition, waste is an unpleasant and excessive by-product that has been stored, discarded or accumulated with the intention of further processing or discarding it (Kimani, 2020; Iravanian; 2020 & Nwosu *et al*., 2016). It originates from industrial, commercial and residential area and thus contain solid; liquid; gaseous or the combination of all (Brandt, 2017). According to Motaung *et al* (2020), the common result of unlawful dumping of waste material includes domestic, construction rubble and demolition. For this reason, the owner has no further use of the illegally disposed or abandoned waste.

According to Eshete *et al*. (2023) households' knowledge is relatively less on waste disposal practices and recycling. In addition, developing countries noted environmental education as another tool to create awareness amongst households. (Owusu, 2021). Waste management, water pollution and ecological issues resulting in unsustainable development has emanated from the gap in environmental knowledge among the youth and the old within developing countries (Afroz, 2021). Lack of knowledge leads to the difficulties of correct waste disposal and separation practices (Kadyamadare & Samson, 2023). Age influences waste separation. As a result, waste separation is practiced more by elderly than young people (Kofi *et al*., 2021). Age can influence maturity; however, it is not always directly associated with it. According to Singhirunnusorn *et al*. (2021) the elderly are willing to sort their waste and sell to recycling companies. Utmost older generations value their planet and become more aware of the effects of improper waste disposal and are more eco-friendly (Kofi *et al*., 2021). Therefore, it is essential to bridge the gap in the knowledge of the young regarding waste segregation and disposal practices in developing countries.

According to Fadhullah *et al*. (2022) and Abas *et* al. (2020) lack of knowledge in proper waste handling and segregation of waste begins at a household level. Desa *et al*. (2023) found that households have low knowledge on source separation and waste reduction. Further revealed that 83.9% of households did not practice waste reduction and did not sort their waste for waste collection. Reasons behind households' lack of interest in waste reduction and separation include lack of education on waste reduction and separation; non-compliance and non-enforcement with policies and laws on waste reduction and separation; inadequate storage bins and lastly no organised recycling and composting programme (Abubakar *et al*., 2022 & Glen, 2020).

Heyasa and Ifegbesan (2023) highlighted that limited waste management knowledge and practices on households has led to negative waste management practices. Most households dispose their waste in rivers, along the roadsides, backyards with sacs, in gully and burn in open air due to poor knowledge (Eshete *et al*., 2023). Others separate wet and dry waste for disposal in rivers and easy burning (Ziblim & Bowan, 2020). The environment is destroyed due to the absence of viable environmental knowledge in most developing countries. Thus, lack of knowledge and awareness has contrived households to be ignorant about the effect of improper waste disposal.

Inadequate knowledge on waste segregation and reduction progressively increases the volume of municipal solid wastes dumped in landfill sites (Desa *et al.,* 2023). Therefore, the remaining landfill space becomes occupied and reaches its capacity at a faster rate than initially planned (Kofi *et al*., 2021). However, poor knowledge among individuals debilitates poor waste management practices, resulting in perpetual issues for future generations (Ampofo, 2020). As a result, there should be a growing urgency of knowledge to educate households.

Perception refers to the predicament of being conscious of something through the five senses: smell; sight; taste; hearing and touch, perception influences individuals' impression; viewpoint; interpretation; and understanding of how individuals view things, it further enables people to react to a phenomenon or situation (Uhunamure *et al*., 2023). Moreover, improper waste disposal practices are influenced by households' perceptions (Kalonde *et al*., 2023). In developing countries, failure to address issues of solid waste disposal was led by individuals' negative perceptions regarding waste disposal practices (Mensah, 2021). For that reason, perception significantly influences waste disposal practices.

Gender roles are most likely to influence the perception of households. Due to traditional roles linked to household activities, women are deeply engaged in managing waste at the household level (Fadhullah *et al.,* 2022). Furthermore, the level of education has been revealed as a significant factor that influences individuals' perception of household waste management (Sharma *et al.,* 2023). People with higher and lower levels of education have a perception that waste management is important (Adekola *et al.,* 2021). However, most individuals believe that it is the responsibility of the district; municipality; council; local authority; and private waste operators to clean waste in their residential areas (Utomo *et al*., 2021). Jeremias *et al.* (2019) observed that less educated people are more willing to separate their waste as compared to the more educated. In addition, educated people spend most of their time at the workplace and not at home (Razaq *et al.,* 2023). Therefore, waste sorting activities depends on the lifestyle and time constraint of people with higher and lower education level. According to Jeremias *et al*. (2019), individuals with lower education levels are aware of the pecuniary benefits associated with segregated waste.

According to Longe *et al.* (2022), households show a low perception of the willingness to pay for solid waste management services. Households are unsatisfied with their local waste collection (Jeremias *et al.,* 2019). Therefore, the unwillingness to pay for waste collection services could be peculiar to their level of satisfaction (Ziblim & Bowan, 2020). Mensah (2021) highlighted that poverty-related challenges could be a reason for the unwillingness to pay for collection services. However, Longe *et al.* (2022) adequate environmental education of the populace and higher income earnings could increase the perceived rate of willingness to pay for waste collection.

According to Lu *et al.* (2022), poor waste management leads to improper waste disposal practices to a degree where waste is disposed in water bodies. Likewise, the motivation to dispose of waste into water bodies attribute from poor perception (Kona *et al*., 2023). For this reason, the municipal authority provides inadequate bins; bins not close or within their proximity, and irregular evacuation of filled bins (Omotayo *et al.,* 2023). With the above-mentioned factors, disposing of waste into the available bins and the motivation of households to comply with the acceptable standards is reduced. Households have a perception that disposing waste into water bodies save them from the unclean environment (Fadhullah *et al.,* 2022). Nonetheless, households believe that poor waste management in water bodies contribute to diseases occurrence such as diarrhoea; typhoid and malaria (Manga *et al.,* 2019). Alemu and Estifanos (2022) households cited that polluted water cause health problems. Thus far, households are cognizant of the perceptions regarding the effect of waste on health and environmental pollution.

Households' behavioural intentions have a significant impact on household recycling, reducing, and reusing behaviour (Rahman *et al*., 2022). Moreover, the significant factors influencing waste classification intentions of households include the perceived behavioural control, attitude and classification knowledge (Alhassan *et al*., 2021). According to Kushwah *et al*. (2023) the contribution to behavioural intention gap entails that individuals do not take responsibility for their actions despite recognizing the increased waste management problems. Households' behaviour on waste disposal can be influenced by the volumes of waste material, the availability of refuse bins, the perceived benefits of the final outcome and the time factors (Wu *et al*., 2023). Negative relationship between pro-environmental behaviour and environmental concern was observed by Ao *et al*. (2023) as there was less participation in waste separation; lack of awareness on consequences of improper disposal. According to Tandon *et al*. (2021) states that separating waste does not necessarily benefit households yet it cost individuals much time and effort. Behavioural intention also influences the choice of waste disposal options (Shi *et al*., 2021).

Households have a negative behaviour on recycling and further emphasized on the accessibility of disposal facilities; proximity and period of time should be convenient and available (Vijayan *et al*., 2023). However, some resort to informal recycling whereby waste is sold to vendors and open-air street markets for financial benefit

(Thakur & Onwubu, 2024). Wang *et al*. (2023) also reported a low recycling rate at Jiangsu Province. Ambiguity was observed by Bhatia and Sharma (2023) in majority of households about the type of recyclable materials. Households are not conceptually clear about materials to recycle. Negative behaviour is found to be a major factor due to lack of knowledge among households (Tang *et al*., 2023). Furthermore, Rathnaraj *et al*. (2023) highlighted that high recycling behaviour is closely associated with households' high level of recycling awareness. The negative behaviour according to Malar (2023) is probably or is related to the lack of a system to separate waste before disposal. The above-mentioned has been observed in many countries as the biggest obstacle to recycling (Zhang *et al*., 2022). Households' level of income influence individuals' behaviour on waste disposal practices and waste management (Handayani, 2022). As a result, households with low level of income are unable to pay for waste disposal services while households with high level of income do not recycle waste (Wang *et al*., 2023). Therefore, both categories have a potential of disposing waste in undesignated areas.

Freshwater has a restricted quantity globally, with its availability constrained by various factors like climate change, overexploitation, and geographical distribution (Mushtaq *et al*., 2020). The disposal and discharge of wastes into aquatic ecosystems has poorly affected majority of freshwater bodies (Bhat *et al*., 2022). The effects of managing immense quantities of waste without proper treatment has led to the deterioration of groundwater quality and the scarcity of freshwaters globally (Kummu *et al*., 2016). It is a primordial right for everyone to have access to proper sanitation and clean water (United States Environmental Protection Agency, 2023). Water bodies are the complementary association of worldwide metabolically functional systems and the essential segments of our biospheres (Bhat *et al*., 2022). Higher generation rates of Municipal Solid Waste (MSW) have an impact on the environment including greenhouse gases (WHO, 2023). Freshwaters are continuously polluted and depleted due to the pressure exerted from the increasing population (Mushtaq *et al*., 2020; Dor *et al*., 2021 & Elbeltagi *et al*., 2021).

Human beings are careless and have been polluting their surroundings by disposing of waste into water bodies (Bhat *et al*., 2022). As reported by the United States Environmental Protection Agency (2023) improperly managed solid waste pollute water bodies, and further lead to increasing flood incidence by blocking drainage water channels. Furthermore, polluted water attracts rodents and insects (WHO, 2023 & United States Environmental Protection Agency, 2023). Some of the MSW include plastic, paper, polythene bags, food, metals, dyes, and other toxic substances (Ahmed *et al*., 2022). Leachate is generated from the uncollected and untreated MSW, which in most cases reaches and penetrate water bodies and further affects diverse components of freshwater ecosystems (Bhat *et al*., 2022). According to Azam *et al*. (2020) untreated waste and leachates contribute to detrimental effects on freshwaters. Continuous dumping of waste in water bodies leads to permanent degradation and lose of resilience with none to very little chance of restoration (Bhat *et al*., 2022).

Temperature stimulates microbial growth and other vital water attributes (Parveen *et al*., 2020). Waste disposal in water intensifies temperatures by enhancing microbial activities (Urooj *et al*., 2020). High temperatures lead to the reduction of solubility of CO_2; O_2 and NH_3 (Akhigbe *et al*., 2022). Respiration rates also escalate due to high temperatures (Pierce *et al*., 2020). High organic matter content is added into aquatic ecosystems through various anthropogenic activities such as dumping of wastes generated from households (Guerrero *et al*., 2022). High temperature also increases bacterial and phytoplankton growth and influences physiochemical and biological characteristics of freshwaters (Bhat *et al*., 2022). Subsequently, the increase in water temperatures in conjunction with the increasing demand of oxygen in organisms lessen the concentration of dissolved oxygen in water (Kumar & Prakash, 2020). Less amount of dissolved oxygen accessible leads to a stressful condition for aquatic animals (Pierce *et al*., 2020).

Dumping of wastes in water bodies causes a sudden shift in pH (Bhat *et al*., 2022). The diversity and density of biota decreases due to acidic pH in water, which stress their physiological mechanisms and ultimately lower reproduction rates (Yang & Xu, 2022). Bhat *et al*. (2022) as well stated that biotic and chemical activities are influenced by any alteration in water pH. Acidic pH is considered inappropriate for the survival of the freshwater fishes and bottom-dwelling invertebrates (Abubakar *et al*., 2022). The alteration of pH particularly when it originates from waste disposal, is not suitable for aquatic ecosystem. As a result of high pollution load, the expeditious growth of algae removes CO_2 from water bodies during the process of photosynthesis, which then escalate the pH in water (Rajagukguk & Nabilah, 2021). This eventually affect the quality of water. Therefore, water becomes unsuitable for domestic use; consumption; agricultural and industrial use (Bhat *et al*., 2022).

The disposal of waste in water leads to a more significant salt proportion which shows a higher Total Suspended Solid (TSS) (Gqomfa *et al*., 2022). The appearance and presence of suspended solids such as plastic items; cardboard; paper; polythene; fruits and vegetables, modify the physical structure of water bodies, alter temperature and reduce penetration of light which result in the capacity of natural water bodies been decreased (Hameed *et al*., 2020). All kinds of materials both biodegradable and non-biodegradable, originating in water bodies are regarded as suspended solids (Bhat *et al*., 2022). If the suspended solid concentration is less than 25 mg/L, there will be no effects on fishes and other aquatic species (Bailey *et al*., 2022). However, if the permissible limits of TSS is above, it mainly influences O_2 inhalation capacity of fishes which then damages their gills and eventually lead to death (Pierce *et al*., 2020). The levels of Dissolved Oxygen (DO) affirm the capability to nurture aquatic life (Bailey *et al*., 2022). Due to waste disposal in freshwaters, the levels of DO decreases and the absence of DO gives a foul odour to water bodies (Bhat *et al*., 2022).

Phosphorus and nitrogen are the two primary nutrients of concern in water bodies (Department of Water and Sanitation, 2023). Moreover, nitrogen is referred to as a pivotal element in fertilisers and usually exists in water as nitrate ($^{-}NO_3$) (Craswell *et al*., 2021). The subsequent flow of nitrogen into aquatic ecosystems limits nutrients and becomes a pollutant (Zaveri *et al*., 2020). Accelerated eutrophication in aquatic ecosystems is associated with higher amounts of bio-available NO_3 (Hu *et al*., 2021). Thus, domestic waste being disposed of into aquatic ecosystems leads to the occurrence of NO_3 (Vries *et al*., 2021). Drinking water with extreme concentration of $^{-}NO_3$ results in blue-baby syndrome (Bhat *et al*., 2022).

Phosphorus is found in water bodies in complex and dissolved forms, as a basic and vital nutrient (Chen, 2021). High levels of phosphorus emanate from anthropogenic activities such as disposing of household waste in water (Kumar & Prakash, 2020). The propagation of microscopic algae in aquatic ecosystem result from the excess phosphorus coming from household waste (Dong *et al*., 2020). According to Shortle *et al*. (2022) secondary "hyperthyroidism is stimulated by its excessive quantity in water, leading to vomiting, diarrhoea and reduction in bone strength in humans. A balanced ecological set up in aquatic environment requires optimal nitrogen and phosphorus levels, however, prodigal nutrient discharge leads to their eutrophication (Le Moal *et al.*, 2022) and further lead to the growth of unwanted algal blooms (Bricker, 2020). The development of unwanted algal blooms reduces water transparency resulting in an anoxic environment, hindering the penetration of light into submerged layers (Shen *et al*., 2020). In addition, another responsibility for unwanted algal blooms is to produce toxins that can be lethal for all forms of biota (Janicka *et al*., 2022). For that reason, high phosphorus concentrations may cause increased loadings of nutrients in water stream.

Disposing of waste into aquatic ecosystems is a common practice in Ba-Phalaborwa Local Municipality and thus threats the habitat of aquatic species. People carelessly dispose of their waste in the water, which has adverse impacts on the river's water quality and further leads to the disease spreading pathogen and toxins. The legislation National Environmental Management Waste Act (NEM: WA) 59 of 2008 intend to revamp waste management procedures while preventing ecological damage and pollution. This legislation guarantees and encourages municipalities to provide efficient waste services. In Ba-Phalaborwa Local Municipality, this regulation is not in effect as communities do not receive regular waste services and, proper and adequate bins for disposal, as such illegal dumping is random and outrageous in many places including in water. There is a lot of solid waste been disposed of in the middle course of the river and where certain places are hotspots for this study.

The legislation National Water Act (NWA) 36 of 1998 was developed to ensure that the country's water resources are conserved; protected; managed; developed; controlled and used in ways that allows for the possibility of promoting the efficient, sustainable, and beneficial use of water in the public interest; promoting equitable access to water; facilitating social and economic development; and redressing the effects of past racial and gender discrimination. From the above-mentioned factors, this regulation is not adhered to at Ba-Phalaborwa Local Municipality. As a result, this study serve as a significant conjunction between illegal dumping of waste in water and anthropogenic activities affecting water quality. Therefore, from this background, this study aims to evaluate households' knowledge, perception, and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality.

1.2. Problem statement.

The survival of all living organisms depends on the affluence of water as a naturally occurring resource (Gleick & Cooley, 2021). Water is a valuable and scarce resource that supports the survival of humans (Kanchan & Neelu, 2020). Currently, one of the main problems the world is experiencing is the scarcity of freshwater. One-third of the total surface water sources such as dams; rivers; lakes and canals supply drinking water to households (Edokpayi *et al*., 2020). An important source of freshwater is surface water bodies. Nevertheless, these surface water bodies and the volume of water available to support all life are constantly declining (Ingrao *et al*., 2023). The river morphology changes due to anthropogenic activities that cause problems of water pollution (Ma *et al*., 2020). In addition, over-exploitation and pollution of water resources emerge from rapid urbanization and industrialization (Bangani *et al*., 2023). Deterioration of water quality present burgeoning threat to human beings and all living organisms (Bhat *et al*., 2022).

Illegal dumping of waste in water is a growing problem that has received little attention in Southern Africa (Gutberlet *et al*., 2020). According to Triassi *et al*. (2021) the proliferation of cities from both developing and developed countries are equally affected by poor solid waste management as an escalating environmental hazard. Waste disposal intentions are also experienced in other BRICS countries as they do not have proper prevention strategies to address this problem (Bukova *et al*., 2019; & Brown and Sako, 2019). It is clear that illegal dumping is a worldwide problem including the C40 municipalities (Chen *et al*., 2021 & Amasuomo and Baird, 2020).

Factors associated with illegal dumping are the same in all municipalities in South Africa (Polasi, 2018). People deliberately discard waste illegally and this has been shown in previous studies (Dong *et al*., 2020; Niyobuhungiro & Schenck, 2022). Therefore, the behaviour of illegal dumping in water is influenced by the long travel distance from their home to authorised landfill site; deficiency of regular municipal refuse and the awkwardness of opening hours at waste management facilities (Aslam *et al*., 2022) and Kubanza (2020) cited that insufficient support for reducing waste and promoting recycling in the general public; poor management of waste activities; restricted refuse removal services in poor areas and unmaintained parks and open spaces near rivers encourage illegal dumping.

The inevitable results of human actions are Municipal Solid Waste (MSW) generation (Bhat *et al*., 2022) and the economic growth of a country is directly proportional to MSW generation Kg per capita per day (World Economic Forum, 2023). Additionally, both human and natural factors accelerate the impact of water pollution (Siddiqua *et al*., 2022). Water quality is directly affected by various human and religious activities like population growth; urbanisation; industrial production and development; climate change and etc (Li *et al*., 2022). Others include agriculture; mining and recreation (Gqomfa *et al*., 2022). One of the reasons for decreasing water quality is the improper disposal of solid waste, gravel, and sand (Ustaoglua *et al*., 2021); irregular MSW management, thereby contributing to water and environmental degradation and public health hazards (Somani, 2023).

Human activities generate wastes as by-products which are commonly discarded and seen as useless (Debrah *et al*., 2021). Nonetheless, how these wastes are handled, managed, stored, collected, and disposed of, can pose risks to both the environment and public health. According to Bangani *et al.* (2023) problems related to Municipal Solid Waste Management (MSWM) are of urgent significance especially in the rapid urbanising cities of the developing world. Furthermore, the capacity of most governments and municipal authorities become overwhelmed to deliver even the most fundamental services due to rapid population growth (Bhat *et al*., 2022). Globally, the uncollected solid waste generated sum up about one to two thirds. Consequently, the uncollected and illegally dumped waste is found in water bodies (Zurbrugg, 2023).

Since the pre-historic period, a major source of environmental concern has always been the production of wastes (Chandler *et al*., 2022). The quantity and rate of waste generation is escalating in these recent times. The variety of waste increases with an increase in the volume of wastes (Srivastava *et al*., 2020). In the pre-historic period, wastes were regarded utterly as a source of nuisance that had to be disposed of. The population was small, and there was a large expanse of land available at that time, therefore, proper management of wastes was not a major issue. In the sixteenth century, a substantial increase in the volume of waste generated began when people migrated from rural areas to cities in respect of industrial revolution (Chandler *et al*., 2022). Indiscriminate littering, open dumps and waste disposal in water bodies has led by large population of people in cities and communities (Amasuomo & Baird, 2020). These dumps pose a significant risk to the public health (Bhat *et al*., 2022).

In 2050, the expected growth in urban population will increase by 90% (Abubakar *et al*., 2022). According to Somani (2023) it is predicted that approximately 70% of the population will reside in urban areas as the global population is anticipated to increase to 8.2 billion by 2024 according to Population.UN.org and further increase to 9.3 billion in 2050. The amount of MSW produced by everyone is predicted to increase due to increased industrialisation and urbanisation. Therefore, it is crucial to ensure that households dispose of their wastes properly, minimising harmful outcomes on public health as more than two billion tons of MSW is generated annually (Gherhes *et al*., 2022). There is a need to assess environmental and human health impacts in relation to waste disposal practices globally.

According to Bangani *et* al. (2023) poor Solid Waste Management (SWM) practices for instance, weak and inadequate waste management system; irregular and uneven waste collection and handling; uncontrolled landfilling and open burning has led to the consequences of waste. Each phase of waste handling; collection; treatment and disposal results in significant environmental and public health issues either directly or indirectly. Indiscriminate dumping of waste in water bodies comes from weak and inadequate SWM (Abubakar *et al*., 2022). This waste disposal practice was also observed in Zimbabwe; Pakistan; Nigeria; India; South Africa; Nepal; Rwanda; Peru; Kenya; Brazil and Guatemala (Dehghani *et al*., 2021). The consequences of such practice include the spread of diseases from the breeding of flies, rodents, and insects causing vector-borne diseases like Zika Virus, dengue, and malaria, and water-borne diseases like leptospirosis, intestinal worms, diarrhoea, and hepatitis; blocking of drains, sewer, and subsequent flooding; leachates; foul odour; suffocation of aquatic animals due to the disposal of plastic bags; and also the release of Greenhouse Gas (GHG) emissions (Siddiqua *et al*., 2022). In addition, rodents are capable of contributing to food poisoning (Pengzhong, 2023). Thus, impacting the lives of both adults and children (Somani, 2023).

Environmental costs and socioeconomic factors reach beyond the boundaries of the cities because of untreated and uncollected waste. Irregular waste collection and handling has negative impacts on environmental sustainability mainly on water contamination (Ogundele *et al*., 2022). Marine pollution is caused by irregular waste collection (Alam & Ahmade, 2023). Abubakar *et al*. (2022) reported that 192 coastal countries produced 275 million metric tons of plastic waste amounting to 1.27 million metric tons (4.4%) per country which ended up in the ocean ecosystems. Plastic waste creates breeding habitats for mosquitoes, increasing the risk of diseases like dengue, malaria, and West Nile fever due to the stagnant water it collects (Bangani *et al*., 2023). Serious environmental, health and safety consequences, for instance animals such as rodents; flies; mosquitoes; dogs and cats carry diseases to the proximate residence (Perkumiene *et al*., 2023). Hence, it is crucial that waste is appropriately disposed of, to minimize the effects on public health on a vast population and to reduce the prevalence of disease-carrying animals. In addition, waste disposed into water bodies leads to serious human health hazards, humans who come into direct contact with polluted water and solid waste are at risk of contracting various infections, chronic illnesses, blood infections, and skin irritations (Somani, 2023). Households throw their remaining waste and unwanted garbage in water bodies and streets. This waste disposal practice led to the creation of leaches that builds up within the water reservoirs (Fadhullah *et al*., 2022). Therefore, waste collectors face serious health threats from direct contact and injury as they are rarely protected (Abel-shafy *et al*., 2021).

Due to rapid improvement of standard of living, households' waste disposal practices play a substantial role in SWM (Yoada *et al*., 2022). Disposing of waste in water is a common practice in rural and remote areas, one of the factors involve stationary waste storage containers (skip bins) being provided primarily at the sides of the main road in urban or semi-urban areas (Fadhullah *et al*., 2022). Lack of land for disposing waste increases the amount of waste generated being illegally dumped in water bodies (Venkateswaran *et al*., 2023). The sustainability of the current MSW practices of using landfills is no longer effective (Rodseth *et al*., 2020). The Ba-Phalaborwa landfill has reached its capacity with the following non-compliance: no sorting and separation of waste; burning of waste; leachate generation; oil spillage and no waste minimisation. For this reason, communities have resorted to disposing waste in unauthorised places such as water bodies. The public perception for such behaviour is primarily rooted by the Not In My Backyard (NIMBY) attitude (Fadhullah *et al*., 2022). Therefore, waste is dumped anywhere due to the absence of a designated landfill site. As a result, they have no other choice of disposal for their wastes.

The risk of bin theft is another reason some households opt not to place their bins out for collection (Guangyu, 2021). Despite having access to regular waste collection services by the municipality, alternatively, they result to illegal dumping (Haywood *et al*., 2021). Communities engage in waste disposal methods that have been attested to destruct the environment and human health such as disposing waste in water (Hilburn, 2021). According to Sepadi (2021) several rural cities frequently dispose or burn waste in unregulated areas. Although dumping waste in unregulated areas is illegal (Ferronato & Torretta, 2020), approximately hundreds of thousands of communities have no collection services (McAllister, 2020). In contrast, communities prefer disposal sites that are low-laying areas and environmentally sensitive such as adjacent to bodies of water or forest edge and wetlands (Fadhullah *et al*., 2022). The inconvenience or absence of collection services, lack of formal system for sorting and disposal has been quoted many times in research as a cause to litter. Consequently, people become accustomed to disposing their waste in undesignated places. Simiya *et al*. (2020) highlighted that people do not change their disposal behaviour out of custom and pure habit even though changes are implemented.

Knowledge has a positive significant and moderating effect on pro-environmental behaviour and implementation intention (Wang *et al*., 2021). Communities with high level of knowledge are more likely to have high behavioural intention towards waste management (Wulan *et al*., 2018). This demonstrate that implementation intention and knowledge are crucial for pro-environmental behaviour on individuals (Smith, 2020). Therefore, people with high knowledge and strong implementation intentions tend to show pro-environmental behaviour (Petrescu *et al*., 2023). The individual's perception influences the perceived behavioural control concerning a particular behaviour. For this reason, individuals are more likely to participate in a particular behaviour when their peers believe it's the right course of action, for example disposing waste in designated area and recycling (Arkorful *et al*., 2022). Similarly, "people tend to perform a certain behaviour when they believe that important others think they should perform it and when they evaluate it positively" (Trois *et al*., 2022).

Ge and Liu (2022) knowledge controls individuals' behaviour and perception towards the environment. According to Islam *et al*. (2021) cited that knowledge and awareness on waste disposal in water bodies with its harmful effect has a significant influence on proper waste disposal practices. Individuals' motivation to indulge in activities such as waste minimisation; recycling and proper waste disposal methods could increase with an increase in their level of knowledge (Azodo, 2019). Person's intention to participate in ecologically friendly behaviours is influenced by environmental knowledge as an essential factor (Wu *et al*., 2022).

Knowledge is very important in the formation of individual's action and is viewed as a cognitive domain (Wulan *et al*., 2018). Therefore, inadequate knowledge on disposing of waste in water is associated with low perception, behavioural intention and attitude (Rasheed *et al*., 2022). There is a strong link between knowledge, perception and behavioural intention on waste disposal in water. Absence of knowledge influences households' perception with regards to their cognizant on disposing of waste in water. Akmal and Jamil (2023) states that households' decision to engage in a particular behaviour is predominantly driven by their level of knowledge. Accordingly, people behave based on what they know about something (Sakollawat *et al*., 2022). There is a relationship between knowledge and behavioural intention.

Many studies had established the effects of waste disposal on water quality in general terms, this study sought to analyze water quality in relation to the types of waste disposed in nearby water bodies by comparing water quality assessment with the perceived impact of waste disposal on water quality. Given the above-mentioned problem, it was significant to raise objectives on households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality.

1.3. Aim and objectives of the study.

1.3.1. Aim.

This research aims to evaluate households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality.

1.3.2. Objectives.

For this study to accomplish its aim, it gathered data among the Ba-Phalaborwa communities guided by the following objectives:

I. To investigate the level of community knowledge and awareness of waste disposal in water.
II. To explore community attitudes, perceptions and practices on waste disposal in water.

III. To examine environmental health, human health and social risks associated with waste disposal in water.
IV. To determine behavioural intention on waste disposal in water.
V. To compare perceived environmental, health and social risks with water quality indices.

1.4. Rationale.

Waste disposal in water is one of the major environmental issues worldwide (Ambrin *et al*., 2022). Water pollution has been a burning issue for scientists and governments. Global scarcity of water reservoirs and serious water pollution should be exceedingly addressed immediately to protect water quality. Kusari (2019) increased population growth, urbanisation as well as many other factors impair our environment. Moreover, the growing demand for water due to population growth places significant pressure on natural resources. This, in turn, leads to an increase in solid waste generation, which contributes to higher levels of water pollution. Ba-Phalaborwa Local Municipality has active economic sectors such as mining; agriculture and tourism, it is therefore regarded as a developing municipality with improved standard of living under Mopani District. There is rapid population growth due to the high employment opportunities from the above-mentioned economic sectors, particularly the mining sector. There is a high population density in residential areas, both in formal and informal townships. Illegally dumped waste of various compositions and sizes was evident in water bodies, and apparent in rural and urban areas (Mopani District Municipality, 2023).

Waste disposal in water is an increasing problem observed globally (Vaverkova *et al*., 2022) and yet there is poor enforcement to combat this pressing issue. Waste management policies and legislations are developed worldwide. South Africa has also established good waste management policies and legislative measures. In addition, there are clear approaches to waste dumping outlined in the National Waste Management (2020), such as a culture of zero tolerance to illegal dumping, littering and pollution; cleaner communities; and well managed and financially stable waste services. Conversely, the practical implementation and enforcement of these policies and strategies remain an issue nationally and even worse in the local municipalities. Officials have highlighted that illegal dumping of waste in water is one of the most prevalent problems in South Africa, and yet there is a rapid increase of illegal dump sites annually (Pikitup, 2022).

In South Africa, an average person generates approximately 3kg of waste per day and 1 ton per year (NWM, 2022). As a result, million tonnes of illegally dumped waste are collected annually across the country (NWM, 2022). This leads to the country spending extremely huge financial costs on cleaning up the illegal dump sites. Furthermore, this study hoped to assist policy makers as well as Ba-Phalaborwa Local Municipality to develop and constantly review and implement the by-laws of illegal dumping in water bodies. This study would further support Ba-Phalaborwa Local Municipality to develop preventative measures that combat waste disposal in water so as to meet the Sustainable Development Goals (SDG) of waste management in 2030.

Water quality and a clean environment improves quality of human's life and influences good health. The water we drink signifies the quality of the environment (Olusanya, 2021). However, the antipode of this is the pernicious dumping of waste into water bodies. Li *et al*. (2022) water bodies are precious sources of drinking water and supports aquatic ecosystem. But, in Ba-Phalaborwa Local Municipality, water bodies were perceived as dump sites. Because of many environmental, health and social risks associated with waste disposal in water bodies. Therefore, it was crucial to conduct an intensive study to compare water quality indices with the perceived impacts of waste disposal in water. The intention was that the outcomes of this study would be able to assist the municipality; communities and government departments in terms of strengthening the level of education and awareness on water quality and the effects of wastes in water. This study among other things, helped to produce data that was useful in analyzing households' knowledge, perception, and behavioural intention of the effects of waste disposal on water quality.

1.5. Chapter overview.

Chapter 1: Introduction – Outlined background of waste disposal in water worldwide, research problem, aim and objectives of the study and further provided the rationale of the study.

Chapter 2: Literature review – Provided the insights of waste disposal in water. This chapter focused on definition of concepts; theorectical and conceptual framework;

legislative framework of waste management and water in South Africa; the growth of waste disposal on water bodies worldwide and in South Africa; factors associated with waste disposal in water; households' levels on knowledge and awareness, attitude, perception, practices and behavioural intention towards waste disposal in water; environmental, health and social risks associated with waste disposal in water; and effects of waste disposal on water parameters (such as dissolved oxygen; turbidity; total suspended solids; bioindicators; pH; nitrates; phosphorus; water temperature; electrical conductivity and chemical oxygen demand) were also discussed.

Chapter 3: Research methodology and analytical procedures – Provided a brief overview on the delineation of the study area; research design and method; population of the study and sampling procedure; sample size; data collection; water quality assessment; validity and reliability of questionnaire; ethical considerations; data analysis of both questionnaires and water quality assessment as well as limitation of the study.

Chapter 4: Results and discussions – Presented and discussed results of the study using descriptive statistics.

Chapter 5: Summary, conclusion, and recommendations – Presented conclusion, summary of the findings and recommendations in relation to the objectives of the study; research problem and the analysis of findings presented in chapter four.

CHAPTER TWO: LITERATURE REVIEW.

2.1. Introduction.

Water is a vital component of the environment (Uddin *et al*., 2021) and survival of all organisms (Kamboj *et al*., 2021). Approximately 70% of the world is covered by water. Water as a resource has multifaceted purposes such as agriculture; domestic uses; cultural values aesthetics; habitat and biodiversity; nutrient regulation; water supply; livestock keeping; recreational activities Omary *et al*. (2023) and nursing grounds (Tampo *et al*., 2021). Huge amounts of water consumption and pollution are caused by human-related activities (Kownacki & Szarek-Gwiazda, 2022). The deterioration of surface water and groundwater quality has been led by anthropogenic activities like disposal of waste; mining and industrial production; livestock farming; heavy metal pollution and increased soil erosion or sedimentation runoff (Uddin *et al*., 2021).

It is predicted that by 2025 all nations nearly two-thirds globally will face water stress. At present, over 1.1 billion people worldwide lack access to clean drinkable water (WHO, 2022). The gradual changes of water quality due to extensive economic, social and population growth, others may include climate and hydrology factors resulted from the accumulation of pollutants in surface water. Besides, one of the most crucial necessities to survive as aforementioned is the optimal quantity of acceptable quality of water. Nevertheless, a challenge arises since water resource management sector fail to maintain the acceptable standard of water quality (Chidiac & Najjar, 2022). Issues of improper waste disposal in water bodies are a worldwide environmental and human-health problem. For that reason, this literature review was useful in providing insights of waste disposal in water and in supporting the stated objectives of the study.

2.2. Definition of concepts.

2.2.1. Waste.

Waste is any liquid, solid or gaseous material that is being discarded (as unwanted, incineration or burning, and or for recycling) (Mubaslat, 2021). It is thus regarded as a substance that is defective, worthless, unwanted and unusable material after its primary usage. According to UNEP (2022) “wastes are objects or substances, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national laws”. Furthermore, a waste product is approximately of a minor economic value (Soysa *et al*., 2022). It can be an obsolete commercial product or by-product of a manufacturing process that is no longer in use for the intended purpose and requires disposal. Wastes depends on what the other person sees or become aware of, what is waste to one person might be a resource to another (Rapson & Molefi, 2021). The National Environmental Management Waste Act (No. 59 of 2008) categorised waste on distinct bases: hazardous waste; municipal solid waste (household refuse/trash and commercial waste); construction and demolition waste; radioactive waste; electronic waste; medical waste and wastewater (sewage which constitutes of bodily waste).

2.2.2. Waste management.

Waste management is defined as the various procedures and approaches designed, outlined and implemented actions and activities to identify, control and handle several types of wastes from their generation to their final disposal (Mubaslat, 2021). This comprises amongst other things the collection, transportation, treatment and disposal in conjunction with monitoring and regulation of the waste management processes. In addition, waste management processes and their full implementation required include recycling and reducing wherever possible as well as waste prevention and reuse. Considerable environmental impacts can be avoided through the application of these processes. Waste management encompasses legal and regulatory frameworks that interrelate to guidance on recycling and other waste management processes. (Vibha, 2022). Thus, it should be done in such a manner that the disposed waste does have health implications to humans or be harmful environment.

2.2.3. Waste disposal.

Waste disposal means getting rid of waste into a landfill site or designated area for the purpose of placement for future recovery, destruction or final burial (Haywood *et al*., 2021). The final stage of disposal is isolating waste as a terminal action for pollution control so as to avoid environmental impact and to protect the environment and humankind from any hazardous components of wastes (Vibha, 2022). The definition of waste disposal can further be delineated as activities and practices that minimize the quantity of wastes in order to reduce and even eliminate hazardous components in wastes. Waste disposal methods include Landfill; Incineration; Recycling; Recovery; Plasma gasification; Composting; Waste-to-energy (WEE) and waste minimisation (United States Environmental Protection Agency, 2023).

2.2.4. Water quality.

According to the Department of Water and Sanitation (2022) water quality describes the condition and suitability of water particularly for drinking purposes based on its chemical, physical and biological characteristics as well as its standards of usage.

2.2.5. Knowledge.

Knowledge is a form of awareness, familiarity, acquaintance or understanding of something or someone (Ghulam, 2022). It is the state of being familiar with or knowing about something. Therefore, household knowledge is a condition of being aware of something within communities. It is often learnt through experience or education which involves the possession of information such as learning, perceiving, or discovering (Pavese, 2021). One can allude knowledge as ideas or facts attained through a study, investigation, skills, observation, descriptions, or information.

2.2.6. Perception.

Perception refers to humans' sensory experience of the universe through the use of their senses to become aware of something (Cohen & Wartofsky, 2021). It also involves how individuals interpret, perceive, and recognize sensory information. As a result, perception is a complex psychological process of understanding presented information through identifying, organizing, and interpreting human sensory information into a purposeful picture of the universe (Amodu *et al*., 2022). Therefore, households' perception is a primitive form of cognitive contact of man with the world around him.

2.2.7. Behavioural intention.

Behavioural intention means the performance of a particular behaviour is measured by a person's relative strength of intention (Maffei *et al*., 2022 & Wayne *et al*., 2022). It also refers to the interest or desire to do certain behaviours (Gibbons *et al*., 2022). Therefore, households' behaviour is commonly his/her intention to engage in that behaviour.

2.3. Theoretical framework.

This study hinged on the Theory of Planned Behaviour (TPB) as a framework to understand human action. It is among the most frequently referenced theoretical models justifying the relationship between behaviour and intention (Zhang *et al*., 2023). The application of TPB model is studied simultaneously with the environmental protection behaviour (Wu *et al*., 2022). Environmental management context includes these behaviours but amongst other things waste sorting and recycling; energy saving; transportation modal choice and green vehicle purchasing (Lin, 2023). According to the TPB model, behaviour is primarily driven by personal intention, whereas intention is driven by subjective norms, attitudes, and perceived behavioural control (Batool *et al*., 2023). Behaviour as well can be directly affected by the perceived behavioural control. Intention is an important and immediate predictor of behaviour considered in numerous studies as it influences other variables (Onwezen *et al*., 2023). In the context of pro-environment behaviour, individuals' personal norms are reflected by their attitudes towards environmental protection (Xu *et al*., 2023). Yet, the TPB model simplifies the effect of personal norms on behaviour. Personal norms involve indicators such as values, morals and ethics which have been included in the recent studies for further development of the TPB model (Nickell & Hinsz, 2023).

The TPB was established on the fundamental basis of Theory of Reasoned Action (TRA) (Wu *et al*., 2022). In the context of TRA, the central role of intention is to determine a planned behaviour (Zhang & Chen, 2023). Two critical factors that influence this variable includes attitude and subjective norms towards behaviour (Cao *et al*., 2023). According to Leong *et al*. (2023) subjective norms are defined as the measure to perform the behaviour in question in conjunction with the perceived social pressure. Attitude from a rational perspective refers to personal evaluation of the behaviour (Capasso *et al*., 2023). Hypothetically, the greater the intention to engage in a certain behaviour, the more likely it is that the behaviour will be performed. The more one perceives intensive social pressure, the more one expects a behaviour that results in favourable consequences (Gumeneez *et al*., 2023). As a result, the construct of perceived behavioural control was introduced in the TPB model as a precedent variable for both behaviour and intention. Therefore, an individual's perception about both environmental and personal factors is based on this variable, to facilitate or hinder their ability to perform a certain behaviour.

TPB associate one's behaviour and belief (Supaprawat *et al*., 2023). According to the TPB theory, there is a relationship between behaviour of people and their attitudes. Chen *et al*. (2023) one of the influences of the person's attitude is knowledge. More specific and complicated contexts are said to be predicted by the TPB as a superior theory to the TRA (Shanbhag *et al*., 2023). The TPB was applied in previous studies and its usefulness was confirmed in predicting both recycling behaviour Passafaro *et al*. (2021); Tang *et al*. (2021) and intention to recycle Fedi *et al*. (2021). Therefore, the behaviour and practices of individuals on waste disposal in water will be portrayed in the TPB because of individuals' belief modelled by their attitude and knowledge. This study concluded that waste disposal practices in water was modelled by households' level of knowledge; attitude; perception and behavioural intention towards SWM. This theory has been adopted in previous studies and proved that after intervention there are positive behavioural changes among communities (Rozenkowska, 2023). Based on these previous studies, the following hypotheses were intended:

2.3.1. Hypothesis 1.

H1: The level of community knowledge and awareness has a positive impact on waste disposal in water.

Knowledge refers to an individuals' possession of a sustainable competitive advantage in relation to waste management and water quality (Ge & Liu, 2022). Sumaya (2022) opined that knowledge controls environmentally friendly behaviour and attitudes as a conditional and situational aspect. Further highlighted that the arousal of interest could increase to some satisfactory degree with an increase in the level of knowledge. Islam *et al*. (2021) alluded that knowledge and awareness on waste disposal in water with its adverse impact, retain vital influence on reuse; reduce and recycling practices. The individuals' motivation to indulge in activities such as proper disposal and technical recycling could be increased by the level of knowledge and awareness. The availability of appropriate recycling materials and a person's perceived recycling knowledge influences and motivates recycling participation among communities (Wang *et al*., 2022). A potential risk to human health and the environment is significantly associated with inadequate knowledge and awareness.

Knowledge is crucial especially in recycling; reusing and handling of waste (Hossain *et al*., 2021). The lifespan of waste or unwanted devices are prolonged through reusing as a vital waste management practice (Yamamoto & Murakami, 2022). This also contributes to reducing waste volume and its potential impact to the environment and possibly to human health hazards. In addition, the necessity of knowledge campaigns and spreading awareness is vital as most of the public is ignorant about the impact of waste disposal in water (Rasheed *et al*., 2022). Waste knowledge is pivotal in explaining the behaviour involving collection and separation of waste (Wang *et al*., 2022). Perceived behavioural control (ease or difficulty) may indirectly influence pro-environmental behaviour through environmental knowledge and awareness (Wu *et al*., 2022). Accordingly, an increase in self-assurance in performing pro-environmental behaviour in the future (i.e. perceived behavioural control) is based on past learning experience and the condition of possessing extensive knowledge of the environment. The concern of making actionable approaches and strategies for addressing and solving issues and improving a particular context (for instance recycling; reusing and reducing) is hinged on the more knowledge one perceives. As a result, the greater the likelihood that a person may feel or believe they have control over the situation.

Wu *et al*. (2022) environmental concern would indirectly influence pro-environmental behaviour depending on individuals' environmental knowledge. Furthermore, this interconnectedness is a fundamental concept of environmental knowledge. Therefore, the greater the amount of environmental knowledge a person gains or acquires, the better their understanding of environmental issues is likely to be as well as their causes and consequences in distinction to a systematic perspective. Hence, the more likely one would perceive the relationship between humans and nature against an ecological and sustainable perspective. As a result, a sense of responsibility for environmental improvement is fostered through knowledge of environmental issues in context to waste management and water quality and further contribute to the advancement of pro-environmental behaviour.

2.3.2. Hypothesis 2.

H2: Community attitudes, perceptions and practices have a positive impact on waste disposal in water.

Attitude is referred to as an evaluation of the natural environment with some degree of favour or disfavour expressed through a psychological tendency (Erhabor, 2023). A change in humans' attitude controls and minimizes adverse bearings associated with the environment and human health risks. Sumaya (2022) found that attitudes either impacts pro-environmental behavioural intentions positively or negatively. Waste separation intention or behaviour is one of the strongest predictors of attitude (Wang *et al*., 2022). Therefore, the participation intention is based on their knowledge and awareness of environmental issues (Zhang *et al*., 2023).

Attitude impacts individuals' behavioural intentions and the perceived behavioural control towards waste disposal, waste sorting and recycling (Mendez-Lazarte *et al*., 2023). Furthermore, attitude affects ones' perception level which leads to poor practices in context to waste disposal in water. Therefore, individuals' attitudes and perceptions influence their behaviour towards waste disposal (Mensah, 2021). Individuals believe that they can perform the behaviour in question, if their attitude towards that certain behaviour is positive. Thus, the more societal pressure, the more likely they will intend to perform the behaviour effectively and the more positive attitudes they will have towards waste management strategies (Wu *et al*., 2022). The opinions that proper disposal practices and recycling are good for the environment and human health are moulded on positive attitudes and perceptions towards waste disposal and recycling (Sumaya, 2022).

2.3.3. Hypothesis 3.

H3: Behavioural intention has a positive impact on waste disposal in water.

Behavioural intention is defined as the likelihood of performing a specific behaviour depending on if there is a strong intention to perform it, the probability of the behaviour to be performed is influenced by the motivational factors (Boston University School of Public Health, 2022). A key predictor of behavioural intention is perceived behavioural control, which refers to individuals' capability on their perception to perform a particular behaviour (Zhang *et al*., 2022). Therefore, people develop intentions to carry out a certain behaviour through certain degree of conscious reasoning (Jia *et al*., 2023). Consequently, an intention to perform in an intrinsic way influences ones' behaviour. According to the TPB, intention influences behaviour and is dependent on individuals' attitude towards the behaviour, perceived behavioural control, knowledge, and subjective norm. An essential cognitive basis upon which attitudes of waste management behaviour develop depends on the understanding of waste disposal issues particularly in water (Zhao *et al*., 2022). The more acquainted one is about the repercussions of waste pollution on the environment, water quality and human health, the greater the chances he or she would have strong beliefs on the advantage of waste management behaviour for instance participating in waste management strategies to reduce health risks which could be caused by waste pollution.

According to Akmal and Jamil (2023) altercated that the immediate determinants of behavioural intention are attitude and subjective norms. As a result, individuals with high moral and personal norms are more willing to participate in recycling activities. Chen *et al*. (2022) confirmed the households' recycling behaviour is significantly affected by subjective norms. However, the association between recycling behaviour and social influence was not found in the study of Hage *et al*. (2022). A third predictor of behavioural intention was introduced by Akmal and Jamil (2023) as perceived behavioural control. According to Wan *et al*. (2022) there is a positive relationship between waste management strategies (i.e. recycling; waste sorting and segregation intention) and the perceived benefits.

Waste sorting behaviour is influenced by peoples' social and physical circumstances (Wu *et al*., 2022). Hence, accessibility of waste management facilities is one of the key circumstantial constraints that hinders and restricts the progression of individuals' intentions to waste recycling behaviour. Perceived behavioural control differs with the convenience and ease of waste sorting in the context of waste facilities. The absence of facilities encourages improper waste disposal in sensitive areas. However, convenience and ease of a behaviour is a subjective feeling. Lack of effective and convenient recycling facilities may hinder keen individuals to participate in waste sorting (Chen *et al*., 2022). Therefore, lack of accessible facilities restricts waste recycling behaviour. As a result, to proceed to the actual behaviour through a benign intention to recycle would not be easy. The shorter the distance, the easier individuals would access the facilities of waste sorting, and the more time will be saved to recycle waste. The more time available to individuals, the more likely they are encouraged to participate in such behaviour (Wang *et al*., 2022).

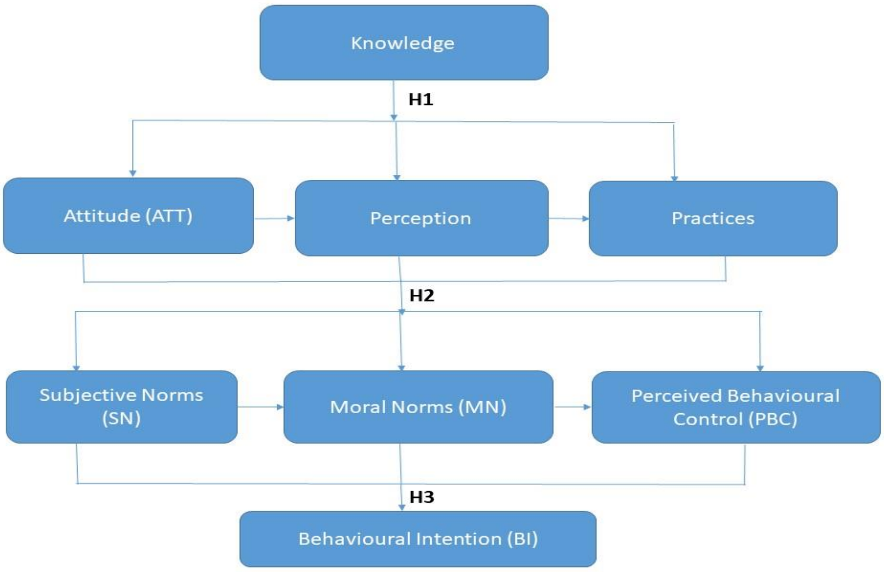

Figure 1: Research model based on the Theory of Planned Behaviour hypothesis (Wang *et al*., 2021).

2.4. Conceptual framework.

This study adopted an ecological model as a conceptual framework that predicates that waste disposal in water is influenced by factors such as community level of factors (knowledge and awareness; attitude; perception; practices and behavioural intention), family backgrounds, personal experiences as well as institutional policies (Zhang *et al*., 2023). Independent variables are inputs of individual capacity which comprises of socio-demographic factors such as gender; age; occupation and education level. In addition, inputs from authorities and other Solid Waste Management (SWM) institutions include laws; policies; regulations; coordination and enforcement. The dependent variables are levels of knowledge and awareness; attitude; perception; practices and behavioural intention. Consequently, dependent variables confide on inputs from independent variables. The creation of influence on the levels of dependent variables is inferred through inputs from the SWM institutions and socio-demographic factors. Achieving a suitable SWM practices in Ba-Phalaborwa requires ultimate output from positive influence of the knowledge, attitude, perception, practices, behavioural intention by individuals and institutional inputs.

Accordingly, deliberate efforts and high levels of cooperation between households of Ba-Phalaborwa, the municipality and other responsible authorities should be amplified to achieve sustainable SWM in order to reduce waste disposal in water. Besides, the local authorities should promote public acceptance of communities' basic services in consideration of understanding their concerns. Enforcement and coordination of laws, policies and regulations should be in place and maximised by authorities through their capabilities. In context to proper Solid Waste Management (SWM), one of the principal factors shaping public acceptance could be considered as public trust in SWM authorities. The involvement of communities in projects such as education and outreach can assist authorities to build this trust and acceptance. On the contrary, demographic factors determine households' perception on waste disposal on water and other issues of SWM. These factors influence households' attitudes and behaviour, and eventually mould their diurnal practices which could either lead to poor or proper SWM in their households. Poor SWM in Ba-Phalaborwa result to illegal waste disposal in water course and river quality.

Acceptance of existing SWM systems may be correlated with the level of education. Its absence may impute to a lower perception of risks and poor waste handling and disposal. Individuals' attitudes and ultimately their practices of SWM is influenced by age as one of the most unpredictable variables. Comparatively, older generation are more likely to be knowledgeable about the existence of SWM infrastructure; are more likely to comply with the laws, polices and regulations; are more likely to articulate their satisfaction level and their levels of trust in authorities compared to young generation. In context to individuals' gender, men are less likely to articulate their concerns related to environmental, health and social risks linked with poor SWM practices than women.

The levels of knowledge and socio-demographic factors of an individual influence their attitude to SWM. Better practices of SWM would ultimately be led by positive attitudes of households. Attitude can be signified through households' participation on recycling, reducing and reusing of solid waste; households' willingness to sort their solid waste before disposal as well as their remuneration to relevant authorities for disposal services. Ba-Phalaborwa Local Municipality, the relevant institutions and individuals should adopt more advanced levels of knowledge, positive attitudes, perception, behaviour and proper SWM as shown in figure 3 below to achieve suitable practices of SWM and to combat waste disposal on water within the municipality.

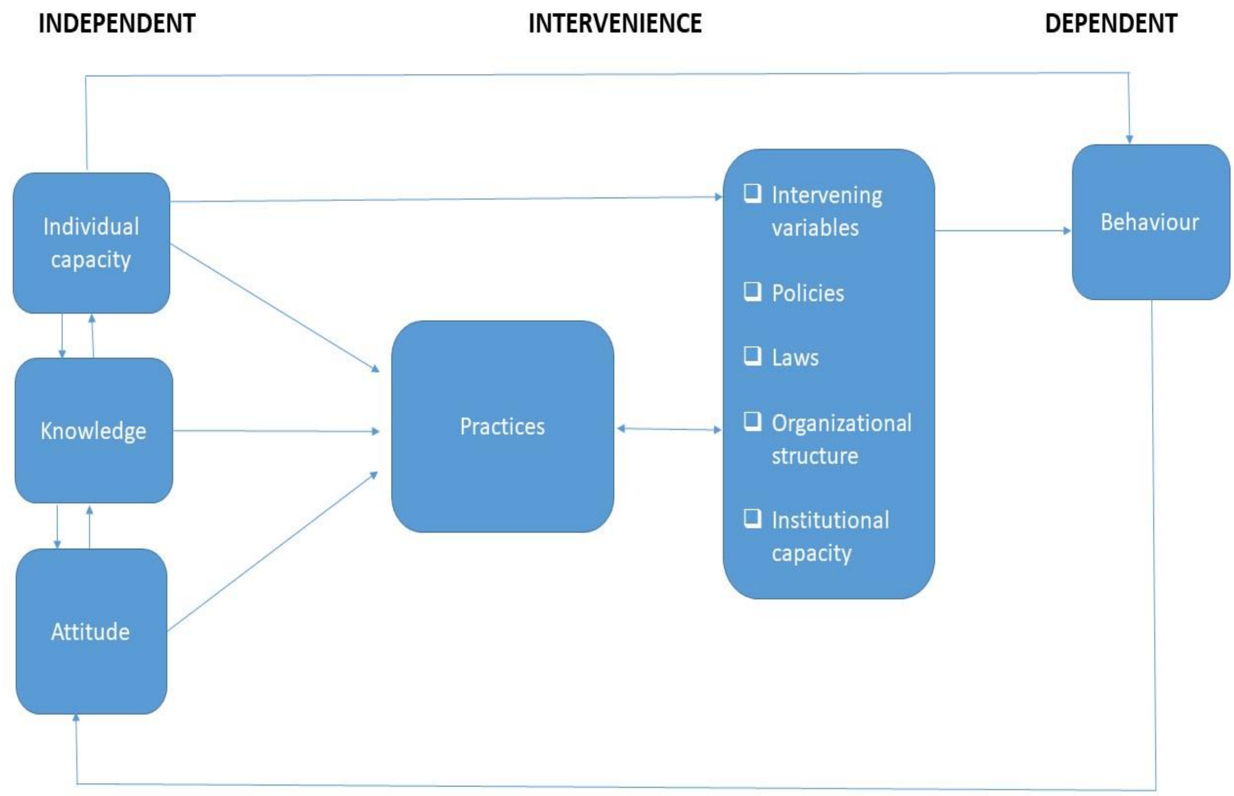

Figure 2: Model of conceptual framework.

2.5. Legislative framework of waste management and water in South Africa.

South Africa has its own policies and regulations despite the numerous international agreements that promote sustainable SWM and environmental management systems (Setzer & Higham, 2023). The aim of these legislative frameworks is to take into consideration the reduction of hazards vulnerable to the environment and protection of public health through facilitating sound waste management practices. Proper waste treatment, sustainable collection and safe disposal of waste should be considered. Accordingly, the primary legislation for waste management in South Africa is the National Environmental Management: Waste Act of 2008 (NEM: WA). It emphasizes on the waste management hierarchy and provides a broad and comprehensive legal framework for waste management in South Africa. The South African National Environmental Management Waste Act (No.59 of 2008) indoctrinates that sustainable development can be achieved by avoiding the generation of waste, if it is beyond the bounds of possibility, it should be reduced; reused; recycled or recovered and be treated and safely disposed of only as a last resort. This act also emphasized on the creation of economic opportunities through the utilisation of waste as a potential resource. Therefore, the National Environmental Management: Waste Act, 2008 (Act

No.59 of 2008) has been introduced as a waste management act in South Africa to manage waste specifically.

South African environmental policy and waste management policies has evolved through the system of international agreements, declarations, and treaties (Knutton, 2023). The foundation and basis of environmental regulation and policy in South Africa has been stipulated in the constitution of South Africa, 1996 (Act 108 of 1996). According to the Bill of Rights Section 24 of the constitution, every South African has the right and opportunity to environmental protection and to live in an environment that is not harmful to their well-being and health. Hence, the application of the National Environmental Management Acts (NEMA) and any other Specific Environmental Management Acts (SEMAs) strive to execute, fulfil, and continue to accomplish these rights through the Department of Environmental Affairs (DEA). The introduction of a few guiding and key principles into South African environmental legislation has been highlighted in Section 2 of the National Environmental Management Act, 1998 (Act No.107 of 1998). In the context of illegal dumping, any person who has caused or may cause a significant degradation or pollution to the environment is responsible for the duty of care to ensure that reasonable measures are taken to prevent such degradation or pollution from occurring, continuing, or recurring (Polluter Pays Principles (PPP)) (DEA, 2023).

The law regulating waste management (NEMA: Waste Act No: 59 of 2008) has been fundamentally reformed for the first time as it addresses all the steps in the waste hierarchy through a coherent and integrated legislative framework (DEA, 2023). The execution of this law was based on the extensive body of environmental legislation established in 1994. Reasonable measures are provided in the NEMA to regulate waste management and protect the environment and human health (NWMS, 2022). South Africa’s international obligations in terms of waste management should give effect as stipulated in the National Waste Management Strategy (NWMS) and specified by the National Environmental Management: Waste Act Section 6(1)(b), Section 43(1)(b) and Section 43(1)(d) (DEA, 2023).

The NWMS is a strategy employed by government-wide and all organs of state to mitigate waste management issues within the citizen of South Africa and private sectors (NWMS, 2020). Moreover, the national norms and standards of waste disposal to landfills has been outlined in the NWMS: 2020. The elemental principles of waste management hierarchy such as the three R's: reduce, reuse and recycle are hinged on the NWMS. Therefore, the waste management trajectory will be informed by the NMWS going forward. Kimani (2020) highlights the overall and long-term aims of the NWMS as: "identifying and quantifying the main waste streams generated and how much ends up in streams; impact of water quality and the surrounding environment; understanding the reasons for poor community waste management; servicing and littering; classifying the status and capacity of landfills with reference to hazardous waste''.

The primary goals of NEM: WA include among other things utilisation of waste in a useful manner, environmentally sound waste management and separation of waste from landfills (Bezuidenhout, 2023). An integrated waste management approach is promoted by NEM: WA (2008) to reduce the undesirable impacts of waste on the environment. Additionally, all municipalities are compelled in terms of the Municipal Systems Act to establish an Integrated Waste Management Plan (IWMP) as a component in their Integrated Development Plan (IDP) and in terms of the NWMS. Appropriate strategies to achieve waste collection standards in each community are set out by the Provincial IWMPs and the municipalities. Municipalities set goals and outline how they will achieve them in these plans.

The Municipal Systems Act of 2000 postulates that municipalities should provide waste disposal infrastructure (such as drop-off facilities) and waste collection services on a municipal level and the management of landfills. The fundamental right of Section 24 of the Bill of Rights in the constitution of South Africa which falls within the National Environmental Management Act 1998, it grounds environmental laws and policies especially the environmental legislation framework developed by NEM: WA (2008). Over and above, the South African environmental legislation was introduced to various additional guiding principles by the NEM: WA (2008) which comprises of the PPP; producer's responsibility and the life-cycle approach to waste management. Furthermore, one plan was developed to incorporate waste generation, disposal, transportation, treatment and recovery on the White Paper for Integrated Pollution and Waste Management for South Africa (Notice 227 of 2000). Unlawful dumping or any other activity or practice related to illegal disposal of waste as an environmentally, socially, and economically undesirable and unacceptable practice has been described in the White Paper on Integrated Pollution Management for South Africa of 2000. This aided in monitoring pollution of the environment through facilitating holistic and integrated management systems for minimization of waste at point sources and pollution prevention.

The three tiers of government in South Africa are obligated and liable to address issues of unlawful disposal of waste and other associated environmental issues through the implementation of legislative framework and regulations. The preeminent authority responsible for waste management and related issues in South Africa on a national level is the Department of Forestry, Fisheries, and the Environment (DFFE). Likewise, environmental authorities responsible for handling waste management matters and regulating waste management at a provincial level: the Department of Environmental Affairs (DEA) and Limpopo Department of Economic Development, Environment and Tourism (LEDET). At the grassroots level, municipal authorities are responsible for enacting various legislative frameworks passed at the national and provincial level through operation and governing. In agreement with South Africa’s constitution, it is the responsibility of the municipalities to provide waste removal, collection, storage and disposal services within their vicinity.

At a local municipal level, Ba-Phalaborwa Local Municipality is governed by the Environmental Conservation Act 73 of 1998 in terms of waste management practices. This act provides and discard litter bags within a feasible time and further provide authority to control and ensure that the public spaces are free of litter. In a nutshell, the act prohibits littering and illegal dumping. The Municipal Structures Act 17 of 1998 is strengthened by this act, it postulates that local municipalities are responsible to oversee waste management within their specific boundaries. The municipality must emphasize waste avoidance, minimization and responsible disposal in conjunction with the implementation of hierarchical waste management. One of the activities that should be promoted by municipalities is recycling as stipulated in the Municipal Systems Act. A comprehensive legislative and policy framework are clearly outlined. This illustrated that South Africa has sound foundation for waste management.

Waste collection and transportation services are provided by the municipality in Ba-Phalaborwa communities. Waste is transported to a designated landfill site. Although the provision of waste management services is the responsibility of local municipality, various shortfalls and challenges are observable in Ba-Phalaborwa specifically within rural and informal residential settlement. As a result, unlawful disposal of waste is a prevalent practice in Ba-Phalaborwa. According to Ba-Phalaborwa Local Municipality IDP (2022/23-2027), waste management services are provided to 22 941 households with a total of 41 115 households. There is a backlog of 18 174 households without waste management services. Even though, their stated target is to provide waste management services to all communities within the municipality (IDP, 2022). The shortfall of this is that parts of urban areas and townships are serviced almost on a weekly basis compared to rural areas. On contrary to the Municipal Systems Act, the percentage of waste recycling is currently very low in the Ba-Phalaborwa Local Municipality. Yet, waste recycling services are not provided by the municipality, on the other hand, the role is left for individuals and private companies. There is a skewed towards settlements with high income level in terms of provision of waste management services, while the burden of solid waste management is often left for lower income settlements or the urban poor residents, which makes them vulnerable to unhealthy living conditions.

Currently, there is a decline of river water quality due to human related activities such as disposal of waste on surface water; urbanization; agriculture and industrialization (Habibur *et al*., 2023). Globally, almost 159 million people are exposed to health risks because they rely on unsafe surface water for domestic usage (WHO, 2022). Water quality degradation is becoming a pressing concern worldwide due to the influence of pollutants like nitrogen and phosphorus, trace elements and rising water temperatures. In context to water quality, the main act that previously replaced laws applicable to water rights and regulates water is the National Water Act 36 of 1998 (NWA) (DWS, 2023). The NWA articulates that South Africa must ensure that its water resources are developed, protected, conserved, used, managed, and controlled in an equitable and sustainable manner for the advantage of all people (DWS, 2023). It aims to meet international standards, manage the effect of droughts and floods, and also protect the environment.

Section 3(1) of the Water Services Act 108 of 1998 (WSA) confirmed that every South African has a right to have access to a basic sanitation and basic water supply and an environment that is not harmful to their health and well-being. However, increasing urbanization and water pollution from anthropogenic activities leads to the Ga-Selati

River in Ba-Phalaborwa Local Municipality been vulnerable to waste disposal as a result of lack of regular monitoring and evaluation of river water quality; infrequent water quality assessments; the unavailability of designated water quality specialist as well as the absence of strategies to devise sustainable management, preservation of aquatic ecosystem and protection of water quality and human health. Even though, South Africa has set out sound and ample legislations, laws, polices and regulations on waste management and water, Ba-Phalaborwa Local Municipality still face a hassle in managing waste and protecting water bodies.

2.6. The growth of waste disposal on water bodies.

2.6.1. In the context of worldwide.

Illegal dumping is the fastest growing waste management issue globally (Ngalo & Thondhlana, 2023). Many communities throughout the United States and African countries experience a major problem pertaining to improper waste disposal. Du *et al*. (2023) an extensive amount of Municipal Solid Waste (MSW) in developing countries is dumped illegally in streams; stormwater drains; rivers; open spaces and streets. So, illegal dumping of waste in water is a risky practice that is common and prevalent in both developing and developed countries.

A study conducted in Nigeria, Ichipi and Senekane (2023) found that illegally dumped solid waste generated by communities was 68%; 10.7% was disposed in an authorised and appropriate landfill site; 20.8% of the remaining waste was disposed in rivers and streams. In addition, approximately 1000 tons of waste was generated daily by the Nairobi citizens. Nevertheless, the local authority only collected at most 10% (<100 tons) of the total waste generated. The remaining generated waste of 9900 tons was unaccounted for. The study further revealed that the residents near water bodies were exposed to health risks due to improper waste disposal. The indiscriminate disposal of waste continues to be the primary method used by municipalities and communities for final waste disposal. This is evident from the referred study above.

Many developing economies will continue to face a challenge in terms of the improper waste disposal in water. Owusu *et al*. (2023) Nigeria and Ghana conducted two separate studies and reached similar conclusions. It was found that solid waste in African countries approximately 80% was disposed of in rivers through illegal dumping. Therefore, it is evident and clear that there is a high spread and prevalence of illegal dumping in water across African countries. Even so, developing countries are more prevalent in improper waste disposal but these does not make developed countries an exception (Awafo *et al*., 2023).

A study conducted in Italy by Vitali *et al*. (2023) found that there is a high rate of illegal dumping and water pollution due to the disposal of hazardous and municipal waste in water bodies. These has been practised subsequent to the 1980s. Fazzo *et al*. (2023) conducted two studies in the United States of America. It was found that a common challenge in rural America was illegal dumping of MSW in water. Moreover, illegally dumped waste contained a mixed stream of waste materials, and it was evident from literature as it was previously alluded by Troisi *et al*. (2023).

According to Census 2011, India is the second most populous country in the world. The total population of India is 1.21 billion which accounts to 17.7% of the world's total population. The urban population is estimated to reach 575 million by 2030. Moreover, the urban areas will be populated by 50% of the country's people by 2050. Speedy urban and population growth, rapid economic development and fast urbanization has an impact in poor MSW management. The high prevalence of illegal dumping is directly impacted by the living standards of the citizen. Furthermore, India has a vast diversity in climatic conditions and Geography. Therefore, excessive waste generation is one of the influencing factors (Shahab & Anjum, 2022).

Tons of waste were generated globally in 2016 amounted to 2.01 billion (Yuan *et al*., 2023). To reach 3.40 billion tons by 2050, the amount will accelerate by 70%. It was delineated that waste management decisions are made daily by governments and individuals that impact the productivity, health, and cleanliness of communities (Mager & Blass, 2022). A study conducted by Mager and Blass (2022) revealed that construction industry was among the most wasteful and polluting sectors according to the European Commission. Approximately 40% of the global Greenhouse Gas (GHG) emissions were generated by the construction industries and the built environment. Construction and Demolition Waste (CDW) accounts for approximately 60% of the total waste produced in Europe. In addition, the study further found that industries and communities had a tendency of disposing of hazardous construction waste in water as they avoided compensation for proper waste disposal. Therefore, the environmental and health impacts of construction waste and other aspects of the built environment were underestimated.

Lin *et al*. (2022) conducted a study on the identification and analysis of the illegal dumping spot of solid waste at Chiliwing segment 5 riverbanks. It was found that waste was thrown into the river by eight States. The total volume of waste dumped into the Ganges River accounted for 60% and about 15% of river pollution came from the industries. Therefore, the findings of Lin *et al*. (2022) concur with those of Mager and Blass (2022).

Brooke and Fenner (2023) illegal dumping has become a major environmental issue in the world and the Southern Africa does not convey much attention to the problem. A study conducted by Mohamed (2023) in Zimbabwe cited that 60% of the collected and transported waste to the official disposal sites was generated in Victoria Falls. Moreover, 40% was illegally dumped in undesignated areas such as open spaces; along the roads; storm drains and alleys. In addition, illegal businesses attributed to 80% of water pollution in Zimbabwe. The study further revealed that Zimbabwe has a high percentage of illegally dumped waste in water. Correspondingly, to Uganda and Botswana (Mohamed, 2023). In Zimbabwe, the municipalities find it hard and unable to cope with the management and removal of waste and ample piles of trash (Brooke & Fenner, 2023).

The Ministry of Environment of Japan conducted an investigation on illegally dumped industrial wastes, it was discovered that approximately 400.000 tonnes of industrial waste was illegally dumped annually in water bodies (Kawamoto *et al*., 2023). Wu *et al*. (2023) found that a community with a high unemployment rate has a higher frequency of illegal dumping in Japan. Previous study of Syafrudin *et al*. (2023) showed that there was a correlation between illegal dumping behaviour with gender; age; education; employment status; nationality and economic bracket.

2.6.2. In the context of South Africa.

South Africa is codified as a developing country according to the global standards (Haas, 2023). Nonetheless, there are contention with regards to this classification. South Africa is one of the biggest economies of the Southern African region (Zondi *et al*., 2023). Some characteristics of a developed country are also reflected in South Africa such as the improvement of infrastructures, wealth and high level of urbanisation. However, the population receives unequal distribution of this level of development. Evident disparities occur from both social and economic perspective (Ngalo & Thondhlana, 2023). Thus, service delivery is one of the notable effects of disparities. Besides, these disparities are illustrated particularly in waste management.

In South Africa, most municipalities do not have a prevention plan to combat illegal dumping. Fazzo *et al*. (2023) found that the city of Johannesburg (CoJ) has a higher dominance, and significant risks associated with illegal dumping. As a result, the total amount of waste produced each year in the CoJ was between 1.6 and 1.8 million tonnes. About 1.85 million households in the CoJ only 45% of households receive daily and lawful waste removal services. With reference to the statement, about 55% of households resort to their own waste management strategies which was commonly waste disposal in water. The study further revealed that the waste materials frequently dumped in water were household waste and builder’s rubble. This concur with the findings that majority of people 56.78% who dumped waste illegally were community members (Grangxabe *et al*., 2023).

Municipalities in South Africa acknowledge that improper waste disposal is a serious challenge. Viljoen *et al*. (2021) found that proper handling of waste at the household level was positively influenced by municipal waste management. The study revealed that 80% of households placed all wastes in the same bin for collection. Curb-side waste management was also practised. In addition, respondents mentioned that they did not practise off-side household waste management and did not take waste directly to the landfill, drop-off centres or for donations. Furthermore, waste management and disposal practices such as composting and reusing were practised by very few households. Most of the households 48.7% were concerned about improper waste disposal in water while 66.9% of households were not bothered.

Illegal dumping may be contemplated as an “egregious issue” within the communities in South Africa. It is also a serious threat in Fisantekraal. Improper waste disposal is considered as an open-ended; complex and intractable problem and further involve justice and rights-based issues. Niyobuhungiro and Schenck (2021) revealed that the prevalence of illegal dump sites and water pollution were severe to a point where the efforts of the community to clean up waste each month was not visible as the dump sites were not lessened. This was evident through the formation of new dump sites and a few extensions of existing ones. The study further revealed that the spaza shop owners and households were identified as the main dumpers according to the morphology composition of the dumped waste.

Marias (2021) water shortages is coined with issues of waste management. According to Saad *et al*. (2024) various towns in South Africa are affected by impacts of waste disposal on water including Vanderbijil Park near Vaal River. Zondi *et al*. (2023) unlawful dumping of solid waste along and into the stream banks was observed within the city of Pietermaritzburg. According to DWS (2023) lack of proper waste disposal led to a decline in water quality, water availability and accessibility in the city of Sekhukhune District Municipality. Therefore, this study sought to fill the research gap and report on the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality.

2.7. Factors associated with waste disposal in water.

The rationality behind the occurrence of illegal dumping in water bodies are complex and varied. Improper waste disposal is an environmental problem, monetary issue and a complicated social matter (Bangani *et al*., 2023). However, recognizing its underlying causes may aid in effectively dealing with the issue of unlawful dumping (Yuan *et al*., 2023). According to Syafrudin *et al*. (2023) a combination of various factors such as high disposal costs; high waste generation; increased population and social norms in most cases result in illegal dumping. Hence, this topic further alluded to the various possible reasons and causes of illegal dumping in water. The root causes of a variety of different crimes among other things indiscriminate or improper waste disposal were discussed using substantial tools such as the concepts of social disorganisation and institutionalised racism.

2.7.1. Institutionalised racism among black and white communities.

According to Wright *et al*. (2021) institutionalised racism is an implicative racism, where white commonality support organizations with discriminatory regulations, policies or laws. Subsequently, the Civil Rights Movement and the passage of the 1964 Civil Rights Act was not of paramount due to the existence of systemic prejudice even today whereby many freedoms are still inaccessible to the marginalised group (Braveman *et al*., 2022). Majority of white communities are kept in authoritative positions due to systemic prejudice whilst minority have high challenges in accessing public schools, getting better paying jobs and safe living conditions. As a result, the eminence of indiscriminate dumping in marginalised communities is associated with inadequate education; health; jobs and increased crime rates. According to Zondi *et al*. (2023) perpetrators or victims of the highest volume of indiscriminate dumping are noted as the amplitude of ethnic groups.

The history of institutionalised racism in the United States varies from the one in South Africa (Fang *et al*., 2023). South Africa's history of institutionalised racism transpired through the system of Apartheid and colonialism (discrimination against coloured and black communities). Waste management is one of the areas that can be observable in the South African society as the result of systemic discrimination (Grangxabe *et al*., 2023). Communities in South Africa are exceedingly affected by poor service delivery (as an influencing factor to illegal dumping in water bodies); weak infrastructure; poverty and unemployment. These factors are mostly experienced in black or coloured communities than white commonality.

2.7.2. The theory of social disorganisation.

According to Maphanga and Madonsela (2023) social disorganisation theory refers to the understanding behind the reason of societal imbalances, for instance higher crime rates. Socially disorganised societies are often characterised as high crime rates due to increased poverty; population growth; and ethnic heterogeneity (Niyobuhungiro & Schenck, 2022). Social disturbance is caused by actions such as public drinking which then result in illegally dumped waste and litter all over. Illegal dumping is associated with the theory of social disorganisation and most likely to experience illegal dumping (Grangxabe *et al*., 2023). Lack of natural surveillance to monitor suspicious activities (illegal dumping) results from high social disorganisation. A collective supervision is difficult to conduct in communities with high ethnic heterogeneity and poverty due to less social networks. The concern about issues of cleanliness and waste management is less in communities with high poverty rates (Niyobuhungiro & Schenck, 2022). Thus, community principles, values and interests are less protected by individuals with low-income level as they do not have human capital and financial means. Therefore, their participation in waste management strategies such as recycling; and neighbourhood association and awareness is less. Perpetrators of illegal dumping may uncurbed due to lack strong social networks within the community.

2.7.3. Waste generation per capita.

There is an extensive increase in the amount of waste generated per capita (Lazo *et al*., 2023). Due to the improving standard of living, people prefer to purchase expensive cars and latest items in the market (Abubakar *et al*., 2023). Consequently, the total amount of waste generation globally is significantly increasing with an advancement in people's lifestyle. The risk of improper waste disposal is absolutely and likely to escalate due to the exponential rise in waste output (Adedara *et al*., 2023). Accordingly, increased waste generation; consumption and wastefulness burdens waste management services on the account of absence of resources for extension of facilities and services.

2.7.4. Social norms in communities.

Many countries do not consider illegal dumping as a significant challenge. Hence, it is distinguished as a minor issue rather than a criminal offense. Human association has a significant impact on individuals' actions on waste management. Individuals who deliberately practice unlawful disposal and do not perceive it as a serious matter, their families and close friends are more likely to perceive unlawful disposal as an adequate disposal method for their refuse. In view of that, embracing or opposing illegal dumping depend on actions and social expectations of people among themselves (Muheirwe *et al*., 2023).

2.7.5. Escalation of population growth.

According to Grangxabe *et al*. (2023) one of the significant causes of illegal waste disposal is the increase in global population. Over the last 50 years, there was a significant acceleration of urbanization in developing countries. The proliferation of illegal waste disposal emanated from informal settlements in developing countries such as South Africa, Uganda and Algeria. One of the primary causes of illegal waste disposal is population growth in conjunction with an increase in informal settlements. As a result, there is a rapid expansion of settlement. This rapid population growth poses a significant challenge in waste management system. Martinho *et al*. (2023) there are no alterations of infrastructure development to maintain waste management systems as societal consumption patterns keeps on changing.

In 2050, waste generation is expected to increase over three time and five time more in 2025 due to an increase population growth and rapidly improving standards of living

(Du *et al*., 2023). An increase in the total human population in the world is associated with an increase in the overall volume of waste generated. The higher the quantity of total waste produced means an exponential rise in population growth (Zondi *et al*., 2023). Even though, there are designated waste disposal areas, a greater number of individuals prefer unauthorised locations to dump their waste whilst a minimal number might utilise authorised waste disposal areas. Illegal waste disposal is expected to accelerate and more likely to intensify as the population growth persist due to large amount of waste been continuous generated. Moreover, land becomes limited due to an increase in population growth (Grangxabe *et al*., 2023). Therefore, humans begin to reside in areas that would have been utilised in the future for proper waste disposal (Du *et al*., 2023). Lack of places for proper waste disposal exorbitantly contribute to illegal dumping as the current and future populations will occupy areas for designated waste disposal.

2.7.6. Inadequacy of decisions and concern in societies.

Decisions of community members leads to the occurrence of illegal dumping (Ngalo & Thondhlana, 2023). A substantial percentage of a society may not be disturbed about improper waste disposal and its repercussion. However, individuals would rather neglect significant community initiatives such as solid waste management strategies and programmes and focus more on issues that promptly affect their lives (EPA, 2020). This leads to issues of illegal dumping and their adverse effects been neglected or unnoticed in societies. Issues of improper waste disposal are also preceded by lack of concern and individuals' indifference.

2.7.7. Dilatoriness of individuals.

According to Kalina *et al*. (2023) individuals are too lazy to drive or carry their waste to designated disposal areas, this is another reason for illegal disposal of waste. On the other hand, lazy people come to a halt of dumping waste in water bodies or isolated areas where it will be difficult for waste management officers or authorities to recognize them. Environmental sensitive areas (such as water bodies and open spaces) near communities are prone to illegal dumping irrespective of them been designated waste disposal areas or not. Unauthorised waste disposal site will accelerate in the future because of individuals' laziness.

2.7.8. Disposal charges.

High disposal charges are being noted as another cause for illegal disposal of waste (Khan *et al*., 2023). The higher the disposal charges, the higher the inspiration for communities to illegally dispose their waste. Therefore, incentives for proper disposal will be lower. Du *et al*. (2023) concordant with the fact that small companies, industries, or individuals in developing nations do not have adequate resources and do not advance their resources. Therefore, lack of resources and funds from private or public sectors leads to countries with low GDP per capita like the Democratic Republic of Congo to face a hassle with waste management practices such as disposal and collection (Khan *et al*., 2023).

2.7.9. Corruption and bribing.

Another factor that leads to improper waste disposal is corruption and bribing (Ngalo & Thondlana, 2023). Government agencies, local workers or state receive special benefits and services through bribery from large corporations. Authorities can be easily manipulated by large companies to dispose their hazardous refuse illegally to avoid proper disposal as they circumvent the financial costs to illegal disposal. Such actions are done for hazardous waste as it is rationally costly to manage and dispose properly.

2.7.10. Lack of mechanisms and control structures.

Mechanisms and control structures are valuable tools for providing good waste management practices in a municipality or community such as monitoring procedures for proper waste management and supervising waste disposal regularly. Authorities should be notified with their job description and properly adhere to duty of care as they will be held accountable for waste management services. Encouraging citizens to take responsibility for their environment and should be held accountable for environmental cleanliness which will assist in controlling the structures. Community members or officials may neglect their responsibilities due to lack of mechanisms and control structures. Challenges of illegal dumping emerge from shortage of control structures. According to Liu *et al*. (2022) shortage of control structures is evident in many countries as well as in Ba-Phalaborwa Local Municipality. In most cases, the conduct of individuals' waste disposal is not monitored due to insufficient workers. Illegal disposal of waste in water bodies; plantations and other areas becomes convenient and easier for individuals as insufficient officials do not monitor such areas (Liu *et al*., 2022). Likewise, frequent monitoring of improper disposal may encumbrances on insufficient financial resources (Yuan *et al*., 2023).

2.7.11. Lack of education.

Environmental sustainability is predominantly affected by poor education (Syafrudin *et al*., 2023). An important tool to transfer knowledge is through education, particularly knowledge on proper environmental management, waste management and proper duty of care on the environment (Ichipi & Senekane, 2023). Moreover, countries where challenges of illegal dumping in water bodies are ponderous, majority of individuals fail to perceive that adverse effects of climate change are led by unlawful disposal (Bangani *et al*., 2023). Therefore, lack of schooling leads to such perception. Child-headed families are prevalent in certain countries where children of school-age are forced to work and provide for their families. Consequently, working at a young age deprives them from going to school, which then leads to absence of primary education and knowledge relation to waste management. Illegal dumping is associated with lack of education as individuals lack the basic knowledge on how to properly manage waste (Thobejane, 2022).

2.8. Households' levels……...towards waste disposal on water.

2.8.1. Knowledge and awareness.

A good knowledge base is imperative to comprehend issues of waste disposal and its associated risks. Selomo (2023) it is acquired through experience and education in the form of skills; facts; description and information. Knowledge has the power to refine individuals' beliefs; norms; attitudes and values towards a sustainable environment (Dzawanda *et al*., 2022). Knowledge is associated with individuals' positive attitude towards waste management whilst attitudes allude to the possession of individuals' positive concern and values about their environment.

According to Zondi *et al*. (2023) environmental perception and individuals' behaviour towards waste management systems may be influenced by one's level of knowledge on SWM. A study of Grangxabe *et al*. (2023) found that knowledge influenced how individuals perceived their environment and whether they comprehended that waste disposal could lead to environmental risks such as the spread of diseases and floods. The study further found that acceptance of SWM authorities and individual's trust to them depends on their level of knowledge. Therefore, one of the fundamental factors in modelling public acceptance is considered as public trust in SWM authorities with reference to waste management and waste disposal.

An increase in knowledge and awareness among residents requires local authorities to conduct effective public outreach. Another important strategy to increase the level of knowledge is public participation and involvement in SWM projects (Eshete *et al*., 2023). According to Nasir *et al*. (2023) further emphasized that a cheaper and more efficient way of reducing household waste is through educating and encouraging individuals to participate in SWM processes. Moreover, Chukwuone *et al*. (2022) found that the level of knowledge and eventually the behaviour towards improper disposal and waste management may be influenced by socio-demographic factors such as age; gender; education; income level and occupation.

Kalonde *et al*. (2023) improper waste disposal in developing countries have been attributed from lack of education and awareness which then led to individuals' negative towards waste management. Adeniran *et al*. (2023) found that lack of knowledge and awareness, and ignorance led to households perceiving that waste can be dumped anywhere. In Ghana, communities shift the blame to government when unlawful waste disposal in water escalate Nell *et al*. (2022), this has been cited as a leading factor due to lack of education and awareness. According to Viljoen *et al*. (2021) lack of interest in waste management issues and people not been responsible to transform their society has led to minimal participation in waste management processes. As well, education and awareness can promote environmental citizen by increasing a sense of ownership in waste management and improving the state of SWM in communities. In Malaysia, environmental awareness and educational campaigns were implemented to influence the conscience of individuals as well as to overcome the issue of improper waste disposal (Syafrudin *et al*., 2023). Therefore, public knowledge can be enhanced through the inculcations of environmental education and awareness which further influence individuals' attitudes positively on proper waste disposal methods. By doing so, waste collection will be eased.

Du *et al*. (2023) low levels of knowledge influence individuals' attitudes, perception, and practices respectively. According to Niyobuhungiro and Schenck (2022) there is a substantial correlation between households' knowledge, attitude, and practices. A study of Niyobuhungiro and Schenck (2022) found that waste management training and skills were not effectively presented in communities, as a result improper disposal of waste was prevalent and continuously grew each year. Grobler *et al*. (2022) found that an increase in community participation and involvement; environmental protection activities and cleaning campaigns has led to a vast knowledge among communities on the effects of improper waste disposal in water such as health risks. As a result, individuals will most likely improve their waste handling practices such as recycling household wastes, have a positive attitude on managing waste and will further attend educational programs and training.

2.8.2. Attitude.

Attitude is a particular aspect of one's environment through enduring predisposition (Moussa *et al*., 2023). According to Kadyamadare *et al*. (2023) how a person bond with the environment denotes their level of attitude on environmental concerns with regards to waste management. Therefore, attitude is a significant aspect of behaviour, and it determines individuals' behaviour. Eshete *et al*. (2023) found a relationship between attitude and behavioural intention been substantially high as attitude was an essential predictor of behaviour. Besides, attitude comprises of three elements which are behavioural tendency to act; perception (emotional impression) and cognition (thought) (Barr *et al*., 2023).

Pretorius (2023) one's attitudes towards waste is conditioned as an important degree on waste generation and waste management processes. A study conducted by Castro *et al*. (2023) found that individuals with negative attitudes towards waste management were not participating in recycling activities. As a result, attitude influences individuals on waste handling and their use of material, their motivation on waste minimization and reduction, their level on waste separation and the magnitude in which they avoid illegal waste disposal and littering (Adefris *et al*., 2023). Therefore, the characteristics of waste generation are not the only factors that influence people's attitude. As a result, effective waste collection services are in demand, but individuals' willingness and interest to pay for collection services depends on their level of attitude (Obuobi *et al*., 2023).

Educational measures and awareness building campaigns on the values of effective waste disposal may positively influence individuals' attitudes towards proper waste disposal to mitigate the negative impacts of waste disposal in water, on the environment and public health (Li *et al*., 2023). Bagastyo *et al*. (2023) people should be informed of their rights as citizens in relation to waste management services and their responsibilities as waste generators in such campaigns. Educational measures and public information may positively influence individuals' attitude towards waste, but lack of practical waste disposal options may hardly be maintained due to the demotion of waste handling patterns (Li *et al*., 2023). According to Pathak *et al*. (2023) improvements in waste collection services either public or societally managed should be coordinated in conjunction with educational programmes and awareness building measures.

A study of Viljoen *et al*. (2021) found that neighbours had a huge influence on people's waste generation and disposal methods. If majority of households in a neighbourhood change their attitude and participate in waste management improvement activities, environmental, health and social impacts will be lessened as there will improve waste handling practices among residents. The feasibility of waste collection depends upon the improved local waste management practices among neighbours. As far as possible, the mitigation of one's negative attitude towards improper disposal requires the adoption of regulation and control measures within communities (Fadhullah *et al*., 2022). Nevertheless, it is often the case that the effectiveness of these measures are sporadic.

A study conducted by Kombiok *et al*. (2022) found that illegal waste disposal and one's attitude could be improved through consensus between authorities and communities, reliable services, and public awareness within communities. Therefore, lack of waste collection services and the absence or inappropriate location of bins led to negative attitude and behaviour towards SWM (Labib *et al*., 2021). Shakil *et al*. (2023) found that households had a negative attitude towards waste disposal such that they saw improper waste disposal as someone's work (someone will not be employed if I don't litter) and that issues of waste disposal are no one's business. Furthermore, different socio-economic groups had different attitudes towards SWM (Eshete *et al*., 2023). The satisfaction of households' basic needs led to residents been sensitive to issues of SWM and been more environmentally conscious (Babazadeh *et al*., 2023). As a result, they possess positive attitude towards waste management.

2.8.3. Perception.

Perception refers to the interpretation and understanding of someone or something Kalonde *et al*. (2023), it plays a crucial role in waste disposal. Households' perception portrays a significant role in modelling the relationship between humans' environment and their health. Sabelone (2023) negative perception among residents displayed little or no attention to proper waste disposal. Education, awareness capacity building and sensitisation with regards to the negative elements of inadequate waste collection may positively influence people's perception (Zondi *et al*., 2023). According to Amkpa *et al*. (2023) the failure to address issues of improper waste disposal in developing countries has been led by negative perception of people towards waste management. A study conducted by Mahale *et al*. (2023) on individuals' perception revealed that more than 50% of households were disposing their waste in water bodies due to their low perception. The waste observed include larger amounts of bottles; plastic products; paper; cans; diapers; polythene bags and food waste.

People still hold the perception that it is the government's duty to clean up after their illegal dumped waste. A study conducted by Abubakar *et al*. (2022) affirmed that the findings of previous studies from Japan, America, Canada, Australia, and Britain. The study revealed that communities found it inconvenient, expensive, and unpleasant to dispose of bulky waste correctly. Hence, communities in Ethekwini Municipality relied on the government and the political party in power to provide waste management services and to pick up waste that has been dumped consciously. Likewise, the growth of illegal dumping in Ethekwini Municipality is still a challenge because of poor MSW services (Niyobuhungiro & Schenck, 2022).

According to Fadhullah *et al*. (2022) waste sorting and treatment can convert domestic waste into a valuable resource. However, Kwakye *et al*. (2024) argued that the process of undergoing waste sorting and treatment before final waste disposal seem not to be sustained on the greater amount of waste generated worldwide. Sarker *et al*. (2024) indicated that households resort to disposing waste in water bodies which furthermost create diseases like typhoid fever and cholera, and produce an offensive odour. The results of individuals' negative perceptions include health risks and environmental contaminants. This signifies that individuals do not perceive that waste disposal in water leads to any negative health implications. The aforementioned statement concurs with the study of Eshete *et al*. (2023) households dispose their sack of wastes into water bodies without perceiving the negative health implications and consequences. One can conclude that households' negative perception led them illegally disposing of their waste in water without thinking about the health risks they will be exposed to.

The general upbringing and setting of settlements duly influenced people's perception on solid waste disposal and its health implications (Sharma *et al*., 2023). According to Debrah *et al*. (2021) adverse economic circumstances in developing countries do not allow individuals to deal with issues of solid waste disposal even though they hold a perception that illegal waste disposal leads to negative health consequences. Awasthi *et al*. (2023) people do little to tackle the situation of improper waste disposal, and they lightly perceive health implications related to improper waste disposal. Low levels of education attribute to low perception of individuals associated with the negative health outcomes of improper disposal of solid waste. A study of Ifyalem and Jakada (2023) found that people's high perception on the negative health consequences of illegal waste disposal was associated with the higher levels of formal education. Such people acknowledge and comprehend the relationship between health effects and improper waste disposal. They show concern and participate on the introduced measures to deal with this situation at an individual level, such acts involve waste separation before final disposal and the placement of refuse bins at their residence.

2.8.4. Practices.

A study conducted by Shahzadi *et al*. (2021) revealed that 72% of households were aware about the unfavourable effects of illegal waste dumping and 95% of households possessed a great attitude towards waste disposal. However, 52% of households showed poor practices in relation to waste disposal. The aforementioned findings concur with those of Dimkpa *et al*. (2023) even though households were aware of the harmful effects posed by improper waste disposal in water, they still practised poor waste disposal such as illegal dumping.

Eshete *et al*. (2023) found that approximately 80% of households practised improper waste disposal in water; gully; along the road and in their backyard, despite majority of households considering illegal waste disposal as a source of potential health risks and environmental pollution. A logistic regression was further employed to analyse the major contributing factors of improper SWM practices which were lack of knowledge about reduce, reuse, and recycle; lack of experience in sorting solid waste; lack of door-to-door waste collection services; ways of disposal or removal and absence of solid waste landfills.

A study conducted by Bowan and Ziblim (2021) found that households used improper waste disposal as their preferred method of disposal and other households further resorted to this method of disposal. Knowledge on waste reduction and separation at source was low among households. As a result, majority of households (83.9%) did not practice waste reduction or even sort their waste for collection. Thus, a very weak correlation was found in the study between knowledge, attitude, and practices (KAP), demographic variables and waste disposal was associated with age (p value = 0.003 < 0.05). The findings concur with those of Uwamwezi (2021) that KAP has a significant impact on households' demographic factors ($p < 0.05$) such as age, gender and education.

2.8.5. Behavioural intention.

Households' motivation and ability to participate in activities such as reducing, reusing, and recycling significantly influence their behavioural intention towards solid waste (Du *et al*., 2023). According to Chengqin *et al*. (2022) attitude has a negative or positive influence on households' behavioural intention. A study conducted by Vijayan *et al*. (2022) found that majority of households did not participate in recycling, they had an attitude that recycling was inconvenient in terms of cost and transport and sound recycling systems were not available within their vicinity which resulted to low rate of recycling intention. One can conclude that attitude and absence of facilities influences households' behaviour. For that reason, recycling programs within communities could be more effective, if factors influencing recycling behaviour were better understood (Pakpour *et al*., 2021).

Tang *et al*. (2023) waste sorting and separation are the most effective strategies to alleviate the occurrence of improper waste disposal as they provide raw materials for recycling and increase waste diversion. According to Shi *et al*. (2021) the utmost significant predictors of waste sorting behaviour and intention depends upon the behavioural attitude and the perceived behavioural control. A study conducted by Alhassan *et al*. (2021) revealed that the demographic factors (such as education and income level; gender; age and employment) influenced households' waste separation behaviour and their disposal method. Zhang *et al*. (2022) another extensive impact on waste separation behaviour was households' satisfaction with government policies. When one is not satisfied with the existing government policies, they are more likely to have a negative behaviour and intention towards waste sorting and separation.

A study conducted by Wang *et al*. (2023) found that households' waste separation intentions were positively influenced by attitude, perceived benefits, social factors, as well as facilitating conditions. Ao *et al*. (2022) sense of belonging, publicity and education, past behaviour, subjective norms, and attitudes were the critical influencing factors to waste classification behaviour. Therefore, the positive intermediary effect of transforming publicity and education to behaviour, attitude to intention, past behaviour to intention lies on sense of belonging of households. The classification behaviour of people easily affects those around them with lower sense of belonging. Residents with higher sense of belonging easily grasp education learnt and transform their behaviour to improve the quality of their environment.

2.9. Risks associated with waste disposal in water.

2.9.1. Environmental risks.

According to Urooj *et al*. (2021) waste disposal in water influenced global warming through exacerbation of geographical alterations in duration, evaporation, precipitation intensity, speed, and frequency (altering the average discharge), soil moisture which then led to floods and droughts. The study further found that the release of GHG intensified and led to minor climatic changes that might had serious effect on water quality. This led to the degradation of river quality and effects on water consumption. Waste disposal in water expose ground and surface water bodies to significant risk of contamination (Abubakar *et al*., 2022). Pollutants present in water influenced soil fertility of the surrounding plants and led to a decrease in crop growth (Mousavi *et al*., 2023).

The direct disposal of waste cause harm to living organisms and result in the excessive levels of chemical and physical substances (Lin *et al*., 2022). A study conducted by Bangani *et al*. (2023) found that plants and animals fed on the accumulated toxic substances in their food chains that were directly disposed into the river. As a result, these toxic substances led to the death and diseases of aquatic plants and animals. According to Kumar *et al*. (2022) found that waste materials disposed of every day in water bodies amounted to 250 grams to 1kg. Ramodipa *et al*. (2023) carbon dioxide and methane attributed from decaying waste and other rotting food. These two were potent GHGs that contributed to climate change (Garcia-Valinas *et al*., 2023).

Waste disposal depletes aquatic ecosystems (Somani, 2023). A study conducted by Andeobu *et al*. (2023) found that the proliferation of algae in water bodies was caused by water pollution, the growth of plants and algae were stimulated by the introduction of nutrients which then led to the reduction of oxygen levels in water bodies. The study further confirmed that water was deprived of life due eutrophication which caused lack of oxygen and suffocation to aquatic plants and animals, and result in dead zones.

2.9.2. Health risks.

The most common disease caused by water pollution is diarrhoea as it is one of the symptoms of gastrointestinal diseases and mainly transmitted through enteroviruses into the aquatic environment (Siddiqua *et al*., 2022). A study conducted Li *et al*. (2022) revealed water from polluted rivers were associated with high risks of diarrhoea. In low-income countries, the leading cause of death and illness in young children was seen as diarrhoea (Perkumiene *et al*., 2023). The annual deaths among children under 5 years of age accounted for 21% of diarrhoeal diseases in developing countries (WHO, 2020). A study in Southern region of Brazil found that factors such as improper waste disposal in water and lack of piped water in their households led to an increased risk in mortality due to diarrhoea (Ouattara *et al*., 2023). The study further revealed that a 4.8 times higher risks of infant death rates from diarrhoea has been experienced more by households without access to piped water than those with access to piped water. One can conclude that the lack of piped water drives households to collect water in polluted rivers.

According to WHO statistics (2020), 19.3 million patients were diagnosed with cancer in 2020, while there was an increase of 10 million deaths from cancer. At present, the development of cancer in human’s lifetime is at one-fifth of all global fevers. Moreover, contaminated drinking water varies with the amounts and types of carcinogens present (Vinti *et al*., 2023). Shammi *et al*. (2023) found that human cancers were more closely associated with a broader contaminant of excessive nitrates levels which then led to colorectal cancer. A significant association between nitrate and colorectal cancer was confirmed by Maleki *et al*. (2021) in a study conducted in East Azerbaijan. The risk of carcinogenic nitrates is a concentration dependent (Gupta *et al*., 2023). When drinking water which exceeds 3.87 mg/L, the risk of colorectal cancer increases significantly (Gupta *et al*., 2023). Also, Luvhimbi *et al*. (2022) found that the risk of colorectal cancer increases when human consume water with lower concentrations of nitrate than the current water standards for drinking (50 mg/L). Therefore, the nitrate levels should not be high or low.

Improper waste disposal in water leads to infectious diseases through the breeding of vector diseases, primitively flies; mosquitoes and rats (Somani, 2023). Gqomfa *et al*. (2022) found that residents suffered from typhoid; malaria; cholera; skin diseases; asthma and cancer due to the negative effects of breeding vectors. Approximately 57.3% of households suffered from skin diseases, followed by 33.6% with diarrhoea. The study further discovered that during flooding season households were exposed to contaminated water even though they did not use water from polluted rivers. Besides, domestic animals would carry diseases to the nearest communities. Thus, poor waste disposal; sanitation and water storage led to health implications in humans.

2.9.3. Social risks.

Poor water quality and water-borne related diseases lead to social implications among communities. Water contamination is the outcome of human activities such as waste disposal in water (Bashir *et al*., 2021). A study conducted by Mulhern (2021) found that the burden of polluted water collection was prone to affect women than men. The study further highlighted that approximately 73% of households relied on women to fetch water and 72% of households spent more than 30 minutes in a day fetching water. For that reason, the reduction in educational opportunities for women and girls were led by gender specific role which resulted in an increase in poverty (Mulhern, 2021).

A study conducted by Fadhullah *et al*. (2022) households residing near polluted water complained about a foul odour in water bodies, further highlighted that it made living challenging. Waste disposal in water increased crime rate and human safety was no longer guaranteed (Ramodipa *et al*., 2023), and led to the hindrance of recreational activities such as fishing; swimming; boating; sailing; rafting and canoeing (Zondi *et al*., 2023). According to Gqomfa *et al*. (2022) found that floods had a potential social risk of destructing settlements; construction and human lives, and further led to health risks.

2.10. Effects of waste disposal on water parameters.

2.10.1. Dissolved oxygen.

According to Siddiqua *et al*. (2022) dissolved oxygen (DO) depicts the quality of water, and it balances and supports the aquatic ecosystem. The decrease of DO in water is influenced by various human activities, one of them being waste disposal in water. A study conducted by Bangani *et al*. (2023) revealed that there was a decrease of 0.607 mg/L of DO in water. Also, in the dry and wet season, the available oxygen decreases as wastes were entering the river. Lukhabi *et al*. (2023) found low concentration of DO in all sampling sites and further observed migration of aquatic species in order to avoid poor conditions, disruption of life cycles, reduction of organismal growth and the death of aquatic organisms.

According to Alvarez *et al*. (2023) an increase in temperature led to lower levels of DO, which resulted in the death of aquatic ecosystem. Hence, DO depends on water temperature. A study conducted by Giri *et al*. (2022) found that the DO level was at 5 mg/L with temperatures at 20º C and 30º C. The study further observed that fish and other organisms could be killed due to low concentration of DO. The reduction of DO was led by the introduction of solid waste from households and industries (Omid *et al*., 2021).

2.10.2. Turbidity and Total Suspended Solids.

A study conducted by Setyaningsih and Sanjaya (2022) found that farmers disposed plastic wrapping in rivers that were used to prevent pests and maintain the quality of fruits during harvesting. High concentrations of turbidity and total suspended solids (TSS) were found in all the sampled sites. Consequently, light could not penetrate the water which interfered with photosynthetic activities and the growth of aquatic plants. The movement of water species were affected by the debilitation of light. The study further found that the flow of river currents was affected as the water remained stable due to wastes disposed. As a result, human-induced activities influence the growth of phytoplankton.

Gqomfa *et al*. (2022) found that high levels of suspended solids were associated with the transmission of disease-causing agents which led to the risk of viral and bacterial diseases. The gills of macroinvertebrates were damaged due to high turbidity (Lukhabi *et al*., 2023). According to Tyler *et al*. (2022) turbid waste has less oxygen as suspended particles absorb heat from sunlight as a result less oxygen settles in warm water than cool water. A study conducted by Heddam (2023) found that turbid water looked dirtier with a foul odour. Apparently, water with less oxygen produces a certain smell.

2.10.3. Bioindicators.

Orozco-Ganzalez and Ocasio-Torres (2023) the quality of aquatic ecosystems is signified by the greatest diversity of aquatic macroinvertebrate communities. Most researchers overlook the use of bioindicators for water assessment (Lukhabi *et al*., 2023). A study conducted by Rico-Sanchez (2022) found a lower diversity of macroinvertebrates due to unfavourable water quality and deterioration of aquatic habitat led to a decrease in the establishment of several macroinvertebrates. In addition, factors such as temperature and poor water quality were observed as disturbing environmental factors for the development of macroinvertebrates in the river. Duque *et al*. (2021) found that waste disposal influenced water quality and increased the levels of nitrates in water bodies which led to a decrease in macroinvertebrate communities. Therefore, anthropogenic activities pose a serious harm to aquatic ecosystem services.

Kownacki and Szarek-Gwiazda (2022) conducted a study on the analysis of diversity and density of benthic macroinvertebrates in contaminated and uncontaminated river. The uncontaminated river had a diversity and abundance of clean water indicators like (Trichoptera; Plecoptera and Ephemeroptera) while the contaminated water had a dominance of Oligochaeta (99.4 – 99.9%). A study conducted by Omary *et al*. (2023) on assessing the impact of human activities during wet and dry season in Pinyinyi River. Mosquito larva (41.0%) was found as the most abundant taxa in dry season while Haplotaxida (19.44%) was found as the most abundant taxa in wet season. One could conclude that macroinvertebrates are found in well-oxygenated and clean water.

2.10.4. pH.

pH indicates the relative acidity or alkalinity of water and the concentration of hydrogen ions (Rugebregt *et al*., 2023). A study conducted by Gqomfa *et al*. (2021) revealed that the average pH recorded in Dief River was 7.16 – 7.98. High levels of pH denoted a higher level of bicarbonate, chloride, and carbonate because of waste disposal in water. Even though, the pH was higher, the WHO standards recommend an ideal pH range of 6.5 – 8.5. Saalidong *et al*. (2022) found that the lives of bacteria were influenced by the higher levels of pH. Further highlighted that very high pH led to water having unpleasant smell, alkaline taste, toxicity of chemical substances like ammonia and precipitation of metals. Households were exposed to water with high pH levels and suffered from extreme diarrhoea, skin-contact diseases such as skin and eyes irritation, and mucous membrane. Saalidong *et al*. (2022) further found that pollution of surface water led to groundwater been more vulnerable and susceptible to direct contamination due to waste disposals in water. As a result, the study affirmed the statement through analysing the relationship between surface and groundwater with water quality parameters such as pH; TSS; turbidity; electrical conductivity (EC) and water temperature. As a result, pollution of surface water led to the contamination of groundwater, of which the contamination persists for longer periods.

2.10.5. Nitrates and phosphorus.

Wastes contain nitrates and phosphates that deteriorate the status of the river. A study conducted by Magna (2021) found high nitrate levels in water and the potentiality of diseases-causing organisms to human-health were observed. In addition, households that consumed the water or used it for domestic purposes, it affected their nervous system, cardiovascular system and further led to the development of gastric cancer. According to Lukhabi *et al*. (2023) the growth of algal blooms was stimulated by high levels of nitrates and phosphates causing the exacerbating of eutrophication.

A study conducted by Li *et al*. (2022) revealed that high nitrates levels had replaced native species with alien species, which grew dramatically in the aquatic ecosystem. United States Environmental Protection Agency (2022) further concur with high levels of nitrates altering the type of aquatic plants and animals. As a result, the alien species led to a depletion of native species due to competition of food resources and survival. Bhat and Qayoom (2021) found that high levels of nitrates and phosphate resulted in fish mortality and other species; community shifts; loss of biodiversity; behavioural change and physiological changes in aquatic species.

2.10.6. Water temperature.

A study conducted by Bangani *et al*. (2023) found that water temperature was higher in dry season 36.10º C and lower in wet season 32.80º C. These findings confirmed that during dry season water quality was not suitable for use compared to wet season. Gqomfa *et al*. (2021) found that the water temperature was slightly different as the samples were taken at different times and days. Therefore, water temperatures were affected by turbidity and soil exposure; TSS; air temperature; stormwater runoffs and groundwater inflows. From both studies, one can conclude that waste disposal in water led to highest levels of temperatures in summer and lowest in winter. As a result, the toxicity of water for domestic use may increase due to high temperatures. According to Joubert (2021) temperature plays a vital role as it changes the organisms' metabolic rates which are affected by the chemical reaction rates. Temperature is one of the major elements controlling the distribution of organisms in an aquatic environment. As temperature increases, there will be an increase or decrease of levels on other water quality parameters.

2.10.7. Electrical conductivity (EC).

Electrical conductivity (EC) refers to how well water can transmit electric current. Mengstie *et al*. (2023) found that the presence of pollutants in water such as potassium, sodium and chloride were influenced by high EC values of 339 µS/cm as the water at source had high pollutants. These findings concur with Khan *et al*. (2023) as anthropogenic activities led to higher concentrations of EC due to the detection of heavy metals such as Ni, Cr and Pb in the stream. Moreover, chinyere *et al*. (2023) conducted a study on the assessment of physico-chemical quality of Uturu Section of Aku River in Southeastern of Nigeria, found that the EC range was 215.32 – 275.46 µS/cm in dry season and 165.18 – 227.42 in wet season µS/cm. Reduced volume and flow of the river was noticed in dry season due to higher EC value.

Masindi *et al*. (2022) found high EC levels of both upstream and downstream. The decrease of EC concentration was observed in July 2020. Thus, rainfall influenced the increased dilution capacity of EC levels in both upstream and downstream. EC concentrations were also influenced by the geology of the area, for instance, water passing through clay soils had higher EC than water passing through granite bedrock. A study conducted by Horiguchi *et al*. (2023) found a sufficient correlation between EC and fecal contamination with a range higher than 300/100mL. Roy and Jubilant (2024) also noticed that high EC levels detect high e-coli or faecal coliforms in polluted water. Kormoker *et al.* (2023) argues that high EC concentration contain higher content of heavy metals such as Zn; Cr; Mn; Fe; As; Pb; Cd; Hg; SO_4^{2-}; CL^- and I^-. The study also revealed that through ingestion, the water has a higher potential of dehydration and cancer risks in human.

2.10.8. Chemical Oxygen Demand (COD).

Chemical Oxygen Demand (COD) is one of the parameters used to observe the level of water pollution (Han *et al*., 2022). Wang *et al*. (2023) conducted a study on water quality assessment and pollution evaluation of surface water sources in China, found that anthropogenic activities together with chemical emissions led to a strong loading of COD in surface water. Loi *et al*. (2022) revealed that high levels of COD caused carcinogenic and mutagenic effects on human health. COD influences the DO levels. Li *et al*. (2023) found that high levels of COD increased organic matter and decreased the DO levels. Therefore, high levels of COD lead to the depletion of DO.

A study conducted by Nguyen *et al*. (2023) on pollution and risk level assessment of pollutants in surface water bodies found that the COD level was three times higher than the permissible limit in both dry and wet season. The high levels of COD severely affected the development and growth of aquatic species. This showed that the water quality was heavily poor and polluted. Ubuoh *et al*. (2023) found that the increased nutrients load and organic matter content attributed to low DO and high COD levels. As a result, human activities such as waste dumping; washing of clothes and cars; bathing; farming and defecation of animals were observed as the major factors to high levels of COD in Nworie River, South-Eastern State of Nigeria.

Khan *et al*. (2023) conducted a study on the evaluation of surface water quality using global water quality index (WQI) revealed that dry season had the highest levels of COD than wet season. The study further suggested that water quality was not suitable for use in dry season. Water pollution was exacerbated by few potential factors such as higher water withdrawal, reduced river flow and decreased groundwater recharge. Tejeda *et al*. (2023) found that majority of the sampled points reached the permissible limits of COD concentrations with up to 6590 mg/L as recommended by the Water National Commission criteria, all the sampled points were classified as highly polluted. High COD concentrations were influenced by DO levels of 0.5 mg/L and temperature levels of up to 37ºC. The study further confirmed that households viewed water bodies as disposal sites.

2.11. Conclusion.

Improper waste disposal practices affect water quality. The effects of water quality increase water shortage, making it difficult for individuals to drink or use polluted water and for aquatic species to survive. Water should be well taken care of, so as to avoid it been a scarce resource. The issue of improper waste disposal in water could be minimized through strengthening regulations; provision of reliable waste collection services; intensifying control structures; and enhancing environmental knowledge and awareness. These factors are necessary for influencing individuals to change their behaviour on how they interact with the environment.

Mismanagement of waste is a worldwide issue that impinge on economic sustainability leading to environmental and water contamination, and social inclusion. Furthermore, the unsustainable management of solid waste is common in developing and transition countries. However, management issues are different between developing big cities and rural areas in terms of solid waste management (SWM) facilities available and the amount of waste generated. Despite this, both countries are affected by problems such as operational; technical; political limitations and economic legislatives.

At present, solid waste handling and management strategies are not adopted by most developing countries and as a result they seem to be failing and struggling to navigate their way around the strategies. Consequently, the high prevalence of illegally dumped municipal and hazardous waste materials in water put people in developing countries at the risk of myriad environmental and health hazards of water pollution. Thus, the next chapter provides a detailed research methodology and analytical procedures to address the research problem and response to the objectives of the study.

CHAPTER THREE: RESEARCH METHODOLOGY AND ANALYTICAL PROCEDURES.

3.1. Introduction.

This chapter concentrates on defining the study area as well as providing an in-depth discussion of the research method and analytical procedures employed in the study. Data collection and data analysis of both questionnaires and water quality assessment are also discussed.

3.2. Delineation of the study area.

This study was conducted at Ba-Phalaborwa Local Municipality (Category B), which was previously known as Phalaborwa Municipality. It is situated on 23º 57' 16.47''S, 31º01' 40.93''E of the North-Eastern part of South Africa in Limpopo Province under Mopani District. In addition, it is one of the five local municipalities found in Mopani District and has a total population of 150 637, with approximately 41 115 households (Stats, 2011).

Moreover, the geographical area of Ba-Phalaborwa Local Municipality is about 7462 km^2, covering an enormous area of private farms and tribal land namely Selwane; Boelane; Majeje; Maseke; Makhushane and Mashishimale Traditional Authority. Namakgale; Lulekani and Gravelotte are the proclaimed townships under the Ba-Phalaborwa Local Municipality, populated by Pedi and Tsonga residents. Phalaborwa is the only town within the municipality. Likewise, the total municipal area constitutes 27% of farms that belong to private owners. Majority of the farms are utilised for both citrus and game farming (Ba-Phalaborwa Local Municipality, 2022).

A central and convenient gateway (entry and exit point) to Kruger National Park and the Greater Limpopo Transfrontier Park through the Mozambique (Masingir-Xai-Xai) channel is found within the municipality. Furthermore, the confluence of the Ga-Selati Rivers and Olifants River are located inward the Ba-Phalaborwa Local Municipality. The economic growth of Ba-Phalaborwa Local Municipality is constantly improving due to the development of mining; agriculture; tourism; agroprocessing; manufacturing; retail and sport, thus provide quality socio-economic infrastructure.

Ba-Phalaborwa Local Municipality has a total of 58.6% of people living in poverty (IDP, 2022). Based on the improved standard of living and population growth, it therefore has the lowest percentage of people living in poverty (Mopani District Municipality

Report, 2023). Service delivery in this municipality is most lacking particularly in waste management. Waste management services are provided to 22 941 households with a total of 41 115 households (IDP, 2022). There is a backlog of 18 174 households without waste management services. The shortfall of this is that parts of urban areas and townships are serviced on a weekly basis compared to rural areas. As a result, there is only one operating licensed landfill site in Ba-Phalaborwa Local Municipality. Servicing six tribal communities; three townships and Phalaborwa town.

This study area was selected based on observations of waste management practices and the rapid increase of waste disposal in water bodies within the municipality. According to Stats (2011) the weekly refuse removal is only 48.8% in the whole municipality. As a result, this denoted that a substantial part of the municipality resorted to their own mode of waste management strategies such as illegal dumping in water. Consequently, there was hindrance of refuse removal in certain areas. This study assisted the municipality through investigating households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality.

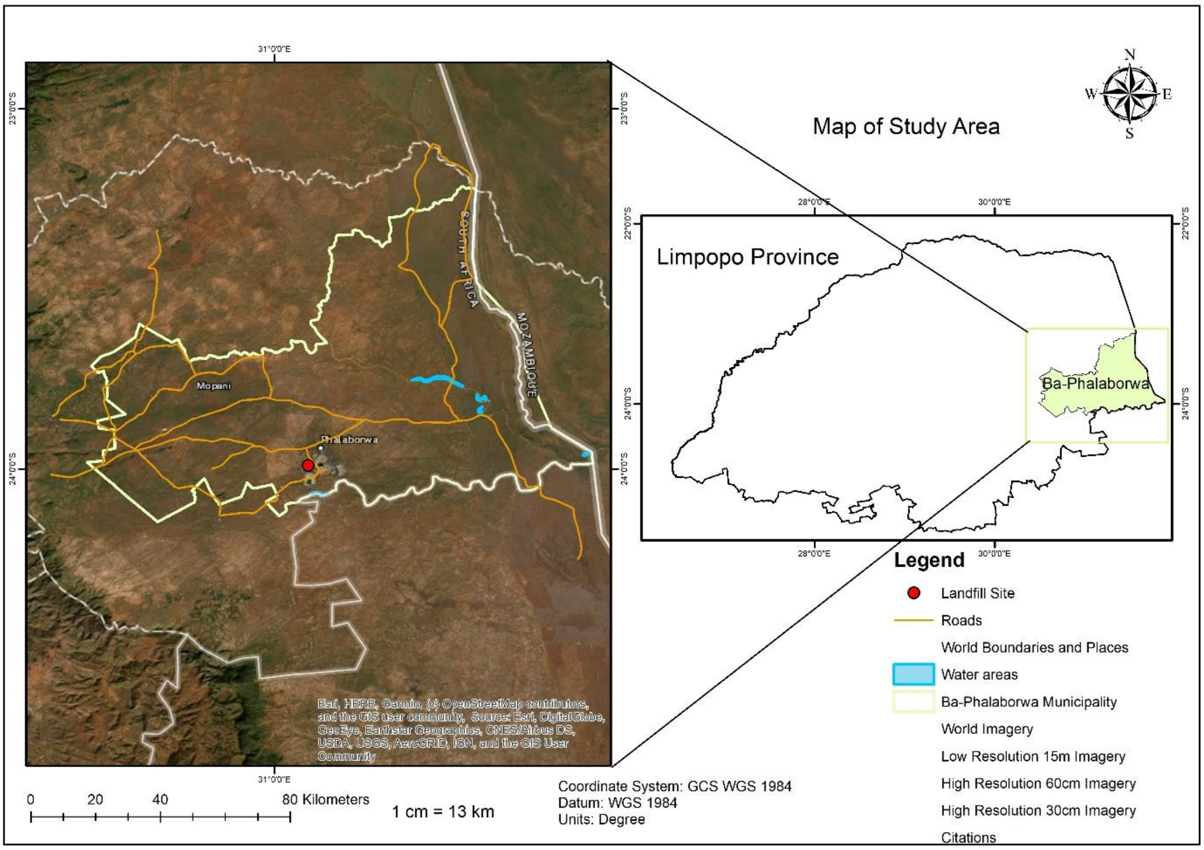

Figure 3: Map of Study area.

3.3. Research design and method.

This study adopted a descriptive research design to examine quantitative data of four communities within Ba-Phalaborwa Local Municipality. The research problem was effectively addressed by employing this research design tool as different components of the study were coherently and logically integrated. A descriptive research design assisted in estimating the prevalence and incidence of waste disposal in water as well as to quantify communities' knowledge; perception and behavioural intention and risks associated with waste disposal in water. This helped the researcher to obtain appropriate statistics about a particular community within the Ba-Phalaborwa Local Municipality. The results of this study provided significant insights that can enlighten and inform future research studies and further assist the researcher to attain a more profound understanding of perceived risks associated with water quality in Ba-Phalaborwa Local Municipality.

3.4. Population of study and sampling procedure.

Based on the census conducted in 2011, the total population of Mashishimale; Maseke; Boelane and Makhushane villages was 29 171 with 7 905 households. In this study, systematic sampling was used to select individuals in a population at a regular interval. Settlements had a more defined residential and grid street pattern, made it easier for the study to employ systematic sampling. A regular interval of every third household on every street in the residential area was used to distribute questionnaires. Individuals in the sampled households were over eighteen (18) years of age and had signed the informed consent form. The researcher distributed the questionnaires to the next households in cases where the residents denied access or participation and where the residents or an individual older than eighteen was unavailable.

3.5. Sample size.

The sampling frame for the study was drawn from 7 905 households, with a total population of 29 171 in Mashishimale; Makhushane; Boelane and Maseke village. These settlements were sampled as the Ga-selati River and its tributaries run along the selected villages. Moreover, this study used a Cochran's formula to determine a representative sample size. Moreover, Cochran's formula was used to calculate an ideal sample size for larger populations with the estimated percentage of the attribute found in the population along with the specified desired confidence and precision level (Sullivan, 2019). Therefore, a sample size was evaluated at a 95% Confidence level with +/- 5% Precision. The calculation was as follows: $n0 = Z2pq/e2 = (1.96)2(.5)\ (.5) / (.05)2 = 384$. Based on the above calculation, the population size was approximately small. Hence, the modified Cochran formula for small population size was used to further refine and filter the sample size. Therefore, the calculation was as follows: $n = n0/\ 1+ (n0 – 1)/\ N = 384/\ 1+ (384-1)/\ (29\ 171) = 384$. The representative sample size of the study population was 384 households. For this study, four (4) villages were purposively sampled as waste disposal in water was prevalent in these communities. To accommodate all the areas, 384 was further divided by the number of communities (4), such that 96 households were interviewed per community.

3.6. Data collection.

This study acquired information from primary data. Primary data was collected through household questionnaires, observations, and water quality assessment.

3.6.1. Primary data collection.

3.6.1.1. Questionnaire.

A questionnaire was developed based on the objectives of this study and was used for data collection from the sampled respondents.

The questionnaire was made up of four sections:

Section 1 included elicit information on level of community knowledge and awareness of waste disposal in water. This was based on a knowledge scale of 26 knowledge items measured on a 2-point scale of aware and not aware.

Section 2 included explored community attitudes, perceptions, and practices on waste disposal in water on a 5-point Likert scale of strongly agree, agree, unsure, disagree, and strongly disagree. The scale covered 25 attitudinal statements.

Section 3 included examined environmental, health and social risks associated with waste disposal in water on a 3-point scale of environmental, health and social risks. The scale covered 57 statements.

Section 4 included determined behavioural intention on waste disposal in water on a 5-point Likert scale of strongly agree, agree, unsure, disagree and strongly disagree. The scale covered 33 behavioural statements.

3.6.1.2. Administration of questionnaire.

The household questionnaires were administered strictly to one household member aged eighteen and above, and who was a permanent resident in the selected household. Each participant took approximately 15 – 20 minutes to answer the questionnaire. The responses from participants were recorded electronically using Google Forms. Furthermore, the questionnaires were prepared in English and in the native language (Sepedi) to accommodate participants who cannot read or write in English (Appendix A and B). Field assistants helped in translating the questionnaires to ensure that participants understand the content of the questionnaire.

3.6.1.3. Data collection.

The researcher randomly selected Ten (10) field assistants in each village, to help in administering the questionnaire. However, the minimum requirement for the selection process was a Grade 12 qualification. The researcher trained field assistants for a period of 3 days before the commencement of data collection. The field assistants were trained on how to collect data and how to use the data collection tools. Moreover, they were familiarised with the questionnaire and the purpose of undertaking this study.

Personal details that could reveal participants' identities like names; identity numbers and cellphone numbers were not captured. The questionnaire was strictly confidential. Participants were not obligated to participate. Accordingly, the participation was willingly and voluntarily. Participants were allowed to withdraw from the questionnaire at any moment during the administration of the exercise. Moreover, the purpose of this questionnaire was to achieve a more profound comprehension of waste disposal practices and waste management in communities within Ba-Phalaborwa Local Municipality and to further make a comparison of the findings obtained in this study with those of other corresponding studies in South Africa; SADC (Southern African Development Community) countries as well as Internationally. Likewise, the questionnaire examined communities' perceived environmental, health, and social risks with water quality assessment.

3.7. Water quality assessment.

Water quality data was obtained from three sampling sites in the Ga-Selati River. GPS coordinates were collected from the sampled site and later coded using QGIS to map waste disposal in water. Three water samples were collected at upper, middle, and lower stream with a distance interval of about 100 meters from each sample point. Water samples were collected in 2-litre plastic bottles that were pre-cleaned and well-rinsed. The sampled water was sealed and secured with proper labeling. Aeration was avoided during the sampling process. The water samples were preserved and carefully transported to the laboratory for physical and chemical analysis.

Water samples were conducted for two seasons (viz dry season and rainy season). As a result, this aided in analyzing and differentiating whether seasonal variance has a significant impact on the effects posed by waste disposal on water quality. Water samples were analyzed to determine physical and chemical variables. In this study, ten water quality indicators were selected (namely dissolved oxygen; turbidity; total suspended sediments (TSS); pH; water temperature; nitrates; phosphorus; chemical oxygen demand (COD); electrical conductivity and bioindicators).

For physical analysis and quality, water temperature was measured using the Hanna Probe Instrument. Odour and colour of water was measured through observations and comparisons. Bioindicators (visibility of macroinvertebrates) was measured using MINISASS on the sampled sites. For chemical analysis and quality, water samples collected on each sampling site during rainy and dry seasons was taken to laboratory at Greater Tzaneen Municipality for further testing.

Water samples were analyzed and re-analyzed three times to validate the results. To further ensure the validity of water quality data, quality assurance protocols, quality control, and standard methods were followed. This study followed similar standard protocols as Ji *et al*. (2022). Water samples were collected early in the morning to avoid an increase or decrease of water temperature caused by weather conditions. Water samples were received by authorised water scientists at the laboratory. The researcher avoided contamination by closing the plastic lids tightly after collection. In addition, the researcher abided by the health and safety measures of wearing gloves and mask during collection, handling and transportation to the laboratory as prescribed by the Department of Water and Sanitation (2023) and WHO (2022).

Figure 4: Water sample points at Ga-Selati River.

3.8. Validity and reliability of questionnaire.

A pilot study was conducted by selecting 30 participants among the residents in the study area. This study further used a similar approach as Malik *et al*. (2022) and Saari *et al*. (2023), a reliability test in SPSS was employed to analyze the reliability of questionnaires for the pilot study. Cronbach's Alpha analysis was utilized, as it was accurate to measure properties of a scale and items in a scale of Likert questionnaire and was commonly used in previous studies (Malik *et al*., 2022). Saari *et al*. (2023) a pilot test was conducted to examine item dependability in the questionnaire. The internal consistency of the pilot test was measured using Cronbach' Alpha analysis. The acceptable internal consistency of alpha = 0.70 was suggested as stated by Cronbach (1951). To obtain authentic and useful information for the study, the questionnaire was face validated and amended by waste management and water quality experts before the commencement of the actual data collection (Saari *et al*., 2023).

3.9. Ethical considerations.

This section elaborated more on the procedures to attain permission from the municipality, Department of health, and gatekeepers of the communities. Furthermore, ethical procedures and issues such as anonymity and confidentiality of participants were discussed below.

An approved ethical clearance certificate from UKZN Humanities and Social Sciences Research Ethics Committee (HSSREC) was obtained in this study with a protocol reference number: HSSREC/00006687/2024, and attached as appendix C. The researcher requested permission from the municipality (Appendix D), Department of Health (DoH) (Appendix E), and local tribal authorities (Appendix F) to undertake the research study. Participants were given informed consent forms before participating. These informed consent forms emphasized more on aspects of confidentiality, voluntarily and willingly participation as well as the purpose and procedures of the study. A sample of the informed consent is attached as Appendix G in English and Appendix H in Sepedi.

To ensure anonymity and confidentiality, no unique identifiers were captured. Data was analyzed as a group with no peculiar reference to individuals. To ensure no harm during participation, the researcher encouraged participants to ask questions when they did not understand any of the interview questions. This ensured that participants answered each interview question with relevant information.

3.10. Data analysis.

3.10.1. Questionnaire.

Statistical Package for Social Sciences (IBM SPSS Version 29.0) and Excel were used to analyze data collected through questionnaires. The data was coded, labelled, and defined in Excel and then exported to SPSS to generate frequency tables. These statistical tools were used to visually represent quantitative data using frequency and percentage tables. Therefore, the researcher was able to appropriately measure; generalise and report the findings of the study using numerical values obtained from SPSS and Excel.

T-test was used to compare the measured mean values and standard deviation of all variables in the questionnaire on confidence level ($p<0.05$). T-test was also used to determine whether the water samples of each point and season were different with a level of significance of 99% (Gangoo *et al*., 2023).

Probit regression was used to determine the level of community knowledge and awareness, attitude, and factors influencing environmental, health and social risks. Principal Component Analysis (PCA) was used to identify underlying constructs from the data while Probit regression was used to determine factors influencing the environmental, health and social risks. The perceived risks were operationalised as dichotomous variable. Knowledge and awareness were modelled as dichotomous variables, indicating whether individuals were aware or not aware, while attitude, as well as environmental, health, and social risks, were modelled as binary outcome variables, classified as high or low.

It was assumed that Y could be specified as follows:

$Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots + \beta_{ki} X_{ki} + U_1$ ………………………………………………1
And that:
$Y_i = 1$ if $Y > 0$ ………………………………………………2
$Y_i = 0$
Otherwise, Where $X_1, X_2 \ldots\ldots\ldots X_n$ represents a vector of random variables, β represents a vector of unknown parameters and U represents random disturbance terms.

Structural equation modelling (SEM) was applied to examine behavioural intentions; attitude; perception and practices as latent constructs in this study. Similarly, to Bourget (2023) and Akmal and Jamil (2021), Confirmatory Factor Analysis (CFA) were employed to test and measure the dimensions in all phases that concoct the latent variables in this research study and to also establish a satisfactory Measurement Model (MM). This analysis was conducted to examine unidimensionality of variable formation in this case it was attitude; perception; practices and behavioural intentions. CFA was used to test the validity and reliability of latent variables through carrying out the unidimensionality test on the endogenous and exogenous variables. Endogenous variables in this study were attitudes; perceptions and practices while the exogenous was the behavioural intention.

The Principal Components Analysis, as specified by Koutsoyiannis (1972), was presented as follows:
Given variables (X_s…original variables of the composite knowledge and awareness, attitude, perception, practices, and behavioural intention of waste disposal in water)
$X_1 \ldots X_p$ Measured in 'n' households.
$P_1 \ldots P_p$: the principal components which are uncorrelated linear combinations of the variables, $X_1 \ldots X_p$, given a$P_1 = \alpha_{11}X_1 + \alpha_{12}X_2 + \cdots + \alpha_{1p}X_p P_2 = \alpha_{21}X_1 + \alpha_{22}X_2 + \cdots +$ . .
.
. . . .
$P_p = \alpha_{p1}X_1 + \alpha_{p2}X_2 + \cdots + \alpha_{1pp}X_{pz}$……………………………………………… (1)
The component loadings were chosen on the condition that the principal components were not related, and that the first component would account for the maximum possible proportion of the total variation in the original variables.

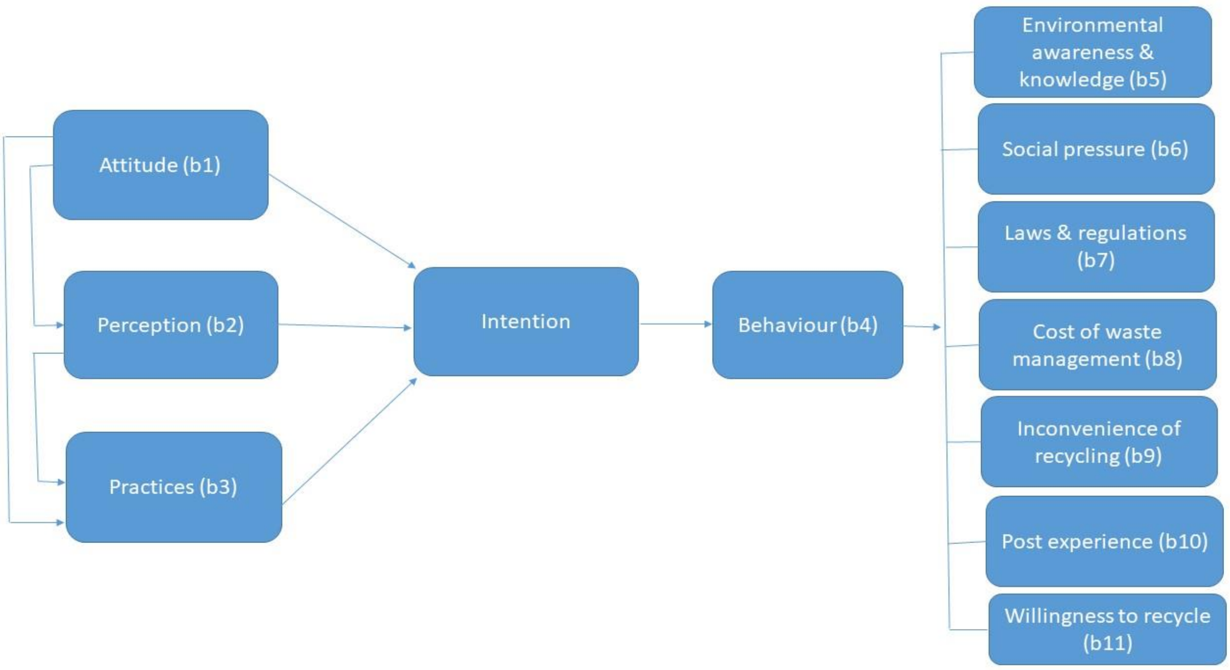

Figure 5: SEM model showing latent constructs of the study.

The following equations were used for the model analysis.

Regression model 1:

Outcome = Intention

Predictors = Attitude; perceptions; practices

(Inner set values relating to intention)

Intention = b01 + b1 (Attitude) + b2 (Perceptions) + b3 (Practices)

Regression model 2:

Outcome = Behaviour

Predictors = Intention

(Inner set values relating to behaviour)

Behaviour = b02 + b4 (Intention)

3.10.2. Water quality parameters.

3.10.2.1. Nitrates.

The mixing/ measuring cylinder was filled with 15 mL of sample water. Contents of one NitraVer 6 reagent powder pillow was added into a cylinder. The cylinder was closed, and a 3-minute reaction time was set and started. The cylinder was shaked vigorously for all the particles to dissolve. When the timer expired, another one was started again for a 2-minute reaction time. When the timer expired again, 10 mL of sample was poured into a sample cell. The cadmium particles were not transferred into the sample cell. The contents of one NitriVer 3 reagent powder pillow was added to a prepared sample cell. A 30 second reaction timer was started. The stopper was placed on the sample cell, the sample cell was shaked gently during the 30 second timer. A pink colour was visible and observed which showed the presence of nitrate in the sample. A 15-minute reaction time was started. When the timer expired, the blank was prepared by filling a second sample cell with 10 mL of the original sample. The blank sample cell was cleaned and inserted into the cell holder. Push zero option was selected and displayed 0.0 mg/L. The prepared sample cell was cleaned and placed into a cell holder. Push read option was selected and NO_3^- results were displayed. The readings of nitrates were recorded using HACH LICO 690.

3.10.2.2. Chemical Oxygen Demand (COD).

DRB200 and HACH LICO 690 instruments were used to analyze measurements of COD in all the samples. Homogenization time was increased as samples had large sediments of solids. The Homogenized samples were poured into a 250 mL beaker and gently mixed with a magnetic stir plate. The DRB200 reactor was powered on and preheated to 150ºC. The samples were prepared by removing the cap from a vial of the selected range. The vial was held at an angle of 45 degrees. A clean pipet was used to add 2.00 mL of the sample to the vial. The blank was prepared by removing the cap from a second vial of the selected range and the vial was held at an angle of 45 degrees. A clean pipet was used to add 2.00 mL of deionized water to the vial. The vials were closed tightly, rinsed, and wiped with a clean paper towel. The vials were held by the cap over a sink, inverted gently, and mixed several times. The vials were getting very hot during the mixing. The vials were placed and closed in a preheated DRB200 reactor. The vials were heated for 2 hours. The reactor was switched off and the vials were left to cool in the reactor for approximately 20 minutes to 120ºC or less. Each vial was inverted several times while it was still warm. The vials were placed in a tube rack to cool to room temperature before reading of results. The HACH LICO 690 was used to read the COD results.

3.10.2.3. Phosphorus pentoxide and Orthophosphate.

The blank was prepared by filling a sample cell with 10 mL of deionized water. The sample was prepared by filling the second sample cell with 10 mL of sampled water. Molybdovanadate reagent of 0.5 mL was added to each cell. All the samples were mixed. A 7-minute reaction time was started. The sample concentration was greater than 30 mg/L PO_4^{3-}, the results were read again at 7 minutes and the amount was still high. A dilution of 1:1 was made, and the test was repeated. When the timer expired, the blank cell was cleaned and inserted into a cell holder. Push zero option was selected and 0.0 mg/L was displayed as PO_4^{3-}. The prepared sample cell was cleaned and inserted into the cell holder. The push read option was selected, PO_4^{3-} and P_2O_5 were recorded using the HACH LICO 690.

3.10.2.4. Total Suspended Solids (TSS).

Each sample of 500 mL was blended with a blender at high speed for exactly two minutes. The blended sample was poured into a 600 mL beaker. The sample was mixed, and 10 mL of the blended sample was immediately poured into a sample cell. The blank was prepared by filling the sample cell with tap water. The blank sample cell was cleaned. The blank was then inserted into the cell holder. The display showed 0 mg/L TSS after push zero was selected. The sample cells were prepared to remove any gas and uniformly residue. The sample cell was cleaned and inserted into the cell holder again. Push read option was selected to show the results in mg/L TSS on the HACH LICO 690. Another method was used to ensure the accuracy of the results. A 934-AH RTU filter papers were weighed before filtrating sampled water. Filtration was conducted with a filter paper. The trapped sediments were left to dry in the laboratory oven for 30 minutes. After drying, the filter papers were weighed and the mass of TSS were calculated.

3.10.2.5. Turbidity.

The HACH 2100Q instrument was calibrated and verified for the 3-point calibration before testing the samples. The instrument was set on a reading mode of rapidly settling. The water sample was filled into the cell till the orientation mark. The sample cell was shaked well for 10 seconds to avoid any of the sedimentation settling at the bottom. The sample cell was held by the cap, wiped, cleaned, and dried before testing the results to avoid any drops or fingerprints that could interfere with the reading. The orientation mark on the test tube was aligned with the alignment arrow on the HACH

2100Q. The sample cell holder was closed securely before taking the readings. The right key (read) was selected to view the results.

3.10.2.6. Electrical conductivity (EC), Dissolved Oxygen (DO) and pH.

The HQ40d instrument was used to measure electrical conductivity, dissolved oxygen, and pH. Calibration was conducted before sample testing. The distilled solution was used to clean the probes before the testing. Samples were filled in beakers and the probe was placed inside. Readings were taken and the probe was distilled before testing another sample.

3.10.2.7. Water temperature.

Water temperatures were taken using the Hanna Probe Instrument. The instrument was conditioned in a pre-treatment oxidize solution for 30 minutes before testing the results. The instrument was set down in a beaker while gently stirring. The set/hold button was used to freeze the reading. The instrument was rinsed before taking the next measurement.

3.11. Limitation of the study.

Acess was denied in some households as they were not welcoming and interested in participating. The researcher had to move to the next household. Systematic sampling technique was time consuming as the researcher had to use a pre-defined pattern. Large sample size made data collection more costly in terms of transportation across all the four villages. Respondents were limited to choose from the given responses in the questionnaire. In addition, some respondents provided inaccurate responses, and their responses were discarded.

3.12. Conclusion.

This chapter presented a brief overview of research methodology, and analytical procedures applied in the study. The next chapter outlines the research findings and discussion in relation to the objectives of the study.

CHAPTER FOUR: RESULTS AND DISCUSSIONS.

4.1. Introduction.

This chapter presents results of households' questionnaires administered and water quality assessment for upper, middle, and lower streams. The results are reported in ten sections. The first section presents socio-economic characteristics; municipal waste management services and system; type of waste and method of disposal. The second section presents households' level of knowledge and awareness on waste disposal in water. The third section presents households' attitude, perceptions, and practices on waste disposal in water. The fourth section presents perceived environmental, health and social risks. The fifth section presents households' behavioural intention on waste disposal in water. The sixth section presents water quality assessment on DO; pH; turbidity; TSS; nitrates; phosphorus; EC; water temperature and COD. The seventh section presents MiniSASS assessments on bioindicators. Furthermore, the eighth section presents Principal Component Analysis (PCA). The ninth section presents probit regression analysis. As a final point, the tenth section presents comparison of households' perception on risks associated with waste disposal in water and analysis of water quality assessment.

4.2. Socio-economic characteristics.

Table 4.1 shows the results on socio-economic characteristics of respondents which include gender; age; education level; employment status and income level. The majority (66.6%) of respondents were females while (33.4%) were males. This might be due to men leaving behind their wives and migrating to urban areas for job opportunities and better income. This agrees with the municipal gender distribution as reported by StatsSA (2011) that there are more females (51.5%) than males (48.5%) in Ba-Phalaborwa Local Municipality. The Integrated Development Plan (IDP) of (2024-2025) also suggests that female residents are more than males. The results also conform to Viljoen *et al*. (2021); Manga *et al*. (2021); Fikadu *et al*. (2022); Senekane (2024) and Ayeleru *et al*. (2023) that majority of respondents in Ba-Phalaborwa Local Municipality or where were females than males.

The study had most respondents (48.3%) in the 18-34 age group, while respondents that are 65 years or older were the least (16.2%). These findings are consistent with Fadhullah *et al*. (2022) and, Dlamini & Zikhali (2024) as majority of the respondents were between the age of 18-35 while those that are 50 years and above were less. In terms of educational level, most (52.5%) of the respondents obtained secondary education while 1.8% had tertiary qualifications. This could be an indication that most residents within the sampled villages are less educated in Ba-Phalaborwa Local Municipality, and it may be a significant factor that influences waste disposal behavior in water. Akmal & Jamil (2023); Sekgobela & Semenya (2023) and Akeju & Omotoso (2023) have reported similar findings that most of the respondents had secondary education as their highest qualification.

On the employment status of respondents, the majority (62.9%) were unemployed whereas (2.9%) were students. Haywood *et al*. (2021) and Kala *et al*. (2020) corroborate with the findings by reporting that unemployed households were greater than 90%. In contrast, Chikowore (2020) revealed that most respondents were self-employed. The majority (64.2%) of respondents had no monthly income while (1.3%) earned between R10 000 and R20 000. This may be because participants are situated in low-income residential. The findings are in agreement with Ngalo & Thondhlana (2023); Kalonde *et al*. (2023) and Kamuzora (2024) as most of respondents were unemployed and depended on pensions; social welfare grants and businesses such as crop and livestock farming.

Table 4.1: Demographic information.

Variables	Options	Frequency	Percentages	Mean	Standard deviation
Gender	Male	128	33.4	1.33	0.472
	Female	255	66.6		
Age	18 – 34 years	185	48.3	2.68	0.737
	35 – 64 years	136	35.5		
	65 years or older	62	16.2		
Education level	Primary school	102	26.6	1.37	0.808
	Secondary school	201	52.5		
	Tertiary qualification	7	1.8		
	None	73	19.1		
Employment status	Unemployed	241	62.9	2.15	1.785
	Working full time	31	8.1		
	Working part time	25	6.5		
	Contract worker	29	7.6		
	Entrepreneur	24	6.3		
	Retired	22	5.7		
	Student	11	2.9		
Income level	Less than 5000	109	28.5	0.49	0.828

	5000 – 10 000	14	3.7		
	10 000 – 20 000	5	1.3		
	More than 20 000	9	2.3		
	None	246	64.2		

4.3. Municipal waste management services and system.

The majority (89.0%) of respondents revealed that they are currently not paying for waste disposal services whereas 2.1% indicated that they are paying less than R100 monthly. This could be that households are not prepared to pay for waste disposal services due to lack of finances and unemployment. The inability to pay for waste disposal services may be due to the high level of poverty and the satisfactory level of the current waste collection services in their localities. It may also be difficult for households to pay for municipal waste management services and concurrently cater for their households' needs and living expenses based on their deficiencies of high unemployment rates, meager income, and educational background. Omotayo *et al*. (2023) also observed that households in Limpopo Province had a low percentage (8.85%) of paying waste disposal services. Bowan and Ziblim (2020) also revealed that majority of respondents were not paying for waste collection services. The findings also concur with Niyobuhungiro and Schenck (2022) that one of main factors of illegal dumping cited by communities was unemployment. This led to households developing apathetic attitude on waste disposal payment and its potential to results in improper dumping of waste in water. Therefore, there is an association of unemployment and apathetic attitude which is led by poverty.

Most (83.8%) of the respondents revealed that the municipality never collect their waste while (5.0%) of respondents attested that their waste is collected once a week. This may be that the municipality does not extend its waste services to rural areas; the collection time might be uncertain or different households in the same residential area receive discrete municipal collection services. The minority of respondents (5.0%) serviced once a week could be residing along the main road or close to public facilities such as schools and clinics. According to Rodseth *et al*. (2020), waste management services decreased by 13% in rural areas. The findings agrees with Rodseth *et al*. (2023) and Noman *et al*. (2023) that most respondents were unserviced and unmanaged in terms of municipal waste collection services and less than 10% of households were serviced once a week. However, the findings disagree with Taye *et al*. (2024) as municipal waste collection services had the highest level on open spaces;

door-to-door and the nearby containers.

The majority (96.9%) of respondents were not satisfied with the current municipal waste removal system whereas 0.5% were very satisfied. This may be because of the absence of waste collection services; inadequacy of waste disposal facilities; poor quality level on the competence and dedication of waste management personnel; low level of public participation in waste management and lack of support from the municipality. The findings also agree with Ikiriko *et al*. (2023) and Dlamini *et al*. (2021) who opined that lack of municipal waste collection services; institutional capacity; knowledge and awareness; and waste disposal infrastructures were the major factors influencing the satisfactory level of households.

Table 4.2: Waste disposal services.

Variables	Options	Frequency	Percentages	Mean	Standard deviation
Waste disposal payment	Less than R100	8	2.1	0.28	0.886
	R100 – R200	12	3.1		
	R200 – R300	11	2.9		
	More than R300	11	2.9		
	None	341	89.0		
Municipal collection	Irregularly	43	11.2	0.21	0.516
	Once in a week	19	5.0		
	Never	321	83.8		
Satisfactory level	Good	8	2.1	1.05	0.295
	Very good	2	0.5		
	Excellent	2	0.5		
	Not satisfied	371	96.9		

4.4. Types of waste.

Data collected revealed that almost 99.0% of the respondents generate waste. This could include greater quantities of plastics; paper; glass bottles; tins and diapers. These findings support the results of Yoada *et al*. (2022); Dladla *et al*. (2021) and Kombiok & Jaaga (2022) as majority of households generated plastic waste and led to poor performance on plastic waste practices. The other common type of waste generated often was biodegradable waste (86.2%). This may be because respondents generate food waste daily. Based on the findings, Fadhullah *et al*. (2022); Bhatia & Sharma (2023); Tsheleza *et al*. (2019) and Omokaro *et al*. (2024) have shown similar results that the common type of waste disposed was biodegradable waste in the form of food waste. This could be due to lack of knowledge on proper handling; storage and recycling which could result in unmanaged and untreated food waste. According to Tsheleza *et al*. (2019), biodegradable waste produces alkaline and acidic pollutants which cause severe contamination of surface and groundwater.

About (71.8%) of respondents were not generating hazardous waste. This could be due to lower income households generate less hazardous waste than higher income households because of their lifestyle and economic factors. The findings concur with Laili *et al*. (2021) that hazardous waste was dominated in urban areas than rural areas and most rural areas generate small quantities of products that include hazardous ingredients such as cleaning products; pesticides; oils and paints. In addition, the findings further reveal that the most dominating hazardous waste was electronic waste (91.6%) such as batteries, phones, and microwaves. The findings concur with Slekiene *et al*. (2024) and Senekane (2024). Over (88%) of respondents were generating agricultural waste. This may be due to most households practicing crop and livestock farming in rural areas. Sarker *et al*. (2024); Devianti *et al*. (2021) and Kokoeva *et al*. (2023) also found that more than 50% of the households generated agricultural waste and were aware that organic fertilisers can be prepared and reused from waste to green fertilisers or as compost. Furthermore, the minority (47.3%) of respondents were generating chemical waste. This could be agricultural chemical products such as pesticides. The findings conform to Sudoma *et al*. (2022) and Kumar *et al*. (2024) that less households in rural areas generate chemical waste from pesticides.

Table 4.3: Categories of waste.

Types	Yes F (%)	No F (%)	Mean	Standard deviation
Biodegradable waste	330(86.2)	53(13.8)	1.86	0.346
Hazardous waste	108(28.2)	275(71.8)	1.28	0.451
Household hazardous waste	249(65.0)	134(35.0)	1.65	0.478
Construction waste	280(73.1)	103(26.9)	1.73	0.444
Chemical waste	181(47.3)	202(52.7)	1.47	0.500
Electronic waste	351(91.6)	32(8.4)	1.92	0.277
Agricultural waste	335(87.5)	48(12.5)	1.87	0.332
Garden waste	370(96.6)	13(3.4)	1.97	0.181
General waste	379(99.0)	4(1.0)	1.99	0.102

4.5. Methods of disposal.

The majority (77.0%) of respondents disposed their waste in water bodies. This may be due to lack of waste collection services and absence of skip bins or storage containers. Storage bins may be inadequate and not strategically stationed. For instance, one storage bin had to cater the whole village whereas it was not positioned at the center. Another factor could be the municipality does not provide residents with disposable plastic bags. Due to high unemployment rates, households may find it difficult to purchase disposable plastic bags. As a results, households may be mandated to resort to their own way of disposing waste. These findings are line with Jakeni *et al*. (2024); Grangxabe *et al*. (2023); Saad *et al*. (2024) and Zondi *et al*. (2023) who found that lack of waste collection services led to a decline in water quality.

More than half (57.7%) of respondents were burning their waste. This may be because household perceive burning of waste as a convenient and easy method to manage waste which is cost-effective and less time consuming. The findings also agree with Firouzkouhi *et al*. (2021); Eshete *et al*. (2023); Dlamini & Zikhali (2024); Ramadan *et al*. (2022) and Smith (2020) as most households practiced open burning as a common method to control waste. According to Pathak *et al*. (2023) and Ramandan *et al*. (2023) found environmental and emission risks related to burning of waste. Open burning resulted in harmful quantities of emissions which led to adverse health risks among residents.

Most (96.3%) of the respondents were not disposing their waste in a designated landfill site. This may be due to the residential proximity, lack of access to the landfill site and experience in municipal waste collection. The findings concur with Bedane (2024) as the majority of residents were not disposing their waste in lawful landfill sites. However, the findings contrast with Tomita *et al*. (2020) as respondents were residing within 5km of close proximity to the landfill site and disposing their waste in a lawful manner but had experienced health risks such as asthma and tuberculosis. The majority (89.3%) of respondents were not using their waste to generate biogas energy. This could be that respondents perceive only human wastes could be used for biogas energy production which led to lack of knowledge and awareness on the type of waste biogas digesters use, and on the biogas technology as a safe bioenergy resource and the development of cultural beliefs as it is considered a taboo to use human wastes. Other factors might include installation and maintenance costs. The findings concur with Uhunamure *et al*. (2020) most of the households were not aware of biogas technology and had no biogas digesters due to financial constraints; lack of knowledge and awareness programmes, assistance and technical availability. Rasimphi *et al*. (2024); Namirembe *et al*. (2024) and Sibanda & Uzabakiriho (2024) also observed similar findings that households were not using their crop residues; food and animal waste to convert them into biogas generation. This could reduce poverty as rural areas have sufficient resources due to crop and animal farming. All the other methods of disposal are depicted in Table 4.4.

Table 4.4: Waste disposal approaches.

Methods	Yes F (%)	No F (%)	Mean	Standard deviation
Landfill	14(3.7)	369(96.3)	1.04	0.188
Incineration	221(57.7)	162(42.3)	1.58	0.495
Waste compaction	105(27.4)	278(72.6)	1.27	0.447
Biogas generation	41(10.7)	342(89.3)	1.11	0.310
Composting	116(30.3)	267(69.7)	1.30	0.460
Vermicomposting	97(25.3)	286(74.7)	1.25	0.435
Waste disposal in water in bodies	295(77.0)	88(23.0)	1.77	0.421
Waste disposal in open spaces	271(70.8)	112(29.2)	1.71	0.455
Skip bin	197(51.4)	186(48.6)	1.51	0.500

4.6. Households' level of Knowledge and awareness on waste disposal in water.

Table 4.5 presents the results of the level of knowledge and awareness on waste disposal in water using 26 items descriptors. The prominent items that respondents are knowledgeable and aware of include understanding the meaning of household waste (86%), Accumulation of waste disposal in rivers cause health risks (86%), Waste should not be disposed in water (70%), and Any type of waste can be recyclable (85%). This may be due to the interventions of Non-Governmental Organisations that are engaging in waste collection and the introduction of "waste to wealth" programs. These findings agree with Thakur & Nel (2021); Kotze (2020) and Pal *et al.* (2023) Non-Governmental Environmental Organisations positively improved households' knowledge, and recycling practices and perceptions in rural areas. Moreover, these findings also agree with Tang *et al.* (2022) households had relevant environmental knowledge on household waste. But disagree with Mensah (2021) households had a narrow perspective and inadequate knowledge on the types and categories of waste.

Conversely, the majority of the respondents were not knowledgeable nor aware of the public support from the municipality and government in the form of awareness campaigns (94%), The municipality and government raise public environmental awareness on the impacts of waste in water (96%), Regular supervision and control on illegal dumping of waste in water is conducted (96%), and the municipality collects waste regularly (98%). This may be due to the fact that there have been no intensive campaigns and education nor regular and effective service delivery in the area of waste collection and recycling. Most respondents were in favour and support of this statement and the findings agree with numerous studies of Roos *et al*. (2022); Kala *et al*. (2020); Adekola *et al*. (2021); Debrah *et al*. (2021); Smith (2020); Viljoen *et al*. (2021) and Flores (2021) lack of public environmental awareness and education pose a hurdle in households' understanding on proper waste disposal practices and waste management issues. As a result, lack of support from the municipality and government contributes and encourages residents to practice poor waste disposal. In terms of regular supervision and control, this may be because households never recognized a municipal or government personnel supervising or controlling the state of illegal dumping of waste in water. In addition, poor supervision may result from inefficient waste management, weak enforcement of municipal by laws, and insufficient local government responsibilities in waste management. The findings agree with Lissah *et al*. (2021) and Jewaskiewitz (2021) the municipal and government personnel have low sense of accountability and responsibility towards waste management. As well, the absence of municipal waste removal services compels residents to resort their own mode of waste disposal. The findings concur with Jakeni *et al*. (2024); Thakur & Onwubu (2024); Huber (2024); Mmereki *et al*. (2024) and Lemanski (2024).

Table 4.5: Level of community knowledge and awareness of waste disposal in water.

Waste and disposal	Aware F (%)	Not aware F (%)	Mean	Standard deviation
I know and understand the definition of waste.	264(68.9)	119(31.1)	1.69	0.463
I know types and categories of waste.	279(72.8)	104(27.2)	1.73	0.445
I understand the meaning of household waste.	328(85.6)	55(14.4)	1.86	0.351
Any type of waste should be disposed in designated areas to avoid potential risks.	286(74.7)	97(25.3)	1.75	0.435
There is adequate landfill site in town.	120(31.3)	263(68.7)	1.31	0.464
Proper waste disposal is the responsibility of everyone.	315(82.2)	68(17.8)	1.82	0.383
Proper disposal of waste creates a healthy environment.	309(80.7)	74(19.3)	1.81	0.395
Waste disposal in water is a burning issue in this town.	259(67.6)	124(32.4)	1.68	0.469
Waste disposal in water is needs immediate attention.	276(72.1)	107(27.9)	1.72	0.449
Waste is the source of water pollution.	269(70.2)	114(29.8)	1.70	0.458
Improper dumping of wastes can eventually lead to pollution of rivers, lakes and wells.	305(79.6)	78(20.4)	1.80	0.403

Accumulation of waste disposal in rivers cause health risks.	330(86.2)	53(13.8)	1.86	0.346
Waste should not be disposed in water.	267(69.7)	116(30.3)	1.70	0.460
Any type of waste can be recyclable.	327(85.4)	56(14.6)	1.85	0.354
I consider waste as wealth.	270(70.5)	113(29.5)	1.70	0.457
Waste is anything without value.	276(72.1)	107(27.9)	1.72	0.449
Selling plastic and bottle waste for recycling is the best way to manage solid wastes.	317(82.8)	66(17.2)	1.83	0.378
Waste can be sorted and sold to recycling companies.	300(78.3)	83(21.7)	1.78	0.413
Organic fertilisers and compost can be prepared from waste.	241(62.9)	142(37.1)	1.63	0.484
Food waste can be reduced in water bodies by generating biogas for fuel.	165(43.1)	218(56.9)	1.43	0.496
The amount of household waste can be reduced by reusing at a household level.	236(61.6)	147(38.4)	1.62	0.487
Solid waste management can be achieved by sorting waste at a household level.	230(60.1)	153(39.9)	1.60	0.490
There is public support from the municipality and government in a form of awareness campaigns.	23(6.0)	360(94.0)	1.06	0.238
The municipality and government raise public environmental awareness on the impacts of waste in water.	17(4.4)	366(95.6)	1.04	0.206
Regular supervision and control on illegal dumping of waste in water is conducted.	14(3.7)	369(96.3)	1.04	0.188
The municipality collect waste regularly.	8(2.1)	375(97.9)	1.02	0.143

4.7. Households' attitude, perceptions and practices on waste disposal in water.

Table 4.6 presents the results of attitudes, perceptions, and practices on waste disposal in water using 25 items descriptors. The prominent items that respondents had positive attitude are Disposing waste in water bodies creates jobs for municipal workers or EPWP (74%), Lack of waste collection services causes people to dispose of waste in water (76%), Unavailability of bins causes people to dispose of waste in water (79%), It is the government and municipal's duty to clean up the illegally dumped waste in water (76%), Disposing waste in water because the municipality does not care (71%) and Disposing waste in water is cheaper than buying refuse bags to dispose in designated areas (70%). This may be due to respondents perceive waste management issues as their own burden as the municipality shows little to no interest on proper waste disposal in rural areas. Hence, respondents perceive improper waste disposal in water as job creation and a sole responsibility on the municipality. These findings concur with Nuzrath & Ruzaik (2023) residents believed that proper waste disposal was the responsibility of the municipality and went to an extend of not showing any interest in waste management but disagrees with Eshete *et al*. (2023) respondents perceived proper waste disposal as a responsibility of everyone. Niyobuhungiro & Schenck (2022) and Kalonde *et al*. (2023) also agree with the findings as respondents had an attitude of improper waste disposal creates jobs for others.

Conversely, the majority of the respondents had a negative attitude on Willing to pay for waste collection services (70%), Willing to travel to the landfill site to dispose waste (72%), Willing to place waste garbage in a nearby area where municipality provide or extend their services (69%) and currently sorting waste for disposal (59%). This negative attitude could be significantly influenced by gender; age; education level; income level; employment status; the frequency and satisfaction of waste collection services; mode of disposal; distance to disposal facilities and the quantity of waste. Opoku *et al*. (2024); Manga *et al*. (2019); Viljoen *et al*. (2021) and Haywood *et al*. (2021) found similar results as the socio-economic factors negatively influenced the relationship and general agreement between households and their participation in improving environmental quality.

Table 4.6: Community attitudes, perceptions and practices on waste disposal in water.

Attitude and perceptions statements	**SA** **F (%)**	**A** **F (%)**	**U** **F (%)**	**D** **F (%)**	**SD** **F (%)**	**Mean**	**Standard deviation**
Any type of waste can be disposed in water bodies.	228(59.5)	49(12.8)	26(6.8)	24(6.3)	56(14.6)	3.96	1.495
Unavailability of bins causes people to dispose of waste in water.	303(79.1)	50(13.1)	13(3.4)	5(1.3)	12(3.1)	4.64	0.869
Lack of waste collection services causes people to dispose of waste in water.	290(75.7)	62(16.2)	9(2.3)	7(1.8)	15(3.9)	4.58	0.934

I will continue to dispose waste in water, If the municipality does not collect waste.	193(50.4)	47(12.3)	65(17.0)	35(9.1)	43(11.2)	3.81	1.421
Disposing waste in water is a good method of disposal.	201(52.5)	66(17.2)	42(11.0)	24(6.3)	50(13.1)	3.90	1.434
I get influenced by people disposing of waste in water.	211(55.1)	59(15.4)	33(8.6)	31(8.1)	49(12.8)	3.92	1.453
Disposing waste in water is cheaper than buying refuse bags to dispose in designated areas.	269(70.2)	62(16.2)	20(5.2)	14(3.7)	18(4.7)	4.44	1.066
Disposing waste in water because the municipality does not care.	270(70.5)	57(14.9)	19(5.0)	17(4.4)	20(5.2)	4.41	1.112
Disposing waste in water bodies creates jobs for municipal workers or EPWP.	283(73.9)	67(17.5)	14(3.7)	8(2.1)	11(2.9)	4.57	0.889
It is the government and municipal's duty to clean up the illegally dumped waste in water.	292(76.2)	38(9.9)	13(3.4)	15(3.9)	25(6.5)	4.45	1.157
Disposing waste in water bodies saves the community from an unclean environment.	178(46.5)	64(16.7)	69(18.0)	38(9.9)	34(8.9)	3.82	1.346
Disposing of waste in water bodies is a serious threat to the environment, human and other living organisms.	259(67.6)	62(16.2)	23(6.0)	15(3.9)	24(6.3)	4.35	1.157
Water sources should be converted into a dumping ground.	186(48.6)	70(18.3)	50(13.1)	30(7.8)	47(12.3)	3.83	1.418
Enforcement of fines and rules will reduce waste disposal in water bodies.	213(55.6)	51(13.3)	48(12.5)	31(8.1)	40(10.4)	3.96	1.396

Signage boards of illegal dumping in water convey meaningful message.	181(47.3)	83(21.7)	53(13.8)	21(5.5)	45(11.7)	3.87	1.370
Willing to recycle, reduce and reuse household waste.	144(37.6)	74(19.3)	43(11.2)	39(10.2)	83(21.7)	3.41	1.582
Interested in waste reduction and minimisation.	150(39.2)	69(18.0)	31(8.1)	34(8.9)	99(25.8)	3.36	1.658
Interested in composting household waste.	126(32.9)	76(19.8)	43(11.2)	42(11.0)	96(25.1)	3.25	1.604
Interested in waste segregation or separation at source.	109(28.5)	68(17.8)	40(10.4)	44(11.5)	122(31.9)	2.99	1.647
Currently sorting waste for disposal.	42(11.0)	46(12.0)	23(6.0)	45(11.7)	227(59.3)	2.04	1.458
Willing to pay for waste collection services.	21(5.5)	26(6.8)	38(9.9)	30(7.8)	268(70.0)	1.70	1.216
Willing to place waste garbage in a nearby area where municipality provide or extend their services.	30(7.8)	34(8.9)	31(8.1)	24(6.3)	264(68.9)	1.80	1.340
Willing to travel to the landfill site to dispose waste.	12(3.1)	32(8.4)	26(6.8)	36(9.4)	277(72.3)	1.61	1.120
As a resident, I have social responsibility to dispose my wastes properly.	176(46.0)	107(27.9)	48(12.5)	28(7.3)	24(6.3)	4.00	1.202
Willing to participate in awareness campaigns and transfer the gained knowledge to family members and acquaintances.	140(36.6)	78(20.4)	69(18.0)	39(10.2)	57(14.9)	3.54	1.443

4.8. Perceived environmental, health and social risks.

Table 4.7 presents the results of the perceived environmental, health and social risks on waste disposal in water using 57 items descriptors. The prominent environmental items that the majority of the respondents perceived are Aquatic organisms cannot survive with less dissolved oxygen (73%), The increased levels of nitrates and phosphates endangers the surrounding plants and animals (66%), Excessive nitrogen and phosphorus lead to the high accumulation of algae (63%), Disposal of heavy materials and waste leads to high turbidity, cloudy or unclear surface water (62%) and High levels of nitrates and phosphates leads to the contamination of food chain in the ecosystem (63%). This may be because of households' environmental consciousness but with lack of environmental education as they might be concerned about the environmental impacts of waste, yet still engage in poor waste disposal practices. The results also conform to Thakur & Onwubu and Adeniran *et al*. (2023) who asserted that respondents were knowledgeable about the potential impacts and risks of improper waste disposal, but malpractices were still evident in water bodies; gullies and along the roadsides.

The prominent health items that the majority of the respondents perceived are High levels of turbidity leads to gastrointestinal illness, diarrhoea, nausea, stomach cramps and headaches (90%), Using water with low dissolved oxygen levels in water cause cardiovascular diseases (88%), Using untreated water with high Chemical Oxygen Demand (COD) leads to cancer-related diseases (93%), Drinking water with less dissolved oxygen leads to bladder cancer and reproductive problems (91%), Low levels of nitrates in water leads to colorectal cancer (92%) and Excessive flies and mosquitoes due to high water temperatures in polluted water leads to malaria (88%). This could be that households are aware of the health risks because they could have been exposed to or experienced water-borne diseases in their lifetime or that of their family members. Furthermore, this may be because of water shortages influences households to collect water in a polluted river; children play in polluted stagnant water while others cross the polluted river on their way to school. Ouattara *et al*. (2023); Omang *et al*. (2021); Siddiqua *et al*. (2022) and Perkumiene *et al*. (2023) also reported similar findings that lack of access to piped water and improper dumping of waste in water led to an increased risk in water-borne diseases. Tomita *et al*. (2020) also observed that households were exposed to health risks over time.

The most occurring social items that the majority of the respondents perceived include Children drown in a polluted river due to poor turbidity (76%), Hindrance of water sports and recreation activities in the water such as fishing, swimming and boating (71%), Waste in water leads to the surrounding community experiencing a foul smell (64%) and Low pH in water causes a sour and soapy taste leads people to dislike their residential area (57%). This may be due to households residing near polluted water are exposed to social risks as they might find be challenging living there. The findings concur with Fadhullah *et al*. (2022); Ramodipa *et al*. (2023); Zondi *et al*. (2023) and Gqomfa *et al*. (2022) most of the households residing close to a polluted river complained about a foul odour in a river; hindrance of recreational activities and a potential social risk of destructing settlements, construction and human lives.

Table 4.7: Perceived risks associated with waste disposal in water.

Risks of wastes in water	Environmental F (%)	Health F (%)	Social F (%)	Mean	Standard deviation
Aquatic organisms cannot survive with less dissolved oxygen.	279(72.8)	84(21.9)	20(5.2)	1.32	0.569
Less dissolved oxygen leads to the death and decomposition of aquatic plants and animals.	261(68.1)	106(27.7)	16(4.2)	1.36	0.561
Waste disposed decreases the amount of dissolved oxygen.	240(62.7)	112(29.2)	31(8.1)	1.45	0.641
Excessive algae growth decreases the amount of dissolved oxygen.	225(58.7)	115(30.0)	43(11.2)	1.52	0.689
Low concentrations of dissolved oxygen affect photosynthesis, respiration, aeration, decomposition and diffusion.	259(67.6)	106(27.7)	18(4.7)	1.37	0.573
Decomposition of aquatic species leads to the release of nutrients in water such as carbon and nitrogen.	246(64.2)	103(26.9)	34(8.9)	1.45	0.653

Polluted water contain toxic compounds (nitrates and phosphates) that affect aquatic animals and life.	218(56.9)	131(34.2)	34(8.9)	1.52	0.654
The increased levels of nitrates and phosphates endangers the surrounding plants and animals.	252(65.8)	84(21.9)	47(12.3)	1.46	0.704
Disposal of heavy materials and waste leads to high turbidity, cloudy and unclear surface water.	236(61.6)	99(25.8)	48(12.5)	1.51	0.708
High turbidity reduces the dispersion of sunlight for aquatic ecosystem.	204(53.3)	109(28.5)	70(18.3)	1.65	0.771
High levels of turbidity leads to gastrointestinal illness, diarrhoea, nausea, stomach cramps and headaches.	22(5.7)	344(89.8)	17(4.4)	1.99	0.319
High levels of Electrical Conductivity leads to the risk of dehydration.	24(6.3)	339(88.5)	20(5.2)	1.99	0.339
Disposal of waste increases water temperatures.	237(61.9)	88(23.0)	58(15.1)	1.53	0.744
Excessive nitrogen and phosphorus leads to the high accumulation of algae.	242(63.2)	102(26.6)	39(10.2)	1.47	0.674
High levels of nitrates and phosphates depletes food resources.	219(57.2)	108(28.2)	56(14.6)	1.57	0. 734
High levels of nitrates and phosphates decreases oxygen for aquatic life.	233(60.8)	107(27.9)	43(11.2)	1.50	0.690
Nitrates and phosphates leach into the ground and contaminate of groundwater.	196(51.2)	88(23.0)	99(25.8)	1.75	0.841
High turbidity increases the risk of flooding and alters proper water flow.	222(58.0)	78(20.4)	83(21.7)	1.64	0.816
Dissolved oxygen decreases due to high levels of pollutants in water.	221(57.7)	111(29.0)	51(13.3)	1.56	0.717
High levels of nitrates and phosphates leads to the contamination of food chain in the ecosystem.	242(63.2)	91(23.8)	50(13.1)	1.50	0.716

High levels of nitrates and phosphates reduce organism's life span and ability to reproduce.	216(56.4)	108(28.2)	59(15.4)	1.59	0.743
Poor water quality due to waste disposal is associated with high nitrates and phosphates levels.	209(54.6)	120(31.3)	54(14.1)	1.60	0.724
Waste disposal in water alters the physical characteristics of water such as pH, temperature, flow rate and turbidity.	249(65.0)	90(23.5)	44(11.5)	1.46	0.693
Low pH levels leads to a decrease in reproduction, growth and eventually death of aquatic species.	199(52.0)	128(33.4)	56(14.6)	1.63	0.726
Low pH levels leads to a reduced biological diversity in water.	186(48.6)	137(35.8)	60(15.7)	1.67	0.732
Low pH levels damages the gills and skin of aquatic animals.	173(45.2)	151(39.4)	59(15.4)	1.70	0.720
Waste disposal decreases the amount of bioindicators (macroinvertebrates).	216(56.4)	101(26.4)	66(17.2)	1.61	0.764
Waste contain high levels of nitrates and phosphates that affects the quality of water and hinder reused.	172(44.9)	56(14.6)	155(40.5)	1.96	0.924
Growth of algae bloom and plants leads to highly coloured water.	160(41.8)	69(18.0)	154(40.2)	1.98	0.907
Low pH levels put pressure on accessibility of water.	127(33.2)	68(17.8)	188(49.1)	2.16	0.894
Using water with low dissolved oxygen levels in water cause cardiovascular diseases.	35(9.1)	337(88.0)	11(2.9)	1.94	0.341
High water temperatures increase the effects of climate change.	197(51.4)	147(38.4)	39(10.2)	1.59	0.669
Waste disposal in water affect the overall health and cause diseases associated with polluted water.	32(8.4)	344(89.8)	7(1.8)	1.93	0.313

Waste disposal in water bodies leads to water-borne disease such as Cholera, Giardia, typhoid, bilharzia and malaria etc.	17(4.4)	356(93.0)	10(2.6)	1.98	0.265
Low levels of nitrates in water leads to colorectal cancer.	19(5.0)	353(92.2)	11(2.9)	1.98	0.279
Drinking water with high levels of nitrates leads to excess heart rate, weakness, fatigue, or dizziness.	15(3.9)	358(93.5)	10(2.6)	1.99	0.255
Drinking water with high levels of nitrates turns the skin grey or blueish in colour.	27(7.0)	350(91.4)	6(1.6)	1.95	0.289
Excessive amount of nitrates leads to methemoglonaemia or baby blue syndrome in children.	13(3.4)	357(93.2)	13(3.4)	2.00	0.261
Drinking water with less dissolved oxygen leads to bladder cancer and reproductive problems.	19(5.0)	350(91.4)	14(3.7)	1.99	0.294
Excessive flies and mosquitoes due to high water temperatures in polluted water leads to malaria.	26(6.8)	338(88.3)	19(5.0)	1.98	0.343
High levels of phosphorus lead to increased risk of stroke, heart attack or death.	30(7.8)	346(90.3)	7(1.8)	1.94	0.305
High levels of phosphorus lead to hyperthyroidism, vomiting, diarrhoea and reduction in bone strength.	17(4.4)	356(93.0)	10(2.6)	1.98	0.265
Water contaminated with waste; pesticides; chemicals; bacteria/faecal run-off affects human health.	23(6.0)	340(88.8)	20(5.2)	1.99	0.335
Water pollution of waste dumping affects human health through long-term and short-term effects.	25(6.5)	342(89.3)	16(4.2)	1.98	0.327
Using untreated water with high Chemical Oxygen Demand (COD) leads to cancer-related diseases.	20(5.2)	357(93.2)	6(1.6)	1.96	0.258
Children under five die each year due to diarrhoeal diseases related to high levels of phosphorus.	18(4.7)	350(91.4)	15(3.9)	1.99	0.294

High levels of total suspended solids cause gastrointestinal problems or even lead to death.	17(4.4)	351(91.6)	15(3.9)	1.99	0.289
A high pH level causes the skin to become irritated, dry or itchy and severe mucous membrane.	21(5.5)	346(90.3)	16(4.2)	1.99	0.311
Low levels of dissolved oxygen lead to bad odour, loss of appetite, headache, nose, and throat irritation.	19(5.0)	349(91.1)	15(3.9)	1.99	0.298
High levels of nitrates and phosphates leads to an increase in water cost for abstraction and treatment.	139(36.3)	114(29.8)	130(33.9)	1.98	0.839
Low pH in water causes a sour and soapy taste leads people to dislike their residential area.	87(22.7)	77(20.1)	219(57.2)	2.34	0.826
Waste disposed in water create bad odour.	96(25.1)	53(13.8)	234(61.1)	2.36	0.857
Waste in water leads to the surrounding community experiencing a foul smell.	97(25.3)	41(10.7)	245(64.0)	2.39	0.863
Environment is unattractive to live in.	129(33.7)	37(9.7)	217(56.7)	2.23	0.923
Hindrance of water sports and recreation activities in the water such as fishing, swimming, and boating.	72(18.8)	40(10.4)	271(70.8)	2.52	0.792
Distribution of river flow causing floods of waste disposed to houses during rainy season.	65(17.0)	47(12.3)	271(70.8)	2.54	0.768
Children drown in a polluted river due to poor turbidity.	53(13.8)	38(9.9)	291(76.0)	2.63	0.719

4.9. Households’ behavioural intention on waste disposal in water.

Table 4.8 presents the results of behavioural intention on waste disposal in water using 33 items descriptors. The prominent items that the majority of the respondents are in favour of include Transporting waste to the disposal location is cumbersome (86%), I believe the nearby waste recycling infrastructure is inadequate (83%), I find it challenging to separate waste for recycling (75%), Disposed household waste in water over the last three months (63%) and I would rather dispose waste in water as recycling makes me feel unsatisfied (58%). This may be because of lack of recycling facilities in rural areas, which might have fostered poor recycling intention in households. The findings agree with Donuma *et al*. (2024) and Mzobea & Msezane (2024) residents were aware that the best management of solid wastes was through selling and recycling of bottle and plastic wastes. However, these practices were hindered in rural areas due to lack of proper waste recycling facilities; law enforcement; incentives and regulations from the municipality and government and lack of support; awareness and enlightenment among residents. The findings contradict with Chikukula *et al*. (2024) most of the households failed to perceive the significance of recycling or utilizing proper disposal sites because of dilatoriness and been unconcerned of the consequences. The study further found that most of the items that were improperly disposed could be reused or recycled such as furniture and appliances.

Conversely, most of the respondents were not in favour of 'To deal' with waste in the future, I'm willing to get in touch with organizations, municipality, and government officials (54.3%) and if there are official collection procedures in place, I plan to drop off my waste (5.0%). This may be because of the inconveniences of transport and cost as Ba-Phalaborwa Local Municipality has one (1) operational landfill site in town that must cater for urban areas, townships and rural areas. The distance is roughly about 20 km from the villages to where it is situated. The findings are in line with Kadyamare & Samson (2023) and Viljoen *et al*. (2021) households had poor waste disposal intention due to traveling cost and transport to designated waste disposal facilities.

Table 4.8: Determination of behavioural intention on waste disposal in water.

Constructs	**Measurements**	**SA** **F (%)**	**A** **F (%)**	**U** **F (%)**	**D** **F (%)**	**SD** **F (%)**	**Mean**	**Standard deviation**
Environmental awareness and attitude towards waste disposal in water.	Disposing waste in water reduce the amount of landfill space and greenhouse gas emissions.	275(71.8)	54(14.1)	25(6.5)	11(2.9)	18(4.7)	4.45	1.057
	Recycling waste is essential for protecting water bodies.	211(55.1)	75(19.6)	44(11.5)	16(4.2)	37(9.7)	4.06	1.305

	The state of water quality can be achieved by recycling waste.	212(55.4)	81(21.1)	36(9.4)	15(3.9)	39(10.2)	4.08	1.311
	It is everyone's duty to dispose waste properly.	253(66.1)	75(19.6)	24(6.3)	17(4.4)	14(3.7)	4.40	1.036
	I would rather dispose waste in water as recycling makes me feel unsatisfied.	221(57.7)	68(17.8)	49(12.8)	19(5.0)	26(6.8)	4.15	1.223
	Communities benefit from proper waste disposal.	267(69.7)	56(14.6)	47(12.3)	8(2.1)	5(1.3)	4.49	0.883
	I find the concept of waste disposal in water bodies to be uninteresting.	226(59.0)	72(18.8)	55(14.4)	11(2.9)	19(5.0)	4.24	1.114
Social Pressure (SP).	I will become more engaged in waste disposal in water if my family and friends are involved.	198(51.7)	61(15.9)	56(14.6)	23(6.0)	45(11.7)	3.90	1.398
	I'm motivated by the media to dispose waste in water.	168(43.9)	72(18.8)	69(18.0)	27(7.0)	47(12.3)	3.75	1.396
	I am often influenced to join in waste recycling by my neighbourhood.	163(42.6)	55(14.4)	49(12.8)	35(9.1)	81(21.1)	3.48	1.600
Laws and regulations (LR).	Individuals in South Africa are required by law not to dispose waste in water.	135(35.2)	87(22.7)	77(20.1)	24(6.3)	60(15.7)	3.56	1.422
	My decision to dispose waste in water is influenced by government policy.	168(43.9)	85(22.2)	60(15.7)	29(7.6)	41(10.7)	3.81	1.353
	If there exists rules or laws pertaining to waste disposal in	188(49.1)	76(19.8)	63(16.4)	30(7.8)	26(6.8)	3.97	1.258

	water, I shall abide by them.							
Cost of waste management.	I dispose waste in water as initiatives for waste disposal are expensive.	307(80.2)	43(11.2)	19(5.0)	4(1.0)	10(2.6)	4.65	0.839
	I believe there should be more money spent on waste management.	313(81.7)	44(11.5)	16(4.2)	3(0.8)	7(1.8)	4.70	0.748
	I consider the processing fees for waste to be exorbitant.	320(83.6)	42(11.0)	14(3.7)	2(0.5)	5(1.3)	4.75	0.671
Inconvenience of Recycling (ICR).	I find it challenging to separate waste for recycling.	287(74.9)	43(11.2)	20(5.2)	12(3.1)	21(5.5)	4.47	1.097
	Sending waste to the collection location would take too much time.	330(86.2)	36(9.4)	11(2.9)	1(0.3)	5(1.3)	4.79	0.631
	Transporting waste to the disposal location is cumbersome.	331(86.4)	33(8.6)	11(2.9)	6(1.6)	2(0.5)	4.79	0.618
	I believe the nearby waste recycling infrastructure is inadequate.	317(82.8)	28(7.3)	26(6.8)	8(2.1)	4(1.0)	4.69	0.777
Past experience (PE).	Waste recycling facilities are something I am quite familiar with.	115(30.0)	56(14.6)	68(17.8)	52(13.6)	92(24.0)	3.13	1.560
	I am familiar with waste and knowledgeable about waste materials.	228(59.5)	60(15.7)	27(7.0)	15(3.9)	53(13.8)	4.03	1.440
	Disposed household waste in water over the last three months.	243(63.4)	54(14.1)	53(13.8)	10(2.6)	23(6.0)	4.26	1.163

Behavioural Intention (BI).	To deal with waste in the future, I'm willing to get in touch with organizations; municipality and government officials.	32(8.4)	30(7.8)	57(14.9)	56(14.6)	208(54.3)	2.01	1.327
	If there are official collection procedures in place, I plan to drop off my waste.	19(5.0)	13(3.4)	54(14.1)	38(9.9)	259(67.6)	1.68	1.141
	I'm willing to take part in government-sponsored environmental programs and awareness campaigns.	97(25.3)	62(16.2)	88(23.0)	38(9.9)	98(25.6)	3.06	1.517
	I'm willing to share my waste disposal experiences with my family.	206(53.8)	81(21.1)	54(14.1)	16(4.2)	26(6.8)	4.11	1.204
	I'm willing to teach my family and friends about the impacts of waste disposal in water.	214(55.9)	87(22.7)	47(12.3)	11(2.9)	24(6.3)	4.19	1.152
Willingness to recycle.	Waste pollution can be reduced by not disposing in water.	195(50.9)	65(17.0)	66(17.2)	19(5.0)	38(9.9)	3.94	1.332
	Participation in educational campaigns will help maintain and fix devices to reduce waste in water.	179(46.7)	75(19.6)	58(15.1)	22(5.7)	49(12.8)	3.82	1.404
	Participation in local collection disposal education will help reduce waste in water.	182(47.5)	68(17.8)	56(14.6)	23(6.0)	54(14.1)	3.79	1.446
	Identification of reputable local recycling businesses will help reduce waste in water.	202(52.7)	69(18.0)	54(14.1)	8(2.1)	50(13.1)	3.95	1.389

	The use of designated disposal collection centers will help reduce waste in water.	207(54.0)	56(14.6)	54(14.1)	10(2.6)	56(14.6)	3.91	1.449

4.10. Results on water quality assessment.

4.10.1. Water temperature.

Table 4.9 presents the results of water temperatures at all the three sampling points in dry and wet season. Upper stream sample had the highest water temperature of 39.9ºC in dry season while lower stream sample had the lowest water temperature of 22.2ºC in wet season. The results show that the average water temperatures of different sampling points with different seasons were roughly of the same mean. In dry season, water temperatures had a difference of 0.1ºC as compared to wet season with a difference of 0.2ºC. This shows that water temperatures were slightly increasing at each sampling point. The slight difference in water could be associated with the samples been taken on different times and seasons. The results clearly indicate that water temperatures were generally high in summer and low in winter. The recorded water temperatures in dry season were above the permissible limit of below 25ºC for no risk detection as recommended by WHO, while in wet seasons the water temperatures were below the permissible limit. This shows that during dry season water quality is not suitable for domestic use compared to wet season.

The results from the study indicate that waste disposal in water led to the highest levels of temperatures in summer and the lowest in winter. Improper waste disposal in water and the exacerbation of temperature in dry season are associated with the excessive breeding of mosquitoes and their population thrive more in hot and dry season. Polluted water becomes a breeding ground of vector diseases, most commonly malaria. According to Gqomfa *et al*. (2022) revealed that residents suffered from malaria and skin diseases due to negative effects of breeding vectors in polluted water, roughly 57.3% households suffered from skin diseases, followed by 33.6% with diarrhoea as the symptoms of malaria. Bangani *et al*. (2023) and Perkumiene *et al*. (2023) also agree that mosquitoes like warm and stagnant water, settling in waste tires; plastics and they multiply 100 times faster than normal. Thus, expose communities to mosquito-borne diseases that have viruses such as Malaria Zika Virus;

Dengue; Chikungunya Virus and West Nile Virus. Therefore, high temperatures in a polluted river led to human health risks such as malaria.

4.10.2. pH.

The analysis of pH results in dry and wet season from all the three sampled points are showed in table 4.9. Upper stream sample had the highest pH level of 10.56 in dry season while Upper stream sample had the lowest pH level of 7.04 in wet season. The pH level of all the sampled sites in dry season fell within the range of 9.5 – 10.5 while the sampled sites in wet season fell within the range of 7 – 7.5. The recorded pH of sampled water in wet season fell within the WHO guidelines of an ideal pH range of 6.5 – 8.5 for drinking, domestic use and irrigation purposes and recreational use, while the sampled water in dry season were above the recommended pH range. The highest pH levels were recorded in dry season and the lowest in wet season. Based on the pH results, sampled water in dry season was alkaline while water collected in wet season was neutral and pure.

The results show that high levels of pH (10.56) in dry season constitute to severe irritation of mucous membranes; skin and eyes been irritated; burnt; dry or itchy. The water had extremely sour and soapy taste; unpleasant and foul smell; and severe rinsing problems during laundry. The lives of bacteria associated with these human health risks are influenced by the high levels of pH. The results are similar to those of Saalidong *et al*. (2022) that very high pH led to water having unpleasant smell and alkaline taste, households were exposed to water with high pH levels and suffered from extreme diarrhoea; skin-contact diseases such as skin and eyes irritation and mucous membrane.

4.10.3. Electrical conductivity (EC).

The highest electrical conductivity level was recorded in upper stream sample at 2860 µS/cm in dry season, while lower stream sample had the lowest recording of electrical conductivity at 1116 µS/cm in dry season. Upper stream sample and middle stream sample in dry season as well as the upper stream sample in wet season were outliers with the highest levels of electrical conductivity whereas the rest of the sampled points were approximately clustered with the same mean. The electrical conductivity both in dry and wet season were over 1000 µS/cm. According to the WHO standards, the electrical conductivity levels should not exceed 400 µS/cm for human consumption and irrigation. In addition, electrical conductivity of freshwater should range between 150 and 500 µS/cm to sustain diverse aquatic life (Gqomfa *et al*., 2021). However, all the sampled points in both dry and wet season exceeded the permissible limit.

High levels of electrical conductivity constitute to the risk of dehydration if ingested. Madilonga *et al*. (2021) also agree that high concentrations of electrical conductivity in water had non-carcinogenic potential risks. However, humans exposed to water with high levels of electrical conductivity had symptoms of dehydration such as extremely thirsty; irritable; confused and drowsy; very dry mouth; no to little urine; low blood pressure; fever and fast breathing and heart rate.

4.10.4. Total Suspended Solid (TSS).

The Total Suspended Solid (TSS) results show that middle stream sample had the highest level of TSS at 95 mg/L in dry season while lower stream sample had the lowest level of TSS at 9 mg/L in wet season. The TSS levels in wet season were slightly decreasing at each sampled point, and the upper stream sample also had a low TSS level which was below the threshold in dry season. The South African water guidelines recommends that the TSS levels should not exceed the permissible of 100 mg/L. The analysis of TSS showed that all the sampled points in dry and wet season did not exceed the limit. However, the middle stream sample was slightly approaching the permissible limit in dry season. This may be attributed to the highest level of turbidity at 356 NTU which could have resulted in the reduction of light penetration or visibility and clarity of water. This led to an increase in suspended solids.

High levels of TSS cause gastrointestinal problem or even lead to death. Suspended sediments contain bacteria and algae that are harmful to humans' health. Lukhabi *et al*. (2023) a risk of gastrointestinal illnesses was determined and high levels of TSS in drinking water affected humans' health and, in most cases led to death.

4.10.5. Chemical Oxygen Demand (COD).

Middle stream sample had the highest level of COD at 1310 mg/L during dry season, while lower stream sample recorded the lowest level of COD at 47 mg/L in dry season. This showed that the COD recorded at the middle stream sample was approximately 28 times higher than that recorded at the lower stream sample in dry season. Upper stream sample in both dry and wet season had approximately the same mean of COD level. However, there was some fluctuation and decrease of lower stream sample (in dry season), middle stream sample and lower stream sample (in wet season) as they are clustered around the same mean. Moreover, the level of COD fluctuates greatly in dry season (upper stream, middle stream, and lower stream sample). The wet season had the lowest levels of COD in all the sampled points as compared to the dry season with only lower stream sample at 47 mg/L in dry season. Low COD in surface water support aquatic species and human beings. High levels of COD indicate high levels of pollution (Tabraiz *et al*., 2023). According to the South African water guidelines, COD levels should not exceed 75 mg/L. The high levels of COD at upper stream and middle stream sample (in dry season) as well as upper stream sample (in wet season) indicate that the river was highly polluted compared to the low levels of COD at lower stream sample (in dry season), middle stream and lower stream sample (in wet season).

COD is a vital pollution indicator that analyses high occurrence of cancer in polluted water. High levels of COD in upper stream and middle stream sample (in dry season), and upper stream sample (in wet season) are associated with carcinogenic diseases. Wang *et al*. (2023) also agree that high levels of COD led to carcinogenic effects and the highest incidence of kidney and liver cancer; oesophageal cancer; followed by breast; pancreatic and lung cancer and lastly colorectal cancer; bone and gallbladder cancer.

4.10.6. Dissolved oxygen (DO).

Lower stream sample had the highest level of DO at 3.1 mg/L in wet season, while upper stream sample had the lowest level of DO at 0.4 mg/L in dry season. The difference of DO levels between lower stream sample (in wet season) and upper stream sample (in dry season) was very high, with lower stream sample (in wet season) been 8 times higher than that of upper stream sample (in dry season). The rest of the sample points had not much difference of DO levels in dry and wet season. There was a slight increase of DO levels in each sample point. The recorded DO levels of sampled water in both dry and wet season did not fell within the range of 6.5 – 8 mg/L or between 80% - 120% as recommended by WHO. The DO levels in all the sampled points were less than 5 mg/L and did not reach the permissible limit that is ideal to sustain healthy life in the aquatic ecosystem. Thus, the aquatic life was at risk in the three sample sites during dry and wet season.

Low concentration of DO levels in both dry and wet season are associated with human health risks such as cardiovascular diseases; bladder cancer; reproductive problems and less DO levels lead to bad odour which cause loss of appetite; headache; irritation of nose and throat. Giri *et al*. (2022) also noticed that the deterioration of the Bagmati River had bacterial contamination with low dissolved oxygen and high organic load. The water was unsuitable for drinking and domestic use as it was associated with human health risks like cardiovascular diseases; carcinogenic risks of bladder cancer which led to reproductive problems. The reduction of DO levels lead to bad odour. The results concur with those of Fadhullah *et al*. (2022) households residing near a polluted river complained about a foul odour which led to health risks such as headache and irritation of nose and throat.

4.10.7. Turbidity.

The results of turbidity for three sample sites in both dry and wet season showed that middle stream sample had the highest level of turbidity at 356 NTU in dry season, while the lowest level was lower stream sample at 1.40 NTU in wet season. Upper stream and middle stream sample (in dry season) as well as upper stream and middle stream sample (in wet season) had very high levels of turbidity compared to lower stream sample in both dry and wet season. The level of turbidity gradually decreases at lower stream sample in both dry and wet season meaning the low levels of TSS attributed to low levels of turbidity. According to the WHO guidelines of water quality, upper stream sample and middle stream sample (in dry season) as well as upper stream and middle stream sample (in wet season) have exceeded the standard limit of not more than 5 NTU or ideally below 1 NTU, whereas lower stream sample in both dry and wet season fell within the permissible limit as recommended by WHO.

High turbid water has human health risks if ingested. The study results show that high levels of turbidity interfere with water disinfection for drinking and domestic use which attributes to human health risks such as diarrhoea; nausea; stomach cramps and severe headaches. Elderly, infants, and people with weak immune systems may be at increased health risk. Similarly, Nawaz *et al*. (2023) highly turbid water was not safe for drinking and other domestic purposes as it was associated with headaches; diarrhoea and stomach cramps. The findings also concur with those of Mann *et al*. (2022) that drinking water with high levels of turbidity led to acute Gastrointestinal (GI) illnesses and the symptoms were bloody diarrhoea; vomiting and nausea; pain and stomach cramps; headache and occasional muscle aches and low-grade fever.

4.10.8. Nitrates.

The analysis of nitrate results showed that upper stream sample had the highest level of nitrate at 12.6 mg/L in dry season while lower stream sample had the lowest level of nitrate at 1.1 mg/L in dry season. The rest of the sample points showed a slight decrease of the nitrate level in both dry and wet season. The WHO standards of nitrate concentrations in drinking water from surface water should not exceed 10 mg/L. The nitrates levels at all the three sampling sites in both dry and wet season did not exceed the recommended limit excluding upper stream in dry season at 12.6 mg/L.

The results show that high levels of nitrates constitute to excess heart rate; weakness; fatigue; nausea; headache or dizziness, and the skin turns grey or blueish in colour because of methemoglonaemia or baby blue syndrome in children and if the child survives, it may cause mental retardation. Similarly, Meride and Ayenew (2022) also agree that blue baby syndrome was common in infants as one of the diseases caused by high concentrations of nitrates in drinking water. Moreover, low levels of nitrates are associated with colorectal cancer. Grout *et al*. (2023); Chambers *et al*. (2022) and Luvhimbi *et al*. (2022) noticed that the risk of colorectal cancer increases when human consume water with lower concentrations of nitrate than the current water standards for drinking.

4.10.9. Phosphorus.

Middle stream sample had the highest level of orthophosphate at 84.3 mg/L in dry season while lower stream sample had the lowest level of orthophosphate at 2.7 mg/L during dry season. There was a rapid decrease of orthophosphate levels at middle stream and lower stream sample during wet season, which indicates that these samples were concentrated around the same mean. Upper stream sample in both dry and wet season had not much difference. A fluctuation of orthophosphate levels was observed during dry season. Middle stream sample had a higher level compared to the rest of the sample points in dry season. This could have been influenced by the higher levels of turbidity, TSS and COD.

The highest level of phosphorus pentoxide recorded was upper stream sample at 27.8 mg/L in wet season while the lowest level was lower stream sample at 2.0 mg/L in dry season. There was a decrease of phosphorus pentoxide levels during dry season. Middle stream and lower stream sample (in wet season) recorded the same amount of phosphorus pentoxide during wet season. There was a slight difference of 1.8 mg/L from upper stream sample in both dry and wet season. According to WHO, the phosphate content should range from 0.08 – 0.10 mg/L or be ≤1 mg/L. All the three sampled sites during dry and wet season have high nutrient content and exceeded the recommended limit of phosphate in water.

High levels of phosphorus constitute to an increased risk of stroke; heart attack and death, others include hyperthyroidism; vomiting; diarrhoea and reduction in bone strength. Moreover, high levels of phosphorus lead to high infant mortality due to diarrhoeal diseases. Isiuku and Enyoh (2020) also agree that water intake with high phosphorus levels indicate non-carcinogenic risk with high risk in stroke; heart attack; hyperthyroidism and infant mortality.

Table 4.9: Water quality parameters in dry and wet season.

Water parameter	**Units**	**Dry season**			**Wet season**		
		Upper stream	**Middle stream**	**Lower stream**	**Upper stream**	**Middle stream**	**Lower stream**
Dissolved oxygen	mg/L	0.4	1.0	2.2	2.5	2.8	3.1
Turbidity	NTU	65.4	356	2.35	82.2	89.0	1.40
Total Suspended Solids	mg/L	29	95	9	50	14	12
pH	$-\log[H^+]$	10.56	9.72	9.25	7.04	7.39	7.48
Nitrates	mg/L	12.6	2.3	1.1	4.7	2.1	1.8
Orthophosphate	mg/L	30.8	84.3	2.7	30.4	4.3	3.8
Phosphorus Pentoxide	mg/L	26.0	12.3	2.0	27.8	3.3	3.3
Electrical Conductivity	µS/cm	2860	1933	1116	2680	1197	1175
Water temperature	ºC	39.9	39.8	39.7	22.6	22.8	22.4
Chemical Oxygen Demand	mg/L	413	1310	47	434	63	51

4.11. Results on bioindicators (macroinvertebrates) assessment in dry and wet season.

Table 4.10 presents the results of bioindicators using MiniSASS score sheet. Both dry and wet season fell within the range of <4.8 - <5.3 river ecological category, with 2.5 score in dry season and 0 score in wet season. This category indicates very poor conditions, and that the river's water quality was critically and seriously modified by wastes disposal. Based on the score, the river had high diversity of macroinvertebrates during dry season and had no diversity of macroinvertebrates in wet season. This could have been influenced by the different temperatures. The river was seriously and severely polluted during dry season and moderately polluted during wet season. The most abundant taxa during dry season were Oligochaetes worms also known as aquatic earth worms. Sowa and Krodkiewska (2020) Oligochaetes successfully inhabit highly polluted water as they are resistant to oxygen deficits (anaerobic conditions) and can survive during dry season and under severe nutrient pollution. Therefore, the findings concur with those of Sowa and Krodkiewska (2020) that Oligochaetes as pollution-tolerant organisms detect the ecological status of a river and the presence of pollution, their diversity and abundance signified the severe extent of pollution and poor river ecological status.

Table 4.10: MiniSASS score sheet of dry and wet season.

Groups	**Sensitivity score (Dry season)**	**Sensitivity score (Wet season)**
Flat worms	3	3
Worms	2	2
Leeches	2	2
Crabs or shrimps	6	6
Stoneflies	17	17
Minnow mayflies	5	5
Other mayflies	11	11
Damselflies	4	4
Dragonflies	6	6
Bugs or beetles	5	5
Caddisflies (cased or uncased)	9	9
True flies	2	2
Snails	4	4
TOTAL SCORE	5	0
NUMBER OF GROUPS	2	0
AVERAGE SCORE	2.5	0

Average Score = Total Score / Number of groups

4.12. Results of the Principal Component Analysis (PCA).

The results of the Principal Component Analysis (PCA) of Households' knowledge, perception, and behavioural intention of the effects of waste disposal on water are in Table 4.11. Four factors were extracted based on the responses of rural households in the study area. The selection of the underlying types, the number of components explaining the data, and the measure of explained variance were determined based to Kaiser criterion (1960), Eigenvalues, and factor loadings greater than or equal to ±0.300. Correspondingly, If the derived component of the study exceeds 0.30, a factor loading poses a significant contribution to the PCA results; thus, all the items explaining each derived component on the scale were expressed properly on the PCA. In order to identify the factors and significance at 1% level of probability, the variables with factor loadings of ±0.346 and above at 10% overlapping variance were used: thus, excluding variables with lower factor loading. The commonalities show the association between variables and the reflection of the squared multiple correlations between each item and all other items as well as the relationship between each variable and all other variables. In this study, the least explained by the analysis is Taking part in environmental programmes (0.309). In accordance to Figure 6, the four extracted components for Households' Knowledge, Perception, and behavioural intention of the effects of waste disposal on water, are denoted as Factor 1 (disposal methods), Factor 2 (campaign), Factor 3 (community pressure), and Factor 4 (water quality), and accounted for 18.05%, 14.85%, 7.29%, and 6.43% of the variance respectively; with a cumulative 46.62% variance.

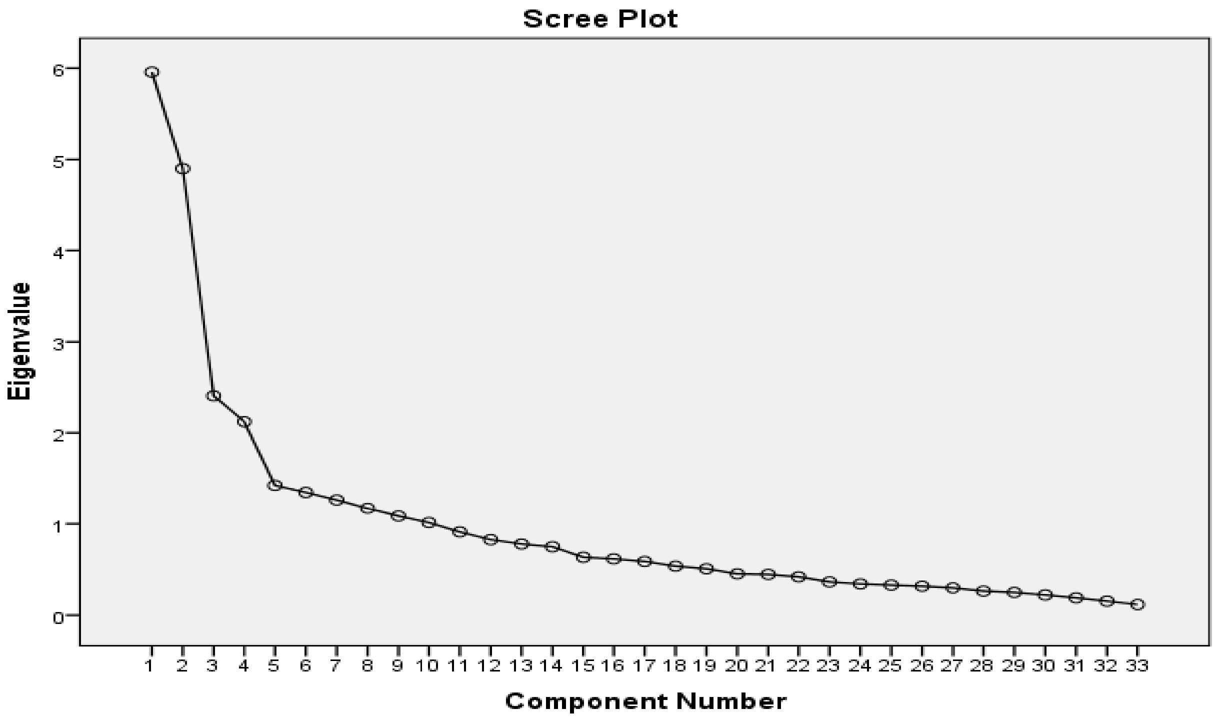

Figure 6: Scree plot of extracted components.

These results attest to the Bartlett's Test of Sphericity with a value of X^2 = 5696.644, p=0.00, and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy of 0.799. The weights of factor loadings were measured according to the influence of the variables in the extracted components. The prominent items under the disposal methods factor are Everyone's duty (.532), Communities benefits (.624), I shall abide by the legislation (.421), initiatives are expensive (.516), More money spent on waste management (.504), Processing fees (.465), Challenging to separate waste (.532), Takes too much time (.510), Transporting waste (.509), Recycling infrastructure is inadequate (.528), Share my disposal experiences (.515), Teach my family and friends (.467) and knowledgeable about waste materials (.466). The results from this study, correlate with the findings of other researchers Nyika *et al*. (2019); Viljoen *et al* (2021) and Ngalo and Thondhlana (2023) that inadequate recycling infrastructure has a significant impact on improper waste disposal. Adeniran *et al.* (2022) stated that challenges to not practicing in waste separation influence their method of disposal.

For campaign factor, the prominent items that were identified include Take part in environmental programmes (.475), Get in touch with organizations, municipality and NGOs (.485), Drop off my waste (.528), Not disposing in water (.525), Participation in educational campaigns (.534), Participation in local collection (.508), Feel unsatisfied

(.-506), Identification of reputable local recycling businesses (.599) and Use of designated disposal collection centers (.575). Jakeni *et al.* (2024); Thakur & Onwubu (2024); Stokes & Lawhon (2022) and Kafula (2024) attested that households' unwillingness and disassociation to engage in environmental programmes has an influence on campaign factor and hinders their level of knowledge and awareness on proper disposal, and further influence their choice of disposal.

The community pressure factor composed of items such as If my family and friends are involved (.531), Motivated by media (.539) and influenced by my neighbourhood (.571). The findings corroborate with previous results of Kekana *et al.* (2023); Kubanza (2024) and Bazaanah & Mothapo (2024) immediate neighbours encouraged each other to improperly dispose of waste. Moreover, social media has the power to promote improper waste disposal. Jiang *et al.* (2021) also stated that publicity through media had a significant influence on encouraging improper waste disposal.

The water quality factor consists of items on Recycling waste is essential (.583) and state of water quality (.606). The findings are in line with Omotayo *et al.* (2020); Njoku *et al.* (2022) and Korstanje *et al.* (2024) as households' willingness to effectively implement recycling activities influence the state of water quality.

Table 4.11: Principal Component Analysis (PCA).

	Components				Communalities
	1	2	3	4	
Everyone's dutyBI4	.532				.568
Communities benefitBI6	.624				.496
I shall abide by legislationBI13	.421				.344
Initiatives are expensiveBI14	.516				.562
More money spent on waste managementBI5	.504				.478
Processing feesBI6	.465				.454
Challenging to separate wasteBI7	.532				.501
Take too much timeBI18	.510				.515
Transporting wasteBI19	.509				.522
Recycling infrastructure is inadequateBI20	.528				.413

Share my disposal experiencesBI27	.515				.438
Teach my family and friendsBI28	.467				.369
Knowledgeable about waste materialsBI22	.466				.350
Take part in environmental programmesBI26		.475			.309
Get in touch with Organizations, Municipality and GOsBI24		.485			.397
Drop off my wasteBI25		.528			.446
Not disposing in water BI29		.525			.566
Participation in educational campaignsBI30		.534			.633
Participation in local collectionBI31		.508			.694
Feel unsatisfiedBI5		-.506			.438
Identification of reputable local recycling businessesBI32		.599			.693
Use of designated disposal collection centersBI33		.575			.702
If my family and friends are involvedBI8			.531		.393
Motivated by mediaBI9			.539		.612
Influenced by my neighbourhoodBI10			.571		.483
Recycling waste is essentialBI2	.			-.583	.752
State of water qualityBI3				-.606	.767

4.13. Results of the Probit regression analysis.

Table 4.12 presents the results of the Probit regression analysis of the determinants of Households' knowledge, perception, and behavioural intention of the effects of waste disposal in water. The study examined the relationship between dependent and independent variables. Dependent variables were knowledge and awareness, attitude, and perceived risks, while the independent variables included age, gender, education level, employment status, income level, biodegradable waste, hazardous waste, household hazardous waste, construction waste, chemical waste, electronic waste, agricultural waste, garden waste, general waste, monthly payment, landfill, incineration, waste compaction, biogas generation, composting, vermicomposting, waste disposal in water, waste disposal in open spaces, skip bin, municipal collection, and satisfactory level on waste collection. All the models are well fitted with Chi-Square values of 7.808E+77 (Knowledge and awareness), 2.352E+77 (Attitude), 559.57, and (Perceived risks), 1.458E+49 at $p < 0.001$.

The determinants of households' knowledge and awareness on waste disposal in water are Attitude ($t=4$, $p<0.01$), Perceived risks ($t=-1.778$, $p<0.10$), Age ($t=1.899$, $p<0.10$), Gender ($t=8.939$, $p<0.01$), Education level ($t=15.144$, $p<0.01$), Employment status ($t=-4.366$, $p<0.01$), Income level ($t=32.137$, $p<0.01$), Biodegradable waste ($t=-10.117$, $p<0.01$), Household hazardous waste ($t=-9.491$, $p<0.01$), Construction waste ($t=7.215$, $p<0.01$), Chemical waste ($t=-14.964$, $p<0.01$), Electronic waste ($t=1.801$, $p<0.10$), Agricultural waste ($t=-13.616$, $p<0.01$), Garden waste ($t=-6.609$, $p<0.01$), General waste ($t=6.884$, $p<0.01$), Monthly payment ($t=-4.914$, $p<0.01$), Landfill ($t=17.955$, $p<0.01$), Incineration ($t=-12.429$, $p<0.01$), Waste compaction ($t=4.78$, $p<0.01$), Biogas generation ($t=16.089$, $p<0.01$), Composting ($t=-4.629$, $p<0.01$), Vermicomposting ($t=-2.034$, $p<0.05$), Waste disposal in water ($t=-8.653$, $p<0.01$), Waste disposal in open spaces ($t=-14.779$, $p<0.01$), Municipal collection ($t=7.728$, $p<0.01$), Satisfactory level ($t=4.842$, $p<0.01$) and Intercept ($t=-4.172$, $p<0.01$). The results show an inverse relationship between knowledge and awareness as independent variables, whereas attitude and the perceived risks as dependent variables. The finding agrees with Mangoro & Kubanza (2023); Bazaanah & mothapo (2024); Ayeleru *et al. (2023)* and Stokes & Lawhon (2024) education level potentially influence households' knowledge on waste management and their compliance with proper waste disposal. Accordingly, lack of education could contribute to high unemployment rates which further influences one's personal development and the development of the municipality in general. Employment status influences households' knowledge and awareness and has the potential to deteriorate the quality of water. Chikowore (2020) also revealed that most respondents were self-employed and managed to purchase and utilize plastic bags and buckets as waste receptacles. This indicates that employment status has a significant association with proper waste management. Furthermore, gender influences households' knowledge as women are more knowledgeable and aware of waste management issues as most of the wastes in household level are managed by women rather than men. The finding agrees with Fadhullah *et* al. (2022) as women were more closely engaged with waste management at a household level than men.

The factors influencing households’ attitude on waste disposal in water are Perceived risks (t=-17, p<0.01), Know and aware (t=-8.125, p<0.01), Age (t=10.449, p<0.01), Gender (t=-22.918, p<0.01), Employment status (t=-15.396, p<0.01), Income level (t=9.145, p<0.01), Hazardous waste (t=5.528, p<0.01), Construction waste (t=14.010, p<0.01), Chemical waste (t=-13.245,p<0.01), Electronic waste (t=-3.296, p<0.01), Agricultural waste (t=2.492, p<0.05), Garden waste (t=10.887, p<0.01), Monthly payment (t=6.3, p<0.01), Waste compaction (t=-5.347, p<0.01), Biogas generation (t=6.995, p<0.01), Composting (t=21.706, p<0.01), Vermicomposting (t=-22.270, p<0.01), Waste disposal in water (t=-7.392, p<0.01), Skip bin (t=3.896, p<0.01), Municipal collection (t=3.044, p<0.01), Satisfactory level (t=-3.667, p<0.01) and Intercept (t=-3, p<0.01). The results show an inverse relationship between attitude as an independent variable, and the perceived risks, knowledge and awareness as dependent variables. The findings agree with Schoeman & Rampedi (2022); Omotoso *et al*. (2020) and Opoku *et al.* (2024) found that income level has a significant influence on households’ waste disposal preferences. Households with less income level tend to not pay for their monthly waste disposal payments, as a result the municipality does not render waste collection services which lead to residents been unsatisfied with the municipal waste removal system and further develop their own waste disposal preferences. Moreover, age has an influence on households’ attitude, elderly people are more willing and interested to practice waste separation activities than young people as they are more aware of the impacts of improper waste disposal in water. The findings concur with Eshete *et al*. (2023) and Viljoen *et al*. (2021) elderly people had a positive attitude on waste management activities than young individuals.

The prominent items within perceived risks are Know and aware (t=-26.8, p<0.01), Age (t=-2.669, p<0.05), Gender (t=5.578, p<0.01), Income level (t=7.352, p<0.01), Biodegradable waste (t=-9.077, p<0.01), Hazardous waste (t=-4.251, p<0.01), Construction waste (t=14, p<0.01), Electronic waste (t=-13.522, p<0.01), Agricultural waste (t=-14.084,p<0.01), Monthly payment (t=4.645, p<0.01), Landfill (t=7.511, p<0.01), Incineration (t=4.473, p<0.01), Waste compaction (t=-3.506,p<0.01), Biogas generation (t=9.332, p<0.01), Composting (t=6.054, p<0.01), Vermicomposting (t=-3.285, p<0.01), Open spaces (t=2.459, p<0.05), Skip bin (t=13.456, p<0.01), Municipal collection (t=4.928, p<0.01), Satisfactory level (t=-3.019, p<0.01) and Intercept (t=-3.591, p<0.01). The results show an inverse relationship between the perceived risks as independent variable whereas knowledge and awareness as dependent variables. There is a statistically significant association between perceived risks and households' level of knowledge. The findings in this study agree with Tomita *et al*. (2020); Omang *et al*. (2021) and Smith (2020) as households' exposure to the perceived risks increase their level of knowledge and awareness.

Table 4.12: Probit regression analysis of the determinants of Households' Knowledge, Perception and behavioural intention towards waste disposal in water.

Parameter	Knowledge & awareness	Attitude	Perceived risks
Attitude	.028 (.007)***		.016(.016)
Perceived risks	-.016(.009)*	-.153 (.009)***	
Know and aware		-.130(.016)***	-.134(.005)***
Age1	.169(.089)*	1.139(.109)***	-.291 (.109)**
Gender1	1.180(.132)***	-3.919(.171)***	.714(.128)***
Education Level	1.363(.090)***	.077(.091)	.110(.088)
Employment Status	-.179(.041)***	-.816(.053)***	-.020(.041)
Income Level	2.346(.073)***	1.262(.138)***	.647(.088)***
Biodegradable waste	-1.993(.197)***	-.302(.226)	-1.779(.196)***
Hazardous waste	.059(.173)	1.067(.193)***	-.795(.187)***
Household hazardous waste	-1.566(.165)***	.044(.187)	.200(.164)
Construction waste	1.277(.177)***	2.676(.191)***	2.548(.182)***
Chemical waste	-2.484(.166)***	-2.437(.184)***	.242(.172)
Electronic waste	.461(.256)*	-.923(.280)***	-2.975(.220)***
Agricultural waste	-2.587(.190)***	.770(.309)**	-2.676(.190)***
Garden waste	-1.976(.299)***	8.557(.786)***	.426(.360)
General waste	3.139(.456)***	.041(.587)	1.456(2.350)
Monthly Payment	-.398(.081)***	.693(.110)***	.367(.079)***
Landfill	4.399(.245)***	-.270(.350)	2.133(.284)***
Incineration	-1.566(.126)***	.186(.143)	.671(.150)***
Waste compaction	.717(.150)***	-.941(.176)***	-.575(.164)***

Biogas generation	4.135(.257) ***	1.532(.219) ***	1.885(.202) ***
Composting	-1.023(.221) ***	4.732(.218) ***	1.447(.239) ***
Vermicomposting	-.423(.208) **	-4.944(.222) ***	-.795(.242) ***
Waste disposal in water	-1.445(.167) ***	-1.375(.186) ***	.233(.165)
Waste disposal in open spaces	-2.276(.154) ***	-.011(.151)	.418(.170) **
Skip bin	.175(.135)	.600(.154) ***	1.978(.147) ***
Municipal collection	.966(.125) ***	.481(.158) ***	.680(.138) ***
Satisfactory level on waste collection	.891(.184) ***	-1.632(.445) ***	-.895(.297) ***
Intercept	-8.394(2.012)***	-6.303(2.101)***	-3.20(.891) ***
Chi-Square	7.808E+77	2.352E+77	1.458E+49
Df	354	354	354
Sig.	.000	.000	.000

4.14. Comparison of households' perception on risks associated with waste disposal in water and analysis of water quality parameters.

Table 4.13 presents the results of perceived risks associated with waste disposal in water using 44 descriptors on environmental, health and social risks. The prominent environmental items that were >50% and in agreement with the laboratory data are Aquatic organisms cannot survive with less dissolved oxygen, Less dissolved oxygen leads to the death and decomposition of aquatic plants and animals, Waste disposed decreases the amount of dissolved oxygen, Excessive algae growth decreases the amount of dissolved oxygen, Low concentrations of dissolved oxygen affect photosynthesis, respiration, and aeration, Decomposition of aquatic species release of nutrients in water such as carbon and nitrogen, Polluted water contain nitrates and phosphates toxic to aquatic animals and life, The increased levels of nitrates and phosphates endangers the surrounding plants and animals, Disposal of heavy materials and waste leads to high turbidity, cloudy and unclear surface water, High turbidity reduces the dispersion of sunlight for aquatic ecosystem, Disposal of waste increases water temperatures, Excessive nitrogen and phosphorus leads to the high accumulation of algae, High levels of nitrates and phosphates depletes food resources, High levels of nitrates and phosphates decreases oxygen for aquatic life, Nitrates and phosphates leach into the ground and contaminate of groundwater, High turbidity increases the risk of flooding and alters proper water flow, Dissolved oxygen decreases due to high levels of pollutants in water, High levels of nitrates and phosphates leads to the contamination of food chain in the ecosystem, High levels of nitrates and phosphates reduce organism's life span and ability to reproduce, Poor water quality due to waste disposal is associated with high nitrates and phosphates levels, Waste disposal in water alters the physical characteristics of water (pH, temperature, and turbidity, Low pH levels leads to a decrease in reproduction, growth and eventually death of aquatic species and High water temperatures increases the effects of climate change. Households' perception on environmental risks corroborates with water quality parameters. According to Abubakar *et al*. (2022); Mousavi *et al.* (2023); Bangani *et al.* (2023); Somani (2023) and Andeobu *et al. (*2023), agree with the perceived environmental risks of waste disposal in water, and the laboratory data confirms the risks identified by households.

The key health items that were >50% and in agreement with laboratory data are High levels of turbidity leads to gastrointestinal illness, diarrhoea, and headaches, High levels of Electrical Conductivity leads to the risk of dehydration, Using water with low dissolved oxygen levels in water cause cardiovascular diseases, Low levels of nitrates in water leads to colorectal cancer, Drinking water with high levels of nitrates leads to excess heart rate, weakness, and fatigue, Drinking water with high levels of nitrates turns the skin grey or blueish in colour, Excessive amount of nitrates leads to methemoglonaemia or baby blue syndrome in children, Drinking water with less dissolved oxygen leads to bladder cancer and reproductive problems, Excessive flies and mosquitoes due to high water temperatures in polluted water leads to malaria, High levels of phosphorus leads to increased risk of stroke, heart attack or death, High levels of phosphorus leads to hyperthyroidism, vomiting, diarrhoea, reduced bone strength, Using untreated water with Chemical Oxygen Demand (COD) leads to cancer-related diseases, Children under five die each year due to diarrhoeal diseases related to high levels of phosphorus, High levels of total suspended solids cause gastrointestinal problem or even lead to death, A high pH level cause the skin to become irritated, dry or itchy and severe mucous membrane and Low levels of dissolved oxygen leads to bad odour, loss of appetite, nose and throat irritation. Households perceived that improper waste disposal in water led to the above-mentioned health risks. The analysis between households' perception on health risks and laboratory data correlate with Tomita *et al.* (2020); Fadhullah *et al.* (2022); Akmal

& Jamil (2021) and Ouattara *et al.* (2023) as the concentration of Biological Oxygen Demand (BOD); nitrates; COD and TSS exceeded the values recommended by WHO and households' perception was based on their prone to infectious diseases.

The prominent social items that were >50% and in agreement with laboratory data are Low pH in water causes a sour and soapy taste leads people to dislike their residential area, Waste disposed in water create bad odour, Waste in water leads to the surrounding community experiencing a foul smell, Hindrance of water sports and recreation activities in the water such as fishing, swimming and Children drown in the polluted river due to poor turbidity. The analysis revealed a connection between households' perception on social risks and water quality parameters. The findings agree with Ramodipa *et al.* (2023); Zondi *et al.* (2023) and Gqomfa *et al.* (2022) water with high pH level had unpleasant smell and households were able to perceive the social risk as it was challenging to live in such area.

Table 4.13: Perceived risks associated with waste disposal in water.

	Perception rate of households (individual surveys)			**Analysis of water quality parameters**	**Agreement between perception and laboratory data**
Risks identified by households	**Environmental**	**Health**	**Social**		
Aquatic organisms cannot survive with less dissolved oxygen.	>50%	< 50%	< 50%	DO+	Yes$_E$
Less dissolved oxygen leads to the death and decomposition of aquatic plants and animals.	>50%	< 50%	< 50%	DO+	Yes$_E$
Waste disposed decreases the amount of dissolved oxygen.	>50%	< 50%	< 50%	DO+	Yes$_E$
Excessive algae growth decreases the amount of dissolved oxygen.	>50%	< 50%	< 50%	DO+	Yes$_E$
Low concentrations of dissolved oxygen affect photosynthesis, respiration, and aeration.	>50%	< 50%	< 50%	DO+	Yes$_E$

Decomposition of aquatic species release of nutrients in water such as carbon and nitrogen.	>50%	< 50%	< 50%	NO_3-+	Yes$_E$
Polluted water contains nitrates and phosphates toxic to aquatic animals and life.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
The increased levels of nitrates and phosphates endangers the surrounding plants and animals.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
Disposal of heavy materials and waste leads to high turbidity, cloudy and unclear surface water.	>50%	< 50%	< 50%	Turbidity+	Yes$_E$
High turbidity reduces the dispersion of sunlight for aquatic ecosystem.	>50%	< 50%	< 50%	Turbidity+	Yes$_E$
Disposal of waste increases water temperatures.	>50%	< 50%	< 50%	Water temp+	Yes$_E$
Excessive nitrogen and phosphorus lead to the high accumulation of algae.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
High levels of nitrates and phosphates depletes food resources.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
High levels of nitrates and phosphates decreases oxygen for aquatic life.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
Nitrates and phosphates leach into the ground and contaminate of groundwater.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
High turbidity increases the risk of flooding and alters proper water flow.	>50%	< 50%	< 50%	Turbidity+	Yes$_E$
Dissolved oxygen decreases due to high levels of pollutants in water.	>50%	< 50%	< 50%	DO+	Yes$_E$
High levels of nitrates and phosphates leads to the contamination of food chain in the ecosystem.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$
High levels of nitrates and phosphates reduce organism's life span and ability to reproduce.	>50%	< 50%	< 50%	NO_3- & PO_4^{3-}+	Yes$_E$

Poor water quality due to waste disposal is associated with high nitrates and phosphates levels.	>50%	< 50%	< 50%	NO_3^- & PO_4^{3-}+	Yes_E
Waste disposal in water alters the physical characteristics of water (pH, temperature, and turbidity.	>50%	< 50%	< 50%	pH+, Water temp+ & Turbidity+	Yes_E
Low pH levels lead to a decrease in reproduction, growth and eventually death of aquatic species.	>50%	< 50%	< 50%	pH+	Yes_E
High water temperatures increase the effects of climate change.	>50%	< 50%	< 50%	Water temp+	Yes_E
High levels of turbidity lead to gastrointestinal illness, diarrhoea, and headaches.	< 50%	>50%	< 50%	Turbidity+	Yes_H
High levels of Electrical Conductivity lead to the risk of dehydration.	< 50%	>50%	< 50%	EC+	Yes_H
Using water with low dissolved oxygen levels in water cause cardiovascular diseases.	< 50%	>50%	< 50%	DO+	Yes_H
Low levels of nitrates in water leads to colorectal cancer.	< 50%	>50%	< 50%	NO_3^-+	Yes_H
Drinking water with high levels of nitrates leads to excess heart rate, weakness, and fatigue.	< 50%	>50%	< 50%	NO_3^-+	Yes_H
Drinking water with high levels of nitrates turns the skin grey or blueish in colour.	< 50%	>50%	< 50%	NO_3^-+	Yes_H
Excessive amount of nitrates leads to methemoglonaemia or baby blue syndrome in children.	< 50%	>50%	< 50%	NO_3^-+	Yes_H
Drinking water with less dissolved oxygen leads to bladder cancer and reproductive problems.	< 50%	>50%	< 50%	DO+	Yes_H
Excessive flies and mosquitoes due to high water temperatures in polluted water leads to malaria.	< 50%	>50%	< 50%	Water temp+	Yes_H

High levels of phosphorus lead to increased risk of stroke, heart attack or death.	< 50%	>50%	< 50%	PO_4^{3-}+	Yes_H
High levels of phosphorus lead to hyperthyroidism, vomiting, diarrhoea, reduced bone strength.	< 50%	>50%	< 50%	PO_4^{3-}+	Yes_H
Using untreated water with Chemical Demand Oxygen (COD) leads to cancer-related diseases.	< 50%	>50%	< 50%	COD+	Yes_H
Children under five die each year due to diarrhoeal diseases related to high levels of phosphorus.	< 50%	>50%	< 50%	PO_4^{3-}+	Yes_H
High levels of total suspended solids cause gastrointestinal problem or even lead to death.	< 50%	>50%	< 50%	TSS+	Yes_H
A high pH level causes the skin to become irritated, dry or itchy and severe mucous membrane.	< 50%	>50%	< 50%	pH+	Yes_H
Low levels of dissolved oxygen lead to bad odour, loss of appetite, nose and throat irritation.	< 50%	>50%	< 50%	DO+	Yes_H
Low pH in water causes a sour and soapy taste leads people to dislike their residential area.	< 50%	< 50%	>50%	pH+	Yes_S
Waste disposed in water create bad odour.	< 50%	< 50%	>50%	pH+	Yes_S
Waste in water leads to the surrounding community experiencing a foul smell.	< 50%	< 50%	>50%	pH+	Yes_S
Hindrance of water sports and recreation activities in the water such as fishing, swimming.	< 50%	< 50%	>50%	pH+	Yes_S
Children drown in the polluted river due to poor turbidity.	< 50%	< 50%	>50%	Turbidity+	Yes_S

4.15. Conclusion.

This chapter presented a comprehensive discussion on the analysis of households' knowledge, perception, and behavioural intention of the effects of waste disposal on water quality. The prominent factors influencing waste disposal in water include age; gender; education level; employment status and income level. Thus, the next chapter provides a summary of the study, and results analysed in chapter four as well as recommendations.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS.

5.1. Introduction.

This chapter presents conclusion, a summary of the findings and recommendations in relation to the objectives of the study, research problem and the analysis of findings presented in chapter four. Furthermore, recommendations aim at combating waste disposal in water and improving waste management practices in Ba-Phalaborwa Local Municipality and South Africa in general.

5.2. Summary.

Water is a valuable and scarce resource that supports the survival of humans. Waste disposal in water is a growing problem that has received little attention in Southern Africa. Households' behaviour on waste disposal in water is influenced by long travel distance from their home to authorised landfill sites; deficiency of regular municipal refuse; the awkwardness of opening hours at waste management facilities; lack of public encouragement for waste minimization and recycling; poor waste activities and limited refuse removal services in poor areas.

Knowledge is very important in the formation of individuals' action and is viewed as a cognitive domain. Inadequate knowledge on disposing of waste in water is associated with low perception, behavioural intention, and attitude. There is a strong link between knowledge, attitude, perception, and behavioural intention on waste disposal in water. Absences of knowledge influences households' attitude and perception with regards to their cognizant on disposing of waste in water. Households' decision to participate and engage in a particular behaviour is predominantly driven by their level of knowledge.

The study was guided and led by the following objectives: to investigate the level of community knowledge and awareness of waste disposal in water; to explore community attitudes, perceptions and practices on waste disposal in water; to examine environmental, health and social risks associated with waste disposal in water; to determine behavioural intention on waste disposal in water; and also to compare perceived environmental, health and social risks with water quality indices. Moreover, this study had a motivation to support Ba-Phalaborwa Local Municipality to develop preventative measures that will aid in combating waste disposal in water so as to meet the Sustainable Development Goals (SDGs) of waste management in 2030. This study produced data that was useful in analysing households' knowledge, perception, and behavioural intention of the effects of waste disposal on water quality.

The literature review provided useful insights of waste disposal in water based on conceptual and theoretical framework; legislative framework of waste management and water in South Africa; the growth of waste disposal on water bodies in the context of worldwide and in South Africa; factors associated with waste disposal in water; households' levels on knowledge and awareness, attitude, perception, practices and behavioural intention; risks associated with waste disposal in water and the effects of waste disposal on water parameters.

This study adopted a descriptive research design to examine quantitative data of four (4) communities within Ba-Phalaborwa Local Municipality. Data was gathered using questionnaires at Makhushane, Mashishimale, Maseke, and Boelane villages with a sample size of 384 respondents. Data was further analysed using Statistical Package for Social Sciences (IBM SPSS Version 29.0) and Excel. Statistical analyses tools that were used include T-test; Probit Regression and Principal Components Analysis (PCA). Water quality assessments were obtained from three sampling sites namely the upper stream, middle stream, and lower stream sample, and were analysed based on the following water quality parameters: water temperature; COD; TSS; nitrates; phosphorus; EC; DO; pH and turbidity. Permission to conduct the study was attained from UKZN Humanities and Social Sciences Research Ethics Committee (HSSREC); the municipality; the Department of health and gatekeepers of the communities.

5.3. Conclusion.

Most of the respondents (66.6%) were females and 48.3% were in the 18-34 age group. Most (52.5%) of the respondents obtained secondary education. Significant percentage of the respondents (62.9%) were unemployed and 64.2% had no monthly income. Most (89.0%) of the respondents were not paying for waste disposal services. The majority (83.3%) of the respondents revealed that the municipality never collected their waste. Almost (96.9%) all the respondents were not satisfied with the current municipal removal system. Nearly (99.0%) of respondents generated general waste and 86.2% of respondents generated biodegradable waste. The majority (91.6%) of the respondents were generating electronic waste. Most (77.0%) of the respondents disposed their waste in water bodies. More than 57.7% of respondents were burning their waste. Moreover, the majority (96.3%) of the respondents were not disposing of their waste in a designated landfill site.

Majority of the respondents were knowledgeable and aware of I understand the meaning of household waste (86%), Accumulation of waste disposal in rivers causes health risks (86%), and Any type of waste can be recyclable (85%). The majority of the respondents were not knowledgeable nor aware of There is public support from the municipality and government in a form of awareness campaigns (94%), The municipality and government raise public environmental awareness on the impacts of waste in water (96%), Regular supervision and control on illegal dumping of waste in water is conducted (96%), and the municipality collects waste regularly (98%).

The majority of the respondents had a positive attitude on Disposing waste in water bodies creates jobs for municipal workers or EPWP (74%), Lack of waste collection services causes people to dispose of waste in water (76%), Unavailability of bins causes people to dispose of waste in water (79%), It is the government and municipal's duty to clean up the illegally dumped waste in water (76%), and Disposing waste in water is cheaper than buying refuse bags to dispose in designated areas (70%). In addition, many of the respondents had a negative attitude on Willing to pay for waste collection services (70%), and Willing to travel to the landfill site to dispose of waste (72%).

On households' behavioural intention on waste disposal in water, many of the respondents were in favour of Transporting waste to the disposal location is cumbersome (86%), I believe the nearby waste recycling infrastructure is inadequate (83%), and I find it challenging to separate waste for recycling (75%). Most of the respondents were not in favour of 'to deal' with waste in the future, I'm willing to get in touch with organizations; municipality, and government officials (54.3%) and If there are official collection procedures in place, and I plan to drop off my waste (5.0%).

Socio-economic characteristics such as gender, age, education level, employment status, and income level influenced the determinants of probit regression analysis on knowledge and awareness, attitude, and perceived risks. Gender had an influence on households' level of knowledge and awareness as women were closely engaged with waste management. Therefore, many women were knowledgeable on issues of improper waste management than men. Age had an influence on households' level of attitude as elderly people were more willing to practice waste separation activities than young people. Employment status had a significant association with proper waste management. Lack of education contributed to high unemployment rates which further influenced one's personal development and the development of the municipality in general. Furthermore, employment status influenced households' level of knowledge and awareness which led to the deterioration of water quality. Income level had a significant influence on households' waste disposal preferences. Households with low-income level tend to not pay for their monthly waste disposal payments.

Households' exposure to the perceived risks increased their level of knowledge and awareness, and perception on risks associated with waste disposal in water. The analysis revealed a significant correlation between households' perception on the identified environmental, health and social risks. The results indicated that households demonstrated good perception on the identified risks. Additionally, many of the respondents experienced those risks hence they were knowledgeable and conscious of the impacts. Households' perceptions on the environmental, health and social risks associated with waste disposal in water were examined and water quality parameters were analysed and correlated with households' perception. Respondents perceived that waste disposal in water affected aquatic plants and animals, and the surrounding environment; led to short and long-term diseases; and experienced a foul smell and hindrance in water sports and recreational activities. Both the households' perceptions and water quality parameters correlate as water quality assessments confirms the associated risks. The congruence of households' perception and laboratory data points need to explore common strategies to manage health risks related to waste disposal in water.

5.4. Recommendations.

A few recommendations are made based on the research findings of the study to lessen waste disposal in water in Ba-Phalaborwa Local Municipality and in other municipalities in South Africa.

- Sustainable management of water bodies and regular monitoring of river water quality should be implemented to restore polluted river water and preserving it to be pollution free for future generations.

- Mopani District Municipality (MDM); Ba-Phalaborwa Local Municipality and local authorities should settle upon and develop strategies for water quality risk assessment and management.
- Ba-Phalaborwa Local Municipality should develop and strengthen regulations and by laws on water quality.
- Ba-Phalaborwa Local Municipality in collaboration with LEDET; DWS and Department of Health should intensify environmental and health education on the impacts of waste disposal in water, avoidance of waste disposal in water, waste separation at source and the importance of recycling. These educational programmes should be strengthened in both communities and schools in the form of using informal activities and outreach methods. This could increase households' participation in proper waste management practices and waste sorting at source. Additionally, these educational programs will encourage positive perception and further promote positive disposal behaviours among households.
- Ba-Phalaborwa Local Municipality should improve and extend waste collection services in rural areas. This will enable households to participate and show interest in waste management.
- Recycling should be encouraged and promoted among residents to combat the flow of waste from their households to water bodies.
- Collection points with lockable and labelled containers according to waste type should be established in all the villages to enable residents to drop-off their waste rather than disposing waste in water. Moreover, these collection points would assist with waste sorting at source, promoting recycling and reducing landfill usage and quantity of waste. This initiative could benefit Ba-Phalaborwa Local Municipality and protect water bodies as it will create jobs for recyclers.
- Ba-Phalaborwa Local Municipality should provide storage containers (Skip bins) and disseminate them strategically in the rural areas.
- The municipality should establish local recycling infrastructures in villages to accommodate individuals who cannot afford to travel to the landfill site.
- Ba-Phalaborwa Local Municipality should implement an incentivization programme for waste collection, sorting, and separation. By offering incentives, the municipality can encourage residents and businesses to actively participate in waste management practices, which would contribute to reducing the

mounting pressure of waste accumulation. This approach could promote greater community involvement, improve waste diversion rates, and alleviate the strain on landfill sites, ultimately leading to a cleaner and more sustainable environment.

- Ba-Phalaborwa Local Municipality should establish additional waste treatment facilities to effectively manage the increasing volume of waste generated, considering the growing elite population. The expansion of waste treatment infrastructure will ensure that the municipality is better equipped to handle the rising demand for waste disposal.

REFERENCE

Abas, M.A., Hassain, N.H., Hambali, K.A., Karim, M.F.A., Hussin, H., Ismail, L., & Fitriani, N. (2020). Public satisfaction and willingness to pay (WTP) for better solid waste management services in rural area of Kelantan, Malaysia. *IOP Conference Series: Earth and Environmental Science*, Vol 756, Pp. 1-20.

Abel-Shafy, M., Hussein, I., & Mansour, S.M. (2021). Solid waste issues: Sources, composition, disposal, recycling, and valorisation. *Egyptian Journal of Petroleum*, Vol 27, Pp. 1-17.

Abdul-Hakeem, O.A., Folahanmi, C.F., Babatunde, A.A., Adebola, A.A., Oluwagbemiga, A.O., Ganiyu, A.S., & Aisha, T.A. (2021). Comparisons of respiratory and skin disorders between residents living close to and far from Solous landfill site in Lagos State, Nigeria. *A Journal of Primary Health care & Family Medicine*, Vol 13(1), Pp. 1-12.

Abubakar, I.R., Maniruzzaman, K.M., Dano, U.L., Alshihri, F.S., Alshammari, M.S., Ahmed, S.M.S., & Al-Gehlani, W.A.G. (2022). Environmental sustainability impacts of solid waste management practices in the Global South. *International Journal of Environmental Research and Public Health*, Vol 19, Pp. 1-26.

Abubakar, I.R., Filho, W.L., & Mifsud, M.C. (2023). Governance in the implementation of the UN Sustainable Development Goals in higher education: global trends. *Environment, Development and Sustainability*, Vol 10, Pp. 1-24.

Adedara, M.L., Taiwo, R., & Bork, H.R. (2023). Municipal solid waste collection and coverage rates in Sub-Saharan African countries: A comprehensive systematic review and meta-analysis. *MDPI Waste*, Vol 1, Pp. 1-25.

Adefris, W., Damene, S., & Satyal, P. (2023). Household practices and determinants of solid waste segregation in Addis Ababa city, Ethiopia. *Humanities and Social Sciences Communicators*, Vol 10, Pp. 1-40.

Adekola, P.O., Iyalomhe, F.O., Paczoski, A., Abebe, S.T., Pawlowska, B., Bak, M., & Cirella, G.T. (2021). Public perception and awareness of waste management from Benin City. *Scientific Reports*, Vol 11, Pp. 1-14.

Adeniran, A., Motsatsi, L., Mbanga, S., Ayesu, E., & Shakantu, W. (2023). An investigation of waste management practice in South African Township: A case study of Ekuphumleni Township, Ndlambe Municipality. *IntechOpen*, Vol 10, Pp. 1-25.

Afroz, R. (2021). Factors Affecting Waste Generation: A Study in a Waste Management Program in Dhaka City, Bangladesh. *Environmental Monitoring and Assessment,* Vol 179, Pp. 509-519.

Ahmed, F., Tumon, M.S.H., Rana, M.S., & Sharmin, N. (2022). A conceptual framework for zero waste management in Bangladesh. *International Journal of Environmental Science and Technology*, Vol 20(2), Pp. 1-16.

Akhigbe, S., Udom, G.J., & Nwankwoala, H.O. (2022) Impact of Domestic and Industrial Waste on Surface and Ground Water Quality Within Slaughter Area, Trans-Amadi Industrial Layout, Port-Harcourt, Nigeria. *International Journal Waste Resource*, Vol 8, Pp. 1-327.

Akmal, T., & Jamil, F. (2021). Testing the role of waste management and environmental quality on health indicators using Structural Equation Modelling in Pakistan. *International Journal of Environmental Research and Public Health*, Vol 18, Pp. 1-11.

Akmal, T., & Jamil, F. (2023). Assessing household's municipal waste segregation intentions in Metropolitan Cities of Pakistan: A Structural Equation Modelling Approach. *Environmental Monitoring Assessment*, Vol 195, Pp. 1-20.

Alam, P., & Ahmade, K. (2023). Impact of solid waste on health and the environment. *Journal of Engineering and Technology*, Vol 2(1), Pp. 1-4.

Alemu, M.G., & Estifanos, T.H. (2022). Assessment of attitude and perception of communities towards solid waste disposal and its implication to urban pollution, Sodo Town, SNNPR, Ethopia. *Journal of Energy Technologies and Policy*, Vol 9(7), Pp. 1-10.

Alhassan, H., Kwakwa, P.A., & Owusu-Sekyere, E. (2020). Households' source separation behaviour and solid waste disposal options in Ghana's Millennium City. *Journal of Environmental Management*, Vol 259, Pp. 1-10.

Alvarez, U.R., Benavides, P.T., Lee, U., & Wang, M. (2023). Life-cycle analysis of recycling of post-use plastic to plastic via pyrolysis. *Journal of Cleaner Production*, Vol 425, Pp. 1-25.

Amasuomo, E., & Baird, J. (2020). The concept of waste and waste management. *Journal of Management and Sustainability*, Vol 6(4), Pp. 1-9.

Ambrin, S., Hussain, M., & Gilani, S.A. (2018). Determination of the level of knowledge, attitude and practices regarding household waste disposal among people in rural community of Lahore. *International Journal of Social Sciences and management*, Vol 5(3), Pp. 219-224.

Amkpa, M.R., Annepu, R., & Themelis, N.J. (2023). Analysis of waste management in Accra, Ghana and Recommendations for further Improvements. *International Journal of Economics, Commerce and Management*, Vol 13, Pp.1-4.

Amodu, L., Oresanya, T., Ben-Enukora, C., Omojola, O., & Oyero, O. (2022). Health communication and awareness of waste disposal effects among Ogun State housing Corporation Residents. *International Conference on Education, Social Sciences and Humanities*, Vol 10, Pp. 1-9.

Ampofo, J.A. (2020). Waste disposal management practices in selected senior high schools within the WA Municipality of Ghana. *International Journal of Management and Entrepreneurship Research*, Vol 2(4). Pp. 1-15.

Andeobu, L., Wibowo, S., & Grandhi, S. (2023). Informal E-waste recycling practices and environmental pollution in Africa: What is the way forward? *International Journal of Hygiene and Environmental Health*, Vol 252, Pp. 1-25.

Ao, R., Fei, H., Jiang, L., Cui, Y., & Zhu, S. (2023). How can China achieve its goal of peaking carbon emissions at minimal cost? A research perspective from shadow price and optimal allocation of carbon emissions. *Journal of Environmental Management*, Vol 325, Pp 1- 23.

Ao, Y., Zhu, H., Wang, Y., Zhang, J., & Chang, Y. (2022). Identifying the driving factors of rural residents' household waste classification behaviour: Evidence from Sichuan, China. *Resources, Conservation and Recycling*, Vol 180, Pp 1-12.

Arkorful, V.E., Zhao, S., & Lugu, B. (2022). Investigating household waste separation behaviour: the salience of an integrated norm activation model and the theory of planned behaviour. *Journal of Environmental Planning and Management*, Vol 66(1), Pp. 1-27.

Aslam, S. (2022). Application of material flow analysis for the assessment of current municipal solid waste management in Karachi Pakistan. *Journal for a Sustainable Circular Economy*, Vol 40(2), Pp. 1-15.

Awafo, E.A., Amankwah, E., & Agbalekpor, A. (2023). Assessing solid waste management practices in the Techiman Municipality of Ghana and the potential of recycling for revenue mobilization and reduction of waste menace. *Cogent Social Sciences*, Vol 9, Pp. 1-16.

Awasthi, P., Chataut, G., & Khatri, R. (2023). Solid waste composition and its management: A case study of Kirtipur Municipality-10. *Heliyon*, Vol 9, Pp. 1-10.

Ayeleru, O.O., Fewster-Young, N., Gbashi, S., Akintola, A.T., Ramatsa, I.M., & Olubambi, P.A. (2023). A statistical analysis of recycling attitudes and behaviours towards municipal solid waste management: A case of the University of Johannesburg, South Africa. *Cleaner Waste Systems*, Vol 4, Pp. 1-10.

Azam, M., Jahromy, S.S., Raza, W., Raza, N., Lee, S.S., Kim, K., & Winter, F. (2020). Status, characterisation, and potential utilization of municipal solid waste as a renewable energy source: Lahore case study in Pakistan. *Environment International*, Vol 134, Pp. 1-25.

Azodo, A.P. (2019). Knowledge and awareness implication on E-waste management among Nigerian Collegiate. *Journal of Applied Sciences and Environmental Sciences*, Vol 21(6), Pp. 1-15.

Babazadeh, T., Ranjbaran, S., Kouzekanani, K., Nerbin, A., Heizomi, H., & Ramazani, M.E. (2023). Determinants of waste separation behaviour Tabriz, Iran: An application of the theory of planned behaviour at health centre. *Frontiers in Environmental Science*, Vol 11, Pp. 1-35.

Bachok, N., Omar, S., Naing, N., & Sarimah, A. (2020). Community health survey of residemts living near a solid waste open dumpsite in Sabak, Kelantan, Malaysia. *International Journal of Environmental Research and Public Health*, Vol 7, Pp. 1-14.

Bagastyo, G.H., Satriyono, R.D., & Ramadani, D.S. (2023). Residentials' household intention to utilize their food waste: A case study in Solo Indonesia. *IOP Conference Series Earth and Environmental Science*, Vol 1256(1), Pp. 1-11.

Bailey, K., Basu, A., & Sharma, S. (2022). The environmental impacts of fast fashion on water quality: A systematic review. *MDPI Water*, Vol 14, Pp. 1-11.

Bangani, L., Kabiti, H.M., Amoo, O., Motebang, D.V.N., & Magayiyana, Z. (2023). Impacts of illegal solid waste dumping on the water quality of Mthatha. *Water Practice and Technology*, Vol 18, Pp. 1-11.

Ba-Phalaborwa Local Municipality Integrated Development Plan (2022). Reviewed Integrated Development Plan for 2022/2023-2027. [Accessed on 07January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjoz8jomYiEAxUFQUEAHWKfDcUQFnoECB0QAQ&url=https%3A%2F%2Fwww.phalaborwa.gov.za%2Fdocs%2Fnotices%2FDRAFT%25202022-23%2520IDP%2520-%252031%2520MARCH%2520APPROVED.pdf&usg=AOvVaw17lJl5kaaj-e3noqxUuQ2B&opi=89978449

Ba-Phalaborwa Local Municipality (2008). Ba-Phalaborwa Local Municipality: Waste Management by-laws, South Africa. [Accessed on 07 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwivmrrnmoiEAxXXU0EAHWLABfMQFnoECCsQAQ&url=http%3A%2F%2Fmfma.treasury.gov.za%2FDocuments%2F06.%2520Annual%2520Reports%2F2008-09%2F02.%2520Local%2520Municipalities%2FLIM334%2520Ba-Phalaborwa%2FLIM334%2520BaPhalaborwa%2520ANNUAL%2520REPORT%25202008-09.pdf&usg=AOvVaw2od5rywfcS9YUBCa3LCgO1&opi=89978449

Ba-Phalaborwa Local Municipality (2022). Ba-Phalaborwa Local Municipality: Waste Management by-laws, South Africa. [Accessed on 07 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjoz8jomYiEAxUFQUEAHWKfDcUQFnoECB0QAQ&url=https%3A

%2F%2Fwww.phalaborwa.gov.za%2Fdocs%2Fnotices%2FDRAFT%25202022-23%2520IDP%2520-%252031%2520MARCH%2520APPROVED.pdf&usg=AOvVaw17lJl5kaaj-e3noqxUuQ2B&opi=89978449

Barr, S., Gilg, A.W., & Ford, N.J. (2023). A conceptual framework for understanding and analysing attitudes towards household waste management. *Environmental and Planning*, Vol 33, Pp. 1-24.

Bashir, L., Lone, F.A., Bhat, R.A., Shafat, A.M., Zubair, A.D., & Ahmad, S.D. (2021). Concerns and threats of contamination on aquatic ecosystems. *Bioremediation and biotechnology*, Vol 5, Pp. 1-26.

Batool, F., Kurniawan, T.A., Mohyuddin, A., Othman, M.H.D., Aziz, F., Al-Hazmi, H.E., Goh, H.H., & Anouzla, A. (2023). Environmental impacts of food waste management technologies: A critical review of Life Cycle Assessment (LCA) studies. *Trends in Food Science & Technology*, Vol 143, Pp. 1-19.

Bazaanah, P., & Mothapo, R.A. (2024). Sustainability of drinking water and sanitation delivery systems in rural communities of the Lepelle Nkumpi Local Municipality, South Africa. *Environment, Development and Sustainability*, Vol 26, Pp. 14223-14255.

Bezuidenhout, K. (2023). Climate change mitigation at city level through the lens of South Africa's regulatory framework for bioenergy. *PER/PELJ*, Vol 26, Pp. 1-32.

Bhat, S., & Quayoom, U. (2021). Implications of waste disposal on freshwater ecosystems. *IntechOpen*, Vol 10, Pp.1-19.

Bhat, R.A., Singh, D.V., Quadri, H., Dar, G.H., Dervash, M.A., Bhat, A.S., Unal, B.T., Ozturk, M., Hakeem, K.R., & Yousaf, B. (2022). Vulnerability of municipal solid waste: An emerging threat to aquatic ecosystems. *Chemosphere*, Vol 287, Pp. 1-13.

Bhatia, A., & Sharma, S. (2023). Identifying determinants of household food waste behaviour in urban Indian. *Cleaner Waste Systems*, Vol 6, Pp. 1-9.

Bourget, G. (2023). Statistical analysis of wastewater treatment plant data. *SN Applied Sciences*, Vol 5, Pp. 1-12.

Boston University School of Public Health (2022). How Discarded Clothes Impact Public Health and the Environment. *Environmental Racism*. [Accessed on 08 January 2024], Available online:

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjN2_uBnYiEAxWwbEEAHZkTBOEQFnoECAgQAQ&url=https%3A%2F%2Fwww.bu.edu%2Fsph%2Fnews%2Farticles%2F2022%2Fthe-aftermath-of-fast-fashion-how-discarded-clothes-impact-public-health-and-the-environment%2F&usg=AOvVaw2SeeMBc3aypPQ_uQIpCDfl&opi=89978449

Bowan, P.A., & Ziblim, S. (2021). Households' knowledge, attitudes and practices towards municipal solid waste disposal. *Journal of Studies in Social Sciences*, Vol 19(6), Pp. 1-18.

Brandt, A.A. (2017). Illegal Dumping as an Indicator for Community Social Disorganization and Crime. *MSc thesis* at San Jose State University, Pp. 45-50.

Braveman, P.A., Arkin, E., Proctor, D., Kauh, T., & Ham, N. (2022). Systematic and structural racism: Definitions, examples, heath damages, and approaches to dismantling. *Health Affairs: Health Equity*. Vol 41(2). Pp. 1-25.

Bricker, N. (2020). Municipal solid waste management: A case study in Istanbul, Turkey. *Chemosphere*, Vol 3, Pp. 1-8.

Brooke, A., & Fenner, R.A. (2023). Improving urban water management and building water supply resilience in the city of Harare, Zimbabwe. *Civil Engineering and Environmental Systems*, Vol 10, Pp. 1-30.

Brown, J., & Sako, D. (2019). 100 Solutions for Climate Action in Cities. *Council for Scientific and Industrial Research*, Vol 14, Pp. 6-9.

Bukova, M., Bondal, A., Skvortsova, O., Nikonova, O., Kholodiakov, A., Guseva, I., & Mirschel, W. (2019). Reclamation of the illegal dump for sustainable development the environment in Sverdlovo of Leningrad Oblast', Russia. *MATEC Web of Conferences*, Vol 73, Pp. 25-45.

Cao, J., Qiu, H., & Morrison, A.M. (2023). Self-identity matters: An extended theory of planned behaviour to decode tourists' waste sorting intentions. *International Journal of Environmental Research and Public Health*, Vol 20, Pp. 1-19.

Capassao, A., Tiwari, R.T., & Dutta, D. (2023). A critical review and future perspective of plastic waste recycling. *Science of the total environment*, Vol 881, Pp. 1-9.

Castro, C., Chitikova, E., Magnani, G., Merkle, J., & Heitmayer, M. (2023). Less is more: Preventing household food waste through an integrated mobile application. *MDPI Sustainability*, Vol 15(13), Pp. 1-23.

Census, (2011). [Accessed on 10 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiw0tDAzYmEAxWIUkEAHRIxBvsQFnoECBQQAQ&url=https%3A%2F%2Fwww.statssa.gov.za%2F%3Fpage_id%3D3839&usg=AOvVaw1c6xMlb2S4AltJYHVZ4EIR&opi=89978449

Chambers, T., Douwes, J., Mannetje, A., Woodward, A., Baker, M., Wilson, N., & Hales, S. (2022). Nitrate in drinking water and cancer risk: the biological mechanisms, epidemiological evidence and feature research. *Australian and New Zealand Journal of Public Health*, Vol 46(2), Pp. 105-108.

Chandler, A.J., Eighmy, T.T., & Harhen, J. (2022). Municipal solid waste incinerator residues. *Studies in Environmental Residues*, Vol 25, Pp. 1-30.

Chen, H.L. (2021). The plastic waste problem in Malaysia: management, recycling and disposal of local and global plastic waste. *Discover Applied Sciences*, Vol 3(437), Pp. 5-20.

Chen, X., Pang, J., Zhang, Z., & Li, H. (2021). Sustainability Assessment of Solid Waste Management in China: A Decoupling and Decomposition Analysis. *MDPI Sustainability*, Vol 6, Pp.9268-9281.

Chen, G., Zhuang, Y., & Govindan, K. (2022). Analysis of factors influencing residents' waste sorting behaviour: A case study of Shanghai. *Journal of Cleaner Production*, Vol 349, Pp. 1-11.

Chen, M., Wang, H., & Zhang, R. (2023). Using the extended theory of planned behaviour to predict privacy-protection behavioural intentions in the Big Data Era: The role of privacy concern. *SHS Web of Conferences*, Vol 155, Pp. 1-6.

Chengqin, E.K., Zailani, S., Rahman, M.K., & Aziz, A.A. (2022). Determinants of household behavioural intention towards reducing, reusing and recycling food waste management. *Nankai Business Review International*, Vol 10, Pp. 1-13.

Chikowore, N. (2021). Factors influencing household waste management practices in Zimbabwe. *Springer Link*, Vol 23, Pp. 386-393.

Chikukula, A.A., Omokaro, G.O., Osazemen, O.G., Saeed, Y.C., Mabangwe, H.S., & Kaisi, I. (2024). Problems and possible solutions to municipal solid waste management in Malawi urban areas – an overview. *Asian Journal of Environment & Ecology*, Vol 23(6), Pp. 42-52.

Chinyere, O., Sanusi, Y., & Anafi, F. (2023). Assessment of the physio-chemical quality of Uturu section of Aku River in Southeastern Nigeria. *Nigerian Journal of Technology (NIJOTECH)*, Vol 42(2), Pp. 1-8.

Chukwuone, N.A., Amaechina, E.C., & Ifelunini, I.A. (2022). Determinants of household's waste disposal practices and willingness to participate in reducing the flow of plastics into the ocean: Evidence from coastal city of Lagos Nigeria. *PLoSONE*, Vol 17(4), Pp. 1-30.

Cohen, M., & Wartofsky, I. (2021). History, philosophy, and science teaching. *Springer Singapore*. Vol 507. Pp. 1-12.

Craswell, E., Singh, B., & Chong, S. (2021). Fertilisers and nitrate pollution of surface and groundwater: An increasingly pervasive global problem. *Discover Applied Sciences*, Vol 3(518), Pp. 1-33.

Debrah, J.K., Vidal, D.G., & Dinis, M.A.P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *MDPI Recycling*, Vol 6(6), Pp. 1-21.

Dehghani, M.H., Omrani, G.A., & Karri, R.R. (2021). Solid waste – sources, toxicity, and their consequences to human health. *Soft Computing Technique in Solid Waste and Wastewater Management*, Vol 10, Pp. 205-213.

Department of Environmental Affairs (2023). Notice 278 of 2009, National Environmental Management: Waste Act 59 of 2008, South Africa. [Accessed on 11 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjqx_n714mEAxUSV0EAHalFAxsQFnoECB0QAQ&url=https%3A

%2F%2Fwww.dffe.gov.za%2Flegislation%2Fgazetted_notices&usg=AOvVaw1uwjaY6wwHfGhbHVTa0eIk&opi=89978449

Department of Environmental Affairs (2023). Notice 293 of 2009, National Environmental Management: Waste Act 59 of 2008. South Africa. [Accessed on 11 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjqx_n714mEAxUSV0EAHalFAxsQFnoECB0QAQ&url=https%3A%2F%2Fwww.dffe.gov.za%2Flegislation%2Fgazetted_notices&usg=AOvVaw1uwjaY6wwHfGhbHVTa0eIk&opi=89978449

Department of Environment, Forestry and Fisheries (DEFF). National Waste Management Strategy; the Department of Environment, Forestry and Fisheries: Pretoria, South Africa, (2020), Pp. 1–70. [Google Scholar]

Department of Water and Sanitation (2023). National Water Act (36 of 1998). South Africa. [Accessed on 11 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwinwYCo2YmEAxVJU0EAHcm7CEgQFnoECBAQAw&url=https%3A%2F%2Fwww.dws.gov.za%2Fiwqs%2Fnwa%2Findex.html&usg=AOvVaw0-g6llL-q_070oHF8NxV5d&opi=89978449

Desa, A., Kadir, N.B.A., & Yusooff, F. (2023). A study on the knowledge, attitudes, awareness status and behaviour concerning solid waste management. *Procedia Social and Behavioural Sciences*, Vol 18, Pp. 1-6.

Devianti, D., Yusmanizar, Y., Syakur, S., Munawar, A.A., & Yunus, Y. (2021). Organic fertilizer from agricultural waste: determination of phosphorus content using near infrared reflectance. *IOP Conf. Series: Earth and Environmental Science*, Vol 644, Pp. 1-10.

Dimkpa, G.C., Ikechukwu, N.S.D., Nwolim, J.P., Nwikasi, K., & Obia, J.C. (2023). Assessment of solid waste management strategies in Elele community, Ikwerre Local Government Area, River state, Nigeria. *Saudi Journal of Medical and Pharmaceutical Sciences*, Vol 9(4), Pp. 258-269.

Dong, H., Xiao, S., Geng, Y., Pan, H., & Wu, F. (2020). An overview of the municipal solid waste management modes and innovations in Shanghai, China. *Environmental Science and Pollution Research*, Vol 27, Pp. 29943-29953.

Donuma, K.U., Ma, L., Bu, C., Lartey-Young, G., Gashau, M., & Suleima, A.O. (2024). Environmental and human health risks of indiscriminate disposal of plastic waste and sachet water bags in Maiduguri, Borno State Nigeria. *Waste Managament Bulletin*, Vol 2, Pp. 130-139.

Dor, A.B., Scavarda, L.F., & Fuss, M. (2021). Improving urban household solid waste management in developing countries based on the German experience. *MDPI Waste Management*, Vol 120, Pp. 772-783.

Du, X., Niu, D., Wang, X., & Bi, Z. (2023). City classification for municipal solid waste prediction in mainland China based on k-means clustering. *MDPI Waste Management*, Vol 144, Pp. 445-453.

Duque, G., Gamboa-Garcia, D.E., Molina, A., & Cogua, P. (2021). Influence of water quality on the macroinvertebrates community in a tropical estuary (Buenaventura Bay). *Integrated Environmental Assessment and Management*, Vol 18, Pp. 1-17.

Dzawanda, B., Moyo, G.A., & Bi, Z. (2022). Challenges associated with household Solid Waste Management (SWM) during Covid-19 lockdown period: A case of ward 12 Gweru city Zimbabwe PMC. *Environmental Monitoring and Assessment*, Vol 194(7), Pp. 1-20.

Edokpayi, J.N., Nkhumeleni, M., Abimbola, M., & Olaniyi, F.C. (2020). Water quality assessment and potential ecological risk of trace metals in sediments of some selected rivers in Vhembe district, South Africa. *Physics and Chemistry of the Earth, Part A/B/C*, Vol 126, Pp. 1-20.

Elbeltagi, M., Saeed, N.K., & Bediwy, A.S. (2021). Role of gastrointestinal health in managing children. *World Journal of Clinical Paediatrics*, Vol 12(4), Pp. 171-196.

Environmental Protection Agency: Washington, DC, USA, 2020. [Accessed on 14 January 2024]. Available online: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=350369

Erhabor, N.I. (2023). Impact of environmental education on the knowledge and attitude of University of Benin students towards waste segregation. *Qeios*, Vol 4, Pp. 1-15.

Eshete, H., Desalegn, A., & Tigu, F. (2023). Knowledge, attitudes and practices on household solid waste management and associated factors in Gelemso town, Ethiopia. *PLoSONE*, Vol 18(2), Pp. 1-13.

Fadhullah, W., Imran, N.I., Ismail, S.N.S., Jaafar, M.H., & Abdullah, H. (2022). Household solid waste management practices and perceptions among residents in the East Coast of Malaysia. *BMC Public Health*, Vol 22(10), Pp. 1-20.

Fang, W., Ding, Y., Geng, J., Liu, Z., Huang, Y., Yang, J., Ma, Z., Liu, J.B.J., & Liu, M. (2023). High potential of coupling the source-separation and incineration promotion to reduce costs based on city level cost-benefit analysis of municipal solid waste management strategies in China. *Resources, Conservation and Recycling*, Vol 197, Pp. 1-40.

Fazzo, L., Manno, V., Iavarone, I., Minelli, G., De-Santis, M., Beccaloni, E., Scaini, F., Miotto, E., Airoma, D., & Comba, P. (2023). The health impact of hazardous waste landfills and illegal dumps contaminated sites: An epidemiological study at ecological level in Italian Region. *Frontiers*, Vol 11, Pp. 1-10.

Fedi, K., Hashmi, M.Z., & Jamil, N. (2021). Microbial and enzymatic degradation of PCBs from e-waste contaminated sites. *Environmental Science and Pollution Research*, Vol 2, Pp. 1-25.

Ferronato, N., & Torretta, V. (2020). Waste mismanagement in developing countries: A review of global issues. *International Journal of Environmental Research and Public Health*, Vol 16(6):1060, Pp.7-10.

Fikadu, S.D., Sadore, A.A., Agafari, G.B., & Agide, F.D. (2022). Intention to comply with solid waste management practices among households in Butajira town, Southern Ethiopia using the theory of planned behaviour. *PLoS ONE*, Vol 17(7), Pp. 1-15.

Flores, M.L. (2021). Program to improve public awareness on solid waste collection in the San Carlos neighbourhood, Huancayo. *Production and Management*, Vol 24(2), Pp. 193-216.

Gangoo, V., Bauza, V., Clasen, T., & Medlicott, T. (2023). Municipal solid waste management and adverse health outcomes: A systematic Review. *BMC*, Vol 18(8), Pp. 1-25.

Garcia-Valinas, M., Arbues, F., & Balado-Naves, R. (2023). Assessing environmental profiles: An analysis of water consumption and waste recycling habits. *Efficiency Series Paper*, Vol 2, Pp. 1-18.

Ge, J., & Liu, B. (2022). Recovery and reuse of waste. Journal of cleaner production, Vol 368, Pp. 1-40.

Gherhes, V., Farcasiu, M.A., & Para, L. (2022). Environmental problems: An analysis of students' perceptions towards selective waste collection. *Frontiers*, Vol 12, Pp. 1-20.

Ghulam, S.T. (2022). Challenges and opportunities in the management of electronic waste and its impact on human health and environment. *MDPI Sustainability*, Vol 15(3), Pp. 1-15.

Gibbons, P.N., Hait, S., & Hussain, C.M. (2022). Challenges, opportunities, strategies of waste management towards sustainability. *Advanced Organic Waste Management*, Vol 10, Pp. 473-490.

Giri, M., Behera, M.R., Behera, D., Mishra, B., & Jana, D. (2022). Water, sanitation and hygiene practices and their association with childhood diarrhoea in rural households' of Mayurbhanj District, Odisha, India. *BMC*, Vol 14(10), Pp. 1-14.

Giri, I., Ritika, K.C., & Khadka, U.R. (2022). Water quality status in Bagmati River of Kathmandu Valley, Nepal. *Ecological Significance of River Ecosystems*, Vol 23, Pp. 481-502.

Gleick, P.H., & Cooley, H. (2021). Freshwater scarcity. *Annual Review of Environment and Resources*, Vol 46, Pp. 319-348.

Glen, R. (2020). Recycling rubber tyres in construction materials and associated environmental consideration. *Resources, Conservation and Recycling*, Vol 155, Pp. 1-25.

Gqomfa, B., Maphanga, T., & Shale, K. (2022). The impact of informal settlement on water quality of Diep River in Dunoon. *Sustainable Water Resources Management*, Vol 8(27), Pp. 1-18.

Grangxabe, X.S., Maphanga, T., Madonsela, B.S., Gqomfa, B., Phungela, T.T., Malakane, K.C., Thamanga, K.H., & Angwenyi, D. (2023). The escalation of informal settlement and the high levels of illegal dumping Post-Apartheid: Systematic Review. *MDPI Challenges*, Vol 14, Pp. 1-15.

Grobler, L., Schenck, R., & Chitaka, T.Y. (2022). Waste management, littering and illegal dumping: A Literature Review. *Council for Scientific and Industrial Research*, Pp. 1-192.

Grout, L., Chambers, T., Hales, S., Prickett, M., Baker, M.G., & Wilson, N. (2023). The potential human health hazard of nitrates in drinking water: A media discourse analysis in a high-income country. *Environmental Health*, Vol 22, Pp. 1-9.

Guangyu, Y. (2021). Disposal of solid wastes, point sources of pollution. *Local effects and its control*, Vol 1, Pp. 1-10.

Guerrero, L.A., Mass, G., & Hogland, K. (2022). Solid waste management challenges for cities in developing countries. *Waste Management*, Vol 30, Pp. 220-232.

Gupta, A.I., Chi, H.N., Mistoh, M.A., & Galassi, A. (2023). Plastic waste issues in Southeast Asia. *Frontiers*, Vol 11, Pp. 1-20.

Gutberlet, J., Jayme de Oliveira, B., & Tremblay, C. (2020). Arts-based and participatory action research with recycling cooperatives. In: Rowell, L., Bruce, C., Shosh, J., Riel, M., editors. *The Palgrave International Handbook of Action Research*, *New York: Palgrave Macmillan*, Pp. 699–715.

Gumeneez, A., Jamil, H.F., & Ahmed, A.E. (2023). An overview of solid waste management and privatization in Kingdom of Bahrain. *Frontiers*, Vol 11, Pp. 1-18.

Haas, S. (2023). Transboundary movement of waste of electrical and electronic equipment: The problem of illegal environmental dumping from an EU and South Africa perspective. *Graz Law Working Paper*, Vol 3, Pp. 1-25.

Habibur, K., Elham, M., & Sohani, V.W. (2023). A first comprehensive estimate of electronic waste in Canada. *Journal of Hazardous Materials*, Vol 448, Pp. 1-13.

Hage, O., Soderholm, P., & Berglund, C. (2022). Norms and economic motivation in household recycling: Empirical evidence from Sweden. *Resources, Conservation and Recycling*, Vol 53(3), Pp. 155-165.

Han, X., Chen, X., Ma, J., Chen, J., Xie, B., Yin, W., Yang, Y., Jia, W., Xie, D., & Huang, F. (2022). Discrimination of Chemical Oxygen Demand pollution in surface water based on visible Near-Infrared Spectroscopy. *MDPI Water*, Vol 14(3003), Pp. 1-14.

Handayani, D. (2022). How does household characteristics influence their waste management? *ICSoLCA*, Vol 74, Pp. 1-5.

Hameed, I., Khan, K., Waris, I., & Zainab, B. (2020). Factors influencing the sustainable consumer behaviour concerning the recycling of plastic waste. *Environmental Quality Management*, Vol 32(4), Pp. 1-34.

Haywood, L.K., Kapwata, T., Oelofse, S., Breetzke, G., & Wright, C.Y. (2021). Waste disposal practices in low-income settlement of South Africa. *International Journal of Environmental Research and Public Health*, Vol 18, Pp. 1-12.

Heddam, A. (2023). Household hazardous waste. *River COG*, Vol 10, Pp. 1-10.

Heyasa, R., & Ifegbesan, A. (2023). Waste management awareness, knowledge, and practices of secondary school teachers in Ogun State, Nigeria-implications for teacher education. *Journal of Solid Waste Technology Management*, Vol 37, Pp. 221–234.

Hilburn, A. (2021). "At Home or to the Dump? Household Garbage Management and the Trajectories of Waste in a Rural Mexican Municipio," *Journal of Latin American Geography*, Vol 14(2), Pp. 1-19.

Horiguchi, H., Shigemura, K., Kitakawa, M., Nakazawa, M., Noyori, T., Inoue, M., Onishi, R., Moriwaki, M., Yoshimura, C., Kobayashi, M., & Suzaki, T. (2023). Electrical conductivity as an indicator to assess the sustainability of river water for recreational use. *Journal of Water and Environment Technology*, Vol 21(4), Pp. 204-212.

Hossain, M.U., Ng, T.S., Dong, Y., & Amor, B. (2021). Strategies for mitigating plastic wastes management problem: A lifecycle assessment study in Hong Kong. *Waste Management,* Vol 131, Pp. 412-422.

Hu, Z., Ding, Y., Zhao, J., Liu, J., & Zhou, J. (2021). A review of china's Municipal Solid Waste (MSW) and comparison with international regions: Management and technologies in treatment and resources utilization. *Journal of Cleaner Production*, Vol 293, Pp. 1-33.

Huber, D. (2024). The establishment of an absorbent hygiene product waste collection system in two informal settlements in South Africa. *Global Health Engineering*, Pp. 1-51.

Ichipi, E.B., & Senekane, M.F. (2023). An evaluation of the impact of illegal dumping of solid waste on public health in Nigeria: A case study of Lagos State. *International Journal of Environmental Research and Public Health*, Vol 20, Pp. 1-12.

Ifyalem, K.J., & Jakada, Z.A. (2023). The influence of housing and waste management facilities on public health. *Journal of Materials and Environmental Sciences*, Vol 14(1), Pp. 62-81.

Ikiriko, T.D., Enwin, A.D., Johnbull, S.W., Udom, M.E.L., & Nwokaeze, E.C. (2023). Assessing residents' satisfaction with waste management approaches in Port Harcourt Metropolis. *International Journal of Research and Review*, Vol 10(11), Pp. 1-11.

Iloms, E., Ololade, O.O., Ogola, H.J., & Selvarajan, R. (2020). Investigating industrial effluent impact on Municipal Wastewater Treatment Plant in Vaal, South Africa. *International Journal of Environmental Research and Public Health*, Vol 17(3), Pp. 1-15.

Ingrao, C., Strippoli, R., Lagioia, G., & Huisingh, D. (2023). Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. *Heliyon*, Vol 9(8), Pp. 1-20.

Iravanian, A. (2020). Types of contamination in landfills and effects on the environment: A Review Study. *IOP Conference Series Earth and Environmental Science*, Vol 614(1), Pp. 1-19.

Isiuku, B.O., & Enyoh, C.E. (2020). Pollution and health risks assessment of nitrate and phosphate concentrations in water bodies in Southeastern, Nigeria. *Environmental Advances*, Vol 12, Pp. 1-8.

Islam, S. (2021). Waste management strategies in the fashion and textiles industry: Challenges are in governance, materials culture, and design centric. *The Textile Institute Book Series*, Vol 10, Pp. 275-293.

Islam, T.M., Huda, N., Baumber, A., Hossain, R., & Sahajwalla, H. (2021). Waste battery disposal and recycling behaviour: A study on the Australian perspective. *Environmental Science and Pollution Research*, Vol 29, Pp. 58980-59001.

Jain, N., Yevatikar, R., & Raxamwar, T.S. (2022). Comparative study of physio-chemical parameters and water quality index of river. *Materials Today: Proceedings*, Vol 60, Pp. 859-867.

Jakeni, Y., Maphanga, T., Madonsela, B.S., & Malakane, K.C. (2024). Identification of illegal dumping and community views in informal settlements, Cape Town: South Africa. *MDPI Sustainability*, Vol 6(4), Pp. 1-14.

Janicka, M.D., Koda, E., & Winkler, J. (2022). Municipal solid waste landfill: Evidence of the effect of applied landfill management on vegetation composition. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, Vol 40(9), Pp. 1-12.

Jeremias, H.I., Gitter, A., & Longe, E.O. (2019). Knowledge, awareness, perceptions and practices on waste management. *Frontiers*, Vol 11, Pp. 1-15.

Jewaskiewitz, S. (2021). Challenges facing municipalities in waste management. *Sabinet African Journal*, Vol 23(2), Pp. 1-9.

Ji, C., Kong, C., Mei, Z., & Li, J. (2022). A review of solid waste management. *Applied Biochemistry and Biotechnology*, Vol 183, Pp. 906-922.

Jia, Q., Islam, S.M., Hossain, M.S., & Li, F. (2023). Understanding residents' behaviour intention of recycling plastic waste in a densely populated megacity of emerging economy. *Heliyon*, Vol 9, Pp. 1-11.

Jiang, P., Fan, Y.V., & Klemes, J.J. (2021). Data analytics of social media publicity to enhance household waste management. *Resources, Conservation and Recycling*, Vol 164, Pp. 1-11.

Joubert, K. (2021). The effect of illegal dumping on surface water quality using diatoms as a bioindicator. *MSc Thesis at North-West University*, Pp. 1-128.

Kadyamadare, G., & Samson, M. (2023). Thinking households – How residents' conceptualisations of waste, reclaimers, and separation at source shape recycling practices. *Urban Forum*, Vol 35, Pp. 25-46.

Kadyamadare, G., Samson, G., & Moore, S.A. (2023). Assessment of waste separation at source by residential households as a tool for sustainable waste practices: A case study of the city of Johannesburg. *MSc Thesis at University of Witwatersand*, Pp. 1-108.

Kala, K., Nomesh, N.B., & Sushil, P. (2020). Effects of socio-economic factors on quantity and type of municipal solid waste. *Management of Environmental Quality: An International Journal*, Vol 11, Pp. 1-16.

Kala, K., Bolia, N.B., & Sushil, P. (2020). Waste management communication policy for effective citizen awareness. *Journal of Policy Modeling*, Vol 42(3), Pp. 661-678.

Kalina, M., Makwetu, N., & Tilley, E. (2023). "The rich will always be able to dispose of their waste": A review from the frontlines of municipal failure in Makhanda, South Africa. *Environment, Development and Sustainability*, Vol 9, Pp. 3-12.

Kalonde, P.K., Chisale, A.A., Mandevu, T., Banda, P.J., Banda, A., Stanton, M.C., & Zhou, M. (2023). Determinants of household waste disposal practices and implications for practical community interventions: Lessons from Lilongwe. *Environmental, Resource, Infrastructure and Sustainability*, Vol 3, Pp. 1-12.

Kamboj, V., Kamboj, N., & Bisht, A. (2021). An overview of water quality indices as promising tools for assessing the quality of water resources. *Environmental Pollution Management: Wastewater Impacts and Treatment Technologies*, Vol 13, Pp. 1-28.

Kanchan, T., & Neelu, H. (2020). Expert systems for solid waste management: A review. *International Review on Computers and Software*, Vol 7(4), Pp. 1608-1613.

Kawamoto, K., Urashima, K., & Kancha, T. (2023). Restoration and recovery technologies for illegal dumping of waste pollution. *Science and Technology Trends; NISTEP Science and Technology Foresight Center: Tokyo, Japan*, Vol 21, Pp. 1-15.

Kekana, H.N., Ruhiiga, T.M., Ndou, N.N., & Palamuleni, L.G. (2023). Environmental justice in South Africa: The Dilemma of informal settlement residents. *GeoJournal*, Vol 88, Pp. 3709-3725.

Khan, H.R.B., Ahsan, A., Imteaz, M., Shafiquzzaman, M., & Al-Ansari, N. (2023). Evaluation of the surface water quality using global water quality index (WQI) models: Perspective of river water pollution. *Scientific Reports*, Vol 13, Pp. 1-15.

Khan, M., Omer, T., Ellahi, A., Rahman, Z.U., Niaz, R., & Lone, S.A. (2023). Monitoring and assessment of heavy metal contamination in surface water of selected rivers. *GeoCarto International*, Vol 38(1), Pp. 1-19.

Kimani, A. (2020). GIS Mapping of community perceptions of illegal waste dumping in Mbekweni, PAARL. *MSc Thesis at University of Western Cape*, Pp. 1-200.

Knutton, M. (2023). Balancing mining and the environment: South Africa's legal framework concerning pollution caused by mining, with examples from the West Rand and Emalahleni. *Master of Law at Stellenbosch University*, Pp. 1-43.

Kodua, T.T., & Anaman, K.A. (2020). Indiscriminate open space solid waste dumping behaviour of householders in the Brong-Ahafo region of Ghana: a political economy analysis. *Cogent Environmental Science*, Vol 6(1), Pp. 1-20.

Kofi, J.D., Guedes, D.V., & Dinis, M.A.P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *MDPI Recycling*, Vol 6(1), Pp. 1-22.

Kokoeva, A., Borukaev, T., Molova, Z., Baziev, I., & Zhidkov, R. (2023). Obtaining fertilizers from organic waste. *BIO Web of Conferences*, Vol 67, Pp. 1-8.

Kombiok, E., Nyamekye, K.A., Adjei, R., & Danquah, L. (2022). Determinants of unsafe plastic waste disposal among households in the Tamale Metropolitan Area, Ghana. Journal of Environmental and Public Health, Vol 3, Pp. 1-6.

Kona, R., Sharma, J.K., Singh, R., & Rawat, L. (2023). Disposal practices and awareness of medicine waste management among general population of Delhi-National Capital Region, India. *Journal of Applied Pharmaceutical Science*, Vol 12(01), Pp. 1-6.

Kormoker, T., Islam, S.M., Siddique, M.A.B., Kumar, S., Phoungthong, K., Kabir, M.H., Iqubal, K.F., Kumar, R., Ali, M.M., & Islam, A.R.M.T. (2023). Layer-wise physicochemical and elemental distribution in an urban river water, Bangladash:

Potential pollution, sources, and human health risk assessment. *Environmental Science Advances, Royal Society of Chemistry*, Vol 12 (1382), Pp. 1-17.

Kownacki, A., & Szarek-Gwiada, E. (2022). The impact of pollution on diversity and density of benthic macroinvertebrates in mountain and Upland Rivers. *MDPI Water*, Vol 14, Pp. 1-16.

Kubanza, N.S. (2024). Analysing the challenges of solid waste management in low-income communities in South Africa: A case study of Alexandra, Johannesburg. *South African Geographical Journal*, Vol 10, Pp. 1-11.

Kubanza, N.S. (2020). The role of community participation in solid waste management in Sub-Saharan Africa: A study of Orlando East Johannesburg, South Africa. *South African Geographical Journal*, Vol 103(1), Pp. 1-14.

Kumar, M., & Prakash, V. (2020). A review on solid waste: Its impact on air and water quality. *Journal of Pollution Effects and Control*, Vol 8, Pp. 1-3.

Kumar, P., Sonowal, K., & Gulia, S. (2022). Sustainable municipal solid waste management in India. *Journal of Environmental and Public Health*, Vol 4, Pp. 1-10.

Kummu, M., Guillaume, J.H.A., & Eisner, S. (2016). The world's road to water scarcity: Shortage and stress in the 20th century and pathways towards sustainability. *Scientific Reports*, Vol 6(1), Pp. 1-7.

Kusari, L. (2019). Waste disposal impacts on surface water quality. *Waste Technology (WasTech)*, Vol 7(1), Pp. 1-5.

Kushwah, S., Gokarn, S., Ahmad, E., & Pant, K.K. (2023). An empirical investigation of household's waste separation intention: A dual factor theory perspective. *Journal of Environmental Management*, Vol 329, Pp. 1-13.

Kwakye, S.O., Amuah, E.E.Y., Ankoma, K.A., Agyemang, E.B., & Owusu, B.G. (2024). Understanding the performance and challenges of solid waste management in an emerging megacity: Insights from the developing world. *Environmental Challenges*, Vol 14, Pp. 1-14.

Labib, O., Manaf, L., Hamzah, A.S., & Zaid, S.S.M. (2021). Moderating effects on residents' willingness in waste sorting to improve waste handling in Dammam City, Saudi Arabia. *MDPI Recycling*, Vol 6(2), Pp. 1-24.

Laili, F.N., & Kristanto, G.A. (2021). Household hazardous waste identification in rural and urban areas (Case study: Belotan Village, Magetan and Cikarang Baru Housing, Bekasi, Indonesia). *Journal of Physics: Conference Series*, Vol 1845, Pp. 1-8.

Lazo, M., Puga, I., Macias, M.A., Barragan, A., & Rivas, A. (2023). Mechanical and thermal properties of polyisocyanurate rigid foams reinforced with agricultural waste. *Case Studies in Chemical and Environmental Engineering*, Vol 8, Pp. 1-15.

Lemanski, C. (2024). Chapter 21: Infrastructural citizenship in post-networked contexts: hybridity in South Africa. *EE Elgaronline*, Pp. 323-338.

Le Moal, M., Chantal, G., Alain, M., & Yves, S. (2022). Eutrophication: A new wine in an old bottle. *Science of the Total Environment*, Vol 651(1), Pp. 1-11.

Leong, S., Lee, S., Koh, T., & Ang, D.T. (2023). 4R of rubber waste management: Current and outlook. *Journal of Material Cycles and Waste Management*, Vol 25, Pp. 37-51.

Li, F., Guo, Z., Mao, L., Feng, J., Huang, J., & Tao, H. (2023). Impact of textile industries on surface water contamination by Sb and other potential toxic elements: A case study in Taihu, Lake Basin, China. *MDPI International Journal of Environmental Research and Public Health*, Vol 20(3600), Pp. 1-15.

Li, V., Dakar, K., Varjani, S., & Bui, X. (2022). Solid waste management techniques: Research trends and challenges. *Science of the Total Environment*, Vol 891, Pp. 1-12.

Li, Y., Zhao, R., Li, H., Song, W., & Chen, H. (2023). Feasibility analysis of municipal solid waste incineration for harmless treatment of potentially virulent waste. *MDPI Sustainability*, Vol 15, Pp. 1-21.

Lin, L., Yang, H., & Xu, X. (2022). Effects of water pollution on human health and disease heterogeneity: A review. *Frontiers in Environmental Science*, Vol 10, Pp. 1-16.

Lin, H. (2023). Generation and management of municipal solid waste in top metropolitans of china: A comparison with Singapore. *Circular Economy*, Vol 2(2), Pp. 1-18.

Lissah, S.Y., Ayanore, M.A., Krugu, J.K., Aberese-Ako, M., & Ruiter, R.A.C. (2021). Managing urban solid waste in Ghana: Perspectives and experiences of municipal waste company managers and supervisors in an urban municipality. *PLoS ONE*, Vol 16(3), Pp. 1-18.

Liu, F., Hua, S., Wang, C., & Hu, B. (2022). Insight into the performance and mechanism of persimmontannin functionalised waste paper for U (VI) and Cr (VI) removal. *Chemosphere*, Vol 287(3), Pp. 1-48.

Loi, L.X., Chua, A.S.M., Rabuni, M.F., Tan, C.K., Lai, S.H., Takemura, Y., & Syutsubo, K. (2022). Water quality assessment and pollution threat to safe water supply for three river basins in Malaysi. *Science of the Total Environment*, Vol 832, Pp. 1-15.

Longe, E.O., Longe, O.O., & Ukpebor, E.F. (2022). People's perception on household solid waste management in Ojo local government area in Nigeria. *Iran Journal of Environmental Health Science and Engineering*, Vol 6(3), Pp. 1-8.

Lu, W., Peng, Z., & Webster, C. (2022). If invisible carbon waste can be traded, why not visible construction waste? Establishing the construction waste trading "missing market". *Resource, Conservation and Recycling*, Vol 187, Pp. 1-17.

Lukhabi, D.K., Mensah, P.K., Asare, N.K., Pulumuka-kamanga, T., & Ochieng, O.K. (2023). Adapted water quality indices: Limitations and potential for water quality monitoring in Africa. *MDPI Water*, Vol 15, Pp. 1-30.

Luvhimbi, N., Tshitangano, T.G., Mabunda, J.T., Olaniyi, F.C., & Edokpayi, J.N. (2022). Water quality assessment and evaluation of human health risk of drinking water from source to point of use at Thulamela Municipality, Limpopo Province. *Scientific Report*, Vol 12(6059), Pp. 1-50.

Ma, M., Tam, V.W.Y., Le, K.N., & Li, W. (2020). Challenges in current construction and demolition waste recycling: A China study. Waste Management, Vol 118, Pp. 610-625.

Madilonga, R.T., Edokpayi, J.N., Volenzo, E.T., Durowoju, O.S., & Odiyo, J.O. (2021). Water quality assessment and evaluation of human health risk in Mutangwi River, Limpopo Province, South Africa. *International Journal of Environmental Research and Public Health*, Vol 18(6765), Pp. 1-16.

Maffei, E.L., Sahin, F.A., Redondi, A., & Bolzan, P. (2022). A 5G-Enabled smart waste management system for University campus. *Sensors*. Vol 21(24), Pp. 1-20.

Mager, A., & Blass, V. (2022). From illegal waste dumps to beneficial resources using drone technology and advanced data analysis tools: A feasibility study. *MDPI Remote Sensing*, Vol 14(16), Pp. 1-30.

Magna, E.K. (2021). Assessment of the impact of solid waste disposal on the portability of surface water and groundwater using Water Quality Index (WQI) in Kpssa, Nkwanta North District of Ghana. *Civil and Environmental Research*, Vol 10(9), Pp. 1-8.

Mahale, P., Amin, V.S., Srinivas, S., Abhishek, N., Yogita, K., Vinutha, H.k., & Shwetha, N.S. (2023). Householder assessment and perception regarding domestic waste generated. *Eur. Chem. Bull*, Vol 12, Pp. 1-34.

Malar, A.I. (2023). Knowledge and practice of solid waste management among households in Obudu local government area, Cross River State, Nigeria. *Scientific Report*, Vol 5(2), Pp. 1-35.

Maleki, M.R., Ashtari, A., Tabrizi, J.S., & Rezapour, R. (2021). Health care waste management improvement interventions specifications and results: A systematic review and meta-analysis. *Iranian Journal of Public Health*, Vol 49(9), Pp. 1611-1621.

Malik, N.A.K., Abdullah, S.H., & Manaf, L.A. (2022). Community participation on solid waste segregation through recycling programmes in Putrajaya. *Procedia Environmental Sciences*, Vol 30, Pp. 1-5.

Manga, V.E., Oru, T.O., & Ngwabie, M.N. (2019). Household perception and willingness to pay for improved waste management service in Mamfe, Cameroon. *African Journal of Environmental Science and Technology*, Vol 13(9), Pp. 1-11.

Mann, A.G., Tam, C.C., Craig, D., & Rodrigues, L.C. (2022). The association between drinking water, turbidity and gastrointestinal illness: A systematic review. *BMC Public Health*, Vol 7(256), Pp. 1-9.

Maphanga, T., & Madonsela, B.S. (2023). Evaluating waste management practices of street vendors in the informal settlement of Cape Town: A case study of Khayelitsha. *Anthropogenic Pollution*, Vol 7(2), Pp. 1-12.

Marias, D.F. (2021). Assessing the impact of municipal solid waste on the environment and on human health. *Science of the Total Environment*, Vol 776, Pp. 1-20.

Martinho, G., Ramos, M., & Pina, J. (2023). Strategies to promote construction and demolition waste management in the context of local dynamics. *Waste Management*, Vol 162, Pp. 102-112.

Masindi, T.K., Gyedu-Ababio, T., & Mpenyana-Monyatsi, L. (2022). Pollution of Sand River by Wastewater Treatment Works in the Bushbuckridge Local Municipality, South Africa. *MDPI Pollutants*, Vol 2, Pp. 1-21.

McAllister, J. (2020). Factors influencing solid-waste management in the developing world. *Merrill-Cazier Library*, Vol 5, Pp. 1-95.

Mendez-Lazarte, C., Bohorquez-Lopez, V.W., Caycho-Chumpitaz, C., & Estrada-Merino, A. (2023). Attitude is not enough to separate solid waste at home in Lima. *MDPI Recycling*, Vol 8(2), Pp. 1-36.

Mengstie, Y.A., Desta, W.M., & Alemayehu, E. (2023). Assessment of drinking water quality in urban water supply systems: The case of Hawassa City, Ethiopia. *International Journal of Analytical Chemistry*, Vol 10, Pp. 1-15.

Mensah, J. (2021). Fisherfolk's perception of waste and attitude to solid waste disposal: Implications for health, aquatic resources and sustainable development. Journal of Environmental and Public Health, Vol 2, Pp. 1-12.

Meride, Y., & Ayenew, B. (2022). Drinking water quality assessment and its effects on residents' health in Wondogenet Campus, Eithopia. *Environmental Systems Research*, Vol 5(1), Pp. 1-7.

Mmereki, D., David.Jr, V.E., & Brownell, A.H.W. (2023). The management and prevention of food losses and waste in low- and middle-income countries: A mini-review in the African Journal. *Waste Management & Research: The journal for a Sustainable Circular Economy*, Vol 42(4), Pp. 1-15.

Mohammed, A. (2023). Domestic solid waste management and its environmental impacts in Addis Ababa city. *Journal of Environment and Waste Management*, Vol 4(1), Pp. 194–203.

Mopani District Municipality Report. (2023). Reviewed Integrated Development Plan 2022/2023. [Accessed on 14 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjuwYuVv4yEAxX9QkEAHT29C0YQFnoECCcQAQ&url=https%3A%2F%2Fwww.mopani.gov.za%2Fdocs%2Fidp%2FREVIEWED%2520%2520IDP%25202022-2023%2520FINAL.pdf&usg=AOvVaw3LY2Orn-wzU6tD_hv_liAi&opi=89978449

Motaung, M.A., Scott, H.A.R., & Roberts, A.M. (2020). Solid waste dumping and burning practices in the Lesotho Lowlands. *MSc Thesis at Central University of Technology, Free State*, Pp. 1-255.

Moussa, H., Balarabe, B.Y., & Ousmane, L.M. (2023). Overview of attitudes and the household solid waste management system in Niamey, Niger: Opportunities and Impacts. *Open Access Library Journal*, Vol 10, Pp. 1-12.

Mousavi, S.H., Kavianpour, M.R., Alcaraz, J.L.G., & Yamini, O.A. (2023). System dynamics modelling for effective strategies in water pollution control: Insights and applications. *MDPI Applied Sciences*, Vol 13(15), Pp. 1-25.

Mubaslat, A. (2021). Introduction to waste management. *International Youth Ambassadors Foundation*, Vol 10(2), Pp. 1-50.

Muheirwe, F., Kombe, W., & Kihila, J.M. (2023). The paradox of solid waste management: A regulatory discourse from Sub-Saharan Africa. *Habitat International*, Vol 119, Pp. 1-22.

Mulhern, E. (2023). Personal attitudes and beliefs and willingness to pay to reduce marine plastic pollution in Indonesia. *Marine Pollution Bulletin*, Vol 173, Pp. 1-40.

Mushtaq, J., Dar, A.Q., & Ahsan, N. (2020). Spatial-temporal variations and forecasting analysis of municipal solid waste in the mountainous city of North-Western Himalayas. *SN Applied Sciences*, Vol 2(1161), Pp. 1-13.

Mzobea, P.F., & Msezane, S.B. (2024). Exploring teachers' perceptions of solid waste management in Umlazi District Schools, South Africa. *International Journal of Curriculum and Instruction*, Vol 16(1), Pp. 1-24.

National Environmental Management (NEMA): Waste Act 59 of 2008: National Waste Management (2022). [Accessed on 17 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjA9NH09YyEAxWvUUEAHblVCLgQFnoECDsQAQ&url=https%3A%2F%2Fwww.gov.za%2Fdocuments%2Fnational-environmental-management-waste-act&usg=AOvVaw2ia2NnANtzwu0ok1XKEv4W&opi=89978449

National Environmental Management (NEMA): Waste Act 59 of 2008: National Waste Management Strategy (2022). [Accessed on 17 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjA9NH09YyEAxWvUUEAHblVCLgQFnoECCcQAQ&url=https%3A%2F%2Fcer.org.za%2Fwp-content%2Fuploads%2F2010%2F03%2FNEMWA-latest.pdf&usg=AOvVaw2hQrtEINnLTnmNtiIk2X1e&opi=89978449

Nasir, N., Januri, S.S., Malek, H.A., & Malek, I.A. (2023). Plastic waste knowledge of households towards a sustainable environment. *IOP Conference Series Earth and Environmental Sciences*, Vol 1151(1), Pp. 1-13.

Nawaz, R., Nasim, I., Irfan, A., Islam, A., Naeem, A., Ghani, N., Irshad, M.A., Latif, M., Nisa, B.U., & Ullah, R. (2023). Water quality index and human health risk assessment of drinking water in selected urban areas of Mega City. *Toxics*, Vol 11(7), Pp. 1-18.

Nell, C., Schenck, C., Blaauw, D., Grobler, L., & Vilijoen, K. (2022). A three-pronged approach to waste composition determination. *Journal of Environmental Management*, Vol 303, Pp. 1-40.

Ngalo, N., & Thondhlana, G. (2023). Illegal Solid-Waste Dumping in Low-Income Neighbourhood in South Africa: Prevalence and Perceptions. *International Journal of Environmental Resource Public Health*, Vol 20, Pp. 1-15.

Nguyen, G.T., Diem, M.T.L., & Huynh, N.T.H. (2023). Pollution and risk level assessment of pollutants in surface water bodies. *Civil Engineering Journal*, Vol 9(8), Pp. 1-12.

Nickell, G.S., & Hinsz, V.B. (2023). Applying the theory of planned behaviour to understand workers' production of safe food. *Journal of Work and Organizational Psychology*, Vol 39(2), Pp. 1-12.

Niyobuhungiro, R., & Schenck, R. (2022). Exploring community perceptions of illegal dumping in Fisantekraal using Participatory Action Research. *Journal of Environmental Management,* Vol 118, Pp. 1-8.

Niyobuhungiro, R.V., & Schenck, C.J. (2021). The dynamics of indiscriminate/ illegal dumping of waste in Fisantekraal, Cape Town, South Africa. *Journal of Environmental Management*, Vol 293, Pp. 1-16.

Njoku, P.O., Edokpayi, J.N., & Odiyo, J.O. (2019). Health and environmental risks of residents living close to a landfill: A case study of Thohoyandou, Landfill, Limpopo Province, South Africa. *International Journal of Environmental Research and Public Health*, Vol 26, Pp. 1-27.

Noman, A.A., Rafizul, I.M., Moniruzzaman, S.M., Kraft, E., & Berner, S. (2023). Assessment of municipal solid waste from households in Khulna city of Bangladesh. *Heliyon*, Vol 9(12), Pp. 1-10.

Nuzrath, A.N.N., & Ruzaik, F. (2023). Public perceptions of the effectiveness of solid waste management in the Colombo Municipality Area. *Sri Lanka Journal of Population Studies*, Vol 10, Pp. 1-14.

Nwachukwu, D.O., Nwelue, K.N.K., Ibekwe, C.C., Anganwu, U.G., Obilor, F., Ekwe-Emeagha, E., Okereke-Ejiogu, N., Ellah, G.O., & Chajianya, D.O. (2018). Effects of household waste generation, disposal and management on Farmers' health in Owerri Metropolis of IMO State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, Vol 3(5), Pp. 1-9.

Nwosu, E.O., Orji, A., & Yuni, D. (2016). Environmental hazards and waste management in Nsukka urban metropolis in Enugu State of Nigeria: how much are people willing to pay? *Environmental Hazards*, Pp. 1-20.

Nyika, J., Onyari, E., Mishra, S., & Dinka, M.O. (2019). Waste management in South Africa. *In book: Sustainable Waste Management Challenges in Developing Countries*, Pp. 327-351.

Obuobi, B., Wang, J., Nketiah, E., Cai, X., & Adjei, M. (2023). What establishes citizens' household intention and behaviour regarding municipal solid waste separation? A case study in Jiangsu Province. *Journal of Cleaner Production*, Vol 423, Pp. 1-15.

Ogundele, O.M., Rapheal, O.M., & Abiodun, A.M. (2022). Effects of municipal waste disposal methods on community health in Ibadan Nigeria. *Open Access Library Journal*, Vol 1, Pp. 61-72.

Olusanya, A. (2021). Impact of municipal solid wastes on underground water sources in Nigeria. *European Scientific Journal*, Vol 8(11), Pp. 1-19.

Omang, D.I., Egbe, G.J., Inah, S.A., & Bisong, J.O. (2021). Public health implication of solid waste generated by households in Bekwarra Local Government area. *African Health Sciences*, Vol 21(3), Pp. 1-10.

Omary, R.R., Lalika, M.C.S., Nguvava, M., & Mgimwa, E. (2023). Macroinvertebrates as bioindicators of water quality in Pinyinyi River, Arshua, Tanzania. *Journal of Water Resource and Protection*, Vol 15, Pp. 1-20.

Omid, A., Ghanbari, M., Safajou, H., & Hossein, K. (2021). Degradation of wastes and organic pollutants in water. *International Journal of Hydrogen Energy*, Vol 46(39), Pp. 20534-20546.

Omokaro, G.O., Michael, I., & Evgenievich, P.V. (2024). Assessing the environmental and health implications of waste disposal: A case study of Africa's Largest Dumping site. *Journal of Geography, Environment and Earth Science International*, Vol 28(5), Pp. 16-30.

Omotayo, A.O., Omotoso, A.B., Daud, A.S., & Olagunju, K.O. (2023). What drivers' payment for waste disposal and recycling behaviours? Empirical evidence from South Africa's general household survey. *Scientific Report*, Vol 11, Pp. 1-14.

Onwezen, M.C., Molenveld, K., Reinders, M.J., & Taufik, D. (2023). The paradox between the environmental appeal of bio-based plastic packaging for consumers and their disposal behaviour. *Science of the Total Environment*, Vol 705, Pp. 1-25.

Orozco-Ganzalez, C.E., & Ocasio-Torres, M.E. (2023). Aquatic macroinvertebrates as bioindicators of water quality: A study of an ecosystem regulation service in a Tropical River. *Ecologies*, Vol 4, Pp. 1-20.

Ouattara, Z.A., Dongo, K., Akpoti, K., Kabo-Bah, A.T., Attiogbe, F., Siabi, E.K., Fweh, C.D., & Gogo, G.H. (2023). Assessments of solid and liquid wastes management and health impacts along the failed sewerage systems in capital cities of African countries: A case of Abidjan. *Frontiers*, Vol 15, Pp. 1-9.

Owusu, P.A. (2021). Impact of Covid-19 pandemic on waste management. *Environment, Development and Sustainability*, Vol 23, Pp. 7951-7960.

Owusu, I.A., Plaza, E., Elginoz, N., Atasay, M., Khatami, K., & Yesil, H. (2023). Conceptual system for sustainable and next-generation wastewater resource recovery facilities. *Science of the Total Environment*, Vol 885, Pp. 1-10.

Pakpour, A.H., Zeidi, I.M., Emmamjomeh, M.M., Asefzadeh, S., & Pearson, H. (2021). Household waste behaviours among a community sample in Iran: An application of the theory of planned behaviour. *Waste Management*, Vol 34, Pp. 1-7.

Parveen, N., Singh, D.V., & Azam, R. (2020). Innovations in recycling for sustainable management of solid wastes. *India Institute of Medical Sciences*, Vol 14, Pp. 1-34.

Passafaro, P., Bacciu, A., Castaldi, V., & Caggianelli, I. (2021). Measuring individual skills in household waste recycling: Implications for citizens' education and communication in six urban contexts. *Applied environmental education and communication, An International Journal*, Vol 15(3), Pp. 234-246.

Pathak, G., Nichter, M., Hardon, A., Moyer, E., Latkar, A., Simbaya, J., Pakasi, D., Taqueban, E., & Love, J. (2023). Plastic pollution and open burning of plastic wastes. *Global Environmental Change*, Vol 80, Pp. 1-22.

Pavese, M.H. (2021). Municipal waste management good practices. *Council for Scientific and Industrial Research*, Vol 5, Pp. 1-5.

Perkumiene, D., Atalay, A., Safaa, L., & Grigiene, J. (2023). Sustainable waste management for clean and safe environments in the recreation and tourism sector: A case study of Lithuania, Turkey and Morocco. *MDPI Recycling*, Vol 8(4), Pp. 1-13.

Pengzhong, L. (2023). Solid waste management – Recent advances, new trends and Applications. *IntechOpen*, Vol 10, Pp. 40-75.

Petrescu, D.C., Rastegari, H., Petrescu-mag, I.V., & Petrescu, R.M. (2023). Determinants of proper disposal of single-use mask: knowledge, perception, behaviour, and intervention measures. *Peer J*, Vol 4, Pp. 1-20.

Pierce, M., Laquatra, J., & Lim, V. (2020). Taking construction site waste management to the next level. *Journal of Green Building*, Vol 4(4), Pp. 29-32.

Pikitup, (2022). Interventions for curbing illegal dumping and littering. Report by Peter Hlubi, GM: Operations, to the Pikitup Board, 10 April 2022.

Polasi, L.T. (2018). Factors associated with illegal dumping in the Zondi area, city of Johannesburg, South Africa. *Council for Scientific and industrial Research,* Pp. 5-8.

Pretorius, A. (2023). Towards a circular economy: A cross-case analysis of recycling in three South African towns. *Development Southern Africa*, Vol 10, Pp. 1-18.

Rahman, A.L., Hossain, A., Rubaiyt, S.A., Mamun, Z.A., Khan, M., & Sayem, M.K. (2022). Solid waste generation, characteristics and disposal at Chittagong University Campus, Chittagong. *Bangladesh Discovery Science,* Vol 4(11), Pp. 25-30.

Ramadan, B.S., Rachman, I., Ikhlas, N., Kurniawan, S.B., Miftahadi, M.F., & Matsumoto, T. (2022). A comprehensive review of domestic-open waste burning: recent trends, methodology comparison, and factors assessment. *Journal of Material Cycles and Waste Management*, Vol 24(11), Pp. 1633-1647.

Ramadan, B.S., Raden, R.T., Syafrudin, M., Khair, H., Rachman, I., & Matsumoto, T. (2022). Potential risks of open burning at household level: A Case Study of Semarang, Indonesia. *Aerosol and Air quality Research*, Vol 5, Pp. 1-17.

Rajagukguk, I.Y., & Nabilah, Y. (2021). The effect of industrial waste on the water quality of Padang River in the industrial area of Tebing Tinggi. *IOP Conference Series: Materials Science and Engineering*, Vol 1122, Pp. 1-9.

Rapson, G., & Molefi, L. (2021). Managing your waste to achieve legal compliance. *African Journals*, Vol 23(3), Pp. 2-6.

Ramodipa, T., Engelbrecht, K., Mokgobu, I., & Mmerek, D. (2023). Status of health care waste management plans and practices in public health care facilities in Gauteng Province, South Africa. *BMC Public Health*, Vol 23(1), Pp. 1-17.

Rasheed, R., Rizwan, A., Javed, H., Sharif, F., Yasar, A., Tabinda, A. B., & Su, Y. (2022). Analysis of environmental sustainability of e-waste in developing countries, a case study from Pakistan. *Environmental Science and Pollution Research*, Vol 29(24), Pp. 36721-36739.

Rasimphi, T., Kilonzo, B., Tjale, M., Tinarwo, D., & Nyamukondiwa, P. (2024). Review of implementation of biogas technology in rural Limpopo Province, South Africa. *SSRN*, Vol 9, Pp. 1-29.

Rathnaraj, N., Duraisami, S.P.A., Parayitam, S., Krishnan, M.M., & Vijayan, R.V. (2023). Exploring e-waste recycling behaviour intention among the households: Evidence from India. *Research Square*, Vol 10, Pp. 1-24.

Razaq, M.I., Bekchanor, A., & Nibah, Y. (2023). Potentials of waste and wastewater Resources, Recovery and Re-use (RRR) options for improving water, energy and nutrition security. *SSRN Electronic Journal*, Vol 10, Pp. 1-9.

Republic of South Africa. 1996. Constitution of the Republic of South Africa Act, 1996, (Act No.108 of 1996).

Republic of South Africa. 1989. Environmental Conservation Act, (Act 73 of 1989), [Accessed on 10 January 2024], Available from http://www.environment.gov.za/sites/default/files/legislations/environment_conservation_act730f1989.

Republic of South Africa. 2008. National Environmental Management: Waste Act. (Act 59 of 2008). Gazette 32000. Government Gazette, 10 March 2009.

Rico-Sanchez, A.E., Rodriguez-Romero, A., Sedeno-Diaz, J., Lopez, E., & Sundermann, A. (2022). Aquatic macroinvertebrates assemblages in rivers influenced by mining activities. *Scientific Reports*, Vol 12, Pp. 1-14.

Rodseth, C., Notten, P., & Blottnitz, H.V. (2020). A revised approach for estimating informally disposed domestic waste in rural versus urban South Africa and implications for waste management. *South African Journal of Science*, Vol 116, Pp. 1-5.

Roos, C., Alberts, R.C., Retief, F.P., Cilliers, D.P., Hodgson, W., & Olivier, L. (2022). Challenges and opportunities for sustainable solid waste management in private nature reserves: The case of Sabi Sand Wildtuin, South Africa, Koedoe. *AOSIS*, Vol 64(1), Pp. 1-9.

Roy, A., & Jubilant, J.K. (2024). Real time water quality monitoring of river Pamba (India) using internet of hings. *Web of Conferences*, Vol 477, Pp. 1-11.

Rozenkowska, K. (2023). Theory of planned behaviour in consumer behaviour research: A systematic literature review. *International IJC*, Vol 47(2), Pp. 1-10.

Rugebregt, M.J., Opier, R.D.A., Abdul, M.S., Triyulianti, I., Kesaulya, I., Widiaratih, R., Sunuddin, A., & Kalambo, Y. (2023). Changes in pH associated with temperature and salinity in the Banda Sea. *IOP Conference Series Earth and Environment*. Vol 1163, Pp. 1-20.

Saad, D., Ramaremisa, G., Ndlovu, M., Chauke, P., Nikiema, J., Chimuka, L. (2024). Microplastic abundance and sources in surface water samples of the Vaal River, South Africa. *Bulletin of Environmental Contamination and Toxicology*, Vol 14, Pp. 1-7.

Saalidong, B.M., Aram, A.S., Otu, S., & Lartey, P.O. (2022). Examining the dynamics of the relationship between water pH and other water quality parameters in ground and surface water systems. *PLoSONE*, Vol 17(1), Pp. 1-17.

Saari, R., Yatim, S.R., Ahmad, R.I., Ayuni, F.S., Rasdi, N.W., Abdullah, S., Muhammad, A.Z., & Saifuddin, A. (2023). Knowledge, attitude, and challenges of high-rise building community towards waste segregation and recycling practice in Metropolitan Kuala Lumpur, Malaysia. *IOP Conference Series: Earth and Environmental Science*, Vol 10, Pp. 1-12.

Sabelone, B. (2023). Residents' perception and attitude on solid waste disposal and its health impacts in Cape Coast Metropolis. *Dama International Journal of Researchers*, Vol 11(1), Pp. 1-31.

Sakollawat, S., Surachai, N.J., Nuttiya. T., & Warajt, S. (2022). Attitudes, behaviours, and information perception for waste management in community households in Kuet Chang Sub-district, Mae Taeng District, Chiang Mai Province. *Social Science Journal*, Vol 12(2), Pp. 1-11.

Sekgobela, S.M., & Semenya, K. (2023). Comparative study of solid waste management in GaMothapo and Seshego in Polokwane Local Municipality Limpopo Province, South Africa. *Research Square*, Vol 1, Pp. 1-13.

Selomo, T.G. (2023). Solid waste management and selection of a solid waste disposal site in the Mankweng Cluster, Polokwane Local Municipality, South Africa. *MSc Thesis at University of Limpopo*, Pp. 10-50.

Senekane, M.F. (2024). Assessing the effects of illegal dumpsites on the environment and human well-being in the rural areas of Limpopo, South Africa. *OIDA International Journal of Sustainable Development*, Vol 17(01), Pp. 11-24.

Sepadi M.M. (2021). Unsafe management of soiled nappies in informal settlements and villages of South Africa. *Cities Health*, Pp. 1-10.

Setyaningsih, W., & Sanjaya, R.S. (2022). The impact of agricultural waste on river water quality of Kreo watershed in Semarang City. *International Conference on Environmental, Energy and Earth Science*, Vol 1041, Pp. 1-14.

Setzer, J., & Higham, C. (2023). Global trends in climate change litigation. *Grantham Research Institute on Climate Change and the Environment*, Pp. 1-58.

Shahab, S., & Anjum, M. (2022). Solid waste management scenario in India and illegal dump detection using deep learning: An AI approach towards the sustainable waste management. *MDPI Sustainability*, Vol 14(23), Pp. 1-40.

Shahzadi, A., Hussain, M., Afzal, M., & Gillani, S.A. (2021). Determination of the level of knowledge, attitude, and practices regarding household waste disposal among people in rural community of Lahore. *International Journal of Social Sciences and Management*, Vol 5(3), Pp. 1-6.

Shakil, S., Nawaz, K., & Sadef, Y. (2023). Evaluation and environmental risk assessment of heavy metals in the soil released from e-waste management activities in Lahore, Pakistan. *Environmental Monitoring and Assessment*, Vol 195(89), Pp. 1-19.

Shammi, A.T., Hassan, N., Golder, M.R., Molla, H., & Islam, S.S. (2023). Health status assessment of people adjacent to temporary waste disposal sites in Khulna City, Bangladesh. *BMC Public Health*, Vol 9(9), Pp. 1-11.

Shanbhag, T.V., Orvestedt, S., & Morley, E. (2023). Impacts of waste on people's health. *BMC Public Health*, Vol 19(9), Pp. 11-29.

Sharma, S., Sudhakara, P., Misra, S.K., & Singh, J. (2023). Critical review on the solid-waste issues: Generation, composition, disposal and their recycling potential for various application. *Journal of Physics*, Vol 18, Pp. 1-29.

Shen, J., Zheng, D., Zhang, X., & Qu, M. (2020). Investigating rural domestic waste sorting intentions based on an integrative framework of planned behaviour theory and normative activation models: Evidence from Guanzhong Basin, China. *International Journal of Environmental Resource and Public Health*, Vol 17(3), Pp. 1-16.

Shi, J., Xu, K., Si, H., Song, L., & Duan, K. (2021). Investigating intention and behaviour towards sorting household waste in Chinese rural and urban-rural integration areas. *Journal of Cleaner Production*, Vol 298, Pp. 1-9.

Shortle, J.S., Mihelcic, J.R., Zhang, Q., & Arabi, M. (2022). Nutrient control in water bodies: A systems approach. *Journal of Environmental Quality*, Vol 49, Pp. 517-533.

Sibanda, T., & Uzabakiriho, J.D. (2024). Animal manure as an alternative bioenergy resource in rural Sub-Saharan Africa: Present insights, challenges, and prospects for future advancements. *MDPI Energies*, Vol 17, Pp. 1-15.

Siddiqua, A., Hahladakis, J.N., & Al-Attiya, W.A.K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environmental Science and Pollution Research*, Vol 10, Pp. 1-23.

Simiya S., Cairncross S., & Swilling, M. (2020). Understanding living conditions and deprivation in informal settlements of Kisumu, Kenya. *Urban Forum*, Vol 30, Pp. 233–241.

Singhirunnusorn, W., Donlakorn, K., Kaewhanin, W., & Kpxguvkicvgu, U. (2021). Household recycling behaviours and attitudes toward Waste Bank Project: Mahasarakham Municipality. *Journal of Asian Behavioural Studies*, Vol 2(5), Pp. 35-47.

Sintayehu, L.B. (2024). Solid waste management practice and landfill suitability the case of Sendafa Town, Ethiopia. *MDPI*, Vol 10, Pp. 1-27.

Slekiene, J., Swan, N., & Kalina, M. (2024). Absorbent hygiene products disposal behaviour in informal settlements: identifying determinants and underlying mechanisms in Durban, South Africa. *BMC Public Health*, Vol 24, Pp. 1-15.

Smith, E.E. (2020). Attitudes and practices of households toward waste management and recycling in Nelson Mandela Bay. *Journal of Contemporary Management*, Vol 17(2), Pp. 1-28.

Somani, P. (2023). Health impacts of poor solid waste management in the 21st century. *IntechOpen*, Pp. 5-20.

Sowa, A., & Krodkiewska, M. (2020). Impact of secondary salinisation on the structure and diversity of Oligochaete communities. *Knowledge & Management Aquatic Ecosystems*, Vol 6, Pp. 1-14.

Soysa, R.N.K., Pallegedara, A., Kumara, A.S., Jayasena, D.M., & Samaranayake, M.K.S.M. (2022). Factors affecting waste generation and segregation behaviour. An analysis using data from the educated communities in the Western and the North-Western Province of Sri Lanka. *MSc Thesis at Wayamba University of Sri Lanka*, Pp. 1-39.

Srivastava, R.R., Pathak, P., & Sharma, O. (2020). Environmental management of E-waste in book. *Electronic Waste Management and Treatment Technology*, Pp. 103-132.

Statistics South Africa. Census (2011). Statistics South Africa: Pretoria, South Africa, 2011. [Google Scholar]

Sullivan, L. (2021). Issues in Estimating Sample Size for Confidence Intervals Estimates of Cochran's Formula. [Online]. Date accessed: 12 January 2024 https://sphweb.bumc.bu.edu/otlt/mphmodules/bs/bs704_power/bs704_power_print.html

Stokes, K., & Lawhon, M. (2022). What counts as infrastructural labour? Community action as waste work in South Africa. *Area Development and Policy*, Vol 9(1), Pp. 24-44.

Supaprawat, S., Penpim, P., Syamsul, H., Ruksit, S., & Phantiga, W. (2023). A review of sustainable development guidelines for Green Universities in Thailand. *Advance Knowledge for Executives*, Vol 2(4), Pp. 1-12.

Sumaya, M. (2022). An assessment of electronic waste knowledge, attitude, intentions and risk perception of sustainable electronic waste management from a developing country perspective. *In: Business Management*, Vol 25(2), Pp. 1-18.

Syafrudin, S., Ramadan, B.S., Budihardijo, A., Munawir, M., Khair, H., Rosmalina, R.T., & Ardiansyah, S.Y. (2023). Analysis of factors influencing illegal waste dumping generation using GIS spatial regression methods. *MDPI Sustainability*, Vol 15(3), Pp. 3-17.

Tabraiz, S., Zeeshan, M., Asif, M.B., Egwu, U., Iftekhar, S., & Sallis, P. (2023). Membrane bioreactor for wastewater treatment: fouling and abatement strategies. *Membrane Technology for Sustainable Water and Energy Management*, Vol 10, Pp. 173-202.

Tampo, L., Kabore, I., Alhassan, E.H., Oueda, A., Bawa, L.M., & Djaneye-Boundjou, A. (2021). Benthic macroinvertebrates as ecological indicators: Their sensitivity to the water quality and human disturbances in a Tropical River. *Frontiers in Water*, Pp. 1-17.

Tandon, A., Jabeen, F., Talwar, S., Sakashita, M., & Dnir, A. (2021). Facilitators and inhibitors of organic food buying behaviour. *Food Quality and Preference*, Vol 88, Pp. 1-15.

Tang, D., Gai, X., Nketiah, E., Adjei, M., Adu-Gymafi, G., & Obuobi, M. (2023). Separate your waste: A comprehensive conceptual framework investigating residents' intention to adopt household waste separation. *Sustainable Production and Consumption*, Vol 39, Pp. 1-14.

Tang, Y., Ogunseitan, O.A., & Singh, N. (2021). Critical reviews in Environmental Science and Technology. Vol 52(1), Pp. 2-8.

Tang, D., Shi, L., Huang, X., Zhao, Z., Zhou, B., & Bethel, B.J. (2022). Influencing factors on the Household-Waste-Classification behaviour of urban residents: A case study in Shanghai. *International Journal of Environmental Research and Public Health*, Vol 19, Pp. 1-9.

Tejeda, A., Montoya, A., Sulbaran-Rangel, B., & Zurita, F. (2023). Possible pollution of surface water bodies with Tequila Vinasses. *MDPI Water*, Vol 15(3773), Pp. 1-14.

Thakur, R., & Onwubu, S.C. (2024). Household waste management behaviour amongst residents in an informal settlement in Durban, South Africa. *Journal of Environmental Management*, Vol 349, Pp. 1-10.

Thobejane, P.M. (2022). Evaluating the implementation of the South African National Waste Management Strategy goals by local government. MSc Thesis at North-West University, Pp. 15-30.

Tomita, A., Cuadros, D.F., Burns, J.K., Tanser, F., & Slotow, R. (2020). Exposure to waste sites and their impact on health: A panel and geospatial analysis of nationally representative data from South Africa, 2008-2015. *The Lancet Planetary Health*, Vol 4(6), Pp. 223-234.

Triassi, M., Alfano, R., Illario, M., Nardone, A., Caporale, O., & Montuori, P. (2021). Environmental pollution from illegal waste disposal and health effects "A review on the Triangle of Death". *International Journal of Environmental Research and Public Health*, Pp. 4-12.

Trois, C., Griffith, M., Brummack, J., & Mollekopf, N. (2022). Introducing mechanical biological waste treatment in South African: A comparative study. *Waste Management*, Vol 27(11), Pp. 1-17.

Troisi, R. Simone, S.D., & Franco, M. (2023). Illegal firm behaviour and environmental hazard: The case of waste disposal. *The Journal of the European Academy of Management*, Pp. 1-13.

Tsheleza, V., Ndhleve, S., Kabiti, H.M., Musampa, C.M., & Nakin, M.D.V. (2019). Vulnerability of growing cities to solid waste-related environmental hazards: The case of Mthatha, South Africa, Jamba. *Journal of Disaster Risk Studies*, Vol 11(1), Pp. 1-10.

Tyler, C.R., McMurtrie, J., Alathari, S., Chaput, D.L., Bass, D., & Ghambi, C. (2022). Relationships between pond water and tilapia skin microbiomes in aquaculture ponds in Malawi. *Aquaculture*, Vol 558, Pp. 1-20.

Ubuoh, E.A., Nwogu, F.U., Ofoegbu, C.C., & Chikezie, P.C. (2023). Environmental pollution loads on surface water chemistry and potentially ecological risks of inland aquatic ecosystem in South-Eastern State, Nigeria. *Environmental Systems Research*, Vol 12(22), Pp. 1-23.

Uddin, M.G., Nash, S., & Olbert, A. (2021). A review of water quality index models and their use of assessing surface water quality. *Ecological Indicators*, Vol 122, Pp. 1-21.

Uhunamure, S.E., Nethengwe, N.S., Shale, K., & Mudau, V. (2023). Appraisal of households' knowledge and perception towards E-waste management in Limpopo Province, South Africa. *MDPI Recycling*, Vol 6(20), Pp. 1-39.

Uhunamure, S.E., Nethengwe, N.S., & Tinarwo, D. (2020). Evaluating biogas technology in South Africa: Awareness and perceptions towards adoption at household level in Limpopo Province. *IntechOpen: Renewable Energy – Resources, Challenges and Applications*, Pp. 1-16.

United States Environmental Protection Agency. (2020). Illegal dumping prevention guidebook. Chicago, IL: United States Environmental Protection Agency, Region 5 Waste, Pesticides and Toxics Division.

United States Environmental Protection Agency. (2022). Volume to weight conversion factors [Data file]. [Accessed on 10 January 2024]. Retrieved from https://www.epa.gov/sites/production/files/201604/documents/volume_to_weight_conversion_factors_memorandum_04192016_508fnl.pdf

United States Environmental Protection Agency. (2023). Wastes. [Accessed on 10 January 2024], Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjX7dHZlYEAxUpU0EAHfoSB1UQFnoECB0QAQ&url=https%3A%2F%2Fwww.epa.gov%2Freportenvironment%2Fwastes&usg=AOvVaw1ysFfCkPz7KrilnkDQlG1S&opi=89978449

Urooj, A., Ilyas, R., & Humayun, N. (2020). Effects of dumping solid waste on water quality of surface water bodies. *Journal of Plant and Environment*, Vol 1(1), Pp. 1-4.

Ustaoglua, F., Yuksel, B., & Arica, E. (2021). Impacts of a garbage disposal facility on the water quality of Cavuslu Stream in Giresun, Turkey: A health risk assessment study a validated ICP-MS Assay. *Aquatic Sciences and Engineering*, Vol 36(4), Pp. 181-192.

Utomo, S.W., Rahmadina, F., Wispriyono, B., Kusnoputranto, H., & Asyary, A. (2021). Metal contents of Lake Fish in area close to disposal of industrial waste. *Journal of Environmental and Public Health*, Vol 10, Pp. 1-10.

Uwamwezi, G. (2021). Knowledge, attitude and practices on waste management in selected secondary schools in Westlands Sub-country, Nairobi country. *MSc Thesis at University Nairobi*, Pp. 1-79.

Vaverkova, M.D., Paleologos, E., Admacova, D., & Podlasek, A. (2022). Municipal solid waste landfill: Evidence of the effect of applied landfill management on vegetation composition. *Waste Management and Research*, Vol 10, Pp. 2-10.

Venkateswaran, K., Singh, N.K., & Chander, A.M. (2023). Microbial technologies in waste management, energy generation and climate change: Implications on Earth and space. *Journal of the Indian Institute of Science*, Vol 103, Pp. 833-838.

Vibha, T. (2022). Topic on waste management. *College Side Kick*, Pp. 1-18.

Vijayan, R.V., Krishnan, M.M., Parayitam, S., Duraisami, S.P.A., & Saravanaselvan, N.R. (2023). Exploring e-waste recycling behaviour intention among the households: Evidence from India. *Cleaner Materials*, Vol 7, Pp. 1-12.

Viljoen, J.M.M., Schenck, C.J., Volschenk, L., Blaauw, P.F., & Grobler, L. (2021). Household waste management practices and challenges in a rural remote town in the Hantam Municipality in the Northern Cape, South Africa. *MDPI Sustainability*, Vol 13(11), Pp. 1-35.

Vinti, G., Bauza, V., Clasen, T., Tudor, T., & Zurbrugg, C. (2021). Municipal solid waste management and adverse health outcomes: A systematic review. *International Journal of Environment Resource and Public Health*, Vol 19(18), Pp. 1-35.

Vries, A., Stoll, C., & Pandey, S. (2021). The growth of e-waste problem. *Resources, Conservation and Recycling*, Vol 175, Pp. 1-22.

Vitali, C., Ruud, J.B.P., Janssen, H., & Nielen, M.W.F. (2023). Micro plastics and Nano plastics in food, water and beverages, Part I. Occurrence. *TrAC Trends in Analytical Chemistry*, Vol 159, Pp. 1-25.

Wan, K., Chen, H., Zhang, Y., & Wang, Y. (2022). Waste to wealth: Chemical recycling and chemical upcycling of waste plastics for a great future. *European Chemical Societies Publishing*, Vol 10, Pp. 1-11.

Wang, L., Fu, C.F., Wong, P.P., & Zhang, Q. (2022). The impact of tourists' perceptions of space-launch tourism: An extension of the theory of planned behaviour approach. *Journal of China Tourism Research*, Vol 18(3), Pp. 549-568.

Wang, J., Nketiah, E., Gai, X., Obuobi, B., Adu-Gyamfi, H., & Adjei, M. (2023). What establishes citizens' household intention and behaviour regarding municipal solid waste separation? A case study in Jiangsu Province. *Journal Cleaner Production*, Vol 423, Pp. 1-12.

Wang, J., Li, J., Mangmeechai, A., & Su, J. (2021). Linking perceived policy effectiveness and proenvironmental behaviour: The influence of attitude, implementation intention and knowledge. *International Journal of Environmental Research and Public Health*, Vol 18, Pp. 1-17.

Wang, J., Zhou, W., Zhao, M., & Guo, X. (2023). Water quality assessment and pollution evaluation of surface water sources: The case of Weishan and Luoma Lakes, Xuzhou Jiangsu Province China. *Environmental Technology & Innovation*, Vol 32, Pp. 1-14.

Wang, Z., Gu, W., Guo, X., Xue, F., Zhao, J., Han, W., Li, H., Chen, W., Hu, Y., Xang, C., Zhang, L., Wu, P., Chen, Y., Zhao, Y., & Jiang, J. (2023). Spatial association of surface water quality and human cancer in China. *NPJ Clean Water*, Vol 6(53), Pp. 1-9.

Wayne, K.C., Cheah, C.G., Chia, W.Y., Lai, S.F., Chia, S.R., & Show, P.L. (2022). Innovations designs of industry 4.0 based solid waste management: Machinery and digital circular economy. *Environmental Research*, Vol 213, Pp. 1-12.

World Economic Forum (2023). Rethinking our development path in South Africa': in conversation with Linda Godfrey, [Accessed on 08 January 2023]. Available online: https://wrf2023.org/rethinking-our-development-path-in-south-africa-in-conversation-with-linda-godfrey/

World Health Organization (2020). WHO Housing and Health Guidelines. World Health Organization; Geneva, Switzerland, [Accessed on 07 January 2024]. Available online: https://www.who.int/publications-detail-redirect/9789241550376 [Google Scholar]

World Health Organization (2022). Soaring e-waste affects the health of millions of children, WHO warns, [Accessed on 07 January 2024]. Available online: https://www.who.int/news/item/15-06-2021-soaring-e-waste-affects-the-health-of-millions-of-children-who-warns

World Health Organization (2023). Guidance on solid waste and health, [Accessed on 07 January 2024]. Available online: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi04amfu4EAxX3SkEAHex1Ce8QFnoECBsQAQ&url=https%3A%2F%2Fwww.who.int%2Ftools%2Fcompendium-on-health-and-environment%2Fsolid-waste&usg=AOvVaw1z3TOvA4NJrBVz4wwXuFPY&opi=89978449

Wu, Y., Kurisu, K., Phuphisith, S., & Fukushi, K. (2023). Household food-waste prevention behaviours in Beijing, Shanghai and Wuhan in China compared with those in Tokyo and Bangkok. *Resources, Conservation and Recycling*, Vol 192, Pp. 1-19.

Wu, L., Zhu, Y., & Zhai, J. (2022). Understanding waste management behaviour among University students in China: Environmental knowledge, personal norms and the theory of planned behaviour. *Frontiers in Psychology*, Vol 12, Pp. 1-13.

Wulan, S.P., Norong, P.L., Siahaan, A.P.U., Lubis, A.I.F., Ainul, M., & Riyadh, M.I. (2018). Relationships among knowledge, attitude, and behavioural intention of waste management technology. *International Journal of Civil Engineering and Technology*, Vol 9(9), Pp. 1-8.

Wright, N., Subedi, D., Pantha, S., Acharya, K.P., & Nel, L.H. (2021). The Role of Waste Management in Control of Rabies: A Neglected Issue. *MDPI Viruses*, Vol 13, Pp. 1-225.

Xu, J., Liu, H., Liu, X., & Gao, C. (2023). Extended theory of planned behaviour to explain the influence mechanism of low-speed driving behaviour. *PLoSONE*, Vol 18(10), Pp. 1-22.

Xu, M., Wang, Z., & Duan, X. (2023). Effects of pollution on macroinvertebrates and water quality bio-assessment. *Hydrobiologia*, Vol 10, Pp. 1-13.

Yamamoto, H., & Murakami, S. (2022). Which consumer psychological factors influence the lifetime of consumer electronic products? A case study of personal computers in Japan. *Waste Management*, Vol 144, Pp. 233-245.

Yang, Y., & Xu, X. (2022). Municipal hazardous waste management with reverse logistics exploration. *Energy Reports*, Vol 8, Pp. 4649-4660.

Yi, L., Fanbin, K., Ernesto, D.R., & Santibanez, G. (2020). Dumping, waste management and ecological security: Evidence from England. *Journal of Cleaner Production,* Vol 167, Pp.1425-1437.

Yoada, R.M., Chiraworah, D., & Adongo, P.B. (2022). Domestic waste disposal practice and perceptions of private sector waste management in urban Accra. *BMC Public Health,* Vol 14(697), Pp.1-10.

Yuan, H., Du, W., Ma, X., Liu, J., & Li, L. (2023). Critical factors to influence the illegal dumping behaviour of construction and demolition waste: An ISM-DEMATEL analysis. *Developments in the Built Environment*, Vol 14, Pp. 1-15.

Zaveri, M., Wang, Q., Tweedy, A., & Wang, H.G. (2020). Reducing plastic waste through legislative interventions in the United States: Development, Obstacles, Potentials and Challenges. *Sustainable Horizons*, Vol 2(100013), Pp. 1-8.

Zhang, Y., Wang, G., Zhang, Q., Ji, Y., & Xu, H. (2022). What determines urban household intention and behaviour of solid waste separation? A case study in China. *Environmental Impact Assessment Review*, Vol 93, Pp. 1-12.

Zhang, B., Lai, K., Wang, B., & Wang, Z. (2023). From intention to action: How do personal attitudes, facilities accessibility, and government stimulus matter for household waste sorting. *Journal of Environmental Management*, Vol 10, Pp. 1-12.

Zhang, R., & Chen, M. (2023). Predicting online shopping intention: the theory of planned behaviour and live e-commerce. *SHS Web of Conferences*, Vol 155, Pp. 1-10.

Zhao, X., Webber, R., Kalutara, P., Browne, W., & Plenaar, J. (2022). Construction and demolition waste management in Australia: A mini review. *Waste Management and Research*, Vol 40(1), Pp. 34-46.

Ziblim, S., & Bowan, P.A. (2020). A planning framework for municipal solid waste disposal decision-making. *Journal of Sustainable Development Studies*, Vol 14(1), Pp. 1-17.

Zondi, N., Qwatekana, Z., & Dube, S. (2023). Modernisation of rural communities: Solid waste management implication. *African Journal of Inter/Multidisciplinary Studies*, Vol 5(1), Pp. 1-11.

Zurbrugg, C. (2023). Solid waste management in developing countries. *EAWAG, SANDEG*, Vol 2, Pp. 1-5.

APPENDIX/ APPENDICES

APPENDIX A: ENGLISH QUESTIONNAIRE.

Date: ___________________________

Participant Number: _______________

Duration: ________________________

Coordinates: _____________________

Purpose of the study: This study explores Households' Knowledge, Perception and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality.

Introduction: Responses should be based on your residential setting. Moreover, support your answer with examples and statements. Please note that your personal identifying information will not be captured. You are at liberty to withdraw in the exercise at any time. Kindly confirm your participation by signing the informed consent form.

DEMOGRAPHIC INFORMATION.

Choose the answer you agree mostly with.

1. What is your age group?
   A. Under 18 years.
   B. 18 – 34 years.
   C. 35 – 64 years.
   D. 65 years or older.
2. What is your gender?
   A. Female.
   B. Male.
   C. Prefer not to say.
3. What is your level of education?
   A. Primary school.
   B. Secondary school.
   C. Tertiary qualification.
   D. None.

4. What is your employment status?
   A. Unemployed.
   B. Working full time.
   C. Working part time.
   D. Contract worker.
   E. Entrepreneur.
   F. Retired.
   G. Student.

5. What is your income level/ expenditure?
   A. Less than 5 000.
   B. 5 000 – 10 000.
   C. 10 000 – 20 000.
   D. More than 20 000.
   E. None.
6. Which type of waste do you generate often?
   A. Plastic, paper and diaper waste.
   B. Biodegradable waste.
   C. Hazardous waste.
   D. Household hazardous waste.
   E. Food waste.
   F. Construction waste.
   G. Chemical waste.
   H. Electronic waste.
   I. Agricultural waste.
   J. Green (garden) waste.
   K. General waste.
7. How much are you currently spending on waste disposal per month?
   A. Less than R100.
   B. R100 – R200.
   C. R200 – 300.
   D. More than R300.
   E. None.
8. What is your method of disposal?

A. Landfill.
B. Incineration.
C. Waste compaction.
D. Biogas generation.
E. Composting.
F. Vermicomposting.
G. Illegally disposing in water bodies.
H. Illegally disposing in open spaces.
I. Skip bin.

9. How often does the municipality collect waste?
    A. Everyday.
    B. Once in two days.
    C. Once in a week.
    D. Irregularly.
    E. Never.
10. What is your current satisfactory level about municipal waste removal system?
    A. Good.
    B. Very good.
    C. Excellent.
    D. Not satisfied.

KNOWLEDGE AND AWARENESS.

I. To investigate the level of community knowledge and awareness of waste disposal in water.

Mark X if you think you agree with the following statement.

Waste disposal methods	**Aware**	**Not aware**
I know the definition of waste and I understand its meaning.		
I know the types of waste and their categories.		

I understand the meaning of household/ domestic waste.		
Any type of waste should be disposed in designated areas to avoid environmental, health and social risks.		
There is adequate landfill site in town for proper disposal.		
Proper waste disposal is the responsibility of everyone.		
Proper disposal of waste creates a healthy environment.		
Waste disposal in water is a burning issue in this town.		
Waste disposal in water is one of the environmental problems that needs immediate attention.		
Waste is the source of water pollution.		
Improper dumping of wastes can eventually lead to pollution of rivers, lakes and wells.		
Accumulation of waste disposal in rivers cause health risk (e.g. cholera, diarrhoea, typhoid, and bilharzia).		
Waste should not be disposed in water.		
Waste papers, plastic bags, a piece of metal, wood and cloths can be recyclable.		
I consider waste as wealth.		
Waste is anything without value.		
Selling plastic and bottle waste for recycling is the best way to manage solid wastes.		
Waste can be sorted and sold to recycling companies.		
Organic fertilisers and compost can be prepared from waste.		
Food waste can be reduced in water bodies by generating biogas for fuel.		
The amount of household waste can be reduced by reusing at a household level.		

Solid waste management can be achieved by sorting waste at a household level.		
There is public support from the municipality and government in a form of awareness campaigns.		
The municipality and government raise public environmental awareness on the impacts of waste in water.		
Regular supervision and control on illegal dumping of waste in water is conducted.		
The municipality collect waste regularly.		

ATTITUDE, PERCEPTIONS AND PRACTICES.

II. To explore community attitudes, perceptions and practices on waste disposal in water.

Mark X if you think you agree on each of the following statement.

Attitude and perceptions statements	**SA**	**A**	**U**	**D**	**SD**
Solid waste; household waste; diapers; used oil or hazardous waste can be disposed in water bodies.					
The unavailability of bins causes people to dispose of waste in water.					
Lack of waste collection services causes people to dispose of waste in water.					
I will continue to dispose waste in water, If the municipality does not collect waste.					
Disposing waste in water is a good method of disposal.					

I get influenced by people disposing of waste in water.					
Disposing waste in water is cheaper than buying refuse bags to dispose in designated areas.					
Disposing waste in water because the municipality does not care.					
Disposing waste in water bodies creates jobs for municipal workers or EPWP.					
It is the government and municipal's duty to clean up the illegally dumped waste in water					
Disposing waste in water bodies saves the community from an unclean environment.					
Disposing of waste in water bodies is a serious threat to the environment, human and other living organisms.					
Water sources should be converted into a dumping ground.					
Enforcement of fines and rules will reduce waste disposal in water bodies.					
Signage boards of illegal dumping in water convey meaningful message.					
Willing to recycle, reduce and reuse household waste.					

Interested in waste reduction and minimisation.					
Interested in composting household waste.					
Interested in waste segregation or separation at source.					
Currently sorting waste for disposal.					
Willing to pay for waste collection services.					
Willing to place waste garbage in a nearby area where municipality provide or extend their services.					
Willing to travel to the landfill site to dispose waste.					
As a resident, I have social responsibility to dispose my wastes properly to prevent waste disposal in water.					
Willing to participate in awareness campaigns and transfer the gained knowledge to family members and acquaintances.					

ENVIRONMENTAL, HEALTH AND SOCIAL RISKS.

III. To examine environmental, health and social risks associated with waste disposal in water.

Mark X if you think each risk listed is environmental, health or social.

Risks of wastes in water	**Environmental**	**Health**	**Social**
Aquatic organisms cannot survive with less dissolved oxygen.			
Less dissolved oxygen leads to the death and decomposition of aquatic plants and animals.			
Waste disposed in water bodies affects the quality of water by decreasing the amount of dissolved oxygen.			
Excessive algae growth decreases the amount of dissolved oxygen.			
Low concentrations of dissolved oxygen affect photosynthesis, respiration, aeration, decomposition and diffusion.			
Decomposition of aquatic species leads to the release of nutrients in water such as carbon and nitrogen.			
Polluted water contains toxic compounds (nitrates and phosphates) that affect aquatic animals and life.			
The increased levels of nitrates and phosphates endangers the surrounding plants and animals.			

Disposal of heavy materials; household waste and other hazardous waste leads to high turbidity where the surface water becomes cloudy or less clear.			
High turbidity reduces the dispersion of sunlight for aquatic ecosystem.			
High levels of turbidity lead to gastrointestinal illnesses such as diarrhoea, nausea, stomach cramps and headaches.			
High levels of Electrical Conductivity lead to the risk of dehydration.			
Disposal of waste increases water temperatures.			
Excessive nitrogen and phosphorus lead to the high accumulation of algae.			
High levels of nitrates and phosphates depletes food resources.			
High levels of nitrates and phosphates decreases oxygen for aquatic life.			
Nitrates and phosphates leach into the ground and contaminate of groundwater.			
High turbidity increases the risk of flooding and alters proper water flow.			
Dissolved oxygen decreases due to high levels of pollutants in water.			

High levels of nitrates and phosphates leads to the contamination of food chain in the ecosystem.			
High levels of nitrates and phosphates reduce organism's life span and ability to reproduce.			
Poor water quality due to waste disposal is associated with high nitrates and phosphates levels.			
Waste disposal in water alters the physical characteristics of water such as pH, temperature, flow rate and turbidity.			
Low pH levels lead to a decrease in reproduction, growth and eventually death of aquatic species.			
Low pH levels lead to a reduced biological diversity in water.			
Low pH levels damage the gills and skin of aquatic animals.			
Waste disposal decreases the amount of bioindicators (macroinvertebrates).			
Waste contains high levels of nitrates and phosphates that affects the quality of water to a point whereby it could not be reused.			
Growth of algae bloom and plants leads to highly coloured water.			

Low pH levels put pressure on accessibility of water.			
Using water with low dissolved oxygen levels in water cause cardiovascular diseases.			
High water temperatures increase the effects of climate change.			
Waste disposal in water affects the overall health and cause diseases associated with polluted water.			
Waste disposal in water bodies leads to water-borne disease such as Cholera, Giardia, typhoid, bilharzia and malaria etc.			
Low levels of nitrates in water leads to colorectal cancer.			
Drinking water with high levels of nitrates leads to excess heart rate, weakness, fatigue or dizziness.			
Drinking water with high levels of nitrates turns the skin grey or blueish in colour.			
Excessive amount of nitrates leads to methemoglonaemia or baby blue syndrome in children.			
Drinking water with less dissolved oxygen leads to bladder cancer and reproductive problems.			

Excessive flies and mosquitoes in the area due to high water temperatures in polluted water leads to malaria.			
High levels of phosphorus lead to increased risk of stroke, heart attack or death.			
High levels of phosphorus lead to hyperthyroidism, vomiting, diarrhoea and reduction in bone strength.			
Water that is contaminated with household and hazardous waste; pesticides; chemicals; bacteria/faecal run-off affects human health.			
Water pollution of waste dumping affects human health through long-term and short-term effects.			
Using untreated water with high Chemical Demand Oxygen (COD) for any domestic uses leads to cancer-related diseases.			
Children under five die each year due to diarrhoeal diseases related to high levels of phosphorus.			
High levels of total suspended solids cause gastrointestinal problem or even lead to death.			
A high pH level causes the skin to become irritated, dry or itchy, or suffer from severe mucous membrane.			

Low levels of dissolved oxygen lead to bad odour which cause loss of appetite, headache, irritation of nose and throat.			
High levels of nitrates and phosphates leads to an increase in water cost for abstraction and treatment.			
Low pH in water causes a sour and soapy taste leads people to dislike their residential area.			
Waste disposed in water create bad odour.			
Waste in water leads to the surrounding community experiencing a foul smell.			
Environment is unattractive to live in.			
Hindrance of water sports and recreation activities in the water such as fishing, swimming, boating.			
Distribution of river flow causing floods of waste disposed to houses during rainy season.			
Children drown in a polluted river due to poor turbidity.			

BEHAVIOURAL INTENTION.

IV. To determine behavioural intention on waste disposal in water.

Mark X if you think you agree on each of the following statement.

Constructs	**Measurements**	**SA**	**A**	**U**	**D**	**SD**
Environmental awareness and attitude towards waste disposal in water.	It is beneficial to dispose waste in water, in order to reduce the amount of landfill space and greenhouse gas emissions.					
	Recycling waste is essential for protecting water bodies.					
	The state of water quality can be achieved by recycling waste.					
	It is everyone's duty to dispose waste properly.					
	I would rather dispose waste in water because recycling makes me feel unsatisfied.					
	Communities benefit from proper waste disposal.					
	I find the concept of waste disposal in water bodies to be uninteresting.					
Social Pressure (SP).	I will become more engaged in waste disposal in water if my family and friends are involved.					
	I'm motivated by the media to dispose waste in water.					

	I am often influenced to join in waste recycling by my neighbourhood.					
Laws and regulations (LR).	Individuals in South Africa are required by legislation not to dispose waste in water.					
	My decision to dispose waste in water is influenced by government policy.					
	If there exists rules or legislation pertaining to disposal in water, I shall abide by them.					
Cost of waste management.	I dispose waste in water because initiatives for waste disposal are expensive.					
	I believe there should be more money spent on waste management.					
	I consider the processing fees for waste to be exorbitant.					
Inconvenience of Recycling (ICR).	I find it challenging to separate waste for recycling.					
	Sending waste to the collection location would take too much time.					
	Transporting waste to the disposal location is cumbersome.					

	I believe the nearby waste recycling infrastructure is inadequate.					
Past experience (PE).	Waste recycling facilities are something I am quite familiar with.					
	I am familiar with waste/ I am knowledgeable about waste materials.					
	How often did you dispose household waste in water over the last three months?					
Behavioural Intention (BI).	To deal with waste in the future, I'm willing to get in touch with organizations; municipality and government officials.					
	If there are official collection procedures in place, I plan to drop off my waste.					
	I'm willing to take part in government-sponsored environmental programs and awareness campaigns.					
	I'm willing to share my waste disposal experiences with my family.					
	I'm willing to teach my family and friends about the impacts of waste disposal in water.					

Willingness to recycle.	Waste pollution can be reduced by not disposing in water.					
	Participation in educational campaigns will help maintain and fix devices to reduce waste in water.					
	Participation in local collection disposal education will help reduce waste in water.					
	Identification of reputable local recycling businesses will help reduce waste in water.					
	The use of designated disposal collection centers will help reduce waste in water.					

APPENDIX B: SEPEDI QUESTIONNAIRE.

MAMETLETŠO B: LENANEOPOTŠIŠO.

Letšatšikgwedi: ________________________

Nomoro ya motšwasehlabelo: _____________

Nako: _______________________________

Dihlomathišo: __________________________

Morero wa thuto ya dinyakišišo: Dinyakišišo tse di tla lebeledisisa ditlamorago tša tsebo ya malapa, temogo le maikemišetšo a boitswaro mabapi le go lahlwa ga ditlakala go boleng bja meetse mo Ba-Phalaborwa Local Municipality.

Matseno: Dikarabo di swanetše go thewa godimo ga lefelo la gago la bodulo. Go feta moo, thekga karabo ya gago ka mehlala le dipolelo. Hle ela hloko gore tshedimošo ya gago ya go hlaola motho e ka se tšweletswe. O lokologile go ikgogela morago mo go dinyakisiso tse nako efe goba efe. Ka botho tiišetša go tšea karolo ga gago ka go saena fomo ya tumelelo.

TSHEDIMOŠO YA PALO YA BATHO.

Kgetha karabo yeo o dumelelanago le yona kudu.

1. Sehlopha sa gago sa mengwaga ke sefe?
   - A. Ka fase ga mengwaga ye 18.
   - B. 18 – 34 ya mengwaga.
   - C. 35 – 64 ya mengwaga.
   - D. 65 ya mengwaga goba go feta moo.
2. Bong bja gago ke bofe?
   - A. Mosadi.
   - B. Monna.
   - C. Ke kgetha go se bolele.
3. Maemo a gago a thuto ke afe?
   - A. Sekolo sa tlasana.
   - B. Sekolo sa magareng.
   - C. Mangwalo a thuto ya godimo.

D. Ga go selo

4. Maemo a gago a mošomo ke afe?

   A. Ga ke šome.
   B. Ke šoma go ya go ile.
   C. Ke šoma nakwana.
   D. Mošomi wa konteraka.
   E. Rakgwebopotlana.
   F. Rotšego modiro.
   G. Moithuti.

5. Maemo a gago a letseno ke afe?

   A. Ka fase ga R5 000.
   B. R5 000 – R10 000.
   C. R10 000 – R20 000.
   D. Ka godimo ga R20 000.
   E. Ga go selo go tse tsa ka godimo.

6. Ke mohuta ofe wa ditlakala wo o tšweletšwago gantši?

   A. Ditlakala tša polasetiki, pampiri le mengato.
   B. Ditlakala tša go bodisa ke diphedi.
   C. Ditlakala tše kotsi.
   D. Ditlakala tše kotsi tša ka gae.
   E. Ditlakala tša dijo.
   F. Ditlakala tša kago.
   G. Ditlakala tša dikhemikhale.
   H. Ditlakala tša elektroniki.
   I. Ditlakala tša temo.
   J. Ditlakala tša serapeng.
   K. Ditlakala tša kakaretšo.

7. O lefa bokae go lahla ditlakala ka kgwedi?

   A. Ka fase ga R100.
   B. R100 – R200.
   C. R200 – 300.
   D. Ka godimo ga R300.

E. Ga go selo.

8. Mokgwa wa gago wa go lahla ditlakala ke ofe?
   A. Lefelo la go lahlela ditšhila.
   B. Go fišwa ga ditšhila.
   C. Go kgatla ditlakala.
   D. Go hlola biogas.
   E. Go dira manyora.
   F. Go dira manyora ka go bodisa.
   G. Go lahla ka tsela yeo e sego molaong ka gare ga meetse.
   H. Go lahla ka tsela yeo e sego molaong mafelong ao a bulegilego.
   I. Lepokisi la ditlakala.
9. Mmasepala o kgoboketša ditlakala ga kae?
   A. Letšatši le letšatši.
   B. Ga tee ka matšatši a mabedi.
   C. Ga tee ka beke.
   D. Ka mo go sa laolegego.
   E. Le ga tee.
10. Ke maemo afe a gago a bjale ao a kgotsofatšago mabapi le tshepedišo ya go tloša ditlakala tša masepala?
   A. Gabotse.
   B. Gabotse kudu.
   C. Gabotse kudukudu.
   D. Ga se ka kgotsofala.

TSEBO LE TEMOŠO.

I. Go nyakišiša maemo a tsebo ya setšhaba le temošo ya go lahlwa ga ditlakala ka meetseng.

Swaya X ge o nagana gore o dumelelana le polelo ye e latelago.

Mokgwa wa go lahla ditlakala	**Lemoga**	**Ga ke lemoge**
Ke tseba tlhalošo ya ditlakala ebile ke kwešiša gore e a bolela.		
Ke tseba mehuta ya ditlakala le magoro a tšona.		
Ke kwešiša tlhalošo ya ditlakala tša ka gae.		

Mohuta ofe goba ofe wa ditlakala o swanetše go lahlwa mafelong ao a kgethilwego go efoga dikotsi tša tikologo, maphelo le tša leago.		
Go na le lefelo le le lekanego la go lahlela ditšhila toropong bakeng sa go lahlwa gabotse.		
Go lahlwa ga ditlakala ka tshwanelo ke maikarabelo a motho yo mongwe le yo mongwe.		
Go lahlwa ga ditlakala ka tshwanelo go hlola tikologo ye e hlwekilego.		
Go lahlwa ga ditlakala ka meetseng ke taba ye e nyakago sedi le hlokomelo motseng wo.		
Go lahlwa ga ditlakala ka meetseng ke ye nngwe ya mathata a tikologo ao a nyakago tlhokomelo ya ka pela.		
Ditlakala ke mothopo wa tšhilafalo ya meetse.		
Go lahlwa ga ditlakala ka mo go sa swanelago mafelelong go ka hlola tšhilafalo ya dinoka, matsha le didiba.		
Go kgoboketšwa ga go lahlwa ga ditlakala dinokeng, matsheng le didibeng go hlola kotsi ya maphelo (mohlala kholera, letšhollo, thaefoete, le bilharzia).		
Ditlakala ga se tša swanela go lahlwa ka meetseng.		
Dipampiri tša ditlakala, mekotla ya polasetiki, seripa sa tšhipi, kota le masela di ka šomišwa gape.		
Ke tšea ditlakala e le lehumo.		
Ditlakala ke selo se sengwe le se sengwe seo se se nago mohola.		
Go rekiša ditlakala tša polasitiki le tša mabotlelo bakeng sa go dirišwa gape ke tsela e kaone ya go laola ditlakala tše di tiilego.		
Ditlakala di ka hlopša gomme tša rekišetšwa dikhamphani tša dirišwa gape.		

Menontšha ya ditlakala le manyoro di ka lokišetšwa go tšwa go ditlakala.		
Ditlakala tša dijo di ka fokotšwa ka meetseng ka go tšweletša biogas bakeng sa makhura.		
Palo ya ditlakala tša ka gae e ka fokotšwa ka go šomiša gape maemong a ka gae.		
Taolo ya ditlakala tše di tiilego e ka fihlelelwa ka go hlopha ditlakala maemong a ka gae.		
Go na le thekgo ya setšhaba go tšwa go mmasepala le mmušo ka mokgwa wa masolo a temošo.		
Mmasepala le mmušo di godiša temošo ya setšhaba mo tikologong ka ga ditlamorago tša ditlakala ka meetseng.		
Tlhokomelo ya ka mehla le taolo ya go lahlelwa ga ditlakala ka meetseng tšeo di sego molaong di a dirwa.		
Mmasepala o kgoboketša ditlakala ka mehla.		

MAIKUTLO, DITEMOGO LE MEKGWA.

II. Go hlahloba maikutlo a setšhaba, ditemogo le mekgwa ka ga go lahlwa ga ditlakala ka meetseng.

Swaya X ge o nagana gore o dumelelana ka ye nngwe le ye nngwe ya polelo ye e latelago.

Dipolelo tša maikutlo le ditemogo	**SA**	**A**	**U**	**D**	**SD**
Ditlakala tše di tiilego, ditlakala tša ka gae, mengato, oli ye e šomišitšwego goba ditlakala tše kotsi di ka lahlwa ka gare ga meetse.					
Go se hwetšagale ga mekotla go dira gore batho ba lahle ditlakala ka meetseng.					

Go hloka ditirelo tša kgoboketšo ya ditlakala go dira gore batho ba lahle ditlakala ka meetseng.					
Ke tla tšwela pele go lahla ditlakala ka meetseng, ge mmasepala o sa kgoboketše ditlakala.					
Go lahla ditlakala ka meetseng ke mokgwa o mmotse wa go lahla.					
Ke hlohloletša ke batho bao ba lahlago ditlakala ka meetseng.					
Go lahla ditlakala ka meetseng go theko e fase go feta go reka mekotla ya ditlakala gore o e lahle mafelong ao a kgethilwego.					
Go lahla ditlakala ka meetseng ka gobane mmasepala ga o na taba.					
Go lahla ditlakala ka meetseng go hlola mešomo go bašomi ba mmasepala goba EPWP.					
Ke mošomo wa mmušo le mmasepala go hlwekiša ditlakala tšeo di lahlilwego ka meetseng ka tsela yeo e sego molaong.					
Go lahla ditlakala ka gare ga meetse go phološa setšhaba tikologong ye e sa hlwekago.					

Go lahla ditlakala ka meetseng ke tšhošetšo ye kgolo go tikologo, batho le diphedi tše dingwe tše di phelago.					
Methopo ya meetse e swanetše go fetoga lefelo la go lahlela ditlakala.					
Phethagatšo ya difaene le melawana e tla fokotša go lahlwa ga ditlakala mafelong a meetse.					
Dipolanka tša maswao tša go lahlela ditlakala ka meetseng mo go sego molaong di fetišetša molaetša wo o nago le mohola.					
Ke ikemišeditše go šomiša gape le go fokotša ditlakala tša ka gae.					
Ke nale kgahlego ya go fokotša ya ditlakala.					
Ke nale kgahlego ya go dira manyoro ka ditlakala tša ka gae.					
Ke nale kgahlego ya go aroganya ditlakala goba karoganyo mohloding.					
Ke aroganya ditlakala gore di lahlwe.					
Ke ikemišeditše go lefa ditirelo tša kgoboketšo ya ditlakala.					
Ke ikemišeditše go bea ditlakala lefelong la kgauswi le moo mmasepala o fago goba o katološago ditirelo tša bona.					

Ke ikemišeditše go ya lefelong la maleba go yo lahla ditlakala.					
Bjalo ka modudi, ke nale maikarabelo a leago a go lahla ditlakala tša ka gabotse go thibela go lahlwa ga ditlakala ka meetseng.					
Ke ikemišeditše go tšea karolo go masolo a temošo le go fetišetša tsebo yeo e hweditšwego go maloko a lapa le bao ba ba tlwaetšego.					

DIKOTŠI TŠA TIKOLOGO, TŠA MAPHELO LE TŠA LEAGO.

III. Go hlahloba dikotsi tša tikologo, tša maphelo le tša leago tšeo di amanago le go lahlwa ga ditlakala ka meetseng.

Swaya X ge o nagana gore kotsi ye nngwe le ye nngwe yeo e lokeleditšwego ke ya tikologo, ya maphelo goba ya leago.

Dikotsi tša ditlakala ka meetseng	**Tikologo**	**Maphelo**	**Leago**
Diphedi tša ka meetseng ga di kgone go phela ka oksitšene ye e hlapolotšwego kudu.			
Oksitšene ye e hlapolotšwego e lebiša go bolaya le go bola ga dimela le diphoofolo tša ka meetseng.			
Ditlakala tšeo di lahlwago ka gare ga meetse di ama boleng bja meetse ka go fokotša palo ya oksitšene ye e hlapolotšwego.			
Kgolo e feteletšwego ya bolele e fokotša palo ya oksitšene ye e hlapolotšwego.			

Mahloriso a tlase a oksitšene a ama tshepedišo ya photosynthesis, respiration, aeration, decomposition and diffusion.			
Go bola ga mehuta ya diphedi tša ka meetseng go lebiša go lokollwa ga phepo ka metseeng go swana le khapone le naetrotšene.			
Meetse a šilafaditšwego a na le metswako ye e nago le mpholo (dinaetreite le difosfate) tšeo di amago diphoofolo tša ka meetseng le maphelo a tšona.			
Maemo a oketšegilego a naetreite le difosfate a bea dibjalo le diphoofolo tša tikologo yeo kotsing.			
Go lahlwa ga didirišwa tše boima, ditlakala tša ka gae le ditlakala tše dingwe tše kotsi go lebiša go tlhakatlhakano ye kgolo moo meetse a godimo a bago le maru le go se hlweke kudu.			
Tlhakatlhakano ya godimo e fokotša go phatlalala ga seetša sa letšatši bakeng sa tshepedišo ya tswalano ya diphedi le tikologo ya tšona ya ka meetseng.			
Maemo a godimo a tlhakatlhakano a lebiša go malwetši a go swana le a ka mpeng, letšhollo, go nyema moko, go tšhošwa ga mala le go opa ke hlogo.			

Maemo a phahameng a mohlagase ka meetseng a lebiša kotsing ya go hloka meetsi mmeleng.			
Go lahlwa ga ditlakala go oketša dithemperetšha tša meetse.			
Naetrotšene ye e feteletšego le fosforo di lebiša go kgoboketšong ye e phagamego ya bolele.			
Maemo a godimo a naetreite le difosfate a fetša methopo ya dijo.			
Maemo a godimo a naetreite le difosfate a fokotša oksitšene bakeng sa bophelo bja ka meetseng.			
Dinaetreite le difosfate di tšholla ka fase gomme di šilafatša meetse a ka fase ga lefase.			
Go tlhakatlhakana mo go phagamego go oketša kotsi ya mafula gomme go fetoša go elela ga meetse ka tshwanelo.			
Oksitšene ye e hlapolotšwego e a fokotšega ka lebaka la maemo a godimo a ditšhila ka meetseng.			
Maemo a godimo a dinaetreite le difosfate a lebiša go tšhilafatšo ya ketane ya dijo ka tshepedišong ya tswalano ya diphedi le tikologo ya tšona.			

Maemo a godimo a dinaetreite le difosfate a fokotša nako ya bophelo bja diphedi le bokgoni bja go tšweletša gape.			
Boleng bjo bo fokolago bja meetse ka lebaka la go lahlwa ga ditlakala bo amana le maemo a godimo a dinaetreite le difosfate.			
Go lahlwa ga ditlakala ka meetseng go fetoša dimelo tša mmele tša meetse go swana le pH, themperetšha, seelo sa go ela le go tlhakatlhakana.			
Maemo a fase a pH a lebiša go fokotšegeng ga tswalo, kgolo gomme mafelelong lehu la mehuta ya diphedi tša ka meetseng.			
Maemo a fase a pH a lebiša go fokotšega ga go fapafapana ga diphedi ka meetseng.			
Maemo a fase a pH a senya di-gills le letlalo la diphoofolo tša ka meetseng.			
Go lahlwa ga ditlakala go fokotša palo ya ditšhupetšo tša diphedi (diphoofolo tše di se nago marapo a mokokotlo).			
Ditlakala di na le maemo a godimo a dinaetreite le difosfate tšeo di amago boleng bja meetse go fihla bokgoleng bjoo bo bego bo sa kgone go šomišwa gape.			
Kgolo ya bolele le dimela ye isa go meetse a mebala e phagameng.			

Maemo a fase a pH a bea kgatelelo go phihlelelo ya meetse.			
Go šomiša meetsi ao a be go le maemo a fase a oksitšene ye e hlapolotšwego ka meetseng a baka malwetši a pelo le methapo.			
Dithemperetšha tša godimo tša meetse di oketša ditlamorago tša phetogo ya leratadima.			
Go lahlwa ga ditlakala ka meetseng go ama maphelo ka kakaretšo gomme go hlola malwetši ao a amanago le meetse ao a šilafetšego.			
Go lahlwa ga ditlakala ka meetseng go lebiša malwetšing ao a rwalago ke meetse go swana le Kholera, Giardia, thaefoete, bilharzia le malaria etc.			
Maemo a tlase a naetreite ka meetseng a lebiša go kankere ya mmala.			
Go nwa meetse ao a nago le maemo a godimo a dinaetreite a lebiša go go betha ga pelo mo go feteletšego, go fokola, go lapa goba go tsenwa ke phefo.			
Go nwa meetse ao a nago le maemo a godimo a dinaetreite a fetoša letlalo goba mmala wa sehla go ba wo talalerata.			

Palo e feteletšego ya dinaetreite e lebiša go methemoglonaemia goba lesea le leputsoa mo baneng.			
Go nwa meetse ao a nago le oksitšene yeo e hlapolotšwego kudu e lebiša go kankere ya tshenya le mathata a pelego.			
Dintšhi le menang ka mo go feteletšego mo lefelong leo ka lebaka la dithemperetšha tša godimo tša meetse a šilafetšego a lebiša go malaria.			
Maemo a godimo a difosfate a lebiša kotsing e oketšegilego ya go hwa lehlakore, tlhaselo ya pelo goba lehu.			
Maemo a godimo a difosfate a lebiša go hyperthyroidism, go hlatša, letšhollo le phokotšo ya maatla a marapo.			
Meetse ao a šilafaditšwego ke ditlakala tša ka gae; ditlakala tša kotsi; sebolayasenyi; dikhemikhale; dipaketheria/ go elela ga mantle go ama maphelo a batho.			
Tšhilafalo ya meetse ka go lahlelwa ga ditlakala e ama maphelo a batho ka ditlamorago tša nako ye telele le tša nako ye kopana.			
Go šomiša meetse ao a sa hlwekišwago a goba le maemo a godimo a dikhemikhale nyakego oksitšene (COD) bakeng sa ditirišo			

dife goba dife tša ka gae go lebiša malwetšing ao a amanago le kankere.			
Bana ba ka fase ga mengwaga ye mehlano ba hwa ngwaga o mongwe le o mongwe ka lebaka la malwetši a letšhollo e amanago le maemo a godimo a difosfate.			
Maemo a godimo a dilo tše di emišitšwego tša sedimente di baka bothata bja ka mpeng goba ga ešita le go lebiša lehung.			
Maemo a godimo a pH a dira gore letlalo le tenege, le ome goba le hlohlone goba tlaišo ya lera la mucous le thata.			
Maemo a tlase a oksitšene e hlapolotšwego a lebiša go monkgo o mobe a feletša a baka go lahlegelwe ke kganyogo ya dijo, go opa ke hlogo, go hlohlona ga nko le mogolo.			
Maemo a godimo a dinaetreite le difosfate a lebiša go koketšego ya ditshenyegelo tša meetse bakeng sa go tšea le go alafa.			
PH ya fase ka meetseng e hlola tatso ye bodila goba tatso ya sesepa e lebiša go batho gore ba se rate lefelo la bona la bodulo.			
Ditlakala tšeo di lahlilwego ka meetseng di hlola monkgo o mobe.			
Ditlakala ka meetseng di lebiša go setšhaba seo se ba dikologilego go itemogela monkgo o mobe.			

Tikologo ga e kgahliše go phela go yona.			
Tšhitišo ya dipapadi tša ka meetseng le mediro ya boithabišo ka meetseng go swana le go rea dihlapi, go sesa, go sepela ka sekepe.			
Phahlalatso ya go elela ga noka yeo e hlolago mafula a ditlakala tšeo di lahlilwego ka dintlong nakong ya sehla sa pula.			
Bana ba nwelela ka nokeng ye e šilafetšego ka lebaka la fokolo ya tlhakatlhakano.			

MAIKEMIŠETŠO A BOITSHWARO.

IV. Go laetša maikemišetšo a boitshwaro ka ga go lahlwa ga ditlakala ka meetseng.

Swaya X ge o nagana gore o dumelelana le ye nngwe le ye nngwe ya polelo ye e latelago.

Dipopego tša go aga	**Ditekanyo**	**SA**	**A**	**U**	**D**	**SD**
Temošo ya tikologo le maikutlo ka ga go lahlwa ga ditlakala ka meetseng.	Go hola go lahla ditlakala ka meetseng, e le gore go fokotšwe palo ya sekgoba sa go lahlela ditšhila le go tšweletšwa ga dikgase tša go hlola boso.					
	Go dirišwa gape ga ditlakala go bohlokwa bakeng sa go šireletša meetse.					

	Boemo bja boleng bja meetse bo ka fihlelelwa ka go šomiša ditlakala gape.					
	Ke mošomo wa motho yo mongwe le yo mongwe go lahla ditlakala gabotse.					
	Nka rata go lahla ditlakala ka meetseng ka gobane go dirišwa gape go dira gore ke ikwe ke sa kgotsofala.					
	Ditšhaba di holega ka go lahlwa ga ditlakala ka tshwanelo.					
	Ke hwetša kgopolo ya go lahlwa ga ditlakala ka meetseng e le yeo e sa kgahlišego.					
Kgatelelo ya leago.	Ke tla tsenela kudu go lahla ditlakala ka meetseng ge ba lapa lešo le bagwera baka ba ka akaretšwa.					
	Ke hlohleletšwa ke boraditaba go lahla ditlakala ka meetseng.					
	Gantši ke tutuetšwa go kopanela go dirišweng gape ga ditlakala le baagišani ba gešo.					
Melao le melawana.	Batho ba Afrika Borwa ba gapeletsega ka lebaka la molao go se lahlele ditlakala ka meetseng.					

	Sephetho sa ka sa go lahla ditlakala ka meetseng se hlohloletšwa ke pholisi ya mmušo.					
	Ge go na le melawana goba molao wo o le go gona mabapi le go lahlwa ga ditlakala ka meetseng, ke tla e obamela.					
Ditshenyagalelo tša taolo ya ditlakala.	Ke lahla ditlakala ka meetseng ka gobane maitapišo a go lahla ditlakala a tura.					
	Ke dumela gore go swanetše go ba le tšhelete ye ntši yeo e šomišwago go taolo ya ditlakala.					
	Ke tšea ditefelo tša go šoma ditlakala e le tše di feteletšego.					
Go se loke ga go dirišwa gape.	Ke hwetša e le tlhohlo go aroganya ditlakala gore di dirišwe gape.					
	Go romela ditlakala lefelong la go kgoboketša ditlakala go be go tla tšea nako e ntši kudu.					
	Go iša ditlakala lefelong la go lahla go boima.					
	Ke dumela gore mananeokgoparara a kgauswi a go šomiša ditlakala gape ga se a lekana.					

Phihlelo ya nakong e fetilego.	Mafelo a go dirišwa gape ga ditlakala ke selo seo ke se tlwaetšego kudu.					
	Ke tlwaelane le ditlakala/ ke na le tsebo ka didirišwa tša ditlakala.					
	Ke gakae o lahlilego ditlakala tša ka gae ka meetseng dikgweding tše tharo tša go feta?					
Maikemišetšo a boitshwaro.	Go šomana le ditlakala nakong e tlago, ke ikemišeditše go ikgokaganya le mekgatlo; bahlankedi ba mmasepala le ba mmušo.					
	Ge e ba go na le ditshepedišo tša semmušo tša go kgoboketša ditlakala tšeo di lego gona, ke rulaganya go lahlela ditlakala tšaka moo.					
	Ke ikemišeditše go tšea karolo mananeong a tikologo le masolo a temošo ao a thekgwago ke mmušo.					
	Ke ikemišeditše go abelana le lapa lešo maitemogelo a ka a go lahla ditlakala.					
	Ke ikemišeditše go ruta lapa lešo le bagwera ka ga ditlamorago tša					

	go lahlwa ga ditlakala ka meetseng.					
Go ikemišetša go diriša gape.	Tšhilafalo ya ditlakala e ka fokotšwa ka go se lahle ka meetseng.					
	Go tšea karolo go masolo a thuto go tla thuša go hlokomela le go lokiša didirišwa tša go fokotša ditlakala ka meetseng.					
	Go tšea karolo thutong ya go lahla ditlakala ya selegae go tla thuša go fokotša ditlakala ka meetseng.					
	Go hlaolwa ga dikgwebo tša selegae tša go šomiša leswa tšeo di nago le botumo bjo bo botse go tla thuša go fokotša ditlakala ka meetseng.					
	Tšhomišo ya mafelo ao a kgethilwego a go kgoboketša ditlakala e tla thuša go fokotša ditlakala ka meetseng.					

APPENDIX C: UKZN ETHICAL CLEARANCE CERTIFATE.

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

04 April 2024

Tshegofatso Sebashe (224104990)
School of Agri Earth & Env Sc
Pietermaritzburg Campus

Dear T Sebashe,

Protocol reference number: HSSREC/00006687/2024
Project title: Households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality.
Degree: Masters

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 15 February 2024 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

Incidents of adverse events and serious adverse events (AEs and SAEs) should be reported in writing to HSSREC, the study sponsors, and any regulatory authority (where appropriate), within 7 working days of the occurrence for local sites and 14 days for all other South African sites.

This approval is valid until 04 April 2025.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)
/dd

Humanities and Social Sciences Research Ethics Committee
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 8350/4557/3587 **Email:** hssrec@ukzn.ac.za **Website:** http://research.ukzn.ac.za/Research-Ethics

APPENDIX D: BA-PHALABORWA PERMISSION LETTER.

BA-PHALABORWA MUNICIPALITY

PRIVATE BAG X01020
PHALABORWA 1390
TELEPHONE
(015) 780 6300
FAXIMILE
(015) 781 0726
E-mail: phalamun@lantic.net

Ref: 5/4/1
Enquiries: Selapyane JB
Your ref:

ALL CORRESPONDENCE TO BE ADDRESSED TO THE MUNICIPAL MANAGER

26 October 2023

University of Kwazulu-Natal, School of Agriculture Earth and Environmental Science
289 Mazisi Kunene Rd
Glenwood, Berea
4001

Dear Ms. T Sebashe

RE: PERMISSION TO PERFORM RESEARCH UNDER THE TOPIC "EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TOWARDS WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY."

Kindly take note that a permission to conduct research within Ba-Phalaborwa Municipality is granted. The following ethical conduct as prescribed during the conducting of the research must be adhered to without compromises:

- Present this letter of permission to the institution supervisor/s a week before the study is conducted.
- In the course of your study, there should be no action that disrupts the routine services, or incur any cost on the Municipality.
- After completion of study, it is mandatory that the findings should be submitted to the Municipality to serve as portfolio of evidence.
- The researcher should be prepared to assist in the interpretation and implementation of the study recommendation where possible.
- The approval is only valid for a 6-month period.
- If the proposal has been amended, a new approval should be sought from Ba-Phalaborwa Municipality.
- Kindly note that the Municipality can withdraw the approval at any time

Wishing you well over the course of your study.

[redacted]
MUNICIPAL MANAGER

APPENDIX E: DEPARTMENT OF HEALTH PERMISSION LETTER.

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH
MAPHUTHA L. MALATJI HOSPITAL

DEPARTMENT OF HEALTH
MAPHUTHA L MALATJI HOSPITAL
COMMUNICATION SERVICES
2023 -11- 23
Private Bag X11020
NAMAKGALE 1391
LIMPOPO PROVINCE

23 November 2023

University of KwaZulu-Natal, School of Agriculture, Earth and Environmental Sciences

King Edward Ave, Scottsville

Pietermaritzburg

3201

Dear Ms T Sebashe

RE: PERMISSION TO CONDUCT RESEARCH ON THE EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TO WARDS WASTE DISPOSAL ON WATER QUALITY.

The Department of Health is pleased to approve your request and grant you permission to conduct research in Ba-Phalaborwa Local Municipality.

Please note the following:

1. Please ensure that you adhere to all the policies, procedures, protocols and guidelines of the Department of Health with regards to this research.
2. This research will only commence once this office has received confirmation from the Provincial Health Research Office Committee in the Department of Health.
3. Please ensure this office is informed before you commence your research.
4. The District office/facility will not provide any financial resources for this research.
5. You will be expected to provide feedback on your findings to the District office/facility.

[redacted]

COMMUNITY LIAISON OFFICER

23 November 2023

DATE

APPENDIX F: LOCAL TRIBAL AUTHORITIES' PERMISSION LETTERS.

MAKHUSHANE TRIBAL AUTHORITY (Makhushane Village).

Makhushane Tribal Authority
Makhushane Village
Phalaborwa
1390
07 November 2023

University of KwaZulu-Natal
King Edward Ave, Scottsville
Pietermaritzburg
3201

RE: PERMISSION TO CONDUCT RESEARCH ON THE EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TOWARDS WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY.

I am writing to formally approve the researcher to conduct the study in Makhushane Village within Ba-Phalaborwa Local Municipality.

Kind Regards

DEPARTMENT OF CO-OPERATIVE GOVERNANCE
HUMAN SETTLEMENTS & TRADITIONAL AFFAIRS
BA-PHALABORWA
TRADITIONAL COUNCIL
07 NOV 2023
PRIVATE BAG X11018 NAMAKGALE
1391
MOPANI DISTRICT SUPPORT CENTRE

[redacted]

MASEKE TRIBAL AUTHORITY (Maseke Village).

Maseke Tribal Authority
Maseke Village
Phalaborwa
1390
07 November 2023

University of KwaZulu-Natal
King Edward Ave, Scottsville
Pietermaritzburg
3201

RE: PERMISSION TO CONDUCT RESEARCH ON THE EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TOWARDS WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY.

I am writing to formally approve the researcher to conduct the study in Maseke Village within Ba-Phalaborwa Local Municipality.

Kind Regards

TRADITIONAL COUNCIL

[redacted]

MAKHUSHANE TRIBAL AUTHORITY (Boelane Village).

Makhushane Tribal Authority
Boelang Village
Phalaborwa
1390
07 November 2023

University of KwaZulu-Natal
King Edward Ave, Scottsville
Pietermaritzburg
3201

RE: PERMISSION TO CONDUCT RESEARCH ON THE EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TOWARDS WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY.

I am writing to formally approve the researcher to conduct the study in Boelang Village within Ba-Phalaborwa Local Municipality.

Kind Regards

DEPARTMENT OF CO-OPERATIVE GOVERNANCE HUMAN SETTLEMENTS & TRADITIONAL AFFAIRS
BA-PHALABORWA
TRADITIONAL COUNCIL
07 NOV 2023
PRIVATE BAG X11018 NAMAKGALE

[redacted]

MASHISHIMALE TRIBAL AUTHORITY (Mashishimale Village).

Mashishimale Tribal Authority
Mashishimale Village
Phalaborwa
1390
07 November 2023

07 NOVEMBER 2023

University of KwaZulu-Natal

King Edward Ave, Scottsville

Pietermaritzburg

3201

RE: PERMISSION TO CONDUCT RESEARCH ON THE EFFECTS OF HOUSEHOLDS' KNOWLEDGE, PERCEPTION AND BEHAVIOURAL INTENTION TOWARDS WASTE DISPOSAL ON WATER QUALITY IN BA-PHALABORWA LOCAL MUNICIPALITY.

I am writing to formally approve the researcher to conduct the study in Mashishimale Village within Ba-Phalaborwa Local Municipality.

Sincerely,

DEPARTMENT OF CO-OPERATIVE GOVERNANCE
HUMAN SETTLEMENTS & TRADITIONAL COUNCIL
BA-SHAYI DITLOU TRADITIONAL COUNCIL
07 NOV 2023
P.O. BOX 1298 BATUBATSE 1398
MOPANI DISTRICT SUPPORT

[redacted]

APPENDIX G: ENGLISH INFORMED CONSENT.

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL
For research with human participants

INFORMED CONSENT RESOURCE TEMPLATE

Note to researchers: Notwithstanding the need for scientific and legal accuracy, every effort should be made to produce a consent document that is as linguistically clear and simple as possible, without omitting important details as outlined below. Certified translated versions will be required once the original version is approved.

There are specific circumstances where witnessed verbal consent might be acceptable, and circumstances where individual informed consent may be waived by HSSREC.

Information Sheet and Consent to Participate in Research

Date:

Greeting: Hello.

My name is Sebashe Tshegofatso from University of KwaZulu-Natal under the Department of Agriculture and Environmental Sciences.

You are being invited to consider participating in a study that involves research about waste disposal on water quality. Your community has been identified as an area that is common in disposing waste in water. The aim and purpose of this research is to explore households' knowledge, perception and behavioural intention of the effects of waste disposal on water quality in Ba-Phalaborwa Local Municipality. The study is expected to enroll 384 participants with 96 participants in each village at Mashishimale, Makhushane, Boelane and Maseke village. It will involve the following procedures, the researcher will introduce herself and present a letter of permission from the municipality, Department of Health and community leaders, and the researcher will distribute the informed consent and thereafter administer the questionnaire. The duration of your participation if you choose to enroll and remain in the study is expected to be 15 minutes.

The study may involve the following risks and/or discomforts such as economic discomforts, participatants may feel uncomfortable to disclose their income level and employment status. The study will provide no direct benefits to participants. However, scientific/other benefits hoped for from the study are enlightening participants on the consequences of disposing waste in water and how they can improve the state of water quality by ensuring proper waste disposal in designated areas.

This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number_____).

In the event of any problems or concerns/questions you may contact the researcher at tel: [redacted], email: [redacted] or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557- Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Participation in this research is voluntary. Participants may withdraw from participation at any point, and that in the event of refusal/withdrawal of participation the participants will not incur penalties or loss of treatment or other benefits to which they are normally entitled. The potential consequences to the participant for withdrawal from the study leads to the researcher resampling households. Procedure/s required from the participants for orderly withdrawal involve informing the researcher about their withdrawal in a polite manner. The researcher will terminate the participant from the study when they do not feel safe or when they verbally or physically abuse the researcher.

Each participant will be allocated a number (e.g. P1) for participant number one. Questions will not probe personal and clinical information to protect their confidentiality. The interview data will be kept safe and locked at the University library for a period of the study.

CONSENT

I (Name)……………………………………have been informed about the study entitled (provide details)………………………………… by (provide name of researcher/fieldworker)……………………….

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at [redacted] or [redacted]

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview / focus group discussion	YES / NO
Video-record my interview / focus group discussion	YES / NO
Use of my photographs for research purposes	YES / NO

____________________ ____________________
Signature of Participant **Date**

____________________ ____________________
Signature of Witness **Date**
(Where applicable)

____________________ ____________________
Signature of Translator **Date**
(Where applicable)

APPENDIX H: SEPEDI INFORMED CONSENT.

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL
For research with human participants

INFORMED CONSENT RESOURCE TEMPLATE

Note to researchers: Notwithstanding the need for scientific and legal accuracy, every effort should be made to produce a consent document that is as linguistically clear and simple as possible, without omitting important details as outlined below. Certified translated versions will be required once the original version is approved.

There are specific circumstances where witnessed verbal consent might be acceptable, and circumstances where individual informed consent may be waived by HSSREC.

Letlakala la tšhedimošo le tumelelo ya go tšea karolo mo nyakišišong ye.

Letšatšikgwedi:

Madume: Thobela.

Ke nna Sebashe Tshegofatso, ke moithuti Yunibesithing ya KwaZulu-Natal ka fase ga lefapha la Agriculture le Environmental Sciences.

O memilwe go tšea karolo go N yakišišo mabapi le go lahlwa ga ditlakala ka ga boleng bja meetse. Setšhaba sa geno se lemogilwe bjalo ka lefelo leo le tlwaelegilego ka go lahla ditlakala ka meetseng. Maikemišetšo le morero wa dinyakišišo ke go hlahloba ditlamorago tša tsebo ya malapa, temogo le maikemišetšo a boitshwaro bja go lahlwa ga ditlakala go boleng bja meetse mo Ba-Phalaborwa Local Municipality. Diyakišišo goba thuto ye e letetšwe go ngwadiša batšeakarolo ba 384, go tla ngwadiswa 96 motseng o mongwe le o mongwe, elego Mashishimale, Makhushane, Boelane le Maseke. E tla akaretša ditshepedišo tše di latelago; monyakišiši o tla itsebiša le go tšweletša mangwalo a tumelelo go tšwa go Mmasepala, Kgoro ya Maphelo le baetapele ba setšhaba, monyakišiši o tla fa tumelelo ye e nago le tsebo gomme ka morago ga fao a laola lenaneopotšišo. Nako ya go tšea karolo ge o kgetha go ingwadiša e letetšwe go ba metsotso ye lesomehlano.

Nyakišišo di ka akaretša dikotsi tše di latelago le/goba go se iketle maikutlong ka go bolela ka ikonomi, batšeakarolo ba ka ikwa ba sa phuthologa go utolla maemo a bona a letseno le maemo a bona a mošomo. Thuto ye e ka se be le dikgolego go batšeakarolo. Le ge go le bjalo, mehola ya mahlale/ ye mengwe yeo e holofetšwego go tšwa nyakišišong ye e sedimoša batšeakarolo ka ga ditlamorago tša go lahla ditlakala ka meetseng le ka moo ba ka kaonafatšago seemo sa boleng bja meetse ka go netefatša gore ditlakala di lahlwa gabotse mafelong ao a kgethilwego.

Nyakišišo goba thuto ye e lekotšwe ka maitshwaro le go dumelelwa ke UKZN Humanities and Social Sciences Research Ethics Committee (nomoro ya tumelelo_____).

Ge go ka ba le mathata goba dipelaelo/dipotšišo o ka ikgokaganya le monyakišiši go nomoro ye ya mogala: [redacted], imeile: [redacted] goba UKZN Humanities & Social Sciences Research Ethics Committee, dintlha tša kgokagano ka tsela ye e latelago:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557- Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Go tšea karolo nyakišišong ye ke ga boithaopo. Batšeakarolo ba ka ikgogela morago go tšea karolo ntlheng efe goba efe. Le gore ge go ka direga gore ba gane goba go ikgogela morago go tšea karolo, batšeakarolo ba ka se hwetše dikotlo goba go swarwa gampe goba dikholego tše dingwe tšeo ka tlwaelo ba nago le maswanedi a go di hwetša. Ditlamorago tšeo di ka bago gona go motšeakarolo bakeng sa go ikgogela morago nyakišišong di lebiša go monyakišiši go kgetha batseakarolo ba bangwe go ya ka ya malapa. Ditshepedišo tšeo di nyakegago go tšwa go batšeakarolo bakeng sa go ikgogela morago ka thulaganyo di akaretša go tsebiša monyakišiši ka ga go ikgogela morago ga bona ka mokgwa wa maitshwaro. Monyakišiši o tla fediša motšeakarolo nyakišišong ge a sa ikwe a bolokegile goba ge a tlaiša monyakišiši mmeleng goba ka mantšu.

Motšeakarolo yo mongwe le yo mongwe o tla abelwa nomoro, (mohlala P1) bakeng sa motšeakarolo wa mathomo. Dipotšišo di ka se nyakišiše tshedimošo ya motho le ya maphelo go šireletša sephiri sa bona. Dikhuthullo tsa poledišano le batseakarolo di tla bolokwa le go notlelwa bokgobapukung bja yunibesithi lebaka le itšego la nyakišišo.

TUMELELO

Nna (Leina)……………………………………………..ba ntsebišitše ka nyakišišo yeo e ngwadilwego le go bitswa ka mokgwa wo (Efa leina la nyakisiso)……………………………………………………… ka (E fa leina la monyakišiši goba mošomi)………………………………………………….

Ke kwešiša morero le ditshepedišo tša thuto ye.

Ke filwe sebaka sa go araba dipotšišo mabapi le thuto ye, gomme ke file le dikarabo ka kgotsofalo yaka.

Ke tsebagatša gore go tšea gaka karolo nyakišišong ye, ke ga boithaopo ka mo go feletšego le gore nka ikgogela morago nako efe goba efe ntle le go ama le ge e le efe goba efe ya mehola yeo gantši ke nago le tshwanelo ya go e hwetša.

Ke tsebišitšwe ka ga tefo efe goba efe yeo e lego gona goba kalafo ya kgobalo ye e ka ntiragalelago ka lebaka la ditshepedišo tše di amanago le thuto ye.

Ge ke nale dipotšišo goba dipelaelo; goba dipotšišo tše dingwe tše di amanago le nyakišišo ye, ke kwešiša gore nka ikgokaganya le monyakišiši go nomoro ya mogala [redacted] goba aterese ya imeile [redacted].

Ge ke na le dipotšišo goba dipelaelo ka ga ditokelo tša ka bjalo ka motšeakarolo wa nyakišišo, goba ge ke tshwenyegile ka lehlakore la nyakišišo goba banyakišiši gona nka ikgokaganya le:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Tumelelo ya tlaleletšo, moo go lego maleba

Ke fa tumelelo ya go:

Rekoto ya modumo poledišano ya ka / poledišano ya sehlopa sa nepo	EE / AOWA
Rekoto ya bitiyo poledišano ya ka / poledišano ya sehlopa sa nepo	EE / AOWA
Tšhomišo ya diswantšho tša ka bakeng sa merero ya nyakišišo	EE / AOWA

____________________ ____________________
Mosaeno wa motšeakarolo **Letšatšikgwedi**

____________________ ____________________
Mosaeno wa hlatse **Letšatšikgwedi**
(Moo go lego maleba)

____________________ ____________________
Mosaeno wa mofetoledi **Letšatšikgwedi**
(Moo go lego maleba)

APPENDIX I: GREATER TZANEEN MUNICIPALITY PERMISSION LETTER FOR WATER QUALITY ASSESSMENT.

GREATER TZANEEN MUNICIPALITY
GROTER TZANEEN MUNISIPALITEIT
MASIPALA WA TZANEEN
MASEPALA WA TZANEEN

FROM NATURE

P.O. BOX 24
TZANEEN
0850

TEL: 015 307 8000
FAX: 015 307 8049

www.tzaneen.gov.za

09 February 2024

Ref.: 4/4/R
Mositsa AM

P.O. Box 8416
NAMAKGALE
1391

Ms. Tshegofatso Sebashe

RE: PERMISSION TO CONDUCT ASSESSMENTS

Your letter dated 08/02/2024 bears reference.

Kindly note that permission has been granted to conduct assessments at the Greater Tzaneen Municipality on the topic "The effects of households' knowledge, perception and behavioral intention towards waste disposal on water quality."

The student is welcome to conduct assessments according to the requirements as outlined in the request letter. However, the student must undertake the responsibility of providing the Municipality with a copy of the final report.

The student is welcome to liaise for further assistance with the Senior Training Officer, Ms. Glacia Hlangwane on tel.no. (015) 307 8378 or by e-mail: glacia@tzaneen.gov.za.

It is trusted that you will find this matter in order

[redacted]
MUNICIPAL MANAGER

A Green, Prosperous, healthy and United Municipality that Provides Quality Services to All