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ASSESSING WASTEWATER AND DOMESTIC WATER PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS AND THE ASSOCIATED HUMAN AND ENVIRONMENTAL IMPACTS: A CASE STUDY OF RUWA TOWN

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Dedications

This dissertation is dedicated to my family, friends and fellow students.

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Abstract

Wastewater management has been a daunting problem in urban councils in Zimbabwe over the past 20 years. The research sought to explore challenges associated with wastewater management in Ruwa. To obtain data, the study adopted a mixed approach design which used both qualitative and quantitative methods questionnaires, interviews and field observations. A total 92 questionnaires were administered randomly amongst residents. Interviews were done for key informants which included, 4 Management Representatives from Ruwa Local Board, 3 Technical Representatives from Ruwa Local Board, and the District Environmental Officer from Environmental Management Agency. Data analyses was done using Statistical Package for Social Sciences (SPSS) version 26 (for one-way ANOVA). A total of 33 domestic water (borehole, tap and well) and 6 wastewater samples (dam and canal) were collected for microbiological and physical analyses. One-way ANOVA was used to analyse microbial and physical data. Water results were tested for normality on SPSS using the Kolmogorov Smirnov test. Differences of physical and microbial properties across sample were tested by performing One Way Analysis of Variance (ANOVA). The Post hoc Least Squares Difference (LSD) at 5% significance level was performed for pairwise comparisons for the samples. Content analysis was used to analyse data from the social survey. The results of ANOVA were presented as tables and for social survey were presented as pie charts and bar graphs. The microbiological analysis revealed that most of water sources (borehole, tap and well) in Ruwa are heavily contaminated with total coliform. In terms of physical nature, all water sources are within World Health Organisation limits. The major causes of poor wastewater management were undersized sewer pipes, aged sewer pipes, lack of funds, broken manholes. Due to the poor wastewater management, the community has suffered from outbreak of diseases such as dysentery, typhoid, cholera and malaria and the environment has suffered from water pollution and odour. The study concluded that the Ruwa Local Board and residents are failing to manage wastewater which is threatening public health and the environment. The study recommends the Government of Zimbabwe to allocate funds that are specifically for wastewater management in local authorities as tariffs paid are not adequate for maintenance of existing structures and connection of new systems.

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List of Abbreviations and Acronyms

ANOVA	Analysis of Variance
DHIS	District Health Information System
EMA	Environment Management Agency
FAO	Food and Agriculture Organisation
RLB	Ruwa Local Board
SPSS	Statistical Package for Social Sciences
WHO	World Health Organizations
ZINWA	Zimbabwe National Water Authority

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

Wastewater is defined as utilized water from any mixture of domestic, industrial, commercial or agricultural exercises, surface runoff or storm water, and any sewer inflow or sewer invasion (Kumar, et *al*, 2020). Therefore, wastewater is a product of domestic, industrial, commercial or agrarian exercises. The quality of wastewater differs contingent upon the source (Van der Hoek *et al*, 2016). Wastewater is regularly characterized by odorous brown to grey waters with suspended solids. The waste water may either be coordinated to a particular spot to be reused or to be uncovered off a long way from individuals as it can cause or prompt the spread of water borne infections like the runs, cholera, among others. Freshwater is becoming a finite resource globally. Municipal wastewater discharges are those produced by small towns and cities. They are considered to be point sources of wastewater pollution, where they are produced and conveyed in sewers and thus disposed of. When not treated, the main environmental concerns relate to conventional pollutants, such as biological, biodegradable, non-biodegradable organic matter, and heavy metals, in that order of importance (Kumar, *et al*, 2020).

1.2. BACKGROUND OF THE STUDY

Wastewater management has had a long history regarding when it began and why it turned into a space of specialization around the world. According to Chrispin & Nolasco (2019) wastewater assortment began in the town of Venice. Venice created one of the first sewer systems to be carried out on the planet that is, the novel gravity driven arrangement of underground channel which they call fognatura. The arrangement of fognatura supplanted the framework which was at first utilized like tossing waste by the street side and the waste were to be moved by the ocean tides. The issue of tides had an issue in wastewater management particularly when tides are not solid as they will leave different wastes which will at that point cause hazard on the environment and hazard to human wellbeing.

As indicated by Akpor and Muchie (2010), the extent of wastewater management has developed since the beginning with changes in the socio-economic conditions, town structures and the environmental concerns. After individuals had understood that appropriate wastewater management is straightforwardly identified with the pace of socio-economic development, a framework to oversee wastewater was carried out known as the sewerage framework. Department of

Environment, Food and Rural affairs (2002), likewise noticed that, the countries in Europe conceded to what they call Urban Waste Water Treatment Directive (UWWTD) in 1991. The order has necessities for wastewater management to be set up and set standards for wastewater management and treatment. This data help to more readily recognize that a ton of difficulties had been noted in wastewater management route back in developed countries and they attempted to think of coordinated waste management approaches meaning there are a ton of issues or issues which should be tended to.

In accordance with Borg (2010) developing countries generally in Asia furthermore spearheaded wastewater management among other developing countries. Mesopotamia for instance utilized vertical shafts to divert wastes into cesspools. Wastes gathered into cesspools were intermittently exhausted by labourers known as rakers. Gathered wastes were offered to ranchers who might utilize them as compost which brought about the creation of sullied foods from tainted wastes. This degrades both the health of individuals just as the environment.

Due to continued use without maintenance the waste stabilisation ponds have suffered significantly from operational and maintenance problems and this has given way to reduced purifying efficiency of the waste water leading to production of effluent with a larger variance from the public health (effluent) regulation standards. The production of effluent with a larger variance from the effluent standard has been majorly attributed to loads on the works that are by far exceeding the design capabilities. The malfunctioning and outdatedness of the systems has led to the community complaining about the odour, overflowing surface sewer, flies and mosquitos. This gives rise to a need to change the technological efficiency of the existing ponds in terms of hydraulic and BOD load by introducing an area efficient treatment method due to lack of space and resources needed to cater for such sewer structures.

According to Muchaendepi, *et al* (2019), the significant test Zimbabwe is looking in wastewater management is because of the kind of sewer and sewerage framework we have which is exhausted and matured. The matured framework isn't being expanded to address the issues of the developing metropolitan populace. Hence local authorities are facing several challenges in managing wastewater. (Matondi, 2013) As of now Zimbabwe in a bid to manage the issues emerging from wastewater management had marked a 144 million US dollar from the Chinese government with the cash focusing to restore the run- down reticulation framework in Zimbabwe's metropolitan regions.

The main aim of this research is to investigate the constraints in wastewater management in urban areas of Zimbabwe with reference to Ruwa Town.

1.3. PROBLEM STATEMENT

Problems of wastewater are severely attacking mostly developing countries. This is because in developing countries, the municipalities are mainly responsible for waste management. So, if the municipality faces economic downfall the whole sector will be affected. Muzondi (2014), states that during a decade of economic recession in Zimbabwe, wastewater management problem was and is still a common phenomenon. This is because local authorities were not able to fully regulate movement and disposal of wastes. Sewerage system often bursts and raw wastewater flooded streams and rivers unmonitored, for example a case of Ruwa River where raw wastewater is found flowing. Hence this little attention paid to wastewater management results in environmental contamination. The World Bank (2006) reported that as population increases, the situation on the environment grows worse and the need for safe, sustainable and affordable sanitation systems will be more critical. In the past decade there has been a massive relocation of industries from Harare to Ruwa. This include companies like, Probands, Megapack, Ngoda breweries, ProPlastics, Buffalo, mechanism. Also there have been massive siting of medium and small industries in Damofalls area. Sewer reticulation systems of Ruwa were designed to cater for a population of around 30000 now it has tripled to 82407 on the District Health Information System (DHIS, 2022) Therefore, industrial wastewater in Ruwa accounts for over 25% of the total volume of wastewater that is drained from Ruwa. Therefore, it is necessary and of prime importance to introduce a solution to Ruwa that navigates around pollution, land, technological and location issues faced by Ruwa in managing wastewater.

1.4. OBJECTIVES OF THE STUDY

1.4.1. AIM

To explore possible challenges associated with wastewater management in Ruwa town.

1.4.2. OBJECTIVES:

i. To characterise the biological and physical nature of wastewater and domestic water sources (borehole, tap and deep well) in Ruwa.
ii. To evaluate the challenges faced in wastewater management in Ruwa.
iii. To identify impacts of wastewater pollution on public health and the environment in Ruwa.

1.4.3 RESEARCH QUESTIONS

I. What are the biological and physical characteristics of wastewater released into the environment in Ruwa?
II. What are the biological and physical characteristics of domestic water in Ruwa?
III. What are the challenges associated with wastewater management in Ruwa?
IV. What are the perceptions of the community on sewage pollution to their health?
V. What are the environmental and public health risks associated with wastewater pollution?

1.5. JUSTIFICATION OF STUDY

If sewage management is properly practiced in Ruwa urban, a lot of people will benefit from the restoration of freshwater sources as it contributes to the Manyame catchment. Mostly people in Ruwa will be at lower risk from health problems caused or resulting from water borne diseases like diarrhoea, dysentery, cholera among others. The environment is actually degrading as a result of poor sewage management as it will affect soil alkalinity resulting in increased species depletion and evasive species. Therefore, proper sewage management will lead to the restoration of the natural environment and maintenance of the natural ecosystems. Moreover, the council will benefit from proper sewage management because instead of channelling resources to sewage management it will embark on other developmental activities which will see Ruwa town growing and developing. Little data has so far been gathered in the management of sewage hence, the research will also help in sustainable sewage management. This project seeks to address the problems faced by Ruwa sewerage system. The study will help curb the massive environmental pollution that is being attributed by the lack of efficient wastewater treatment system.

CHAPTER 2: LITERATURE REVIEW

2.1. THE CHALLENGES OF URBAN SANITATION

Urban wastewater administration could be a priority issue for cities all over. Major insufficiencies within the arrangement of this essential benefit contribute to natural wellbeing issues and the corruption of rare water assets. The fast development of cities and the accompanying concentration of populace leads to expanding sums of wastewater that have to be overseen securely (Shaddel *et al*, 2019). The relative victory in giving cities with usable water has driven to more prominent volumes of wastewater requiring administration, both household and mechanical. As populace densities in cities increment, the volumes of wastewater produced per family surpass the invasion capacity of neighbourhood soils and require more noteworthy waste capacity and the presentation of sewer frameworks (Wang *et al*, 2019). Wastewaters streaming out of cities can, in turn, influence downstream water assets and undermine their feasible utilize. The blend of issues and the capacity to bargain with these sanitation problems differs amongst cities and countries (Valipour and Singh, 2016).

2.2. GRIT ACCUMULATION

Grit incorporates sand, rock, cinder, or other overwhelming strong materials that are "heavier" (higher particular gravity) than the natural biodegradable solids within the wastewater (Chrispim and Nolasco, 2019). Grit moreover incorporates eggshells, bone chips, seeds, coffee grounds, and huge natural particles, such as nourishment waste. Expulsion of grit avoids pointless scraped spot and wear of mechanical hardware, coarseness statement in pipelines and channels, and collection of coarseness in anaerobic digesters and air circulation bowls (Wang *et al*, 2019).

Grit evacuation offices regularly go before essential clarification, and take after screening and comminution. This avoids expansive solids from interferometer with grit taking care of gear. In auxiliary treatment plants without essential clarification, grit expulsion ought to go before air circulation (Metcalf and Whirlpool, 1991). Numerous sorts of grit evacuation frameworks exist, counting circulated air through grit chambers, vortex-type (paddle or fly actuated vortex) grit expulsion frameworks, debris tanks (short-term sedimentation bowls), even stream grit chambers (velocity-controlled channel), and hydro tornados (cyclonic inertial partition) (Chrispim and Nolasco, 2019). Various factors must be taken into consideration when selecting a grit removal process, including the quantity and characteristics of grit, potential adverse effects on downstream processes, head loss requirements, space requirements, removal efficiency, organic content, and cost (Panagopoulos & Haralambous, 2020). The type of grit removal system chosen for a specific facility should be the one that best balances these different considerations.

2.3. ENERGY CHALLENGES IN WASTEWATER MANAGEMENT

Energy utilization is one of the biggest costs in working a wastewater treatment plant. Wastewater treatment is evaluated to devour 2 - 3% of a created nation's electrical control, or roughly 60 tWh (terawatt hours) per year (Chrispim & Nolasco, 2019). In metropolitan wastewater treatment, the biggest extent of energy is utilized in organic treatment, for the most part within the run of 50 - 60% of plant utilization (Panagopoulos & Haralambous, 2020) Wastewater organization is still routinely seen as an energy-demanding issue requiring exorbitant courses of action, rather than a resource. In show disdain toward of the reality that most countries spend significant wholes of imperativeness treating wastewater to release it as innocuously as conceivable into getting waters, wastewater talks to a mostly-untapped, conceivably colossal source of energy, tallying inborn imperativeness embedded interior wastewater organics. Energy request (for the most part electric) of wastewater treatment to require measures may be a noteworthy component of the urban water cycle by and large costs (Shaddel *et al*, 2019). It was evaluated that 30% to 35% of total cost of wastewater treatment offices is due to electric energy supply (Chrispim and Nolasco, 2019). More rigid limits for supplement expulsion or obligatory evacuation of presently-unregulated contaminants, such as contaminants of emerging concern (CEC) and pharmaceuticals and individual care items (PPCP), with presentation of extra handle steps, might suggest a critical increment in vitality request of treatment workplaces, hence energy diminishment and recuperation speak to an energy supportability issue for keeping up required benchmarks.

Various endeavours to adjust standard forms to form them less energy seriously have come about in elective results, primarily due to the need of standardized energy checking strategies and normal energy reviews in these offices, basic for distinguishing any potential for change (Valipour & Singh, 2016). Wastewater treatment plants (WWTPs) consume high amounts of energy which is mostly purchased from the grid. Many measures have been put in place to analyse the possible solutions for both reducing the energy consumption and increasing the renewable energy production in the plants. This will include all possible aspects which may assist to move towards energy neutrality in WWTPs (Panagopoulos and Haralambous, 2020).

2.4. WASTEWATER POLLUTION

Good water quality is vital to human health, social and economic development, and also the ecosystem. As populations grow, natural environments become degraded therefore there is need to ensure there are sufficient and safe water supplies for everyone. However, this phenomenon is becoming increasingly challenging. A major part of the solution is to produce less pollution and improve the way we manage wastewater. The costs of wastewater management are greatly outweighed by the benefits to human health, economic development and environmental sustainability that is providing new business opportunities and creating more 'green' jobs (UN-Water, 2011). Basically in low-income regions of cities and towns inside creating nations, a huge extent of wastewater is released specifically into the closest surface water deplete or casual seepage channel, at some point without or with exceptionally small treatment. In expansion to residential gushing and human squander, urban-based clinics and businesses such as small-scale mining and engine carports, frequently dump profoundly poisonous chemicals and restorative squander into the wastewater framework. Separated from than fair an elective source of water, secure wastewater administration might offer assistance ensure our environments and deliver us energy, supplements and other recoverable materials (UN- Water, 2011).

Water must be carefully overseen amid each portion of the water cycle: from new water reflection, pre-treatment, conveyance, utilize, collection and post-treatment, to the utilize of treated wastewater and its extreme return to the environment, prepared to be dreamy to begin the cycle once more. Due to populace development, quickened urbanization and financial improvement, the amount of wastewater produced and its volumes by large contamination stack are expanding universally. The accessibility of secure and adequate water supplies is inseparably connected to how wastewater is overseen. Expanded sums of untreated sewage, combined with agrarian runoff and mechanical release, have corrupted water quality and sullied water assets around the world. All inclusive, 80% of wastewater streams back into the environment without being treated or reused, contributing to a circumstance where around 1.8 billion individuals utilize a source of drinking water sullied with defecation, putting them at chance of contracting cholera, diarrhoea, typhoid and polio. Distant from being something to dispose of or disregard, wastewater will play a major part in assembly the developing water request in quickly extending cities, improving vitality generation and mechanical advancement, and supporting maintainable horticulture (UN WWDR, 2017).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. INTRODUCTION

This section pursues to explore the methods and techniques that were used to collect data. In this chapter, the researcher uncovers the instruments that were used in addressing research objectives outlined in chapter one. The main objective of a research methodology was discussing the approach to the research project and how to administer it (Saunders, *et al.,* 2011). This section also discussed the research population, design, instruments, population sampling techniques, sources, presentation and analysis of data.

3.2. STUDY AREA

Ruwa was established in 1990 by the Zimbabwean government and it is still referred as Ruwa Local Board (RLB). According to (Shipekesa & Jayne, 2012), the Ruwa had a population of 52 073 people distributed in eight (8) suburbs of the town, which has since increased to 82 407 people distributed in twelve (12) suburbs. The Town of Ruwa is located at 21 km peg from Harare and 180km from Mutare along the major Harare-Mutare road and railway line.

Ruwa is a Harare dormitory urban settlement in Zimbabwe. It is at the provincial boundary of the Harare Metropolitan province and Mashonaland-east province, and is located in the Mashonaland-east province. According to Muzondi (2014), Ruwa straddles across 3 types of soils, namely black basalt soil, sands, and gravel. The Town of Ruwa lies on a watershed, which stretches from Rusape to Harare and is at an altitude of about 1422 meters. The area has predominantly moderate slope ranges from gently sloping slopes to rugged terrain. The Municipal area is dissected by numerous streams most of which drain into the Ruwa River, a tributary of the Marimba River. The zone is for the most part influenced by northeast winning winds, which are dominant from August to November during which their mean speed is in the range of 8.0 to 9.3 knots (MSD, 2014). It lies in Agro-ecological region two experiencing tropical savanna climate. The mean temperature is 18°C and mean annual rainfall for Ruwa is 450-600mm. The area sometimes experienced rainfall shortages during the farming season resulting in periodic droughts.

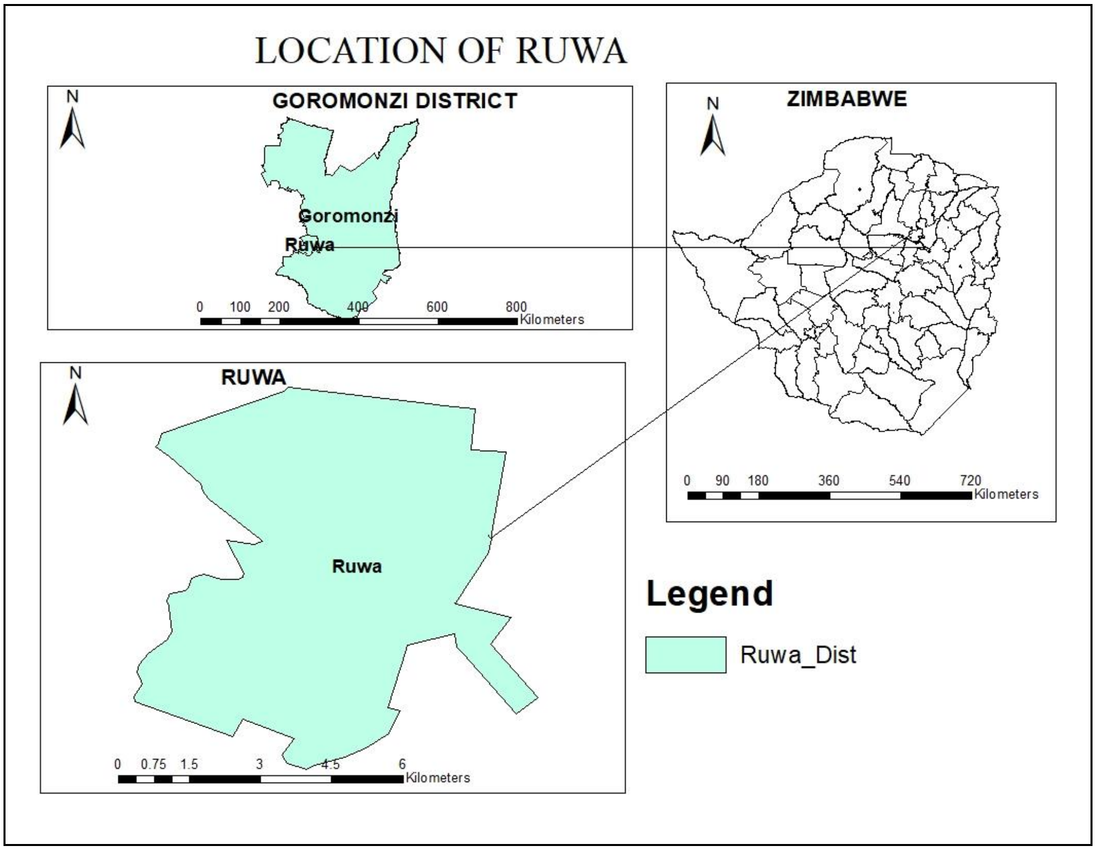

Figure 3.1: Study area map

3.3. RESEARCH DESIGN

The research design is characterized by Trochim, (2006) as the generally procedure that's utilized by the analyst to coordinated the diverse components of the consider venture in a rational and steady way, subsequently, making beyond any doubt the research project will viably address the research problem. This is a mixed approach design where both qualitative and quantitative information were utilized from the study area.

3.4. STUDY POPULATION

Saunders *et al*., (2011) defines population as the set of all members which a researcher intends to draw conclusions about. (Marczyk & Dematteo 2010) further define population as all the elements of interest to the researcher. This means that population is the category of people which the researcher found as having relevant data in which a sample was derived from. The target population is the total group of individuals from which the sample might be drawn (McLeod, 2014). This insists that the study research included the nine wards of Ruwa as the target population. Ryan,

(2010) characterized an objective populace as that which the scholar wishes to study, test and draw deductions from.

3.5. SAMPLE SIZE

A sample is characterized by Daniel, (2012) as a subgroup of components from a universe. A sample can be any measure. He assists states that the bigger the populace the more likely the test will share the same characteristics as the populace; therefore, a suitable technique was used. Singh and Masuku (2012) referred to sample size as a representative sample that possesses all the important characteristics of the study population from which it is drawn. In addition, Singh and Masuku (2012) asserted that the sample size has to be a representative of the study population for effective generalization of the study findings. Ryan (2013) suggested a mathematical approach to determine the sample size as follows:

Sample size determination: $\boldsymbol{n} = \frac{N}{1+N(e)^2}$

Where n is the sample size,

N is the population size

$\boldsymbol{e}$ is the acceptable sampling error. Thus, the sample used will be computed using:-

N= 25 140 households

$\boldsymbol{e}$ = 0.05

n = 25 140 / [1+ 25 140 (0.05^2)]

n = 394 households

However, in this study a sample size of 100 respondents was used as part of data collection because the number proved to be feasible and practical for the study. The proportion of the sample size was 25.4 % of the expected sample size of 394 respondents (households). The composition of the respondents was as follows:

- 4 (four) Management Representatives from Ruwa Local Board
- 3 (three) Technical Representatives from Ruwa Local Board
- 1 (one) District Environmental Officer (DEO) from EMA
- 92 respondents from Ruwa Town

3.6. SAMPLING

Ross *et al* (2000) defined that sampling involves the selection of subjects from a defined study population to represent the whole. The fusion of both probability and non-probability sampling techniques were employed comprising of systematic, purposive and convenient sampling respectively. There are 9 wards, 12 suburbs and 25 140 households in Ruwa.

3.6.1. SAMPLING TECHNIQUE

Ross *et al* (2000) described the sampling technique as a way by which a sample is drawn from the population. Amongst sampling techniques that were used in this study, Patton (1990) described purposive sampling as where subjects are selected because they possess some characteristics to achieve a certain goal. Thus, the researcher chose the Ruwa Town Council technical and administrative personnel who amongst others includes the Environmental Health Officer (EHO), Wastewater Technician, the Town Plumber, the RLB Council Chairperson, Wastewater Pump Station Attendant Supervisor, the Town Administrator and the Town Secretary to be part of the research target. In addition, purposive sampling was used to select the District Environmental Officer (DEO) for Ruwa as another key respondent on this research. These key respondents are directly responsible for day to day management of the wastewater in Ruwa town, and they do possess key answers to the questions in this research. Furthermore, the DEO is the key custodian chiefly involved in the enforcement of the EMA, Chapter 20:27 of 2003 in Ruwa Town.

Convenience sampling was used to select Ruwa town as the study setting since it is the only town conveniently located within the researchers' jurisdiction. Convenience sampling was also employed on the twelve locations of Ruwa urban whereby four (4) locations namely Ruwa, Springvale, Damafalls phase 6 and Cranbrook will be selected as representations of the study area. Residents who dwell in these locations with sewer lines and those present during time of the research were selected until the desired number was reached.

Systematic sampling was used in the selection of the 23 households from each of the four locations identified. First the average sample population was determined by diving the total population of 25140 by 12 which is the number of suburbs in Ruwa (25140/12= 2095 average sample population). To determine the sampling interval, the average population size of 2095 was then divided by the desired sample size of 100 (2095/100= 20.95). Therefore, the sampling interval was to be every 21th member of the sample population of 2095. The random start up point was determined (by lottery) by picking a number between 1 and 21 at random. The number obtained was the first sampling unit to be collected, while the remaining 22 sampling units were obtained by selecting every 21th house of the 2095 households in each suburb. This process was done in all the selected four suburbs which are Springvale, Ruwa, Damafalls phase 6, and Cranbrook.

3.7. DATA COLLECTION INSTRUMENTS

These are the instruments the researcher used to get guidance to the data. The researcher used questionnaires, interviews, field observations and experiments as the instruments (techniques) for data collection. The procedures for data collection give guidelines for the data analysis, presentation and for the summary of findings. The research using research instruments will follow a well-defined sequence and the obtained data will be analysed against information already available to match the obtained data.

3.7.1. QUESTIONNAIRE

A questionnaire is defined as the main instrument for collecting data which comprises a set of standardized questions to collect individual data (Mc Leod, 2019). Questionnaires in this study were used to target residents in Ruwa to obtain information on their knowledge and perceptions on wastewater management amongst other things (Appendix 1). The researcher used questionnaires in this study because it offers a wide coverage of the target population which allows for easier and broader collection of data and saves the researcher time and it is economical as the researcher will not spend too much money. In this study, the questionnaire which included both close-ended and open-ended questions was used to obtain data from residents in Ruwa.

The aim of using questionnaires was to obtain natural data straight from participants which would be descriptive yet precise and allow participants to show their thoughts, rationale and perceptions. The questionnaires were compiled in the English language because it makes it easier for the researcher to gather the data afterwards as the research is being done in English however, due to language barriers the research would translate some of the questions provided. A pilot survey was done by the researcher where she chose a smaller sample of 5 residents to administer questionnaires as a way to validate the relevance, feasibility and to identify problems and challenges that might occur before questioning the whole sample.

3.7.2. INTERVIEWS

In this research semi-structured interviews were used to obtain information from informants such as technical and administrative personnel at Ruwa Local Board, and enforcement agent from the Environmental Management Agency, (Appendix 2). This is because face-to-face interviews provide a full and further in-depth conversation between the interviewer and interviewee making them feel comfortable in a friendly environment thus the interviewee gives out more information needed. The researcher, through interviews sought information on challenges being faced in wastewater management, and to get key informants to give out their perspective on health and environmental impacts of wastewater pollution in Ruwa. Appointments for the interviews were made over the phone for the EMA officer and Ruwa Local Board Representatives. All interviews were done face-to-face and data obtained during interviews was captured by asking questions and noting down relevant details from the interviewee under each question. The researcher compiled an interview guide (Appendix 2) to keep track of relevant details to be obtained.

3.7.3. FIELD OBSERVATIONS

Field observations are a qualitative data collection method, which is used to observe naturally occurring behaviour of people in their natural settings. In this research filed observations may provide insights on community life and practices with relation to household wastewater management; and it will also help the researcher to tap into and understand the management of wastewater in Ruwa urban (Appendix 4). A field observation checklist (Appendix 3) was developed to guide on the layout of the sewerage reticulation system, characterise on the physical nature of wastewater, and the general handling of wastewater by the Ruwa Wastewater section.

3.7.4. WATER AND WASTEWATER SAMPLING AND EXPERIMENTAL ANALYSIS

At each sampling site, wastewater or domestic water sample was collected into an open sterilized plastic jug (to avoid contamination) for onsite measurements. The temperature, electrical conductivity, pH and turbidity were measured on site. Temperature was measured using a thermometer, pH and electrical conductivity were measured using a water quality multi-meter and turbidity was measured using turbidimeter. Using the procedure described above, a total of thirty-nine (39) water samples were collected from 13 sites in Ruwa community with 3 samples on each site for replication purposes. Of the 39 samples, 6 (six) were wastewater which were collected from 2 sites in the same community (Ruwa dam and canal); of the 33 samples, fifteen (15) samples were collected from 5 domestic wells, six (6) from 2 water taps and twelve (12) from 4 boreholes. This was done to determine if there was sewage discharged in the environment. Sterilized 200ml bottles were used on sterile water sprouts on borehole tap water, while sterilised bottles tied with a sterile string tied were used to collect well samples; and sterilized bottles facing upstream of water flow were used to collect water samples from irrigation canal and dam. Sterilised collection bottles (200ml) used for water samples packaging were then transported in cooler boxes to the Government Analyst Laboratory (GAL) within six (6) hours as part of sample preservation to reduce any bias in results. A total of 39 collected water samples were sent to the GAL for microbiological analysis. Other precautions on water sample collection were taken as per the stated method of collection on Appendix 5.

3.7.5. SECONDARY DATA

Secondary data defines the data that has already been accumulated via primary sources and made available for researchers to apply for their very own research. Government and Council records, disease investigations reports, EMA notices and reports, Wastewater strategic plans, published sources, newspapers, journals, internet and websites from Ruwa Local Board, and other related wastewater data which was helpful in determining the socio-economic constraints of wastewater management in Ruwa Town.

3.8. DATA ANALYSIS

Data analysis is the method of bringing arrange, structure and meaning to the mass of collected data. Qualitative data analysis could be a look for common articulations almost connections among categories of information. Data collected for bacteriological, physical and socio-economic survey were subjected using Microsoft spreadsheet version 2016. Statistical Package for Social Science (SPSS) software version 26 was used to analyse the data for means, maximum and minimum values for physical and biological parameters (domestic and wastewater quality) and frequencies (social survey). Specifically, one-way ANOVA was used for microbial and physical data. Prior to carrying out ANOVA, data for microbial and physical properties for water tested for normality on SPSS using the Kolmogorov Smirnov test. Differences of physical and microbial properties across sample were tested by performing One Way Analysis of Variance (ANOVA). The results of ANOVA were presented as tables and for social survey were presented as pie charts and bar graphs.

3.9. RELIABILITY AND VALIDITY

Reliability is the extent by which various scholars researching on the same subject in a similar framework reveals identical or close to identical results. (Kurniawan *et al*, 2014) defined reliability as the extent of consistence that is shown by the procedure utilised in a research in order to provide more bankable results. Piloting of the questionnaires and interviews were carried out with the National Rehabilitation Hospital employees in Ruwa, and the necessary adjustments were done to ensure improved reliability of the research instruments.

3.10. ETHICAL CONSIDERATIONS

Ethics are an integral part of every research and the nature of this study makes it imperative for the researcher to follow and strictly observe ethical considerations, as hinted by Barnett-Page & Thomas, (2009). Sjoberg *et al*, (2007) characterized research ethics as the application of ethical rules and proficient codes of conduct to the collection, investigation, announcing and distribution of data almost investigate subjects. The researcher considered ethical principles including informed consent, anonymity and confidentiality. Confidentiality is when responses of the study subjects are not linked with the individuals who provided them when the study results are communicated as indicated by (McCain, 1991). This research did not ask for any personal information from the respondents. All study participants volunteered with their full consent. Permission to conduct the research was also sought from the Environmental Health Officer for Ruwa Town Council and the District Environmental Health Officer for Goromonzi District at large.

CHAPTER FOUR: RESULTS

4.1 PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF WASTEWATER AND DOMESTIC WATER IN RUWA

The temperature, turbidity, colour and conductivity were high in wastewater (dam and canal) and were within limits for domestic water sources. Although they were within limits, tap water recorded lowest temperature, turbidity, colour and conductivity than borehole and domestic well water. Domestic water was free from odour whereas wastewater had odour (Table 4.1)

Generally, *E. Coli* counts were higher in dam, water canal and domestic wells (Table 4.2). Dam water recorded the highest E. Coli counts (173 cfu/100ml) where borehole 1, 2 and 4, well 3 and tap 1 and 2 had no E. Coli counts. However, post hoc (LSD) at 95% confidence interval revealed that domestic well 1, 2 and 5 were statistically similar to water canal and dam water in terms of E. Coli counts. All sites recorded at least 1 count of total coliforms except for tap 2, borehole 4 and domestic well 3 which had no total coliform counts (Table 4.2). Tap 1 recorded the highest total coliform counts (373 cfu/100ml) followed by dam and canal.

Table 4.1: Physical characteristics of wastewater and domestic water in Ruwa (Mean±SE)

Sample	Temperature (ºC)	Turbidity (NTU)	Colour (TCU)	Odour	Taste	Conductivity (µS/cm)
Water Canal	29.8±0.06	13.8±0.06	52±0.5	Yes	-	571±0.57
Dam	30.1±0.11	14.2±0.58	64±0.5	Yes	-	592±1.15
Borehole 1	24.2±1.15	1.8±0.58	6±0.5	Clear	Nil	182±1.15
Borehole 2	23.9±1.32	1.8±0.58	6±0.5	Clear	Nil	189±1.15
Borehole 3	24.6±1.73	1.7±0.12	5±1.15	Clear	Nil	193±1.20
Borehole 4	24.3±0.58	1.6±0.81	5±1.52	Clear	Nil	191±0.57
Tap 1	23.2±1.73	1.2±0.57	4±1.7	Clear	Nil	169±1.15
Tap 2	23.1±1.15	1.2±0.57	4±1.7	Clear	Nil	171±1.82
Domestic well 1	24.2±0.57	1.3±0.12	8±1.15	Clear	Nil	176±0.57
Domestic well 2	24.4±0.17	1.5±0.12	8±1.52	Clear	Nil	184±1.15
Domestic well 3	23.8±0.11	1.4±0.12	7±1.15	Clear	Nil	183±1.15
Domestic Well 4	23.6±0.07	1.3±0.23	8±0.57	Clear	Nil	183±1.15
Domestic well 5	24.1±0.06	1.4±0.57	8±0.57	Clear	Nil	181±0.57
WHO 2017 (drinking water)	**25.0**	**5**	**15**	**Clear**	**Inoffensive**	**400**

Table 4.2: E. Coli and Coliform counts in water samples (Mean±SE)

Sample	Total E. Coli (cfu /100ml)	Total Coliform (cfu /100ml)
Water Canal	**151**±0.57	**174**±0.57
Dam	**173**±1.73	**189**±0.57
Borehole 1	0±0.00	**14**±1.15
Borehole 2	0±0.00	**01**±0.57
Borehole 3	**3**±0.00	**101**±1.15
Borehole 4	0±0.00	0±0.00
Tap 1	0±0.00	**373±1.73**
Tap 2	0±0.00	0±0.00
Domestic well 1	**126**±0.57	**134**±1.15
Domestic well 2	**139**±1.15	**120**±0.57
Domestic well 3	0±0.00	0±0.00
Domestic Well 4	**17**±0.00	**103**±0.57
Domestic well 5	**122**±1.15	**109**±0.57

4.2 QUESTIONNAIRE RESPONSE RATE

In this research, a total of 92 questionnaires were administered to gather information on health and environmental impacts of wastewater pollution, challenges of wastewater management and establish perceptions of residents towards wastewater management. Of the 92 questionnaires distributed, a total of 88 questionnaires were returned, some were not answered as participants decided to drop out of the survey thus 95% response rate was attained. A research response rate that represents 60% and above of the sample is valid and reliable (Fincham, 2008). In this study, all interviews were carried out thus a 100% response rate.

4.3 DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

Questionnaire survey results show that, the majority of respondents were female (68%) and males (32%). In this survey, the most dominant group of respondents in terms of age were 25-34 years constituting 40.2 % accompanied by 35-45 years as the second most dominant age group with 22.8%. The 55+ age group was the lowest with 5.4%. Almost all age groups were represented which is relevant to the study to establish solid perception of the different age groups towards wastewater management. Educational levels for the respondents were sought as this may affect their understating of wastewater management. The questionnaire survey results showed that of the 100% responded questionnaires, 90% had attained at least basic O' level high school education. The largest group with a 40.2% rate had attained O' level education those who had reached the degree level were 16.3%. Those who had reached diploma level constituted 14.1% of the respondents and those who had reached A' level constituted 19.5%. Those who had primary education only constituted 9.7%. Duration of stay in Ruwa was sought from the respondents as this was assumed to influence the understanding of wastewater management challenges and problems (environmental and health) in the area. The survey revealed that more than half of the respondents have stayed in Ruwa for at least 6+ years. Those who have stayed longest (8+ years) in Ruwa constituted 28.2% of the respondents whereas those who had stayed least (0-2 years) constituted the lowest percentage (7.6%). The highest percentage (35.8%) were those who had stayed for 6-8 years in Ruwa.

4.4 PERCEPTIONS OF RUWA RESIDENTS TOWARDS WASTEWATER MANAGEMENT

4.4.1 Management of wastewater treatment facility

Most of the respondents (63%) strongly agreed that the sewage treatment ponds are not being maintained whereas 14% of the respondents agreed that little maintenance is being done and 33% had no idea if the ponds are being maintained.

4.4.2 Payment of sewer tariffs

The survey revealed that the largest population (81%) pay sewer tariffs, 13% of the respondents indicated that they do not pay tariffs due to frequent wastewater overflows which are attributed to damaged sewer pipes. The other 6% does not pay because the tariffs are expensive. The Ruwa Local Board administration representative also confirmed that not all residents are paying sewer tariffs and some of the houses (illegal) are not even registered with the council. He also indicated that the amounts that are charged for tariffs are very little such that they cannot maintain sewer system for 5% of Ruwa houses.

4.4.3 Responsibility for maintenance of sewer system in Ruwa

The majority of the respondents (93%) had the view that Ruwa Town Council has the responsibility of maintaining wastewater systems in Ruwa, 3% had the view that landlords should maintain the wastewater systems, 2% had the view that all the occupants of a household have the responsibility to maintain wastewater systems and 2% indicated that the community members should collectively maintain their wastewater system. According to the EMA officer, there is a pattern in the way they neglect wastewater which gives them the conclusion that they do not care. Fig. 4.5 shows views of respondents regarding who should maintain wastewater systems. The Ruwa Local Board representative confirmed that it is the responsibility of the Board to maintain sewer system but they also encourage the residents to collaborate with the board whenever they can for timeous maintenance of the sewer system.

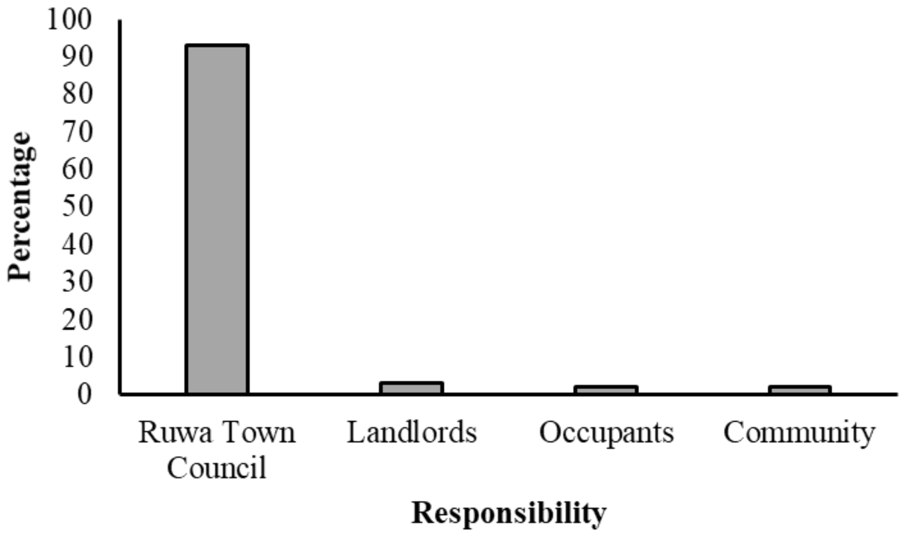

Figure 4.1: Respondents views on wastewater system maintenance responsibility

4.4.4 Perception in wastewater management functionality

The majority of the respondents (69%) responded that the wastewater management system is performing very poor, 13% responded that it is poorly performing, 6% responded that it is performing well and the other 12% have no idea if the wastewater system is performing (Fig.4.6). The Ruwa Local Board representative agreed with most of the residents that their wastewater treatment ponds are no longer functioning as expected and there is high possibility of ground and surface water pollution. He also added that at one time water quality tests were carried out by the Ministry of Health and Child Care and Ruwa residents were given water disinfectants.

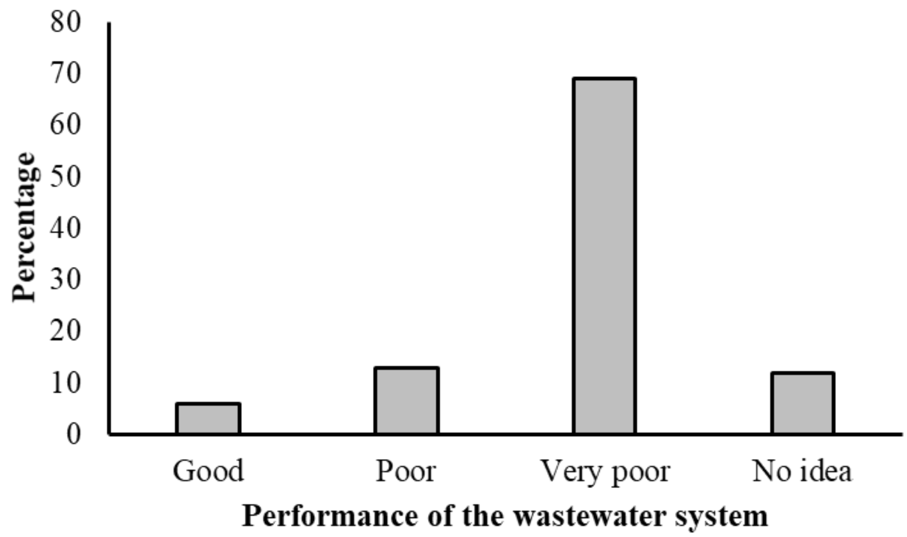

Figure 4.2: Performance of wastewater management system in Ruwa

4.5 CHALLENGES FACED IN WASTEWATER MANAGEMENT IN RUWA

4.5.1 Technical challenges

The study revealed that there are several technical challenges which are being faced in Ruwa with regards to management of wastewater. The majority of the respondents (29%) indicated that poor functioning ponds is one of the challenges they are facing. The respondents also indicated undersized and overaged pipes, broken and open manholes as other technical challenges they are facing in wastewater management (Fig. 4.7).

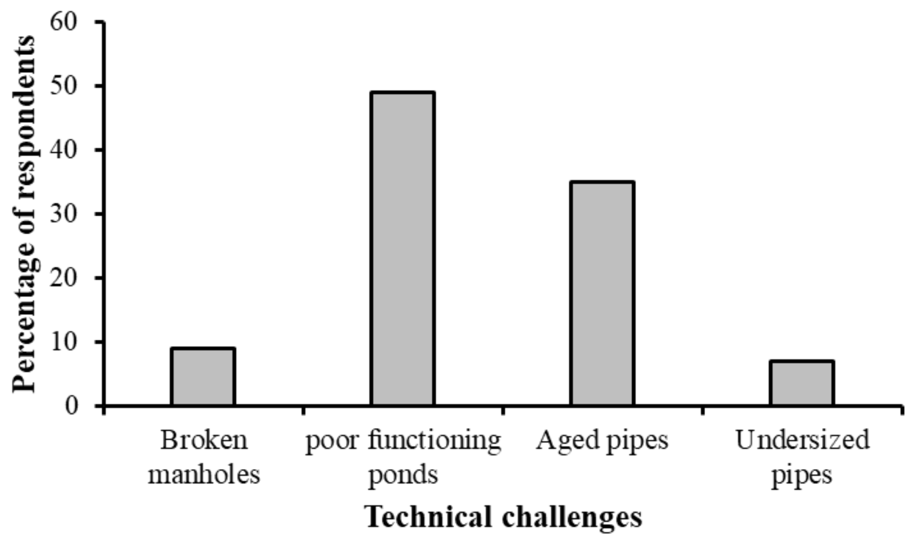

Figure 4.3: Views of respondents on technical challenges being faced

4.3.2 Social challenges

The respondents indicated several social challenges that are attributed to poor wastewater management in Ruwa. Most of the respondents (42%) highlighted user attitude as the most social challenged, followed by illegal connections (33%), extending housing on top of sewer lines (11%) and lastly not paying sewer tariffs (14%), (Fig 4.8)

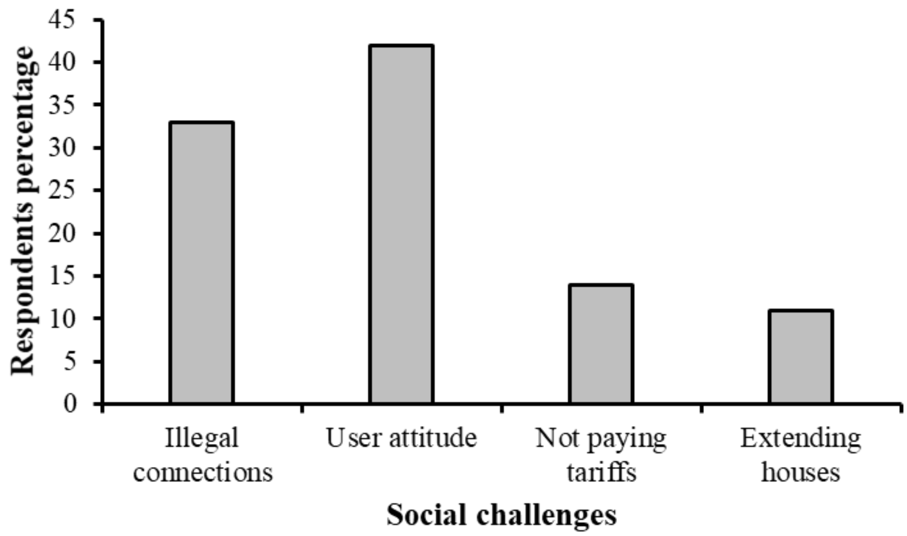

Figure 4.4: Views of respondents on social challenges being faced

4.3.3 Institutional challenges

Information obtained from interviews shows that there are a number of challenges Ruwa Town Council is facing in wastewater management. Such problems include shortage of capital, shortage of man power, lack of equipment and lack of incentives.

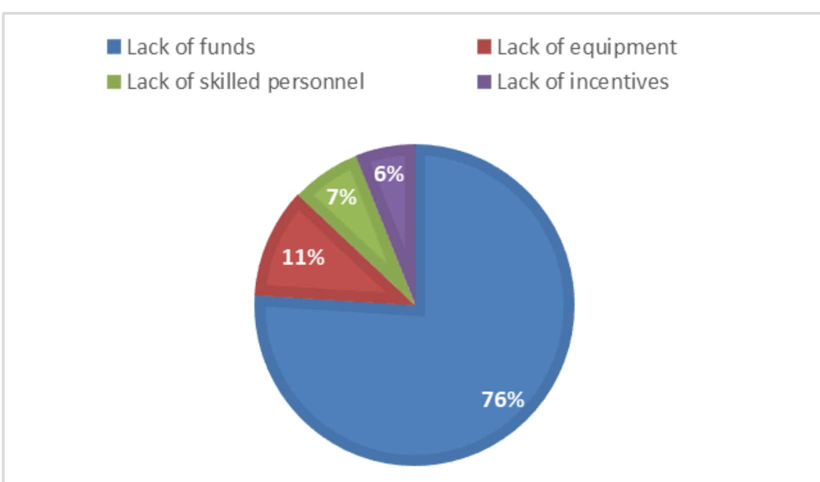

Figure 4.5: Institutional challenges being faced in Ruwa

4.6 IMPACTS OF WASTEWATER POLLUTION

4.6.1 Environmental impacts of wastewater pollution

The study sought Ruwa residents' perceptions on environmental impacts of wastewater pollution. The most common environmental impact from respondents was odour (71%), followed by insects (17%), and polluting domestic water (12%). The EMA officer indicated that the water which is being discharged into the environment from wastewater ponds does not comply with legal requirements and in 2020 Ruwa Local Board was fined for polluting the environment however no reaction was done as the penalties are too low. The researcher observed *hyacinth* species which is growing in and around the wastewater treatment ponds, this is a sign of pollution. Sewage was observed flowing in the streets (appendix 4).

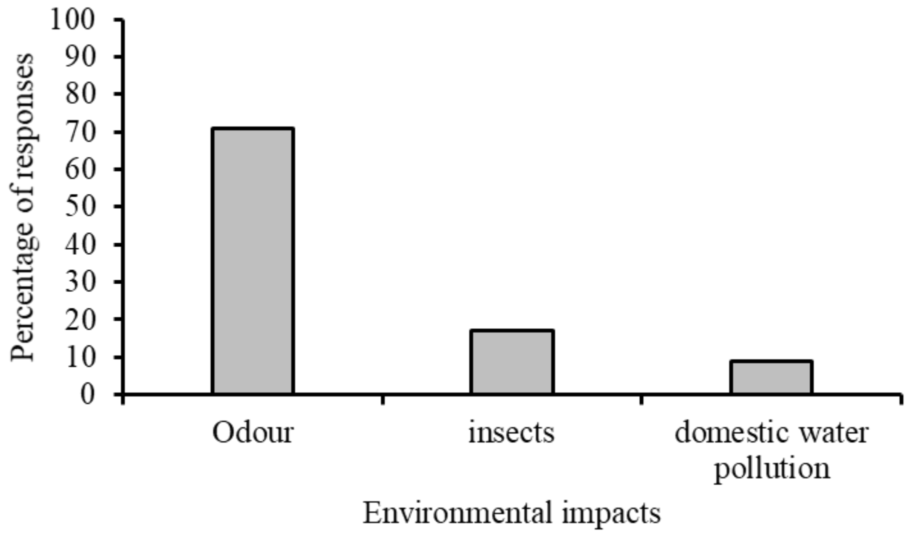

Figure 4.6: Environmental impacts of wastewater pollution

4.6.2 Health effects of wastewater pollution

The study revealed that there are several cases of water borne diseases. The majority of respondents have the view that typhoid, bilharzia, dysentery, cholera were the most common health effects of wastewater pollution in Ruwa with dysentery being the most common disease followed by diarrhoea.

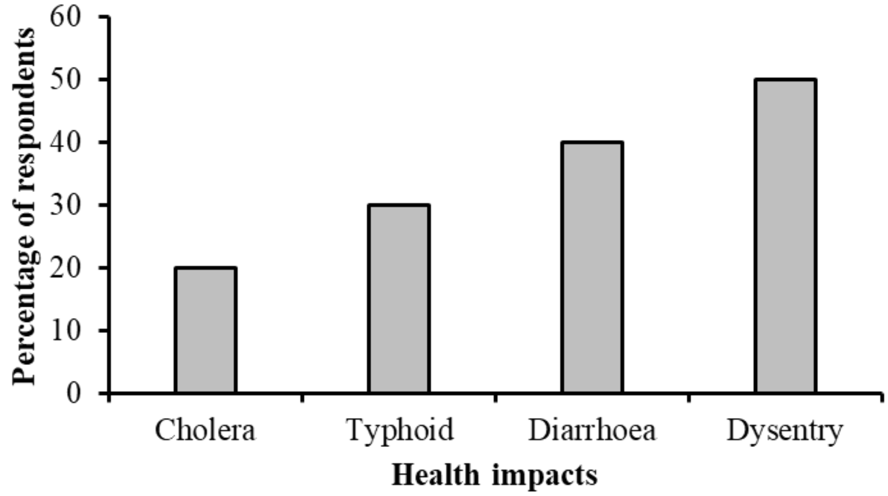

Figure 4.7: Health effects of wastewater pollution in Ruwa

4.7 PERCEPTION OF RUWA RESIDENTS ON MEASURES TO PREVENT WASTEWATER POLLUTION

The respondents aired their view on measure to mitigate causes of improper wastewater management in Ruwa. Some of the measures include, periodic maintenance of sewer systems and wastewater ponds, payment of tariffs by residents, proper treatment of wastewater before disposal, allocation of funds specifically for wastewater management.

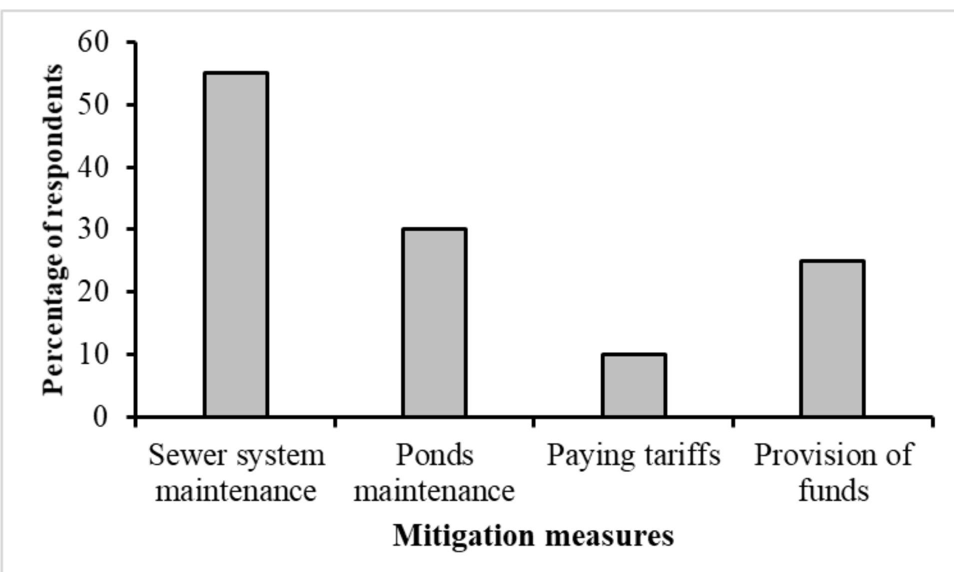

Figure 4.8: Mitigation measure for wastewater management challenges in Ruwa

CHAPTER FIVE: DISCUSSION

5.1 PHYSICAL AND BACTERIOLOGICAL ANALYSIS OF WASTEWATER AND DOMESTIC WATER

Temperature (23.1 – 24.2 ^{o}C), turbidity (1.2 – 1.8 NTU), colour (4 – 8 TCU), taste (nil) and conductivity (181 – 193 μS/cm) for domestic water sources were on within WHO (2017) drinking water limits. This implies that domestic water sources are not heavily polluted in terms of physical nature. Lower conductivity recorded by domestic water sources imply that the water is not considerably ionised and it has lower ionic concentration activity.

Microbial load is an indicator of the level of contamination of the wastewater. The presence of *Escherichia coli* is an indicator that the water is contaminated by faecal. The World Health organisation, (2006) requires no *Escherichia coli* in 100ml of drinking water. This shows that most of drinking water sources in Ruwa are heavily contaminated. The contaminated water from the boreholes, tap and domestic wells (Table 4.1) could be due to sewer pipes which are bursting and untreated wastewater which is being released from the wastewater treatment ponds to the environment. This was confirmed by the EMA officer who indicated that the wastewater which is being released from wastewater treatment ponds is not meeting their requirements. The contamination could also be due to septic tanks and Blair toilets in area with no sewer system. The wastewater finds its way into surface water bodies and ground water which is then drawn by residents through boreholes and wells.

5.2 CHALLENGES FACED IN WASTEWATER MANAGEMENT

The respondents aired their views on wastewater management through questionnaires, focus group discussions and interviews and they sited lack of resources, lack of finance, shortages of labour, illegal connections, aged pipes, undersized pipes and not paying tariffs as main challenges. The wastewater pipes in Ruwa have aged and are now smaller in capacity as the increase in population has resulted in more wastewater being generated. The rate of population increase in Ruwa is outweighing the rate of development for the area. The increase in population is related to the increase in wastewater that is produced but there is no upgrading of the sewer system. Over the past 30 years, many new houses have been built and industries have been set up putting pressure on the same capacity wastewater management system. Also, newly built houses are taking very long time to have a functional wastewater system. Councils are overlooking this aspect as they are concentrating on issuing land for accommodation without providing wastewater collection systems (World Bank, 2002).

This concurs with World Health Organisation, (2013) report which states that rapid population increase in developing countries without upgrading the wastewater treatment system (for example pipes) to meet the increasing population is resulting in wastewater management problem. The wastewater management system will not be able to handle large volumes of wastewater produced by the increased population. However, this is in contrast with World Bank, (2002) which reported that the main challenges of wastewater management in developing countries are lack of planning by town planners and overpopulation. On the other hand, Amoatei & Bani, (2011) reported that wastewater management challenges in most developing countries are caused by lack of technological knowledge, efficient institutions and technical know-how of wastewater treatment process.

Most of councils in Zimbabwe have been hit by the financial crisis making them offer poor services, Ruwa Town Council is not an exception. Due to financial crisis, councils are continuously failing to offer services they used to offer especially in maintenance of wastewater management facilities. As per the interview with one of Ruwa Local Board representatives, most of residents in Ruwa are not paying their wastewater tariffs and most of them are not even registered and this has affected the council financially as the wastewater to be managed has increased but the finance to manage the wastewater is not increasing. This concurs with finding of Mara, (2003) who reported that local authorities raise funds through collecting tariffs so the deferment to pay all due tariffs in time by residents makes it difficult for the authorities to offer a smooth service. Contrastingly, Brant, 2009 reported that the Government should allocate funds to the councils for the services they offer rather than depending on little tariffs paid by residents.

Behaviour of residents was noted as another challenge which is being faced by the local authority. Manholes are being vandalised as residents steal cast iron which covers manholes. Residents will then dump solid waste in the open manholes thereby blocking wastewater resulting in bursting of pipes. This has resulted in bursting of wastewater pipes making the management of wastewater a challenge since there is not readily available finance to make replacement for such material and equipment. This concurs with the finding of Kumar *et al.*, (2011) who reported that residents in developing countries tend to vandalise equipment in which they benefit from hence they suffer the consequences at local authorities take their time to replace the defective or missing equipment.

5.3 PERCEPTIONS TOWARDS WASTEWATER MANAGEMENT

Questionnaire survey results indicated that most of the respondents perceived that wastewater management was sorely the local authority's responsibility and they were not responsible for anything regarding wastewater except to pay tariffs. These perceptions were based of ignorant and unconcerned residents who felt that the rates they paid towards such services would relieve them of the duty to manage wastewater at household level. A few respondents had the opposite view that they were partially responsible for wastewater management at household level. According to the EMA officer, there is a pattern in the way they neglect wastewater which gives them the conclusion that they do not care.

Willingness to pay for services was seen to be another issue affecting wastewater management in Ruwa. This is because as much as residents claim to be paying their rates, local authority claims otherwise. Residents are not paying as much as they should hence it hinders the local authority's ability to provide efficient services. Unfortunately, residents do not understand and are still unwilling to pay for better services hence crippling the wastewater management efforts.

5.4 AWARENESS ON ENVIRONMENTAL AND HEALTH EFFECTS OF WASTEWATER POLLUTION

Most of the residents were aware of the negative impacts caused by wastewater pollution. Their awareness is due to evident outbreaks of the diseases that are a result of poor sanitation. Most disease-causing waterborne microorganisms come from animal and human faecal waste. Similarly, World Health Organisation, (2006) reported that improper management of wastewater results in the outbreak of waterborne diseases. The study revealed that there are outbreaks of water borne diseases such as typhoid, bilharzia and dysentery. In addition, malaria was also reported as stagnant wastewater from burst pipes and wastewater ponds are creating favourable conditions for mosquitos to breed. This supports the finding of a study carried out by Kumar *et al*., (2011) in Nigeria who reported that bursting of sewer pipes in Nigeria was causing outbreak of malaria due to the creation of appropriate breeding conditions for mosquitos.

Poor quality wastewater is responsible for the degradation of the receiving water bodies such as rivers, underground water (Kvernberg, 2012). The effect of the pollutants to the environment depend on the volume of discharge and the concentration of the pollutants in the wastewater. This is the same scenario in Ruwa as Ruwa River and boreholes in some areas are polluted with microbial and chemical components that are from wastewater. Eutrophication in Ruwa river was evidenced by the presence of algae and plants that are growing in wastewater ponds and Ruwa river.

The algal bloom has been reported to deplete dissolved oxygen hence causing serious water quality problems (Mekala *et al*., 2008). This eutrophication also favours the growth of cyanobacteria which produces toxins that can cause health problems such as skin irritation, liver damage, and gastroenteritis if a person is exposed to such water (Kvernberg, 2012).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

Wastewater management has been a daunting problem in urban councils in Zimbabwe over the past 20 years. The research sought to assess the biological and physical characteristics of wastewater and domestic water and explore challenges associated with wastewater management in Ruwa. To obtain data, the study adopted a mixed approach design which used both qualitative and quantitative methods questionnaires, interviews and field observations. Data analyses were done using Statistical Package for Social Sciences (SPSS) version 26 (for one-way ANOVA). A total of 33 domestic water (borehole, tap and well) and 6 wastewater samples (dam and canal) were collected for microbiological and physical analyses. Differences of physical and microbial properties across sample were tested by performing One Way Analysis of Variance (ANOVA). The Post hoc Least Squares Difference (LSD) at 5% significance level was performed for pairwise comparisons for the samples. Content analysis was used to analyse data from the social survey. The results of ANOVA were presented as tables and for social survey were presented as pie charts and bar graphs. The microbiological analysis revealed that most of water sources (borehole, tap and well) in Ruwa are heavily contaminated with total coliform. In terms of physical nature, all water sources are within World Health Organisation limits. The major causes of poor wastewater management were undersized sewer pipes, aged sewer pipes, lack of funds, broken manholes. Due to the poor wastewater management, the community has suffered from outbreak of diseases such as dysentery, typhoid, cholera and malaria and the environment has suffered from water pollution and odour.

6.2 CONCLUSIONS

The study concludes that domestic water sources (tap, well and borehole) in Ruwa are not polluted in terms of physical characteristics but are polluted in terms of biological characteristics (E. coli ranging from 122 – 139 cfu/100ml) except for tap water. The study concludes that wastewater management problem in Ruwa are due to lack of finance, undersized pipes (due to population increase), age pipes, broken manholes and lack of finance to fund wastewater management services. The occurrence of diseases (bilharzia, dysentery, typhoid, cholera), creation of mosquito breeding ground are the major health effects of wastewater pollution and groundwater and surface water pollution, odour and eutrophication are the major environmental effects of wastewater pollution in

Ruwa. The wastewater piping system and wastewater ponds are not functioning causing untreated wastewater to flow into the rivers, streets and infiltrating into the soils impacting human health and the environment. The council is currently not capacitated to maintain its wastewater pipes and wastewater treatment ponds.

6.3 RECOMMENDATIONS

The Government of Zimbabwe is recommended to intervene on waste management issues in urban councils by equipping and ensure responsible authorities are enforcing the regulations on wastewater.

The study recommends Ruwa Local Board wastewater management unit must be strengthened by providing them with basic equipment and tool which is required to maintain back-holes, wastewater pipes, wastewater treatment ponds. Aged, undersized and damaged wastewater pipes should be replaced and all the houses should be connected to the sewer line and have a well-functioning sewer system. The study recommends the Ruwa Local Board should make the residents aware and educate them on the importance of proper wastewater management and use and maintenance of wastewater facilities to reduce pollution and promote public health.

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APPENDICES

APPENDIX 1: COMMUNITY QUESTIONNAIRE ON SOCIO-ECONOMIC CONSTRAINTS OF WASTEWATER MANAGEMENT

My name is Regis Musara, a student at Bindura State University undertaking BSc Degree in Safety, Health and Environment Management. I am carrying out a research entitled “Assessing wastewater and domestic water physico-chemical and biological parameters and the associated human and environmental impacts: A case study of Ruwa town.” I am asking you to participate in this research by answering questions. May you kindly answer all questions and do not write your name on the questionnaire as the information is strictly confidential. Indicate your answer with a tick in the boxes provided. Data obtained from this will be used for academic purposes only.

DATE ………………………QUESTIONNAIRE NUMBER ………………….…

SECTION A: PARTICIPANTS DETAILS ***(****Tick applicable answer****)***

1. Sex ☐ male female ☐
2. Age [years]…………………………………………………..
3. Level of education ……………………………………………………
4. Duration of stay in Ruwa (years)…………………………………….

SECTION B: COMMUNITY AWARENESS AND SENSITIZATION ***(****Tick all applicable answers****)***

5. Is your house connected to the council sewer system? ☐ Yes ☐ No

6. Do you pay wastewater tarrifs? Yes ☐ No ☐

7. Are you aware of the possible impacts of Wastewater pollution? ☐ Yes ☐ No

8. Who is conducting community awareness and sensitization campaigns on wastewater pollution in your community?

RUWA COUNCIL	**EMA**	**MINISTRY OF HEALTH**	**NONE**

If being sensitized, in your own words what is your understanding of the possible impacts of Wastewater pollution?

………

………

………

SECTION C: WATER AND SANITATION *(* Tick all applicable answers ***)***

9. What kind of toilet do you use at home?

WATER SYSTEM	**BLAIR TOILET**	**BOTH**	**OTHER, SPECIFY**

6. What is the source/s of your water at home?

COUNCIL WATER	**WELL**	**BOREHOLE**	**ALL**

7. How do you dispose of household wastewater?

……
………………………………………………………………………………………………………

8. How often do you experience sewer burst and flows?

WEEKLY	FORTNIGHTLY	MONTHLY

9. In what way(s) are you affected by sewer burst/ blockages?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………………………

10. What is the frequency in attendance of sewer blockages and burst by responsible authority?

WITHIN 24HRS	24HRS- 72HRS	72HRS- 7 DAYS	7DAYS+	NEVER

11. In your own opinion, what do you think are the major contributing factors to poor wastewater management?

……
……
……………………………………………………………………………………………………

12. In your own opinion, what do you think can be done to mitigate the major contributing factors to poor wastewater management you highlighted above?

……
……

THANK YOU

APPENDIX 2: INTERVIEW GUIDE ON SOCIO-ECONOMIC CONSTRAINTS OF WASTEWATER MANAGEMENT

My name is Regis Musara, a student at Bindura State University undertaking Bsc Degree in Safety, Health and Environment Management. I am carrying out a research entitled “Assessing wastewater and domestic water physico-chemical and biological parameters and the associated human and environmental impacts: A case study of Ruwa town.” I am kindly requesting you to participate in this research by answering questions. May you kindly answer all questions and do not give your name during the interview as the information is strictly confidential. Data obtained from this will be used for academic purposes only.

DEPARTMENT……………………………. OCCUPATION …………………………..………

DATE ……………………………

INTERVIEW GUIDE NUMBER ……………………..……….

SECTION A: PERSONAL DETAILS

1. Sex**.** Male/ Female
2. Age ……………….
3. For how long have you been at Ruwa Local Board? …………………………………………..
4. Highest level of education attained ……………………………………OR Tick below

Primary/ Secondary/ Tertiary

SECTION B NEGATIVE IMPACTS OF WASTEWATER TO HUMANS AND THE ENVIRONMENT

5. Where do sewer spills usually occur?

   Industrial/ Domestic

6. How often do you encounter sewer leaks incidents?

Rarely often /Very often

7. Where were the most spills recorded? ……………………………………………………..…..
8. What are the sources of sewer spills?

Sewer pipe bursts /direct disposal

Other……………………………………………………………………………………………….

9. Who is responsible for cleaning up the polluted sites?

…………………………………………………………………………………………………

(b). How is cleaning of polluted sites conducted?

……………………………………………………………………………………… ………

10. How has been the council responding to wastewater bursts or spills? ……………………………………………………………………………………………
11. What are the environmental problems associated with wastewater in Ruwa? ……………………………………………………………………………………………… ……………………………………………………………………………………………… ……………………………………………………………………………………………… ……………………………………………………………………………………………… ……………………………………………………………………………………………… ………………………………………………………………………………………………..

12. What are the health problems associated with wastewater?

……
……………………………………………………………………………………………………

……
…………………………………………………………………………………………

13. Does top management demonstrate an interest in the environmental related issues? Yes/ No

14. Does council have a wastewater management policy? No/ Yes

SECTION C: ASSESSING THE WASTEWATER MANAGEMENT CHALLENGES AT RUWA LOCAL BOARD (Tick where applicable below)

15. Whose responsibility is it to manage and protect the environment from wastewater and its effects?

    Officials /Top management /EMA /Collective responsibility.

16. Sewage is a visible form of pollution. Are there sewage polluted sites that you can identify in Ruwa?
    ………………………………………………………………………………………………
    ………………………………………………………………………………………………
    ………………………………………………………………………………………………
    ……………………………………………………………………………………

17. Where is the wastewater or sewage from the sewer pump stations disposed? ………………………………………………………………………………………

18. What are the wastewater disposal methods?

....
....
....

19. Are there any trained personnel in wastewater handling? Yes/ No

IN THE FOLLOWING SECTION INDICATE YOUR RESPONSE USING THE INDEX:

(1) Agree strongly **(2)** Agree **(3**) Moderate **(4)** Disagree **(5)** Strongly disagree

20. Knowledge on wastewater pollution response and wastewater handling practices is low amongst employees?

    ……………………………………………………………………………………………

21. The company lacks trained personnel who are trained and equipped to deal with spills or bursts.

    ……………………………………………………………………………………………

22. In terms of waste water, is the monetary budget allocated enough to handle its management?

    ……………………………………………………………………………………………..

23. What are the constraints to the remediation of waste water disposal/ attendance?

    ……………………………………………………………………………………………..

THANK YOU FOR YOUR PARTICIPATION

APPENDIX 3: FIELD OBSERVATION GUIDE ON SOCIO-ECONOMIC CONSTRAINTS OF WASTEWATER MANAGEMENT

PUMP STATION NAME	WASTEWATER PHYSICAL PARAMETER CONSIDERED	COMMENTS
USAID	Colour	
	Solid composition	
Chiremba	Colour	
	Solid composition	
Windsor	Colour	
	Solid composition	

ASSESSMENT INDICATOR	COMMENT
Visible blockages	
Pump stations operational state	

Machinery and equipment condition	

TYPE OF WATER BODY	**INDICATOR**	**COMMENTS**
Irrigation canal from Ruwa ponds	Colour of water	
	Type of indicator vegetation	
Ruwa river	Colour of water	
	Type of indicator vegetation	
Ruwa dam	Colour of water	
	Type of indicator vegetation	

APPENDIX 4: PICTORIAL EVIDENCE OF WASTEWATER POLLUTION IN RUWA

Latitude:-17.886634, Longitube: 31.202276	Latitude: -17.8988037, Longitude: 1.2469052

(a) *evidence of raw sewage disposal into Ruwa river* ***(b)*** *evidence of environmental pollution by sewage in Ruwa community*.

APPENDIX 5: SOME OF WASTEWATER ANALYSIS LABORATORY RESULTS

Telephone 792026/7

Telegraphic Address
"MEDICUS", Harare
Fax: 708527

ZIMBABWE

Reference:

GOVERNMENT ANALYST LABORATORY
P.O. Box CY 231
Causeway
Zimbabwe

GOVERNMENT ANALYST
02 AUG 2022
P. O. BOX CY231, CAUSEWAY
ZIMBABWE

LABORATORY TEST REPORT

Lab Ref: F831/ 22

Customer name and address:
Regis Musara
Ruwa
Goromonzi

Email: regismusara@gmail.com

Tel: 0783 663 395

Customer Ref: 18- Dam Water

Sample Type: Drinking water

Sample Description: Dam water

Condition of sample: Packaged in sterilized bottle

Date taken: 20/07/2022

Date received: 20/07/2022

Sampling method used: Random

Sampling done by: Customer

Tests done: Total E. coli/ Total coliforms

Date(s) of analysis: 27-28/07/2022

Date report issued: 28/07/2022

Date reported: 28/07/2022

Environmental conditions: Incubation at 37°C for coliforms and 44.5°C for E. coli.

Analysis carried out at: **Government Analyst Laboratory**
49 Josiah Tongogara Cnr Mazowe Street, Harare

Reviewed by: F. Chinyanzhu Deputy Director Food Control   Authorised by: M.L. Mudyambiri Director Government Analyst Laboratory

The Government Analyst Laboratory is a National Regulatory Food and Water Testing Laboratory whose operations are benchmarked to ISO17025 standards for testing laboratories. It falls under the Ministry of Health and Child Welfare and administers the Food and Food Standards Act with other stakeholders.

RESULTS

Test/ Parameter/ Analyte	Units	Test Method	SOP Ref	Guideline Range	Measurement uncertainty (±)	Actual Result	Remarks
Total Coliform Count	cfu/ 100ml	Membrane filtration	SOP/F/08	0/100ml	-	>100	Monitoring
Total E. coli	cfu/ 100ml	Membrane filtration	SOP/F/07	0/100ml	-	>100	Treatment

Key

cfu/ 100ml = colony forming units per hundred millilitres

SOP = Standard Operating Procedure

Decision Rule: If the determined laboratory test report result is above maximum permissible limit or below minimum permissible limit, then the sample has failed. The measurement uncertainty has been factored in.

*Implies non- compliance taking into consideration the measurement uncertainty.
** implies results from sub-contraction.

Additions to, deviations, or exclusions from the method: None

Opinions and Interpretations

1. According to the analysis done, sample F831/22 needs treatment before domestic use since there was growth of viable micro-organisms. The presence of E. coli is suggestive of faecal contamination.
2. Please submit another sample for chemical analysis if you have not done so.

Technical Signatory/ Competent Analyst
Name B K Samende *Signature* BSamende *Date* 25/07/22

For: Director Government Analyst
/flm

DISCLAIMER:

a) The results relate only to the sample(s) as received and tested by the laboratory.
b) Report is issued without alteration.
c) If published or produced, the report must be reproduced in full with approval from Government Analyst Laboratory ie the reproduction must contain the whole report, nothing exempted or added.
d) Report can be issued as hard copy or by electronic means.

END