BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF NATURAL RESOURCES MANAGEMENT

Effects of Solid Waste on Physico-Chemical Water Quality of Unprotected Wells in Brockdale, Bindura

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DEDICATION

This project is devoted to my lovely mother and father, sisters, Olivia, Regina and Amanda and brothers, Gaylord, Admire and Arthur, my friends Tariro, Norah and my husband. Thank you for the help that made me the character I am today.

ACKNOWLEDGEMENTS

Firstly,I just want to thank the Almight God for his protection, mercy and love.My honest gratitude is going to the Bindura University Laboratory for providing all of the materials and reagents which were used in the course of the project. Mr Nyamugure for coaching me the way to use SPSS, Mr Musodza for assisting with GIS and Mr Kadema and Mr Richakara assisted in series, practise, evaluation of the samples Thank you, Ms Masona, my academic supervisor, in your exceptional guidance and counsel.

ABSTRACT

Waste disposal sites create a lot of leachates, which includes a lot of chemicals that can contaminate ground water. Observing the concentration of probable pollution at a number of sampling sites can assist to decide the effect of solid waste on unprotected wells. The physico-chemical quality of groundwater at Brockdale, Bindura were studied within the month of February. A total of 39 samples were collected from thirteen wells and analyzed for pH, Nitrates, Lead, Copper, Iron, Manganese, TDS and EC at the Bindura University Laboratory. All statistical tests were performed at alpha level 0.05 using IBM SPSS Version 20. Pearson correlation and GIS maps were used to show the correlation distance between the wells and dumpsite. One way ANOVA showed that physicochemical concentration was significantly different ($p<0.05$) among all the wells. One sampled T-test showed a significant difference ($p<0.05$) and the physicochemical concentrations of TDS, EC, Nitrates, Iron and Manganese were below the WHO drinking water standards expect pH, lead and copper concentrations were above the WHO water quality guidelines threshold. It was recommended that government agencies such as EMA and Bindura municipality should engage in more research to monitor contaminant levels and plan mitigation strategies. At the same time Bindura municipality should collect the garbage twice per week to avoid the illegal dumping of garbage.

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LIST OF ACRONYMS

ANOVA	Analysis of variance
Cu	Copper
EC	Electrical Conductivity
EMA	Environmental Management Agency
Fe	Iron
GIS	Geographical Information System
Mn	Manganese
pH	Potential Hydrogen ion concentration
Pb	Lead
SPSS	Statistical Package for Social Science

WHO	**World Health Organisation**

CHAPTER 1

1.1Background of the study

The amount of waste produced around the world is increasing (Of & Based, 2010). Due to rapid population expansion, the world's cities generated 2.01 billion tons of solid waste in 2016, equating to a daily footprint of 0.74 kilogram (S, 2013). Waste creation is anticipated to climb from 70% in 2016 to 340 percent in 2050(Agency et al., 2013). According to Hoornweg et al. (2012), increases in solid waste are influenced by population expansion, improved living conditions, and urbanization. As a result, the concept that solid waste collection in metropolitan areas is becoming a severe global problem has gained traction. Poor solid waste management is currently afflicting developing countries, where waste collection is a serious concern for municipal governments (Ogwueleka, 2009).

According to the World Health Organization, 2012, solid waste removal takes precedence in Africa above water quality (Zerbock, 2003). In urban Africa, rapid population development is resulting in the production of unpleasant hazardous substances (UNEP, 2010). The assumption that any dumpsites made official by local authorities automatically become landfills is the reason why most African countries suffer from the effects of poor waste management(*Solid Waste Impacts on Water Quality*, 2022)

According to Mangizvo (2010), municipalities in Africa will continue to dump garbage in open places due to economic restrictions. Masocha (2004), noted that Zimbabwe's main waste disposal infrastructure was open dumpsites, and the few landfills that could be reached were polluted. Ground water samples for the Golden Quarry sale?? in Harare, Zimbabwe's largest city, were found to be above the exceptional criteria for coliforms, cadmium, iron and lead in a study conducted by Love et al. (2006). One study identified trace levels of lead, iron, and copper in soils within a 50-meter radius of the Mucheke municipal dumpsite in Masvingo.

According to statistics, 60 percent of solid waste in Zimbabwe is generated in cities and discarded in open areas, posing a significant threat to the environment and people (Masocha, 2002). The Environment Management Act, Chapter 20:27, governs solid waste management in Zimbabwe. According to Section 70(1) of the EMA Act, "No man or woman shall dump or dispose of any waste in a manner that causes environmental pollution or ill fitness of any character." As a result, under the EMA Act, anybody whose sport??? action generates waste is required to take measures to reduce waste generation, such as treatment, reclamation, and recycling.

Solid waste goes through uncountable changes in physical, chemical and microbiological processes once it is disposed while releasing 'leachate'. It is a toxic liquid comprised with massive amount of organic and inorganic compounds. This leachate migrate via the soil structure continuously and leads to ground water contamination if not prevented using necessary structural measures (Kanmani and Gandhimathi, 2013). It is against this background that a study was carried out to determine the impact of solid waste on ground water quality in Bindura Brockdale. This was necessitated by inadequate rubbish collection which has become a serious concern in society, and may in health issues, disease outbreaks, and environmental damage. (Dahiya & Chandra, 2006).

1.2 STATEMENT OF THE PROBLEM

Solid waste management has become a serious public health and environmental concern in Zimbabwe. Domestic garbage such as refrigerators, diapers, televisions, and other objects has been dumped into waste stabilization ponds in Bindura and Brockdale, whose depth is the same as the level of a nearby open well. Drinkers of water from a nearby well are dissatisfied with the flavor and odor, which might be due to higher physico-chemical parameters in the water.

1.3 OBJECTIVES OF THE RESEACH

1.4 AIM

The major aim was to find out how solid waste affects ground water.

1.5 OBJECTIVES

- To determine the level of pollutants as compared to WHO standard water quality?
- To determine the variation of selected physico-chemical water quality parameters in wells in Bindura
- To investigate the relationship between levels of specific physicochemical contaminants in wells and distances from the dumping site.

1.6 RESEACH QUESTIONS

a. How the level of pollutants as compared to WHO standard water quality?

b. What are the levels of physico-chemical parameters of the leachate and selected sites?

c. How do levels of pollutants in wells vary with distances from the sampling sites?

1.7 JUSTIFICATION OF STUDY

The research is mostly focused on the town of Bindura Brockdale. Scholars such as Tevera et al. (2013), Bere,2013, Mahamba,2015, Mangizvo,2010, Jambwa, 2011, Nyakudya and Stroosnijder, 2011, Mapira,2012. In comparison to large cities like Harare, there is a lack of research into small towns like Bindura(Kativu,2001). As a result of the growth of small cities, the research mainly focuses on residents of Bindura Brockdale. Garbage generation is increasing as a result of population growth and economic uncertainty, therefore, municipality of Bindura is unable to serve a large area (Saei, 2012). This research is going to benefit the community and the Bindura municipality council and EMA. The Bindura municipality we use the information to strategist's ways and laws that would protect health of local people. The information would be used to design a proper dumpsite which is lined.

CHAPTER 2

Literature Review

2.1 Global importance of ground water

Water is important and needed to assist and preserve the existence of life on earth (WHO, 2012). The majority of diarrhea disease worldwide (88%) is because of volatile???? water, terrible hygiene, and negative sanitation (WHO, 1996). The World Health Organization has estimated that approximately 1.1 billion people globally are consuming hazardous water. Thousands of children in developing countries under the age of five die every day due to ingesting contaminated water, which is an issue. Lack of potable water delivery, hygiene, and primary sanitation is related to the high morbidity and mortality from water-associated ailments (WHO, 2004). Millions of lives are being moved out of location in lots of growing international places due to a lack of safe drinking water and the right sanitation measures. About 22 African global locations, collectively with China, are failing to provide potable water to half of their population. These pressures result in water pollutants, which in turn contribute to waterborne sickness outbreaks across the world. Water pollutants additionally call for a growth in chemical substances used for their remedy, thereby making them very highly priced for treatment (ZINWA, 2012).

Solid waste is not like sewage, which is a time period for liquid waste (Mader 2011). When Tchobanoglouset (1993) describes solid waste as garbage from animals and systems outdoors, that is typically considered as undesirable. Commercial, residential trash, and construction particles all fall under the category of strong waste, which incorporates both unsafe and non-risky elements (Zerbock 2003). According to GIM (2009), strong waste originates from water waste discharges, in addition to atmospheric gas emissions from commercial, household, and institutional activities in metropolitan regions. Kemal (2007), for example, defines stable waste as rubbish discarded from mining, industrial, and business activities.

2.2 Groundwater pollution at the dumpsite

The physical, chemical, and biological aspects of groundwater make up its quality. Physical water quality parameters include temperature, color, taste, turbidity, and odour (Harter, 2000).Alkalinity, acidity, pH, and total hardness are all chemical properties of water. Groundwater has been damaged by disposal coming from household and industrial operations as a result of the increase in population and growth of urbanization. Landfills have long been the primary method of garbage disposal due to its convenience and the fact that the hazard of groundwater contamination was not recognized at the time (Smith & Edger, 2006).

The subsequent contamination of groundwater via discharged leachate is the most serious environmental issue surrounding the landfill (Afolayan et al., 2012). The replenishing of an aquifer with water from the land surface is known as groundwater recharge (Bhattacharya, 2010). Because groundwater and surface water are interconnected, when groundwater becomes contaminated, the risk of surface water contamination rises as well. The entire breakdown of wastes is achieved by the interaction of physical, chemical, and biological processes. Chemically loaded leachate is one of the byproducts of this interaction. Although ground water pollution can take years to manifest, the chemicals in leachates frequently respond in unexpected ways, affecting the ecosystem as a whole.

Heavy metals are good indicators of contamination in urban soils and street dust, according to Kholoud et al. (2009). They appear in gasoline car components, oil lubricants, industrial, incinerator emissions, and municipal wastewater discharge. Heavy metal contamination is a major source of worry due to its toxicity and potential damage to human life and the environment. Children in metropolitan areas are more likely to be exposed as a result of unintended hand-to-mouth contact when playing on the streets. According to Taylor and Allen (2006), landfills are most associated with the polluting of groundwater by waste-derived liquids in terms of scenario evaluation. Any location where trash is concentrated, processed, and kept, even for a short time, could be a point source of groundwater contamination.

Groundwater pollution is caused by the presence of undesirable and hazardous material and pathogens beyond certain limits. Much of the pollution is due to anthropogenic activities like discharge of sewage, effluents and waste from domestic and industrial establishment.

Considerably, a number of detailed studies of leachate paths indicate that they rarely extend more than a few hundred metres from the landfill, before all but a handful of the most persistent contaminants are completely attenuated (Christensen et al., 1994; Robinson et al 1999). Concentrations of both reactive and conservative contaminants decrease with the distance along the groundwater flow path therefore, leachate migration is in line with the distance decay principle (Taylor, 1983). It should be noted that the concentration of a pollutant at any point removed from its source may vary throughout the year due to seasonal influences on recharge and release of the contamination, or reaction times governed by variations in factors such as temperature (Taylor & Allen, 2006). Hence, seasonal variation differentiates the concentration of leachate in groundwater. Conversely, deeper aquifers tend to be more susceptible to contamination from local land use activities, and can be vulnerable to nitrate and microbial contamination (McLeod et al., 2005).

2.3 Groundwater Quality Influencing Factors

Groundwater chemistry, in turn, depends on several factors, which include geology, the degree of chemical weathering of rock kinds, and the presence of recharge water. Groundwater is greatly affected by natural and anthropogenic factors, such as vegetation, climatic variation, permeability of sediments, and topography. Anthropogenic factors include the nature of human activities, urbanization, industrialization, and waste management disposal, among others. (Aghazade & Mogaddam, 2010).

Groundwater quality can also be affected by climatic variations such as rainfall and evaporation. In semi-arid regions where discharging groundwater evaporates, precipitation infiltrating through the soil can re-dissolve salts and carry them back to the groundwater. In areas with higher precipitation or sand with lower evaporation, precipitation reaching the groundwater is less mineralized.

Waste is placed in refuse dumps; therefore, it quickly becomes part of the dominant hydrological system. Rainfall, snowmelt, and groundwater, as well as liquids created by the waste itself, percolate through the deposit and mobilize other waste components. The content of leachate and the degree of contamination it causes are influenced by a number of factors, including the age of the landfill and the type of waste it contains.

The rate and characteristics of leachate production are influenced by a variety of factors, including solid waste composition and cover design. In relation to local activities, as well as the quality and kind of items that communities consume, the composition and amount of discarded waste vary nationally and regionally. (Longe & Balogun, 2010; Papadopoulou et al., 2007). Organic matter decomposition can affect the physico-chemical quality of groundwater and accelerate the mobility of hazardous chemicals such as metals and solvents. Increased prosperity and industrialization lead to increased trash creation, and leachate from garbage disposed of in highly industrialized areas can contain a wide range of anthropogenic toxins.

2.6 Water Quality Standards and Recommendations

The WHO Drinking-Water Quality Guidelines address the physical, chemical, and microbiological aspects of water quality. The guidelines are updated on a regular basis based on scientific research and consultations with various stakeholders and specialists. Each country establishes its own criteria and guidelines to govern the quantities of pollutants allowed in its various water sources (Onemano and Otum, 2003).

The World Health Organization's (WHO) recommendations on water quality are not required but meant to serve as a starting point for individual nations to develop and manage national water quality standards. By eliminating or reducing contaminants to a minimum permissible level, the implementation of the WHO recommendations ensures the safety of drinking water supplies.

The GDWQ is a questionnaire designed to protect public health around the world. The conversion and adaption of the underlying philosophy, direction, and given quantitative values to quality standards set by each country is the most critical stage of execution of these standards. In contrast to developed countries that have established higher standards for dealing with water quality issues, Kenya's situation remains volatile.

2.4 Drinking Water Quality Requirements

The quality of water for human consumption is not determined by ambient water quality.There is a need to have guidelines for drinking water quality to protect the public health (WHO, 2017). Drinking water is considered to be safe when it does not present major effects at different exposures.

Table 2.1: WHO drinking water standard qualities.

Parameter	Unit	Requirements
Chemical s		
Cadmium	mg Cd/l	5.0
Copper	mg Cu/l	1.0
Mercury	mg Hg/l	1.0
Lead	mg Pb/l	0.01
Cyanide	mg Cn/l	0.1
Chromium	mg Cr/l	0.05
Manganese	mg Mn/l	0.1
Iron total	mg Fe/l	0.3
Zinc	mg Zn/l	5
Chromium	mg Cr/l	0.05
Physical		
Colour	Pt. Co scale	15
Odour	Pt. Co scale	Odourless
Ph	Pt. Co scale	6.5-8.5
Total dissolved solids	mg/l	1500
Total hardness	mg/l	500

Turbidity	FTU	5
Taste	Pt. Co scale	Tasteless

2.5 Solid waste's impact on ground water quality

2.6 Formation of Leachate

Surface and groundwater pollution have been related to municipal SOLID waste disposal centers. It is important to monitor the recent degradation of organic compounds at dumping sites (Zouboulis, 2002). Leachate is formed while solid waste from various assets is deposited in dumps and landfills. Physical, chemical, and organic techniques all contribute to this (Kjeldse and co-people, 2002).

The toxicity of leachate is decided by water and climatic conditions (WHO, 2006). In their study of groundwater contamination, researchers like Kjeldsen et al. (2002) observed that water availability is vital in strong waste decomposition. Contaminant retention is motivated by geology, compaction, and moisture content.

2.7Leachate Composition

The handling and disposal of waste continue to be neglected in poor countries with inadequate technology for coping with strong waste generation and control (Tatsi and Zouboulis, 2002). Solid waste management procedures that aren't evolved enough endanger the exceptional and long-term viability of soil and water resources. Pollution from leachates within the municipality is a major issue for municipal waste management.

2.8Trace Elements

Solid waste leachates have been determined to include natural and inorganic additives. The majority of them come from carelessly positioned sturdy waste. Cu, Pb, Mg, and Fe are a number of the most commonly recommended trace elements; most of them are confined via water under wonderful rules because of toxicity and life (Jorstad, 2006).

Heavy Metals 2.9

Copper (Cu)

Landfill leachates usually comprise natural acids, and inside the urban surroundings, the leachates, when combined with hurricane waters containing Cu, may be a supply of poisonous Cu natural complexes in streams and estuaries (Fraser et al., 2009).

Manganese (Mn)

Young children appear to take in greater manganese than older children, but excrete less. This makes it especially important for pregnant women and youngsters to have clean drinking water (APEC water, 2011). The necessary anthropogenic sources of ecological manganese encompass municipal wastewater discharges, mining and mineral processing emissions from pollutants, metal, and iron production, and, to a much lesser extent, emissions from the combustion of fuel components.

Nitrates

Some groundwater has a nitrate awareness that offers a health chance, in particular for toddlers. Consuming an excessive amount of nitrate will have an impact on how the blood carries oxygen and can cause methemoglobinemia. It can cause pores and skin to turn a bluish shade and, if left untreated, results in death or contamination, especially in infants under six months of age, who have excessive threat. It causes anemia, coronary heart diseases, and lung ailments. Hand dug wells with casings that are not watertight are prone to nitrate because of the reality that nitrate can seep down and contaminate the ground water. High levels of nitrate in water may be the end result of runoff or leakage from fertilized soil and waste water. Kanmani and Gandhimathi (2013)

Lead

Lead is a toxic metal that can cause long-time health and behavioral issues. It is commonplace that metal is determined by the path of the surroundings in lead, primarily based on paint, air, soil, family dirt, and meals. The well may additionally have additives that have lead in them, and that lead can get into ingesting water. It can damage the brain, kidneys, and frightened devices.

Lead may also be present in the pipes and other components of your family's water machine and plumbing.Lead impacts groundwater quality because of the corrosion or wearing of materials. (Rizvi et al., 2016).

Iron

Iron makes up at least 5 percent of the Earth's crust. When rainfall percolates through the soil, the iron inside the earth's crust dissolves, causing it to go into the water supply, which includes the wells. Iron is not considered hazardous to health as it transports oxygen in our blood.(Nwankwoala HO et al., 2022).

CHAPTER 3

RESEARCH METHODOLOGY

3.1Description of study area

Bindura is located in the Mazowe valley, about 88km north-east of Harare. Brockdale is a town in Mashonaland Central, Zimbabwe. Housing units in Brockdale are being built 4.3 kilometers along Shamva Road, directly across from Ezekiel Guti University. This area is currently being used as a dumpsite for domestic waste, taking advantage of naturally existing ponds full of water. Bindura's latitude and longitude are 17.3° and 31.3°. (Nangombe et al., 2018). According to the population census, the town had a population of 46,275 in 2012. The soil type is loam soil because it holds moisture and also allows for good drainage. The temperature in Bindura ranges from 24 degrees to 26 degrees Celsius from January to May, and 22 degrees from June to July, and August to September, 31 degrees Celsius. Average rainfall ranges from 100mm to 400mm per year.

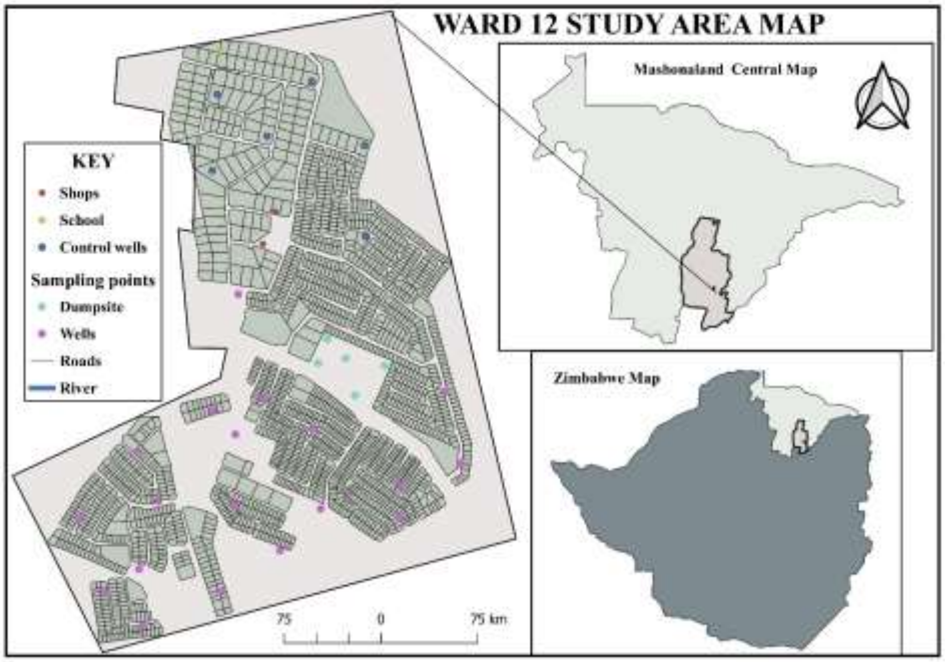

Fig 3.1 Map of the Study area

3.2 Research plan

An experiment study design was used to characterize the leachate quality and determine the quality of ground water in the nearby residential area. A completely randomized design with thirteen sampling well points and five from the dumpsite leachate was used. Calculated general random numbers were used for randomization. A total of three replicates were collected per site. The samples were taken early in the morning to avoid disturbance of the water source. The water collected upslope provided the study's background (control) sample. The samples were collected during the rainy season.

3.3 Parameter

Temperature (^{0}C), pH, Nitrate, Electrical conductivity (EC), Iron (Fe), Copper (Cu), and Lead (Pb) were among the physical and chemical parameters investigated in this work. The rationale for choosing these characteristics are based on the fact that they are common pollutant components found in groundwater near dumpsites. These parameters were selected to test the unknown within the dumpsite and in the well 100m from the dumpsite.

3.4 Data collection

The data was gathered using primary data sources. Water samples and field observation are the most important data.

3.4 .1Leaching procedure

Field visits were also done on dumpsites to assess the status of the illegal dumpsite. The primary records turned into accumulated through observations through looking at the sort of waste. This approach is primarily based on belief and statistics, which have boundaries. The Toxicity Characteristic Leaching Procedure is a chemical evaluation technique used to determine whether there are risky elements present in a waste. The take a look at involves taking leachate from a dumpsite and studying the samples in the laboratory. Hence, the results from the analyses can prove whether the waste is dangerous to the surroundings or not.

3.4.2Water sampling for physicochemical parameter

The water samples were tested offsite and there were analyzed in the laboratory (table 3.2) for pH, EC, temperature, TDS, Pb, nitrates, iron, copper and manganese. The samples were randomly taken using calculated number that is after 5 houses to prevent bias.

Table 3.1 shows water sampling points

Sampling point	Coordinates	Distance from the dumpsite
Well 1	31.3643853 -17.3271564	100m

Well 2	31.3643822 -17.3271691	120
Well 3	31.3643901 -17.3271580	150
Well 4	31.3644203 -17.3271905	160
Well 5	31.36707 -17.32740	200
Well 6	31.365487 -17.327350	250
Well 7	31.365696 -17.327291	300
Well 8	31.3666053 -17.3277373	350
Well 9	31.3665172 -17.3277373	400
Well 10	31.661442 -17.3277882	450
Well 11	31.3669696 -17.3276290	500
Well 12	31.3669696 -17.3274417	575
Well 13	31.3669609 -17.3274076	580

Grab or laboratory sampling was used to collect water at thirteen sampling sites. A total of three replicates were collected per site. The containers were rinsed with distilled water to avoid contamination. After collecting the sample, each bottle was labeled indicating the site number, distance from the dumpsite and coordinates. The samples were transported to the laboratory for physicochemical analysis in a cooler box. All parameters were analyzed (table 3.2) offsite at Bindura University laboratory.

3. 2 Physico-chemical water quality sample analysis

Parameter	**Method**	**Units**	**Reference**
pH	Electrode		(*Ground Water Quality Assessment Using GIS and Remote Sensing_ A Case Study of Juja Location, Kenya*, n.d.)
Temperature	Electrode	Degrees celcius	(*Ground Water Quality Assessment Using GIS and Remote Sensing_ A Case Study of Juja Location, Kenya*, n.d.)
EC	Electrodes EC meter AD3000	µS/cm	(Rizvi et al.,2016)
TDS	Electrodes EC meter AD3000	Ppm	(Rizvi et al.,2016)
TSS	Oven or Gravimetric	mg/L	Rizvi et al., 2016)
Nitrates	Spectrophotometric SOP/CM28	mg/l N	(Rizvi et al., 2016)
Phosphorus	Spectrophotometric	mg/L	Rizvi et al., 2016)
Total hardness	EDTA titration	mg/l CaCO3	(Rizvi et al., 2016)
Metals	AAS	mg/L	(Nartey et al., 2012)

The results were recorded against water quality standard using WHO water quality guidelines.

3.4.3 World Health Organization drinking water standards

All the physico-chemical analyses were compared against the WHO standard water quality. (table 3.3)

3.3 WHO guidelines

Parameter	Unit	Requirements
Chemical		
Copper	mg Cu/l	1.0
Lead	mg Pb/l	0.01
Manganese	mg Mn/l	0.1
sIron total	mg Fe/l	0.3
Zinc	mg Zn/l	5
Physical		
Colour	Pt. Co scale	15
Odour	Pt. Co scale	Odourless
pH	Pt. Co scale	6.5-8.5
Total dissolved solids	mg/l	1500
Taste	Pt. Co scale	Tasteless

Source; (WHO, 2017)

3.5 Statistics correlation analysis

GPS was used to measure the distance between the dumpsite and the well (WHO and UNICEF, 2006). The sampling points were entered into the QGIS 2.5 to determine the distant from the dumpsite and the wells. For calculations, Pearson correlation coefficient was used to test analyzes the statistical relationship or association, between two variables. It is used to measure the correlation between the dumpsite and wells.

Data analysis

Data analysis was done on water quality parameters. The collected data were analyzed using Microsoft Excel as well as Statistical Package for Social Scientists (SPSS) where simple descriptive statistics were obtained and results were summarized as graphs and pie charts for discussions. Qualitative data from the water sample were analyzed using one way ANOVA The variations in water were determined using Pearson correlation analysis. The T-test with one sample physicochemical characteristics was also compared to drinking water regulations set by the World Health Organization (WHO). T-test with one sample physicochemical characteristics was also compared drinking water regulations set by the World Health Organization (WHO). The results of the physico- chemical parameters that were examined were coded then placed into the Statistical Package for Social Sciences to calculate means and standard deviations.

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CHAPTER 4

RESULTS

4.1 The variations of the physico-chemical analyses of the leachate

Fig 4.1, It clearly shows iron ranges from 2.104 mgl to 2.23 mgl. Nitrate concentrations ranged from 66mgl to 85mgl, lead concentrations from 0.051mg/l to 0.0639mgl, copper concentrations from 0.0201mg/l to 0.0472mg/l, iron concentrations from 2.1041mg/l to 3.8877mg/l, and manganese concentrations from 70mg/l to 79mgl (Fig 4.1). The concentration of pH was highest at sampling point 2 (5.61) and lowest at point 5 (4.24). This is shown in Fig 4.2. The variation of TDS was high on site 1 with 1388 ppm and lower on site 4 with 1161 ppm (Fig 4.3). The temperature ranges from 22.2 oC to 15 oC, as shown in fig 4.4. EC was high on site 5 with 725s and lower on site 1 with 425s. (Fig 4.5)

The concentration of leachate in the dumpsite

Fig 4.1 showing the leachate from the dumpsite (heavy metals)

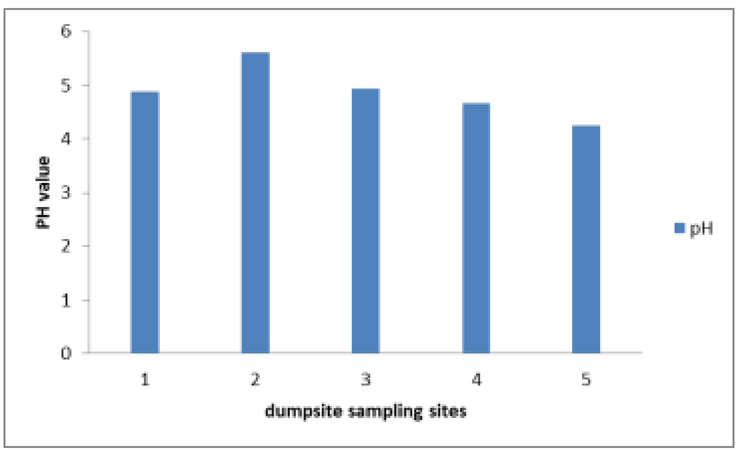

Fig 4. 2 pH concentration in dumpsite

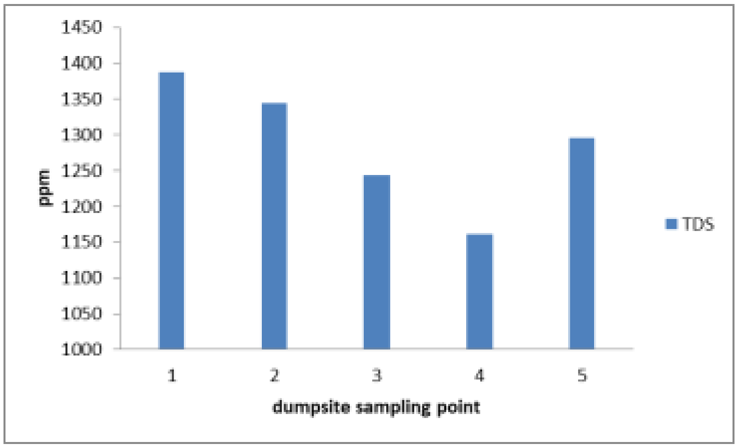

Fig 4.3 Concentration of TDS.

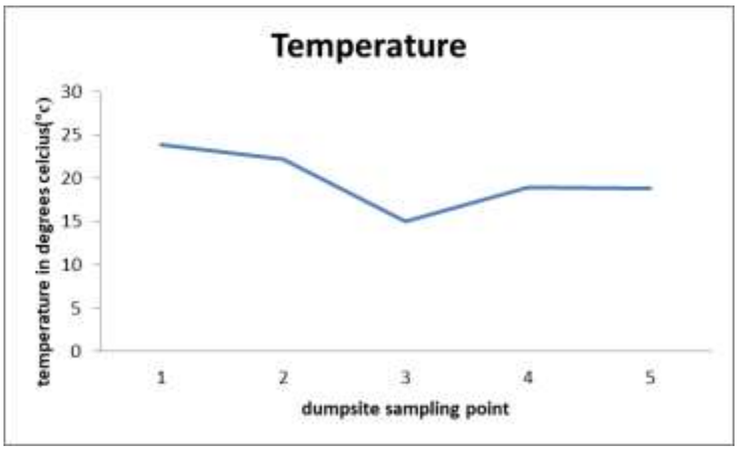

Fig 4.4 Temperature in the dumpsite

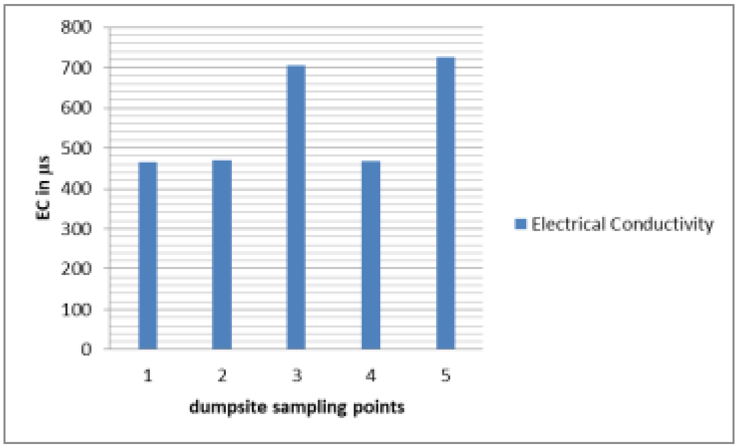

Fig 4.5 EC variation in dumpsite

Use error bars to show if there was a difference

4.2 The variation of selected physico-chemical water quality parameters in wells in Bindura

Variation of the concentrations of TDS, EC, Nitrates, pH, Temperature, Lead, Copper, Iron, and Manganese showed a significant difference (p 0.05) across all sites, respectively (table 4.1). Samples 25, 26, 27, 28, 29, and 30 were control wells. The pH values were lower in samples 28 and higher in samples 29. EC concentrations were higher in wells 1 and 2 and the lowest in sample 24 (table 4.1). Variations in concentrations of temperature were highest at well 15 and lowest at well 3 in table 4.1. The total dissolved solid absorption in surface water was greater than might be due to the leaching of various contaminants into water. The concentration of manganese and nitrates was also higher in the unprotected well water samples. The pH ranges from 6 to 7.46 across all the sites (Table 4.1). The variation of TDS varies from 135 ppm to 191 ppm (Table 4.1). EC varies from 270 S to 740 S (Table 4.1).

PARAMETERS	WELL1	WELL2	WELL3	WELL4	WELL5	WELL6	WELL7	WELL8L	WELL9	WELL10	WELL11	WELL12	WEELL13
pH	6.73±0.56	6.68±0.56	6.7±0.56	6.67±0.56	6.72±0.56	6.72±0.56	6.57±0.56	6±0.056	7.46±0.56	6.63±0.56	6±0.56	6.26±0.056	6±0.56
TDS	159±328	175±328	226±328	236±328	271±328	164±328	191±328	156±328	181±328	188±328	135±328	156±328	181±328
EC	740±98	734±98	370±98	396±98	320±98	442±98	463±98	473±98	338±98	345±98	270±98	314±98	368±98
TºC	19.2±4	15.2±4	18.9±4	20.1±4	19±4	11±4	20.4±4	21.1±4	21.1±4	20±4σ	25.6±4	26.3±4	26.3±4
Pb	-0.02±0.054	-0.006±0.054	-0.0018±0.054	-0.275±0.054	-0.0071±0.054	-0.0544±0.054	-0.057±0.054	-0.0688±0.054	-0.0905±0.054	-0.1008±0.054	-0.0718±0.054	-0.0449±0.054	-0.0772±0.054
Cu	0.01278±0.115	0.413±0.115	0.0205±0.115	0.134±0.115	0.0277±0.115	0.083±0.115	0.0094±0.115	0.0055±0.115	0.108±0.115	0.6622±0.115	0.0108±0.115	0.0005±0.115	0.001±0.115σ
Fe	1.7097±0.853	2.7354±0.853	2.7355±0.853	1.9599±0.853	1.012±0.853σ	1.8168±0.853	2.2761±0.853	0.00099±0.853σ	0.0045±0.853	0.663±0.853σ	1.4568±0.853	1.0153±0.853	1.4568±0.853
NITRATES	50±9.5	50±9.5	50±9.5	53±9.5	55±9.5	50±9.5	50±9.5	52±9.5σ	51±9.5	50±9.5	50±9.5	40±9.5	50±9.5

Mg	50±12	52±12	53±12	51±12	52±12	50±12	50±12	20±12	25±12	27±12	50±12	39±12	47±12

4.1 variations of physical-chemical parameters

4.3 The correlation between levels of selected physico-chemical parameters.

Statistics show that physicochemical parameters correlate with one another. Iron has a strong relationship with copper and lead. Positive 1 indicates that the physicochemical parameters have a complete positive connection. A value of 0.8 implies that there is moderately strong 0.6 indicates a moderately strong association. There is no association if the value is 0. If the number is -1, there is a negative association; -0.8, a moderately strong negative relationship; and 0.6, there is a moderately strong negative link. The relationship between pH and other physicochemical factors is inverse. There is a rather significant negative link between pH, TDS, and nitrates (-0.906). There is no association between pH and temperature, EC, lead, copper, iron, and manganese. TDS and

		pH	TDS	Nitrates	Temperature	EC	Lead	Copper	Iron	Manganese
pH	Pearson Correlation	1	-.906**	-.781**	-0.226	-0.21	-.386**	-0.13	-.410**	-.382*
TDS	Pearson Correlation	-.906**	1	.853**	0.261	0.223	.524**	0.01	.410**	.554**

Nitrates	Pearson Correlation	-.781**	.853**	1	0.202	0.125	.463**	-0.116	0.255	.566**
Temperature	Pearson Correlation	-0.226	0.261	0.202	1	-0.19	0.227	-0.156	-0.283	-0.164
EC	Pearson Correlation	-0.21	0.223	0.125	-0.19	1	.383*	-0.023	.603**	0.188
Lead	Pearson Correlation	-.386**	.524**	.463**	0.227	.383*	1	0.015	.416**	.413**
Copper	Pearson Correlation	-0.13	0.01	-0.116	-0.156	-0.023	0.015	1	.361*	-0.06
Iron	Pearson Correlation	-.410**	.410**	0.255	-0.283	.603**	.416**	.361*	1	.379*
Manganese	Pearson Correlation	-.382*	.554**	.566**	-0.164	0.188	.413**	-0.06	.379*	1

Table 4.2 showing correlation of selected physicochemical

4.4 Comparison of physico-chemical parameters with WHO guideline

The mean concentrations of pH, Nitrates, EC, Temperature, TDS, Lead, Copper, Iron, and Manganese showed a significant difference (p 0.05) across all sites, respectively (table 4.3). The pH, EC, Cu, Fe, and lead mean concentrations were all within the WHO guidelines threshold, but TDS, nitrates, and manganese exceeded the WHO guidelines threshold (table 4.3).

parameters	Ph	TDS	EC	Temperature	Copper	Iron	Lead	Nitrates	Manganese
Highest value ± std	7.46±0.308	1400±147542	740±97.649	27±13.781	1±0.115	2±0.858	0±0.54	89±89.253	79±11.788
WHO guidelines	6-8.5	≤600	≤400	35-40	≤5.0	≤0.3	≤0.01 mg\l	≤50	≤50

Table 4.3 showing comparison of the mean of water quality parameter to WHO guidelines

CHAPTER 5

DISCUSSION

5.1 The concentration of leachate in the dumpsite

The variation of physio-chemical analyses of the leachate samples is presented in fig 4.1. It clearly shows that the iron ranges from 2.104 mgl to 2.23 mgl. Nitrate concentrations ranged from 66mgl to 85mgl, lead concentrations from 0.051mg/l to 0.0639mgl, copper concentrations from 0.0201mg/l to 0.0472mg/l, iron concentrations from 2.1041mg/l to 3.8877mg/l, and manganese concentrations from 70mg/l to 79mgl (Fig 4.1. Hence, it is able????? to be concluded that the leachates from the dumpsite are liable for the acidic degree of the pattern wells. This is corroborated by a study conducted on ground water, which revealed a similar pattern. According to Adedu, Ada and Gbenga et al. (2011), It has also been supported by Mcbean (1995) that alkaline pH supports the growth of methanogens, which convert much of the organic contaminants in leachate to gas.

The variation of TDS was high on site 1 with 1388 ppm and lower on site 4 with 1161 ppm (Fig 4.3). The temperature ranges from 22.2 oC to 15 oC, as shown in fig 4.4. EC was high on site 5 with 725s and lower on site 1 with 425s (Fig 4.5). This indicates that leachate over time can be a threat over a long time can be a threat to ground water quality.

This has been supported by a few researchers. For example, Adeolu et al. (2011 illustrated that the presence of heavy metals in the leachate is related to the type of the soil. The author additionally explains that high EC and TDS move leachate into ground water. The author additionally demonstrated that leachate delivered by disintegrating waste permeates into the soil and pollutes ground water and nearby streams. Adeniyi (1986) figured out that the presence of natural matter substances might impact low pH estimation. With respect to the rate of consumption, for example, it might straightforwardly affect human wellbeing. As indicated by Cox (1995), the presence of marginally corrosive is because of the filtering of natural acids from rotting vegetables.

5.2 The variation of selected physico-chemical water quality parameters in wells in Bindura

The distribution of TDS, EC, Nitrates, pH, Temperature, Lead, Copper, Iron, and Manganese showed a significant difference (p 0.05) across all sites, respectively (table 4.1). Variation of the concentrations of TDS, EC, Nitrates, pH, Temperature, Lead, Copper, Iron, and Manganese showed a significant difference (p 0.05) across all sites, respectively (table 4.1). Samples 25, 26, 27, 28, 29, and 30 were control wells. The pH values were lower in samples 28 and higher in samples 29. EC concentrations were higher in wells 1 and 2 and the lowest in sample 24 (table 4.1). Variations in concentrations of temperature were highest at well 15 and lowest at well 3 in table 4.1. The total dissolved solid concentration in surface water was higher than normal. This may be due to the leaching of various pollutants into water. The concentration of manganese and nitrates was also higher in the unprotected well water samples. The pH ranges from 6 to 7.46 across all the sites (Table 4.1). The variation of TDS varies from 135 ppm to 191 ppm (Table 4.1). EC varies from 270 S to 740 S (Table 4.1).

All manganese and nitrate concentrations in all groundwater tests were excessive (table 4.2) and did not meet WHO drinking water quality guidelines, while greater levels were reported at the Brockdale, Bindura, and functioning dumpsite. The way the values changed from well to well showed no clear pattern. Fe, Cu, and lead, on the other hand, were found to be below the regulatory limit. For some wells, just manganese and nitrates exceeded the regulation limit. Other environmental variables, such as soil type or activity near the wells, might be the cause. If there is a high level of toxic metals in drinking water, it causes long-term diseases. For example, cancer, clotting of blood, skin diseases, stomach ulcers, and death. (Zaryab et al., 2022).

The presence of large quantities of heavy metals in the leachate shows that they came from a landfill's diverse wastes. Corrosion of plumbing materials is one of the most serious consequences of an acidic environment, and this may have implications for water quality in Lagos. The acidic quality of Lagos groundwater is typical of coastal groundwater, whose pH is mostly determined by its hydrogeological environment (Longe et al., 1987).

5.3 Comparison of the obtained results from Brockdale wells, Bindura with WHO water guidelines

All physicochemical parameters (temperature, TDS, manganese, nitrates, pH, lead, copper, iron) had significantly different concentrations across all locations. The pH concentration was within the WHO drinking water standards. Analysis of physical properties of sampled well water in table 4.3 shows that in all sample locations they are found to be within the WHO standard. The temperature ranged between 11 and 26.7 degrees Celsius, below the standard limit of 35-40 degrees Celsius, an indication of the presence of bacteria in the water. A hydrooscopic plant was observed growing in the dumpsite. Therefore, TDS, Manganese, and nitrates are above the WHO drinking water standards. It means there is a high probability of causing deadly diseases, for example, kidney failure, heart failure, and death. High nitrates are caused by the dumping of domestic waste that contains fertilizers, causing eutrophication at the same time, causing leachate to seep deep down, affecting wells nearby.

5.4 The correlation between levels of selected physico-chemical pollutants in wells with distances from the dumping site

Some of the parameters were found to have a statistically significant correlation with each other. According to Table 4.2, in the correlation of selected physico-chemical parameters, they are correlating with each other. Iron is significantly correlated with copper and lead. Positive 1 shows that there is a perfect positive relationship between physico-chemical parameters. 0.8 indicates that it is fairly strong. 0.6 indicates a moderately strong relationship. is no relationship. If the value is -1, there is a perfect negative relationship; -0.8, there is a fairly negative relationship; and 0.6, moderately strong negative relationships. pH and other physicochemical parameters have a negative correlation relationship. The correlation between pH and TDS and nitrates is fairly strong and negative (-0.906). There is no correlation between pH and temperature, EC, lead, copper, iron, and manganese. For TDS and other physico-chemical parameters, there is a positive relationship except for pH, which is negative with a value of 0.906. There is a positive relationship with TDS, temperature, EC, lead, iron, and manganese and a negative relationship with pH and copper. temperature, there is no relationship among the parameters. For manganese, copper, iron, and EC, there is a negative relationship. (Table 4.2). Similar research indicates that high TDS concentrations can indicate that these ions came from the same source. (Helena et al., 2000; Silva-Filho et al., 2009) suggest that a high correlation of o.88 between nitrates and lead indicates a strong impact of domestic sewage on groundwater quality. There was a negative correlation between the distance from the dumpsite and the well. It clearly suggests that there is a high risk of ground water contamination if the leachate is left for a long time. This would also affect the health of local people.

The use of synonyms of some words has rendered some of your work meaningless

CHAPTER 6

Conclusion and recommendations

Physico-chemical water quality of Brockdale was affected downslope and the water quality levels were above the recommended WHO threshold for most parameters except lead, pH , copper and iron which was within the WHO threshold. Ground water satisfactory is relying at the type of the pollutant. Water quality of Brockdale wells was generally very higher in the leachate in the dumpsite and the wells which are less than 200m indicated that there were presence of heavy metals, physical parameters analysis were within the threshold of WHO standards. Nitrates and Manganese were high than the threshold of WHO drinking water standard. Based on the results found in the project, Nitrates and Manganese in water and even small amount of lead found in water could impact harmfully to aquatic life, humans and the environment which is indicative that people utilizing the river water are prone to diseases such as miscarriages, low blood content, cancer etc. The Bindura Municipality Council were recommended source space for dumping, relatively far from the wells.

RECOMMENDATION

- To control groundwater pollution via dumpsite, therefore, there is a need for proper waste management plans, layouts, and strategic control of waste.
- Bindura municipality needs to locate the dumpsite far from the overall populace to avoid infection of the water supply.
- Government agencies, including EMA and Bindura municipality, should participate in more training to reveal contaminant degrees and plan mitigation techniques.
- Bindura municipality should collect the garbage twice a week to avoid the illegal dumping of garbage.
- There is also a need to seek funding to facilitate the drilling of boreholes away from contaminated areas, which is a safe water source.

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