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Proposal for Proper Technology to Purify Mine Wastewater from a Mine Crater.

Area – Mashaba, Zimbabwe

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Declaration

I, Nemiah Magazine, do hereby declare that this thesis – entitled Proposal of Proper Technology to Purify Mine Wastewater from a Mine Crater in Mashaba, Zimbabwe – is the Author's (2020) work (all other source and supporting material was duly otherwise acknowledged or referenced).

In Prague ______________

Nemiah Magazine

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Abstract

The aim of the study was to propose an efficient water purification technology to reduce water pollution load taking into consideration local conditions and World Health Organization standards. The specific objectives were to identify the main pollutants and evaluate their impacts to the environment and community. Data on pollution levels was collected from abandoned asbestos and gold mines. A total of 53 water samples, 15 samples for tap water and 32 secondary data from local authorities were collected from the study area. To make comparisons on current available water sources, we collected fifteen drinking water samples from residential areas in the Mashaba mining area. Results of the study indicated that the level of mercury (Hg) and Copper (Cu) were within the limits which are set out by WHO guideline for drinking water, except for iron (Fe), arsenic (As), zinc (Zn) and Manganese (Mn). Furthermore, results from the abandoned gold and asbestos dumps indicated that Mn and Fe were higher in asbestos as compared to gold mines. Cu levels were significantly lower in both asbestos and gold abandoned mines in the study area. Economically low cost and easy to use are the key factors which made us choose the best suited water purification technologies for Mashaba community. Therefore, in this study we proposed the adoption of the SORAS, ionization and reverse osmosis technologies. Furthermore, our findings show that any of the above stated technologies can be used in mitigation of hazards arising from wastewater from mining activities.

Keywords: Zimbabwe, wastewater, technologies, purification and pollution.

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Abbreviations

As	Arsenic
°C	Degrees Celsius
DG	Dissolved gas
EMA	Environmental Management Agency
Fe	Iron
GDP	Gross Domestic Product
GMB	Grain Marketing Board
g/cm^3	Mass in grams divided by volume in cubic centimetres
km^2	Square Kilometre
km	Kilometre
mg/kg	Milligram of Medication Per Kilogram
mg/m^3	Milligrams Per Cubic Meter
mg/l	Milligrams Per Litre
MFL	Million Fibres per Litre
NGOs	Non-Governmental Organisation
RBZ	Reserve Bank of Zimbabwe

RO	Reverse Osmosis
RPAZ	Radiation Protection Authority of Zimbabwe
SAZ	Standards Association of Zimbabwe
SDGs	Sustainable Development Goals
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
UN	United Nations
µg	Micrograms
$\mu g/m^3$	Micrograms (One-Millionth of A Gram) Per Cubic Meter
µg/l	Micrograms Per Litre
$	United States Dollar
Ωm	Omega Meter
K	Kelvin
WHO	World Health Organisation
ZINWA	Zimbabwe National Water Authority

1 INTRODUCTION AND LITERATURE REVIEW

There are currently no proper or competitively priced purification methods for developing countries. The waterborne bacterium causes the spread of diseases and death in many poor communities. Water which is to be used in agriculture must be purified to extend the cleanliness and accurately operate various agricultural technology that would help avoid infection by numerous pollutants to yield or plants (Alley 2007). A mechanical device for irrigation that uses nozzles must get admission to secure sublimate water that encompasses purification of iron and carbon materials, algae, rust and lots of different water infection problems. This water and sanitation state of affairs in African countries faces several challenges around capability, behaviours and the lack of investment in those sectors throughout and with the despair of the remaining decade (Muleya et al. 2019).

Access to easily purified water can be a basic right that is necessary for the survival of humanity. However, it remains the biggest issue to be addressed by many of the developing countries (Baker 2006). Water scarcity brought about by climate change and population increase creates unbalance between delivery and demand. The reuse of wastewater must be an absolute necessity in water erratic regions. Thus, management and reuse of wastewater has come to be a primary concern for agriculture and enterprises which consume lower volumes of water (Ertas & Ponce 2005). For example, water is a primary and indispensable useful resource in all mining projects. It may also be used in all production levels; within the cooling of certain equipment, waste separation of precious minerals, reduce dirty (Crump et al. 1998). However, large volumes of water produced present a great deal of environmental risks. This is mainly because of leachate and sludge produced.

The quality of the mine water varies in significantly from mine to mine and it also depends on the several conditions in nearby areas. Water bodies are considered to have most of all pollution with more than 90% of contaminants found in suspended particles and bottom sediments (Kanda et al .2017). The prevailing poor state of the Zimbabwe economy has made provision of general services (in particular safe drinking water) to the population by local authorities difficult (Muleya et al. 2019).

The 2013 National Water Policy recognises that the quality and condition of Zimbabwe's surface and groundwater resources are deteriorating, calling the need to give a sustainable look on water management and reuse (Murwira et al. 2014). The deterioration in the quality of water resources is due to multi-sectoral factors that include discharge of untreated or partially treated wastewater from cities, towns and industries. This could just be the tip of an iceberg, as it is also known that blue-green algal bloom in lakes is toxic and can pose a substantial health risk for communities accessing affected water for drinking, irrigation and recreation. Specifically, toxins can destroy cells in the liver and other internal organs and may act on the nervous system leading to respiratory failure. Other health impacts of algal blooms can include gastric upsets, fever, headaches, skin irritations, and numbness and paralysis of the arms and legs. Human deaths have been associated with blue-green algal blooms, and deaths of livestock and wildlife are common.

The use of toxic substances to extract minerals such as gold is slowly poisoning our waters with toxins that do not degrade easily and these are cyanide and mercury, and further prolonged exposure to such toxins can result in serious health problems to both aquatic and various biodiversity in vulnerable communities (Bakir et al. 1973). Human health risks include the carcinogenicity of arsenic, cadmium toxicity to the kidneys and the destruction of the central nervous system by lead (Bernard et al. 2001; Gilbertson & Carpenter 2004). Although mining activities in Zimbabwe are now subject to EMA effluent discharge regulations, many thousands of historic mining waste dumps and tailings dams are generating acid mine drainage and releasing toxic heavy metal enriched acid water to the environment.

In Zimbabwe, there are completely different sets of sectors which target the water challenges are faced by the country. There are vital variations in assessments of coverage and investment demand within the water sector, thus an enormous gap has left the agricultural sector liable to water shortages. The WHO / UN agency Joint program (JMP) in Zimbabwe figures give an optimistic situation for future sector development which might help in attempting to assist the world (FAO 2012). In 2008, the JMP cancelled the supply of safe water for 82% in the Republic of Zimbabwe and improved sanitation for 68%. This estimate is beyond national coverage estimates and a 69% not up to national targets for SDGs (drawn from the JMP coverage estimates). Thus, this study seeks to review and evaluate the contamination of water by the mining sector, thus covering the agricultural water in Mashaba mine, a small mining community in Zimbabwe that suffers from erratic water problems to the drinking of contaminated water.

1.1 Geology and Hydrogeology of the Study Area

Figure 1: Hydrogeology Map of Zimbabwe

Source: Zimbabwe Ministry of Energy and Water Resources Development (2011)

The geological development plays an important role in the development of the modern scenery of Zimbabwe. The topography is made up of intruding resistant and soft rocks which shape the natural landscape. A continuous cycle of erosion has led to the development of various unique topography which shapes and forms various soil structures found within the country. The resurrected fossil structures mingle with the resistant rocks to form magnificent plateaus. In figure 2 below you can see the overall country various years of a geological cycle which shape the current landscape. The magnificent country has plenty of various hydrological faults and exposure of various granite and sedimentary rocks which cut across the country, with the most area being Mutare with high hills and highest peak. For Mashaba we see artificial hills a product of mine residuals and excessive eroded rivers which link with the Mushandike and Chibi area. The area depends mostly on stored water like dams and underground water which in competition with local mines , hence this leading to the need to research on the water use and management of the area.

1.1.1 Hydrological structure of Zimbabwe

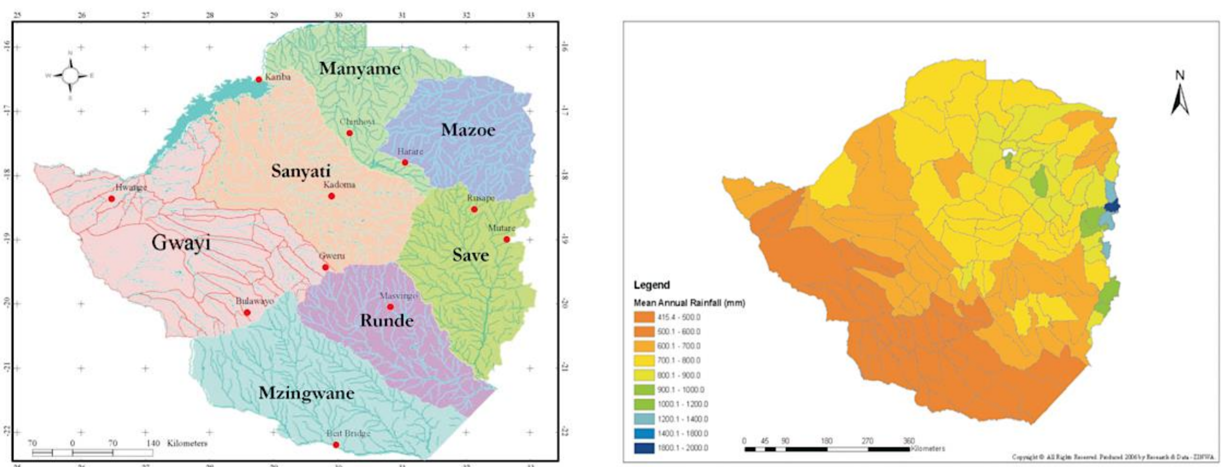


Figure 2: Shows the hydrological structure of Zimbabwe for all provinces

Source: Data and Research Department, ZINWA (2012)

The present geomorphological structure of Zimbabwe is shaped by various factors, continuous erosion cycles, weathering, climatic conditions and various rivers and basins. With six various drainage patterns across the country, A, B, C, D, E and F these shows various basins and rivers across the country. The country consists of seasonal rainfall, this includes both dry and rainy season with a winter period which can last up to 4 months between May-August and the rainy season from October to March, however, these seasons have been changing due to the fact of climate change. The peak annual rainfall has shifted from December to March, where you see most rivers flooding and the advent of cyclones which are posing natural disasters, for example, the recent cyclone IDAI which destroyed the eastern part of the country, affecting both the natural landscape and human lives. Drought is experienced in various year ranges, with the most popular one being of 1992 and affecting various ecosystems which include both animal and the natural biodiversity. With the advent of black empowerment and communal based mining activities, Zimbabwe drainage system has been affected mostly in form of illegal mining activities which include alluvial gold mining in the rivers posing various forms of erosion and pollution which are not monitored or controlled by the government, this is common in areas like Mashaba, Zvishavane and Mberengwa.

After the year 2000 after the land resettlement scheme, Zimbabwe has also suffered from the stream bank cultivation practises which affect the hydrological cycle of the country and lead to siltation of the rivers, thus changing the filtration and underground water storage cycles. Most agricultural activities within the country mostly rely on the stored water from dams and the one underground, this also shows that Zimbabwe hydrological cycle also uses natural aquifers to supplement surface water which may be affected by erratic rainfall patterns.

The eastern highlands which is the northern part of the country which has an annual rainfall of 800 to 850 mm around the year, allows the area to recharge most of the hydrological areas of Zimbabwe. To sustain water shortages which are caused by various droughts within the country, Zimbabwe has constructed several dams, and for Mashaba area the nearest being the Kyle dam which is 40km from the area and also feed the local area with drinking water and some various

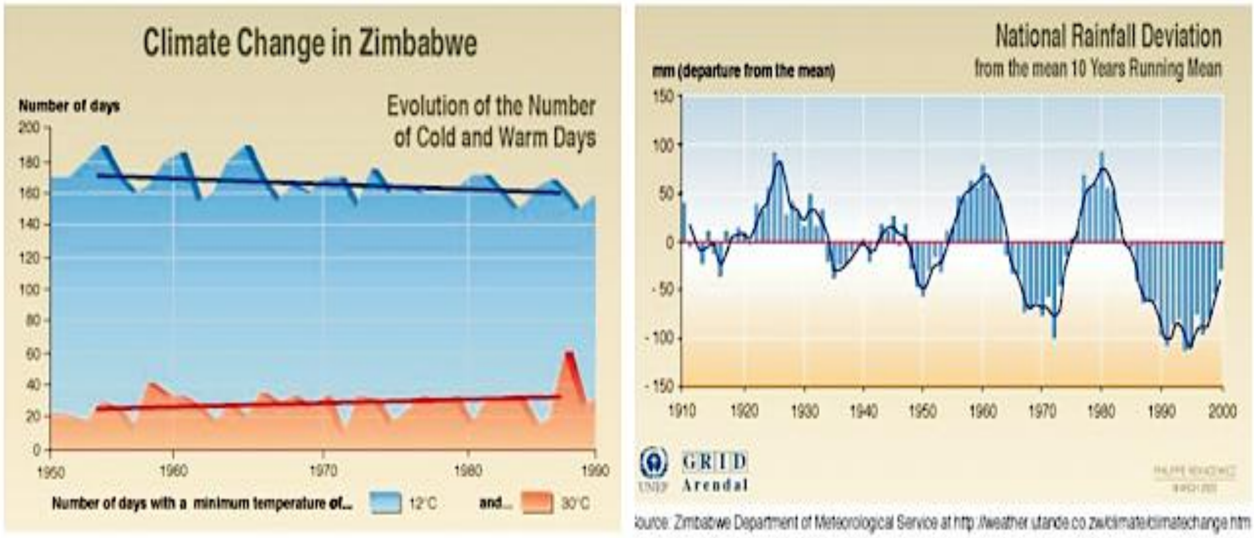


Figure 3: Warm and cold days and precipitation deviation in Zimbabwe

Source: Zimbabwe Department Meteorological Services

Table 1: Showing Runoff and Storage Potential in Zimbabwean Catchments.

Catchment	MAR	Potential Storage (2XMAR)	Potential Yield 10%	Present Commitment	Use
	$x10^6$Ml	$x10^6$Ml	Strorage (x106Ml	10% Yield (Ml)	%
Gwayi	1.8	3.7	0.9	0.2	11.2
Manyame	3.3	6.6	2.0	2.6	46.6
Mazowe	4.6	9.2	2.8	0.3	17.6
Mzingwane	1.8	3.4	1.2	1.3	27.1
Runde	2.1	4.3	1.2	2.5	41.0
Sanyati	3.9	7.8	2.1	0.6	20.5
Save	6.1	12.2	4.4	1.2	18.3
Total	23.7	47.2	14.5	8.7	24.6

Source: World Bank 2012

boreholes found within the area. To control water and improve management the government of Zimbabwe has formulated a water body agency called the Zimbabwe National Water Authority which acts as the natural water custodians, hence allowing monitoring and water distribution management for the whole country. This is particularly effective in the southeast of Zimbabwe where water from the Lesapi Dam is fed into the Save catchment, thus maintaining controlled flow during the dry season for the irrigation projects south of Birchenough Bridge. Lake Kyle, Lake McDougall and Bangala Dam all provide water for the intensive agriculture in the Triangle-Chiredzi-Nandi area.

The Mashaba schist belt produces far more diverse terrain than its surrounds, although remaining wholly within the Post-African erosion cycle, with a possible Pre-Karoo ancestry. South and east of Mashaba, trending towards Mushandike Dam, Bulawayan banded ironstones with minor amounts of Sebakwian rocks form ridges up to 300 metres high, e.g. Koodoo Kop (1338 metres) south of Mashaba. Within these ridges, banded ironstone and quartzite from the caps or cores and are flanked by softer sediments, chlorite schist and greenstones (Wilson, 1968). Also, Mashaba water system is fed by the Mushandike catchment area which focuses mostly on agriculture and wildlife management.

Three kilometres south of King Mine, several low, rounded hills are composed of well-cleaved phyllites and chloritic schist. North of Téméraire Mine, brown serpentinites from the Mashaba Igneous Complex build a curving ridge with steep gradients, culminating in Nyamunda (1385 metres). The north-western arm of the complex forms the conspicuous line of hills from the most distant peak at Shamba (1340 metres) through Bungwe (1251 metres), Dowa (1200 metres) and Mushwe (1272 metres). The summit of Mushwe and the ridges of its flanks are formed from wide quartz veins. Along this ridge, an 80-metre-wide zone of poikilitic harzburgite is associated with the dominant dunite and peridotite (Wilson, 1968). Through the eastern arm of the Mashaba Igneous Complex, the same rock-types form the range of hills along the northern margin of the Masvingo schist belt, whereas along with the northern offshoot they provide no relief and are topographically similar to the surrounding granite at about 1070 metres above sea-level. Hence this shows the presence of mineral within the area, and Agri potential due to the red clay soils.

1.2 Importance of mining

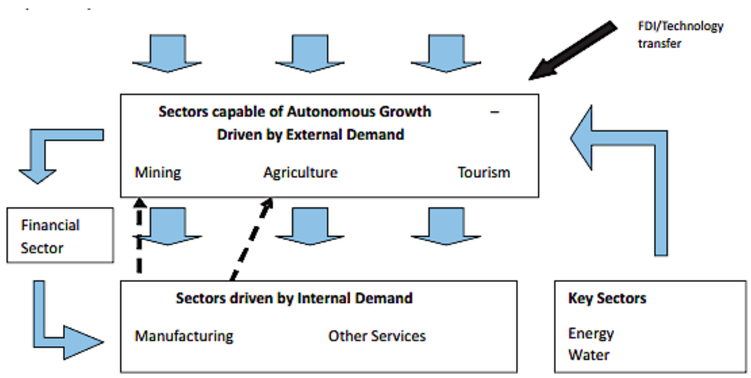


Figure 4: Linkages in the post-crisis Zimbabwean Economy

Source: World Bank (2012b)

Mining in Zimbabwe often takes place in agriculturally productive areas of transboundary river systems. This gives rise to conflicts between farmers and miners, which need to dispose of large volumes of waste and wastewater on the one hand,not meeting the water quality needs of the environment, agriculture and other water users (Ravengai et al. 2005a). The mining sector has positive and negative effects on a countries economy. Mining brings services, administration and government revenues, responsibilities and opportunities for economic process, value effective and financially viable growth, and diversification. However, market fluctuations and resource revenues bring challenges in changing natural resources wealth into properly economic process and development. This has seen most of the mining degraded just like the case of the Mashaba leading to water strain and environmental pollution .Whilst idle mining results humper local resources, water and soil suffer the major consequences.

1.2.1 Causes of water pollution due to mining.

- Cross-contamination of unpolluted water with discharged minerals throughout use.
- Discharge of waste material due to improvement of minerals.
- Underground water gets impure principally as a result of activity and percolation.
- Mine sludge or excreted scrap might block natural water flows or causes siltation of rivers.
- Oil from machines may additionally cause pollution thereby contaminating the water.

1.2.2 Characteristics of wastewater

Classification of wastewater at a mine site can be grouped to the following;

- Ground water
- Process wastewater
- Domestic wastewater
- Surface run-off

The most probable contaminants within the wastewater are made by a typical mining business may be generally classified into 5 classes. Out of those 5 classes, biological pollutants primarily from domestic and sanitation facilities among the agreeableness building and typically they must be connected to an urban sewer or a properly designed waste disposal system, imaging pollutants are specific to metallic element and connected open-cut mines (Cairncross 2004). Necessary to understand that "effective hindrance of contamination at sources" is that the sole resolution offered for managing radioactive material water. Before the closing of Mashaba mine, water that was in the open pit at varied locations had crystal rectifier to associate environmental risk, as people, placental and therefore the natural flora and fauna may be exposed to impure water, therefore, motion health risk and environmental hazard.

1.2.3 Physio-Chemical Properties of Polluted Water:

1. pH – pH is a numeric scale accustomed to specifying the concentration of hydroxyl ions of water.
2. Colour -the colour of the wastewater generally depends upon the matter dissolved.
3. TDS – Total Dissolved Solid is a combination of all inorganic and organic substances contained during a liquid in molecular, ionizing or micro-granular.
4. TSS – Total Suspended Solid is a water quality parameter used to show access to the standard of wastewater once treatment in the wastewater treatment plant.
5. BOD – Biological Oxygen Demand is a quantity of oxygen required by microorganisms to cause biodegradation of organic and inorganic pollutants.
6. DG – Dissolved gas analysis measures the quantity of oxygen vapour dissolved in a solution.

7. COD – The amount of oxygen required for oxidizing inorganic pollutants by chemical reaction and is thought as Chemical Oxygen Demand (COD).

1.3 Country Profile Analysis

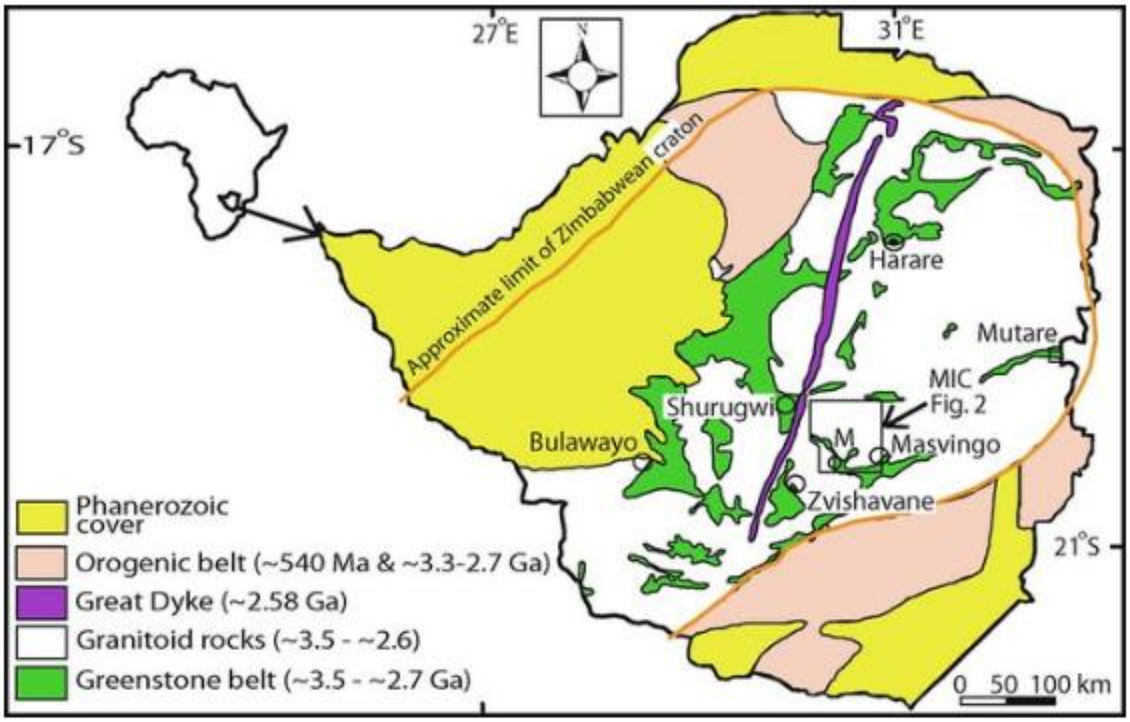


Figure 5: Map of Zimbabwe

Source – Exploring Africa (2020)

The name Zimbabwe comes from the Shona phrase, *dzimba dzemabwe*, means homes of stone or stone buildings that are symbolized by the Zimbabwe ruins close to the city of Masvingo. Zimbabwe is inland and located in Southern Africa with an area of 390,757 square kilometres. The country is divided into ten provinces and sixty-two districts. The capital town is Harare and has some major cities such as Bulawayo, Gweru, Kadoma, Kwekwe, Masvingo and Mutare. According to the ZIMSTAT (2012) census, the population of Zimbabwe is estimated to be 13.061 million with 52% being female. Two-thirds of the population is below the age of 25 and the dominant ethnic groups are Shona and Ndebele. The situation of access to drinking water in Zimbabwe is still far from reaching world standards, mostly the rural areas are left to suffer for themselves as the coverage to provide safe drinking water has never been a priority for the rural areas as the government is failing to provide safe amounts of drinking water to the urban population, this is due to the poor economic condition of the country, suffering from bad politics, high corruption levels ,and lack of private partnership programs focusing on the rural areas. Programs like WASH have taken the move to sponsor drilling of boreholes in the rural areas to improve safe water access, small scale resettled farmers because of less capital, they resort to wells which are considered not that safe to provide water for their families and communities. This shows a marginalised approach by the Zimbabwean government in addressing drinking water which is safe for their citizens.

1.3.1 Economy

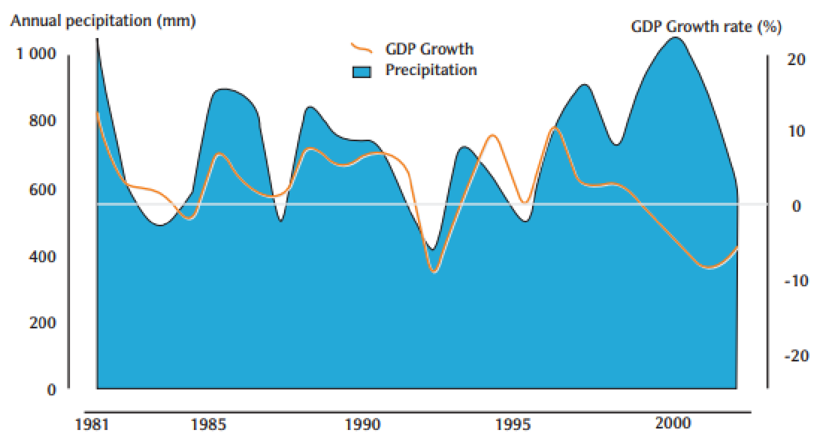


Figure 6: Relationship between annual precipitation and GDP

Source: Zimbabwe Government (2012)

Table 2: Key Statistics for Zimbabwe

Key Statistics for Zimbabwe	
Real GDP growth (2018)	4.5%
GNI per capita, Atlas method (current US$) (2018)	$820
Population, total (2018)	13,061,239
Population by sex (2018)	Females - 6,780,700 (51.9%) Males - 6,280,539 (48.1%)
Poverty headcount ratio at the national poverty line (% of population) (2018)	72.3%
Life expectancy at birth, total (years) (2012)	58
Literacy rate, adult total (% of people ages 15 and above) (2013)	91.3%
External debt US$ (2013)	$8.934 Billion

Source: ZimStats (2012)

Zimbabwe's economy has faced severe challenges over the past decade, reaching a peak crisis in 2007 and 2008. The Gross Domestic Product (GDP) is stated to have dropped by 53% and official inflation peaked at 231 million per cent in 2008; capability activity in business fell below 10% in 2009. During the same period, the economic condition remained widespread; infrastructure deteriorated; the economy became in formalized, and there were severe food and foreign currency shortages. The country conjointly faced sanctions from some western countries and therefore the halt of funding from the Bretton Woods establishments. The adoption of the multi-currency system brought about the stabilization and turnaround of the economy in 2009.

The multi-currency period saw the removal of surrender needs on export yield, removal of exchange restrictions, the top of Grain Marketing Board (GMB) monopoly, imposition of budget constraints on parastatals, and therefore the reform of monetary and monetary policy frameworks and establishments like the Reserve Bank of Zimbabwe (RBZ). Going to 2018, the economy was in shortfall, depending mostly from imports and foreign aid. This has impacted various economic sectors due to poor political system and government incompetence.

For Zimbabwe, the investment gap to satisfy the national targets is US$365 million annually for water and US$336 million for sanitation. There is a need for more investment in rehabilitating the available infrastructure especially urban areas and the neglected rural water systems. The major challenge in the Zimbabwean situation is that there is low and rampant inflation and corruption affects the country water woes so failing to deal with the long-standing demand of freshwater and management (Zinyama & Nhema 2016). Overall a funding strategy has to be developed that takes under consideration Zimbabwe's current business resource base and learns the teachings from the decline within the sector, water shortages additionally emanates from unhealthy management, focusing and lack of property about to mention simply some (Madhekeni & Zhou 2017). Within the short term, there is needed to repair and rehabilitate crucial existing infrastructure in rural to ensure the short term sectors become healthy, and generate revenues to meet local and international standards (Scoones et al. 2019).

There are completely different sets of targets for the water sector in Zimbabwe. The calculable coverage and investment need additionally vary significantly to location and priority based on government capabilities and sanitation methods (Glasgow 2000; Mutiro & Lautze 2015). The World Health Organization / United Nations International Children's Emergency Fund Joint program (JMP) optimistic situation for future sector development. In 2008, the JMP cancelled the availability of safe water for 82% in Zimbabwe. This estimate is beyond national coverage estimates, and additionally not up to national targets for SDGs (drawn from the JMP coverage estimates). With the prevailing conditions, it is important to note that the incapacity of this government in addressing the current water issue has left the state in shortages, poor hygiene and people exposed to water-borne diseases with several people's lives lost.

1.3.2 Rural Water Supply Situation in Zimbabwe

- Up to 60% of the population drinks water from open wells and rivers.
- Most rural water lacks assessment and no government program is in place to make sure safe access to drinkable for individuals and animals.
- Rural water scenario lacks responsibility, measures in place to manage natural water like rivers and access to well water shows an enormous gap in natural water management.
- Rethink the policy of maintenance and the development of a regulated, competitive water resources management structure through analysis and community management tools.
- Sector-wide approach growth, beginning with the agricultural sector.
- Confronting the needs of Zimbabweans in relocated and marginal community areas in accessing and managing clean water.

The costs related to making rural water supply are for the most part borne by the government or supporters. The duty for making, managing and holding water resources rests to local authorities, would be a passed through approach.

1.3.3 Maintenance plan for rural areas.

A strategy for rural infrastructure depends on public funding and this could be accepted for rural districts and techniques for getting with little non-public firms. This low maintenance rating thus represents the minimum price recovery. Therefore while not government funding on rural exploitation this has left all contaminated water sources by mining domain to be dangerous places that are liable to cross water bodies contamination and community and placental at risk (Nyamadzawo et al. 2012; Nyirenda 2016). Additionally, this implies a lack of proper management at intervals the mining ministry and therefore the Environmental Management Agency of Zimbabwe is lagging behind on safe water disposal or recycle to change sensible water management and proper utilise (Nyamadzawo et al. 2013).

1.3.4 Strategy for fracking in the mining sector

Rural mining law should be explained. Most mine uses water for fracking and this suggests most of the water utilized in mining gets contact with the mineral itself. This suggests that every time the water from boreholes or mining business should be pure to realize safe drinking levels that profit rural population and agricultural method. This foster proper water management, this can be best attained if the government of Zimbabwe implement a proper guideline procedure, monitoring, assessment and evaluation of current running mine sites.

1.4 Water and Constitution of Zimbabwe

The Water Crisis Section 77 of Zimbabwe's Constitution states that "every person contains a right to safe, clean and potable water and therefore the State should take cheap legislative and different measures, among the bounds of the resources accessible there, to attain the progressive realisation of this right (Hove et al. 2016)." Lack of key water treatment chemicals forced Harare's water treatment plant Morton Jeffrey to halt production on 23 September 2019, affecting over 1 million individuals with no access to safe running water. Harare City Council cited foreign currency shortages because of the reason for the closure. World Health Organisation (WHO) stipulates that ideally all and sundry ought to access between 50-100 litres of water per day to make sure the foremost basic desires are met and therefore the eruption of illness is prevented (WHO 2015). This conjointly shows the importance of water purification for the rural sector because it has been created a constitutional mandate for people to have access to clean safe water, but this has not been a case with rural water that see neglected zones while not a transparent platform to manage water provides for primary agriculture and therefore the rural population (Moyo et al. 2017).

Sustainable development goal six, urges duty bearers to make sure availableness and property management of water and sanitation for all. Within the current situation, this goal remains a phantasy unless there are additional commitment and political will on the part of the local and central government. Even at the continental level, Africa is servery affected by water deficits most people face on the continent and therefore the N'gor Declaration by Africa has hinged on lightness the importance of accessibility of fresh and cheap water (Lindoso et al. 2018). Some residents have resorted to drilling boreholes to access clean water, but these boreholes need electricity to pump water, one thing that may be a challenge considering the constant power cuts lasting up to eighteen hours daily. Hence showing the incapacity of local authorities to implement proper water management and revenue channels to distribute safe water to marginal communities.

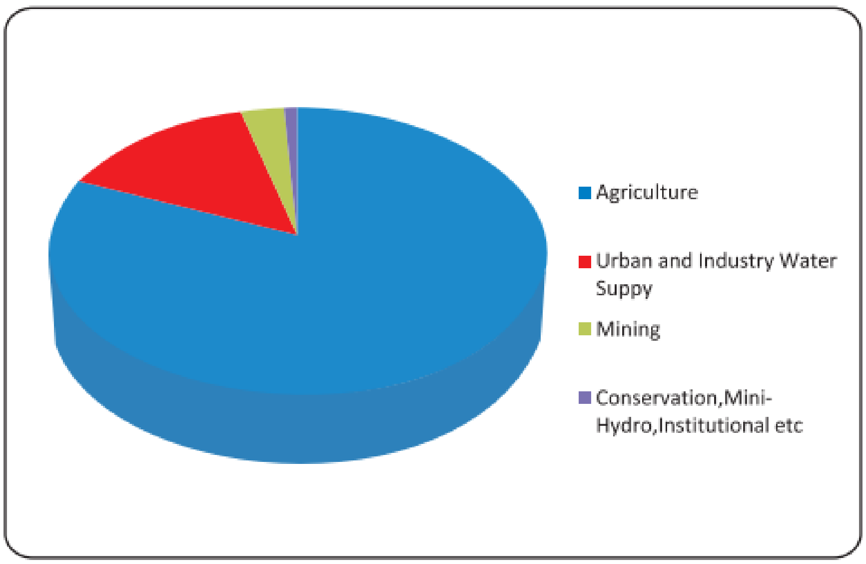


Figure 7: Sectoral water use in Zimbabwe, excluding primary uses, power generation and environmental uses.

Source: ZINWA (2009)

Generally, several local authorities throughout the country cannot pump running water to residents because of power cuts. Those with water tanks on their properties place confidence in people or in-camera closely held water corporations to pump water into the tanks at an extended value typically pegged in USD leading to vulnerability of the poor. Residents are principally enthusiastic about town or donor-drilled boreholes. These water sources are typically unclean because of poor sanitation thus this caused additional analysis required within the water scenario in Zimbabwe to present water issues for each primary urban areas and secondary rural population.

The potency of solid-liquid ripping plants is directly related to auxiliary chemicals for particle aggregation. For the utilization of agricultural material, solid-liquid separations are formed tougher attributable to the lamellar nature of a big variety of existing salt minerals, making natural process necessities. That ensures that the pulp or traces of clay minerals are problematic. Nyamangara et al. (2011) note that the expansion within the mass of fleece polymers decreases the floccule density attributable to the modification in the amount of water that's contained in the floc structure that transports to future pollution of surrounding soils and also the agricultural turn out of the encircling areas.

Figure 8: Progress in water supply and sanitation coverage

Source: JMP Report (2010)

In a study done in France at a coal open solid mine, water purification was done to change safe disposal of mine wastewater into the setting to get rid of iron and metallic element from the mine wastewater (UNESCO 2012). The mine water pumped-up out of the reservoir was characterized by high concentrations of dissolved iron and metallic element activity out from iron pyrites. Iron and metallic elements are soluble and precipitate when aerated, vaporization the water with generally orange-coloured particles of iron hydroxide. The treatment plant reduces these iron and manganese concentrations to the allowable statutory levels (1 mg/l for manganese and 2 mg/l for iron). The treatment method at Vouters is noted as "passive" since the oxidized particles settle naturally because the water moves through the various stages.

The mine water is first channelled down a series of 4 aeration cascades, which permit for flexibility within the operations. Studies by the post-mining unit have made innovations during this space and this conjointly show the move in attempting to eradicate significant metal pollution that is found in mine wastewater (NIEHS 2014), that is in line with this study which intends to foster proper water use and disposal through purification.

Besides, disposal of mine polluted water for operational and safety functions poses a big risk of pollution to surface waters if not responsibly handled, nonetheless this water will be treated to absolutely redress the positioning water balance (Rasethe et al. 2013). Analysis done by Pall will facilitate with innovative, property filtration solutions that permit mines to satisfy discharge necessities, treat water for utilising (e.g. as method water or to manage shortages in arid areas), facilitate mines improve their water use index and lessen enthusiastic about external water provides. This goes on to point out that for this paper it will conjointly consider proposing the pall approach in mitigating the pollution of water for property utilise and increase environmental safety (Columbia 1998).

A tremendous quantity of water is employed in mining operations and it's not uncommon for a gold mine to use over one million U.S. gallons (157 m^3/hr) of incoming water daily for make-up water and operations, probably inserting extended stress on the atmosphere (upon discharge) and encompassing communities. For this reason, it's straight forward to visualize however the world mining water market pay exceeds 1 billion annually and a lot of this is often being driven by dynamical mine water standards. Mine water standards have become a lot of tight with bigger social control. New standards have set individual constituents, have outlined most daily masses, and are accenting human health/aquatic life (Kanda et al. 2017). This has seen an outsized gap between a lot of financial gain countries and fewer incoming countries, policy to properly manage mine wastewater, in Zimbabwe continues to be preliminary in such some way that the mining business doesn't invest a lot of cash in land reclamation and wastewater purification to change safe discharge and use, creating a huge environmental impact to the surrounding communities , thus exposing the community to unsafe water and distorted terrains.

The developments in the Ministry of Water Resources Development and Management has currently assumed leadership for the area, rejuvenating and lengthening the mandate of the coordinating body, the National Action Committee. However, some institutional roles still want additional clarification on who leads and owns what sector parts and the way resources ought to be channelled. Zimbabwe’s leads to the CSO2 record, that assesses the pathway by which cash is changed into water and sanitation services, reflects the acute challenges that the arena currently faces, particularly in designing, budgeting, equity, monitoring, output, maintenance, and market development. While this paper focus isn't targeted on the management of water situation in Zimbabwe, seeks to additionally suggest the water management on the small sector, for this case Mashaba. At Independence in 1980, Zimbabwe adopted a well-developed urban sector and a neglected rural sector. The careful JMP sub sectoral figures show restricted progress in potable water provided over the entire amount and a decline in piped supply access. Despite vital efforts to develop rural infrastructure, the imbalance between urban and rural se rvices remains a feature of the condition in Zimbabwe these days, 68% of these while not associate improved potable supply board rural areas and up to 42% of the agricultural population practices open defecation. Hidden behind the coverage statistics, there has additionally been a major decline within the quality of urban and rural services (poorer water quality, intermittent provides, and longer walking distances). Sanitation coverage has stagnated since 1990, with solely a slow reduction in open defecation.

While not a recovery within the water and sanitation sector, Zimbabweans can face additional Asiatic cholera outbreaks, a lot of deaths, illnesses, continued economic condition, and negative impacts on livelihoods, industry, tourism, food production an d agriculture, pollution of rivers and watercourses, this primarily interprets to a lot of hardship, significantly for girls and kids (Booth & Zeller 2005). Thus, finding rural water drawback will improve the lifetime of ladies and kids who are largely hit by water challenges. Thus, treatment of wastewater and usage will persist a furthered manner in finding water challenges for the Mashaba community.

Waste stabilization ponds are common technologies for industrial sewer water treatment due to cheap technologies for mining sewer water treatment with low capital and operative prices (EAWAG 2014). They are standards in locations wherever massive tracts of land are on the market and cheap. Despite the recognition of waste stabilization ponds, restricted studies on the utilization of this technology for the removal of significant metals from mining sewer water had been conducted (EAWAG 2014). The few studies conducted on waste stabilization ponds have shown a poor performance within the removal of metals, thanks to this limitation of scanty literature availableness, larger attention is paid to the utilization of constructed wetlands for mining sewer water treatment. Thus, this study seeks to propose technologies to clean mine wastewater. This entails dealing with existing strategies and mixing them with the ones on the market.

According to JMP figures, the rural water and sanitation sector has stagnated since 1990, with piped water access declining. The government's estimates replicate the breakdown public sector finance and loss of capability for repairs, maintenance, and spares. Several rural boreholes and wells the mainstay of the agricultural water infrastructure are not functioning. The JMP reports that 98% of these while not associate improved potable supply are in rural areas. Thus, the requirement to form certain the agricultural population, particularly those that are liable to access contaminated water from mining activities get safe access to correct clean and sublimate water to extend the living standards of poor communities.

Table 3: Coverage and investment figures

	Coverage		**Target**	**Population requiring access**	**CAPEX requirements**		**Anticipated public CAPEX**			**Assumed HH CAPEX**	**Total Deficit**
	1990 %	2008 %	2015 %	000/year	Total	Public	Domestic US$ million/year	External	Total		
Rural Water supply	**70**	**40**	**100**	**757**	**174**	**157**	**6**	**33**	**39**	**4**	**131**
Urban Water Supply	97	60	100	374	369	148	20	34	54	81	234
Water Supply Authority	**78**	**46**	**100**	**1131**	**544**	**305**	**26**	**67**	**93**	**85**	**365**
Rural Sanitation	**35**	**25**	**80**	**686**	**90**	**45**	**2**	**12**	**14**	**14**	**62**
Urban Sanitation	99	40	100	483	325	227	11	25	36	15	273
Sanitation Total	**54**	**30**	**85**	**1124**	**415**	**272**	**13**	**50**	**50**	**29**	**336**

Source: JMP 2010 Report

The on above of table from CSO2 cost accounting shows the gap and increase decline between a rural and urban facility that may be a major concern why this paper have preferred to look on the water state in Zimbabwe and take a look at Mashaba mine wastewater as an are of my analysis. The graph and the table show a huge gap which the government has failed to address in meeting their goals over a period of years. The decline is increasing by year posing a huge gap for Zimbabwe to reach a stage of safe access to safe drinking water and sanitation standards, hence proper research and data analysis of marginalised areas takes us to a step close to addressing these challenges.

1.5 Heavy metals pollution and emission.

For the aim of this analysis, the paper looks at gold and amphibole mining serious metal elements because of the very fact that concerning the study, the mining space specialised on amphibole happens as asbestos. It is found in ultramafic complexes, for example, Mashaba Igneous rocks, in huge serpentinites and slip fibre zones during which shears are stuffed with matted fibres within the great dyke e.g. Ethel mine. There are sixty deposits scattered within the Masvingo, Insiza, Gwanda, Mberengwa, and Shurugwi, that are worked on for asbestos. The areas even have each formal and informal current and dominant mining areas that conjointly mine gold as they are the foremost common minerals found in these areas running as the second most activity other than agriculture.

Moreover, in an in-depth study in laboratory species, amphibole has not systematically hyperbolic the incidence of tumours of the digestive tract. There is no consistent proof that eaten amphibole is dangerous to health and thus it had been ended that there was no ought to establish a health-based guideline process for asbestos in drinking water.

Heavy metals are a category of pollutants which may cause environmental pollution of surface water bodies. These metals may be leached into the surface water or well water, drawn up by plants and may bond semi for good with soil elements like clay or organic matter, which later affect human health. Once serious metals enter into a water body, they will damage aquatic organisms, through the processes of chemical sorption and physical precipitation, serious metals will accumulate within the sediments of the water surroundings (Muleya et al. 2019). Serious metal contents of the surface sediments are typically considerably higher compared with those within the water body, thus it's vital to explore the serious metal contents within the surface sediments. Several countries still have amphibole cement water pipes, there seems to be no concern for the health of shoppers receiving the water and no programmes to specifically replace amphibole cement pipe.

Water is extremely vital natural resources, widely used throughout the planet for domestic, industrial or agricultural functions and moving into the atmosphere in numerous sources. However, the matter of water quality is additionally severe within the areas wherever mining and mineral processes' industries are carried out. This is so particularly in mining mistreatment open solid in erratic water region, this result in the competition between local communities and therefore the company for underground water and water in local rivers also in processes, many categories of wastes are made which can cause numerous forms of pollution then ultimately contamination happens. So, it is of importance to contact tests for underground water in each developing country like Bangladesh wherever 95% of the transportable facility comes from groundwater each in rural and urban areas and 70% of irrigation water additionally comes from groundwater sources. This goes like Zimbabwe water situation, where most of the agriculture and urban cities has now resort in accessing groundwater for drinking as the local municipalities are incapable to provide sufficient water for everyday sustenance.

Impact of mining on aquatic ecosystems became a problem of growing concern and mining by its nature consumes, diverts, and seriously pollutes water resources (Grandjean et al. 1992). Mining and edge operations, besides grinding, concentrating ores, and disposal of tailings, are sources of contamination within the surface atmosphere, at the side of discharge or overflow of waste matter, runoff from downfall or snow soften, evacuation from the highest of waste piles, and discharge of in groundwater to streams (Hylander & Goodsite 2006). Pollution issues caused by mining embrace acid mine evacuation, metal contamination, and multiplied sediment levels in streams (Horvat et al. 2003).

The generation of acidic evacuation and also the unharness of water containing high concentrations of dissolved metals from mine wastes (Kjellstrom et al. 1986; Jorgensen et al. 2004). The chemical activity of metals happens once precipitation from downfall or snowmelt infiltrates through ore or waste materials and dissolves or desorbs metals from the solid material. As a consequence, streams transport high contents of unhealthful trace components appreciate As, Cd, Pb, Zn, Cu, Sb and Se. Serious metals are a vital category of pollutants which may manufacture extended hurt to the atmosphere after they are higher than sure concentrations (Kjellstrom et al. 1989).

These components are leached into the surface water or groundwater, damaging plants, and may bond semi for good with soil elements appreciate clay or organic matter, that later affect human health (Lemly 2002). Once serious metals enter a water body, they will destroy aquatic organisms through the processes of chemical absorption and physical precipitation, serious metals will accumulate within the sediments. Serious metal contents of the surface sediments are typically considerably higher compared with those within the water body, therefore it is important to explore the serious metal contents within the surface sediments (Lemly 2003).

Heavy metals like arsenic and chemical element compounds are exceptionally unhealthful and harmful to human health as they are found in effluents and leaches from industries, tableware and ceramic industries dye, chemical and fertiliser producing industries, oil processing and alternative chemical industries. Arsenic happens naturally within the soil from wherever it reaches to the bottom water (Murata et al. 2004). Exposure to heavy metals is related to injury to the lungs and alternative organs. There is restricted proof that chronic exposure will cause biological process and generative effects, individuals are exposed to metal by respiration contaminated air, drinking contaminated water, or by intake foods that contain this metal. Lead could be a serious, soft grey metal (Murata et al. 2004). Mahaffey et al. (2004) classify lead as a probable human substance. Exposure to results from respiration contaminated air, contacting lead-contaminated soils, or drinking contaminated water. Water contamination with lead happens once water passes through older pipes containing lead, lead solder, or brass fixtures that contain lead (Mahaffey et al. 2004). Therefore the supply of lead within the analysed water is additionally associate vital half to the current research as all this metal is measured to check if they are offered in sensible quantities, therefore to avoid the long-run result of native individuals drinking contaminated water (Stern & Smith 2003). As such, managing the impact of mining operations on the quality of both groundwater and surface water is crucial for sustainable mining operations (Ravengai et al. 2005a).

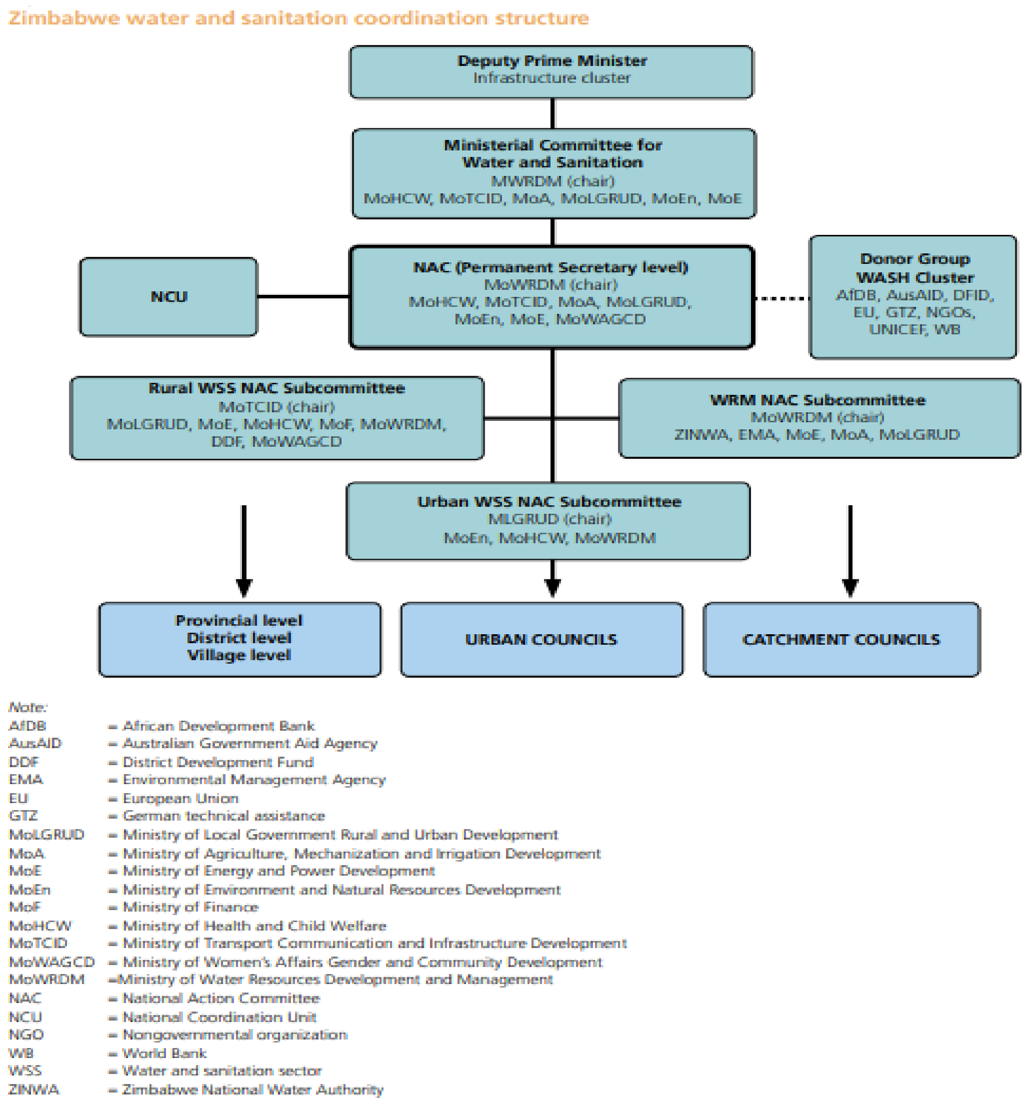


Figure 9: Zimbabwe's water and sanitation structure

Source: World Bank (2012)

It is against the above-stated background that this thesis focuses on proposing basic methods which can be used to purify the water that promote safe environmental to human, mammal and aquatic life. It conjointly seeks to determine however water from mine dumps may be used for the larger smart of the setting. Purifying contaminated water from these mine dumps can give a clean and safe community with safe water to drink, provide water for irrigation purposes. Previous studies have targeted on the purification of water from mine dumps were a lot of focus was on utilization the water to reprocess within the mines(WHO 1990; Donna et al. 1997; Vojdani et al. 2003) while this analysis focuses on safe disposal of wastewater to the setting and avoid negligence when living mines. Mine dumps should be properly monitored and be protected to make sure human safety conjointly guaranteeing safety to humans and aquatic life. The paper can open doors to proper disposal and reprocessing of water, water reclamation and correct water management systems in erratic water regions. This water when purification may be used either for domestic or industrial functions.

Now Mashaba is the home to a satellite of Great Zimbabwe University that have over 15000 students living and residing in this small mining town. This was an initiative that was exploited by the university when they saw that the town had buildings and residential homes which may cater for the university ought to expand and have find good facilities throughout its growth process. Through this initiative, this saw the students facing water challenges that were caused by the cut of water provides by the Zimbabwe National Water Authority (ZINWA) because of high water bill debts between the residents and therefore the authorities. Thus, this conjointly demands the necessity to purify this water to assist the enhanced population and should generate a favourable profit because the new population will meet water bills to support the sustenance of the project.

2 AIMS OF THE THESIS

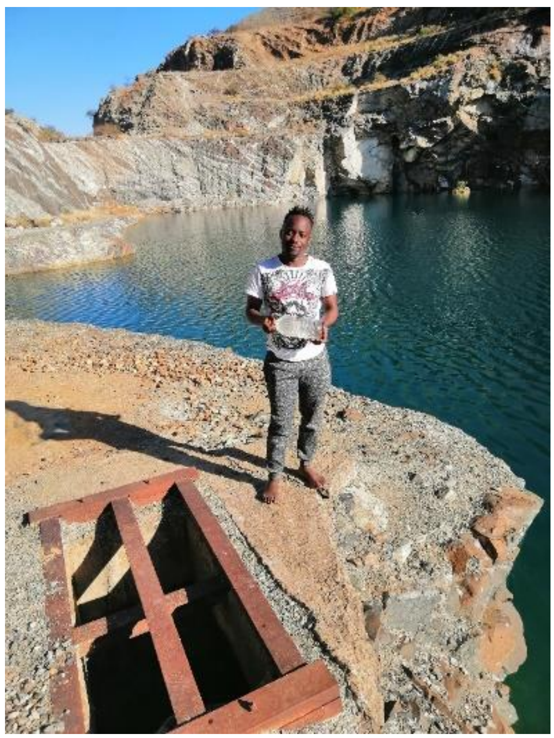
To analyse waste-water chemical contents from mining activities and propose effective treatment methods for the benefit of Mashaba community. To achieve this aim we defined the productive and contrary components of various water treatment methods. The proposed technology should satisfy the WHO guideline for drinking water.

2.1 Specific objectives:

- Defined water challenges facing Mashaba community.
- To test chemical levels of water samples from asbestos and gold mining.
- Identify main pollutants and point out potential impacts on households and environment.
- To propose productive and contrary components of various water treatment methods.

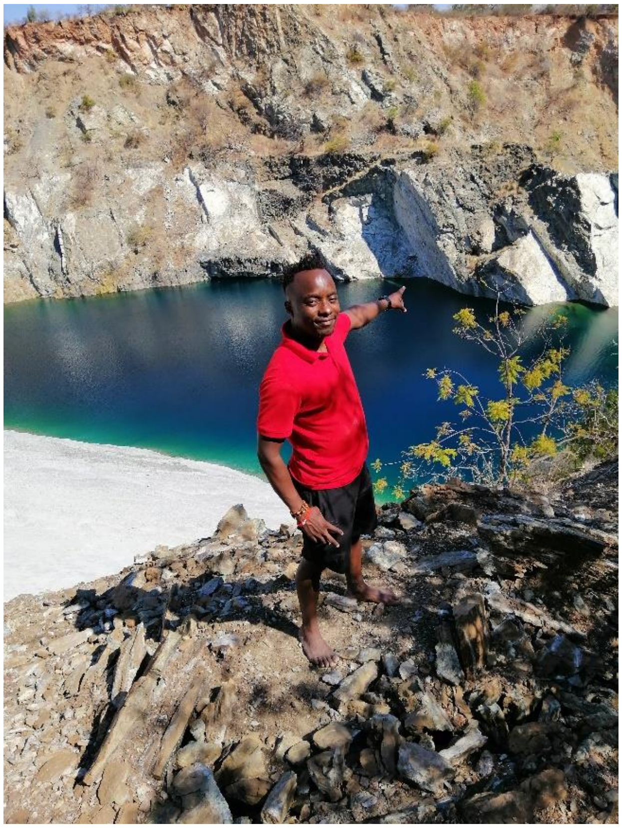
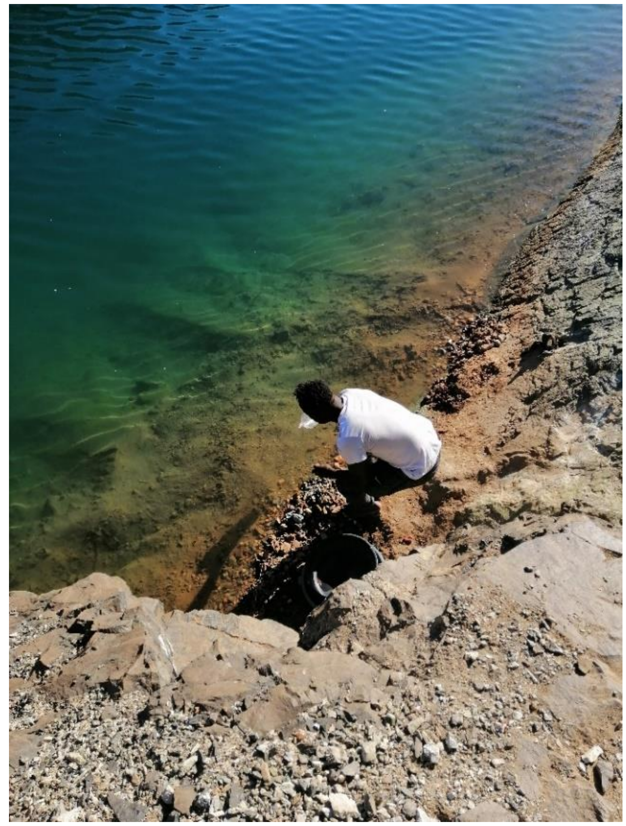
3 MATERIALS AND METHODS

The first step is to collect water samples with a tube collector of mine dump idle water and test for mineral contaminants. To collect scientific professional literature and articles related to the topic. The second step would be an analysis of the data collected, practical evaluation based on primary data collected (analysing of water samples and other primary data) and data processing to ascertain the presumed quality of the treated water. To compare the collected data with internodal standards. The final step would be to propose various technology design of an upgraded water purification technology, which can maintain and retain water quality according to WHO standards**.**



Source: Author 2020

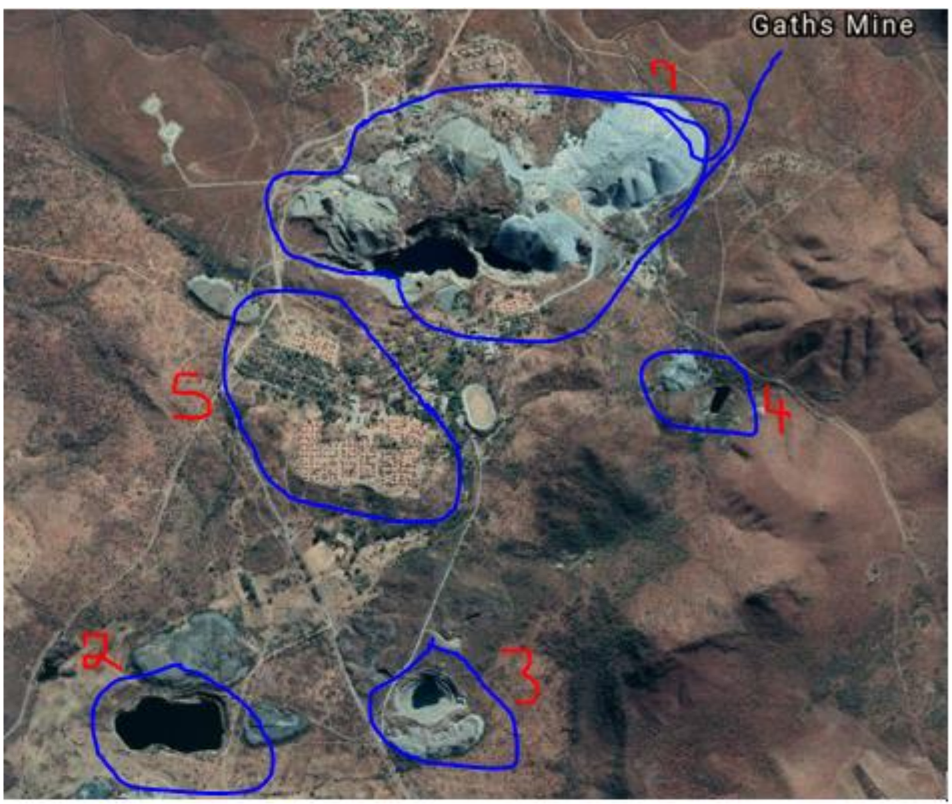
Figure 10: Student collecting water samples from Mashaba Mine

The researcher collected 53 water samples in tubes from Mashaba gold and asbestos mine open cast dumbs. Samples were collected on specific locations of two opencast sites where there was water which is exposed to the environment. The researcher also collected 32 scientific professional literature of preliminary results of water tests from the mines and local authorities. These were obtained from the Zimbabwe National Water Authority (ZINWA). A sample of drinking water from Mashaba was collected using 15 tubes were collected and marked to see and compare the prevailing standard of the tap water which is being provided to the residents. The water samples were tested for the following contaminants to see if there are no amount of harmful asbestos and gold elements which passes the World Health Guideline, SAZS:1997 and SANS:2017 for drinking water as the water is to be documented for purification standard and to enable the local community to use it for sustainable agriculture and environmental reclamation process. Water was frozen and transported to Czech Republic to maintain its BOD and COD. Sample testing was done at the department of chemistry at the faulty of Agrobiology.

3.1 Study area

In Zimbabwe, Masvingo there is a small mining town called Mashaba where there are several water challenges from erratic drinking water to water for agricultural activities. The town is located about 40km from Masvingo where the main activity is mining. Mashaba has three mines mining asbestos, gold and iron, this includes Gates mine, Temeraire and King mine. There about 15 500 people who reside and work in this town both facing water challenges due to the closure of Gaths mine by the government during their confrontation with the former mine owner Mutumwa Mawere. This left the town with serious drinking water problems for residents leading to residents depending on water from mine shafts. This has left residents, livestock and aqua life into danger as they are drinking mine wastewater which may be contaminated from various dangerous minerals which may have long term effects on their health.

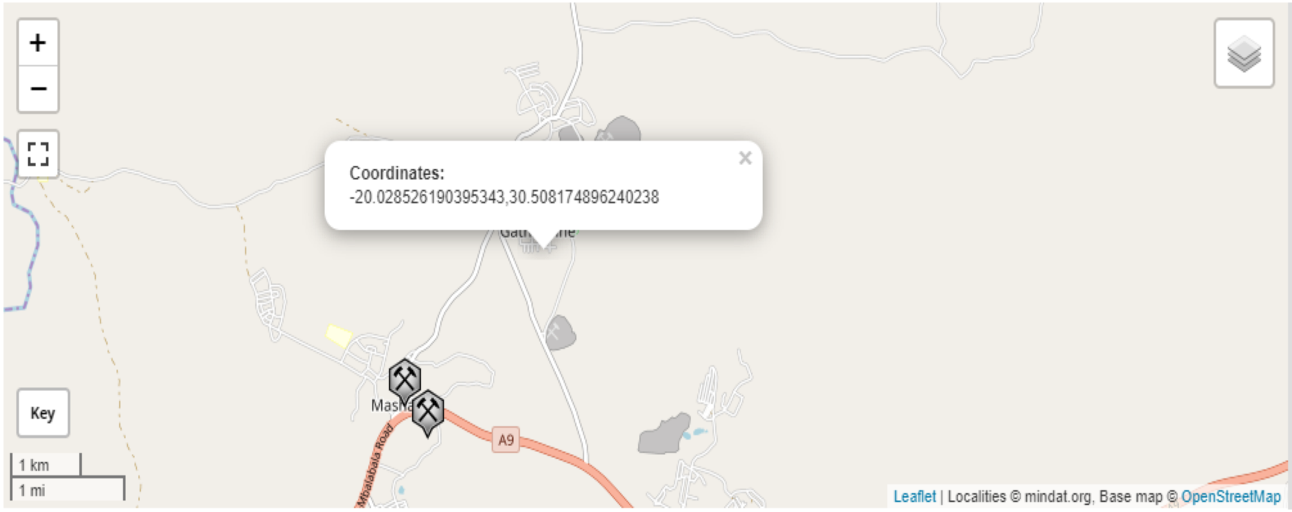


Key

1- Pool 1
2- Pool 2
3- Pool 3
4- Pool 4
5- Student residence

Figure 11: below shows the aerial view of the Mashaba Gath Mine

Area- 8,895.57m (4.68 square km) based on google earth.



Dumps of King asbestos mine

King Mine, Masvingo, Zimbabwe

Latitude & Longitude (WGS84):	20° 5' 51'' South , 30° 31' 17'' East
Latitude & Longitude (decimal):	-20.09750,30.52139
GeoHash:	**G#:** ksmtwt2gx
GRN:	S14E21

Locality type:	Mine		
Köppen climate type:	BSh : Hot semi-arid (steppe) climate		
Nearest Settlements:	**Place**	**Population**	**Distance**
	Mashava	12,994 (2012)	7.9km NNW
	Masvingo	76,290 (2010)	32.2km E

Figure 12: Aerial/Side view of the study area

Source: Mindata (2020)

Table 4: Specification of the problem

Tap water availability connections	**3465**
Piped water	**2999**
JoJo tanks availability	**26**
The treatment plant in the area	**1**
Water demand	**4500 cubic meter/day**
Waterworks Staff	**25**
Number of Hydrant public	**4**
Piped water Supply Coverage	**25%**
Water capacity estimates	**50%**
Household water need the ratio	**6500 cubic meter/day**
Estimated Production capacity	**7040 cubic meter/day**

Source : Author (2020)

The table above show tabulated data for Mashaba water supply and stuff. The connections have been summed to show the connection range for both village, and low suburb residential area. Piped water shows also the coverage potential of the existing infrastructure which provide running water in the area, from the residential to the Hospital found in the area. Water supply coverage and estimates where calculated using the data taken from ZINWA which shows the overall Mashaba area water mapping. Production capacity was also calculated using the water potential for the area, looking at the potential growth and stipulated years range of the expected demand. The existing infrastructure show dilapidating conditions, with no signs to show improvement in the water management growth potential, but an increase in waste capability due to the increase in population. During various semester periods , various increase in the number of students also marked as the potential seasonal water strain with an increase with Mashaba community residents which in the long run deserve a roadmap to design and propose various waste management methods to deal with seasonal growth , to promote a healthy water recycling culture for the whole community. This research adds up to the growth process of finding various mitigation methods which can help the Mashaba town to manage, improve and sustainability use water efficiently and productively.

3.2 Table showing physical and chemical properties

Characteristic	Asbestos	Amosite	Chrysotile	Tremolite[a]	Actinolite[a]	Anthophyllite	Crocidolite
Synonyms	No data	Mysorite, brown asbestos; fibrous cummingtonite/ grunerite	Serpentine asbestos; white asbestos	Silicic acid; calcium magnesium salt (8:4)	No data	Ferroantho-phyllite; azbolen asbestos	Blue asbestos
Trade name	No data	No data	Avibest; Cassiar AK; Calidria RG 144; Calidria RG 600	No data	No data	No data	No data
Chemical formula	No data	$[(Mg,Fe)_7Si_8O_{22}(OH)_2]_n$	$Mg_3Si_2O_5(OH)_4$	$[Ca_2Mg_5Si_8O_{22}(OH)_2]_n$	$[Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2]_n$	$[(Mg,Fe)_7Si_8O_{22}(OH)_2]_n$	$[NaFe_3^{2+}Fe_2^{3+}Si_8O_{22}(OH)_2]_n$
Chemical structure				See Figure 4-1			
Identification numbers:							
CAS registry	1332-21-4	12172-73-5	12001-29-5	14567-73-8	13768-00-8	17068-78-9	12001-28-4
NIOSH RTECS	CI6475000	BT6825000	GC2625000	XX2095000	AUO550000	CA8400000	GP8225000
EPA hazardous waste	No data	No data	No data	No data	No data	No data	No data
OHM/TADS	7217043	No data	No data	No data	No data	No data	No data
DOT/UN/NA/ IMCO shipping	IMCO 9.0 UN2212 UN2212	No data	IMCO 9.3 UN2590	No data	No data	No data	No data
HSDB	511	2957	2966	4212	No data	No data	No data
NCI	CO8991	No data	C61223A	CO8991	No data	No data	CO9007

[a]Tremolite and actinolite form a continuous mineral series in which Mg and Fe(II) can freely substitute with each other while retaining the same three-dimensional crystal structure. Tremolite has little or no iron while actinolite contains iron (Jolicoeur et al. 1992; Ross 1981; Skinner et al. 1988).

Sources: EPA 1985b; HSDB 2001a, 2001b, 2001c, 2001d; IARC 1977

CAS = Chemical Abstracts Service; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

Asbestos fibres are essential with chemicals inert, or nearly, therefore. They are do not evaporate, dissolve, burn, or endure important reactions with most chemicals (CATF 2000). In acid and neutral binary compound media, atomic number 12 is lost from the outer brucite layer of asbestos. Mineral fibres are a lot of proof against acid attack and everyone forms of amphibole are resistant to attack by alkalis (Chissick 1985; World Health Organization 1998).

The geologic or industrial word amphibole is broadly speaking applied to fibrous kinds of the siliceous snakelike minerals mentioned on top. Amphibole minerals kind below special physical conditions that promote the expansion of fibres that are loosely secure d in a very parallel array (fibre bundles) or matted lots (Budtz-Jorgensen et al. 2004). The individual fibrils, that are promptly separated from the bundles of fibres, are finely acarbose, rod-like crystals. Deposits of fibrous minerals are usually found in veins, during which the fibres are at right angles to the walls of the vein. Within the general mineralogical definition, fibre size isn't such a health restrictive agency use a lot of restricted definition of amphibole fibres, and thus, solely a set of amphibole fibres is subject to rules and employed in reportage fibre concentrations. U.S. geographical point air rules apply to asbestos, crocidolite, amosite, and also the asbestiform kinds of amphibole, tremolite, and amphibole (OSHA 1992). Before 1992, these rules noted asbestos, crocidolite, amosite, amphibole, tremolite, and amphibole. Since no asbestiform and asbestiform kinds of the last three minerals have the identical name, new legislation was required to specifically exclude the no asbestiform kinds of these minerals. The word amphibole is usually additional when the mineral (e.g., asbestos) to indicate that the asbestiform style of the mineral is being noted. This is often not necessary for asbestos, crocidolite, or amosite as a result of the no asbestiform varieties have completely different names (i.e., serpentine, riebeckite, and cummingtonite-grunerite).

OSHA defended the change in definition by way of noting that there was an absence of considerable proof that exposed employees might be at great danger because the non-asbestiform tremolite, anthophyllite, and actinolite were now not regulated inside the asbestos general. OSHA (1992) stated that non-asbestiform amphibole airborne particles are regulated utilizing a separate well known for "not in any other case specified" particulate dust to guard against "the tremendous dangers of respiratory outcomes which all particulates create at higher ranges of exposure." OSHA defines an asbestos fibre for counting functions as a particle with a length >5 µm and a length: width ratio (factor ratio) >3:1. It should be noted that other corporations use different definitions of asbestos fibres for counting functions. For example, EPA defines the fibre as any particle with thing ratio >5:1 when analysing bulk samples for fibre content. Most amphibole and serpentine minerals inside the earth's crust are of nonfibrous paperwork and are therefore now not asbestiform. Fibrous forms may arise collectively with nonfibrous bureaucracy inside equal deposits. Non-asbestiform amphiboles may arise in many numerous forms, including flattened prismatic and elongated crystals and cleavage fragments.

These crystals showcase prismatic cleavage with a perspective of approximately 55E among cleavage planes. When large pieces of nonfibrous amphibole minerals are crushed, as may additionally occur in mining and milling of ores containing the minerals, microscopic fragments can be shaped that have the appearance of fibres however are usually shorter and feature smaller length: width ratios (particle length >5 µm and a length: width ratio >3:1) than debris traditionally defined as fibres by health regulatory agencies (American Thoracic Society 1990; Case 1991; Ross 1981; Skinner et al. 1988). However, some cleavage fragments may additionally fall inside the dimensional definition of fibre and be counted as an asbestos fibre in air samples or biological samples, unless evidence is furnished that the particles are non-asbestiform. Hence that is the expected situation with the King mine in Mashaba of which nanofibrous factors are expected to be inside the wastewater found within the idle mine dumb.

3.3 Specification of the problem

After the Mashaba mine was closed, it solely left residents jobless. However, it additionally left the 15500 residents of the little mining city with a water crisis. Residents began to resort on drinking unprotected water from the noncurrent mine shaft, putting them in danger of water-borne diseases (UN 2014). The city was being supplied with water from a 40km away plant that had been discontinuous and caused this water surges.

In a recent water report revealed by the United Nations agency 2019, it declared that concerning 60% of the Zimbabwean population is exposed to water shortages, therefore this drives the research worker to appear on the water downside in Mashaba and the way it is addressed to satisfy local people wants. On the opposite report of Newsday 2017, it declared that each resident and illegal miners are at risk of the hazards of pollution and their below ideal conditions, over that environmentalists have expressed concern.

According to the Radiation Protection Authority of Zimbabwe (RPAZ), abandoned and exhausted gold mines will pose water pollution challenges to communities if the wastewater is not treated. The authority submits that some environments within the mining areas are already in peril of contamination. There additionally random gas and ooze water containing radioactive and hepatotoxic materials from piles of so-referred to as waste rock (Clarkson 1993; Grandjean et al. 1999).

It is of importance to check and recommend potential purification technology for the wastewater that was left on Mashaba mine. Minerals like Hg, Pb and As poses serious environmental problems if exposed in water which feeds natural ecosystems (Bernard et al. 2002; Cheuk & Wong 2006). Mashaba is selected by the researcher as a result of it situated in his province of resident and former University of bachelor study. In step with the results and preliminary tests by ZNWA, it is recommended that the wastewater be tested for contamination and therefore, it's vital to check and recommend technology that is in line with the area economic specifications.

3.4 Water test report from ZINWA Mashaba King and Lenox Mine Dumb

Table 5: shows water report from ZINWA for Mashaba mine Zimbabwe

Demand Specification				
Client : Zinwa Runde Catchment				
Address : Box 250				
Attend by : R Maranganye				
Email : maranganye@yahoo.com Cell : 0772674387				
Intended use of the treated water: Consuption at Mandamabwe Area				
Design Information				
Quantitative Requirements	Average	Maximum		
Flow rate of water				
Source Water	River	Well	Water Supply	Wastewater
Parameter	Unit	Raw water Average	Raw water Maximum	Set point value
Temperature	˚C			
Conductivity at 25˚C	µS/cm	134		
Ph at 25˚C		5		
Turbidity	NTU	4		
TDS	mg/l	85		
Cu	mg/l	0.263	1.240	0.002
Hg	mg/l	0.0013	0.0026	0.0001
Pb	mg/l	0.015	0.002	0.00023
Cd	mg/L	0.0009	0.0011	0.0007
Asbestos	MFL	566	22	250
NTU Turbidity	mg/l	10	13	7
As	mg/l	0.13	0.0017	0.15
Mn	mg/l	0.70	0.25	0.66
Fe	mg/l	0.28	0.12	0.25
Zn	mg/l	6.60	0.25	4.50

Source : Author (2020)

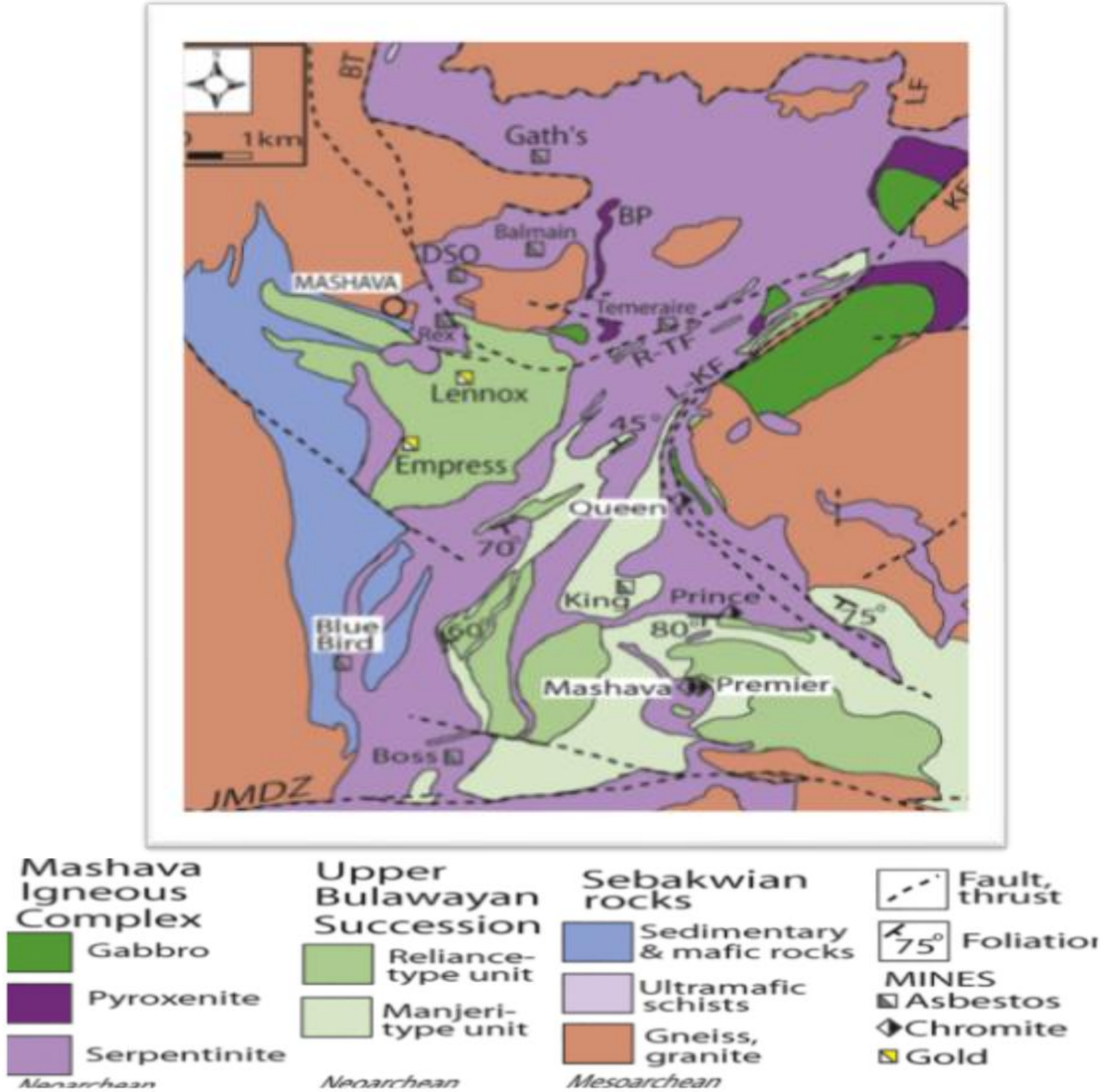


Figure 13: showing the geological study of the Area.

Source: Science Direct (2020)

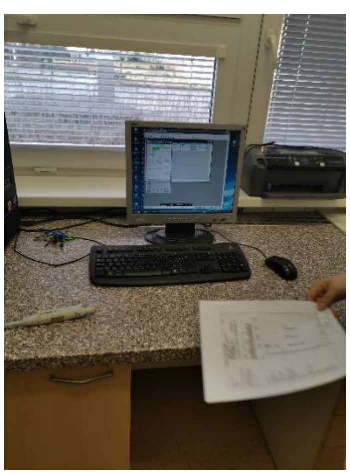
Figure 14 shows the geological layout of Mashaba area and therefore the various different mines of active and domain sites (Mugumbate et al. 2001). The open forged areas that have water mine dumbs embody Gaths, Terraire, Balmain, Dso and Rex that the research worker manages to acquire samples for examination. The study area is additionally thought of being in the south lower part and lies within the lower side of the great dyke that have an enormous variety of deposit minerals. The soil structure is usually composed of mineral, red and dark clay soils with an earth science look of artificial hills from mining activities and semi-arid vegetation.

3.5 Water Analysis

Before analysis, the water samples were dissolved overnight from freezing where they were kept. Water samples were taken to the Faculty of Agrobiology at Czech University of Life Sciences Prague within the laboratory for analysis. Water samples wherever tested using Atomic absorption spectroscopic analysis using AMA 254 machine. The primary component to be tested was mercury that was administered through first swing blanks of two hundred µmm within the machine to check and show residual components which may be administered. The detection rate of the blank was of less significance to 0.0026 ppm that showed that the mercury level was below the United Nations agency water limits. Mercury concentration in the water sample makes up my mind by binary compound generation atomic absorption photometer. The employment of atomic absorption spectroscopic analysis to beat the matter reducing interference of signals from alternative chemical compounds because the fluorescing of elemental mercury is different from that of alternative compounds.

After final all the pretest checks, different concentrations of water samples were introduced. Individual testing was performed at an amount of 0.1ppm, followed by the addition of various volumes (0.1mL (0.1ppm), 0.2mL, 0.3mL, 0.4mL, 0.5mL, 1mL, 2mL, 3mL, and 4mL) to the 200mL of wastewater from Mashaba mine.

A 1 mL liquid syringe with associate degree eighteen gauges 1.5” needle was accustomed to introduce every volume into the testing equipment. Testing was performed once each minute for a minimum of one hour with the J505 in automotive vehicle sample mode. Results were saved as 'mercury in the water'.



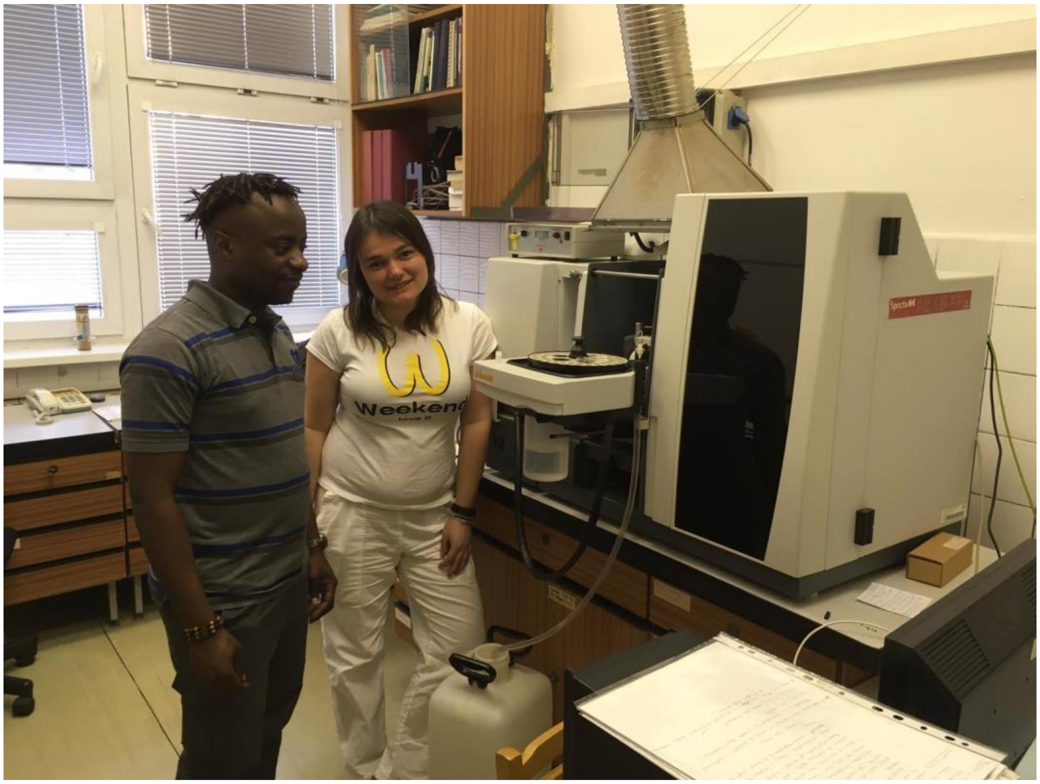


Figure 14: Researcher doing water sample test at Laboratory.

Source: Author (2020)

After the completion of the mercury testing, the instrument zero check was performed, and also take a look at results were kept within the device exploitation the name ‘posttest zero.’ when the completion of all testing, the J505 was far from the testing equipment, and also the tableware and stir bar used were cleansed.

3.6 Statistics Analysis

Statistical analyses were performed using Statistical Package for Social Scientists (Version 25, SPSS Inc., Chicago IL, USA). One half the worth of the several limits of detection limit was a substitute for those values below the limit of detection and utilized in applied statistical analysis. The data was averaged to give out the mean value of various post test results for each mineral for all samples.

4 RESULTS

4.1 Experimental Results

The results from the samples of the 'pre-solution 2' testing was initial averaged, and this average was far away from the results yielded by the Hg testing. The water sample results where then averaged for the mean, with also the ZINWA affluent results being averaged to create an easy report and analysis of the results using the statistical software SPSS version 25, compute a mean variable method.

The amount conversion was performed by the Jerome® J505, yielding ends up in µg/l. The flow was quantified employing a tag flow meter by fixing it to the front of the device and acting a sampling. The computed values were then compared with the expected values calculated by the subsequent calculation.

This interprets µg/L into the overall mass of mercury found within the samples and therefore the results are summarized in the following table:

Table 6: Mercury results of the water sample.

Injection Volume	**Hg** (µg/l**)**
0.2ml	0.126
0.2ml	0.224
0.2ml	0.225
0.2ml	0.221

Source : Author 2020

The table above show mercury tests computed means which indicated a low detectable rate of mercury in the water samples. Concentrations of As, Mn, Fe, Cr, noble metal and Mo were determined by an inductively coupled plasma mass spectrographic analysis (IPS-MS; Hewlett-Packard, HP-4500, Avondale, PA, USA).

4.1.1 Arsenic concentration in water samples

Arsenic concentration within the samples ranged between 0.12 mg/l and 0.40 mg/l. On the opposite hand, as concentrations of the mine water were from 0.45 mg/l to 0.15mg/l (median worth of 0.18 mg/l). Concerning 60% of the mine sewer water samples during this study exceeded the World Health Organization guideline worth of 0.01mg/l for as in drinkable water. Within this study, comparatively high as a concentration within the wastewater could replicate the reaction and alternative sulfide-bearing in mine water. Therefore, this shows that the Mashaba community were drinking water with high As concentrations because it wasn't detected or tested throughout erratic water days.

4.1.2 Other trace elements in the water samples

The research also analyzed other trace elements in the water sample which are most common in asbestos and gold mining activities. The concentration of Mn, Fe, Cu and Zn in the water which was higher than those other elements. Mostly Cr, Hg and Pb were quite low. Sb was not detected in the water sample. In sample B, which had water from the area tape water, was tested and yielded a low concentration of the trace elements when compared to the WHO standards.

The research also managed to compare the collected water samples to the tap water, WHO , SAZS, EU, USA and mean African standard guidelines to properly evaluate the exposure risk and the need for purification needed. In the findings, the mine wastewater test samples had a magnitude of 45% which exceeded the WHO guidelines of 0.05 mg/l for Mn in drinking water. Manganese is an essential element but a known mutagen (Beckman et al 1985). Manganese ingestion in water is considered causing neurological damage (Kondakis et al,1989), which is a health risk for the people of Mashaba of which they lack safe drinking water. Below is a table which show overall test results when compared to affluent international standards , with WHO guideline and SA guideline mainly used as the major guideline.

Table 7: Mashaba tests results vs International standards (Compared means)

Parameter	Site A	Site B	Tap Water	ZINWA	WHO GDL	US GDL	EU GDL	CHINA GDL	Africa GDL	SA GDL	Units
Mn	0.55	0.67	0.25	0.66	0.5	0.05	0.05	0.10	0.207	0.1	mg/l
Fe	0.66	0.27	0.01	0.25	0.2	0.3	0.2	0.3	n/d	2.0	mg/l
Cu	0.203	0.245	0.001	0.002	2.0	1.0	2.0	1.0	n/d	2.0	mg/l
Zn	6.7	3.0	3.5	4.5	5.0	5.0	3.0	0.20	n/d	5.0	mg/l
As	0.12	0.40	0.0035	0.15	0.01	0.05	0.01	0.01	0.041	0.01	mg/l
Hg	0.002	0.001	0.003	0.0001	0.02	0.02	0.01	0.01	0.02	0.06	mg/l
Pb	n/a	n/a	0.0015	0.00023	0.010	0.015	0.010	0.010	0.062	0.1	mg/l
Ni	n/a	n/a	n/a	n/a	0.020	0.100	0.020	0.020	0.093	0.07	mg/l
Sb	n/a	n/a	n/a	n/a	0.010	0.050	0.010	0.010	0.016	0.02	mg/l
Cd	n/a	n/a	n/a	0.007	0.003	0.005	0.005	0.005	0.007	0.003	mg/l
$Mg_3Si_2O_5(OH)_4$	600	n/a	n/a	250	1	n/a	n/a	n/a	n/a	n/a	MFL
Cr	n/a	n/a	n/a	n/a	0.050	0.100	0.050	0.050	0.065	0.05	mg/l

Source : Author (2020) (GDL- guide line for drinking water)

Notes: *African standards are based on mean average found in various published articles for example Takawira Gara et al (2017) Health Safety of Drinking Water Supplied in Africa: A Closer Look Using Applicable Water-Quality Standards as a Measure. South African standards are based on the SANS 1675:2007 Ed.2.*

For the samples, Hg was detected in sample A which was of the mine wastewater from the Asbestos site, of which the sample B which was from the second site of Gold mining also show trace elements availability in water. In the studies done in Shurugwi by the platinum mine company, they found similar results which indicated availability of trace elements in mine wastewater, that before the underground water exposed to mine wastewater. Pollution of water to trace elements like As and Hg were high to levels of 0.40mg/l and 0.12mg/l 1-1 and 0.002mg/l and 0.001mg/l 1-1 respectively. Although Hg and Mn concentration in the rivers around Mashaba was also tested by the ZINWA studies showed that around the Mandamabwe area, leaching through seepage, trace elements concentration of <0.15 mg/l 1-1 for As. Although the concentration of As, Mn and Fe are relatively showing high in Mashaba due to the study results the concentration shows concern for purifying the water which will be of a very positive impact in lessening water shortages and allowing safe land and water reclamation in the area. This will also add up to safeguarding the livestock and aquatic life of the area. However the research might have faced many challenges including on the detection level due to the amount of time the samples have stayed before testing, that may have affected detection levels of Hg, Pb and other trace elements in this study compared to other studies done in the same area surrounding Mashaba mine. Hg and As in this study were relatively low than other studies for example (44 mg/kg 1-1) and as (11 mg/kg 1-1) though levels over the WHO guideline of the drinking water. These findings indicated that the tested level can expose the residents of Mashaba community to health hazards and will be better if we propose purification technology which can better peoples live and enable proper use of wastewater either for drinking or declared greywater qualities.

Before the results obtained after the test was done to the water samples, the researcher decided to propose various technology to purify heavy metals from the contaminated water of Mashaba wastewater. Various technology and implements will be discussed below concentrating on trace elements like As, Hg, Mn, Fe, Cu and Zn. Water as a natural resource, must be managed and protected for use and distribution, proper sanitation for human health and agriculture production, can be promoted by ensuring people have access to safe drinking water. In erratic regions, where water bodies are few and many people walk long distances to acquire such an important element of everyday life mostly women, therefore it is important to make sure for Mashaba residents they use the available water resources effectively, in generating income and making sure the poor have access to safe drinking water.

Looking at the available data from the tests done from the water samples, it is of paramount importance we ensure proper selection of technology which is economically viable for the area to ensure that this project may be implemented in future to benefit the local people. The water must be regulated to meet the WHO water standards for drinking water. The area has been exposed to water shortages and unable to curtail the water issue due to lack of resources, supply and proper technology and lack of government coordination. The proposed technology will have to mitigate mainly As, Mn, Zn and chrysotile fibers which were detected in the water samples of Mashaba area.

4.1.3 Asbestos fibers removal in water.

With the study focus to mitigate the various heavy elements found in water, it of most importance this research discusses how to mitigate asbestos fibers which were detected in the water samples. The WHO has considered Asbestos fibers in drinking water to be problematic in drinking water due to the use of pipes which are made from asbestos to transport water in various cities. In a study done in Washington in 1977, where people were interviewed due to the abundance of asbestos fibers in drinking water within the region , it was found that there was no enough evidence to link cancer with asbestos find in water, but for male candidates it was thought it affected stomach and pharyngeal cancer but with inconsistence sex results in other studies

In the USA the EPA has considered asbestos prevalence in water of 7 MFL as dangerous to humans in drinking water hence posing a risk of developing benign intestinal polyps. In 1992 EPA added asbestos to the list of 90 contaminants often found in water. This has also motivated the researcher to look on how asbestos can be removed from water to benefit the Mashaba community. Water treatment methods using coagulation/filtration direct and diatomite filtration and corrosion control can mitigate asbestos fibers in drinking water. The WHO has recommended the mitigation of asbestos to 1 MFL in drinking water which poses no harm to human consumption.

4.1.4 Proposal of new technologies to mitigate the As level.

The planned technologies are going to be hierarchal consistent with 3 vital aspects learned from the study: pollution levels mitigations, geographic region and country native conditions
In areas wherever the water contains unsafe levels of As, the immediate concern is finding a secure supply of water. There are 2 main options: Finding a replacement safe supply or removing As from the contaminated source. If the As level of the safe water supply can't be established, the

short goal is to cut back As levels. There are many ways obtainable for removal of As from water, the subsequent vital ways are mentioned below:

- Oxidation
- Coagulation, precipitation and filtration
- Adsorption (sorptive filtration)
- Ion exchange

4.1.4.1 Ion Exchange technology

Ion exchange is the exchange of ions with ionized species in water with ion exchangers, ie H+, and OH- ions. The process is reversible and can be regenerated by washing with excess ions. The principle of this technology is as follows. Water flows through the bed of ion exchange resins where the ions in solution migrate into the beads. Here, depending on the relative densities of the changes, they compete for exchange sites. The resins are 1 mm thick porous particles made of highly crosslinked, high ion exchange sites with high ion exchange rates (Elga Veolia 2019).

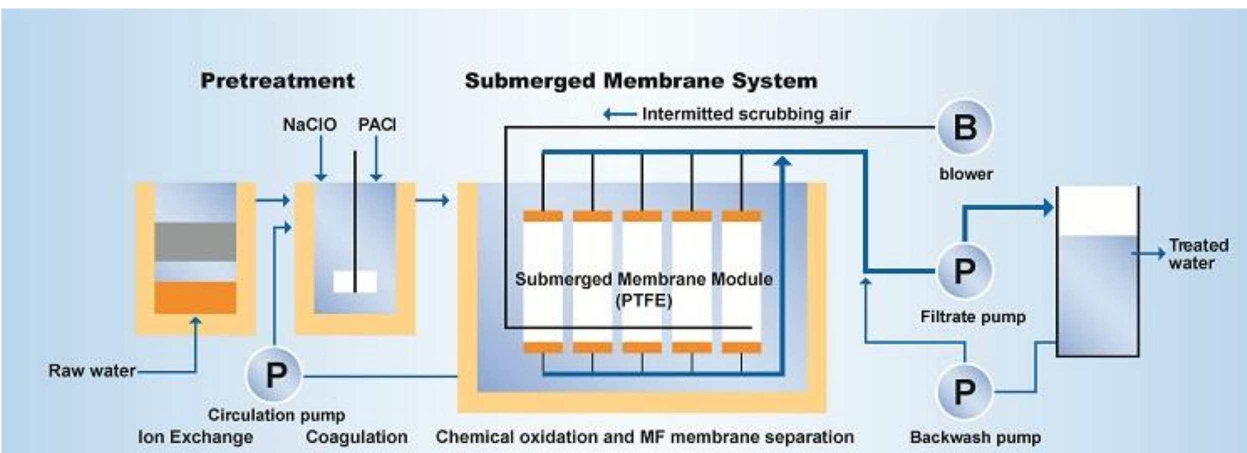


Figure 15: Schema proposed technology with Ion Exchange.

Image source: Maenza (2020)

Deionization beads are cationic or anionic and exchange either H+ ions for cations, which may be Na+, Ca 2+, or OH-ions for anions, which may be Cl-, NO 3-. The hydrogen ion from the cation exchanger is combined with the hydroxyl ion exchanger to form clear water. (Elga Veolia 2019)

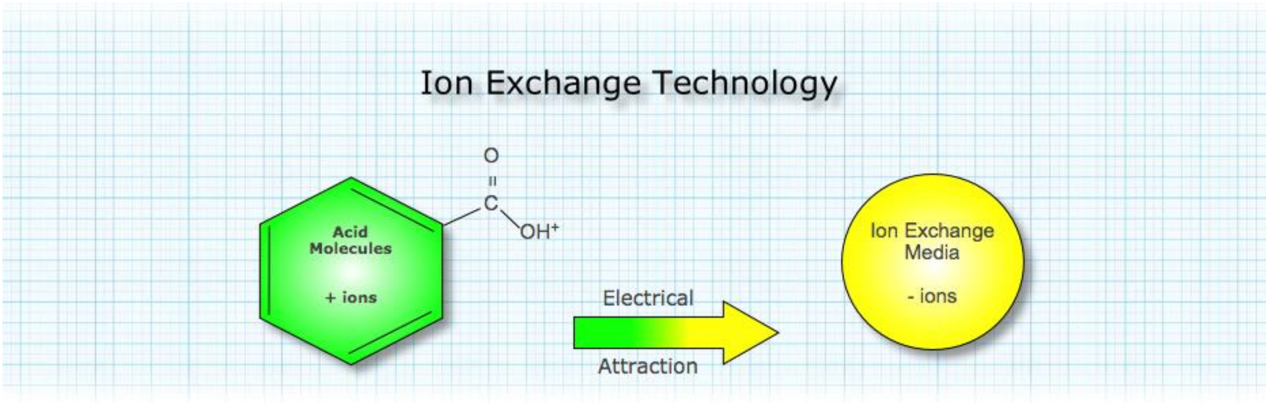


Figure 16: Ion exchange

Image Source : EPA (2015)

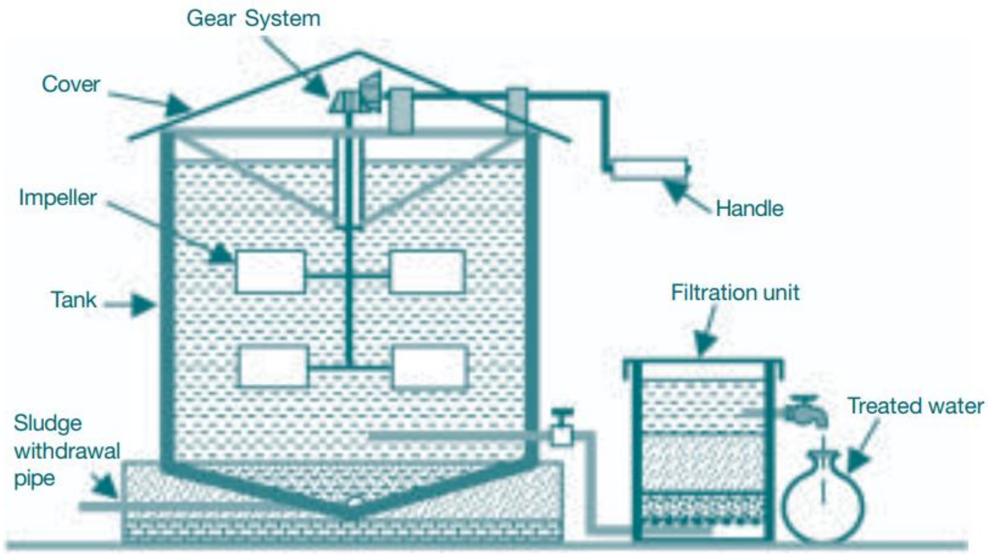
The ion exchange resin beds are available as containers and are commonly used for some time before replacement. This occurs when cations and anions have replaced most of the active sites H+ and OH-. Once depleted, they can be regenerated by washing with excess desirable ions using strong acids and bases. This reverses the process and removes unwanted cations and anions. This process requires the use of chemicals (Elga Veolia 2019). Ion exchange technology can mitigate As levels and Fe through utilisation of Fe to scale back As levels to permissible quantities in drinking water, hence applicable for Mashaba area.

Figure 17: Ion Exchange Technologie

Source Fluid med technologies (2020)

4.1.4.2 Membrane Solar oxidation and precipitation of Fe (III)-oxides with adsorbed As(V)

SORAS may be a straightforward technique that uses irradiation of water with daylight in PET or alternative UV-A clear bottle to scale back arsenic levels in drinking water. The SORAS technique is implemented in 2 steps: the primary step consists a chemistry reaction (through the action of the star ultraviolet light) of As (III) to As(V) followed by the second step consisting in pre cipitation or filtration of As(V) absorbable on Fe(III)-oxides, that are either naturally available or value-added and unbroken in suspension by the addition of oxidants. It can be a water treatment technique used at the home level to treat little quantities of drinking water. The wastewater in Mashaba naturally contains a metallic element (II) and Fe (III); thus, SORAS might cut back arsenic contents and would be accessible to everybody at just about reduced costs (WEGELIN et al. 1999).



Bucket Treatment Unit (left) and Stevens Institute Technology (right), two household-level filters for arsenic removal from drinking water.

Figure 18: The schematic approach of SORAS

Source*:* Sswm technologies (2020)

4.1.4.3 Removal of Mercury in the Environment

Removing Hg from water may be achieved exploitation of four processes: Coagulation/Filtration, Granular activated charcoal, Lime Softening, and Reverse diffusion.

Coagulation/filtration could be a commonplace remedy that makes use of AlSO4 that reacts with the Hg to form a solid which may precipitate out of the water. The sludge then ought to be disposed of in a very safe way. this fashion is helpful as a result that it is economically cheap and reliable.

Granular activated charcoal uses porous carbon media. This media could be a serious charcoal material because the water passes through, the dissolved contaminants are absorbed and continued the solid surface. This method has its limitations as a result of the effectiveness depends on the concentration of mercury within the water. This can be used considering the area economic conditions as it is economically viable but require proper knowledge transfer.

Lime Softening uses excess Ca (OH) to lift the pH level than the serious metal precipitates out as Hg (OH). A good thing about this technique is lower prices and verified dependableness. In reverse diffusion, water is pushed through a semi-permeable membrane, a standard membrane material could be a polymeric amide film. This produces top-quality water however with higher costs.

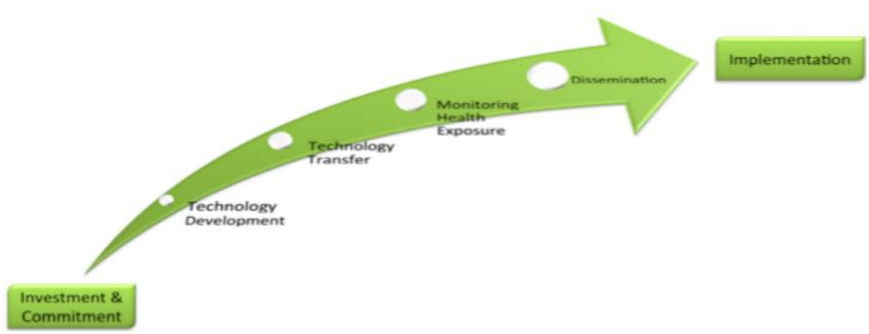


Figure 19: The relationship between technology and implementation

Source: Author (2020)

To address water safety and sanitation issues in recognition of SDG 6, which calls for clean water and sanitation for all people, UNICEF partnered with UNDP and Oxfam to build a water kiosk to supply safe and clean drinking water poor communities. The established water kiosk is supplied with water from a high-yielding solar-powered borehole, pumping 5 000 liters per hour and will serve almost 1000 families.

This technology displayed below can be implemented after the technology, the use of water kiosk, as a form to enable prepaid water access thus generating income to the community. This enables easy management and maintenance of the technology as the revenue generated can be used for maintenance and worker renumerations. This can also lead to the sustainability element of the project as to what UNICEF Zimbabwe has implemented in the urban areas of Zimbabwe.

Figure 20: showing a recommended kiosk style for water access.

Source : UNICEF Zimbabwe (2020)

4.1.4.4 Reverse Osmosis technology

Reverse Osmosis is the technology used to separate salt from water using a thin membrane. This method is considered very cost intensive as it uses more energy and a more prominent technology in the water purification process. This method has gained much popularity by its effectiveness in saving water erratic regions from lack of water, by accessing saltwater for drinking water. This method proves to be the best when mitigating heavy metals from mine wastewater. The success rate has been linked to be 95% plus with drawbacks of removing other vital elements of drinking water which promotes taste. For this research this technology is proposed as the last possible solution because of high cost which are associated with this technology, considering the country conditions and high maintains needs. The pressure applied needs to overcome the pressure level. The diagram below show effectiveness of the RO procedure on water treatment:

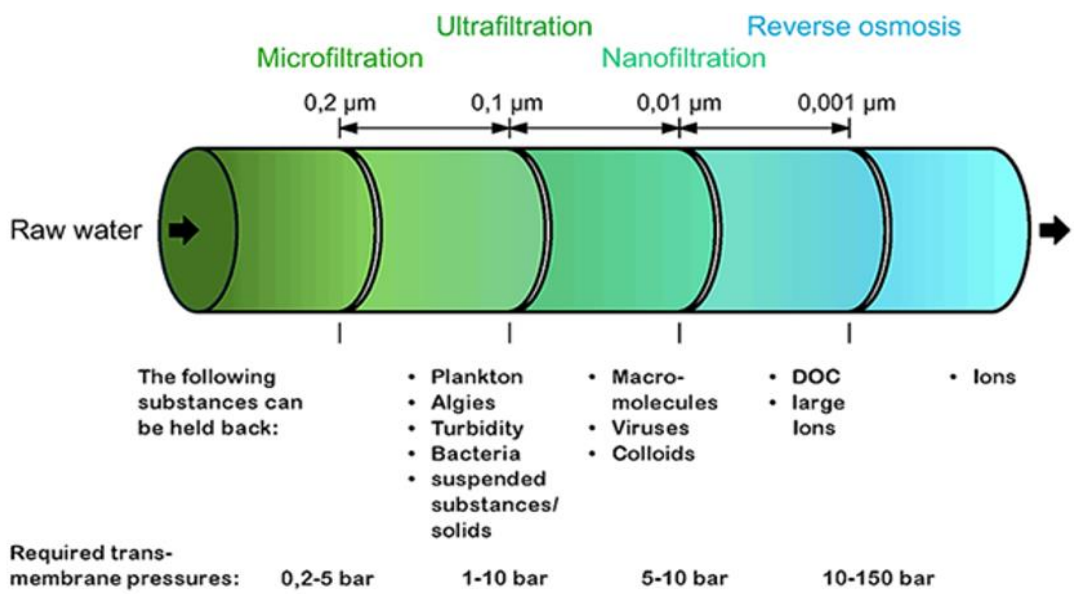


Figure 21: Reverse Osmosis technology simplified schematic.

Source: Wasserhaus Reverse-Osmosis Systems (2020)

When pressure is applied to the concentrate solution (Figure 22), the water molecules are forced to flow through the semi-permeable membrane (The contaminants are left behind since the semi-permeable membrane is barely permeable to water molecules and not permeable to ions and alternative contaminants) the process is mastered from microfiltration to nanofiltration capabilities.

4.1.4.4.1 How does reverse osmosis work?

In apply, reverse diffusion is applied as a crossflow filtration method. A hard-hitting pump is employed to extend the pressure on the wastewater and force the water to flow across the semi-permeable membrane., exploit most half (approximately 95%-99%) of the dissolved substances in the water, in this case removing all the heavy metals to leave a clean, safe and reliable water to drink.

Within the membrane system, the feed water is going to be split into a low-saline product, known as permeate, and a high isosmotic solution, known as concentrate, brine or reject stream (See schematic below).

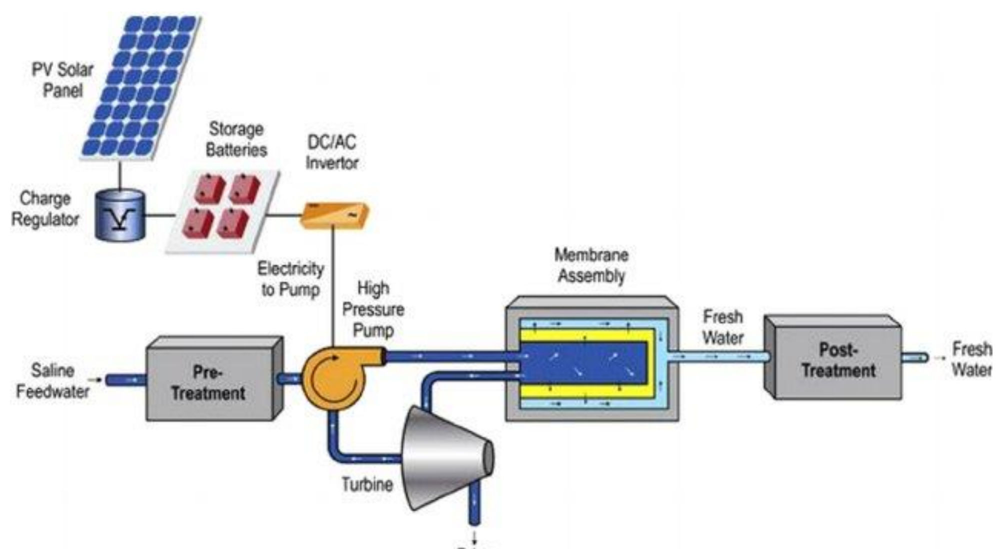


Figure 22: Schematic representation of reverse osmosis

Source: Waterept (2020)

As the feedwater enters the artificial separator membrane exert a force (enough to beat diffusion pressure), the water molecules force penetrate a semi-permeable membrane and also the heavy metals in this case and alternative contaminants aren't allowed to pass and are discharged through the concentrate stream, which matches to empty or is fed back (totally or partially) into the feed water stream to be recycled through the artificial separator system to save lots of water or to resolve hydraulic problems within the system.

4.1.4.4.2 What will RO remove from water?

Reverse osmosis will take away dissolved salts (ions), particles, colloids, organics, bacterium and pyrogens from the water. An artificial separator membrane rejects contaminant which is not permeable to the membrane and charge. Any contamination that features a relative molecular mass bigger than one hundred eighty prosecutors is presumably rejected by a properly running artificial separator system. Besides, the larger the constant of the contamination, the bigger of seemingly it'll be unable to experience the artificial separator membrane. RO membranes don't take away gases like CO2 or O2. These gases don't seem to be extremely ionizing (charged) whereas they’re in presolution and have an awfully low relative molecular mass. The water is electrically neutral, it implies that the total of cations equals the sum of ions once expressed as equivalents. This conjointly happens with artificial language permeate, for every ion that passes through the membrane, an ion should experience yet.

The permeate can continuously be electrically neutral, there'll be a charge balance. Hence this makes reverse osmosis the most effective technology to purify heavy metals for the planned area, but the challenges happen on the country-specific drawback on the affordability and implementation, as in Zimbabwe up to now the technology has not been enforced even within the major cities Harare and Bulawayo are lacking resources to keep up the obtainable water plants. This leaves us to realize that despite considering reverse osmosis as the best most probable, technology to be useful for Mashaba, it is very sad to consider it for this project considering the country conditions and lack of government support. However, if the energy source can be altered to solar and make sure the amount of water pumped will be sufficient for the technology, it will be great for this technology to be considered in the future and be properly implemented for Mashaba area.

4.1.4 Simplified Technology SWOT analysis

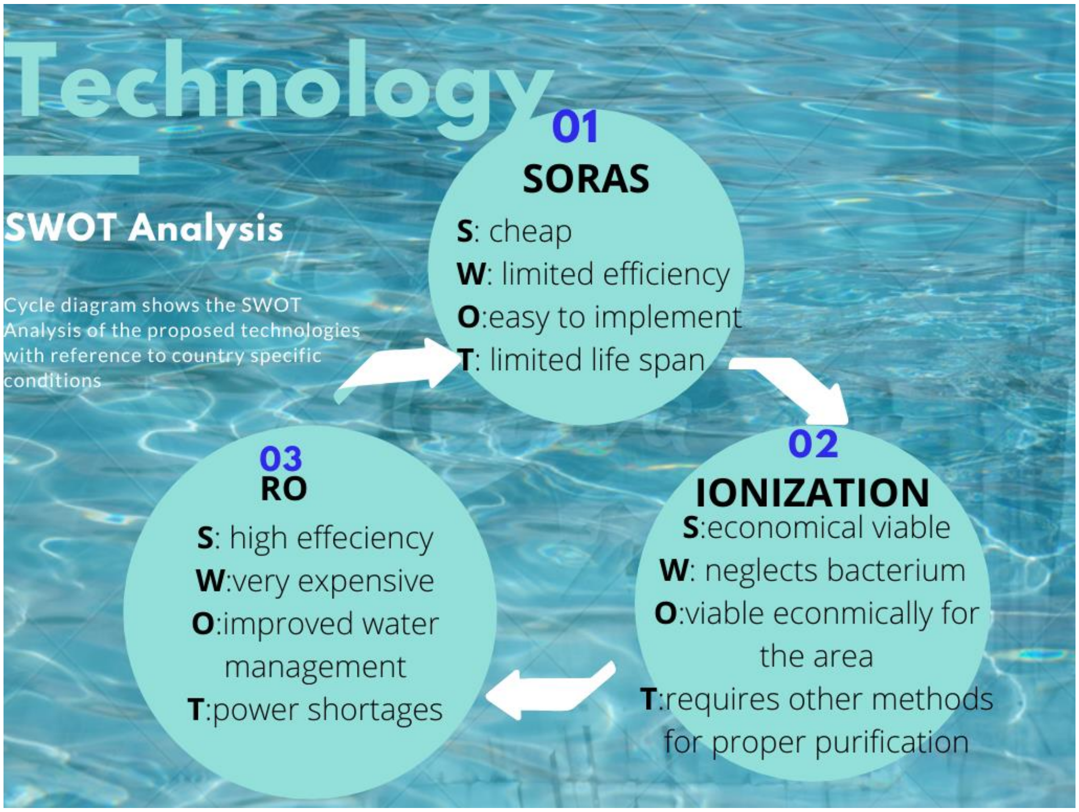


Figure 23: technology assessment hierarchy based on country specific conditions and pollution load

Source: Author (2020)

***Notes**: A basic SWOT analysis was choosen for this project as a guideline prior to available data on the costs and implement ability of the technology. Cheap in this case means lower costs compared to the other technologies, while very expensive relates to the amount of money required to launch the technology on ground, thus considering raw materials, supply and maintenance.*

Based on the results the paper has come up with a basic technology SWOT analysis to show which technology is most relevant for Mashaba area. The SWOT analyses is a baseline recommendation considering the remoteness of the area, power shortages and current economic potential. SORAS being mostly recommended, whilst RO being the most effective for mitigating the pollution load.

5 DISCUSSIONS

Figure 24: A woman fetching water from open source river in rural Mashaba

Source: UNICEF Zimbabwe (2020)

Water access has been masculinised in Zimbabwe, leaving women and kids fetching water. From the picture above 60 % of rural workload is mainly done by women, leaving them at a vulnerable position in the community. Improving water access in Mashaba will also improve women livelihoods, they will no longer move various distances to fetch this important resource. This has also motivated the researcher in ensuring the data from this research can be used for both environmental, community and address gender gaps in rural areas.

Many of these gold mines are associated with major contamination problems, especially high levels of acidity and metals (Ravengai et al. 2005b). Results of this study show that the surface water is slightly contaminated concerning Mn, Fe and Zn. Such contamination is attributed to the release of metals from the oxidation of metal-bearing sulphides in the mine dumps. Most mining operations share similar sets of activities or materials that generate contaminants and lead to pollution of surface water resources. The following mining sources generate a diversity of contaminants that have been shown to have adverse effects of varying intensity on surface waters, groundwater, aquatic plants, surface water biota and submerged sediments.

Results of the study showed that Sample B has ions of Fe around 0.66 mg/l which is lower than what Nyamangara et al. (2011) in a study on river pollution due to gold mining and Fe ions of 0.85 mg/l. The extraction of other minerals also poses a direct threat to both surface and groundwater quality. Work done at Trojan Nickel Mine (near Bindura) reported high concentrations of sulphide (over 100 µg/l) as well as high levels of Pb (> 1.0 µg/l) and nickel (Ni) from the rock dump (Lupankwa et al. 2006). Water samples taken from Pote River located downstream from the mine dump had elevated levels of Pb, As and Ni which rendered the water unfit for domestic use. The deterioration in the quality of surface water has also been observed at Iron Duke Mine in the Mazowe catchment. Upstream of the mine premises, water in the Yellow Jacket River was not contaminated yet downstream it was contaminated with iron (Fe), nickel (Ni), copper (Cu), cobalt (Co), lead (Pb), zinc (Zn), and sulphate ions ($SO4^{2-}$) (Ravengai et al. 2005a). Acid mine drainage seeping from tailing dams is degrading water quality of the Yellow Jacket and Mazowe Rivers. At Madziva mine, also located in the Mazowe catchment, acidic effluent with high concentrations of iron, nickel and sulphate emanating from the tailings dam was detected in both surface and groundwater (Lupankwa et al. 2004). Hence no major treatment plants are in these areas focusing on treating the wastewater, despite billions earned , the companies dispose the water into the natural environments posing various environmental problems, this has driven this research to look on formidable cheap and relevant technologies which can be implemented for Mashaba mine and the rest of the great dyke to save communities and the natural biodiversity of the areas.

Manganese values in terms of domestic water in Mashaba were at 0.67 mg/l and the findings of the study indicated that the levels of manganese were above the WHO recommended limits of 0.5 mg/l indicating that water treatment may not have in effect into the removal of the heavy metal ion from drinking water. These findings contradict findings by Muleya et al. (2019) in a study of water quality in Zvishavane found out that manganese levels were within the WHO recommended limits. Manganese is an essential element for humans although previous epidemiological studies have suggested that soluble manganese is associated with adverse effects on learning in children. Hence mitigating it from mine wastewater will improve the water quality for Mashaba and enable safety of the community and surrounding livestock.

In terms of domestic water, from the secondary data generated from the ZINWA Mashaba area, the following results were obtained. Mn values from sample B were 0.67 mg/l, Fe was 0.27 mg/l, Cu was 0.245 mg/l and Zn was 3 mg/l. Results of the study tend to contradict findings by Muleya et al. (2019) in a study in Zvishavane Zimbabwe who found out that of the combined tap water, open well and borehole sources values reported were above WHO recommended limits of 2 mg/l copper, same as allowable limit of 2 mg/l for EU. Concentrations in drinking-water range are likely to be a result of the corrosion of interior copper plumbing. This also showed that Mashaba community is exposed to drinking water which has high volumes of Mn and Fe, exposing community and their livestock to serious health problems. Hence, prior to the findings the mitigation measures of Mn and Fe using the ion exchange technology can go a long way in saving the community and enable environmental safety, thus saving both the aquatic and natural environment.

Results of the study found out that very low levels of Cu were found in water in Mashaba and higher values were found in Zvishavane samples in a study by Muleya et al. (2019) which indicated that acceptable levels of Cu ion in both taps, well and borehole water. The 15 tap water sources reported an average of 0.01 mg/l of Fe during the period of sampling with two of the points reporting levels of 0.54 mg/l (Platinum Park) and 0.80 mg/l (Arise) ranging was between 0.01-0.54 mg/l. This may be attributed to the high alkalinity value (255 µg/l and 240 µg/l respectively), steel fixtures on water pipes could be corroding into drinking water. WHO guideline set the recommended iron limits at 0.2 mg/l and the maximum allowable limit at 1 mg/l). The high levels of Fe in samples could explain the observed typical light brown colour and taste of Zvishavane drinking tap water. These values are above the World Health Organisation drinking water guidelines (WHO1996), Zimbabwe wastewater quality limits (MRRWD, 2000) and the South African domestic water use standards (Ravengai et al. 2005a).

The values for lead (Pb) were very high as compared to what was established by Kanda et al. (2017) in a study in Shamva, Zimbabwe. Results of the study which show elevated values of As, Mn and Zn are in line with findings by van Straaten (2000) in Tanzania which indicated elevated concentrations of metals including Hg, As and Cu in stream sediments. Results of the study showed that abandoned mining area of Mashaba still exhibits levels of heavy metals which is in line with findings by van Straaten (2000) further showed that water surveys in the Tanzanian and Zimbabwean study areas showed elevated metal concentrations only in areas of present and past small-scale gold mining activities, but drinking water samples were not contaminated. However, the results of the study tend to contradict with van Straaten (2000) in terms of contamination of drinking water as there have been traces of the heavy metals from the test results from ZINWA. However, this should be noted that the presence of Hg can be linked with the production of gold which was once prevalent in one of the study sites. Van Straaten (2000) indicated that all drinking water sources in the Shinyanga study area were within drinking water standards, even those water sources spatially very close to contaminated gold processing sites. At the point sources processing sites, tailings. Hg is lost mainly as elementary metallic Hg with a very low dispersibility and consequently only small amounts of Hg are mobilized into solution.

The results of the study showed that there is evidence of contamination water by the contaminants from the gold and asbestos mines. These results to a larger extent contradict the findings made by Wei et al. (2013) who found out that asbestos mining-affected drinking water. The effect of asbestos mining was felt in a study in China by Wei et al. (2013) under which revealed that the drinking water has been contaminated by asbestos fibres from crocidolite mineral in soil and rock. Except for Cr, Pb, Zn, and Mn, the mean concentrations of Ni, Na, Mg, K, Fe, Ca, and SiO_2 were much higher in both surface water and well waters from the asbestos area than in well water from the control area.

6 CONCLUSIONS

Based on the findings it can be indicated that there are high levels of As, Mn, Fe and Zn in the wastewater found in Mashaba. For the other trace elements, it can be concluded that except for Mn, Fe, Zn and As, the level of Hg and Cu were within the limits which are set out by WHO, EU and US. For the abandoned gold and asbestos dumps, it can be concluded that Mn and Fe are in very high concentrations in gold than in asbestos mines. Cu levels were significantly lower in both asbestos and gold abandoned mines in the study area. Results of the study showed that there were high As and Mn levels and as such the study proposes the adoption of the SORAS, Ionization and reverse osmosis technologies as water purification measures which can be used to purify water from abandoned asbestos and gold mines.

6.1 Water Resources Planning and Management

Water management improvement in Mashaba will need to improve, considering the findings. The area can benefit from various water management and harvesting techniques which may save the community from water stress issues and enable a healthy water environment. Clifton et al (2010) discusses how water stress areas can adapt or implement technique to sustainability utilise ground water reserves, which in this research paper will be useful to recommend for Mashaba as the community can utilise ground water for effective access to safe drinking water.

The research also suggest that proper training of the community for proposed technologies is of paramount importance as this can promote the project sustainability, on issues to do with community water management, proper repair and linkages monitoring, health pricing and accountability per community scale ,and creation of jobs and community sustenance, as this will save a lot of stress from ZINWA which normally overlook water projects. Water pricing is based on a national uniform blend that is set low relative to other areas, to stimulate water use and help revive irrigated agriculture. However, ZINWA water policy which focus on removing water issues from the political arena and promote rural water access and reliance. Under the 1998 Water Act, water allocation planning was undertaken by Catchment Councils .Hence the community must also be taught issues to do with climate change which is a global phenomenon and how they should protect and manage their water as it is a very important aspect of everyday life.

It is also worth to note that prior to natural water resource management, the government must step in safeguarding the natural environment from big companies which are profit orientated and ensure that EMA have the right tools to make companies responsible for using natural water resource on matters to do with environmental reclamation, water recycling and safe disposal while in operations and after operations.

The research recommends that water management must be taught on grassroot level, community must be protected and water disposal and use must have clear guidelines in rural areas which in line with Mashaba area, the local rural district councils must be trained on the monitoring, management, technology transfer and relevant skills of clean water for natural water surfaces of either local or international companies. The writer would like to continue with this study later for postgraduate studies, looking on other elements of mining which pollute the environment, this goes to soil pollution of the Mashaba area, natural environment alterations and effects on the productive land of agriculture. Prior to this work, the research would also like to further research on the relationship between remoteness and water management, thus looking on the social political factors. The research recommends proper water management, exploitation and reuse in water erratic regions.

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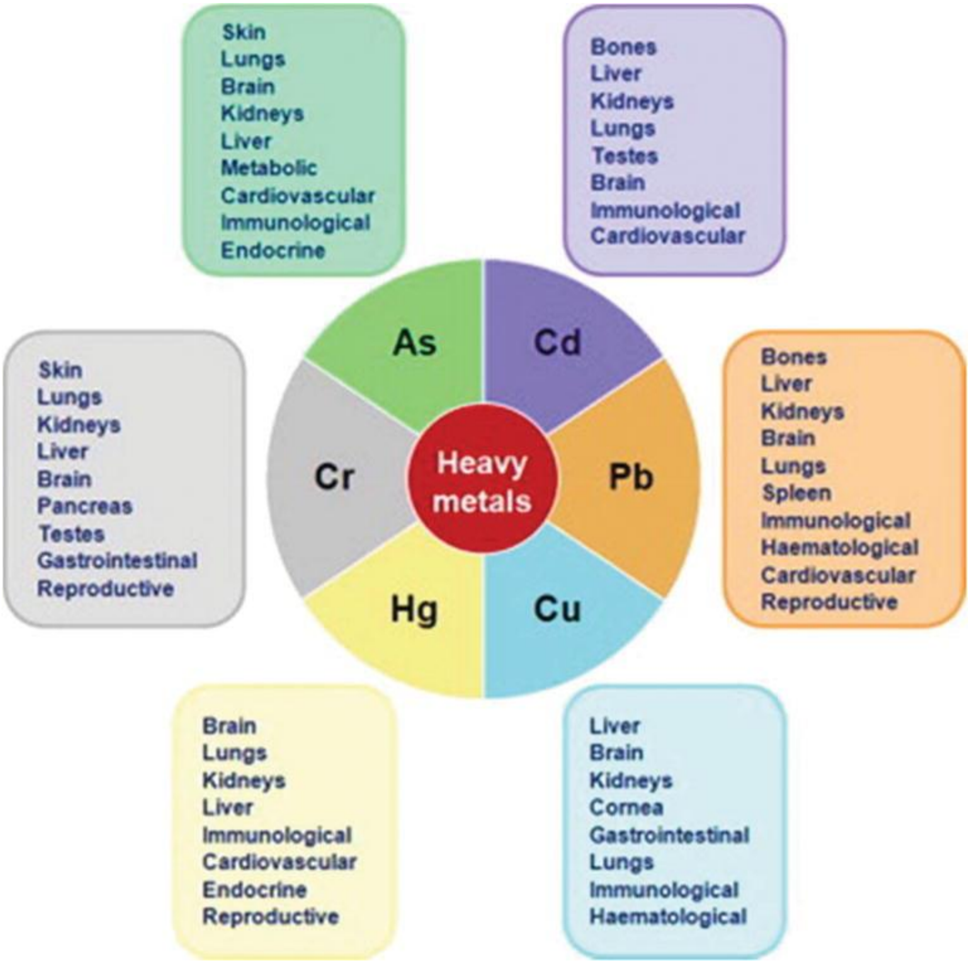
8.0 Appendix

8.1 Water test report 2

Parameter	Site A	Site B	Tap Water	ZINWA	WHO GDL	US GDL	EU GDL	CHINA GDL	Africa GDL	SA GDL	Units
Mn	0.55	0.67	0.25	0.66	0.5	0.05	0.05	0.10	0.207	0.1	mg/l
Fe	0.66	0.27	0.01	0.25	0.2	0.3	0.2	0.3	n/d	2.0	mg/l
Cu	0.203	0.245	0.001	0.002	2.0	1.0	2.0	1.0	n/d	2.0	mg/l
Zn	6.7	3.0	3.5	4.5	5.0	5.0	3.0	0.20	n/d	5.0	mg/l
As	0.12	0.40	0.0035	0.15	0.01	0.05	0.01	0.01	0.041	0.01	mg/l
Hg	0.002	0.001	0.003	0.0001	0.02	0.02	0.01	0.01	0.02	0.06	mg/l
Pb	n/a	n/a	0.0015	0.00023	0.010	0.015	0.010	0.010	0.062	0.1	mg/l
Ni	n/a	n/a	n/a	n/a	0.020	0.100	0.020	0.020	0.093	0.07	mg/l
Sb	n/a	n/a	n/a	n/a	0.010	0.050	0.010	0.010	0.016	0.02	mg/l
Cd	n/a	n/a	n/a	0.007	0.003	0.005	0.005	0.005	0.007	0.003	mg/l
$Mg_3Si_2O_5(OH)_4$	600	n/a	n/a	250	400	n/a	n/a	n/a	n/a	n/a	MFL
Cr	n/a	n/a	n/a	n/a	0.050	0.100	0.050	0.050	0.065	0.05	mg/l

Source : Author (2020) (GDL- guide line for drinking water)

8.2 Effects of Heavy Metals in the human body



Source: Effects of Heavy metal (2020)