INDUSTRIAL ATTACHMENT REPORT FOR

CHIMPUNGU BRENDON (R1811761)

CIVIL AND WATER ENGINEERING

FACULTY OF ENGINEERING AND BUILT ENVIRONMENT

INTEGRITY • KNOWLEDGE • DILIGENCE
INNOVATIVENESS • PROFESSIONALISM

UNIVERSITY OF ZIMBABWE

UZ SUPERVISOR: ENG P MARINDIKO

COMPANY SUPERVISOR: ENG T KAPETA

CITY OF HARARE

HARARE WATER

THIS INDUSTRIAL ATTACHMENT REPORT WAS SUBMITTED TO UNIVERSITY OF ZIMBABWE IN PARTIAL FULFILMENT OF THE BACHELOR OF HONOURS DEGREE IN CIVIL AND WATER ENGINEERING

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DEDICATION

I dedicate this project to my family for its unwavering mutual support and their desire to see me succeed in my academics towards achieving a goal of becoming a prominent Civil engineer.

ACKNOWLEDGEMENTS

Firstly, I would like to thank the Lord God almighty for giving me this opportunity to have an industrial attachment at City of Harare.

Secondly, I would want to thank Eng T Kapeta, Eng Chawasemerwa company supervisors, Mr Mamvura wastewater workshop superintended, Mr Chabata and Mr Munyoro Morton Jeffery water works superintendents, Mr Chiradza and Mr Makusha Firle wastewater works superintendents and all plant attendants for their guidance, encouragement and knowledge they imparted on me throughout my attachment period. I would also want to thank City of Harare at large for the opportunity they granted me of having industrial attachment in their organization.

Lastly I would like to express my deepest gratitude to my academic supervisors Eng Marindiko and Eng Nyakutsikwa and to all the lecturers in the Civil and water engineering department for the knowledge they gave to me which made it possible to undertake this industrial exposure.

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ABBREVIATIONS

SAZ……Standard Association of Zimbabwe

SHE……Safety, Health, Environment

WHO……World Health Organization

EMA……Environmental Management Agency

CoH……City of Harare

BOD……BiochemicalOxygenDemand

COD……ChemicalOxygenDemand

DO……DissolvedOxygen

SS……Suspendedsolids

TH……TotalHardness

TA……TotalAlkalinity

TDS……TotalDissolvedSolids

NTU……NephelometricTurbidityUnit

HTH……HighTestHypochlorite

P.E……PrinceEdward

M.J……MortonJaffray

ML/day……Megalitresperday

SG……SpecificGravity

ABSTRACT

This report summarizes the activities which the student engaged in and the knowledge he acquired from the activities he carried out during the period of his industrial attachment. The student was attached to work at Harare Water department under the City of Harare. The student worked at various stations in the department including working at old mutual house, wastewater and water workshop, Firle wastewater works and Morton Jeffery water works. This report comprises of the responsibilities and position of the student in the organization at assigned various stations. It also encompasses the skills learnt and developed by the student. This write-up also illustrates the processes involved and equipment used in the treatment process of wastewater at Firle and raw water treatment at Morton Jaffray water treatment plant. Discussed in this report is a summary of the company background information, works done and the lessons learnt by the student. This report also highlights some of the challenges faced by the organization at its various stations and recommendations made by the student to overcome these challenges.

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CHAPTER ONE

1. INRODUCTION

1.0 Introduction

For the period which the student is given the opportunity to be on industrial attachment, he or she is given the chance to bridge the gap between theoretical knowledge and real field work since the student would have the privilege of being under the guidance of a qualified Industrial Supervisor. The main focus of tertiary institutions, either public or private is on professional career development using varying methods of training (Mukabeta & Taruvinga, 2001). Industrial attachment was first introduced worldwide in the form of apprenticeship with learners going through training under skilled mentorship Whalley (1986). It is during the attachment period that the student gets to develop work related skills such as good communication skills, self-reliance skills, and establishment of industry networks and contacts. Industrial attachments also benefit the Tertiary education institutions, the organisation at which the student is attached and the employer. The benefits to the institution includes getting feedback on the performances of the students from the industry (Dondofema, 2020).The employer is also able to identify potential employees which they can assimilate into their system after completion of their studies.

The purpose of this chapter is to account for the time spent by the student at Harare water a department under the City of Harare in acquiring knowledge on his industrial attachment. This chapter highlights the municipality of Harare's organizational structure and operations as well as its vision, mission and core values. However more emphasis will be given on the stations the student was attached to. These stations included Firle wastewater treatment plant, Morton Jeffrey water works, wastewater and water workshop and old mutual house for engineering drawings, designs and work.

1.1 Company Background

The city of Harare as an administrative body carries the responsibility of providing services to people who stays in Harare and the bordering local authorities. The organisation has its roots traced to 1890 when it was established as a Fort by the Pioneer Column, a military volunteer force of settlers organized by Cecil John Rhodes. It was declared a Municipality in 1897 comprising of seven wards and seven councillors. Councillor Fairbridge was the first mayor. Salisbury became a city in 1935. Its original name was Fort Salisbury named after the British Prime Minister Lord Salisbury of 1890 and it subsequently became known as Salisbury. It later became the capital of the Federation of Southern Rhodesia, Northern Rhodesia and Nyasaland from 1953 to 1963. After the Federation period it remained the capital of Southern Rhodesia. When the black majority attained independence from white colonial rule in 1980, Salisbury was renamed Harare on the 18th of April 1982. Despite the unstable beginning, City of Harare has grown both structurally and demographically. As industry grew rapidly, the need for more labour arose due to population growth. City Of Harare faced challenges of delivering more

services to the growing population hence it resorted to recruiting more employees to cope with the increase in the number of people which in turn led to the rising need in creation of more Departments. The first black Mayor and Town Clerk were Councillor Gwata and Edward Kanengoni respectively after 1980. In 1996 Mr Salomon Tavengwa was the first black executive Mayor elected by the electorate. Currently, Herbert Gomba is the ceremonial Mayor of Harare. Accordance with the Town Planning Act of 1976 the City of Harare is responsible for providing safe, clean drinking water, sewerage reticulation, road infrastructure and accommodation to its residents. Harare water department has responsibilities which involve production of drinking water, distribution of water, sewage collection and wastewater treatment in Harare.

1.2 Business Activities

The major business activities of the City of Harare is to provide services for its residents such as,

- Production and distribution of drinking water
- Sewage collection and wastewater treatment
- Garbage collection
- Rehabilitation of roads

1.2.1 Organisation objective

- To deliver and develop high quality goods and services to its stakeholders in a move to attract internal and external investments.
- To conduct a local poverty evaluation to produce a local profile on Harare.
- To use this profile as a basis for City -wide dialogue on how best to address poverty.
- To ensure the provision and accessibility of services to the urban poor thereby conforming to the human rights concerns of the urban poor thus promoting local civic participation.
- To conduct an institutional audit of the main stakeholders of the organization.
- To hold a City Consultation workshop in an effort to develop specific action plans for poverty reduction.
- To make an analysis of the environment in order to identify opportunities and threats of the organization.

The main motive of the Organisation is not to make profit but to provide quality service and infrastructure development. However to finance the services it provides for its residents the CoH collects revenue from individuals and business organizations in the city which would finance projects run by the city. Some of the revenue is used for upgrading and expansion of its water and sewer networks.

1.3 Cooperate Culture

1.3.1 Vision

- Harare to achieve a world class city status by the year 2025.

1.3.2 Mission

- To provide all consumers with affordable quality water and waste water services all the time.

1.3.3 Core Values

- Commitment
- Integrity
- Transparency

1.4 Organograms

1.4.1 The structure of the organisation

The City of Harare is a parastatal that falls under the Ministry of Local Governance Urban and Rural Development. It is headed by the Town Clerk and councillors. The City of Harare is comprised of six departments with different sections, all overseen by the Town Clerk.

1.4.2 The organogram of the City of Harare

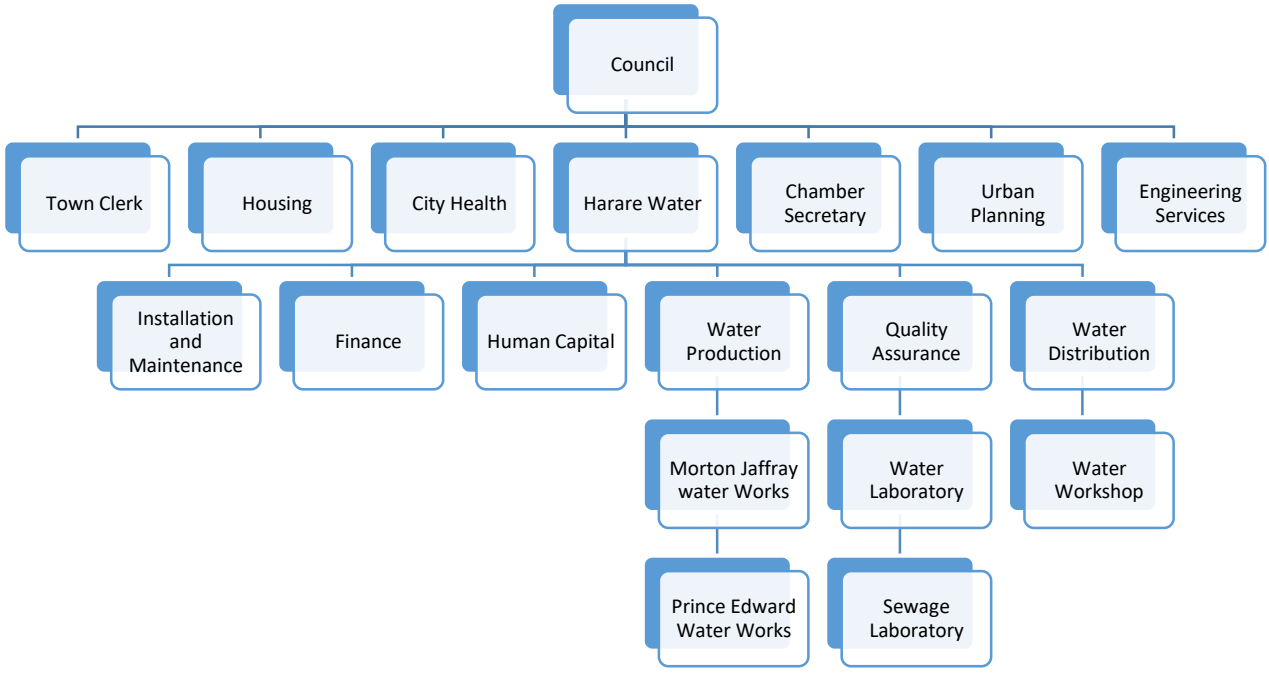

Figure 1: The organogram of the City of Harare

1.4.3 Harare Water Department

Harare Water Department is made up of eight divisions, namely Human capital, Finance, Water Production, Water Distribution, Wastewater, Quality Assurance, Maintenance, Project and Technical Services. This department has a mandate of delivering potable safe water and wastewater services to everyone who resides in Harare and surrounding local Authorities like Chitungwiza, Epworth, Ruwa and Norton. The department is working towards achieving the Sustainable Development Goal that ensures the availability and sustainable management of clean water and sanitation for all.

The services offered by the Organisation are split into:

1.0 The service delivery organs which are:

- Waste management
- Housing and Community services
- Engineering services
- Fire services
- Road and water drainage
- Road traffic signals
- Survey
- Welfare administration
- Cemetery services
- Educational institutions
- Public health services
- Water provision
- Plumbing services
- Sewerage reticulation blockages and treatment

2.0 The Planning, Regulatory and administrative organs:

- Urban Planning Services
- Human Capital
- Finance
- Corporate services (chamber secretary)
- ICT and Communication
- Emergency services

1.4.3.1 The responsibilities and activities of six divisions of Harare water department

Division	**Responsibilities**
Wastewater	Garbage collection, treatment of wastewater.
Water production	Responsible for producing potable water.
Water distribution	Responsible for distributing the final product to the city.
Human Capital	Responsible for recruiting qualified employees, handling employee relations and compensation of employees.
Finance	Allocating funds to all departments, setting company budgets as well as making payments.
Quality assurance	Upholding and maintaining the quality of raw materials, products, processes and procedures.

Maintenance	The department works with water production, water distribution and wastewater in maintaining and servicing the plant equipment.

Table 1: The Responsibilities of the six divisions of the Harare Department

CHAPTER 2

2.0 FIRLE WASTEWATER TREATMENT PROCESS

2.1 Background

Phosphorus Nitrogen are the major and primary causes of eutrophication in surface water. The symptoms of over-enrichment include low dissolved oxygen, increase in aquatic death. Large amounts of nutrients in water can also enhance the activity of microbes, such as Pfisteria, which may be hazardous to human (U.S. EPA, 2001). The principle behind wastewater treatment is to assimilate and speed up natural chemical and biological processes by which water purifies itself in water bodies since the increased population renders the self-cleansing process difficult. The municipal wastewater from households, industries and storm water, largely composed of water (greater than 99%), contains suspended and dissolved organic, inorganic matter, pathogens, dissolved gases (methane, hydrogen sulphide and carbon dioxide among others) and nutrients which need to be removed at various stages of the treatment to prevent pollution in rivers.

The department of wastewater management has five wastewater treatment plants shown on the table below

Plant Name	Treatment Criteria	Design Capacity	Discharge River
Firle	2 biological filter and 3 BNR units	144.0	Mukuvisi
Crowborough	2 Biological and 1 BNR units	54.0	Marimba
Hatcliffe	1 BNR unit	2.5	Mazowe
No table of figures entries found .Donnybrook	Waste stabilization ponds	12.0	Ruwa
Marlborough	Waste stabilization ponds	7.0	Gwebi

Table 2: Harare wastewater treatment plants

2.2 FIRLE SEWAGE WORKS EQUIPMENT AND PROCESS DESCRIPTION

Firle sewage works is the biggest sewage treatment plant in Zimbabwe located 12 km upstream of Lake Chivero along Mukuvisi River. It has 5 units and having a design capacity of 144ML/day. The catchment area of Firle sewage works stretches from Mukuvisi to Chisipite, CBD, Hillside, Greendale, Eastlea, Harare Hospital, light industry, Msasa Park, Highfield, Glen Norah, Glen View, Budiriro, Waterfalls, Mbare, Adbernie and Southerton.

Wastewater enters the plant through two trunk mains of diameter 1350mm that discharge water into the stabilization box. The stabilization box helps to calm the tenacity of the influent as it will damage the plant equipment. It also helps in mixing the industrial and domestic wastewater to provide a uniform mixture to avoid the overloading of the system organically since the domestic wastewater has high BOD. The stilling box is also designed with steel gates to control the amount of influent getting into the treatment plant. From the stabilization box it is channelled to the split box where it is directed to different screen chambers.

2.2.1 Block Flow Diagram

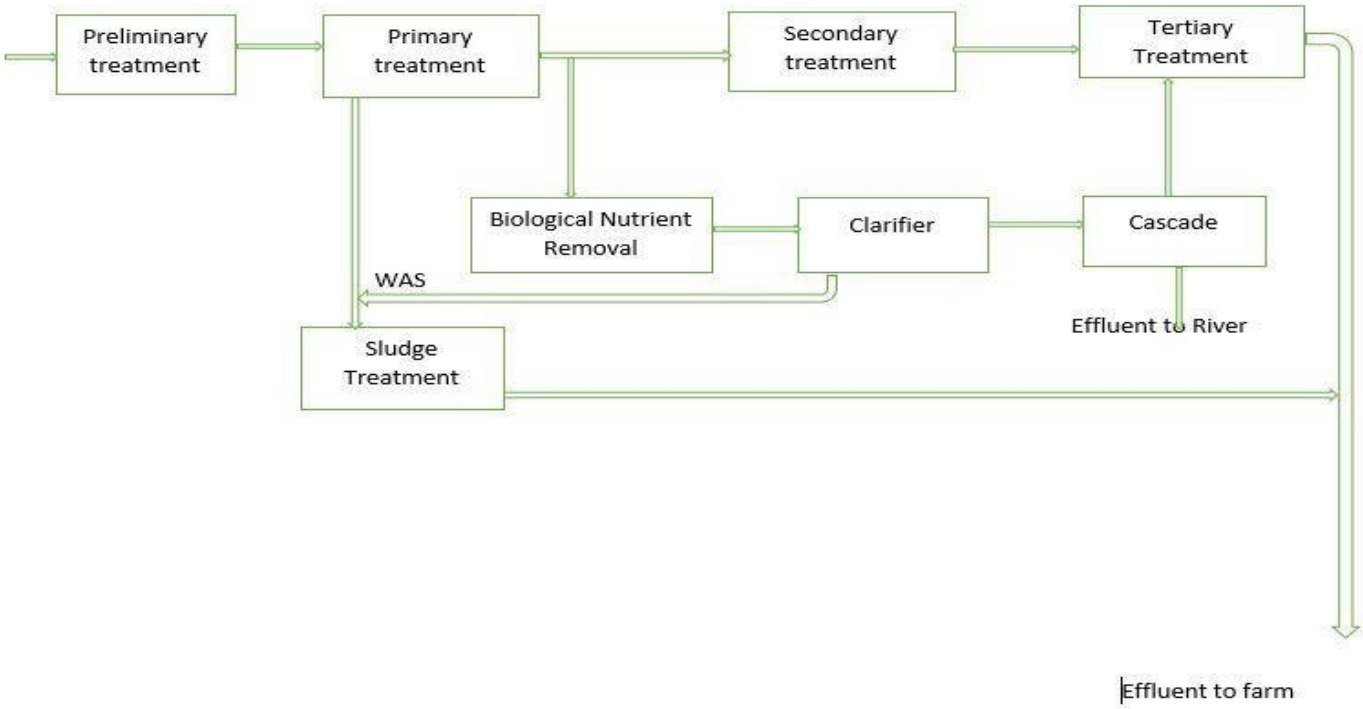

Figure 2: Firle wastewater treatment block flow diagram

2.3 Wastewater Treatment Process

At Firle there are four categories of treating wastewater namely the Preliminary stage, Primary stage, Secondary stage and the Tertiary stage.

2.3.1 Firle Process Flow Diagram

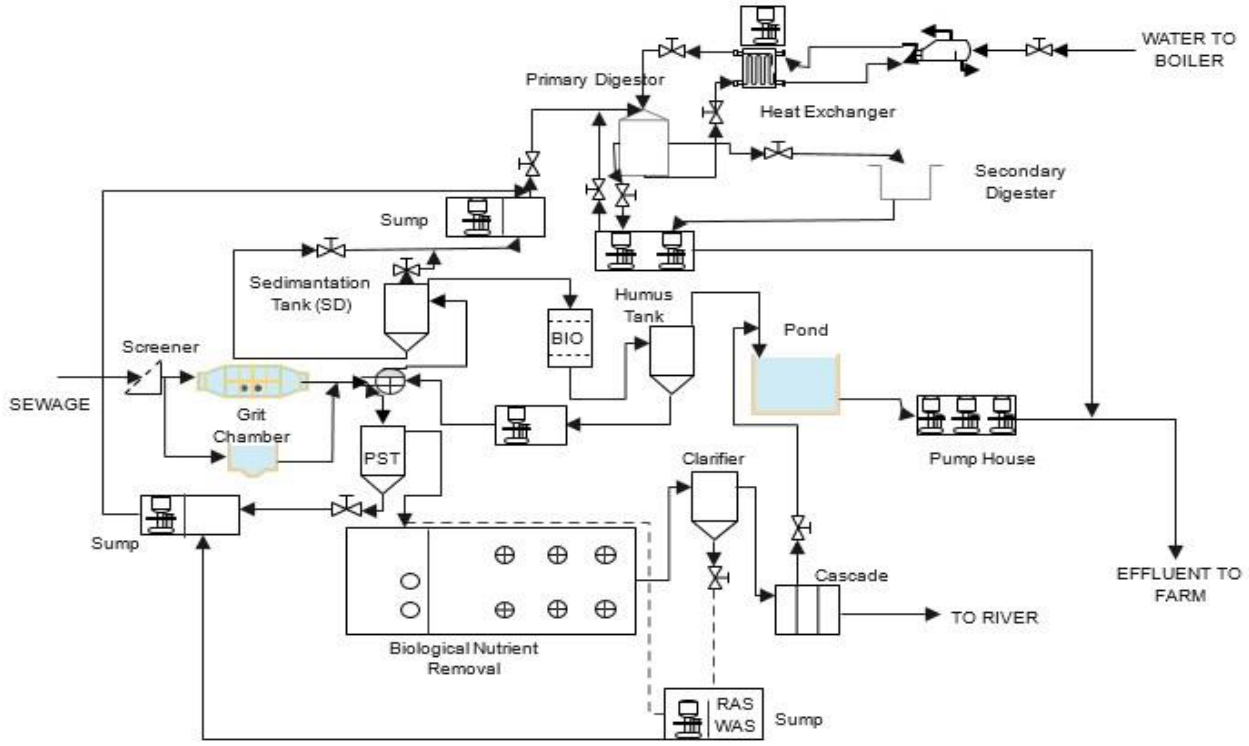

Figure 3: Firle wastewater process flow

2.4 Preliminary Treatment

This stage involves the removal of inorganic substances such as sand, gravel, plastics, sticks, metal particles, cloth and rags from clothing industries in wastewater.

2.4.1 Screening

From the Inlet the influent (raw sewage) goes to the screens for the screening of heavy debris, plastics, rags and other foreign objects not wanted from the waste water. The main objective of screening is for the foreign objects from the wastewater not to interfere with the treatment processes as this would result in the damage of effluent pumps or breakdowns as well as the blockage of sludge pipes. The wastewater from the inlet first passes through the coarse screens which have a bar spacing of 75mm-100mm, this type of screen removes large and heavy suspended inorganic solids. Just after coarse screens there are medium screens to trap some of the inorganic solids which could have escaped the first screening stage. The final stage of screening involves the use of fine screens which have a bar spacing of 10mm-50mm so as to remove small inorganic solids which could have escaped the first two screening stages. The materials collected at the screens are called screenings. At Firle treatment works screenings are then removed from the screens manually using specially designed rakes, forks, brushes and then placed on the concrete surface although other countries use mechanical method. The wastewater allowed to pass through the screens goes into the next preliminary stage which is the grit removal.

Figure 4: Coarse and medium sized screens

2.4.2 Grit removal

This process involves the removal of sand and gravel particles from the wastewater which may settle in the settling tanks through the process of sedimentation. Grit removal process is important because grit choke the system, wear mechanical components and settle along treatment equipment as this cause the reduction of capacity of the plant if the grit is not removed.

2.4.2.1 Types of grit removal

a Vertical grit removal chambers

It consist of rectangular concrete baffles which are 9m deep. Each baffle has two orifice gates which allows water to flow off the chamber. The baffles are designed in such a way that they reduce speed or velocity of flow to $0.3ms^{-1}$ to allow grit settling as the wastewater will be flowing with a steady and low velocity. The grit chamber is designed in such a way that the grit will slip off to the deepest end of the chamber (it is shallow at the inlet of the chamber and increases its depth to the end of the chamber) where an air compressor lift pump is used to pressurize air which then agitates the settled grit. The pressurized grit will be forced to the grit conveying pipes. The 150mm conveying pipes will convey grit to the grit box. The grit undergo water horsing to remove the organic matter carried with it before disposal.

Figure 5: Vertical grit removal chamber

b Horizontal/Mechanical grit removal chambers

They are rough shallow circular units designed with weirs or flumes to reduce the velocity of flow to 0.3m/s which is the crucial velocity of flow in the grit utility chamber. At this velocity the sedimentation of grit material which has a higher density occurs much more rapidly compared to organic solids. The settled grit will be scooped by a scrapper which is driven by electric motors, deposited to a collection sump where water is drained. Grit elevator lifts the grit and deposits it into a trailer which is carried regularly for disposal. There are organic pumps which separate organic and inorganic grit so that the organic grit proceeds for the treatment process. The volume of the collected grit can also be determined.

Figure 6: Mechanical grit removal section

2.4.3 Splitter box

It splits the wastewater to different respective treatment units. The box has high depth to allow for settling of grit that escaped from the grit removal chambers. It also receives Return Activated Sludge (RAS) from humus tanks which has starved bacteria to act on new food to aid the process of settling in Primary Settling Tanks.

Figure 7: Wastewater splitter box

2.5 Primary Treatment

At this stage there is need to separate faecal matter/organic matter and the influent through the process of sedimentation in the Primary Settling Tanks.

2.5.1 Primary Settling Tanks

Primary Settling Tanks are circular, conical and inverted in shape and the conditions in these tanks are very quiescent to allow sludge settlement at the lowest point where it can be collected. PSTs are also called Dortmund tanks and they have a depth of 9m. The effluent from the preliminary stage is introduced at approximately 15m depth below the top surface to allow the settling of sludge in the tank. There is a desludging valve at the bottom of the tank which when opened draws-off settled sludge from the tank. The scum which consists of the grease, oil, and fluffy floating material are drawn off from the PST using a scum draw-off pipe and mixed with settled sludge on the sump where it is pumped to the Primary Digesters. There is regular desludging of PSTs to avoid sludge build-up which can choke the system and to prevent algae formation which may lead to the reverse process Primary Settling Tanks are cleaned regularly. The effluent from the PSTs gravitates to either biological filters which uses the convectional system or Biological Nutrient Removal system.

Figure 8: Figure showing a Primary Settling Tank

2.6 Secondary Treatment Process (Convectional process)

2.6.1 Biological Filters

Biological filters are circular concrete structures of depth ranging from 0.9m – 2.5m which contains highly permeable media of suitable size to prevent clogging and enhance air circulation. This is usually made of gravel, lava stone, plastic or rock as used at Firle Wastewater Works. New technologies use plastic balls, interlocking sheets of corrugated

plastic, or other types of synthetic media. This technology provides more contact surface area and a more conducive environment for bacteria growth and biological treatment. The effluent from PSTs decants in a channel into a division box where it is evenly distributed into biological filters. Bio-filters mainly aim at treating Biological Oxygen Demand (BOD) through the use of micro-organisms found on the filter media in the bio-filters Wastewater is sprinkled uniformly over the top of the filter media by a rotating distributor with arms mounted on a distributor pivot. The arms are circular pipes with nozzles that discharge the effluent onto media although other countries use open channels with overflow weirs. The rotating arms are hydraulically driven by the thrust induced as the water is discharged from the distributor arm or can be electrically driven by a motor as in other countries. The attached growth (fixed film) principle is applied within a trickling filter. As wastewater trickles down the filter, microorganisms adsorb and attach themselves onto the surface of the media. As wastewater continues to flow past the media, organic matter is then degraded by a population of the attached bacteria before it trickles down the full depth. The microorganism layer continues to grow as bacteria grows and continues to adsorb on media hence the slime layer (biomass) increases in thickness. With time, anaerobic conditions develop at the surface of the medium since the organic matter and oxygen are consumed before reaching the medium surface hence inner bacteria is deprived of food and oxygen. This complicated respiration at the surface of the media reduces the ability of the bacteria to cling on the media surface hence all the accumulated bacteria on that media falls and escapes within the effluent. This self-cleansing action is cyclic and new bacteria film layer continues to be attached and removed from the system. For effective operation, the bacteria growth in the filters should equal the number of bacteria flushed out of the filter to avoid solid accumulation in the filter which can lead to clogging hence leading to reduced air circulation thereby reducing filter efficiency. The effluent is collected at the perforated under drain bottom and channelled via a launder to a distribution box that directs it to humus tanks

2.6.2 Humus Tank

It is a secondary settling tank found after the bio-filters which has a similar working principle to that of PST. In humus settling tanks there is no scum and the outer baffle board required. SST are for removing humus sludge, separation of dead and drying insects from the bio-filters and settling of BOD and colloidal particles. Humus is removed by the principle of hydrostatic pressure which builds when the draw-off valve is opened which forces the humus sludge underneath the tank to draw out and flow to the sump where it is pumped to the split box which is found after the preliminary stage. The Return Activated Sludge then gravitates to PST where it settles as sludge which is later drawn off to the sump where it is then pumped to the Primary Digester. If the Humus is not removed it will absorb the dissolved oxygen and result in de-nitrification thus reversing the chemical changes that have taken place in the filters. The effluent from the humus tank then gravitates to the maturation ponds for the tertiary treatment process.

Figure 9: Humus tank

2.7 Tertiary Treatment Process

2.7.1 Maturation Ponds

Maturation ponds are large and shallow with a length of 174m, a width of 120m and a depth of 2m, allowing sunlight to penetrate the volume of the water along the pond destroying pathogens in it as the final treatment. These ponds must be shallow and they should cover a large area, sufficient to give a retention period of 15-25 days. Maturation ponds reduce the ammonia, nitrate and phosphates. Maturation ponds act as buffers in the event of overloading or a breakdown at the sewage works. Treated effluent is then pumped to the farms for irrigation of cattle farms. Before the effluent is pumped to the farm mixed with the treated sludge from the digesters to irrigate the grass fields and in doing so the phosphorus and nitrogen still in the effluent wastewater is taken up by the plants and as it infiltrates and percolate into the ground it filters the remaining impurities making it safe for disposal into the rivers/streams.

2.8 Biological Nutrient Removal (BNR)

Biological Nutrient Removal Treatment system can also be called Modified Activated Sludge (MAS). Effluent from the PSTs designated for unit 3-5, which uses the BNR process decants and makes its way to a division box where it is evenly distributed among the available units. Unit 4 and unit 5c is the only unit functioning at the moment. Unit 4 has a length of 90m a width of 32.8m and a depth of 4.7m and also has a design capacity of 18ML/d. In the activated sludge process the carbonaceous organic matter of wastewater provides an energy source for the production of new cells in a process called synthesis while at the same time releasing energy from the conversion of this organic matter through a process of respiration.

2.8.1 The BNR System

It has three zones for the treatment of wastewater, the fermentation basin, anoxic zone and the aeration zone from the arrangements of the zone but the process runs from fermentation to aeration to anoxic zone.

2.8.1.1 Fermentation zone

In this stage settled raw water from the primary settling tanks and the return activated sludge (RAS) from the BNR's clarifier mixes. This zone is kept under anaerobic conditions. De-nitrification takes place and bacteria is starved due to very little oxygen. This results to the release of phosphates. There two stirrers in the fermentation stage to agitate the contents so as to discourage sedimentation and keep the particles in suspension.

2.8.1.2 Anoxic zone

This is the second zone in the reactor. Again, this zone is kept under anaerobic conditions however there is oxidized nitrogen. De-nitrification occurs in this zone as bacteria uses the oxygen from the oxidized nitrogen releasing nitrogen gas.

$2NO_3 \Rightarrow N_2+3O_2$.

2.8.1.3 Aeration zone

This is the third and last zone of the three stage BNR reactor. After the Anoxic zone, the influent goes to the Aeration zone where there is nitrification and phosphates uptake. NH_4 $NO_2 \Rightarrow NO_3 \Rightarrow$

Ammonia is converted to Nitrate by Nitrosomonas species bacteria and Nitrate is further converted to Nitrite by Nitrobacteria species. Oxygen is subjected into the effluent by the help of aerators and after the retention time which is 15 to 25 days the effluent is discharged from the BNR through the weir.

2.8.2 Clarifiers

From BNR the effluent goes to the division box where it is then uniformly distributed to the three clarifier for unit four and each clarifier receiving 6ML/day. In the clarifiers, sludge is removed using the telescopic valve and the scouring valve. Much like the PSTs, settleable solids including the microorganisms from the BNR settle at the bottom and the clear effluent decants in a channel. The sludge from the clarifier carries active bacteria which is still needed in the BNR treatment process. As such, it is de-sludged into a sump where some of it is pumped back to the fermentation zone mixed with the incoming raw wastewater from the PSTs as return activated sludge (RAS), while the unwanted sludge is wasted, Waste activated sludge (WAS)

is also removed from the surface and it is pumped straight to the secondary digesters; it is also known as excess sludge. The outputs of the clarifiers are RAS (underflow), WAS and overflow.

2.8.3 Cascade

The effluent from the clarifiers goes to the cascade where it is re-aerated to increase its dissolved oxygen while releasing traces of nitrogen gas that might still be in the water. In the cascading the water runs down the series of steps. As water runs down the steps there is introduction of oxygen to the effluent. Little or no oxygen in the effluent cause increases in BOD, COD and this can be seen through death of aquatic life, so cascade increases the dissolved oxygen in the effluent. However, only the wastewater treated by the BNR method is released into the river. This is because this wastewater has been treated of the nutrients that cause eutrophication, nitrogen and phosphorus. In case of a breakdown in the system or the final effluent does not meet the required standards, the effluent is channelled to the ponds. This is the stage where the treated wastewater is polished and made ready to introduce to the receiving waters of Mukuvisi River.

Figure 10: Figure showing a cascade for spread aeration

2.8.3.1 BNR effluent standards to the river

Components	Amount (mg/l)
Ammonia	0.2
Phosphates	0.1
4 Hours PV (BOD)	10.0
COD	60.0
Suspended Solids	25.0
Total Nitrogen	10.0

Table 3: Table showing effluent standards

2.9 Sludge Treatment

2.9.1 Digesters

They are categorized into primary and secondary digesters.

Figure 11: Figure showing primary and secondary digesters at the plant

2.9.1.1 Primary Digesters

Two types of P.Ds used at Firle Sewage Treatment Works are the Water sealed digesters that are fed one by one at a time and Towered System Digesters which can be fed equally up to four digesters at once. Primary digesters receive untreated raw sludge from P.S.T's of the conventional treatment and from the PSTs of the BNR system. These digesters are sealed at the top to provide anaerobic conditions and they are doom shaped at the roof top for easy collection of methane gas at the cone apex. The sludge can be supplied into digesters either at the top so that it mixes the treated and untreated sludge or at the middle of the digesters so that as sludge accumulates, scum which is less dense is forced upwards where it spills into scum collectors. When the PD is full and the sludge is treated and meet the detention time of 18 to 28 days, we drop a third to the secondary digesters and feed a third to the PD. When the PD is full it now undergoes the mixing process. Mixing in the digester is crucial and very important as it helps to ensure even temperature distribution, uniform biomass distribution for the bacteria to act on and breaking blanket layers formed due to different sludge material densities. Mixing can be achieved by drawing off sludge from the bottom and simultaneously feeding it at the top for about 3-4 hours. Three layers on the PD which needs to be mixed are the thick sludge, watery sludge and a scum blanket hence mixing provides equal distribution of food for the

bacteria. The bacteria can only work under its optimum temperature of 37°C, since raw sludge has low temperature it has to be heated to achieve this temperature. The process of heating uses double shell heat exchanger in which sludge is pumped to the heat exchanger and pumped back to the PD. Heating continues until the required temperature is met. The retention time of a P.D ranges from 20-28 days. The measure of the treatment process is determined by the amount of methane gas produced. A sludge level indicator gauge is used to detect how much sludge is contained in the digester. When emptying the P.Ds, only about a third is pumped to secondary digesters with the help of five digester sludge pumps and the remaining two thirds of the treated sludge containing starved bacteria should be maintained in the PD before feeding a third of raw sludge to the digesters

2.9.1.2 Secondary digester

The secondary digesters can also be referred to as the holding tanks since there is little or no process occurring in the digester. They are open on top to allow uv-light to penetrate through the digester and kill all the microorganisms that has managed to escape from the PD. The digesters receive treated sludge from primary digesters. The three Sludge injection pumps are used to pump the treated sludge into lines that convey effluent from maturation ponds of the conventional method to farms for further treatment.

CHAPTER THREE

3.0 Morton Jaffray Water Treatment Process

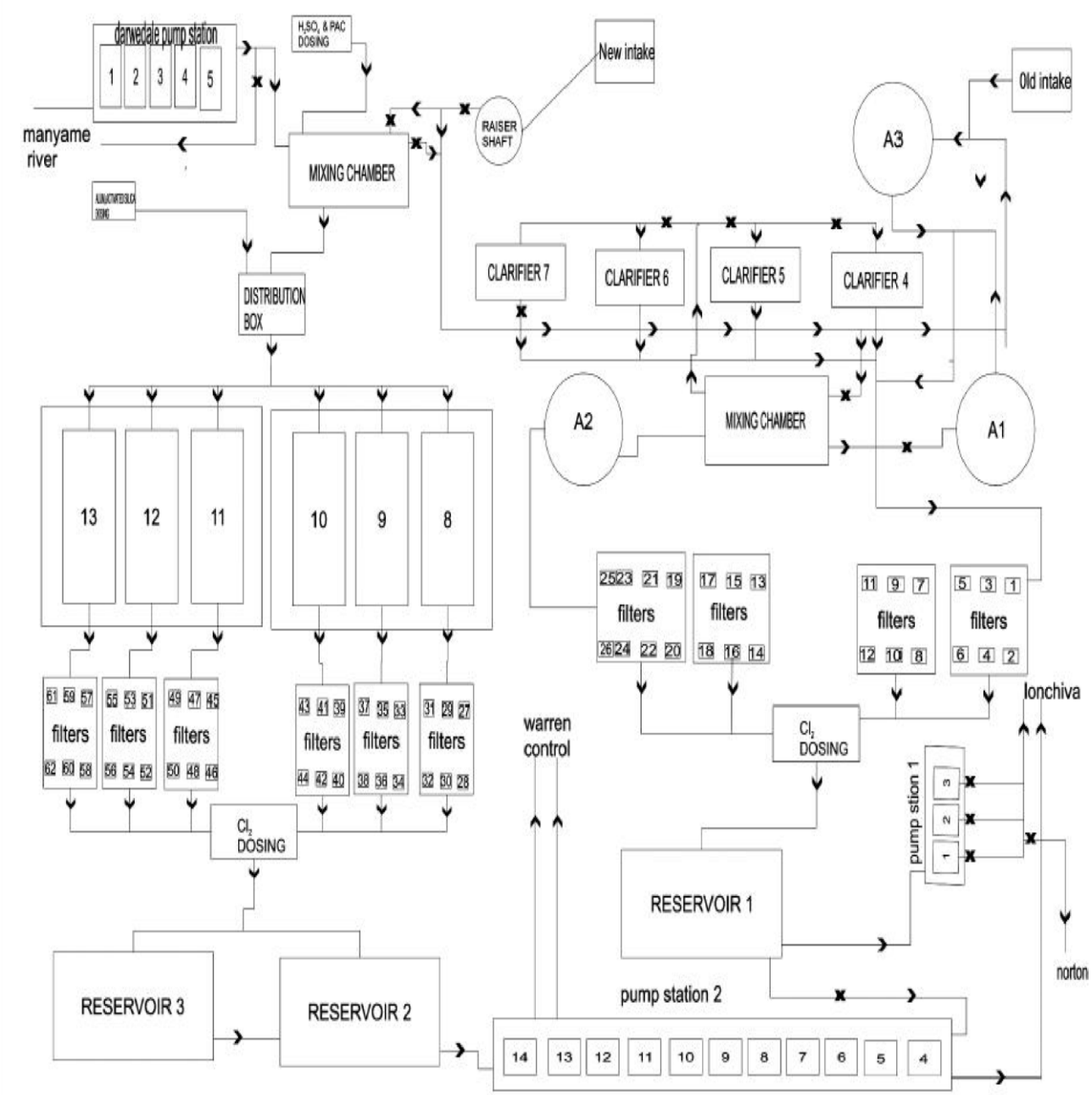

Figure 12: Process flow sheet for Morton Jaffray water works

3.1 Introduction

Morton Jaffray water supply infrastructure was originally designed to supply 350 thousand people. MJ water works was commissioned in 1954 with the purpose of supplying Harare residents with potable safe water, which was in line with the Sustainable Development Goal that ensures the availability and sustainable management of clean water and sanitation for all. The infrastructure was upgraded progressively with the last phase commissioned in 1994 to supply over 2.5million people with safe and potable water. Clean water provisions fights bacterial diseases such as typhoid, dysentery and cholera. Currently the plant is providing Harare, Chitungwiza, Norton and Inkomo Barracks with safe clean water.

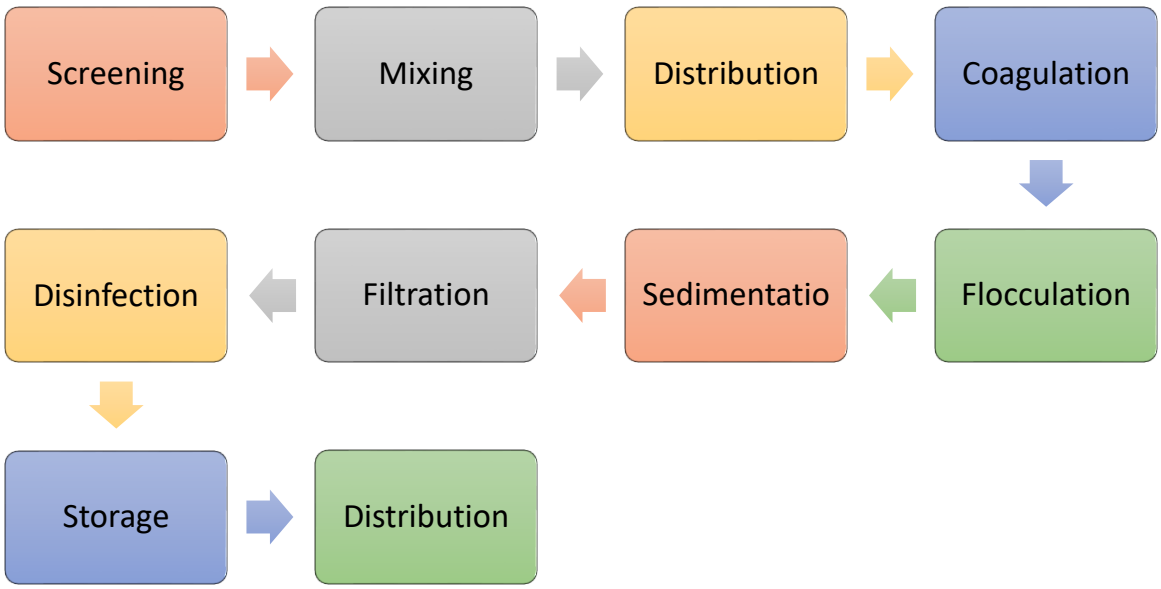

Figure 13: Block flow processes for stages in raw water treatment

3.2Water treatment process

3.2.1 Raw water abstraction

There are two sources of raw water to Morton Jaffray water works which are Lake Chivero and Lake Manyame. The use of Lake Chivero and Lake Manyame as sources of raw water is to allow blending of raw water to improve the quality of the final product. The quality of water at Lake Chivero has depreciated due to effluent water from industries upstream of the lake and there is also increased algae growth in the lake which thereby compromise the quality of the final water produced. Raw water from Lake Manyame is relatively clear and clean compared to the one from Chivero hence to counter all this raw water from Lake Manyame and Lake Chivero are blended.

3.2.2 The Mixing Chamber

At the mixing chamber water from the two lakes is mixed and activated carbon is also added to the water for the adsorption process which helps to eliminate smells from the raw water. There are specially designed weirs at the mixing chamber which allows raw water to cascade over them, thus removing hydrogen sulphides trapped in it via spread aeration.

3.2.3 The Distribution Chamber

Raw water from the mixing chamber containing activated carbon, high pH and high turbidity flows to the distribution chamber, where it is split into six different channels each leading to a different clarifier.

3.2.4 The Channels

The aluminium sulphate added to the water along the channels has positively charged aluminium ions which reacts with negatively charged colloidal particles in water thus forming flocs. These particles help to trap suspended matter from the water. Silica solution is also added to help the flocculation process, thus enlarging flocs such that they settle easily.

3.2.5 The Pulsator Clarifier/Suspended Blanket Clarifier

Figure 14: Figure showing a Pulsator clarifier

In the clarifier water is introduced from the bottom of the clarifier in pulses hence the name Pulsator. Clean water moves in the vertical direction, collects in the launders and then flows into the filters. Sludge moves in the horizontal direction, collects in sludge hoppers and the finds its way out through the sludge disposal system.

3.2.6 Filtration Process

Rapid gravity sand filters are used for the filtration process. As from the filter name, these filters employ sand of uniform grain size to ensure a rapid filtration process. The filtration process removes excess turbidity and suspended particles from the water, thus making the water transparent/clear. Cleaning of the sand filters can be done through the backwashing process and this aids in removing flocs carried over from clarifiers, avoiding mud boring and killing the bacteria in the filter media.

Figure 15: Figure showing a rapid gravity sand filters under backwashing process

3.2.7 Disinfection Process

Chlorine solution is added to the water from the filters to disinfect the water by killing bacteria in it. Chlorine is used as a disinfectant because it has a residual effect which takes care of future bacterial contaminants.

3.2.7.1 pH Control

Dosing aluminium sulphate in the treatment of water leaves it with low pH and water which is acidic have a tendency of corroding pipework. Lime is added to water in the sump as a corrective measure to lift its pH to between 7.5 and 8.3

3.2.8 Storage

After the process water is stored in the reservoirs for about two hours, before being pumped from the treatment works to the consumers.

CHAPTER FOUR

4 WORKDONE BY THE STUDENT (ACTIVITIES)

4.0 Introduction

This chapter gives a detailed explanation of what the student has covered during the internship period. It also explains the description of all the departments in which the student has gained knowledge during his attachment period on his program in the City of Harare.

4.1 The student setting up a dumpy level and taking levels in Sunningdale area

The legs of the tripod stand were tightened and then pressed firmly into the ground with the base plate almost horizontal. The tripod should be firm so that it does not move in the process of taking levels. On the telescope the bubble was adjusted to be at the centre. The invert level of the existing manhole and the ground levels were taken to determine the path of the proposed sewer line into the existing sewer line for Sunningdale residential area clusters

4.1.1 Levelling Field Results

BS	IS	FS	RISE	FALL	RL	REMARKS
4.014					100.00	MHIL
	0.538		3.476		103.476	Ground next to MH
1.594		2.422		1.884	101.592	In the road
	2.772			1.178	100.414	L33
		4.045		1.273	99.141	L55
∑BS		∑FS	∑Rise	∑Fall		
5.608		6.467	3.476	4.335		

Table 4: Table showing levelling field results for Sunningdale area

4.1.1.1 Outcome

From the levelling results obtained during field work of the Sunningdale area survey, from L55 to existing manhole backflow of sewer is likely to occur because of very small/ close to zero gradients and from L33 to existing manhole there is possible flow of sewer. Therefore other means of sewage disposal had to be imposed for the cluster homes such as use of a bio-digester which is in objection with EMA regulations of discharging effluent into streams. The commissioning of a pump station, although running costs are incurred during the process.

4.1.2 Rehabilitation of Rufaro Stadium

The student participated in the project of rehabilitating Rufaro Stadium, a project being done with the City of Harare and City parking.

Figure 16: Figure showing students taking levels at Rufaro stadium

As a student engineer at training I was involved in taking levels for the proposed irrigation line for Rufaro football pitch under the supervision of Engineer Gore. Levels for the perforated drainage pipe line were also taken by the student to have a gradient of the pipe line. With the assistance of the Engineer the student also inspected the drawing of the proposed water and sewer line connection for Rufaro Stadium food-court into an existing sewer line at site before approval the proposed sewer line on the drawing.

4.2.0 Wastewater and Water workshop

The student was assigned to work at the workshop for 6 weeks where he had the knowledge of conveyance of sewage and potable water distribution. The student had the opportunity to work with plumbers in this division and here are some of the activities which the student carried out at the workshop during the process of familiarizing with the conveyance of wastewater and potable water in Harare.

4.2.1 Maintenance of pump stations

During the attachment period the student was involved in the maintenance of water pump stations which included Avonlea pump station, Orange Groove pump station, Alexander Park pump station, Avondale pump station and Greendale pump station. For maintenance the student swept floors of the pump houses and cut grass harbouring snakes around the pump houses which made operations of the pumps at the pump house difficult.

Figure 17: Figure showing student cutting grass at Greendale pump station

4.2.1.2 Operation of pump stations for example Greendale pump station

Figure 18: Figure showing a high rise reservoir

4.2.2 The student opened small gate valves using key valves

Figure 19: Figure showing a student opening gate valves

On this particular day the northern suburbs of the CBD and Westgate were not receiving potable water from the city council. For this exercise the student drove around the city with the maintenance team

opening small gate valves for water distribution such that water would flow to these suburbs with the opening of the main gate valve from Warren control.

4.2.3 Calibration of water meters for residential stands

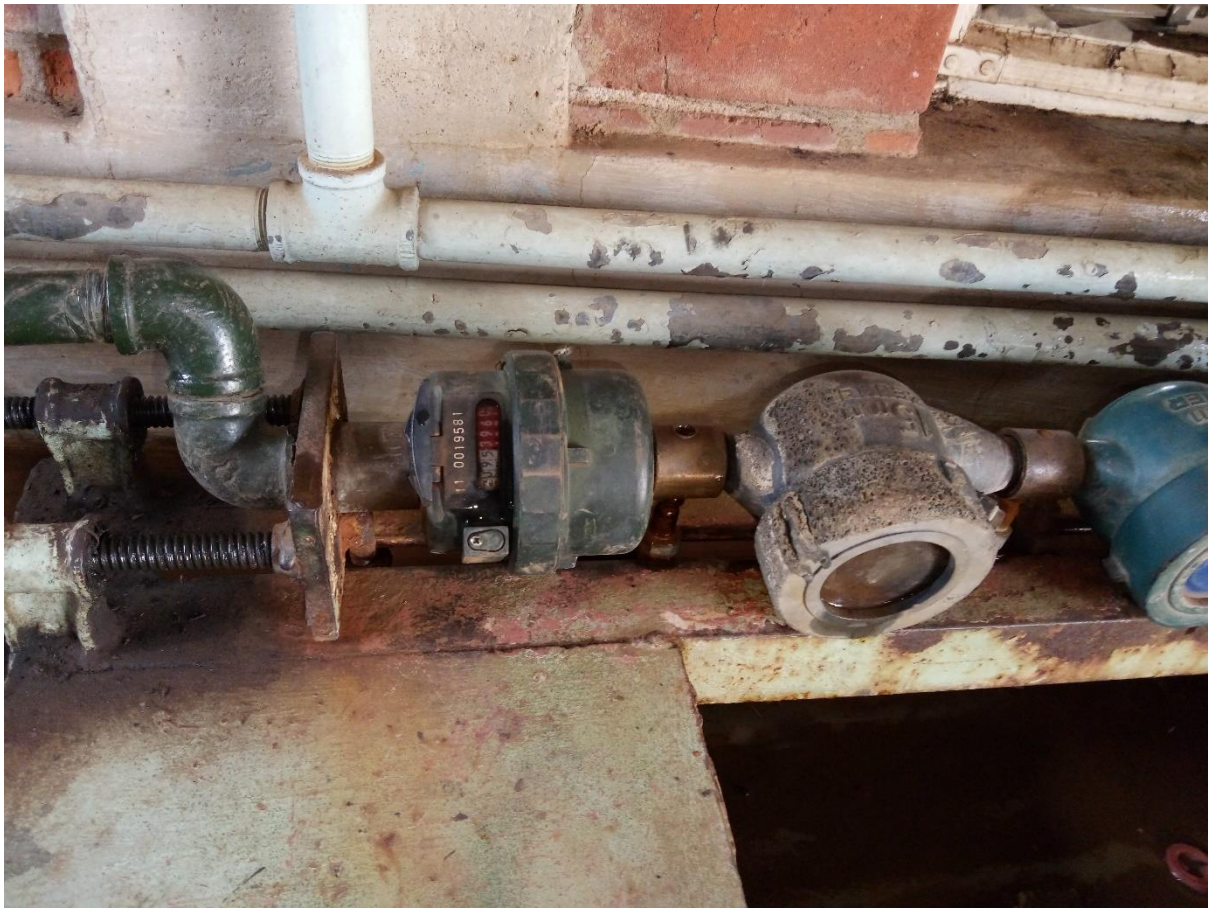

Figure 20: Figure showing a water meter under calibration

The student calibrated water meters for clients who complained of being overcharged by the city council. For water meter calibration three consecutive water meter tests for the same meter were carried by the student using a 500 litre water meter test machine. Initial and final water meter readings were taken before and after running the water meter for the 500litres of water to note the final reading on the meter so as to compute the volume of water recorded by the meter. This volume was computed by subtracting the initial meter reading from the final meter reading with an error of ± 10 litres being taken into account. I learnt that at times the water meter of the client might be with no fault and the client may be complaining of being overcharged whilst the client will be having water leaks from the laid pipes after the water meter connection.

4.2.4 Diversification of sewer line pipes

The sewer pipes laid were for conveyance of wastewater from Mashonaland Holdings in Gunhill to an existing main sewer line which comes from the North Eastern pump station sewer line. GRCP pipes were used at some connection points because of the pressure of the wastewater from the North Eastern pump station. Three Manholes were put in place at every point where there was a change in direction to the flow of wastewater. A 1.7m x 4.8m chamber with a vent was installed along the line to allow for the escape of gases which could result in pipes having a shorter life span.

4.2.5 Excavation work and repairing of a burst 1300mm diameter water line

Bursting of a new 1300mm diameter water line for the conveyance of potable safe water from Morton Jaffray resulted in flooding of the area. Excavation work was done along Bulawayo road near Lake Chivero just outside the premises of Morton Jaffray using a JCB to find the position of the leakage along the line. It was every worker's responsibility to ensure that all excavations were done safely to reduce or eliminate the risk of accidents.

Figure 21: Figure showing excavation works at MJ

A centrifugal pump was used to drain all the water which had flooded the area and discharging it into a nearby drain whilst the excavation works were being done until the point of leakage was found.

The student and the plumbers improvised to minimize the volume of water leaking. Wooden sticks were sharpened and then a hammer was used to hit the sticks to force them to the point where the leak was. This was done to minimize the volumes of potable clean, safe water being wasted whilst waiting for welders to deal with the burst.

4.2.6 Unblocking a blocked sewer line at Morris Depot

The student worked with plumbers to unblock blocked sewer lines. Unblocking of sewer lines was done manually using connected steel rods to push any foreign materials in the sewer line which could have caused the blockage. At first the student assisted in opening the manholes, manholes were then left open for some time before plumbing works were carried out for the poisonous gases entrapped in the manhole to escape into the environment. A blower was used at times to blow air/oxygen into the manhole if the manhole was deeper. One of the manhole along the line was plugged so that sewage could not flow to the next manhole along the line then a honey sucker was used to empty the manhole which the plumbers wanted to work on. Steel rods were then used to remove the choke from the line and when the choke was removed the plugged manhole was then unplugged and sewage started flowing off normally. The figure below shows a manhole filled with sewage as a result of blockage of a sewer line.

Figure 22: Figure of a blocked sewer line

4.2.7 Routine and periodic maintenance of manholes

The student was involved in routine and periodic maintenance works. The student participated in visual surveys of the conditions of the manholes to identify the ones that needed clearing. The manhole cleaning process was done manually with workers getting into the manhole to remove the foreign objects such as stones, plastics and bottles. The routine check was done on manholes because cast iron manhole lids were being stolen especially in Mbare. The student proposed the use of concrete manhole lids and PVC manhole lids rather than using the cast iron ones which are being stolen and sold to scrap metal buyers. As a student engineer at training I was also responsible for seeing that safety procedures were being taken into considerations when working at manholes.

4.3.0 Activities and responsibilities assumed at Morton Jaffray water works

The student was assigned to work at Morton Jaffray for 4 weeks where he had the knowledge of the processes of raw water treatment, chemical dosing of raw water, laboratory work and backwashing of filters at the plant. These were the activities done by the student at the plant:

4.3.1 Chemical House

Due to limited time the student worked at the chemical house for one week doing the following activities:

- Collected chemical stock daily for chemicals in the chemical house.
- Monitored mechanical equipment and reported malfunctions to electricians or workshop.
- Checked on hourly basis alum levels of alum tanks in use.
- Monitored and changed alum dosing pumps flow rates, corrected under doses and overdoses.
- Transferred alum from storage tanks to old works using pumps**.**
- Received results from the lab and analysed them.
- Visually inspected clarifiers.
- Balanced chemicals used and chemicals in stock at the end of every shift.
- Prepared activated silica using sulphuric acid and silica.
- Visually checked alum, silica flow into the flow channels.

4.3.2 Laboratory

The student worked at Morton Jaffray laboratory doing lab work for a week. Here are the responsibilities of the student at the laboratory:

- Determined percentage chemical composition of received alum i.e. granular of liquid alum.
- Determined the chlorine demand of filtered water.
- Tested free chlorine and residual chlorine in final water.
- Visually inspected clarifier performance.
- Cleaned laboratory work benches and floors.
- Tested for SG, temperature, percentage oxide and percentage aluminium sulphate in received liquid alum from ZIMPHOS.
- Tested for TA of activated silica in silica preparation tanks.
- Sampled and tested for pH, TA, turbidity in raw water, filtered water and final water.
- Tested for free and total chlorine in final water.
- Prepared N/50 -HNO_3, N/20 –NaOH and bromothymol blue indicator.

4.3.3 Filter

The student worked at rapid gravity sand filters for a week with the assistance of plant operator the student backwashed sand filters, recorded backwashed filters and monitored the

treated water reservoir level. Backwashing of sand filters was done to remove the flocs carried over from clarifiers, to avoid mud boring, cleaning the filter and killing of the bacteria in the filter media by using treated water with chlorine from the reservoir.

4.4.0 Activities and responsibilities assumed at Firle sewage works

At Firle sewage works the student assumed various working roles along the stages in the wastewater treatment process for the four weeks he was at Firle.

4.4.1 Intake/Pre-treatment area

At the pre-treatment area the student assisted the general hand working at the screening area. The student removed screenings manually using racks and specially designed forks and the screenings were then placed on a concrete floor next to the screens, where the screenings were hosed with a jet to remove organic material carried with it. The student then cleaned the working area using the reticulated effluent and hard brooms to remove smells that could have been of nuisance.

4.4.2 Primary treatment stage

During the days there was not much work at the treatment plant the student was involved in the maintenance of Primary Settling Tanks which involved cleaning the launders and weirs to remove the growth of algae that will reverse the process. On a daily routine the student would assist the operator working at the PSTs where the student desludged settled sewage and removed scum from the settling tanks. These operations were done so that sludge will not continue to accumulate in the settling which would result in blockage of the sludge draw-off pipe and as a result desludging of settling tanks was done twice a day.

CHAPTER 5

5.1 Occupational Health and Safety

The Occupational Health and Safety (OHS), section is under the Human Resources department. This section works hand in hand with the OHS policy which stipulates that all employees should be dedicated to the protection of their well-being at work and also prevent any possible accidents as well as protection of the environment where they work. The council believe that all employees should work in a physically, mentally and socially health and safe environment. Harare water department has a designated health and safety office that overlooks the day to day running of the entire organization in terms of health. It is regulated by the Factories and Works Act (20 of 1948), Healthy and Safety Act (1974), Labour Act (16 of 1985) and the National Social Security Authority. The Health and Safety Department is responsible for ensuring compliance with health and safety regulations, environmental regulations and quality control in all municipality departments. On the accident prevention aspect NSSA's aim is to create an awareness of, and promoting health and safety at all places of work. Encouraging adoption of health and safety legislation through factory and machinery inspection. Employees under the Harare water department and working in the field are provided with safety wear in the form of work suits, gloves, gumboots, overalls, safety shoes and helmets.

5.2 Hazard Control

5.2.1 Elimination

Elimination is a hazard control strategy based on completely removing a material or process causing a hazard and is the most effective of the five members of the hierarchy of hazard controls in protecting workers, and where possible should be implemented before all other control methods. Many jurisdictions require that an employer eliminate hazards if it is possible, before considering other types of hazard control. Elimination is most effective early in the design process, when it may be inexpensive and simple to implement. It is more difficult to implement for an existing process, when major changes in equipment and procedures may be required. Elimination can fail as a strategy if the hazardous process or material is reintroduced at a later stage in the design or production phases

5.2.2 Substitution

The second best way to control a hazard is to substitute something else in its place that would be non-hazardous or less hazardous to workers. For example, a non-toxic (or less toxic) chemical could be substituted for a hazardous one.

5.2.3 Engineering Controls

If a hazard cannot be eliminated or a safer substitute cannot be found, the next best approach is to use engineering controls to keep the hazard from reaching the worker. This could include methods such as using noise dampening technology to reduce noise levels; using local exhaust ventilation that captures and carries away the contaminants before they can get in the breathing zone of workers.

5.2.4 Administrative Controls

Administrative controls involve changes in workplace policies and procedures. They can include such things as warning alarms and labelling systems reducing the time workers are exposed to a hazard, and training.

5.3 Personal Protective Equipment

The water and wastewater workshop, wastewater treatment plants and potable water treatment plants are the three divisions in the Harare Water Department which have the field workers. These working divisions need PPE in their respective working fields because of the nature of their job. Typical PPE for these divisions includes respirators, gloves, goggles, helmets, work suits and safety shoes. Personal Protective Equipment is the least effective method of protecting workers from hazards. This is due to the negligence of some of the workers who do not want to wear their PPE on purpose and they end up selling their PPE well knowing that they will receive a new set of PPE at the start of a new year. As a result the Organization will end up having workers without necessary protective clothing.

5.4 Recommendations for PPE

The organization should prioritize issuing gloves, overalls and gumboots for the employees working at the sewerage division prior to the rise in the spread of cholera in Harare. Respiratory masks for all the wastewater treatment workers especially the ones involved with manhole works.

5.5 Health and Environmental Considerations

5.6 Quality Control and Quality Assurance

Harare water Department has a quality assurance section that ensures that the residents from Harare and neighbouring local authorities receive safe potable water and the wastewater

discharged into receiving streams meets EMA standards. This department comprises of the water laboratory which tests and checks the quality of portable water from the known water sampling points which includes consumer taps, reservoirs and final water sampling point at the treatment plant. It also comprises of the sewerage laboratory which tests wastewater parameters at wastewater treatment plants. Sampling of water during its distribution is done to monitor if there is any contamination of the water under distribution along the line during transportation. If there is contamination along the line post chlorination can be done along the distribution at reservoirs.

5.7 Budgeting Processes

The finance department is responsible for preparing company budgets and managing company monetary issues. It makes payments on purchases and receives payments on sales. It allocates funds to all departments to support the activities of each section of the company.

CHAPTER 6

6.1 Skills Gained

The industrial attachment at City of Harare was an essential part of the student's academic programme. There were academic benefits and self-development of the student, moreover the student managed to acquire important skills. The former had a major impact in the student's life. In the end, the importance of the internship outweighed the problems faced during the year. The skills the student managed to pick are:

6.1.1 Time Management

One of the important skills the student gained as a student engineer during his first two weeks working in the Sanitation Banking Hall was time management. Work started at 8 am in the morning and ended at 4 pm in the evening.

6.1.2 Communication Skills

Working with clients of varying personalities and behavioural traits at the front desk helped the student to improve and work on his patience. Good communication skills were also shown through the care given to customers/clients by the student in explaining some of the things to clients such as new water meter connection procedures. The student got to appreciate the importance of communication through hierarchy.

6.1.3 Practical Experience which improved technical skills

The student was involved in every practical aspect required in the field. The student managed to perfect some technical skills which had been previously learnt in class. Some of the skills the student got to improve are setting up the dumpy level quickly and taking readings from the staff, interpretation of engineering drawings, and production of engineering drawings using software such as AutoCAD, operation of pumps, backwashing of filters and so forth.

6.1.4 Teamwork

Associating and complementing with co-workers in different departments was a necessary skill. Through team work set targets and goals were possible to achieve within set dates and working hours.

6.1.5 Problem Solving

The student managed to gain a problem solving mentality as it was part of his duty to solve the issues and challenges that were being faced by his team while performing tasks that had to be completed.

6.1.6 Establish Industry Networks and Contacts

During my attachment at City of Harare I was fortunate to establish contacts with the plant Superintendeds, Production Engineers, plant Operators. They were of great assistance during the attachment and their arms were always open to help the student in the areas which needed explanations.

6.1.7 Exposing the student to challenges and demand of the work place

One of the major benefits was exposure in the industry. The theory learnt during Water and Public Health lectures became more complete in reality. The student grasped fully the processes of wastewater and raw water treatment and various designs of structures involved in both treatment processes.

CHAPTER 7

7.0 Relevance of Theory Learnt During Lectures

The theory learnt from the courses offered by the department of civil engineering proved to be quite helpful during the attachment. The application of the theory learnt in lectures was required of the student. Knowledge assimilated from engineering survey was of essence during field work when the student was taking levels for sewer line designs. The knowledge was not only useful in taking levels but it was also vital in computations of gradients which were used in deriving engineering conclusions before any design work was done.

Water and public health a level 3 engineering course was an eye opener for the student when he was dealing with wastewater at treatment plants. The knowledge which the student had for the course was cemented.

The student also appreciated Computer applications for engineers and engineering drawing courses. At times the student could be given a task of providing the information pertaining the number of reservoirs in the city for a maintenance program, knowledge obtained from QGIS was essential for the student.

CHAPTER 8

8.0 Challenges Experienced

Despite the positives that were obvious during the attachment period, the student faced challenges which threatened to hinder the progress necessary for a good working environment. The major ones included

8.1 Student

8.1.1 Issues with time management/self-management

This was the first time of the student being in a working environment, assuming responsibilities. There were issues with management of time especially when it came to submission of reports, which was due to short notices given by the Supervisors. The rotations done by the student in getting to familiarize with various work stations in the organisation also had an effect on time management to the student. This is because each station had its working hours which were different from other stations and this made it difficult for the student to adjust.

8.1.2 Bus fare issues

The student experienced monetary challenges to providing transport fares for himself. The student did not receive promised food and transport allowances and this put him in a position of providing finances to propel his internship.

8.1.3 Allotment of trivial work

During the first months of the internship the student did not get the chance to handle the important activities of the Organisation. Assisting roles were delegated for the much of the first two months and this was a challenge to the student because work related confidence was lost during these first two months. Although this was not to the student's expectations, a lot was learnt during those stages.

8.1.4 Hesitant to ask questions

As an Engineering student working with skilled and professional workers on site, a lot was made of the student's theoretical abilities. There was lack of communication between the student and the workers at time. It was tough asking questions since the engineering title was constantly brought on rather than being treated as a student on job training.

8.2 City of Harare

8.2.1 Inadequate resources

The student noticed that multitasking especially at wastewater and water workshop resulted in shortage of resources allocated to workers. There was this incident at Chidziva where workers had to shout at each other on the issue of sewer unblocking steel rods. The project which was being done at Gunhill for Mashonaland holdings for diversifying a sewer line had to be put on hold because of the unavailability of excavators, the only excavator present at the time was for the water workshop and was being used on another project at MJ.

8.2.2 Employee burnouts

Complaints from workers for not receiving enough salaries led to loss of motivation from workers and workers have lost a zeal for their jobs. Some of the workers have resorted to coming to work late and well knowing that no action is going to be done for such indiscipline. Some workers had to report for work even during weekends with the motive of getting overtimes to compensate for the salaries being received and not for the love of the work. At one point all the workers from the foreman to the general hand were complaining about the monies deposited into their nostro accounts, clearly not much work was done on this particular day because of the mob of the employees.

CHAPTER 9

9.0 Observations on company technology/processes that can be improved

During the attachment when the student was working at various divisions in the City of Harare; wastewater and water workshop, Firle sewage works and MJ he observed some of the areas and processes which needed improvement.

9.1 Observations at Firle sewage works

9.1.1 Large quantities of Grit in wastewater

The student observed that the major challenge at a wastewater treatment plant were large volumes of grit in the raw sewage especially during the rain seasons. Grit cause choking of the system, wearing of mechanical components and settling along treatment equipment resulting in the reduction of the capacity of the plant if the grit is not removed. After conducting a research the student discovered that washing of dishes at homes using sand instead of vim especially in high density areas (locations) and stormwater run-off which goes into stormwater drains which are channelled into sewer lines are major causes of grit accumulation in waste water.

9.1.1.1 Improvement to the treatment process

The student pointed out the need to separate stormdrain system from sewer line system so that surface run-off during rain seasons which carries a lot of sand particles does not get into the sewer lines. The stormwater should also be treated to remove coarse solids before discharge into stormwater ways through the use of vortex separators.

9.1.2 There are no devices for the constant monitoring of effluent parameters for the BNR system

The effluent from the BNR system has to meet some standards of the City Council and EMA before being discharged into Mukuvisi River. Samples of effluent are taken to the city lab on every Wednesdays for quality assurance checks to see if the effluent is not a danger to aquatic life. This means that the city lab will recommend adjustments on the treatment process depending on the standards of the parameters tested and this would take days before the recommended action gets to the plant.

9.1.2.1 Installation of probes at the BNR system

The student would encourage the installation of probes for the constant monitoring of pH, nitrates, phosphates, ammonia and total nitrogen from the wastewater undergoing the treatment

process. Through this the plant operators at Firle would know the adjustments to be made on the treatment process to maintain the right levels of the stated parameters.

9.1.3 No devices to monitor the amount of influent getting into the plant

Installation of totalizers at the inlet so as to monitor how much influent is coming into the plant over a 24 hour period.

9.2 Observations made at Morton Jaffray water works

9.2.1 No devices for the constant monitoring of chlorine levels in final water at the reservoirs

The student would want to urge the installation of probes on reservoirs to detect chlorine levels when they are low and other automatic devices to automatically boost low chlorine levels in the reservoir.

9.2.2 Treated water wastages

A lot of treated water from storage reservoirs is lost cleaning rapid gravity sand filters during the backwashing process. The filters have leakages due to broken nozzles and the continuous use of the filter will result in having water with higher turbidity in filter beds.

There is need to repair filters and use modern methods to reduce water losses and recycle the water back into the plant for the retreatment process to ensure that it is safe for drinking. The student would also encourage the City Council to channel the water towards an irrigation scheme.

9.3 Observations made on unblocking a sewer line

From the perspective of a student engineer under training, workers could not follow normal safety procedures when working at manholes to remove a choke causing blockage from a sewer line. Working in a manhole comes with serious safety hazards which can put the workers at risk, therefore employees are supposed to be trained and taught good hygiene practices. Below are the safety procedures workers should follow when working at manholes:

1. Warning signs which are clear should be displayed close to the working area to warn by passers and other workers of the dangers associated with working at a maintenance hole.
2. Firstly loosen the manhole cover/lid before fully opening it and then stand at the safest distance possible away from the manhole. This allows poisonous gases (Hydrogen sulphide

and other hazardous gases) entrapped inside the manhole to escape into the surroundings without suffocating the worker.

3. The aeration of the maintenance hole follows and this is done by using blowers to blow air into the hole to increase oxygen concentration levels inside the manhole.
4. Manholes contain contaminants which are harmful to human health, wearing of the right PPE is required at this stage. This includes wearing of respirators, overalls, gumboots, gloves, work suits, helmets and rescue ropes.
5. Allow the person with the right PPE to enter the utility hole whilst being tied to a rescue rope and wearing his helmet, respirator, gumboots and overalls.
6. After entry into the manhole the person removes foreign materials in the utility hole which can cause blockage if not removed through the use of a bucket system tied with a rope.
7. Steel rods are then directed into the sewer line to remove the possible choke from the line and when the choke is removed sewage flow normalises.
8. The final stage is disinfection of the working area to avoid cross contamination of the nearby areas after disposing the sewage material.

CHAPTER 10

10.0 Recommendations and Conclusion

10.1 Recommendations

During the time which the student was attached at the City of Harare, he made some observations and would like to suggest the following to both the University of Zimbabwe and the host company. The following are suggestions that may be of help to the institution of the trainee and to the organisation that has provided the student with industrial training.

10.1.1 Recommendations to the University of Zimbabwe Civil Engineering Department

1. The trainee recommends the UZ Civil Engineering Department to engage the industry to secure internship vacancies for students to avoid situations whereby students fail to get attachment. From the trainee's personal experience the attachment place was got at a later date and instead of having a full year attachment the student ended up having an attachment for 8 months. This came with its disadvantages for instance the student did not have ample time to prepare his reports and much of the engineering concepts had not been mastered. Some of the concepts which are going to be learnt by the student are not going to be accounted for in the report.
2. Attachment visits should be compulsory and they should be done earlier by the institution to instil confidence in students and to make sure that students are doing work which is significant to their fields of study.
3. To organise frequent field trips for students. This helps students to have an appreciation of what is being learnt in class and be able to apply it to the real world than having principles and processes just being explained to them.
4. The Civil Engineering Department should improve on their communication with the students. They should set up monthly progress check-ups just to check if the student is still in the right direction.
5. Some of the softwares being employed in the industry should be part of the curriculum and by the time students go for their attachment they will be fully equipped.

10.1.2 Recommendations to the city of Harare

1. I recommend the City of Harare to resuscitate wastewater treatment plants in order to produce quality water for its residents. Wastewater treatment and water treatment in as much as we want to separate these two they are like rotating arms, one being the giving arm and the other one being the receiving arm.

2. To update its on-site laboratory equipment for an effective quality control process and to rehabilitate the laboratory at Firle sewage works for sampling effluent parameters at site. If not done on site some parameters such as pH and temperature may change during transportation to the city lab.
3. City of Harare must employ more qualified SHEQ officers to ensure that employees comply with safety regulations. Moreover to make SHEQ officers' job much easier the organization must provide workers with Personal Protective Equipment (PPE) and impose strict measures on wearing of protective equipment at work stations.

10.2 Conclusion

The trainee's internship has been an excellent and rewarding experience, since the student had a chance to explore in his field and develop his career to becoming a professional Civil Engineer. The industrial attachment at the City of Harare gave the student an opportunity to participate and this furnished a lot of knowledge to the student of the realities of the working environment. The experience gave the trainee a chance to meet with professionals from various disciplines. Interacting with such people inspired the student to work hard towards achieving certain goals in life and developing strong intrapersonal skills. In Conclusion the attachment experience was beneficial to the student because it granted the student with hands on experience in various areas of civil engineering and development of critical skills such as self-reliance, good communication and team work. Finally, the student wishes to progress well in his academics while making to the best use all the information absorbed during a long, adventurous and informative year.

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