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CIVIL ENGINEERING DEPARTMENT

CONSTRUCTION TECHNOLOGY

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CHAPTER ONE: GENERAL INTRODUCTION

1.0 Introduction

The design of efficient and sustainable waste management systems is critical for promoting environmental health and community well-being. This research proposal focuses on the development of a bio-digester and septic tank system tailored for urban and rural applications. The study aims to explore innovative design principles, material selection, and operational efficiencies to create a cost-effective, eco-friendly solution for managing household and industrial waste. By addressing the challenges associated with traditional waste disposal methods, this project seeks to contribute to improved sanitation, renewable energy production, and the reduction of environmental pollution, thereby supporting the sustainable development goals of the targeted communities.

1.1 Background of study

The management of organic waste is a growing concern worldwide, particularly in urban and rural areas where traditional waste disposal methods often fail to meet environmental and health standards. Bio-digester and septic tanks present viable solutions for converting organic waste into biogas and nutrient-rich slurry, which can be utilized for energy and agricultural purposes respectively. According to the United Nations Environment Programme inefficient waste management practices contribute significantly to environmental pollution and public health issues. The integration of bio-digester and septic tanks can mitigate these effects by providing sustainable waste treatment options.(UNEP, 2017)

In recent years, there has been an increasing emphasis on the development of bio-digesters and septic tanks due to their dual benefits of waste management and energy production. Studies have demonstrated that bio digester can significantly reduce greenhouse gas emissions by capturing methane that would otherwise be released into the atmosphere. Furthermore, the slurry produced as a by-product of the digestion process is rich in nutrients and can be used as a fertilizer, thereby supporting sustainable agricultural practices (Singh, 2019)

Despite their potential, the adoption of bio-digesters and septic tanks varies significantly across different regions. In developing countries, the implementation of these systems is often hindered by economic constraints, lack of technical expertise, and insufficient infrastructure Conversely, developed countries have made significant strides in optimizing the design and efficiency of these systems, integrating advanced technologies to enhance their performance

The socio-economic benefits of bio-digesters and septic tanks are well-documented. They provide an alternative source of energy, reduce reliance on fossil fuels, and promote environmental sustainability. Moreover, these systems can create job opportunities and stimulate economic development in local communities through the establishment of maintenance and operation services

In recent years, the Rwandan government has intensified efforts to promote renewable energy and sustainable waste management. The Rwanda Energy Group (REG) has been actively involved in expanding the bio-digester program, focusing on both rural and urban areas. The government's Vision 2050 strategy emphasizes the importance of renewable energy and environmental sustainability, with bio-digesters playing a crucial role in achieving these goals (Rwanda., 2020)

1.2 Problem statements

Lycee de Lake Muhazi, like many educational institutions in Rwanda, faces significant challenges related to waste management and energy supply. The school generates a considerable amount of organic waste daily from its kitchen, dining facilities, and grounds maintenance activities. Currently, this waste is either disposed of in landfills or burned, practices that are not only unsustainable but also harmful to the environment. The improper disposal of organic waste contributes to greenhouse gas emissions, attracts pests, and poses health risks to students and staff. Furthermore, the reliance on conventional energy sources, such as wood and charcoal for cooking, exacerbates deforestation and environmental degradation while also being economically burdensome. (FAO., 2017)

The lack of an efficient waste management system and sustainable energy source has significant implications for the school's operational efficiency and environmental footprint. Traditional waste disposal methods are inadequate and contribute to environmental pollution and health hazards. Additionally, the school's dependence on wood and charcoal for cooking is both unsustainable and costly, leading to the depletion of local forests and contributing to air pollution and respiratory illnesses among the school community.

However, the successful design and implementation of a bio-digester system at Lycee de Lake Muhazi require a comprehensive understanding of the technical, economic, and social factors involved. There is a need to assess the feasibility of the bio-digester, considering the amount and type of organic waste generated, the energy needs of the school, and the local environmental conditions. Additionally, the project must address potential challenges related to the maintenance and operation of the bio-digester, as well as ensure the involvement and acceptance of the school community. (Singh A. K., 2019)

1.3.Purpose of the study

To design and evaluate a bio-digester for Lycee de Lake Muhazi, aiming to provide a sustainable solution for managing the school's organic waste while producing renewable energy. The study seeks to determine the optimal design, materials, and operational strategies for the bio-digester to ensure maximum efficiency and cost-effectiveness. Additionally, it aims to assess the environmental and socio-economic benefits, such as reducing waste management costs, lowering the school's carbon footprint, and enhancing community awareness and acceptance of biogas technology. Ultimately, the study intends to demonstrate

1.4.Research objectives

- To design an efficient and cost-effective bio digester suitable for Lycee de Lake Muhazi.
- To analyze the potential biogas production from available organic waste at Lycee de Lake Muhazi.
- To evaluate the environmental benefits of implementing a bio digester in reducing organic waste and greenhouse gas emissions.
- To assess the economic feasibility and potential cost savings of using a bio digester compared to traditional waste management methods.
- To investigate the potential uses of the biogas produced, such as for cooking, heating, or electricity generation within the school premises.

- To explore the social and educational impacts of the bio digester project on students and staff at Lycee de Lake Muhazi.

1.4.1.Main objectives

Main objectives are to discuss about the design of bio digester at lycee de lake muhazi by showing the way the digester should be durable and long last for the users and even environment

1.4.2 Specific objectives

The specific objective are formulated as follow:

- Design Specification
- Waste Characterization
- Biogas Yield Estimation
- Environmental Assessment
- Economic Analysis
- Energy Application Feasibility

1.5 Research questions

- What are the optimal design parameters and components required for an efficient bio digester at Lycee de Lake Muhazi?
- What types and quantities of organic waste are generated at Lycee de Lake Muhazi that can be used as feedstock for the bio digester?
- How do different types of organic waste impact the biogas production rate and overall efficiency of the bio digester?
- How does the use of a bio digester reduce greenhouse gas emissions and improve waste management practices at the school?

- Is the bio digester project economically viable compared to traditional waste disposal and energy procurement methods?

- How feasible is it to use the biogas for cooking, heating, or electricity generation within the school premises?

1.6 Scope and limitation of the study

The scope of this study involves the comprehensive design, development, and implementation of a bio digester at Lycee de Lake Muhazi, focusing on design specifications, waste characterization, biogas yield estimation, environmental and economic assessments, energy application feasibility, educational and social impacts, and implementation and maintenance planning. However, the study faces limitations including resource constraints, time constraints, limited data availability, technical challenges, environmental factors, and varying levels of stakeholder engagement. Despite these limitations, the study aims to provide valuable insights and practical recommendations for sustainable waste management and renewable energy production at the school. (Paliwal, 2019)

1.7.The significance of the study

The study's significance lies in its potential to provide a sustainable solution for managing organic waste and generating renewable energy at Lycee de Lake Muhazi. By implementing a bio-digester, the school can reduce environmental pollution and greenhouse gas emissions, achieve energy self-sufficiency, and realize significant cost savings. The project also offers practical learning opportunities for students, fosters community engagement, and can serve as a model for other institutions. Additionally, it contributes to local economic development through job creation and informs policy on waste management and renewable energy, ultimately enhancing the overall quality of life and promoting sustainable practices. (Rogoff, 2020)

1.7.1. Administrative significance

By designing and implementing a bio digester, the study offers a practical solution for reducing organic waste and generating renewable energy, which can contribute to cost savings on waste disposal and energy procurement. The project aligns with institutional goals of environmental responsibility and resource efficiency, providing a model for other educational institutions. Additionally, it supports administrative decision-making by offering detailed guidelines for implementation and maintenance, ensuring that the bio digester system is effectively integrated into the school's infrastructure and management practices.

1.7.2 Personal significance

By engaging in the design and implementation of a bio digester at Lycee de Lake Muhazi, the researcher gains hands-on experience in sustainable technology and waste management, enhancing their expertise and professional development. The project fosters a deeper understanding of renewable energy solutions and their practical applications, aligning with personal values of environmental stewardship. Additionally, the study provides a platform for meaningful impact within the school community, offering a real-world example of how academic research can drive positive change and inspire future initiatives. (Harris, 2018)

1.7.3 Academic significance

By providing a detailed analysis of the design, waste management, biogas production, and economic feasibility of a bio digester at Lycee de Lake Muhazi, the research offers valuable insights into the practical application of sustainable technologies in similar settings. The study also enriches the academic discourse on renewable energy solutions and their integration into school systems, serving as a reference for future research and projects in the field. Additionally, it advances the understanding of the socio-economic and environmental impacts of bio digesters, adding depth to the literature on sustainable development and waste management practices.

1.7.4. Socio-economic significance

By providing a detailed analysis of the design, waste management, biogas production, and economic feasibility of a bio digester at Lycee de Lake Muhazi, the research offers valuable insights into the practical application of sustainable technologies in similar settings. The study also enriches the academic discourse on renewable energy solutions and their integration into school systems, serving as a reference for future research and projects in the field. Additionally, it advances the understanding of the socio-economic and environmental impacts of bio digesters, adding depth to the literature on sustainable development and waste management practices. (Khanal, 2018)

1.7.5 Organization of the study

It begins with an introduction that outlines the background, problem statement, objectives, and significance of the study. The literature review follows, providing a comprehensive analysis of existing research on bio digesters, waste management, and renewable energy. The methodology section details the research design, data collection methods, and analytical techniques employed. The results and discussion chapter presents the findings, interprets the data, and evaluates the bio digester's feasibility and impact. Finally, the study concludes with recommendations for implementation, maintenance strategies, and suggestions for future research, ensuring a thorough and cohesive examination of the project from conception to practical application.

CHAPTER 1: General Introduction

This chapter deals with the introduction, problem statement, research objectives, research questions, scope of the research, significance of the research, and finally, the organization of the study.

CHAPTER 2: Literature Review

This chapter explores the design and application of bio digester, focusing on their role in sustainable waste management and renewable energy production,

CHAPTER 3: Materials and Methods

This chapter discusses the methods and procedures used, defines the instruments employed in the investigation, and describes the techniques used to collect all the necessary data.

CHAPTER 4: Results and Discussions

This chapter presents the analysis and interpretation of the findings.

CHAPTER 5: Conclusion and Recommendations

This final chapter presents the conclusions and recommendations, summarizing the outcomes of the research.

CHAPTER TWO: LITERATURE REVIEW

2.0. Introduction

There will be 22 megacities (populations exceeding 10 million) by the end of this century, 18 of which will be in the Third World due to the ongoing migration of people from rural to urban areas. These cities have enormous needs for heat and energy. This chapter will compile information on how to discover solutions from humans themselves for the problems of energy and heat scarcity, as well as toilet waste management, in order to provide enough heat and energy to feed the growing population. The group had gathered to talk about the problem and offer design suggestions for the biodigester. This chapter will compile concepts and data, as well as methods for evaluating the biodigester's design based on what other authors have written about it. (Gupta, 2021)

2.1. Conceptual Review

A bio-digester is a system that uses anaerobic digestion, a process where microorganisms decompose organic waste in the absence of oxygen, to produce biogas and digestate. Biogas, consisting mainly of methane and carbon dioxide, serves as a renewable energy source, while digestate is a nutrient-rich byproduct used as fertilizer. The efficiency of this process is influenced by the bio-digester's design principles, including reactor type, mixing, and heating systems. These concepts are interrelated, as the design impacts the effectiveness of anaerobic digestion, biogas production, and the quality of the digestate, underscoring the importance of an integrated approach to bio-digester design and operation. (Zhang, 2022)

2.2 Terminologies

- **Bio-Digester**: A bio-digester is a system designed to break down organic waste through anaerobic digestion, a process that occurs in the absence of oxygen. This technology is crucial for converting organic waste into biogas and digestate, a nutrient-rich byproduct. The bio-digester's primary function is to facilitate the decomposition of organic materials and harness the energy released in the form of biogas.

- **Anaerobic Digestion**: Anaerobic digestion is the biological process by which microorganisms decompose organic matter in an oxygen-free environment. This process involves four stages: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Anaerobic digestion is central to the operation of bio-digesters, as it is the mechanism that converts organic waste into biogas and digestate.

- **Biogas**: Biogas is a mixture of methane (CH_4) and carbon dioxide (CO_2) produced during anaerobic digestion. It is a valuable renewable energy source that can be used for electricity generation, heating, and as a fuel for vehicles. The efficiency of biogas production is closely linked to the design and operational conditions of the bio-digester.

- **Digestate**: Digestate is the solid and liquid material remaining after the anaerobic digestion process. It is rich in nutrients and can be used as a fertilizer or soil conditioner. Understanding the characteristics of digestate is important for evaluating the overall efficiency and environmental impact of a bio-digester.

- **Design Principles**: The design principles of a bio-digester encompass factors such as the reactor type (e.g., batch, continuous, or plug-flow), the mixing and heating systems, and the materials used for construction. These design elements influence the efficiency of the anaerobic digestion process, the quality of the biogas produced, and the handling of the digestate.

2.3. Theatrical review

It examines the core theories and models related to bio-digesters, focusing on how these theoretical frameworks inform the design and functionality of anaerobic digestion systems. It explores key theoretical concepts such as the principles of anaerobic digestion, including the stages of hydrolysis, acidogenesis, acetogenesis, and methanogenesis, which collectively drive biogas production. The review also considers various design models that influence the efficiency of bio-digesters, such as batch versus continuous reactors and the impact of mixing and temperature control. By linking these theoretical perspectives to the study's objectives, the review highlights how theoretical insights guide the design process, optimize performance, and address potential challenges in bio-digester systems. (Ward, 2014)

2.3.1. Classification of Bio Diegester

Based on Operation Mode

- **Batch Digesters**: These digesters are filled with organic waste and sealed for a specific period. After digestion, the digester is emptied, and a new batch is started. They are simpler but less efficient for continuous operations.

- **Continuous Digesters**: Organic waste is continuously fed into the digester, and digestate is continuously removed. These systems are more complex but offer steady biogas production.

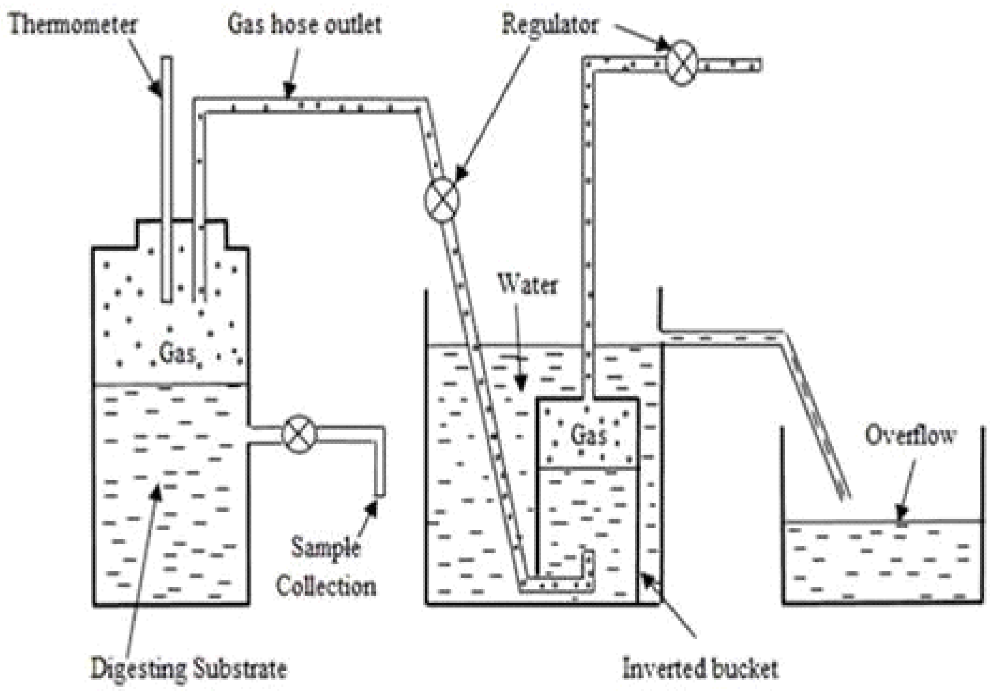


Figure 2.3.1. *Showing the bio digester based on operation mode*

Based on Design

- **Covered Lagoon**: A large, open-air pit covered with a membrane to capture biogas. It is generally used for large-scale operations and is less efficient but cost-effective.

- **Fixed-Dome Digesters**: These digester have a fixed, dome-shaped roof and a concrete or brick construction. They are commonly used in developing countries.

- **Floating-Dome Digesters**: These digesters feature a floating dome that rises and falls with the volume of biogas produced. They are often used for small to medium-scale operations.

- **Composting Digesters**: These digesters combine aerobic composting with anaerobic digestion to handle different types of waste and optimize nutrient recovery.

2.4.Review of related literature

2.4.1.Overview of Bio Digesters

Definition

Bio Digester: A bio digester is an engineered system that converts organic waste materials, such as food waste, animal manure, and human excreta, into biogas (a mixture of methane and carbon dioxide) and a nutrient-rich slurry that can be used as fertilizer. The process involves anaerobic digestion, which is a natural biological process carried out by microorganisms in the absence of oxygen.

How a Bio Digester Works

1. **Input of Organic Waste:**

The bio digester is fed with organic waste, such as food scraps, animal manure, sewage, or agricultural residues. These materials are usually mixed with water to create a slurry, which makes it easier for microorganisms to break down the waste.

1. **Anaerobic Digestion Process:**

The waste is then introduced into an airtight chamber where anaerobic digestion takes place. Anaerobic digestion involves several stages:

- **Hydrolysis:** Large organic molecules are broken down into smaller molecules such as sugars, amino acids, and fatty acids by enzymes.
- **Acidogenesis:** These smaller molecules are further broken down into volatile fatty acids, along with gases such as hydrogen and carbon dioxide.
- **Acetogenesis:** The volatile fatty acids are converted into acetic acid, carbon dioxide, and hydrogen.
- **Methanogenesis:** Finally, methanogenic bacteria convert acetic acid, hydrogen, and carbon dioxide into methane (CH_4) and carbon dioxide (CO_2), producing biogas.

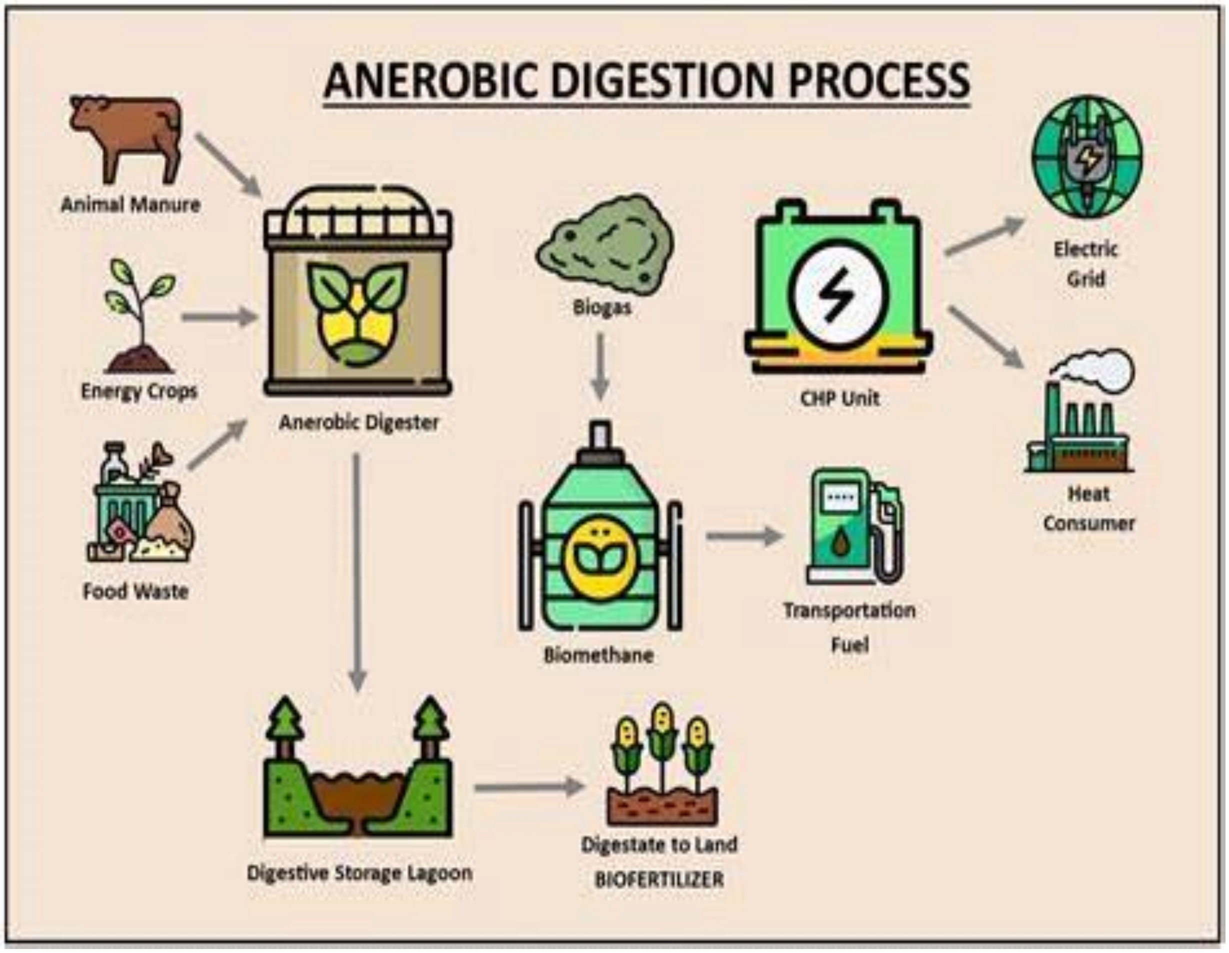


Figure 2.4.2.*Showing anerobic digestion process.*

1. **Biogas Production:**

The methane-rich biogas produced during methanogenesis can be captured and used as a source of renewable energy. It can be burned for cooking, heating, or even generating electricity. The biogas is typically composed of 50-75% methane, 25-50% carbon dioxide, and trace amounts of other gases like hydrogen sulfide.

1. Effluent and Slurry:

The remaining byproduct is a nutrient-rich slurry known as digestate. This digestate can be used as an organic fertilizer, which is especially valuable in agricultural settings. It contains essential nutrients like nitrogen, phosphorus, and potassium, which are beneficial for plant growth.

1. **Continuous or Batch Process:**

Bio digesters can operate on a continuous or batch basis. In a continuous process, waste is added and digested material is removed regularly. In a batch process, the digester is filled with waste and sealed until digestion is complete, after which the digester is emptied and refilled.

2.5.DISEASES CAUSED BY IMPROPER TOILET WASTES MANAGEMENT

Unimproved sanitation practices and consequent exposure with human excreta can lead to a variety of diseases and related problems. These include typhoid, schistosomiasis, hepatitis A, cholera, fluorosis, guinea worm disease, trachoma, and diarrhea The most prevalent and harmful illnesses are thought to be typhoid, schistosomiasis, trachoma, and diarrhea (UNICEF., 2014)

Diarrhea

A disorder that causes a person to lose water and electrolytes, which can result in dehydration and occasionally even death. It is the primary health issue linked to inadequate sanitation practices, with four billion illnesses and 1.8 million fatalities each year (1.6 million of which are children under five) ((WHO), 2014)

Typhoid

A bacterial infection that may cause nausea and headaches. It is transmitted by swallowing contaminated food or water, and it affects 12 million people annually ((CDC), 2020)

Trachoma

An infectious bacterial illness that can result in pain and possibly blindness by roughening the inside surface of the eyelid. Because of this illness, almost six million people are blind today, proper sanitation might cut illness rates by as much as 25%. When oxygen molecules create free radicals in a biological context, oxygen toxicity happens. ((WHO), 2014)

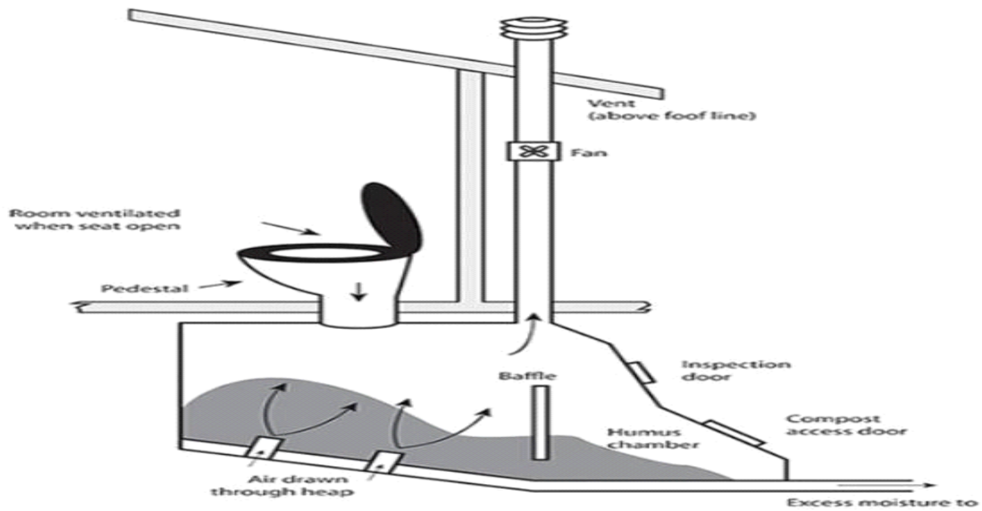
2.5.1.METHODS OF TOILET WASTES MANAGEMENT:

- Ventilated improved pit latrines.
- Compost toilets.
- Toilets connected to the conventional septic tanks onsite.
- Toilets connected to biogas plants onsite. Which also called bio digester toilet system .

2.6.COMPOSITE TOILETS

Is a method of sanitation that can turn organic waste and excrement into a leafy, soil-like substance with a nice earthy smell that can be safely disposed of in the environment once enough time has elapsed for combustion.

***Figure 6**:compost toilet with beneath waste collector*



2.6.1.WORKING OPERATION OF COMPOSITE TOILETS

In a vault or container that is specifically made for the purpose, waste and toilet paper are collected and processed by a composting (or biological) toilet system. Urine is collected separately for composting toilets that are expressly made to accept only faces, while some accept urine. Organic food waste and other biodegradable home waste can be added to the vault. Then, the waste goes through a composting process. All composting toilets require the regular addition of bulking agents to toilet systems that employ heat to dry waste in a vault. Depending on the intensity of use, a little amount should ideally be used after each use or at least once a day to cover the skin and absorb moisture to avoid unpleasant odors .Some advantages and disadvantages

2.6.2. Advantage

- Water conservation
- Lower monthly water bills
- Reduction of size requirements of wastewater collection system, perhaps even elimination of the need for a septic system
- Generation of nutrient-rich fertilizer

- Aerobic digestion of wastes using naturally produced heat reduces unpleasant odor and increases pathogen die-off.
- Aerobic digestion has potential for reduction of nitrogen and reduction in leachate by evaporation.
- Groundwater contaminations is prevented if there is no waste water discharge.
- Produces a valuable humus - compost/soil conditioner. The value of the fertilizer (N.P.K.) is estimated at 9100Rwfr per person per year.

2.6.3 .Disadvantages

- reluctant to use content for agricultural purposes
- reluctant to touch or convey own feces to a new site
- Careful operation is essential. Ash or vegetable matter has to be added regularly.
- Compost could be a health hazard if it is removed before decomposition is complete.
- It may be necessary to collect urine separately.
- Upfront cost of buying a ready-made toilet
- Direct handling of human waste material

TYPES BIODIGESTER TOLET SYSTEM

1. WET BIODIGESTER

Is a type of anaerobic digester specifically designed to process waste materials with a high moisture content, typically greater than 85%. In this system, organic waste is mixed with a substantial amount of water to create a slurry, which allows the waste to flow more easily and facilitates the anaerobic digestion process. The wet bio digester is often used for treating liquid or semi-liquid waste, such as animal manure, sewage, and food waste. This type of digester is widely utilized in agricultural settings and wastewater treatment plants due to its efficiency in handling large volumes of waste and producing significant amounts of biogas. The effluent from a wet bio digester,

1. DRY FERMENTATION BIODIGESTER

Is designed to process organic waste with lower moisture content, typically between 15% and 40%. Unlike wet bio digesters, which require a slurry-like consistency, dry fermentation systems handle solid or semi-solid waste, such as crop residues, yard waste, and municipal solid waste. The process occurs in an airtight chamber where the waste is stacked in layers, and anaerobic bacteria break down the organic material without the need for additional water. This type of digester is particularly suitable for areas where water resources are limited or for processing high-fiber waste materials. Dry fermentation bio digesters produce biogas, which can be used for energy, and a solid digestate, which can be utilized as compost or soil conditioner. These systems are often preferred in agricultural and municipal waste management settings due to their ability to handle large volumes of solid waste with minimal water input.

Criteria for the design of this series

The purpose of the bio digester must meet the following standards:

- The cost to build the bio digesters must be minimal and low-cost.
- The bio digester should be as uncomplicated as possible and not involve advanced engineering to solve.
- The bio digester must be dependable and induce a positive impact on the spirits of LYCEE DE LAKE MUHAZI

Building Process

Thither are many important processes involved in the expression of the bio digester, the basics can be split into the next steps:

- Resources must be sourced including cement, mixers, bricks, PVC piping and plastic.
- A pit must be dug
- A concrete slab must be placed in the tank and the toilet inlet.
- The walls of the bio digester must be built and PVC piping laid.
- Plastic Lid and gas storage bags must be made.

The bio digester tank is mostly underground this means the foremost affair that must be done is a hole big enough to accommodate the digester needs to be grasped. Concrete must then be mixed and poured to form the tank base.

Factors affecting the operation:

- The amount of water needed
- The use of sea water or brackish water
- Additional input material
- The expected life of a gas plant
- The effect of scum formation in a continuous-type digester

Factor affecting the design

- Availability of building material
- The level of water table
- Input materials to be used
- The amount of gas required for different applications
- Gas production from different input materials

CHAPTER THREE: DATA COLLECTION AND ANALYSIS

3.0 Introduction

This chapter presents the methods and procedures used in gathering, analyzing, and interpreting data relevant to the design of a bio-digester in the Muhazi Sector, Rwamagana District. The effectiveness of the bio-digester design depends on a thorough understanding of various factors, including the availability and characteristics of feedstock, local environmental conditions, and community needs.

The data collection process was tailored to address these critical factors. A combination of qualitative and quantitative approaches was employed to ensure comprehensive data coverage.

Surveys and interviews with local residents, farmers, and stakeholders were conducted to gain insights into the availability and types of organic waste suitable for the bio-digester. Additionally, environmental data such as temperature, humidity, and soil characteristics were collected to assess the feasibility of the bio-digester in the region.

In this chapter, the methods used to collect this data will be detailed, along with the tools and techniques employed for analysis. The data analysis will focus on identifying key trends and patterns that will inform the final design of the bio-digester, ensuring it meets the specific needs of the Muhazi Sector community while optimizing efficiency and sustainability.

3.1 Description of the Study Area

LYCEE DE LAKE MUHAZI is one school of government sponsored located in MUHAZI SECTOR; In this place has the annual average of rainfall of 865.5mm/year, the daily mean maximum temperature is **290**. Mainly RWAMAGANA is situated between 1°57'2, 7''of south latitude and 30°26'8''of

longitude. It is composed of 14 Sectors, 82 cells and 474 villages (Imidugudu) with a population of 310,238 (Provisional population and survey results 2012) on a surface area of 691.6 km2.

RWAMAGANA Administrative map.

The study area for this project is the Muhazi Sector, located in the Rwamagana District of Rwanda's Eastern Province. Muhazi is characterized by a combination of rural and semi-urban landscapes, making it an ideal location for studying the implementation of bio-digester technology in a diverse environmental and socio-economic context.

3.1.1 Geographic Location and Climate

Muhazi Sector is situated along the shores of Lake Muhazi, a prominent freshwater lake in the region. The area spans both lowland and hilly terrains, with altitudes ranging from 1,400 to 1,700 meters above sea level. The climate in Muhazi is classified as tropical, with distinct wet and dry seasons. The average annual rainfall ranges from 900 to 1,100 mm, with the wet season occurring from March to May and September to December. The temperature varies between 15°C and 28°C, making it conducive for agricultural activities.

3.1.2 Socio-Economic Activities

The population in Muhazi Sector primarily engages in agriculture, with a focus on both crop production and livestock rearing. The main crops grown include maize, beans, sweet potatoes, and bananas. Livestock farming is also prevalent, with cattle, goats, and poultry being the most common. These agricultural practices generate significant organic waste, which presents an opportunity for bio-digester technology to convert waste into valuable energy and fertilizers.

In addition to agriculture, fishing in Lake Muhazi and small-scale trading are other important economic activities. The presence of smallholder farmers and their reliance on traditional farming techniques make Muhazi an ideal candidate for the introduction of sustainable energy solutions like bio-digesters.

3.1.3 Environmental and Energy Challenges

The region faces several environmental challenges, including soil erosion, deforestation, and waste management issues. The reliance on wood and charcoal for cooking has led to deforestation, while improper disposal of agricultural and household waste contributes to environmental degradation. These challenges underscore the need for sustainable energy solutions that can mitigate environmental impact while providing economic benefits to the local community.

3.1.4 Community Needs and Potential for Bio-Digester Implementation

The community in Muhazi Sector has expressed a growing need for alternative energy sources that are affordable, sustainable, and easy to maintain. The availability of organic waste from agriculture and livestock presents a significant opportunity for the implementation of bio-digesters. Such a system would not only provide clean energy for cooking and heating but also produce organic fertilizers that could enhance soil fertility and agricultural productivity.

3.2 Sample size for Research Purpose

By using Solving's formula, which requires a definite population, sample size can be determined. The following formula, n=N/ (1+N (a) 2) or n=N/ (1+N (e) 2), has been used to decide the data analysis and interpretation of our sample since we must apply it in order to attain or reach at a particular precision required for decision making.

Where; n: sample size

N: research population

a/e: level of significance or confidence level.

It is an assumption that follows statistical research standard, and it sets either 5% or 10%, minimally and maximally respectively. Data collected from questionnaires have been analyzed and presented in charts and tables

RESEARCH POPULATION SIZE	sample	REMARKS
	Level of confidence is 90% Degree of accuracy/margin of error 10%	
34	25	staff
100	50	People around the school
322	76	Students from lower secondary school

Table 5:show research sample size for stuff

n=34÷(1+34x0.1x0.1) =25 staffs

sample size for people around school

n=100÷(1+1,00x0.1x0.1) =50 people around school

sample size for students

n=322÷(1+322x0.1x0.1) =76 students

Note students under research are those in o'level.

The population size of 456 people was used in the table above to calculate the sample size for this study. The population was divided into three categories: the staff of LYCEE DE LAKE MUHAZI, which consisted of 25 people; the people around the school, which consisted of 50 people; and the average of the people or students in the daily study, which consisted of 322 people and included 77 people. This resulted in a total sample size of 151 people, a 90% confidence level, and a 10% margin error (degree of accuracy).

The data presented in this study demonstrates the population research and sample size of individuals who feign to use one of the various toilet waste management systems. Of these, the population of 456 is best divided into three groups to better understand the project: staff, students, and people who live nearby the school.

Types of toilet waste management	Sample size,level of confidence of 90 and margin of error of 10%					
	staff		student		People around school	
	Pop research	Pop size	Pop research	Pop size	Pop research	Pop size
People who use Vip latrine	34	25	322	66	39	28
People who use composite toilet	20	17	25	20	20	17

People who use toilet connected to septic tank	39	28	125	56	44	31
People that use toilet connected to biogas plant	10	9	21	17	5	5

Table 6:show the response to questionnaire

3.2.1 Sample Procedure

- **fine Objectives:** Establish the goals and intended outcomes of the bio-digester project, including the type of waste to be processed and the desired energy output.

- **Site Assessment:** Conduct a thorough assessment of the proposed site, evaluating factors such as soil type, proximity to waste sources, water availability, and environmental conditions.

- **Design Criteria:** Develop design criteria based on the site assessment and project objectives. This includes determining the size and capacity of the bio-digester, the type of materials to be used, and the expected input and output flow rates.

- **Material Selection:** Choose appropriate materials for construction, considering factors like durability, cost, and resistance to corrosion. Common materials include reinforced concrete, steel, and high-density polyethylene.

- **System Design:** Create detailed design plans for the bio-digester, including the layout, dimensions, and configuration of key components such as the digester tank, inlet and outlet ports, mixing mechanisms, and gas collection systems.

- **Hydraulic and Thermal Modeling:** Perform hydraulic and thermal modeling to ensure optimal performance of the bio-digester. This involves simulating the flow of waste and heat within the system to optimize design parameters.

- **Construction Plan:** Develop a construction plan outlining the steps and timeline for building the bio-digester. This includes site preparation, assembly of components, and installation of necessary infrastructure.

- **Safety and Maintenance Considerations:** Incorporate safety features and maintenance protocols into the design to ensure safe operation and ease of maintenance. This includes designing for proper ventilation, access for cleaning, and emergency shutdown procedures.

- **Testing and Commissioning:** Once constructed, conduct testing to ensure the bio-digester operates as intended. This includes checking for leaks, verifying gas production rates, and assessing the efficiency of waste digestion.

- **Monitoring and Evaluation:** Establish a monitoring and evaluation plan to track the performance of the bio-digester over time. This involves regular inspections, data collection on output, and adjustments as needed based on performance data.

3.3 Research Instrument

- **Flow Meters**

- **Purpose:** Measure the flow rate of input materials (e.g., organic waste) and output products (e.g., biogas, digestate).

- **Types:** Ultrasonic, electromagnetic, and turbine flow meters.

- **Gas Analyzers**

- **Purpose:** Analyze the composition of biogas to determine concentrations of methane (CH4), carbon dioxide (CO2), hydrogen sulfide (H2S), and other gases.

- **Types:** Infrared sensors, electrochemical sensors, and gas chromatography.

- **pH Meters**

- **Purpose:** Monitor the pH level of the digestate to ensure it remains within the optimal range for microbial activity.

- **Types:** Digital pH meters with electrodes.

- **Temperature Sensors**
- **Purpose:** Measure the temperature within the digester, as temperature affects the efficiency of the anaerobic digestion process.
- **Types:** Thermocouples, thermistors, and resistance temperature detectors (RTDs).

- **Pressure Gauges**
- **Purpose:** Monitor the pressure inside the digester and gas collection systems to prevent overpressure and ensure safe operation.
- **Types:** Analog and digital pressure gauges.

- **Level Sensors**
- **Purpose:** Measure the level of input waste, digestate, and biogas within the digester to manage feeding and remove excess material.
- **Types:** Ultrasonic, capacitive, and radar level sensors.

- **Biogas Flow Meters**
- **Purpose:** Measure the volume of biogas produced to evaluate the performance of the bio-digester.
- **Types:** Rotary vane meters, diaphragm meters, and turbine meters.

- **Sampling Devices**
- **Purpose:** Collect samples of the digestate and biogas for laboratory analysis.
- **Types:** Sample probes, gas sampling bags, and liquid sampling containers

- **Data Loggers**
- **Purpose:** Record data from various sensors over time for analysis and troubleshooting.
- **Types:** Digital data loggers with multiple channel inputs.

3.3.1 Choice of Research Instrument

According to my research on bio-digesters depends on the specific objectives of your research and the parameters you need to measure or control. Here's a guide to help you select the appropriate research instruments:

- **Purpose and Objectives**
- **Define Research Goals:** Clearly outline what you aim to achieve with your research. Are you focusing on performance evaluation, efficiency analysis, or design optimization?
- **Identify Key Parameters:** Determine the parameters you need to measure (e.g., biogas production, waste degradation, temperature).
- **Type of Data Required**
- **Quantitative Data:** Instruments like flow meters, gas analyzers, and temperature sensors provide numerical data for analysis.
- **Qualitative Data:** Observational tools or manual sampling might be used to gather qualitative insights.
- **. Accuracy and Precision**
- **High Accuracy:** For critical measurements, such as gas composition or flow rates, choose high-accuracy instruments like gas chromatography for biogas analysis.
- **Precision Needs:** Instruments should offer precise measurements to ensure reliability in your results.

Instrument Features

- **Range and Sensitivity:** Select instruments with ranges and sensitivity suitable for the expected levels of your parameters.
- **Data Logging:** Consider instruments with data logging capabilities if long-term monitoring is required.
- **Budget and Resources**
- **Cost Considerations:** Balance the cost of instruments with your research budget. Sometimes, less expensive alternatives can suffice if they meet your accuracy needs.
- **Availability:** Ensure that the instruments you choose are available from reputable suppliers and can be maintained or serviced.
- **Ease of Use**
- **User-Friendliness:** Option for instruments that are easy to operate and interpret. User manuals and training resources can be helpful.
- **Integration:** Ensure that the instruments can be integrated into your existing setup or system.
- **Maintenance and Calibration**
- **Regular Maintenance:** Choose instruments that require manageable maintenance and calibration to ensure continued accuracy.
- **Calibration Requirements:** Some instruments, like pH meters and gas analyzers, require regular calibration to maintain their accuracy.
- **Examples of Research Instruments**
- **For Biogas Measurement:** Gas analyzers (infrared or electrochemical sensors), biogas flow meters.
- **For Waste and Digestate Analysis:** pH meters, temperature sensors, and flow meters.
- **For Performance Monitoring:** Data loggers, pressure gauges, and level sensors.

3.3.2 Validity and Reliability of Instrument

Validity refers to the extent to which an instrument measures what it is intended to measure.

Types of Validity

- **Content Validity:** Ensure the instrument covers all aspects of the concept being measured. This often involves expert reviews to confirm that the instrument fully represents the construct.
- **Construct Validity:** Verify that the instrument accurately measures the theoretical construct it is intended to assess. This can be achieved through correlation with other validated measures or through factor analysis.
- **Criterion Validity:** Evaluate how well the instrument predicts outcomes or correlates with other established measures. This includes:
- **Concurrent Validity:** Compare the instrument's results with those of another validated tool measured at the same time.
- **Predictive Validity:** Assess how well the instrument predicts future outcomes or behaviors.

Validity Testing:

- **Expert Review:** Consult experts in the field to review and provide feedback on the instrument.
- **Pilot Testing:** Conduct preliminary testing of the instrument with a small sample to identify any issues and make necessary adjustments.
- **Statistical Analysis:** Use statistical techniques like factor analysis to assess construct validity and correlation analysis for criterion validity.

RELIABILITY

- **Define Reliability:**

- **Reliability** refers to the consistency and stability of an instrument's measurements over time and across different conditions.

- **Types of Reliability:**

- **Internal Consistency:** Measure how consistently the items within the instrument assess the same construct. This is often evaluated using Cronbach's alpha, which indicates the degree to which items are correlated.

- **Test-Retest Reliability:** Evaluate the stability of the instrument's results over time by administering the same test to the same group at different points in time and comparing the results.

- **Inter-Rater Reliability:** Assess the consistency between different raters or observers using the same instrument. This is important for instruments involving subjective judgments or evaluations.

- **Reliability Testing:**

- **Calculate Cronbach's Alpha:** For instruments with multiple items, compute Cronbach's alpha to check internal consistency. A value above 0.7 is generally considered acceptable.

- **Conduct Test-Retest:** Administer the instrument to the same group at two different times and calculate the correlation between the two sets of results.

- **Measure Inter-Rater Reliability:** Use statistical methods such as the Kappa coefficient to assess the agreement between different raters.

3.4 Data Gathering Procedure

1. Develop a Data Collection Plan

- **Objective:** Clearly define the objectives of data collection, such as assessing the performance of the bio-digester, evaluating the quality of biogas, or analyzing the efficiency of waste digestion.

- **Parameters:** Identify the specific parameters to be measured, such as biogas production rates, waste input characteristics, and temperature.

3.5 Data Analysis and Interpretation

1. Introduction to Data Analysis

- **Objective:** Begin by explaining the purpose of data analysis in your study. Emphasize that data analysis helps in making sense of the collected data, revealing patterns, trends, and correlations that inform the design and implementation of the bio-digester.

- **Methodology Recap:** By mention the methods used to collect the data (e.g., surveys, field measurements, interviews, etc.). This sets the context for the analysis that follows.

2. Data Cleaning and Preparation

- **Data Cleaning:** Discuss the steps taken to clean the data, such as handling missing data, removing outliers, and correcting errors. Ensure the reader understands that accurate data is crucial for reliable analysis.

- **Data Categorization:** Explain how the data was categorized for analysis. For example, if you collected data on household waste production, categorize the data into relevant segments like organic waste, non-organic waste, etc.

3. Descriptive Analysis

- **Statistical Summary:** Provide a statistical summary of the data. This could include mean, median, mode, standard deviation, etc. for key variables like waste production rates, household sizes, and energy consumption.

- **Graphs and Charts:** Use visual aids such as bar charts, pie charts, and histograms to illustrate the distribution and frequency of the data. For instance, a pie chart could show the percentage of different types of waste generated in the community.

4. Comparative Analysis

- **Regional Comparison:** Compare the data from MUHAZI Sector with similar regions or with historical data, if available. Highlight similarities and differences that could influence the bio-digester design.

- **Trend Analysis:** Analyze any trends over time or across different demographics within the sector. For example, you might find that waste production increases during certain seasons or varies by household size.

5. Interpretation of Results

- **Key Findings:** Summarize the key findings from your analysis. Explain what the data reveals about the waste generation patterns, energy needs, and potential for bio-digester implementation in the MUHAZI Sector.

- **Implications for Bio-Digester Design:** Discuss how the data informs the design of the bio-digester. For instance, if the data shows a high production of organic waste, this might suggest the need for a larger or more efficient digester.

- **Challenges Identified:** Highlight any challenges or limitations identified during the analysis. This could include data limitations, unexpected trends, or external factors that could impact the bio-digester's success.

The data analysis plays a crucial role in shaping the design of the bio-digester and forming the basis for recommendations to stakeholders. Here's how:

- **Guiding the Design Phase**

- **Waste Volume and Composition:**

- **Design Size and Capacity:** Analysis of the waste volume and its composition informs the size and capacity of the bio-digester. For example, if the data shows a high proportion of organic waste, the digester will need to be designed with sufficient capacity to handle this input and ensure optimal biogas production.

Retention Time: The type of waste influences the retention time, which is the duration waste needs to be kept in the digester to fully break down. Understanding the waste composition allows for the design of a system that ensures efficient digestion.

- **Energy Needs:**

- **Output Requirements:** By analyzing the community's energy consumption patterns, you can design the digester to meet specific energy output requirements. For instance, if the community has a high demand for cooking gas, the digester can be optimized to maximize biogas production.

- **System Efficiency:** The efficiency of the bio-digester can be tailored based on the energy needs. This might include incorporating advanced technology or additional processing steps to enhance biogas yield.

- **Seasonal and Demographic Variations:**

- **Design Flexibility:** If the analysis shows seasonal variations in waste production (e.g., more waste during harvest seasons), the bio-digester can be designed with features that allow for flexibility in input loads. Similarly, demographic variations (e.g., larger households producing more waste) can guide the design to ensure it meets the diverse needs of the community.

- **Site Selection and Infrastructure:**

- **Optimal Location:** Data analysis might reveal the best locations for the bio-digester based on factors like proximity to waste sources, accessibility, and topography. This ensures that the infrastructure is efficiently utilized and easy to maintain.

- **Scalability:** The design might include provisions for future scalability if the data suggests potential growth in waste production or energy needs.

3.6 Ethical Consideration

Ethical Considerations in the Design and Implementation of the Bio-Digester Project

When working on a project like the design and implementation of a bio-digester, especially in a specific community like the MUHAZI Sector, ethical considerations are crucial to ensure that the project benefits the community and respects their rights and well-being. Below are the key ethical considerations you should address in your project:

- **Informed Consent**

- **Community Involvement:** Ensure that the community members are fully informed about the project, its goals, potential benefits, and any risks involved. They should understand how the bio-digester will affect their daily lives, especially in terms of waste management practices and energy usage.

Voluntary Participation: Participation in the project, whether it's providing waste or using the biogas, should be entirely voluntary. Community members should not feel coerced into participating due to social pressure or other factors.

- **Respect for Cultural Practices**

- **Cultural Sensitivity:** Consider the local customs, traditions, and beliefs regarding waste management and energy usage. Some communities may have specific practices or taboos related to waste that could affect their willingness to participate in the project.

- **Adaptation of Design:** The design and operation of the bio-digester should respect these cultural practices. For instance, if certain waste materials are traditionally treated in a specific way, the project should consider integrating or adapting to these practices.

- **Equity and Fairness**

- **Inclusive Participation:** The project should ensure that all community members, regardless of socio-economic status, gender, age, or other factors, have equal access to participate in and benefit from the bio-digester. This includes equitable distribution of biogas and by-products like organic fertilizer.

- **Avoiding Displacement:** The project should be designed and implemented in a way that does not displace or disadvantage any group within the community. For example, site selection for the bio-digester should avoid encroaching on land that is important for community use or that could lead to social conflicts.

- **Privacy and Confidentiality**

- **Data Protection:** If the project involves collecting personal data from community members (e.g., household waste production data), it's important to protect their privacy. Personal data should be anonymized where possible, and secure measures should be in place to prevent unauthorized access.

- **Confidentiality of Responses:** Any surveys or interviews conducted should respect the confidentiality of participants. Their responses should not be shared in a way that could identify them without their explicit consent.

- **Environmental Responsibility**

- **Sustainable Practices:** The design and operation of the bio-digester should prioritize environmental sustainability. This includes ensuring that the digester does not lead to harmful environmental impacts, such as pollution or depletion of natural resources.

- **Waste Management:** The project should promote responsible waste management practices, ensuring that all waste is processed in an environmentally friendly manner. This includes proper handling of any by-products of the digestion process, such as sludge, which should be disposed of or utilized in a way that does not harm the environment.

- **Transparency and Accountability**

- **Open Communication:** Maintain transparency with the community and other stakeholders about all aspects of the project. This includes openly sharing information about the project's progress, any challenges encountered, and the decision-making processes.

- **Accountability Mechanisms:** Establish clear mechanisms for accountability, where community members can raise concerns or complaints about the project. There should be a process in place for addressing these issues fairly and promptly.

- **Health and Safety**

- **Risk Management:** Identify and manage any potential health and safety risks associated with the bio-digester. This could include risks related to the handling of waste, operation of the digester, and use of biogas. Provide training to the community on safe practices.

- **Emergency Preparedness:** Develop and communicate emergency response plans in case of accidents or malfunctions, ensuring that the community knows what to do in such situations.

- **Long-Term Sustainability**
- **Community Ownership:** Encourage community ownership and involvement in the long-term operation and maintenance of the bio-digester. This can be achieved through training programs and the establishment of local management committees.
- **Capacity Building:** Build the capacity of the local community to manage and sustain the bio-digester after the initial project phase. This ensures that the benefits of the project continue long after external support has ended.
- **Social and Economic Impact**
- **Economic Opportunities:** Consider how the project can create economic opportunities for the community, such as jobs in the operation and maintenance of the bio-digester or through the sale of biogas and organic fertilizer.
- **Mitigating Negative Impacts:** Assess and mitigate any potential negative social or economic impacts of the project. For instance, if the project leads to changes in local waste management practices, ensure that it does not negatively affect those who previously earned a livelihood from waste collection.

3.7 Limitation of the Study

Every research project has limitations that must be acknowledged to provide a balanced and transparent understanding of the findings. Recognizing these limitations is important for interpreting the results accurately and identifying areas for future research. Here are some common limitations that might apply to your study on the design of a bio-digester in the MUHAZI Sector:

- **Scope of Data Collection**
- **Geographical Limitation:** The study is limited to the MUHAZI Sector in the RWAMAGANA District. This geographical focus means that the findings may not be directly applicable to other regions with different environmental, social, or economic conditions.

Sample Size: The number of households or businesses surveyed or studied might be limited due to time, resources, or accessibility. A small sample size may affect the generalizability of the results, as the data might not fully represent the entire community

- **Time Constraints**

- **Limited Time Frame:** The data collection might have occurred over a short period, possibly not capturing long-term trends or seasonal variations in waste production and energy consumption. This could lead to a partial understanding of the community's waste generation patterns.

- **Seasonal Variations:** If data was collected during a specific season, it might not account for variations in waste production and energy needs that occur during other times of the year.

- **Data Accuracy and Reliability**

- **Self-Reported Data:** If the study relied on self-reported data from surveys or interviews, there might be issues with accuracy due to respondents' recall bias, misunderstanding of questions, or intentional misreporting.

- **Measurement Errors:** Any errors in measuring waste quantities, energy consumption, or other variables could impact the accuracy of the data analysis. Inconsistent data collection methods could lead to skewed results.

- **Technological and Logistical Constraints**

- **Technology Availability:** The availability and reliability of technology for data collection, such as digital tools for measuring waste, might have been limited. This could have affected the precision of the data collected.

- **Logistical Challenges:** Physical and logistical challenges in reaching certain areas or households might have limited data collection, especially in remote or difficult-to-access regions of the MUHAZI Sector.

- **External Influences**

- **Environmental Factors:** Unforeseen environmental factors, such as extreme weather conditions or natural disasters, could have affected the waste generation patterns or energy consumption during the study period.
- **Economic Changes:** Any sudden economic changes, such as inflation or shifts in local industries, could have impacted the community's waste production or energy needs, potentially skewing the study's findings
- **Cultural and Social Dynamics**
- **Cultural Sensitivity:** The study may not have fully captured the cultural and social dynamics that influence waste management practices in the community. If cultural factors were not adequately considered, the data might not reflect the true waste management behaviors of the community.
- **Community Engagement:** Limited community engagement or reluctance to participate in the study might have led to incomplete or biased data. If certain groups were underrepresented, the study's findings might not reflect the diversity of the community.

- **Financial and Resource Limitations**
- **Budget Constraints:** Limited financial resources may have restricted the scope of the study, affecting the ability to conduct more extensive data collection, hire specialized personnel, or invest in advanced data analysis tools.
- **Resource Availability:** The availability of resources, such as transportation for field visits or materials for data collection, might have limited the depth and breadth of the research.

CHAPTER 4: DESIGN SPECIFICATION (RESULT AND DISCUSSION)

4.1 Introduction

In this chapter, we present the design specifications for the bio-digester tailored to the MUHAZI Sector in RWAMAGANA District, focusing on the technical and operational parameters essential for its successful implementation. The design specifications include the capacity requirements, material selection, system layout, and performance criteria, all of which are critical for ensuring the bio-digester's efficiency and sustainability. This section outlines the rationale behind each specification, providing a clear understanding of how these design choices address the specific needs of the region and contribute to the project's overall goals.

The cost of designing a biodigester toilet system project depends on a number of factors, including location (region), material type, required storage tank capacity, size, quality, and manufacturer**.**

DETERMANATION OF TANK SIZE

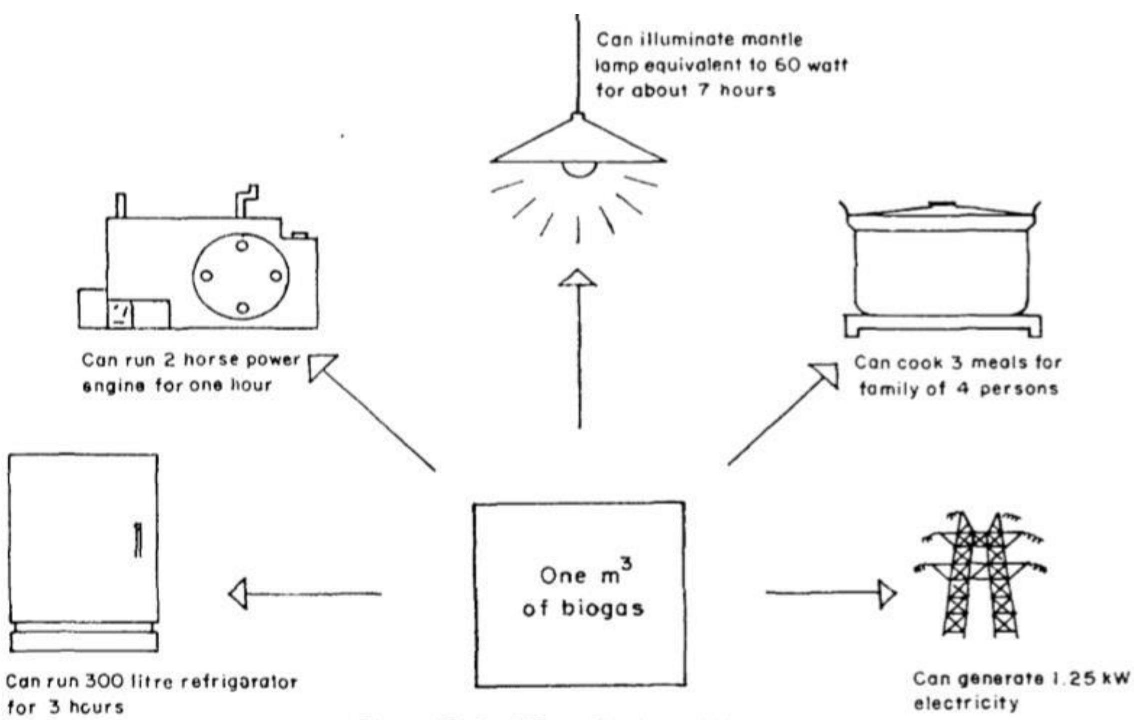


Figure: different application of one meter cube (updated guide book of bio digester)

4.2 CALCULATION

- **BIOGAS PRODUCTION FROM HUMAN WASTE:**

We'll assume 200g (or 200ml) of night soil, 800ml of pee, and 1litre of flush water each person, with a slurry temperature of 27oC in 60 days, yielding 24litres of gas per person using the toilet. If 1m3 of gas is required every day, then 1000/24=42 people must use the restroom.

In 60 days, 42 people can produce 1m3 of gas using a digester tank with a volume of 5040l (equivalent to 5.04 m3). Updated manual on biogas development.

In our case we have:

42 people equals 1 m3 of gas.

1 person = 1 m3 of gas/42 people.

1414 people = 1 m3 of gas divided by 42 people equals 33.67 m3 of gas.

The volume of digester now

42 people equals 5.04m3 of digester.

1 person = 5.04m3 of digester tank/42 people.

1414 people equals 5.04m3 of digester tank. To address an unexpected consequence at LYCEE DE LAKE MUHAZI, we constructed a 200m3 digester tank to accommodate 1414 people divided by 42 people over 60 days.

ANALYSIS AND DESIGN

DETERMINATION OF FIELD DENSITY OF SOIL BY CORE CUTTER METHOD

AIM:

To determine the density of soil by core cutter method

APPARATUS:

- Cylindrical core cutter. Measure the height (h) and internal diameter (d) of the core cutter and apply grease to the inside of core cutter.
- Weighthe empty core cutter (w_1).
- Clean and level the place where density is to be determined

d)Using a steel rammer, drive the core cutter into the earth to its full depth.

PROCEDURE:

- Measure the core cutter's height (h) and internal diameter (d), and lubricate the interior.
- Clean and level the place where density is to be determined.
- Use a steel rammer to drive the core cutter into the soil to the desired depth.
- Use a crowbar to excavate the earth around the cutter, then carefully lift it without disturbing the soil.
- Trim and clean the sample's top and bottom surfaces, as well as the water's exterior surface. Weigh the core cutter using dirt (w_2).
- Using a sample ejector, remove soil from the core cutter and collect a representative sample to assess moisture content (w).

OBSERVATION:

INTERANAL DIAMETER OF CORE CUTTER (D) =10cm

HEIGHT OF THE CORE CUTTER (h) =13cm

VOLUME OF THE CORE CUTTER (v) =1021.02cm^3

SPECIFIC GRAVITY OF THE CORE CUTTER (G) =2.738

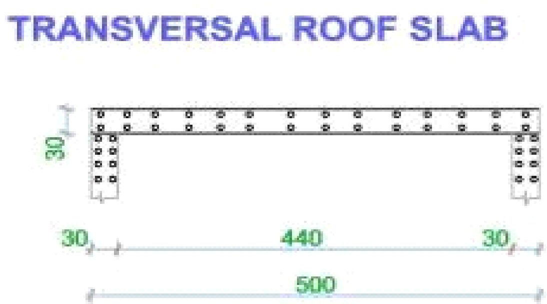
EMPTY WEIGHT OF CYLINDER (w_1) =1.004 kg

WEIGHT OF CYLINDER WITH SOIL (w_2) =4.570 kg

CALCULATION:

WEIGHT OF SOIL= 4.570-1.004 =3.566 g/cc =35.66 KN/m.

4.2 DESIGN OF BIO DIGESTER TANK



The digester tank capacity is 200m3.

Shape: Rectangular subterranean digester tank, unit weight of soil=35.66 KN/m3.

Soil bearing capability equals 230 KN/m2.

Freeboard = 0.25 m. Materials offered include M20 grade concrete and Grade 1 steel. Characteristic Strengths

σcb = 7 N/mm2, σst = 140 N/mm2, σctb = 1.7 N/mm2, m = 13, j = 0.84.

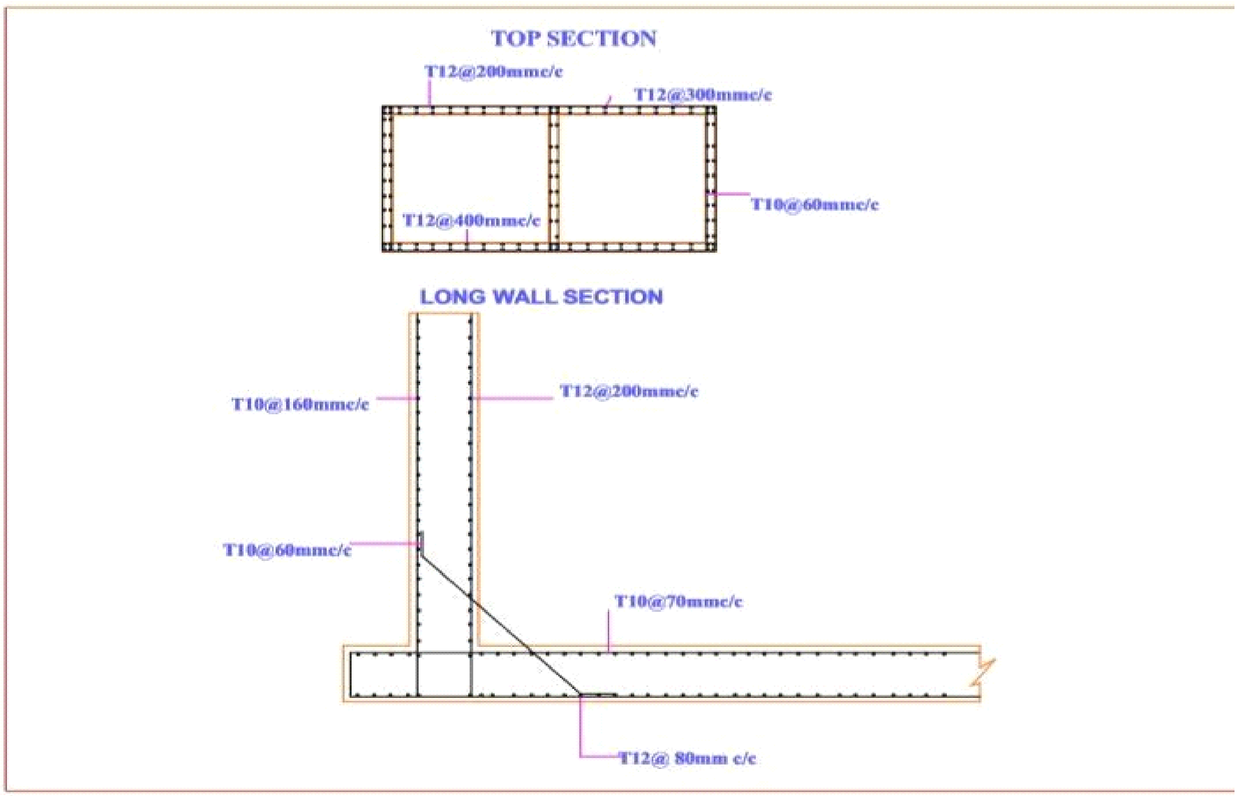
DIMENSION CALCULATION

Required capacity= 200 m^3

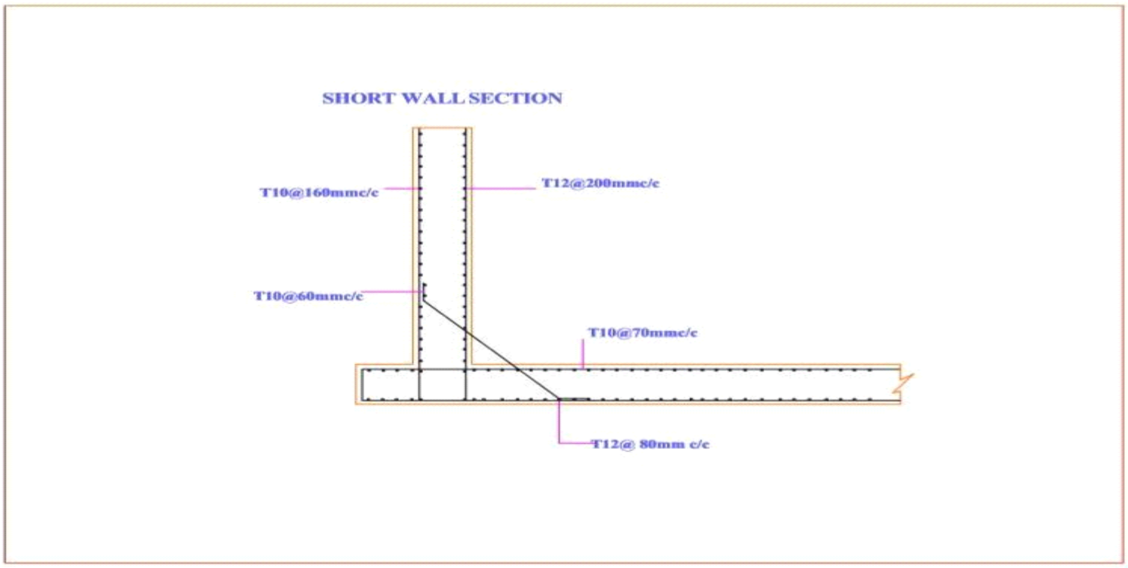
Total height with free board= 4.25 m

Area of tank in plane = 200÷4= 50 m^2

Use 10x5x4.25 m



Reinforcement detail in both long and short wall



4.3 BIO DIGESTER DESIGN SPECIFICATION

Bio-Digester Type

- **Type of Bio-Digester:**
- Specify the type of bio-digester (e.g., fixed-dome, floating-drum, tubular).
- Justification: Explain why this type was chosen based on efficiency, cost, and suitability.

- **Material Selection**
- **Construction Materials:**
- List the materials used (e.g., concrete, steel, plastic).
- **Reasons for Material Choice:**

- Explain why these materials were chosen in terms of durability, cost, and availability.

- **Structural Design**
- **Components:**
- **Digester Chamber:** Describe the design and construction of the main digestion chamber.
- **Inlet and Outlet:** Provide specifications for the inlet and outlet systems.
- **Gas Storage:** Detail the design of the gas storage system.

4.4 COST ESTIMATION

- **Calculation for the bills of quantities**

BILLS OF QUANTITY BIO DIGESTER

	DESCRIPTION OF WORK OF ITEM	UNIT	Quantity	Rate in frw	Amount in frw
I. **PRELIMINARY WORKS**					
1.	Site clearance	Lm	1	50,000	50,000
2.	Installation of working place	l.m	1	50,000	50,000
3.	Excavation of earth work	l.m	1	300,000	300,000
4.	Setting out	l.m	1	25,000	25,000
SUB TOTAL					**425,000**

II. <u>DIGESTER TANK</u>					
1	Concrete in long and short wall	m3	5.8	200,000	1,160,000
2	Bottom and top slab concrete	m3	0.504	200,000	100,800
3	Stone masonry in construction	m3	0.336	50,000	16,800
SUB TOTAL					**1,277,600**
III. <u>PLUMBING WORK</u>					
1	Distribution pipe	l. s		60,000	60,000
SUB TOTAL					**60,000**
IV. <u>EXTRA WORKS</u>					
1	Scaffolding	l.s	50	5,000	250,000
SUB TOTAL					**250,000**
TOTAL					**2,012,600**
CONTIGENCIES 4%					**80,504**
GRAND TOTAL					**2,093,104**

GRAND TOTAL IN LETTERS : Two million ninety three thousand one hundred and four

RESULT:

- Important information: In LYCEE DE LAKE MUHAZI, firewood is always purchased at a rate of 14,000 Rwf per m3. This means that in a term or three months, they must consume 20 steri, or 20 m3, which is equivalent to 280,000 Rwf.

- Keep in mind that there are three trimesters to the academic year. Therefore, 280,000*3=840,000Rwf is the current amount of gas produced from toilet waste in two months.

Additionally, during the academic year, 33.35 m3*9/2trimester=150.075 m3 of biogas are produced.

- By referring to biogas expert we found that one person require between 150lto 300l or 0.15 m3to 0.3m3per day in developed nation

- During implementation, the total investment for the existing system was 3654600 Rwf. In contrast, the bio digester system, which is one of the current systems, had a total investment of 2,093,104 Rwf. If LYCEE DE MUHAZI keeps using firewood for cooking, they will have to pay 840000Rwf over the course of a year.

- After speaking with an expert on human fertilizer, we found that whereas one person can produce humus equal to 9100 Rwf annually, 1414 research students produce 9100 * 1414 = 12,867,400 Rwf annually.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The design of the biodigester at Lycée de Lake Muhazi is a significant step towards sustainable waste management and renewable energy production for the institution. Through the careful assessment of waste resources available, along with the specific energy needs of the school, the proposed biodigester design offers an efficient solution to convert organic waste into biogas. This not only reduces the environmental impact of waste disposal but also provides a reliable and cost-effective energy source that can alleviate the dependency on traditional fuels.

5.2 RECOMMENDATION

To ensure the successful implementation and long-term operation of the biodigester, the following recommendations are proposed:

- **Regular Monitoring and Maintenance:**

- Establish a routine maintenance schedule to ensure the biodigester operates efficiently.
- Regularly monitor the input materials to maintain the balance between carbon and nitrogen for optimal biogas production.

- **Training and Capacity Building**:

- Provide training for the school's technical staff and students on the operation and maintenance of the biodigester.
- Integrate the biodigester project into the school's curriculum to enhance learning about renewable energy and sustainability.

- **Community Engagement:**

- Involve the local community in the project to raise awareness about the benefits of biodigesters.
- Explore opportunities to expand the project to neighboring schools or communities to maximize the environmental and economic benefits.

- **Continuous Improvement:**

- Conduct periodic assessments to identify potential improvements in the biodigester's design and operation.
- Stay updated with advancements in biodigester technology and consider upgrades as necessary to enhance efficiency and output.

- **Funding and Support:**

- Seek external funding or partnerships to support the initial costs and future expansion of the project.
- Collaborate with governmental and non-governmental organizations to ensure ongoing support and recognition of the biodigester's impact.

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APPENDEX

The research question that will be used are the questions that will help us to carry out the necessary information related DESIGN BIODIGESTER which is located in LYCEE DE MUHAZI

The name: UWINEZA OLIVIER

ULK POLYTECHNIQUE

Advanced Diploma Program

DEPARTMENT OF CIVIL ENGINEERING

Option: Construction Technology

Instructions

- ❖ Open-End questions, write the answer in the space provided

QUESTIONAIRE RESERVED TO LYCEE DE MUHAZI/ MUHAZI SECTOR

1) What is the impact of using firewood in the cooking process

a. Poor sanitation ....

b. lung cancer...

c. Eye disease...

2) Is there around MUHAZI sector has the way to use fertilizers from toilet waste managegment

YES or NO........................

3) Is there any waste toilet management in LYCEE DE LAKE MUHAZI?

YES or NO........................

4) If yes, what is it?

a) Ventilated improved pit latrines..............................

b) Toilet connected to convectional septic tank....................

c) Toilet connected to Bio Digester..

5) Who will support in implementation of this research project

a) World vision.............................

b) LYCEE de lake muhazi.......................

c) Muhazi sector...................................

d) Rwamagana district........................