CHAPTER 18: DESIGN OF WASTEWATER COLLECTION AND TREATMENT INFRASTRUCTURE

18.1 Introduction of the Unit of Learning

This unit covers the competencies required to design wastewater collection and treatment infrastructure. It involves the collection of wastewater infrastructure design data, analysis of wastewater infrastructure design data, and calculation of wastewater infrastructure design parameters, drawing wastewater infrastructure units, and compiling wastewater infrastructure design reports. This standard applies to Water Industry.

18.2 Performance Standard

Apply hydraulic engineering principles, analyze structural elements, design structural elements, collect wastewater infrastructure design data, analyse wastewater infrastructure design data, calculate waste water infrastructure design parameters, draw wastewater infrastructure units, compile a wastewater infrastructure report based on standards and fluid properties.

18.3 Learning Outcomes

18.3.1 List of Learning Outcomes

a) Apply hydraulic engineering principles
b) Analyze structural elements
c) Design structural elements
d) Collect wastewater infrastructure design data
e) Analyze wastewater infrastructure design data
f) Calculate wastewater infrastructure design parameters
g) Draw wastewater infrastructure units
h) Compile a wastewater infrastructure design report

18.3.2 Learning Outcome No 1: Apply Hydraulic Engineering Principles

18.3.2.1 Learning Activities

Learning Outcome No 1: Apply Hydraulic Engineering Principles	
Learning Activities	**Special Instructions**
1.1 Identify ***properties of fluids*** 1.2 Identify ***tools and equipment*** for measurement of pressure, velocity, and discharge 1.3 Apply hydraulic principles	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.2.2 Information Sheet No 18/LO1: Apply Hydraulic Engineering Principles

Introduction to learning outcome

This learning outcome covers fluid properties, fluid pressure measurement, discharge and velocity measurement, head losses in pipes, and simple channel sections.

Definition of key terms

Pascal's law- A pressure change at any point in a confined incompressible liquid is transmitted throughout the fluid such that the same change occurs everywhere.

Area of the flow-The region through which a fluid flows

Rate of flow-the the volume of fluid that flows per unit time.

Content/Procedures/Methods/Illustrations

1.1 Identify *properties of fluids* (Density, Surface Tension, Viscosity, Specific Weight, Specific Gravity, Compressibility, Capillarity, Specific Mass) based on standards

Table 51: Properties of fluids

Density	Mass per unit volume
Surface tension	The tendency a liquid surface to behave like a thin stretched elastic material.
Viscosity	Friction in fluids
Specific weight	Weight per unit volume of a material
Specific gravity	The ratio of density of a given substance to the density of a reference material
Compressibility	The measure of the relative-volume change of a fluid in reaction to pressure variation
Capillary	The capability of a liquid to flow in thin spaces without the aid of external forces

1.2 Identify tools and equipment for measurement of pressure, velocity, and discharge based on fluid properties

Table 52: Tools and equipment

Equipment/Tool	Use
Manometer	Measures gas pressure
Venturi meter	Increase the velocity of flow thus reducing the pressure to deduce flowrate
Orifice meter	Measures the flow rate of steam
Pitot tube	Measures fluid flow velocity
Weirs	Control the flow rate of a river
Notches	Regulate the flow of fluid
Mouthpiece	Tube opening for fluid discharge
Orifice	Hole opening for fluid discharge
Hydrostatic bench	Bench used for a wide range of fluid experiments
Open channel models	Simulation for fluid flow in open channels

Apply hydraulic principles based on the types of fluids

Hydraulic principles is an application of Pascal's law.

Types of fluids include;

1. Ideal fluid- Has no viscosity and is incompressible hence not affected by Pascals principles
2. Real fluid- has viscosity hence hydraulic principles applicable
3. Newtonian fluid-Refers to a real fluid that conforms to newton’s law of viscosity

4. Non-Newtonian fluid- A real fluid that does not obey the newtons law of viscosity
5. Ideal plastic fluid-shear stress is proportional to its shear strain

Conclusion

This learning outcome covered fluid properties, fluid pressure measurement, discharge and velocity measurement, head losses in pipes, and simple channel sections.

Further Reading

Read a book on introduction to fluid mechanics

18.3.2.3 Self-Assessment

Written Assessment

1. Select the odd one out in the fluid types listed.
    a) Ideal
    b) Real
    c) Newtonian
    d) Elastic
2. Which equipment measures gas pressures?
    a) Venturi meter
    b) Manometer
    c) Orifice
    d) Weir
3. The ratio of the mass of a fluid to its volume is called
    a) Capillary
    b) Specific mass
    c) Specific gravity
    d) Specific weight
4. Which one is not a variable considered in fluid mechanics.
    a) Pascal’s pressure law
    b) rate of flow
    c) Area of flow
    d) Couple coplanar forces
5. Derive Pascal’s law from first principles.
6. Summarize the types of fluids

7. Evaluate the functions of the following
    a) Weir
    b) notch
    c) mouthpiece
    d) orifice
    e) venture meter
    f) manometer
8. Distinguish between specific weight and specific gravity
9. Explain the properties of a real fluid
10. Highlight the applications of surface tension in real life
11. Differentiate between a notch and a weir
12. Discuss the benefits of understanding fluid mechanics to an engineer.
13. There exist no ideal fluids. Discuss

Oral Assessment

1. Based on the pressure law experiment.
2. What are the observations made from the experiment?
3. What conclusion can be made based on the above observations?

Practical Assessment

Set up an experiment to demonstrate Pascal's pressure law.

18.3.2.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

18.3.2.5 References

Singh, V. P. (2016). Review of Fundamentals of Open Channel Flow by Glenn E. Moglen.

Abdulrahman, A. (2017). Numerical Solution of Manning's Equation in Rectangular Channels. International Journal of Civil and Environmental Engineering, 11(6), 740-743.

Castro-Orgaz, O., & Hager, W. H. (2019). Computation of Steady Transcritical Open Channel Flows. In Shallow Water Hydraulics (pp. 183-200). Springer, Cham.

18.3.3 Learning Outcome No 2: Analyse Structural Elements

18.3.3.1 Learning Activities

Learning Outcome No 2: Analyse Structural Elements	
Learning Activities	**Special Instructions**
2.1 Identify ***Properties of materials*** 2.2 Analyse ***Section properties*** 2.3 Analyse ***structural elements***	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.3.2 Information Sheet No 18/LO2: Analyse structural elements

Introduction to learning outcome

This learning outcome covers the theory of simple bending, forces in frames, deflection in beams, section properties, properties of materials, and moments in beams.

Definition of key terms

Stress: This is defined as the intensity of the force acting on a member

Strain: This is a measure of the deformation of a material.

Mohr's theorem: Mohr's theorem is an engineering tool utilized to calculate maximum and minimum principal stresses and shear stresses.

Content/Procedures/Methods/Illustrations

2 .1Identify *Properties of materials* (Stress, Strain, Elasticity, Plasticity, Stiffness, Young's modulus) based on the job requirements.

The properties of materials are a key consideration for which the material is considered suitable for a specific need. The common physical and mechanical properties include some of the following:

i) Elasticity- This is defined as a material's ability to return to its original configuration when the twisting force is removed, which is the opposite of plasticity.

ii) Stress- Repeated stresses can lead to fatigue which can lead to fracture. Therefore higher repeated stresses will accelerate the time to failure.

iii) Strain- The ability of a material to deform and return to its original shape determines the point the material will no longer return to its original shape after being loaded.

iv) Plasticity- This determines the ability of a material to hold a new shape when subjected to a distortional force.

v) Stiffness- This refers to the ability of a material to resist deformation in response to a distortional force.

vi) Young's modulus- This is the relationship between the force applied and the resulting deformation. This is a key determination for applications where a high degree of stiffness is required under load.

2 .2Analyse *Section properties* (Centre of gravity, Centroids, 1st moment of area, 2nd, Section modulus, moment of area, Radius of gyration) based on the materials, loading, and sizes.

Section properties refer to the mathematical properties of structural shapes and they are applied to a great extent in structural analysis and design.

i) Centroids- This defined as the center of the moment of the area of a cross-section of material. Therefore, the centroid of a material is the geometric center of the material. Materials, therefore, have a different location of the centroids based on their shape.

ii) Center of gravity- This is the point from which the entire weight of an object is considered to act.

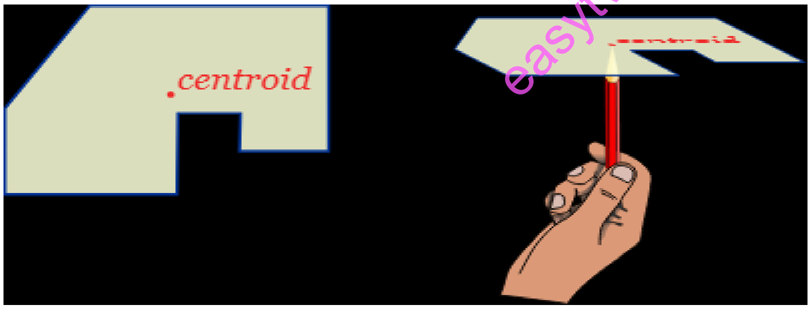


Figure 178: Center of gravity
Source: https://.mathsisfun.com].

iii) 1st moment of the area- This describes the distribution of an area about either its x or y-axes. It is determined as the summation of the product of each area and its distance from the axis.

iv) 2nd moment of the area- This is also known as moment of inertia and it measures the capability of a material to resist bending about a certain axis. As a result, structural elements with a higher moment of inertia have a higher capacity to resist bending.

v) Section modulus- It is defined as the proportion of the total moment countered by the section to the stress in the extreme fibre which is equal to yield stress.

vi) The radius of gyration- This the root mean square distance of the particles of a structural element about an axis of rotation.

2.3 Analyze *structural elements* (Stress, Strain, General slope and deflection formula, Double integration, McCauley’s method, Mohr’s theorems) based on material and loadings.

Structural analysis is the method(s) by which we find out the effects of loads on physical structures and internal forces. Structural analysis is a mandatory precursor to structural design. The science of structural analysis is so extensive that it would require several books to describe all the methods sufficiently.

i) Stress- This the internal resistance that the member to balance the effect of externally applied loads.

ii) Strain-This is the ratio between the changes in the length of the structural member to the original length as a result of an externally applied load.

iii) General slope and deflection formula- This formula expresses that the deflection can be computed by taking the double integral of the bending moment equation. It is used to compute deflection in beams.

iv) Macaulay's method- is referred to as the double integration method and to find expressions for the deflection of loaded beams. It is very efficient when applied to discrete loading.

v) Mohr's theorems- This a method to determine the rotation, slope, and deflection of beams and frames. It is also known as the moment area theorems. It is also used to calculate deflection in beams.

Conclusion

This learning outcome covered the theory of simple bending, forces in frames, deflection in beams, section properties, properties of materials, and moments in beams.

Further Reading

Read more on:

1. Structural analysis 8th edition by R.C Hibbeler.
2. Structural analysis by Gregory Mikaelson.(Youtube)

18.3.3.3 Self-Assessment

Written Assessment

1. Which of the following is not a property of a material considered during job requirements?
   a) Ductility
   b) Toughness
   c) Plasticity
   d) Centroid

2. Which of the following are all structural analysis methods?
   a) Double integration method
   b) Slope and deflection formula
   c) Mohr's theorems
   d) 1st moment of area

3. Elabourate with examples why structural analysis is a mandatory precursor to structural design.

4. The following are all section properties except?
   a) Center of gravity
   b) Moment of inertia
   c) Section modulus
   d) Stress

5. Differentiate between structural determinate and indeterminate methods.
6. From first principles, derive the Mohr's circle state of stress.
7. Describe what is a continuous beam?
8. Describe what structural analysis software packages exist in the market and their features.
9. Most structures encountered in real life are indeterminate structures. From the foregoing, write an essay describing the various structural analysis methods that exist for indeterminate structures.

Project Assessment

Analyse an example of a continuous beam use Prokon software (obtained from either a textbook or the internet) and compare your manual solution with the solution obtained from the software.

Oral Assessment

1. How did your solution in the project assessment above compare with that of the software?
2. What indeterminate structural analysis methods work best for you?

18.3.3.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras
- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

18.3.3.5 References

John Case, Lord Chilver, and Carl Ross. (2003). Strength of materials and structures. John Wiley and Sons Inc. New York.

18.3.4 Learning Outcome No 3: Design Structural Elements

18.3.4.1 Learning Activities

Learning Outcome No 3: Design Structural Elements	
Learning Activities	**Special Instructions**
3.1 Identify structural elements 3.2 Design structural elements are designed 3.3 Produce structural drawings	• Group discussions • Demonstration by trainer • Online videos • PowerPoint presentation • Exercises by trainee

18.3.4.2 Information Sheet No 18/LO3: Design Structural Elements

Introduction to learning outcome

This learning outcome covers identifying structural elements, designing of structural elements and the production of structural drawing based on the design.

Definition of key terms

McCauley's method: Refers to the double integration method used to find expressions for the deflection of loaded beams.

General slope formula: This formula expresses that the deflection can be computed by taking the double integral of the bending moment equation.

Deflection formula: This calculated by integrating the function that describes the slope of the member.

Content/Procedures/Methods/Illustrations

3.1 Identify structural elements based on the requirements

Structural elements have to do with the part of the building that is concerned with preserving the physical integrity (ensuring the structure satisfies the ultimate limit state and the serviceability limit state requirements) and continues to exist in the world as a physical object. Understanding the structure of a building requires an intuitive ability which depends on the knowledge of the functional requirements of the structure and the ability to differentiate between the non-structural and structural parts of a building.

The following are some of the structural elements:

i. Foundations – The foundation is a structural element that transmits load to the underlying soil or rock, the loads supported by the foundation and its self-weight in such a way that the soil is not overstressed or excessive settlement occurs.
ii. Columns- These are vertical members that majorly resist axial compressive loads.
iii. Beams- These are horizontal members that primarily carry vertical loads and resist failure in bending.
iv. Walls- A wall is a structure that demarcates the different spaces in a building as well as the external boundary. Some walls are load-bearing and carry the structural loads of the building.
v. Ties-This is a slender structural element that carries the loads in tension.
vi. Struts- This a structural member that carries the loads in compression only.
vii. Trusses-This a structure that is composed of a series of struts and is used to carry loads in compression.
viii. Frames- This type of structure is composed of beams and columns that are either pin or fixed connected.
ix. Slabs-This are horizontal structures built to provide a flat surface in buildings.

3.2 Design structural elements based on design codes

The design of members refers to the sizing of members to ensure they fit functional requirements during the ultimate limit state as well as the serviceability limit state. Design of structures in Kenya is the preserve of registered and licensed professional engineers, according to the Engineers Act (2011), however, graduate engineers and technologists (diploma holders) have an opportunity to contribute during the design phase under the guidance of the professional engineer.

The design of members is guided by design codes upon which reference is made during the design process. The following are some of the design codes currently in use in Kenya:

i. Design of reinforced concrete structures- BS 8110
ii. Design of steel-framed buildings- BS 5950
iii. Design of timber structures- BS 5628
iv. Design code on the occupancy load requirements of a building- BS 6399 Part 1.

The following is the procedure followed in the design of a beam according to BS 5950:

i. Determine the loading condition of the beam.
ii. Calculate the design load of the beam.
iii. Perform structural analysis to determine the design moment and the design shear.
iv. Perform a strength classification and section classification.
v. Choose a section based on its moment capacity equation.
vi. Perform a moment capacity check.
vii. Perform a shear capacity check.

viii. Evaluate whether it’s a low or high shear load.
ix. Perform a deflection limits check.
x. Perform a web bearing check.
xi. Perform a web buckling check.

3.3 Produce structural drawings based on the design.

Structural drawings have to be produced as the design process evolves since the drawings are required in the construction of the structure. Production of structural drawings takes place as follows:

i. The schematic architectural drawings are obtained from the architect. (Conceptual design phase)
ii. The engineer determines the loadings applied to the structure based on the drawings and performs design to size the members according to the forces applied to the building. (Developed design phase)
iii. As the design process evolves the engineer produces more detailed drawings, bar bending schedules, notes, specifications, details, and at the end of this stage we have construction ready documents. (Technical design phase)
iv. The drawings are included in a tender pack to be tendered together with drawings from other disciplines during the bidding and tendering process.

Conclusion

This learning outcome covered the structural elements of a building, design of steel, and production of structural drawings.

Further Reading

British Standards Institute. (2002). Design of reinforced concrete structures-BS 8810. BSI.
British Standards Institute. (2002). Design of steel structures-BS 5950. BSI.
British Standards Institute. (2002). Design of timber structures-BS 5628. BSI.

18.3.4.3 Self-Assessment

Written Assessment

1. Compare and contrast the following types of foundation
    a) Mat
    b) Isolated footing
    c) Combined footing
2. Which of the following is not a check done during the design of a reinforced concrete beam?
    a) Shear capacity check.
    b) Moment capacity check.
    c) Web buckling check.
    d) Deflection check
3. Which of the following is not a phase during the design of structures?
    a) Technical design
    b) Developed design
    c) Conceptual design
    d) Handover
4. Which of the following is not a structural element?
    a) Ties
    b) None
    c) Trusses
    d) Joists
5. Design a reinforced concrete beam of your choice according to the design code BS 8110.
6. Describe the various type of foundations and when should be used.
7. Describe the design principles that should guide an engineer during the design process.
8. Describe the main design theories.
9. Write an essay describing how an engineer with poor communication skills can lead to poor quality construction.

Project Assessment

Using a BIM software application of your choice obtain architectural drawings from the internet and develop a corresponding structural model.

Oral Assessment

Describe how you as a student pursuing a diploma of civil engineering can develop shop drawings for fabrication of steel members when requested by the professional engineer.

What skills have you gained as a result of performing the project assessment described above?

18.3.4.4 Tools, Equipment, Supplies and Materials

- Computers
- Rulers, pencils, erasers
- Drawing sheets
- Software
- Projectors
- Calculators
- Internet

18.3.4.5 References

W.H Mosley, R. Hulse, J.H Bungey (2012). Reinforced Concrete Design. Red Globe Press, New York.

N. Subramanian (2010). Steel structures design and practice. Oxford university press, New Delhi.

Abdy Kermani (2008) Structural timber design. Blackwell Science, London.

18.3.5 Learning Outcome No 4: Collect Wastewater Infrastructure Design Data

18.3.5.1 Learning Activities

Learning Outcome No 4: Collect Wastewater Infrastructure Design Data	
Learning Activities	**Special Instructions**
4.1 Map out areas to be surveyed 4.2 Prepare ***tools for data collection*** 4.3 Collect ***data and information***	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.5.2 Information Sheet No 18/LO4: Collect Wastewater Infrastructure Design Data

Introduction to learning outcome

This learning outcome covers mapping out an area in preparation for wastewater data collection, tools, and methods to collect relevant data preparation and determination of relevant amounts and types of data to be collected from an area to better the wastewater management of the area.

Definition of key terms

Stabilization pond- These are large man-made water bodies that use natural processes in treating domestic water, sewage, and sludge as well as animal or industrial waste.

Detention time- this defines the time required for a known amount of wastewater to go through a tank at a set flow rate.

Scour Velocity- the speed of water that is required to dislodge settled solids from the stream bed.

Content/Procedures/Methods/Illustrations

4.1 Map out areas to be surveyed based on job requirements/specifications.

Wastewater management map is essential and assists in identifying where current wastewater servicing exits and where it is planned and also shows where servicing should be avoided. We can also use the map for supporting policies in the development plan, for example, when a plan needs new developments for connection to services where they are available, this can be shown on the map, it identifies how and where the development will connect and determines cost implications of accommodating development in areas with specific services. From a map, we can identify areas where ejectors and disposal fields are not allowed due to factors such as public health issues, soil limitations, environmental issues, policies or other reasons. The layering of wastewater system maps over land use designation maps will help integrate land use with wastewater management planning.

To map out an area for surveying we consider our topic which is wastewater and identify the various factors that we consider. These factors mainly focus on drainage and conservation of the environment. The main factors can be

- Infrastructure – in terms of crowding of buildings
- Population – population density is a major factor since a large amount of wastewater is expected
- Nearness to water bodies (rivers and streams) – conservation of the environment is important hence disposal of wastewater into them should be limited.
- Wildlife such as fish in water bodies
- Relocation plans for people living in areas where the wastewater treatment plant is expected to be developed.

4.2 Prepare tools for data collection (Stopwatch, Checklists, Questionnaires, Stationery, and Sampling equipment) based on information required.

In accordance with the study, we will use research methodologies to collect data on the area we have mapped out. Since water is a human resource we mainly focus on the population in terms of policies and essential needs by them. We are going to depend mainly on primary and qualitative data.

Primary data involves obtaining data directly from individuals and qualitative data is data we use for description without measurement.

Our data would be got by the following methods:

- Sample surveys
- In-person interviewing
- Telephone interviewing
- Mailed questionnaire
- Observations
- Case studies

4.3 Collect *data and information* (Population size and flow rate) based on tools prepared.

The data and information required in wastewater normally focus on the environmental and health issues, the goal is to better the hygiene of the general population and to ensure clean water is available for use by the population.

From the data tools and methodologies, we are expected to obtain the following information:

- The general population in the area
- What amount of the population have access to clean water
- Are there any rampant waterborne diseases in the mapped out area and if there are specify
- Understand and research the wastewater drainage system in the area.
- Public opinion in accordance with wastewater management in the area.

Conclusion

This learning outcome covered mapping the area, tools preparation, and quantity of wastewater data collection.

Further Reading

Read further

On wastewater infrastructure and data collection on

https://www.gov.mb.ca/mr/plups/pdf/wwg.pdf

18.3.5.3 Self-Assessment

Written Assessment

1. Summarize the reasons for mapping out an area.
2. From a map, we can identify where ejectors and disposal points can be placed, choose a factor that is not used to identify areas for disposal points and ejectors.
    a) Policies
    b) Soil limitation
    c) Health issues
    d) Water cleanliness

3. Which of the following is not a method of obtaining data
    a) using questionnaires
    b) sampling
    c) counting
    d) case studies
4. Predict the goal of data collection for wastewater treatment among the following
    a) To better hygiene of the public.
    b) To come up with systems
    c) Identifying new infrastructure
5. Explain the importance of mapping
6. Summarize the factors that can be used to identify disposal fields for wastewater treatment?
7. Outline the various method of data collection to obtain data which is helpful in wastewater treatment?
8. Explain the various methods of data collection?
9. Describe the types of information obtained for wastewater treatment?

Oral Assessment

1. Differentiate between primary and secondary data
2. Elaborate the term qualitative data?

Case Study Assessment

Briefly explain the impact of wastewater treatment in the area you currently stay **in.**

Oral Assessment

Construct questions that can be used to obtain data by using face to face interaction as a method of obtaining data?

Practical Assessment

In groups, use the questions you came up with to role play and practice on the face to face method of collecting data.

Project Assessment

Compose a questionnaire and hand them over to the public around your area then analyze and interpret the data obtained.

18.3.5.4 Tools, Equipment, Supplies and Materials

- Computers
- Software
- Cameras

- Construction manuals
- Projectors
- Flip charts
- Calculators
- Rulers, pencils, erasers
- Charts with presentations of data
- Drawing sheets
- Internet
- Relevant videos

18.3.5.5 References

Water, Wastewater, and Stormwater Infrastructure Management, Second Edition (2012): Neil S. Grigg

Wastewater Irrigation and Health: Assessing and Mitigating Risk in Low (2010): ...edited by Pay Drechsel, Christopher A. Scott, Liqa Raschid-Sally, Mark Redwood, Akica Bahr

Strategic Asset Management of Water Supply and Wastewater Infrastructures (2009): edited by Helena Alegre, Maria do Ceu Almeida

18.3.6 Learning Outcome No 5: Analyse Wastewater Infrastructure Design Data

18.3.6.1 Learning Activities

Learning Outcome No 5: Analyse Wastewater Infrastructure Design Data	
Learning Activities	**Special Instructions**
5.1 Arrange data and information 5.2 Clean data 5.3 Present data	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.6.2 Information Sheet No 18/LO5: Analyse Wastewater Infrastructure Design Data

Introduction to learning outcome

This learning outcome covers categorizing population into various classes, analyzing and cleaning climatic and hydrological data, and producing topographical maps and ground profiles from survey data.

Definition of key terms

Hydrostatic bench- is a self-contained bench that is equipped with all apparatus needed for a comprehensive range of experiments on properties of fluids and hydrostatics.

Open Channel-defined as a design of flow enclosed in a conduit with a free surface commonly known as a channel.

Weirs- simply defined as a barrier across the width if a river to alter its flow.

Content/Procedures/Methods/Illustrations

5.1 Arrange data and information based on various themes.

In the middle of qualitative data analysis, we have another job of identifying themes, this can be done by reviewing literature and come from the phenomena being studied, already agreed-upon professional definitions, local common-sense constructs, and researchers.

Data can be arranged using various techniques, in modern trends and computing data is mostly arranged in Microsoft Excel for easier and faster interpretation and analysis.

Apart from Excel sheets data can also be grouped using;

- Pie charts
- Graphs
- Flow charts
- Tabulations

5.2 Clean data as per best practice.

After collecting and arranging data there is a need for it to be cleaned by a process known as data cleansing, this can be defined as a process of detecting and correcting inaccurate data from the database arranged. We shall focus on the quality of data, the quality can be assessed by the following factors:

- Validity
- Accuracy
- Completeness
- Uniformity
- Consistency
- Uniformity

Data cleansing also involves several processes i.e.

i. Data auditing by use of statistical methods
ii. Workflow specifications by removing anomalies
iii. Workflow execution where correctness is verified after the specification
iv. Post-processing and controlling by inspection of the results.

5.3 Present data based on various themes

Table 53: Data based on various themes

THEMES	PARAMETERS OF CALCULATION
Wastewater contamination extent	Data can be sorted into 3 main categories as municipal, agricultural, or industrial wastewater.
Geological data	Focusing on the vegetation in terms of infiltration and soil conditions.
Discharge requirements	Policies are a tool that can be used to come up with wastewater data this is based on requirements by bodies such as NEEMA and KEBS
Sizing of components	Here data is sorted as Primary, secondary and tertiary

Data presentation should be clear and easy to interpret it can be done by a graphical format or tabular, data can be in figures or textual.

The following are methods of presenting data

- Bar graph – used mainly for comparison
- Pie chart – shows percentages
- Line graph – useful in displaying data that changes over time
- Pictographs- uses small identical or figures of objects called isotopes in making comparisons.

Conclusion

This learning outcome covered categorizing population into various classes, analyzing and cleaning climatic and hydrological data, and producing topographical maps and ground profiles from survey data.

Further Reading

Read further areas:

https://www.slideshare.net/rubyocenar/presentation-of-data-37973327

18.3.6.3 Self-Assessment

Written Assessment

1. Data processing is a process of Quality of data can be assessed through the following except which one
    a) Completeness
    b) Validity
    c) Uniformity
    d) Presentation
2. Which of the following is not a method of presenting data?
    a) pie chart
    b) line graph
    c) creating models
    d) bar graphs
3. Explain the term data cleansing
4. Evaluate the sue of the hydrostatic bench.
5. Explain ways in which themes can be identified from a database?
6. explain various methods of data arrangements
7. Classify the modern techniques of arranging data

Oral Assessment

Explain the following processes:

a) Data auditing
b) Workflow specification

Case Study Assessment

Using hydrological data from your area, tabulate and interpret the data then present it

Oral Assessment

Briefly explain the following methods of data presentation.

1. Pie charts
2. pictograms

Practical Assessment

Give an example of a pictogram using data provided,

Project Assessment

Using hydrological data from your area, arrange clean, and present the data using your preferred method.

18.3.6.4 Tools, Equipment, Supplies and Materials

- Software
- Pencils
- Ruler
- T-square
- Scale rule
- Eraser
- Set square
- Drawing board

18.3.6.5 References

Analyzing, completing, and generating data for WWTP modeling: a critical review (2014). : CristinaMartinabPeter A.Vanrolleghema

Measuring the efficiency of wastewater services through data envelopment analysis (2015): A. Guerrini; G. Romano; C. Leardini; M. Martini

Water & Wastewater Infrastructure: Energy Efficiency and Sustainability (2013): Frank R. Spellman

18.3.7 Learning Outcome No 6: Calculate Wastewater Infrastructure Design Parameters

18.3.7.1 Learning Activities

Learning Outcome No 6: Calculate Wastewater Infrastructure Design Parameters	
Learning Activities	**Special Instructions**
6.1 Identify ***design Parameters*** to be calculated 6.2 Identify ***tools for parameter calculation*** 6.3 Calculate various wastewater infrastructure design parameters	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.7.2 Information Sheet No 18/LO6: Calculate Wastewater Infrastructure Design Parameters

Introduction to learning outcome

This learning outcome covers Sizing of the pipes, Hydraulic flow in pipes, Depth of flow, Gradient, and Sizing of treatment units. Pipe sizing is a process in which various pipes are made concerning its diameter. The difference in pipe sizes affects the pressure and the velocities of the fluid flowing within the pipes. Narrow pipes result in higher velocities of flow.

Definition of key terms

BOD: (biochemical oxygen demand). This is the quantity of oxygen dissolved required by anaerobes to digest organic material in the water at a given temperature over a specified duration of time.

TSS :(total suspended solids). This is the dry mass of undissolved suspended particles in a given water sample that can be trapped and filtered such as silt.

Gradient: This is the inclination nature of a slope (upward or downward)

Content/Procedures/Methods/Illustrations

6.1 Identify *design Parameters* (Screening units, sedimentation tanks, grit chamber, trickling filters, stabilization ponds, activated sludge system) to be calculated based on the wastewater design manual.

There are many design parameters to be calculated based on the wastewater design manual. They include;

- Hydraulic load- wastewater influent expressed in per person per day.
- Mass load-indicator of water quality and pollution level
- BOD - (biochemical oxygen demand).
- COD-chemical oxygen demand.
- The volume of suspended solids

6.2 Identify *tools for parameter calculation* (Theodolite, Dumpy level, GPS, Total station, levelling staff, booking sheet, Soil sampler, Adequately equipped soil mechanics labouratory, Flow Measuring structures, and devices, Stopwatch, Questionnaires) based on the parameter to be calculated.

Tools used during the calculation of hydraulic load include; booking sheet, flow measuring structures, and devices and a stopwatch. Tools used during the calculation of Mass load. Mass load requires an adequately equipped soil mechanics lab to determine the pollution level.

BOD is measured by BOD analyzers

Table 54: Tools used during the calculation of Mass load

Tool Name	Description
Theodolite	Measures horizontal and vertical angles
Dumpy level	Measures points on the same horizontal plane
GPS	Global positioning system
Booking sheet	Tabulation of survey data
Stopwatch	Performs accurate timing
Soil sampler	Analyze soil samples

Pipe diameter size is required to determine the discharge and area of discharge at a given time to calculate the hydraulic load.

6.3 Calculate various wastewater infrastructure design parameters based on design codes.

How hydraulic load is obtained = (design flow in gal/day)/area in feet^2.

Mass load= total water flow* conc. Of substance required in mg/l).

Below is an example of how mass load is calculated;

EXAMPLE 1

Mass loading calculations:

Given:

Average flow rate Q=300l/min

Washing Day = 10hours

Washing span = 60 days/year

Average total phosphorous concentration = 0.4 mg/L

1 kg = 1000000 mg

Total water flow (TWF)

TWF = Q × WD × WS

300 L/min * 60 min/hr *10 hrs/day*260days/yr

46800000

Mass loading of phosphorous

MLP = TWF*TP

46800000 L/yr*0.4 mg/L

18720000 mg/yr

Convert to kilograms

MLP = 18720000 MG/YR&* 1kg/1000000mg

18.72 Kg/yr

Conclusion

This learning outcome covered Sizing of the pipes, Hydraulic flow in pipes, Depth of flow, Gradient, and Sizing of treatment units.

Further Reading

Read further on the measurement of BOD

18.3.7.3 Self-Assessment

Written Assessment

1. Which of the following is not a design parameter in wastewater analysis?
   a) Hydraulic load
   b) Lateral wind load
   c) suspended solids (TSS)
   d) mass loading

2. The indicator of the water pollution level is known as.

- a) Mass load
- b) Hydraulic load
- c) BOD
- d) COD

3. Which instrument measures horizontal and vertical angles?

- a) Theodolite
- b) Stopwatch
- c) Dumpy level
- d) Soil sampler

4. Discuss the following terms as used in the waste water analysis

- a) Design parameter
- b) Hydraulic load
- c) Mass load

5. Calculate the hydraulic loading rate given: design flow is 12860 gallons per day, the area is $19.2m^2$

6. Discuss four parameters of wastewater analysis

7. Describe how suspended solids are removed in wastewater?

8. Discuss the effects of the variation of BOD in wastewater.

9. Sizing the pipe to be small is a necessary evil. Elabourate.

Oral Assessment

What were your observations during the visit to the nearby water treatment plant?

What conclusions can be made?

Practical Assessment

Experiment to determine the content of parameters in wastewater**.**

Illustrate the direction of the flow of wastewater in various stages.

18.3.7.4 Tools, Equipment, Supplies and Materials

- Software
- Pencils
- Ruler
- T-square
- Scale rule
- Eraser
- Set square
- Drawing board

18.3.7.5 References

CPL Grady et al (2011), Biological wastewater treatment. New York
Marcos Von Sperling, (2007), Basic Principles of wastewater treatment. Berlin.

18.3.8 Learning Outcome No 7: Draw Wastewater Infrastructure Units

18.3.8.1 Learning Activities

Learning Outcome No 7: Draw wastewater infrastructure units	
Learning Activities	**Special Instructions**
7.1 Identify and gather ***drawing tools, equipment, supplies, and materials*** 7.2 Draw ***wastewater infrastructure units*** based on the design parameters Draw ***wastewater infrastructure units*** 7.3 Submit wastewater infrastructure drawings for approval	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.8.2 Information Sheet No 18/LO7: Draw wastewater infrastructure units

Introduction to learning outcome

This learning outcome covers drawing the different sections and profiles or different parts of the wastewater treatment unit and legal requirements. It also equips the learner with the knowledge of different chambers in the waste water treatment.

Definition of key terms

Equalization tank-A holding tank that ensures consistent flow and loading to subsequent processes over a given period

Rotating biological contactors- is a type of secondary (Biological) treatment process following the removal of grit sand and sediments that allows a biological film to come in contact with the wastewater to remove pollutants before discharge to the environment. It consists of a shaft with mounted rotating discs where biological degradation of pollutants takes place

Oxidation ditch-A circular trough installed with aerators used to purify wastewater by removal of pollutants via oxidation decomposition and adsorption

Content/Procedures/Methods/Illustrations

7.1 Identify and gather *drawing tools, equipment, supplies and materials*

Table 55: Drawing tools, equipment, supplies and materials

TOOL	FUNCTION
pencil	Sketching elements in a wastewater treatment plant
ruler	Draw straight lines
eraser	Delete errors that have been sketched
Drawing board	Provide a stable drawing surface
Masking tape	Mount the paper into place
Set square	Making right angles on the drawings

Identify and gather *drawing tools, equipment, supplies and materials*

The tools that are used in the technical drawing and design office include.

Software**,** Pencils**,** Ruler**,** T-square**,** Scale rule**,** Eraser**,** Set square**,** Drawing board**,** Supplies: Masking tapes**,** Materials: Drawing paper**,** Photocopying /printing papers**,** Equipment: Computer**,** Printer**,** Photocopiers) based on available resources and complexity of the design.

b. Draw *wastewater infrastructure units*

Sewer, Screen, Grit chamber-horizontal, aerated/spiral, Sedimentation tanks, Activated sludge system, Trickling filters(rock and plastic), Ponds, Oxidation ditch, Aerated lagoons, Stormwater drains, Equalization tank, Sequential Batch Reactor, Rotating biological contactors, Oil and grease trap) based on the design parameters.

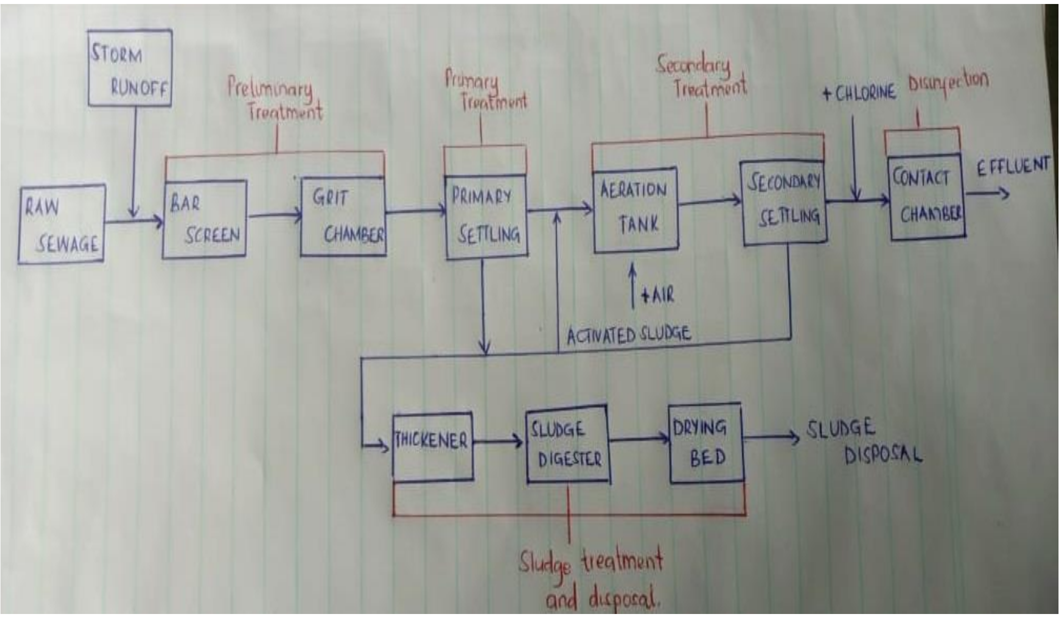


Figure 179: Draw wastewater infrastructure units

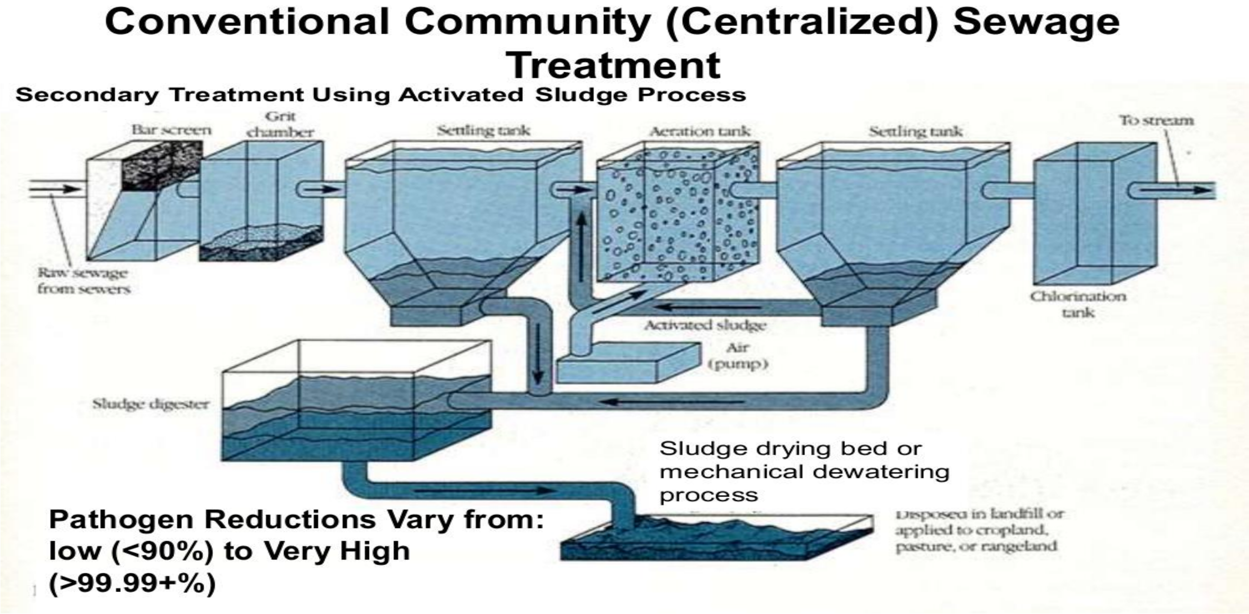


Figure 180: Sewage treatment

Source: Biological wastewater treatment (2011)

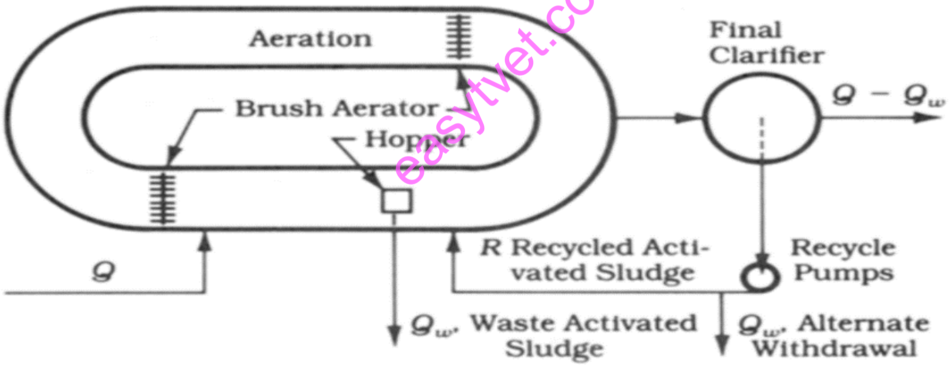


Figure 181: Oxidation ditch

Source: Biological wastewater treatment (2011)

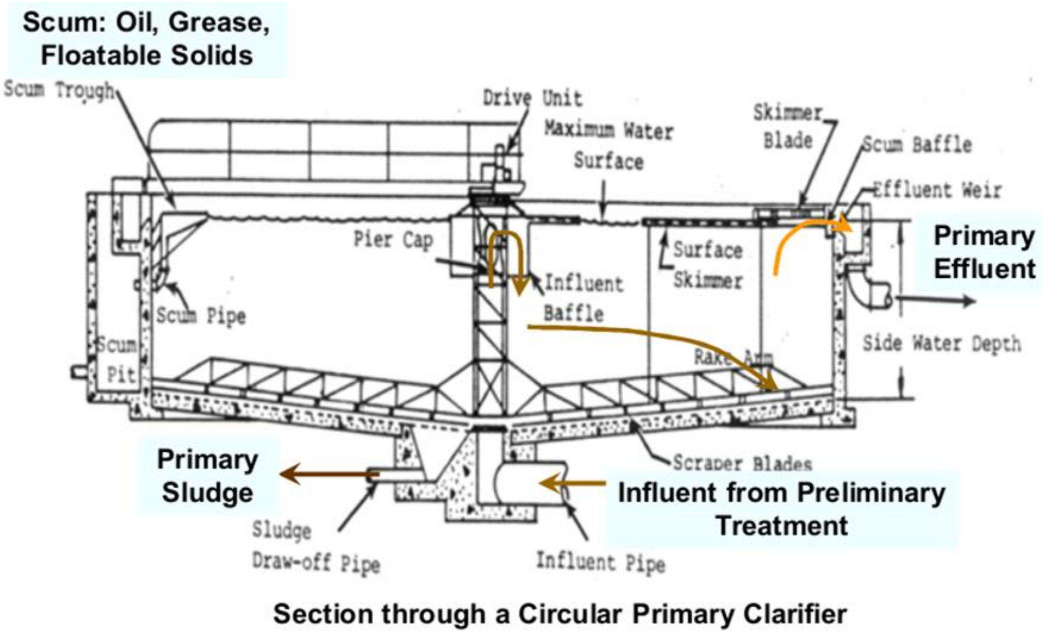


Figure 182: Circular primary clarifier

Source: Biological wastewater treatment (2011)

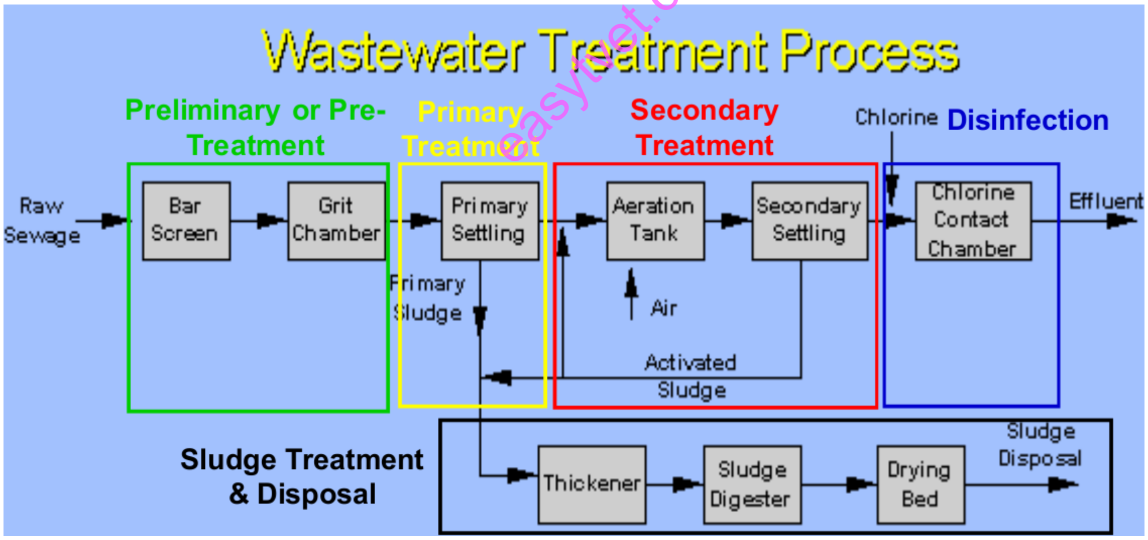


Figure 183: wastewater treatment process

Source: Biological wastewater treatment (2011)

c. **Submit wastewater infrastructure drawings for approval as per legal requirements.**

The various elements of a wastewater treatment plant work as follows;

1. Bar racks to remove large debris
2. Primary treatment were Type II sedimentation for flocculated particles. The SOR ranges from 25-60 m/d, td ranges from 1.5 to 2.5 hours.

3. Secondary treatment involving the use of microorganisms to remove BOD of any solids that pass primary treatment. Oxygen is limited and must be supplied. The most common secondary treatment process is activated sludge.
4. Secondary sedimentation to remove microorganisms from secondary treatment.
5. Disinfection to kill pathogens using chlorine (typically HOCl).

The legal requirements of wastewater infrastructure drawings must;

1. Be of sound engineering adhering to the technical standards put in place
2. Should be well planned to meet the future demands
3. The drawings must be approved by the relevant bodies to ensure it meets the standards in place
4. Should exhibit knowledge of the regulatory frameworks in place.
5. Stakeholders involved should stick to their roles.
6. The drawing must be able to cater for the future demand of the infrastructure

Conclusion

This learning outcome covered drawing the different sections and profiles or different parts of the wastewater treatment unit and legal requirements.

The legal requirements are contained in the water act of the constitution.

N/B Legal Requirements

Water quality Regulations, 2006

Further Reading

Read further on how wastewater treatment units can be made more efficient.

Read the water regulations act of 2006.

18.3.8.3 Self-Assessment

Written Assessment

1. Which chamber in a wastewater treatment plant traps solid material of sewage?
   a) Primary storage.
   b) Aeration zone
   c) Sedimentation tank
   d) Bar racks

2. Which one is not a microorganism in wastewater?
    a) Coliforms
    b) Aerobes
    c) Anaerobes
    d) Symplistica pteridophyte
3. What is the role of microbes in wastewater treatment?
4. State the importance of activated sludge?
5. Compare the composition of the influent and effluents of a wastewater treatment plant?
6. Describe how wastewater is treated?
7. As an engineer, what improvements can you make to a storm drain to improve its role and efficiency?
8. Describe the 3 main stages of wastewater treatment?
9. The activation chamber is the main section of treatment. Discuss.

Case Study Assessment

Given a city with a population of 50000 residents and a wet humid climate design a wastewater treatment plant to meet the demand of the city.

18.3.8.4 Tools, Equipment, Supplies and Materials

- Software
- Pencils
- Ruler
- T-square
- Scale rule
- Eraser
- Set square
- Drawing board

18.3.8.5 References

CPL Grady et al (2011), Biological wastewater treatment. New York.
Marcos Von Sperling, (2007), Basic Principles of wastewater treatment. Berlin.

18.3.9 Learning Outcome No 8: Compile Wastewater Infrastructure Design Report

18.3.9.1 Learning Activities

Learning Outcome No 8: Compile Wastewater Infrastructure Design Report	
Learning Activities	**Special Instructions**
8.1 Obtain design report format from the wastewater design manual. 8.2 Prepare a design report 8.3 Submit a design report to the client	• Group discussions • Demonstration by trainer • Online videos • Powerpoint presentation • Exercises by trainee

18.3.9.2 Information Sheet No 18/LO 8: Compile Wastewater Infrastructure Design Report

Introduction to learning outcome

This learning outcome covers technical report writing and legal requirements. The learner is also equipped with knowledge on how to design report based on the format from the waste water design manual.

Definition of key terms

Questionnaires: - Is an instrument used in research consisting of a series of questions which are intended for gathering information

Discharge: - Is the volumetric flow rate transported through a given cross-section

Sludge: - These are bio-solids that can be reused after stabilization processes such as composting and anaerobic digestion.

Content/Procedures/Methods/Illustrations

8.1 Obtain design report format from the wastewater design manual.

Title Page
Declaration
Dedication
Acknowledgment
Abstract
CONTENTS
LIST OF TABLES

LIST OF FIGURES
LIST OF APPENDICES

CHAPTER 1 INTRODUCTION
1.1 Background
1.2 Problem Statement
1.3 Objectives
1.4 Scope and Limitations of the Study
1.5 Brief and Methodology
CHAPTER 2 2.0 LITERATURE REVIEW
CHAPTER 3 3.0 ROLE OF WASTEWATER TREATMENT INFRASTRUCTURE
CHAPTER 4 4.0 METHODOLOGY OF THE STUDY
CHAPTER 5 5.0 DATA ANALYSIS AND DISCUSSIONS
CHAPTER 6 6.0 CONCLUSION AND RECOMMENDATIONS
REFERENCES
APPENDIX 1
APPENDIX II

8.2 Prepare a design report based on the identified format.

Abstract

To ensure that public health standards are upheld, it is imperative to dispose of human and industrial effluents so that they do not damage the natural environment or pose a danger to human health. Wastewater treatment process aims at removing contaminants from wastewater which is then converted into an effluent that can be recycled back to the water cycle rendering minimal impact on ecosystems.

Wastewater treatment technologies can be classified into mechanical systems, aquatic (Lagoons), and terrestrial treatment systems.

The non-conventional treatment was adopted as was adopted in this particular report because they are easily maintained, less energy-intensive, lower operational and maintenance costs, and is environmentally friendly.

CHAPTER 1 INTRODUCTION

Wastewater includes water and wastes released to the environment and originating from a variety of uses including commercial, residential, and industrial sources. Sewage is waste expelled from domestic dwellings such as commercial, institutional and residential establishments. The composition is expected to be organic because of the consistency of carbon composites.

These contaminants are toxic and dangerous to the environment and human health and thus should be treated prior to being released into the environment in the case when it is discharged back into the watercourse.

The treatment process employs physical, chemical, and biological processes to treat wastewater. The process occurs in a wastewater treatment infrastructure. The infrastructural design is dictated by the wastewater characteristics whereby each stage of treatment say mechanical treatment, biological and sludge treatment sections, are designed based on the wastewater characteristics and the organic loading.

CHAPTER 2 DESIGN

Waste stabilization ponds consist of three stages of treatment, namely,

Table 56: Waste stabilization ponds stages

Primary stage	Solids are separated
Secondary	Dissolved biological matter converted into a solid mass using water-borne bacteria
Tertiary	Biological solids are neutralized then disposed of and treated. Chemical disinfection is conducted at this stage

2.1 DESIGN PROCESS

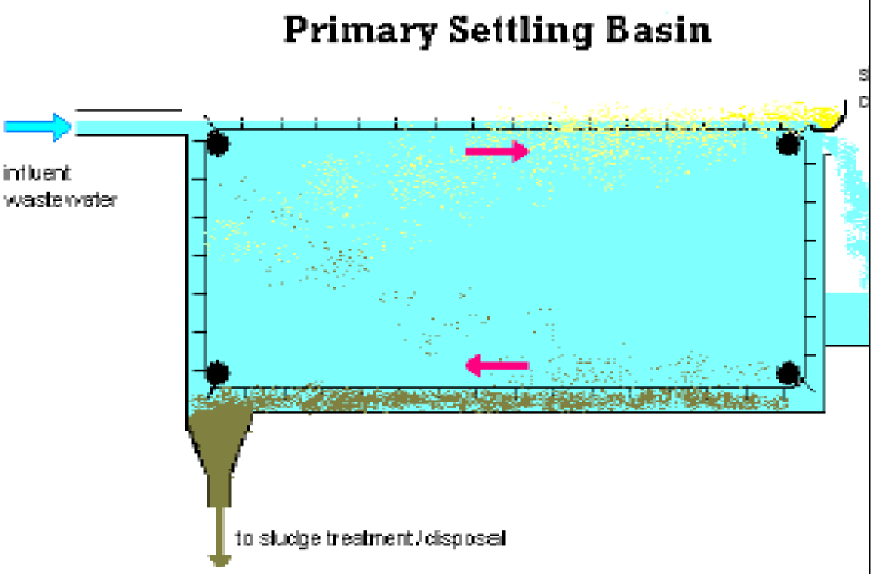
Table 57: Design process

<table>
<tr><td></td><td>PRELIMINARY TREATMENT</td><td></td></tr>
<tr><td>REF</td><td>CALCULATION</td><td>REMARKS</td></tr>
<tr><td></td><td>BAR SCREEN DESIGN
Screens are used for the removal of coarse solids. Their design applies the following criteria.
<table>
<tr><th>Manual bar screens</th><th>Mechanical bar screens</th></tr>
<tr><td>Bar spacing range between 2- 5cm</td><td>Bar spacing range between 1.5 – 4 cm</td></tr>
<tr><td>Screen mounted at an angle of 30^0 - 45^0</td><td>Screens mounted at an angle of 3</td></tr>
<tr><td>Bar thickness is 1cm thick, 2.5cm wide.</td><td>Bar thickness is 1cm thick, 2.5cm</td></tr>
<tr><td>The minimum approach velocity is 0.45 m/s to avoid grit deposition.</td><td>Min approach velocity in the bar
m/s to avoid a deposition.</td></tr>
<tr><td>Max velocity is 0.9 m/s to prevent washout of solids through the bars.</td><td>Max velocity is 0.9 m/s to
washout of solids through the bar</td></tr>
</table>
</td><td></td></tr>
</table>

<table>
<tr><td></td><td>Empirically described by the following equation
<table>
<tr><td>Q = AV or A = $^{Q}/_{V}$
Where
Q= design flow, m^3/s
A = bar screens cross-section
V = approach velocity of channel, m/s

Adopt rectangular channels with depth to width ratio = 1.5 for most efficient section</td><td>Head loss through the bar screen
$$\frac{(V^2 - V'^2) \times 0.7}{2g}$$
Where:
H = head loss
V = velocity through the openings
V’= approach velocity, (m/s)
g = acceleration due to gravity</td></tr>
</table>
The typical head loss coefficient for a clean and clogged coarse screen is 0.8 and 0.5 respectively.</td><td></td></tr>
</table>

<table>
<tr><td></td><td>PRIMARY TREATMENT</td><td></td></tr>
<tr><td>REF</td><td>CALCULATION</td><td>REMARKS</td></tr>
<tr><td></td><td>The purpose of the primary stage is to remove sand and grit and other settleable organic solids that settle at the bottom and keep suspended organic matter in water.



Tchobanoglous and Schroeder, (1985).

Settling Theory</td><td></td></tr>
</table>

$V_s = \sqrt{4g\,\frac{(\dot{\rho}-\rho)d}{3C\rho}}$ Where: V_s = settling velocity $\dot{\rho}$ = particle density ρ = liquid density d = particle diameter C = drag coefficient	$V_h = \sqrt{8\beta\,\frac{(\dot{\rho}-\rho)gd}{f}}$ Where: V_h = scour velocity B = friction face-off particles F = Darcy-weisbach friction factor

Particle density (Kg/m^3)		Settling Vs, (m/s)	
		0.1 mm	0.2mm
sand	2650	25	74
Organic matter	1200	3.0	12
Organic	1020	0.3	1.2

	GRIT CHAMBER	
REF	CALCULATION	REMARKS

The purpose of the grit chamber is to remove organic matter with a higher density greater than 2000 Kg/m^3 and particle size 0.1 – 0.2 mm to protect pumps from abrasion and to prevent clogging of digesters.

$A = W \times H = \frac{Q}{V}$	$\frac{V''}{V} = \frac{H}{L}$

Where:
A = grit chamber area
H = Height of grit chamber
W = width of grit chamber
L = Length of grit chamber
V" = Velocity of scouring
V = settling velocity

	SECONDARY TREATMENT	
REF	CALCULATION	REMARKS
	This stage is included to treat dissolved organic matter that forms the degradable biological content. The mechanism works by introducing micro-invertebrates into raw wastewater that aids in	

the digestion of the organic matter. Three approaches exist in a fixed-film system, suspended film system, and lagoon system.
The lagoons system is addressed in performing this design. Lagoons work by holding water for several months to allow the natural degradation of sewage.

Biological Treatment
The purpose of biological treatment is to capture solids that are unable to settle. The solids are trapped into a biological floc or biofilm.

2.2 LOADING

This describes the amount to be applied to the treatment process

1. Population Loading

   The geometric growth model is used to determine the population increase over a specified design period is divided into three segments, initial year 5years, Basic year (10 years), and Final year (25 years).

$$\mathrm{Pt} = \mathrm{P0}(1 + r)^t$$

Where:

P_0 = initial population

P_t = population after t years

	SECONDARY TREATMENT	
REF	CALCULATION	REMARKS

Waste Stabilization Ponds

The most important design parameters for WSP include:

Climate	Temperature, Net radiation, Solar insulation.
Flow	Normally 85% of the in-house water consumption.
BOD	Measured based on a 24hour flow weighted data.

Organic Loading

Biochemical oxygen Demand (BOD)

BOD loading is estimated from the following equation

$$\mathrm{Li} = 1000\frac{B}{q}$$

Where

L_i = waste water BOD (mg/l)

B = BOD contribution (g/capita.day) Range (30-70g/capita.day)

Q = wastewater flow (L/capita.day)

Anaerobic Ponds

Continuous organic load of wastewater is received daily into the first stage of biological treatment which is a basin that is 3 – 5 m deep. The high wastewater loading depletes all oxygen and thus anaerobic conditions prevail.

At the bottom of the pond solids, settle and anaerobic digestion of sludge occurs

Anaerobic Pond Design

Designed based on volumetric loading $\lambda_{v,}$ (g/m^3/d)

$$\lambda \mathrm{v} = \frac{\mathrm{Li}Q}{\mathrm{Va}}$$

Where:

L_i = influent BOD (mg/l), Q = flow rate (m^3/day)

V_a = anaerobic pond volume

	SECONDARY TREATMENT	
REF	CALCULATION	REMARKS

The recommended influent BOD loading is in the range of (100 – 400g/m^3.day.

Hydraulic retention time is then calculated as,

$$t = \frac{\mathrm{Va}}{Q}$$

Volumetric loading table

Temperature (℃)	Volumetric Loading (g/m^3.d)	BOD removal (%)
< 10	100	40
10-20	20T−100	2T+20
20-25	10T+100	2T+20
>25	350	70

Mara and Pearson, (1986).

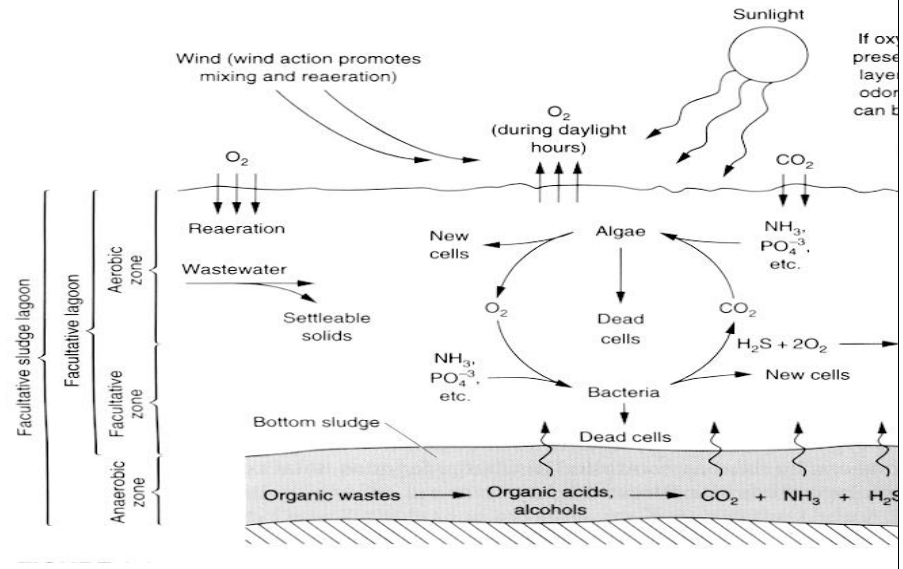
Mid depth area

$$\mathrm{A1} = \frac{\mathrm{V1}}{\mathrm{d1}}$$

Facultative Ponds Design

Allow shallow depths of basins (1.5 – 2m), to enable light penetration and photosynthetic production of oxygen, so that microbial action of decomposing organic material can be favored.

An anaerobic state exists at the bottom of the pond where settleable solids are degraded.



Tchobanoglous and Schroeder, (1985).

	SECONDARY TREATMENT	
REF	CALCULATION	REMARKS

Facultative pond design

Their design assumes they are completely mixed reactors in which BOD5 removal, adheres to first-order kinetics.

$$\frac{\mathrm{Le}}{\mathrm{Li}} = \frac{1}{(1 + \mathrm{K1t})}$$

$$\mathrm{t} = \frac{(\mathrm{Le}/\ \mathrm{Li}\ \ - 1)}{1/\ \mathrm{K1}}$$

the mid area depth

$$A = \frac{Qt}{D}$$

Facultative ponds are designed on the based on surface loading ,λ_s,

$$\lambda \mathrm{s} = \frac{10\mathrm{Li\ Q}}{\mathrm{Af}}$$

where:

Li = the influent sewage concentration (mg/L)

A_f = Facultative pond area (m^2)

Surface loading value is given by: $\lambda_s = 20T - 120$

Retention time θ_f ,(days)

<table>
<tr><td></td><td>

$$\theta f = \frac{AfD}{Qm}$$

Where:
Q_m = mean flow, (m^3/day)
D = pond depth usually 1.5m).

</td><td></td></tr>
</table>

<table>
<tr><td></td><td>TERTIARY TREATMENT</td><td></td></tr>
<tr><td>REF</td><td>CALCULATION</td><td>REMARKS</td></tr>
<tr><td></td><td>

Maturation pond

The objective of maturation ponds is to remove pathogenic microbes in the wastewater. The removal process occurs due to sunlight in the water column. Basin depth ranges between (0.8 – 1.5m).

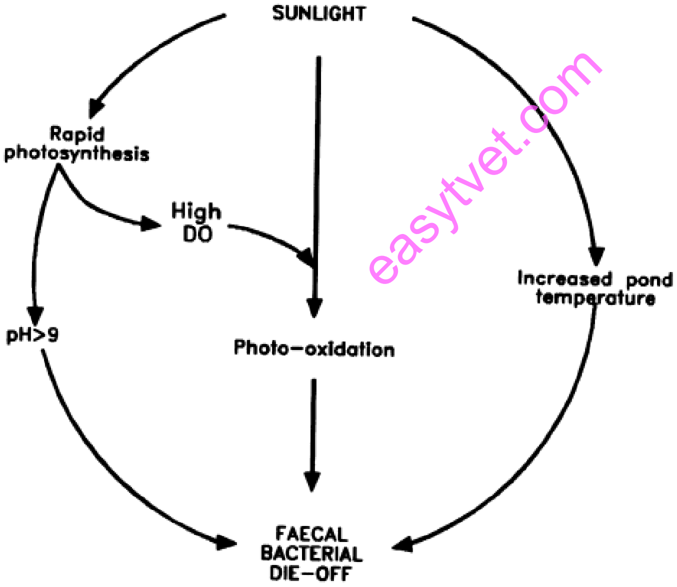


Figure 3.4 Conceptu mechanisr faecal colif off in ponc

Tchobanoglous and Schroeder, (1985).

<u>Design of Maturation Ponds</u>

They are designed based on first-order kinetic models as in a completely-mixed reactor.

$$Ne = \frac{Ni}{1 + KT\,\theta}$$

The maturation ponds are normally arranged in series

$$Ne = \frac{Ni}{[(1 + t1\,KT)(1 + t2KT)(1 + t3\,KT)n]}$$

</td><td></td></tr>
</table>

	$\mathrm{KT} = 2.6(1.19)^{T-20}$ $\mathrm{V3} = \mathrm{Q} \times \mathrm{t3}$ Mid area depth $\mathrm{A3} = \frac{\mathrm{V3}}{\mathrm{d3}}$	

	TERTIARY TREATMENT	
REF	CALCULATION	REMARKS
	Where: Ne and Ni = number of faecal coliform per 100mlin the effluent and influent KT = first-order rate constant for faecal coliform removal per day Θ = retention time (day). CONCLUSION In non-conventional treatment design, the selection of treatment processes depends on the wastewater quality. In case the wastewater is found not to contain pathogenic microorganisms then the engineer can decide the design for only three stages of treatment say Preliminary, primary, and secondary excluding maturation ponds. Other designers may exclude preliminary treatment when the wastewater has no or minimal, large objects. The design methodology presented applies to all non-conventional treatment system. Variations my occur only in the selection of data to be used.	

8.3 Submit a design report to the client as per best practice

The report is presented in the form of slides that explain the design process. The engineer must be conversant with all the processes so that the slides only assist him to plan the presentation.

The seven rule applies in preparing the slides that is seven slides, seven sentences and seven words per sentence

TITLE SLIDE
PROJECT TITLE
NAME
SPECIALITY

PROBLEM STATEMENT

- The need for the waste treatment plant
- Challenges in implementing the project
- Solutions to the above challenges
- Future changes in trends

METHODS AND MATERIALS

- Design criteria
- Materials required for design
- Tools, equipment, and machinery required

DATA COLLECTION

- Types of data
- Methods of collection of data
- Data transfer and storage

DATA ANALYSIS

- Empirical and numerical modeling
- Design codes referencing
- Design software applications

RESULTS AND RECOMMENDATIONS

- Design report presented
- Sizes of infrastructure decided upon
- Approval of the project

CONCLUSIONS

Conclusion

This learning outcome covered technical report writing and legal requirements.

Further Reading

Arrhenius equation and its application
Linear growth models and exponential growth models

18.3.9.3 Self-Assessment

Written Assessment

1. In characterizing wastewater which of the terms doesn't describe wastewater source.
   a) Industrial sources
   b) Underground sources
   c) Residential sources
   d) Commercial sources
2. Wastewater treatment process is grouped into three, mechanical treatment, biological treatment, and chemical treatment, which of the following is not included in mechanical treatment.
   a) Removal of large objects
   b) Removal of sand and grit
   c) Primary sedimentation
   d) Faecal coliform removal
3. Which of the following is true about detention time?
   a) Oxidation pond detention time range = (3 – 5) days
   b) Facultative pond detention time range = (25 – 180) days
   c) Aerated pond detention time range = (7 – 20) days
   d) Storage pond/HCR pond detention time range = (100 – 200)
4. Which one is the odd one out?
   a) Activated sludge
   b) Trickling filter
   c) Rotating biological contactors
   d) Grit chamber
5. Tertiary treatment is also called high-rate secondary treatment. Which one of the following is not removed at this stage?
   a) Nitrogen
   b) Phosphorous
   c) Refractory organics
   d) Non dissolved solids

6. Why is it important to pre-treat industrial wastewater before releasing it to the treatment plant?
7. Discuss the chemicals used in wastewater treatment
8. Which are the regulatory bodies which control the quality of effluent discharged into the environment.
9. Describe the mechanism of treatment in an activated sludge system
10. Analyse the types and operational principles of conventional systems

Practical Assessment

In your university labouratory perform tests for BOD_5 by conducting an experiment using samples from your school kitchen.

Oral Assessment

Make a slide presentation describing the geotechnical procedures conducted on a proposed wastewater treatment site and present to your class.

Project Assessment

Design a suspended growth system using OPENMDELICA software application

18.3.9.4 Tools, Equipment, Supplies and Materials

- Software
- Pencils
- Ruler
- T-square
- Scale rule
- Eraser
- Set square
- Drawing board

18.3.9.5 References

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