# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

## FACULTY OF ENGINEERING

## DEPARTMENT OF CIVIL AND WATER ENGINEERING

### Water Quality and Treatment

### ECW 5101

### Main Examination Paper

### December 2024

This examination question paper consists of 4 pages.

| | |
|---|---|
| **Time Allowed:** | **3 Hours** |
| **Total Marks:** | **100** |
| **Examiner's Name:** | **Jeremiah Chimhundi** |

## INSTRUCTIONS

1. Answer **ALL** questions.

2. Use of calculators is permissible.

## ADDITIONAL INFORMATION

Graph Paper

## MARK ALLOCATION

| QUESTION | MARKS |
|---|---|
| 1. | 25 |
| 2. | 25 |
| 3. | 25 |
| 4. | 25 |
| **TOTAL POSSIBLE MARKS** | **100** |

## Question 1

Slow sand filtration (SSF) is a chemical free water treatment technique which has been found very effective especially for low income, low technology communities. Draw a fully labelled SSF system and explain the design, operation and maintenance features to assure the production of clean potable water.                                                                                                                [25]

## Question 2

a.  State and explain any three mechanisms through which particles flocculate.                [10]

b.  The following data was extracted from initial designs of the Umlazi Water Treatment Plant assessment report by SEGAfrica. As a junior civil engineer working for SEGAfrica propose a permissible design for the flocculation basin.

The following parameters and the manufacturer's data are provided:

Assume the 1st iteration gives a satisfactory impeller diameter.

**Design flow rate = 11.5x10³ m3/d**

**Flocculation time = 30 min**

**Three flocculator compartments with G =70, 50, 30 s⁻¹**

**Water temperature = 5 °C**

**kinematic viscosity = 1.519**

**Dynamic viscosity = 1.519 x 10⁻³ Pa.s**

**Place impeller at one-third the water depth**

*State all assumptions necessary.*

From manufacturer's data the following impellers are available:

| Impeller type | Impeller diameters (*m*) | | | Power number ($N_p$) |
|---|---|---|---|---|
| Radial | 0.3 | 0.4 | 0.6 | 5.7 |
| Axial | 0.8 | 1.4 | 2.0 | 0.31 |

[15]

## Question 3

a. According to sedimentation theory, particle settling is categorised into four types. State and briefly describe the types giving at least one application example. **[5]**

b. The city of Mutare is planning to install a new settling tank as an upgrade to their existing water treatment plant. Design a settling tank to remove 65% of the influent suspended solids from their design flow of 0.5 m³/s. A batch-settling test using a 2.0 m column and coagulated water from their existing plant yielded the following data:

| Depth, m | Sampling time, min | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 10 | 20 | 40 | 60 | 90 | 120 |
| 0.5 | 41 | 50 | 60 | 67 | 72 | 73 | 76 |
| 1.0 | 19 | 33 | 45 | 58 | 62 | 70 | 74 |
| 2.0 | 15 | 31 | 38 | 54 | 59 | 63 | 71 |

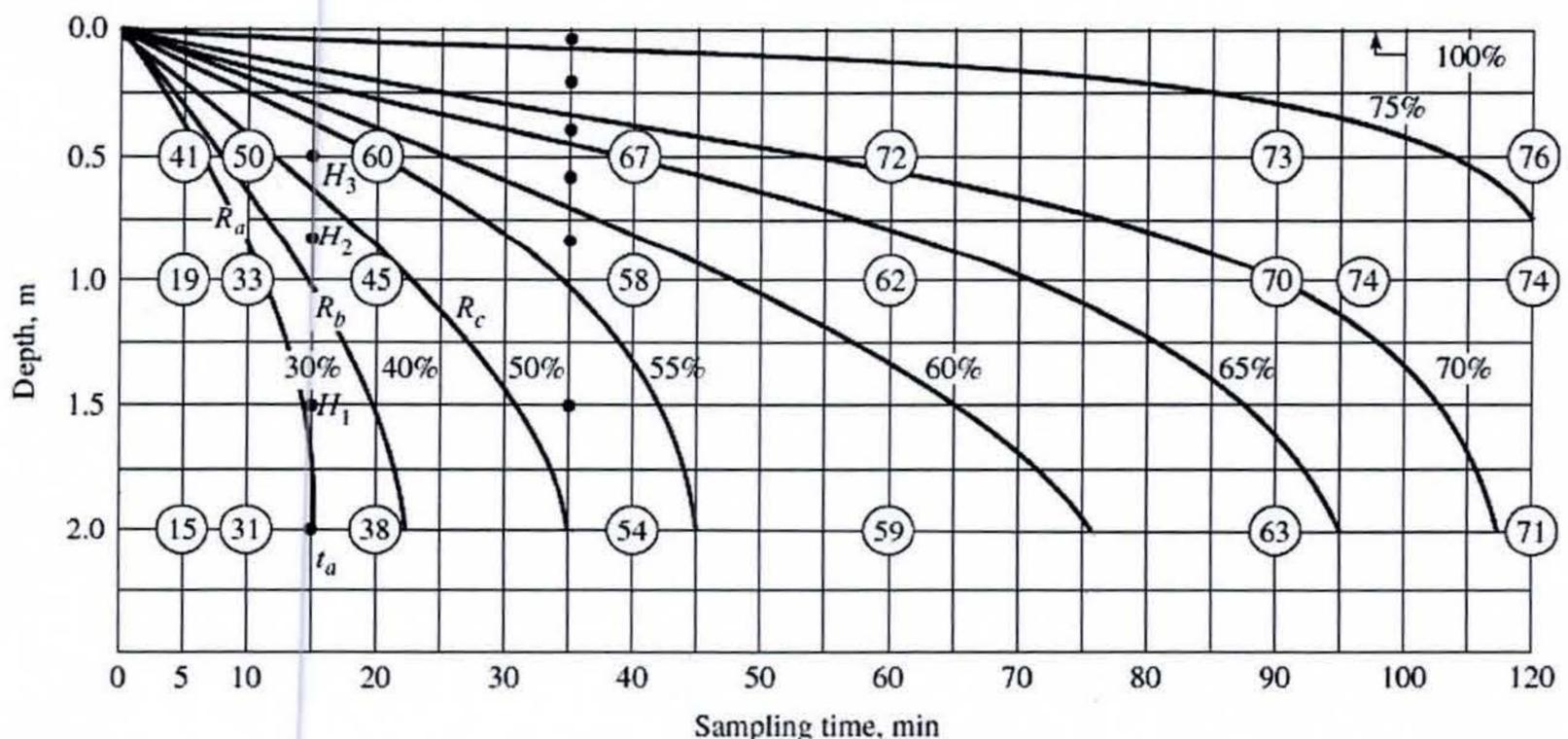**Figure Q3-1: Percentage removal as a function of time and depth**



**Figure Q3-2: Isoconcentration lines for Type II settling test using a 2-m-deep column**

State all the assumptions necessary for the design. **[20]**

## Question 4

a. List and explain the key elements of a water quality monitoring plan. **[5]**

b. Critically evaluate the use of chloramines as an alternative to free chlorine disinfection. **[5]**

**c.** With aid of neat sketches describe the terms, lake stratification and turnover and their application in water quality management. **[5]**

**d.** State the two types of intake structures, specify their respective design type and applications in water quality and treatment. **[5]**

**e.** Results of chlorine demand test on a raw water are given Table Q4-1. Determine the break-point dosage and the chlorine demand. **[5]**

**Table Q4-1: Results of chlorine demand test on a raw water**

| Sample no. | Chlorine dosage (ppm) | Residual chlorine after 0.167hrs contact. (ppm) |
|:---:|:---:|:---:|
| A | 0.2 | 0.18 |
| B | 0.4 | 0.34 |
| C | 0.6 | 0.48 |
| D | 0.8 | 0.46 |
| E | 0.9 | 0.27 |
| F | 1.0 | 0.18 |
| G | 1.2 | 0.38 |
| H | 1.4 | 0.58 |
| I | 1.6 | 0.78 |