Technical Assistance
HYDROLOGY PROJECT

World Bank & Government of The Netherlands funded

Training module # WQ - 45

How to Measure Sulphate

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DHV Consultants BV & DELFT HYDRAULICS

with
HALCROW, TAHAL, CES, ORG & JPS

Table of contents

1. Module context

This module deals with the significance of sulphate to water quality and method for measuring sulphate. Modules in which prior training is required to complete this module successfully an other available, related modules in this category are listed in the table below.

While designing a training course, the relationship between this module and the others, would be maintained by keeping them close together in the syllabus and place them in a logical sequence. The actual selection of the topics and the depth of training would, of course, depend on the training needs of the participants, i.e. their knowledge level and skills performance upon the start of the course.

No.	Module title	Code	Objectives
1.	Basic water quality concepts	**WQ - 01**	• Discuss the common water quality parameters • List important water quality issues •
2.	How to prepare standard solutions	**WQ – 04**	• Select different types of glassware • Use an analytical balance and maintain it • Prepare standard solutions •
3.	Major ions in water	**WQ - 28**	• Know the major ions in water and air sources • Understand the significance of major ion concentrations •
5.	Emission Spectroscopy and Nephelometry	**WQ - 35**	• Understand the principles of emission spectroscopy and nephelometry • Explain how emission spectroscopy and nephelometry are used for specific laboratory analyses

2. Module profile

Title	:	How to Measure Sulphate
Target group	:	HIS function(s): Q2, Q3, Q5, Q6
Duration	:	Theoretical session of 30 min, plus Practical Laboratory session of 120 min, plus Report writing session of 30 min.
Objectives	:	After the training the participants will be able to*:* • Understand the relevance of sulphate to water quality • Know how to analyse sulphate
Key concepts	:	• Turbidimetric method • Relation of Sulphate concentration to different water uses
Training methods	:	Lecture, Laboratory Analytical exercises, Report preparation
Training tools required	:	Board, flipchart, OHS, Complete Laboratory Facilities for Sulphate Analysis
Handouts	:	As provided in this module Including SAP for Analysis of Sulphate
Further reading and references	:	• Chemistry for environmental engineers - C. N. Sawyer, P. L. McCarty & G. F. Parkin, McGraw - Hill, Inc., 1994 • Standard methods for the examination of water and wastewaters, AWWA, 19th edition, 1995

3. Session plan

No	Activities	Time	Tools
1	***Preparations*** • Prepare reagents according to SAP for sulphate measurement • Prepare samples as follows using tap water and sulphate standard: A = Tap water B = Tap water + 100 mg/L SO_4^{-2} C = Tap water + 200 mg/L SO_4^{-2}		
2	***Introduction***: • Introduce the session • Ask the question, 'Why do we need to measure sulphate?' • Talk about the occurrence of sulphate in the environment • Discuss the sulphate cycle • Discuss sulphate as a plant nutrient and the problems it can cause in the aquatic environment • Describe this sulphate method in terms of its chemistry, the theory of nephelometry and potential inteferences: **Refer to SAP for Sulphate**	30 min	OHS
3	***Practical Session*** • Allow participants to conduct analysis according to SAP: **Refer to SAP for Sulphate** • Stress the need to write-up material as the analysis is proceeding • Be available to guide participants and answer questions	120 min	
4	***Report Writing*** • Allow participants to complete their reports • Give the 'correct answers' to the sulphate determinations • Ask participants to suggest reasons for difference between their results and the 'actual results'	30 min	

4. Overhead/flipchart master

OHS format guidelines

Type of text	Style	Setting
Headings:	OHS-Title	Arial 30-36, with bottom border line (not: underline)
Text:	OHS-lev1 OHS-lev2	Arial 24-26, maximum two levels
Case:		Sentence case. Avoid full text in UPPERCASE.
Italics:		Use occasionally and in a consistent way
Listings:	OHS-lev1 OHS-lev1-Numbered	Big bullets. Numbers for definite series of steps. Avoid roman numbers and letters.
Colours:		None, as these get lost in photocopying and some colours do not reproduce at all.
Formulas/Equations	OHS-Equation	Use of a table will ease horizontal alignment over more lines (columns) Use equation editor for advanced formatting only

Measurement of Sulphate

- Compounds of sulphur, particularly sulphate (SO_4^{2-}) are abundant in the earth's crust
- Sulphur is an essential element for life as it is present in proteins

Sulphur Cycle

- Organic sulphur (Plants and Animals)
- Waste and death + bacterial action

  $\longrightarrow H_2S$
- Photosynthesis and non photosynthetic oxidation

  $\longrightarrow S \longrightarrow SO_4^{2-}$
- Uptake of SO_4^{2-} by plants $\longrightarrow$ animals
- Bacterial reduction (SO_4^{2-}) $\longrightarrow H_2S$

Measurement of Sulphate

- Sulphate is Taken up by plants and micro-organisms
- Oxidation of hydrogen sulphide and sulphur to sulphate normally results in loss of dissolved oxygen in the aquatic environment
- Under anaerobic (no dissolved oxygen) conditions sulphate in water can be reduced to hydrogen sulphide
- Hydrogen sulphide is toxic, corrosive and foul-smelling (the smell of bad eggs)

Measurement of Sulphate

- The nephelometric (turbidity) method for sulphate determination:
  - *Relies on sulphate ion being precipitated by barium chloride in an acetic acid medium*
  - *The resulting suspension is then measured for light scattering with a nephelometer*
  - *Colour or suspended material may interfere but can be overcome by measuring against a blank*

Experiment

Aim:

- To determine the concentration of sulphate ion in a number of different samples by nephelometry

Method:

- Collect a sample from each of the buckets A, B and C
- Determine sulphate in each sample using SAP for sulphate

Experiment

- Write your report which should include:
  - *the aim of the investigation*
  - *the results that you have produced*
  - *the sulphate concentration of the samples and what this means in terms of water quality*

5. Evaluation sheets

6. Handout

Measurement of Sulphate

- Compounds of sulphur, particularly sulphate (SO_4^{2-}) are abundant in the earth's crust
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- Waste and death + bacterial action
  $\rightarrow H_2S$
- Photosynthesis and non photosynthesis oxidation
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- Uptake of SO_4^{2-} by plants $\rightarrow$ animals
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Measurement of Sulphate

- Sulphate is taken up by plants and micro-organisms
- Oxidation of hydrogen sulphide and sulphur to sulphate normally results in loss of dissolved oxygen in aquatic environment
- Under anaerobic (no dissolved oxygen) conditions sulphate in water can be reduced to hydrogen sulphide
- Hydrogen sulphide is toxic, corrosive and foul-smelling (the smell of bad eggs)
- The nephelometric (turbidity) method for sulphate determination:
  - *Relies on sulphate ion being precipitated by barium chloride in an acetic acid medium*
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- Collect a sample from each of the buckets A, B and C
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- Write your report which should include:
  - *the aim of the investigation*
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  - *the sulphate concentration of the samples and what this means in terms of water quality*

Add copy of Main text in chapter 8, for all participants.

7. Additional handout

These handouts are distributed during delivery and contain test questions, answers to questions, special worksheets, optional information, and other matters you would not like to be seen in the regular handouts.

It is a good practice to pre-punch these additional handouts, so the participants can easily insert them in the main handout folder.

8. Main text

Contents

How to Measure Sulphate

1. Introduction

Compounds of sulphur, particularly sulphate (SO_4^{2-}), are abundant in the earth's crust and also, therefore, in natural waters. Sulphur is also an essential element for life as it is present in protein compounds.

Figure 1 shows a simplified representation of the sulphur cycle in nature. The essential elements of this cycle also apply in the aquatic environment as described below.

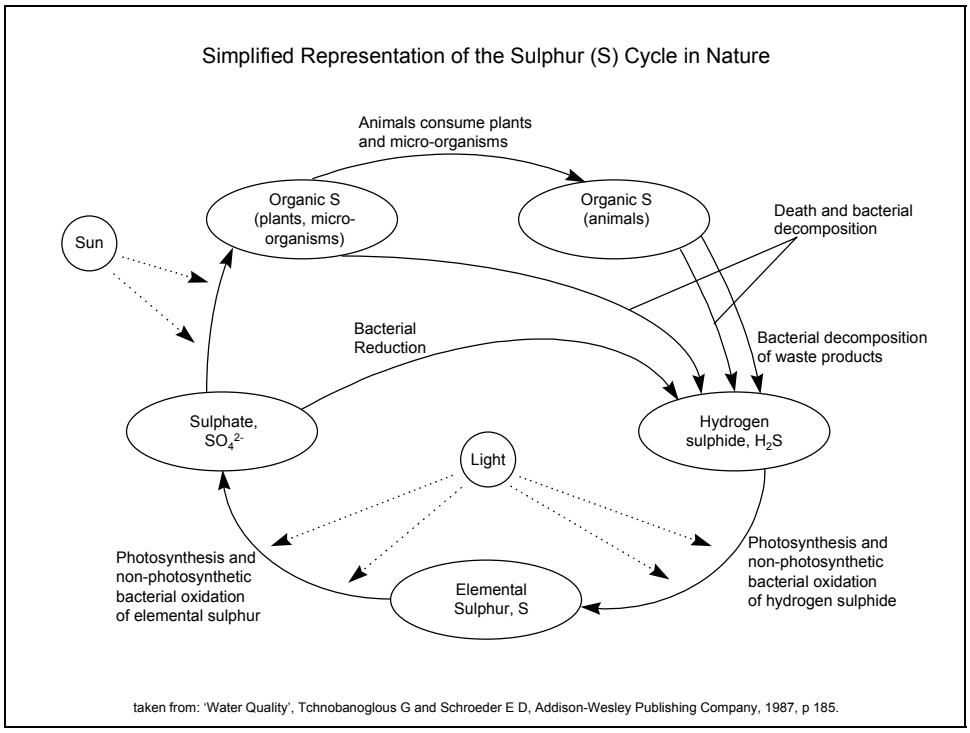

Figure 1: Simplified Representation of the Sulphur Cycle in Nature

Under aerobic water conditions (i.e., in the presence of dissolved oxygen) elemental sulphur can be oxidised by bacteria and algae to sulphate. This is taken up by plants and micro-organisms and passed on to animals when they feed. The death and decomposition of plants, animals and micro-organisms and the decomposition of animal wastes produces hydrogen sulphide which can, in turn, be oxidised to elemental sulphur under aerobic conditions.

Both the oxidation of hydrogen sulphide to sulphur and the oxidation of sulphur to sulphate would normally result in the loss of dissolved oxygen in a water body. This can be problematic if sufficient dissolved oxygen is lost as it is used for respiration by plants and animals.

A particular problem that can arise from the sulphur cycle in the aquatic environment occurs when anaerobic (no dissolved oxygen) conditions apply. In this case, sulphate which is normally present in environmental water, is converted by reducing bacteria direct to hydrogen sulphide (H_2S) gas. This causes an excess of hydrogen sulphide which is corrosive, toxic and foul-smelling (the smell of bad eggs). In addition, the gas can inhibit

growth of many organisms by reacting with, precipitating and thereby making unavailable many of the trace metals which are necessary for life.

2. Nephelometric (Turbidity) Method

This method relies on the fact that sulphate ion can be precipitated by barium chloride in an acetic acid medium. Measurement of the light scattering of the resulting suspension is carried out using a nephelometer and sulphate concentration is determined by comparison with a standard curve.

3. Experiment

Aim

a. To determine the concentration of sulphate ion in a number of different samples by nephelometry.

Method

a. Collect a sample from each of the buckets marked A, B and C.
b. Read the SAP for sulphate measurement.
c. Determine the sulphate in each sample according to the Standard Analytical Procedure for sulphate.

Observations & calculations

a. Fill in the following table as you proceed with the method:

Sample	Turbidity
5.0 mg/l Standard Solution	
10.0 mg/l Standard Solution	
20.0 mg/l Standard Solution	
30.0 mg/l Standard Solution	
40.0 mg/l Standard Solution	
A	
B	
C	

b. Use the values of the standard solutions in the table to plot a standard curve of sulphate concentration versus turbidity.
c. Read the sulphate concentration of the three samples from the standard curve.

Report

When writing your report the following aspects should be addressed:

- the aim of the investigation
- the results that you have produced
- the sulphate concentration of the samples and what this could mean in terms of water quality