Environmental Sampling and Analysis

Author:
Mimi Suliza binti Muhamad
email:
msuliza@uthm.edu.my

Abstract:
This text book introduces the fundamental knowledge on environmental sampling and analysis that is essential for students of Bachelor of Civil Engineering Technology (Environment), UTHM. Chapter 1 present the topic on sampling plan which include sampling protocol, planning a sampling event, and selection of appropriate methodology. Chapter 2 present the topic on sampling method which covers the topics of quality control of sample, sampling location, and types of environmental sampling including water, air, and soil sampling. Chapter 3 is the topic on sample preservation and storage. This chapter discusses on preservation techniques, sample storage, disposal, and sample holding time. Chapter 4 is the topic about microbiological analysis which include multiple tube method, pour plate method, membrane filtration method, and pathogen analysis. Chapter 5 present the topic on analytical data in which discusses how the collected environmental data is analyse. This chapter include the statistical for environmental data, errors in analytical data, as well as standardization and calibration. Chapter 6 is the topic on instrumentation which explain the instrument and method used to analyse sample. This chapter discuss on method and analytical instrument such as spectrophotometry, electron microscopy and elemental analysis, Fourier transform infrared, total organic carbon analyzer, atomic absorption spectrophotometer, ion chromatography, solid/liquid chromatography, gas/liquid chromatography and mass spectrometry.

Keywords : Atomic absorption spectroscopy, DR6000, IR spectrum, Fourier transform infrared spectroscopy, Transmission electron microscope

ENVIRONMENTAL
Sampling and Analysis

MIMI SULIZA MUHAMAD

Penerbit UTHM

ENVIRONMENTAL
Sampling and Analysis

MIMI SULIZA MUHAMAD

Penerbit UTHM
2023

ISBN : 978-629-7566-76-4
Authors: Mimi Suliza Muhamad

Published & Printed by:
Penerbit UTHM
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja,
Batu Pahat, Johor
Tel: 07-453 8698/8529
Fax: 07-453 6145

Website: http://penerbit.uthm.edu.my
E-mail: pemasaran.uthm@gmail.com
http://e-bookstore.uthm.edu.my

Penerbit UTHM is a member of
Majlis Penerbitan Ilmiah Malaysia
(MAPIM)

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-629-7566-76-4

CONTENT

PREFACE

Environmental Sampling and Analysis text book presents the fundamental knowledge about environmental sampling and analysis that is essential for students of Bachelor of Civil Engineering Technology (Environment), UTHM. Chapter 1 is on sampling plan in which students will learn about sampling protocol, planning a sampling event, and selection of appropriate methodology. Chapter 2 is about sampling method. This covers the topics on quality control of sample, sampling location, and types of environmental sampling including water, air, and soil sampling. Chapter 3 is about sample preservation and storage. This chapter discusses on preservation techniques, sample storage, disposal, and sample holding time. Chapter 4 is on microbiological analysis which include multiple tube method, pour plate method, membrane filtration method, and pathogen analysis. Chapter 5 is about analytical data in which discusses how the collected environmental data is analyse. This chapter include the statistical for environmental data, errors in analytical data, as well as standardization and calibration. Chapter 6 is about instrumentation which explain the instrument and method used to analyse sample. This chapter discuss on method and analytical instrument such as spectrophotometry, electron microscopy and elemental analysis, Fourier transform infrared, total organic carbon analyzer, atomic absorption spectrophotometer, ion chromatography, solid/liquid chromatography, gas/liquid chromatography and mass spectrometry.

1

SAMPLING PLAN

1.1 Sampling Protocol: Planning a Sampling Strategy

Sampling is a process of obtaining a representative fraction of a sample from a large study area which is also term as population. It is frequently the phase in the overall analytical process that restricts the procedure's precision. When an inhomogeneous solid, such as ore, dirt, or a piece of animal tissue, or large inhomogeneous liquid, such a lake, needs to be analyzed, environmental sampling is crucial. Sampling for chemical analysis always involves statistics as conclusions about a considerably greater amount of material can be made from the study of a small lab sample. It is done by analyzing a finite number of samples taken from a population. For conclusion of a population, statistical methods like mean and standard deviation are used.

The presence of the sample matrix, which may contain species with chemically similar properties to the analyte or react with the same reagent as the analyte, makes it difficult to analyse the true matrix. This may result in instrument response that is difficult to differentiate from analyte. Matrix effect is the interference caused by unnecessary species in the matrix. Sampling is often conducted to verify compliance for the water quality standard and effluent discharge standard as well as to determine whether the treatment processes are efficient.

2

SAMPLING METHOD

2.1 Quality Control

Chain of custody is procedures and documentation that present sample control. The chain of custody documentation as shown in Figure 2.1 is a record that is use to tracks sample custody and handling from the time of collection through analysis, reporting, and disposal. Chain of custody control is based on the idea that a sample is always in someone's custody and that person is therefore liable for it. Traceability shows who handled the sample from collection, preservation, storage, and analysis. It allows for routine control of samples and also helps in litigation issues. The chain of custody documentation is usually start from the laboratory where the form is fill out completely with information such as sample name, type of sample, time of sample, date, preservative, bottle and volume used as well as the analysis needed. Apart from that, labels and seals are also needed for sample bottles. Other type of documentation includes facility field log books/bench sheets, analysis request sheet, record of delivery to laboratory, assignment of sample, receipt and logging of sample.

Permanent maker should be use to label which is then attached to a sample bottle or container. The label should contain information such as location, type of sample, date and time of collection, preservative, analysis collector, facility, and other observations that may affect the method or results of the analysis.

3

SAMPLE PRESERVATION AND STORAGE

3.1 Preservation Techniques

Preservation is a process that is necessary to ensure sample integrity and maintain the stability of analytes until analysis. Preservation can be done by control pH, chemical addition, using amber or opaque bottles, refrigeration, filtration, and freezing. There are some general considerations in preserving water sample such as microbiological testing of water should start as soon as possible after sample collection. Samples should be kept in ice preferably at <10°C during transport if they can't be analyzed within 1hour after collection. Samples should be analyze on day of receipt whenever possible and refrigerate overnight if arrival is too late for analyzing on same day.

Preservation of sample is done for several reasons which is to maintain the integrity of the sample, retard biological action, reduce hydrolysis of chemical compounds and prevent volatility of analyte. Preservation also depends on analysis to be conducted on the water sample. Figure 3.1-3.3 shows the preservation method of some compound and water quality parameters.

4

MICROBIOLOGICAL ANALYSIS

4.1 Microorganisms

Microorganisms are organisms or infectious agents of microscopic or sub microscopic size, which include bacteria, algae, fungi, protozoa, and viruses. single-celled. The consequences of microbial contamination in water are the possibility for transmission of disease-causing microorganisms (pathogens) via water contact (oral or fecal route). Human contact to pathogens includes ingestion, primary contact, and secondary contact. Some pathogens in water can cause water borne diseases as shown in Table 4.1. The challenges with routine testing for pathogens in water is that sometimes only few microorganisms present and limited survival time. Sometimes there just too numerous pathogens to be analyze with time and cost prohibitive.

5

ANALYTICAL DATA

5.1 Statistical Analysis for Environmental Data

Statistical calculations are used in order to improve decisions regarding the quality of experimental measurements. These applications include defining a numerical interval around the mean of a set of replicate analytical results within which the population mean can be expected to lie with a certain probability. This interval is called the confidence interval (CI). Determining the number of replicate measurements at a given probability is needed to ensure that an experimental mean falls within a certain confidence interval.

Estimating the probability that an experimental mean and a true value or two experimental means are different. Determining whether what appears to be an outlier in a set of replicate measurements is the result of a gross error or it is a legitimate result. Outlier is one reading that is very different from rest. The least-squares method is used for constructing calibration curves.

5.1.1 Mean, Median, and Standard deviation

Analytical results should be reported as the mean value and the standard deviation. The results of various statistical tests on the data should also be included when appropriate. Significant figures should be based on statistical evaluation of the data. When possible, graphical presentation

6

INSTRUMENTATION

6.1 Analytical Instrument

Analytical instruments encompass a wide range of instrumentation that is to qualitatively and quantitatively analyze samples. The wide range of available equipment also allows for a wide range of testing methods and their respective applications. Analytical instruments include electrochemical analysis, chromatographs e.g., gas chromatography (GC), ion chromatography (IC) and high performance liquid chromatography (HPLC), mass spectrometry (MS), spectroscopy e.g., Fourier transform infrared spectroscopy (FTIR), atomic absorption spectroscopy (AAS), energy dispersive X-ray (EDX), and fluorescence, electron microscopy e.g., scanning electron microscope (SEM), field-emission scanning electron microscopy (FESEM), and transmission electron microscopy (TEM), particle size analyzers, Brunauer-Emmett-Teller (BET) analyzer, inductively coupled plasma (ICP), rheometers, thermal analyzers e.g., thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC), total organic carbon (TOC) analyzer, and various hybrid technologies e.g., GC-MS and HPLC-MS, etc.

BIBLIOGRAPHY

Adnan, M., Mustafa, K., Fida, O., Majdi, D., & Fuad, A. R. (2012). Effect of methanol in the wash-solvent bottle and the onguard cartridges on the determination of different anions using ion chromatography. American Journal of Analytical Chemistry, 2012.

Agri4all (2023). Bulk density soil sampling kit w/compact slide hammer. Retrieved 8 September 2023 from https://www.agri4all.com/product/make-sampling-efficient-bulk-density-soil-sampling-kit-w-compact-slide-hammer-ams-inc-46602-kenya

Ahmed, M. F., Rogers, J. D., & Farooq, K. (2012). Impacts of saturation on rainfall-triggered slope failures at the Simbal Landslide, Pakistan. In ARMA US Rock Mechanics/Geomechanics Symposium (pp. ARMA-2012). ARMA.

Alahi, M. E. E., & Mukhopadhyay, S. C. (2017). Detection methodologies for pathogen and toxins: A review. Sensors, 17(8), 1885.

AlDossari, F. M. (2023). Upgraded analytical protocols in bauxite refining industry using composite sampling approach to minimize laboratory analysis load. Materials Sciences and Applications, 14(2), 94-116.

AlphaLab Inc. (2023). Earth magnetometer EM2. Retrieved 8 September 2023 from https://www.alphalabinc.com/products/em2/

Analysis DOO (2022). Fourier transform infrared (FTIR) spectroscopy and microscopy. Retrieved 8 September 2023 from https://analysisdoo.com/products/fourier-transform-infrared-ftir-spectroscopy-and-microscopy/

Apex Gasgen (2020). Pressure swing adsorption (PSA) technology – How it works. Retrieved 8 September 2023 from https://www.apexgasgenerators.com/post/pressure-swing-adsorption-psa-technology-how-it-works

Aryal, S. (2022). Thin layer chromatography- definition, principle, parts, steps, uses. Retrieved 8 September 2023 from https://microbenotes.com/thin-layer-chromatography/

Bartram, J. & Pedley, S. (1996). Chapter 10 - Microbiological analyses in Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes. Bartram, J., and Ballance, R. (Eds.) CRC Press.

Bhosale, A. (2021). Ground penetrating radar (GPR): The most advance way of archeological investigations. Retrieved 8 September 2023 from https://www.linkedin.com/pulse/ground-penetrating-radar-gpr-most-advance-way-akshay-bhosale?trk=public_profile_article_view

Britannica, The editors of encyclopaedia (2023). Tissue culture. Retrieved 8 September 2023 from https://www.britannica.com/science/tissue-culture

Broad Institute (2023). What is mass spectrometry? Retrieved 8 September 2023 from https://www.broadinstitute.org/technology-areas/what-mass-spectrometry

Buffalo-niagara gardening (2012). Scoop of soil in garden trowel. Retrieved 8 September 2023 from https://buffalo-niagaragardening.com/2012/11/27/is-your-garden-soil-contaminated-what-you-should-know-buffalo-ny/scoop-of-soil-in-garden-trowel/

Byju's (2023). Paper chromatography. Retrieved 8 September 2023 from https://byjus.com/chemistry/paper-chromatography/

Chasteen, T.G. (2017). Photoionization detector (PID). Retrieved 8 September 2023 from https://www.shsu.edu/~chm_tgc/PID/PID.html

Civil digital (2023). Split spoon sampler. Retrieved 8 September 2023 from https://civildigital.com/split-spoon-sampler/

Covalent Metrology (2023). Transmission electron microscopy (TEM). Retrieved 8 September 2023 from https://covalentmetrology.com/techniques/transmission-electron-microscopy-tem/

Direct industry (2023). Total organic carbon analyzer TOC-L Series. Retrieved 8 September 2023 from https://www.directindustry.com/prod/shimadzu-europa/product-25210-515652.html

Duncan, D., Walker, M., & Harvey, F. (2007). Regulatory monitoring and testing: water and wastewater sampling. Environment Protection Authority.

Evident (2023). Field portable XRF for agriculture: Environmental quality assessments. Retrieved 8 September 2023 from https://www.olympus-ims.com/en/applications/field-portable-xrf-agriculture-environmental-quality-assessments/

Farmer junction (2020). Soil testing kit (20 tests). Retrieved 8 September 2023 from https://www.farmerjunction.com/shop/soil-testing-kit-20-tests/

Forestry suppliers Inc. (2023). Forestry suppliers carbon steel auger buckets. Retrieved 8 September 2023 from https://www.forestry-suppliers.com/p/78401/30901/forestry-suppliers-carbon-steel-auger-buckets

Geomatrix Earth Science Ltd (2015). Conductivity meters. Retrieved 8 September 2023 from https://www.geomatrix.co.uk/land-products/electromagnetic/electromagnetic-conductivity-meters/

Hach (2023). Water analysis to help you every step of the way. Retrieved 8 September 2023 from https://my.hach.com/

Home Service Publications, Inc. (2019). Using a power auger. Retrieved 8 September 2023 from https://www.familyhandyman.com/project/using-a-power-auger/

Huntop (2023). China bulb planter seedling remover tool bulb transplanter HT5822B. Retrieved 8 September 2023 from https://www.htcn.com/product/bulb-planter-seedling-remover-Bulb-Transplanter.html

IAEA. (2004). Soil sampling for environmental contaminants. IAEA Tec-Doc-1415.

Industrial quick search (2023). Electrostatic precipitators. Retrieved 8 September 2023 from https://www.iqsdirectory.com/articles/air-pollution-control/electrostatic-precipitators.html

Instrumentation tools (2023). Flame ionization detector (FID) principle. Retrieved 8 September 2023 from https://instrumentationtools.com/flame-ionization-detector-fid-principle/

JEOL (2023) Scanning electron microscopes (SEM). Retrieved 8 September 2023 from https://www.jeol.com/products/science/sem.php

Kalishwaralal, K., Jeyabharathi, S., Sundar, K., & Muthukumaran, A. (2016). A novel one-pot green synthesis of selenium nanoparticles and evaluation of its toxicity in zebrafish embryos. Artificial cells, nanomedicine, and biotechnology, 44(2), 471-477.

Karki, G. (2018) Most probable number (MPN) method for counting coliform. Retrieved 8 September 2023 from https://www.onlinebiologynotes.com/most-probable-number-mpn-method-for-counting-coliform/

Labs Services (2022). Field emission scanning electron microscopy — FESEM. Retrieved 8 September 2023 from https://www.labs-services.com/product/field-emission-scanning-electron-microscopy-fesem/

Lelab (2023). YSI ProSample portable samplers. Retrieved 8 September 2023 from https://www.ysimalaysia.com.my/showproducts/productid/4207659/cid/436999/ysi-prosample-portable-samplers/

Lin, X., Reponen, T. A., Willeke, K., Grinshpun, S. A., Foarde, K. K., & Ensor, D. S. (1999). Long-term sampling of airborne bacteria and fungi into a non-evaporating liquid. Atmospheric Environment, 33(26), 4291-4298.

Miller, J.C., & Miller, J.N. (1993). Statistics for analytical chemistry. Ellis Horword, PTR Prentice Hall, Chichester, 233.

Metrohm (2022). 930 Compact IC Flex. Retrieved 8 September 2023 from https://www.metrohm.com/en_my/products/ion-chromatography/930-compact-ic-flex.html

Monash University Malaysia (2023). Atomic absorption spectrometer. Retrieved 8 September 2023 from https://www.monash.edu.my/science/research/research-facilities/applied-chemistry/atomic-absorption-spectrometer

Northern Geotechnical Engineering, Inc. (2023). Thin walled Shelby tube sample. Retrieved 8 September 2023 from https://www.nge-tft.com/our-services/Geotechnical-Engineering/Subsurface-Exploration,-Sampling-and-Monitoring/Soil-and-Rock-Sampling-Methods/Thin-Walled-Shelby-Tube-Sample

Oregon State University (2006). Fume hood types. Retrieved 8 September 2023 from https://ehs.oregonstate.edu/LVSG-FH-type

Pharma air modular systems (2007). Biological safety cabinet. Retrieved 8 September 2023 from https://pharmaair.co.in/bio-safety-cabin/

Polltech Instruments (2016). Dust fall jar. Retrieved 8 September 2023 from https://polltechinstruments.com/dust-fall-jar.html

Prodigy Scientific Inc. (2021). Agilent 7890 / 5975C GCMS. Retrieved 8 September 2023 from https://prodigyscientific.com/product/agilent-7890-5975c-gcms/

Raji, W. O. (2014). Review of electrical and gravity methods of near-surface exploration for groundwater. Nigerian Journal of Technological Development, 11(2), 31-38.

Rijal, N. (2022a). Most probable number (MPN) test: principle, procedure, results. Retrieved 8 September 2023 from https://microbeonline.com/probable-number-mpn-test-principle-procedure-results/

Rijal, N. (2022b). Bacteriological analysis of water. Retrieved 8 September 2023 from https: //microbeonline . com / analysis - of - water - membrane -filtration technique/#google_vignette

Safetyware Sdn Bhd. (2023). Gamma-scout radiation detector. Retrieved 8 September 2023 from https://safetyware.com/product/gamma-scout-radiation-detector/

Skoog, D., West, D. M., & Holler, F. J. (1996). Fundamentals of analytical chemistry (7th ed.). Fort Worth: Saunders College Publishing Harcourt Brace.

Srivastava, N., Singh, A., Kumari, P., Nishad, J.H., Gautam, V.S., Yadav, M., Bharti, R., Kumar, D. & Kharwar, R.N., (2021). Advances in extraction technologies: Isolation and purification of bioactive compounds from biological materials. In Natural bioactive compounds (pp. 409-433). Academic Press.

Stauffer, E., Dolan, J. A., & Newman, R. (2008). Gas chromatography and gas chromatography—Mass spectrometry. Fire debris analysis, 235-293.

Sunmonu, L. A., Suleman, K. O., Bello, I. T., Tijani, L. O., & Ogunbode, A. O. (2017). Geophysical investigation on the fracture distribution of Iwo-Olupona Area south-western Nigeria using VLF-EM techniques. Journal of Fundamental and Applied Sciences, 9(2), 736-745.

Tankeshwar, A. (2022). Pour plate method: procedure, uses, (dis) advantages. Retrieved 8 September 2023 from https://microbeonline.com/pour-plate-method-principle-procedure-uses-dis-advantages/

The State of Queensland (2017). High and low volume air samplers. Retrieved 8 September 2023 from https://www.qld.gov.au/environment/management/monitoring/air/air-monitoring/measuring/samplers

Xylem Inc. (2023). Global water - WS705 composite, discrete water sampler. Retrieved 8 September 2023 from https://www.xylem-analytics.com.au/productsdetail.php?Global-Water---WS705-Composite-Discrete-Water-Sampler-64

AUTHOR BIOGRAPHY

Dr. Mimi Suliza binti Muhamad is currently a senior lecturer at Civil Engineering Technology Department, Faculty Technology Engineering, Universiti Tun Hussein Onn Malaysia (UTHM). She received her Diploma in Civil Engineering at Universiti Teknologi Malaysia (UTM) in 2009. Then she received Bachelor of Civil Engineering at UTM in 2012 and proceed her study in postgraduate under fast-track programme and received PhD in Civil Engineering at UTM in 2016. Her experienced in teaching Environmental Sampling and Analysis course is since 2020.

INDEX

ENVIRONMENTAL
Sampling and Analysis

This text book introduces the fundamental knowledge on environmental sampling and analysis that is essential for students of Bachelor of Civil Engineering Technology (Environment), UTHM. **Chapter 1** present the topic on sampling plan which include sampling protocol, planning a sampling event, and selection of appropriate methodology. **Chapter 2** present the topic on sampling method which covers the topics of quality control of sample, sampling location, and types of environmental sampling including water, air, and soil sampling. **Chapter 3** is the topic on sample preservation and storage. This chapter discusses on preservation techniques, sample storage, disposal, and sample holding time. **Chapter 4** is the topic about microbiological analysis which include multiple tube method, pour plate method, membrane filtration method, and pathogen analysis. **Chapter 5** present the topic on analytical data in which discusses how the collected environmental data is analyse. This chapter include the statistical for environmental data, errors in analytical data, as well as standardization and calibration. **Chapter 6** is the topic on instrumentation which explain the instrument and method used to analyse sample. This chapter discuss on method and analytical instrument such as spectrophotometry, electron microscopy and elemental analysis, Fourier transform infrared, total organic carbon analyzer, atomic absorption spectrophotometer, ion chromatography, solid/liquid chromatography, gas/liquid chromatography and mass spectrometry.

Penerbit UTHM

ISBN 978-629-7566-76-4

04100

9 786297 566764

For more information, please scan the code