EXPERIMENT FEST

HANDBOOK
EARTH AND ENVIRONMENTAL SCIENCE

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

newcastle.edu.au/experimentfest

INTRODUCTION

Experiment Fest is an experiment program designed to provide enriching educational experiences for senior high school students who are studying Physics, Chemistry, Biology, Earth and Environmental Science, and Food Science.

Experiment Fest is supported by the University of Newcastle's College of Engineering, Science and Environment, and takes place at both the Callaghan and Ourimbah (Central Coast) campuses of the University of Newcastle.

All experiments are complemented by notes, follow-up discussions and questions to enhance your learning experience.

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WELCOME

Welcome to the College of Engineering, Science and Environment at the University of Newcastle.

Experiment Fest is a wonderful chance to give you practical experience which complements your classroom learning while giving you a first-hand look at University life and facilities. Science is an exciting field of study, allowing you to move with the times and contribute actively and responsibly to society. There are many education opportunities in science after high school. Here in the College we provide study and research programs in fast-moving modern fields that make our world work.

The College staff and students who will be taking you through the experiments today are involved in contemporary science research. Please ask questions and utilise your time with them.

Take this day to enjoy being out of the classroom, exploring science with fellow students and participating in valuable experiments and discussions which will help you in your HSC and beyond.

I wish you well in your studies. I hope you apply yourselves to the learning process with enthusiasm and you enjoy your time at the University. We hope to see you studying with us in the future!

Best wishes,

Professor Craig Simmons

Pro Vice-Chancellor
College of Engineering, Science and Environment
The University of Newcastle

STUDYING EARTH AND ENVIRONMENTAL SCIENCE

Students in the School of Environmental and Life Sciences are taught by top academics and use world-class facilities while earning their qualifications. We also have strong connections to industry, which students can access through field trips and career-ready placements.

Bachelor of Environmental Science and Management:

If you have a passion for science, sustainability and want to play a part in solving the environmental problems facing our society, the Bachelor of Environmental Science and Management at the University of Newcastle is for you. You'll learn to understand and combat the critical issues placing a growing strain on the earth's natural resources such as climate change, human impacts, and the biodiversity crisis. Find scientific solutions to our current environmental problems.

Earth Sciences: The Earth Sciences major is for those that are looking to build new concepts working in a variety of environments.

You will learn about coastal environments and processes, weather and climate change and hydrogeological landscapes and gain work ready skills in fieldwork and spatial sciences. You will learn from leading science researchers who will guide you through a tailored program, specifically designed to give you the skills that employers are seeking. You'll be able to follow your passions and customise your study with a wide range of disciplinary choices, incorporating many areas of study. Find scientific solutions to complex problems and gain the confidence that employers are looking for.

Bachelor of Coastal and Marine Science:

Work with some of the most unique and diverse coastlines and marine ecosystems in the world. Learn from experts in marine, coastal and ecological fields, giving you practical skills to make a difference to our world. Our coastal and marine environments face issues like climate change, pollution and urbanisation. By understanding these ecological, physical, conservation, societal and management issues, we can help find solutions to these problems.

WHY STUDY EARTH AND ENVIRONMENTAL SCIENCE

The world's most complex issues, such as climate change, natural resource management, and food and water security, need to be addressed by those with transdisciplinary skills. By studying STEM, you will learn skills in creative and innovative thinking, ethical and sustainable practice, and communication – becoming a more-than-disciplinary practitioner.

OPPORTUNITIES FOR FURTHER STUDY IN EARTH AND ENVIRONMENTAL SCIENCE

After completing one of our three-year degrees, you may undertake Honours. An Honours equips you with highly sought after and respected skills and knowledge, giving you a competitive advantage.

With increasing competition in all sectors of employment, students who graduate with an Honours degree have a distinct advantage. It is often considered by employers as an added skill and has been used by previous graduates to pursue higher positions and salaries. You can develop and carry out research on a topic of interest, potentially leading to further academic study such as a research degree.

An Honours year is available to students as a separate program in the form of an additional one-year full-time (or equivalent part-time), to those who meet the entry requirements that allows you to further develop your specific area of interest and is a pathway into research degree study.

The University of Newcastle is a leader in research. You will have the opportunity of being involved with research at the forefront of your discipline.

RESEARCH AT THE UNIVERSITY OF NEWCASTLE

The School of Environmental and Life Sciences has developed an enviable reputation, with many of our researchers being recognised at both national and international level for their work studying our planet and life on it.

CAREERS IN EARTH AND ENVIRONMENTAL/COASTAL AND MARINE SCIENCE

The College of Engineering, Science and Environment care about our students and are interested in giving as much direction as possible to those making career choices and beyond. The possible career paths listed below include a range of opportunities for graduates at degree, honours, and post graduate study levels.

- Climate change adaptation practitioner
- Coastal scientist
- Coastal and Marine Park Governance Officer
- Conservation and ecology
- Ecologist
- Environmental Compliance Officer
- Environmental impact assessment
- Environmental science
- Environmental health and sustainability
- Earth sciences
- Laboratory and research work
- Marine biologist
- Mining and exploration
- Urban and regional planning
- Sustainability manager
- Manager of urban or regional development
- Environmental officer
- Government departments, councils
- Policy development
- Natural resource management
- Social impact assessment
- NGOs or private industry

For more information on the College of Engineering, Science and Environment, check out our website:

newcastle.edu.au/college/engineering-science-environment

For more information on our degrees visit:

newcastle.edu.au/study

FOR MORE INFORMATION VISIT NEWCASTLE.EDU.AU

Experiment Fest – Earth and Environmental Science

Background

Australia is rich in both renewable natural resources (eg water, agricultural production, sunlight) and non-renewable natural resources (eg minerals, fossil fuels). Students examine how the extraction and disposal of waste can greatly impact on the surrounding environment, affecting the quality and availability of renewable resources such as water and living organisms. The extent of this impact is referred to as an 'ecological footprint'.

Scientific models of resource extraction, use and management have developed over time in response to new discoveries and through the incorporation of sustainable practices, many of which have been developed by Aboriginal and Torres Strait Islander Peoples. The world's population is increasing and more natural resources are being extracted to provide food, consumer goods, energy and infrastructure. Sustainable management of both natural resources and waste is vital for human long-term survival.

Introduction:

Environmental monitoring is an important part of Earth and Environmental Science. Human use (extraction and disposal) of natural resources can have negative effects on the surrounding environment, however, downstream effects of these processes can only be determined through routine environmental monitoring. Water quality and quantity is key for healthy and functioning ecosystems and the presence or absence of certain parameters (or indicators) is extremely important in determining the health of an ecosystem. The monitoring of water quality involves the determination of a number of parameters *in-situ* (measured in the field) and the collection of samples for later laboratory analysis.

The contamination and pollution of water is one of the most important areas of earth and environmental science. There are significant issues in both developed and developing nations, and as such, a range of environmental standards and regulations relating to water quality have been introduced to ensure healthy ecosystems. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (https://www.waterquality.gov.au/anz-guidelines) aim to facilitate the

productive and sustainable use of water resources while still maintaining the biological communities and ecological processes that the resource supports, consistent with the principles of ecologically sustainable development. The guidelines use a range of indicators to assess the health of ecosystems. These indicators include: turbidity, pH, dissolved oxygen, nutrients and heavy metals.

Turbidity is a measure of the cloudiness of water due to suspended particles. Large particles in water will tend to quickly settle but small particles may take a significant amount of time to settle particularly if the water is being continually agitated. High turbidity prevents light from penetrating through water and so inhibits the growth of submerged aquatic plants. Disturbing soil and land through industry and agriculture can result in high levels of sediment runoff during heavy rain. Stormwater runoff and pollution from urbanised areas can also lead to increased turbidity. Turbidity is measured by determining how much light passes through a given sample and the ways in which the suspend particles diffract the light.

The pH of waterways is one of its most important characteristics as most plants and animals have a relatively small pH window in which they can survive. Water typically has a more stable pH than that of soil due to dissolved minerals and so are often able to absorb substantial amounts of acid before a significant pH change is observed. Changes in pH in water can result from numerous causes such as industrial or agricultural runoff, acid rain or chemical spills. Acidic waters are particularly problematic as they can kill many organisms (particularly micro-organisms) directly as well as depleting nutrients from sediments and soils.

Dissolved oxygen in water systems is necessary for the survival of aquatic species such as fish and it is one of the primary indicators used in assessing the health of river and lake ecosystems. Oxygen is dissolved into water primarily through surface interaction with the atmosphere, flowing water or wave action and from photosynthesis. Decreased dissolved oxygen concentrations can be caused by catchment runoff following heavy rain.

Many ions and metals which are essential are found in water and can act as both necessary nutrients or as toxins depending on the type of ion or metal and in what concentration it is found. Nitrates, for example, form an important part of the nitrogen cycle required for all organisms to survive, however, excess nitrates from fertilisers can lead to excessive algal growth and subsequent oxygen depletion of aquatic systems. High levels of nitrates in drinking water can also be toxic. Determination of many ions and metals (including the ones we are investigating) can be carried out using a spectrophotometer. Many ions and metals absorb light at a specific wavelength in the visible or ultraviolet spectrum often resulting in strongly coloured solutions. Nitrate ions for example strongly absorb light in the ultraviolet region (around 200nm). The amount of light absorbed by the nitrate ions is proportional to its concentration so we can determine the concentration based on the amount of light it absorbs (which is directly proportional to the strength of colour produced).

The aim of this session is to investigate the water quality associated with an urbanised/agricultural catchment. We will investigate the physical and chemical characteristics and the units of measurement of water samples collected in the field. These characteristics will include pH, electrical

conductivity, turbidity, temperature, dissolved oxygen, and the concentrations of nitrate (NO_3^-), (ortho)phosphate (PO_4^{3-}) and ammonium (NH_4^+). The results you obtain will then be compared to a variety of environmental standards and an assessment made regarding the water quality for your catchment.

The tasks for this session are to:

1. Develop a catchment map of key activities and processes and identify potential sources of nutrient pollution
2. Measure water quality parameters and collect samples from on campus locations
3. Measure nutrient parameters in collected samples
4. Compare water quality data to environmental guidelines
5. Develop measures to reduce nutrient pollution

Task 1 – Catchment map of key activities

In a group of 3-4 students, develop a list of all the components and activities that are likely to be undertaken in an urbanised catchment with some agricultural activities. Using the butcher paper and pens, draw a conceptual model of your catchment with each feature identified. You should include the potential sources of nutrient pollution for your catchment (hint: not all of them will be a point source of pollution).

Task 2 – Measure water quality parameters and collect samples on campus

In your group, you will visit two (2) locations on campus to measure water quality and collect water samples for nutrient analysis in the laboratory. The Horiba Water Quality Monitoring Meter is industry standard equipment for measuring *in situ* water quality:

1. Turn instrument on by pressing the Power button ⏻ for 2 seconds (takes ~10 seconds to boot up)
2. Put the probe into the water (so the all the openings are covered with water) and suspend it at least 30 cm above the bottom (do not rest it on the bottom of the waterway). Move the probe gently from side to side or in a circular motion.
3. After 30 seconds, press the ESC button and then the MEAS (measure) button.
4. When the readings stop flashing, record the data (see table below).
5. Repeat steps 2-4 if you wish to take further readings.

Table 1: water quality data from on campus locations

Measured parameter	Site 1	Site 2
Temperature (°C)		
pH		
Salinity (ppt)		
Electrical conductivity (mS/cm)		
Turbidity (NTU)		
Dissolved Oxygen (mg/L)		
Dissolved Oxygen (%)		
Colour/Odour		

Water samples will be collected from each site for analysis of nutrients (nitrate, phosphate and ammonium) in the laboratory:

1. Label the sample bottle (yellow-capped and ~120ml in size) with the LOCATION (SITE), DATE and GROUP NAME.
2. Using the bottle in the holder at the end of the extendable sampling pole, plunge the bottleneck downwards about 20cm below the surface. Turn the mouth of the bottle upwards and towards the current, or if there isn't one, create a current by moving the pole and bottle horizontally. Fill the bottle to half way, rinse and pour out on the bank. DO NOT empty the water back into the waterway as it may disturb the sediment on the bed and affect your sample. Repeat this process.
3. On the third time, fill the bottle to the top
4. Pour ~20ml into your yellow-capped sample container, screw on the lid and rinse the sample bottle (and its lid). Pour out the water and repeat the process.
5. On the third time, fill the yellow-capped container and tightly close the lid.

Task 3: Measuring nutrient parameters

Determination of nutrient concentrations can be carried out using a spectrophotometer and a process known as colorimetry. Colorimetry is an analytical technique used to determine the

concentration of a coloured solution. Many nutrients absorb light at a specific wavelength in the visible or ultraviolet spectrum often resulting in strongly coloured solutions. Nitrate ions, for example, strongly absorb light in the ultraviolet region (around 200nm). The amount of light absorbed by these nutrients is proportional to their concentrations and we can determine the concentration based on the amount of light it absorbs using spectrophotometry.

Using the handheld HACH Colorimeters and instructions provided, determine the concentration of nitrate (NO_3^-), (ortho)phosphate (PO_4^{3-}) and ammonium (NH_4^+) in each of the samples you collected. Enter your data into the table below.

Table 2: Nutrient data from on campus locations and additional sources

Measured parameter	Site 1	Site 2	Sewage Effluent	Dairy Farm Effluent	Agricultural Runoff	Upstream creek
Nitrate (NO_3^-; mg/L)						
(ortho) Phosphate (PO_4^{3-}; mg/L)						
Ammonium (NH_4^+; mg/L)						

Task 4: Comparison of water quality data with environmental guidelines

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (https://www.waterquality.gov.au/anz-guidelines) aim to facilitate the productive and sustainable use of water resources while still maintaining the biological communities and ecological processes that the resource supports, consistent with the principles of ecologically sustainable development. The guidelines use a range of indicators to assess the health of ecosystems. Using your field and laboratory water quality data and the guideline values below, make an assessment as to whether the sites you sampled are considered "healthy" or not. Note: values within the range or below the trigger value indicate a healthy ecosystem.

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Table 3: Environmental Guidelines for slightly disturbed ecosystems in south-east Australia.

Parameter	Trigger Value or Range
Turbidity (NTU)	6 - 50
pH	6.5 - 8.0
Electrical Conductivity (mS/cm)	0.125 - 2.2
Ortho Phosphate (mg/L)	0.020
Nitrate (mg/L as $N\text{-}NO_3$)	0.040
Ammonium (mg/L as $N\text{-}NH_4$)	0.020
Dissolved Oxygen (% Sat)	85 - 110

Task 5: Develop measures to reduce nutrient pollution

Given that many catchment activities can affect sustainability, using the water quality data you have collected and the catchment conceptual model you developed, what are some management options that could be used to reduce water pollution in our waterways?

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Acknowledgement

The University of Newcastle extends sincere gratitude to Orica for financially supporting Experiment Fest through Orica's Community Investment Program. Orica's investment in the future of our region's students, continues to promote the value of education and lifelong learning, fostering a brighter future for all.

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