Introduction to Soil Science

This self-directed study is designed to assist students who have had limited background in soil science and water quality issues in New Zealand, to become familiar with the foundational knowledge needed to help prepare them for the Intermediate Sustainable Nutrient Management course. This background in soil science is critical, therefore, students are advised to devote sufficient time to completing this study in order to meet the prerequisites of the Intermediate Sustainable Nutrient Management course.

Using the textbook "Soil Science: Sustainable Production and Environmental Protection" by McLaren and Cameron, Oxford University Press 1996, read the following suggested Chapters and navigate through the additional resources listed below to gain an understanding of the importance of soil in order to sustainably manage nutrients in agriculture and protect water quality.

The way we live and use our land can result in excess nutrients (like nitrogen), chemicals, pathogens (disease-causing microorganisms) and sediment entering freshwater and causing degradation of water quality. Visit the following webpages for an overview of freshwater in New Zealand:
https://www.mfe.govt.nz/fresh-water/why-freshwater-matters
https://www.mfe.govt.nz/overview-our-freshwater-2020

1. How would you define the concept of water quality?
2. What are the four main issues currently affecting freshwater in New Zealand?

Legislation and policy are important to consider as they will determine the boundaries which we must farm within. The Government has set a national target of 90% of specified rivers and lakes to be safe for primary contact by 2040. The expectation is that more of these rivers and lakes will be safe for primary contact more of the time. The risks to human health from contact with fresh water must be reduced. The path nutrients take to water is through soil or carried on soil particles, therefore, soil science plays an important role in understanding how we are to comply with these national targets.

Here is a link to a summary of the Resource Management Act (RMA). The full legal document can be found through this link if you would like to view it.

The purpose of the RMA is to promote the sustainable management of natural and physical resources. The RMA allows for central government to develop National Policy Statements (NPS) about important environmental issues. The NPS for Freshwater Management (NPS-FM) is the instrument which directs regional councils to implement the governments policies under the RMA. There have been a number of NPS-FM iterations: About NPS
The most recent iteration was in 2020: NPS-FM 2020

3. What is the objective of the NPS-FM?
4. State 2 requirements of the freshwater NPS.

Read Chapter 1 *The soil profile* and answer the following questions:

5. What are the seven morphological features used to describe the soil profile?

Read Chapter 2 *Soil formation*

6. What different factors affect soil formation and why?

Read Chapter 3 *Classification and characteristics of New Zealand soils*

7. Allophanic, Pallic and Recent soils are often used for farming. Discuss the potential for nutrient leaching, water holding capacity and drainage ability for each of these soils.

Additional information:
Introduction to the digital soil map (Smap):
https://www.landcareresearch.co.nz/about/news/snippets/more-than-8-million-hectares-of-new-zealand-soil-now-digitally-mapped
To explore the digital soil map of New Zealand visit: https://smap.landcareresearch.co.nz/
https://www.landcareresearch.co.nz/about/news/video/s-map-online-tutorial

8. Download a factsheet for a soil near where you live.
   Note the following for that soil type: texture, potential rooting depth, drainage class, topsoil P retention, nitrogen leaching vulnerability, dairy effluent (FDE) risk category and relative runoff potential.
9. Comment on how these soil properties might influence the risk of nutrient loss on your chosen soil type.

Read Chapter 5 *The physical and mechanical characteristics of soil*
Sections 5.1, 5.1.1-5.1.3, 5.2, 5.2.1, 5.2.2
**Note:* equations do not need to be known but could be helpful for understanding concepts.

10. Describe the different soil textures found in New Zealand soils.

Read Chapter 8 *Soil aeration and temperature* **Section 8.1**

11. Describe the importance of aeration on plant growth.

Read Chapter 10 Section 10.2 – 10.6 *Soil organic matter*

12. What is the average range of organic matter levels in New Zealand soils?
13. What are the factors influencing the levels of organic matter in soil?

Read Chapter 12 *Ion Exchange in soils and soil acidity*
Watch the following video on cation exchange capacity:
https://www.youtube.com/watch?v=HmEyymGXOfI&list=RDQMVo4LGhsuBBg&start_radio=1

14. Describe what 'Cation exchange capacity' is.
15. What charge does a soil colloid have in New Zealand?

Read Chapter 13 *Nutrient availability*

16. What are the essential nutrients for the normal life cycle of a plant?
17. In what form are nutrients taken up by the plant?
18. Describe how the amount of available nutrient in the soil in measured?
19. Become familiar with the chemical formulas for the different forms of nitrogen-nitrate, nitrite and ammonium and the chemical symbols for phosphorus, potassium, sulphur, calcium, magnesium and sodium.

First, watch the following video for an overview on nutrient cycles including nitrogen and phosphorus https://www.rotoruafarmers.org.nz/gmp-understanding-nutrient-cycles/

Read Chapter 14 *Soil, plant and fertiliser nitrogen*

20. Draw the Nitrogen cycle for an agricultural system.
21. Define the following terms: mineralisation, adsorption, denitrification and volatilisation.
22. Is organic nitrogen available for plant uptake?
23. What forms of nitrogen are taken up by plants?
24. What form of nitrogen is more prone to leaching and what plant available form of nitrogen is held by the soil?

Read Chapter 15 *Soil, plant and fertiliser phosphorus*

25. Draw the Phosphorus cycle for an agricultural system.
26. Explain how organic forms of phosphorus can be made available for plant uptake via mineralisation?
27. Describe how phosphorus is held by the soil?
28. How does this phosphorus retention (also known as anion storage capacity) influence the amount of phosphorus available for plant uptake?
29. How does this phosphorus retention influence the risk of phosphorus loss to the environment?

For additional reading on Sulphur, Potassium and other nutrients see Chapters 16 and 17.

Read Chapter 19 Soil Fertility and *Fertilizer management* **Sections 19.3 – 19.7**

30. Define what is meant by 'maintenance fertiliser'
31. What is the percentage of phosphorus is in the fertiliser product superphosphate?
32. How does this phosphorus retention influence the amount of P fertiliser required in agricultural soils?

The Fertiliser Association have a range of booklets outlining specific fertiliser use on NZ farms. http://www.fertiliser.org.nz/site/resources/booklets.aspx

Have a look at this booklet: Fertiliser Use on New Zealand Dairy Farms, particularly pg 23-37

Read Chapter 21 *Soils and the quality of the environment*

33. What are the two main nutrients that pollute water?
34. Explain why eroded soil (sediment) is an environmental concern?
35. What is the main source of pathogen contamination to water?
36. What are the main greenhouse gases and how are they generated?