POLAR TREC

TEACHERS AND RESEARCHERS EXPLORING AND COLLABORATING

Creatures Under Foot: Soil Chemistry and Microscopic Animals

Overview

Students will collect soil samples and analyze them with some of the same procedures used by researchers in the McMurdo Dry Valleys, Antarctica. Soil microfauna (e.g. nematodes) will be extracted from the samples using a Baermann funnel. Students will compare their own data to published data from researchers working in Antarctica.

Details

- Lesson
- Antarctic
- About a week
- Download and Share
- High school and Up

Objectives

- Collect and analyze soil samples for moisture, pH, and electrical conductivity.
- Use a Baermann funnel to extract soil microfauna (e.g. nematodes).
- Observe, identify (morphospecies) and count the extracted animals.
- Analyze a published data set and compare the results to student-collected data.

Materials

Soil Samples
Ring Stands
Funnels
Wire Mesh
Rubber Tubing
Tubing Clamps
Facial Tissue
Electronic Balance
Stereomicroscope
60 mm Petri Dishes
Soil Sample Tins
Drying Oven
Conductivity Probe
pH Meter

Lesson Preparation

- Prior to the lab students need to be able to use stereomicroscopes.
- Prior to the lab analysis students need to know how to use a spreadsheet to organize data and perform basic calculations.
- Print copies of the Soil Chemistry and Microscopic Animals Worksheet (in Lesson Materials).

- Students will need access to the research paper listed under Resources.
- Prepare counting dishes by printing the Grid for Nematode Counting file (in Lesson Materials) on a transparency sheet. Cut out the grid blocks and attach them to the bottom of 60 mm petri dishes.
- Collect soil samples for use in class or have students bring their own samples.

Standards

Next Generation Science Standards (NGSS) – High School Life Sciences

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

*HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
*HS-LS2-2. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS4 Biological Evolution: Unity and Diversity

*HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Procedure

1. Collect, or assign students to collect, soil samples in one-quart zip-top plastic bags. Ideally, soil samples should be refrigerated until the lab period. Soil can be collected with a hand garden trowel.
2. Measure 50 grams of each soil sample into a pre-weighed soil can and follow the procedure for Gravimetric Soil Moisture outlined on page 4 of the Standard Procedures for Soil Research in the McMurdo Dry Valleys LTER document which is linked to under Resources.
3. Measure 20 grams of soil into a 150 ml beaker and follow the procedure for Soil pH outlined on page 5 of the Standard Procedures for Soil Research in the McMurdo Dry Valleys LTER document.
4. Prior to measuring the electrical conductivity of your sample, measure the conductivity of a 0.01M KCl standard so you will be able to adjust conductivity for your laboratory environment. After measuring the pH add an additional 60 ml of di-H20 to the sample in the beaker and follow the protocol for measuring electrical conductivity on page 5 of the Standard Procedures for Soil Research in the McMurdo Dry Valleys LTER document.
5. Set up Baermann funnels and add some water to test for leaks; instructions for constructing Baermann funnels can be found by following the links listed under Resources. Place 50 grams of soil on top of a lotion-free facial tissue suspended on the wire mesh in the Baermann funnel. Fold in the sides of the tissue and fill the funnel with additional water to cover the soil sample.
6. After 24 hours open the clamp on the Baermann funnel to collect 10-20 ml of water into a conical tube or a nematode counting dish.

7. Make observations of the nematodes and other microfauna. Use size, shape and movements of the nematodes to identify morphospecies. Count and record the nematodes recovered from each soil sample.
8. Use the published description of the distribution of nematodes in Victoria Land, Antarctica to predict the soil chemistry where each of the three common nematodes (*Scottnema*, *Eudorylaimus*, and *Plectus*) would be found (Adams et al. 2014).
9. Use data from the Soil Elevational Transect Experiment to test your predictions by calculating the mean soil moisture, pH and electrical conductivity for samples containing each of the three nematode species found in the McMurdo Dry Valleys. There is a link to the data under Resources.
10. Compare student collected data to the analyzed data from the McMurdo Dry Valleys.

Extension

- The Data Analysis and Comparisons portion of the activity could be eliminated to shorten the activity or if computers are unavailable.
- Inquiry modifications – if enough soil is collected, students could experiment with the Baermann funnel protocol (type of tissue used or cheese cloth, length of time, etc.) to compare nematode yields.
- Additional Data Analysis – After calculating means for each of the three soil parameters for each of the three nematode species combinations in the McMurdo Dry Valleys, students can graphically represent the data and calculate standard deviation and standard error for the samples. Additional variables from the data set could also be analyzed.

Resources

Links for Lab Protocols, Data, and Information

- Baermann Funnels – American Phytopathological Society
- Baermann Funnels – Tylka Lab at Iowa State University
- Baermann Funnels – Nematode-Plant Expert Information System
- MCM LTER Soil Chemistry Protocols
- MCM LTER Soil Elevational Transect Experiment Data
- Tough Tardigrades PolarTREC Journals The entries for Nov. 7th, 2016 and Jan 5th, 6th, 9th, and 19th, 2017 will be useful.

Research Paper for the Activity

Adams, B. J., Wall, D. H., Virginia, R. A., Broos, E., & Knox, M. A. (2014). Ecological biogeography of the terrestrial nematodes of Victoria Land, Antarctica. ZooKeys, (419), 29-71. doi:10.3897/zookeys.419.7180

Assessment

Soil Chemistry and Microscopic Animals Worksheet found in Lesson Materials.

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Soil Chemistry and Microscopic Animals

Soil is a combination of inorganic minerals, organic matter and living organisms. Soils play a critical role in terrestrial ecosystems and biogeochemical cycling. The living organisms in soil include large species like plants, earthworms and insects but there are also many microscopic organisms: bacteria, fungi, algae and animals. Nematodes, Rotifers and Tardigrades are common microscopic soil animals.

The distribution of living organisms in soil ecosystems is influenced by the physical and chemical properties of the soil. In this activity you will be collecting soil samples and analyzing their physical and chemical properties. You will also be observing and counting the microscopic animals living in the soil samples. Additionally, you will compare your local soils with published data on soils from Antarctica.

As you work through these activities record your results below:

Soil Sample

1. Record your soil sample ID ____________________.

2. Where was your soil sample collected? (record GPS coordinates if possible)

   ____

3. What was the local environment of your soil sample (e.g. habitat, slope, aspect)?

   ____

   ____

Use the protocols provided by your teacher to measure the gravimetric soil moisture, pH, and electrical conductivity of your soil sample. Record your results below.

4. Gravimetric Soil Moisture

A. Mass of the soil can and lid __________g

B. Mass of soil can, lid and soil (add approximately 50 grams of soil) _________g

C. Mass of soil can, lid and soil after 24 hours in the drying oven __________g

D. (B-C/C-A) * 100 = _________% g/g

5. pH

A. Measured pH of 1:2 soil to water mixture after 10 minutes __________.

6. Electrical Conductivity

A. Measure the EC of a 0.01M KCl solution __________

B. Measure the EC of a 1:5 soil to water dilution after 10 minutes _________µS/cm

C. Temperature corrected EC of soil sample = (1,411.8/A) * B

_______________ µS/cm

Measure approximately 50 grams of soil and use the protocol provided by your teacher to set up a Baermann funnel. Record the exact amount of soil measured. After 24-48 hours transfer 10-20 ml of water from the bottom of the baermann funnel to a conical tube or a counting dish.
Using a stereomicroscope observe the various types of animals in your sample. You likely will have lots of nematodes. Use physical characteristics like size, shape and behavior to identify the different types (morphospecies) of nematodes. Describe the types below:

7. Microscopic Soil Animals

A. Amount of wet soil placed in Baermann funnel _____________g

B. Nematode type #1 (description) - ____

C. Nematode type #2 (description) - ____

D. Nematode type #3 (description) - ____

E. Other species (descriptions) - ____

____

Move the dish back and forth systematically to count the nematodes in the dish. You may choose to count the total nematodes or you can count the nematodes of each morphospecies. The grid on the bottom of the dish will help you keep track of the animals so you don't double count.

F. Nematode type #1 (count) - ___________

G. Nematode type #2 (count) - ___________

H. Nematode type #3 (count) - ___________

I. Total Nematodes (count) - ___________

J. Total Rotifers (count) - ___________

K. Total Tardigrades(count) - ___________

Data Analysis and Comparisons

Examine the article "Ecological Biogeography of the Terrestrial Nematodes of Victoria Land, Antarctica" (Adams et al. 2014). Pay particular attention to the information about habitat for *Scottnema*, *Eudorylaimus* and *Plectus* (on pages 36, 44, 50 and 56). Use the information in the article and the table below to make predictions about the relative distribution of nematodes according to the chemical and physical characteristics of Dry Valley Soils.

	Soil Characteristics		
Species	Soil Moisture	pH	Electrical Conductivity
Scottnema			
Eudorylaimus			
Plectus			

A. Which nematodes are likely to occur together? Which are likely to occur alone?

Navigate to http://www.mcmlter.org/content/soil-elevational-transect-experiment and download the Soil Elevational Transect Experiment data as a .csv file. You can also find explanations of each of the experiment and each of the data fields on the webpage. For this investigation, you will use six columns of data: SOIL_WATER_CONTENT, STL, ETL, PTL, PH, and CONDUCTIVITY. You may choose to hide or delete the other columns. To simplify your comparisons, delete all data <u>rows</u> that have missing values for any of the three soil characteristics (i.e. soil_water_content, pH, conductivity). You may find it useful to sort the data in order to do this.

B. How many rows of data do you have left? ____________

Once you have eliminated the missing values investigate the data by finding which of the three species are found together and which are found in isolation.

C. Which species is found in isolation? ____________

D. Which species is sometimes found with only one other species? ____________

E. Which species is only found in the presence of both of the other species? ____________

F. Calculate the mean Soil Water Content, pH, and Electrical Conductivity for samples that contain only the species listed in 'C' above.

Soil Water Content ____________% g/g

pH ____________

Conductivity ____________ µS/cm

G. Calculate the mean Soil Water Content, pH, and Electrical Conductivity for samples that contain only two of the three species.

Soil Water Content ____________% g/g

pH ____________

Conductivity ____________ µS/cm

H. Calculate the mean Soil Water Content, pH, and Electrical Conductivity for samples that contain all three of the species.

Soil Water Content ____________% g/g

pH ____________

Conductivity ____________ µS/cm

I. How do your calculated means fit with your predictions about the distribution of nematodes in the McMurdo Dry Valleys?

J. How does the soil water content of your sample compare to the McMurdo Dry Valley data?

K. How does the pH of your sample compare to the McMurdo Dry Valley data?

L. How does the electrical conductivity of your sample compare to the McMurdo Dry Valley data?

M. Calculate the number of nematodes/dry kg of soil from your soil sample. Use the percent soil moisture calculated in part 4 (Gravimetric Soil Moisture) and the data recorded in part 7 (Microscopic Soil Animals).

Nematodes per kg = 1000*(number of nematodes/(weight of soil sample-(weight of soil sample*(percent soil moisture/100))))

___________________ nematodes/kg dry soil

N. How does the number of nematodes in your sample compare to the Antactic Dry Valleys?

Literature Cited

Adams, B. J., Wall, D. H., Virginia, R. A., Broos, E., & Knox, M. A. (2014). Ecological biogeography of the terrestrial nematodes of Victoria Land, Antarctica. ZooKeys, (419), 29-71. doi:10.3897/zookeys.419.7180

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Template for Nematode Counting Dish Gridlines