MISSOURI AGRICULTURAL EDUCATION

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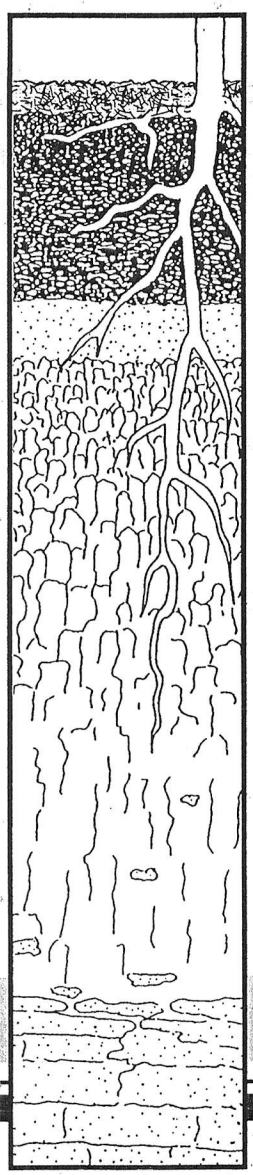
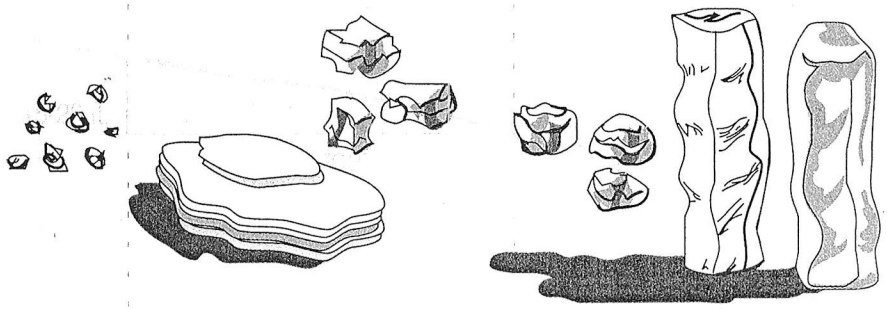


SOIL SCIENCE



Evaluation, interpretation, and management of soil

INSTRUCTOR PACKET

IN COOPERATION WITH
AGRICULTURAL EDUCATION, DEPARTMENT OF PRACTICAL ARTS AND VOCATIONAL-TECHNICAL EDUCATION, COLLEGE OF EDUCATION AND COLLEGE OF AGRICULTURE, UNIVERSITY OF MISSOURI-COLUMBIA
AND
AGRICULTURAL EDUCATION SECTION, DIVISION OF VOCATIONAL AND ADULT EDUCATION, DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION, JEFFERSON CITY, MISSOURI

INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA • COLUMBIA, MISSOURI 65211

Available from:
Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, MO 65211
314-882-2883

The activity which is the subject of this product was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, information or opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

SOIL SCIENCE

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Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, Missouri 65211

Volume 27
Number 2

Catalog Number 10-5050-I
June 1995

ACKNOWLEDGMENTS

Thanks and recognition are given to the members of the Soils Advisory Committee for providing their valuable time and useful suggestions in developing this course of study. Committee members included Steve Brown, DESE Supervisor, Agricultural Education; Leon Busdieker, Teacher, Warren Co. R-III; Amon Herd, Associate Director (Retired), IML; Harry James, Professor, Soil Science, Department of Agriculture, Southwest Missouri State University; Richard Linhardt, Professor, Agricultural Education, University of Missouri-Columbia; Delbert Lund, DESE Supervisor, Vocational Planning and Evaluation; Mike McCrory, Teacher, Clopton R-3; Randy Miles, Professor, School of Natural Resources, University of Missouri-Columbia; Paul E. Minor, Soil Scientist (Retired), USDA, Soil Conservation Service; John Poelmann, Research Associate, University of Missouri-Columbia; and Richard Tummons, Soil Scientist, USDA, Soil Conservation Service.

Appreciation is also extended to the staff members from the Instructional Materials Laboratory, including Harley Schlichting, Director; Phyllis Miller, Assistant Director; Dan Stapleton, Assistant Director; Eileen Woody, Project Coordinator; Susan M. Rhyne, Editor; Sondra Small, Administrative Assistant; Jan Trimble, Word Processor; and Monte Bach, Student Technical Assistant.

Many people contributed information, suggestions, and ideas for this text. Among those who deserve our special credit are:

Paul Minor for reading, commenting, and providing content revisions.

John Baker, Bill Broderson, Herb Huddleston, Paul Minor, Wiley Nettleton, C.L. Scrivner, and Fred Young for providing slides and photos.

Evie Liss in Oregon for helping us contact Herb Huddleston.

Dr. Steve J. Thien for the use of the flowchart on soil textures.

Dan Stapleton for illustrating the text.

Special thanks are due to the writer, Amon Herd, who worked diligently to complete this guide. We were all saddened by his passing in April 1995. Amon spent 48 years in the field of education as our friend and supporter. This guide is dedicated to his memory.

Richard Linhardt, Professor
Agricultural Education
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FOREWORD

Agricultural Education curriculums are built on the core courses, Agricultural Science I and II. This Soil Science Instructor Guide enables agricultural education to remain technically current and to provide applicable curriculum for students with an occupational objective in agribusiness and/or production agriculture and/or horticulture. This Soil Science Guide is also appropriate for use in Agricultural Science II, Crop Science, Agricultural Structures, Soil and Water Management, Nursery Operation and Management, Turf Management, Fruit and Vegetable Production, Landscaping, and Conservation of Natural Resources. This unit represents 15 hours of instruction for agriculture students in the tenth grade or above.

To meet the demand for greater accountability, this guide incorporates the needed component parts to implement the Vocational Instructional Management Systems (VIMS). The instructor's guide includes: objectives, competencies, motivational techniques, teaching procedures, discussion items, activities, transparency masters, and evaluations. One copy of the student reference is also included and is an integral part of this curriculum. The student reference contains thirty-two color plates as well as valuable tables and charts. Additional copies of the student reference can be purchased separately.

This curriculum contains 13 lessons, which cover a wide range of topics including: Why soil is important, how soils are formed, the importance of soil color, texture, and structure, a description of a soil profile, soil chemistry, soil fertility, site characteristics, taking soil samples and interpreting the results, water movement through soil, ways to manage soil, and describing the environmental impact of soil and water management. Helpful information for conducting soil contests is found in **Appendix I: How to Organize and Manage a Soil-Judging Contest**. The new soil judging scorecard for Missouri is included in **Appendix II: Evaluating and Interpreting the Landscape Soil Pedon.**

Richard Linhardt, Professor
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Terry Heiman, Director
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OBJECTIVES

1. The student will be able to explain the importance of soil.

2. The student will be able to describe how soils are formed.

3. The student will be able to explain the importance of soil color.

4. The student will be able to explain the importance of soil texture.

5. The student will be able to explain the importance of soil structure.

6. The student will be able to describe a soil profile.

7. The student will be able to explain how plants exchange anions for cations.

8. The student will be able to identify what plants get from the soil to be healthy and what gives maximum yields.

9. The student will be able to prepare a sample for analysis.

10. The student will be able to evaluate the effects of soil on water.

11. The student will be able to describe the various site characteristics.

12. The student will be able to identify ways to conserve and manage the soil.

13. The student will be able to describe the environmental impact of soil and water management.

NOTE: Percent of accuracy should be set by instructors to reflect passing grades within their school systems.

COMPETENCIES

1. Explain the importance of soil.

2. Describe how soils are formed.

3. Explain the importance of soil color.

4. Explain the importance of soil texture.

5. Explain the importance of soil structure.
6. Describe a soil profile.
7. Explain how plants exchange anions for cations.
8. Identify what plants get from the soil to be healthy and what gives maximum yields.
9. Prepare a soil sample for analysis.
10. Evaluate the effects of soil on water.
11. Describe the various site characteristics.
12. Identify ways to conserve and manage the soil.
13. Describe the environmental impact of soil and water management.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Use an actual growing plant to explain the importance of soil and how it affects the growth of plants.
2. Discuss how soils are formed. Survey class as to the different types of soil and how they are formed.
3. Discuss the Munsell Color Notations.
4. Illustrate how texture influences the workability of soil.
5. Use soil samples to demonstrate the different types of structure.
6. Use soil monoliths for observing the different horizons.
7. Use pH paper to test a number of household solutions, such as tapwater, ammonia, vinegar and lemon juice.
8. Visit a fertilizer manufacturer.
9. Discuss why soil tests are important.
10. Invite a prominent farmer to visit the class and explain proper management of the soil.

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.
2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in soil science.

REFERENCES AND MATERIALS

1. Student Reference

   Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995.

2. Teacher References

   Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc., 1990.

   Plaster, J. Edward. *Soil Science & Management*, 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

3. Audiovisuals

   Soil Testing, Video. (Available fro Instructional Materials Laboratory, 2316 Industrial Drive, Columbia, Missouri 65202)

4. Teaching Aids

   Soil Texture Kits. (Available from Instructional Materials Laboratory, 2316 Industrial Drive, Columbia, Missouri 65202)

SOIL SCIENCE
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
- **3 Mastered** - can work independently with no supervision
- **2 Requires Supervision** - can perform job completely with limited supervision
- **1 Not Mastered** - requires instruction and close supervision
- **N No Exposure** - no experience or knowledge in this area

3	2	1	N	COMPETENCIES
				1. Explain the importance of soil.
				2. Describe how soils are formed.
				3. Explain the importance of soil color.
				4. Explain the importance of soil texture.
				5. Explain the importance of soil structure.
				6. Describe a soil profile.
				7. Explain how plants exchange anions for cations.
				8. Identify what plants get from the soil to be healthy and what gives maximum yields.
				9. Prepare a soil sample for analysis.
				10. Evaluate the effects of soil on water.
				11. Describe the various site characteristics.
				12. Identify ways to conserve and manage the soil.
				13. Describe the environmental impact of soil and water management.
				_____
				_____

Student ratings on specific competencies evaluated during the program are available upon the student's written request. Parent's or guardian's signature is necessary if the student is under 18 years of age.

Soil Science

Class/Section: _____

Student Names:

COMPETENCIES

1. Explain the importance of soil.
2. Describe how soils are formed.
3. Explain the importance of soil color.
4. Explain the importance of soil texture.
5. Explain the importance of soil structure.
6. Describe a soil profile.
7. Explain how plants exchange anions for cations.
8. Identify what plants get from the soil to be healthy and what gives maximum yields.
9. Prepare a soil sample for analysis.
10. Evaluate the effects of soil on water.
11. Describe the various site characteristics.
12. Identify ways to conserve and manage the soil.
13. Describe the environmental impact of soil and water management.

UNIT - SOILS

Lesson 1: Importance of Soil

Objective: The student will be able to explain the importance of soil.

Study Questions

1. **What is soil?**
2. **What are some reasons for studying soil?**
3. **How are soils different?**
4. **What are career opportunities in soil science?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 1.
2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc., 1990.
3. Plaster, J. Edward. *Soil Science & Management*, 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
4. Transparency Masters
   a) TM 1.1: Soil Definition
5. Activity Sheet
   a) AS 1.1: Making Soil Artificially

UNIT - SOILS

Lesson 1: Importance of Soil

TEACHING PROCEDURES

A. Introduction

Give an overview of this unit and how it relates to other courses. Introduce this chapter on the importance of soil.

B. Motivation

1. Ask students how soil is important to them. Have students bring small samples of soil from their yards and identify similarities and differences. Have students list what they think makes up their soil.

2. Use an actual growing plant to demonstrate the importance of soil and how it affects the growth of the plant. Have the students explain the interdependence of the plant and soil.

   a) What does the soil do for the plant?
   b) What does the plant do for the soil?

C. Assignment

D. Supervised Study

E. Discussion

1. Discuss what soil is. Soil has different meanings for different people. Ask students to give their own definition of soil. TM 1.1.

   What is soil?

   a) Soil has different meanings for different people.
   b) To the farmer, soil is a medium in which crops grow.
   c) To the engineer, soil is a building material which supports foundations, roads, or airport runways.
   d) The public, in most cases, just takes the soil for granted. It is just "dirt."
   e) To the soil scientist, soil is a living, naturally occurring dynamic system at the interface of air and rock.
   f) Soil covers the earth in a very thin layer and supports plants and supplies them with air, water, and nutrients.
   g) Soils form in response to forces of climate and organisms that act on parent material in a specific landscape over a period of time.

2. Discuss the importance of soil and how it affects people. Discuss human dependence on the soil. Contrast plant life with human life. Humans cannot manufacture their own food from the four primary resources of soil, air, water, and sunlight. Human life depends completely on green plants that take nutrients and water from soil and combine them with air and sunshine to provide a foods supply.

What are some reasons for studying soil?

a) Soil is an essential natural resource that needs to be used properly and protected.
b) A study of soil will increase understanding of how this resource supports life.
c) Soil is composed of layers or horizons that are described in terms of their properties. If soils are managed properly, they will continue to support people for many generations to come.
d) People depend on soil: It is expected to produce crops, support buildings and highways, grow trees for forests, provide places for recreation and wildlife habitats, and be a safe place for disposal of wastes.
e) Missouri has nearly 1,000 different soil types. It is necessary to study the soil before beginning construction or planting a crop so that its hazards and limitations are known.

3. Use actual soil samples and discuss the physical characteristics of each. (Caution - Do not go into a lot of detail at this time. This chapter is an introduction and should provide an overview, rather than an in-depth analysis of soil properties.)

How are soils different?

a) Missouri alone has nearly 1,000 different soil types, ranging from deep to shallow, clayey to sandy, wet to dry, and level to very steep.
b) Some of the differences in soils are so slight (like small differences in the thickness, percent of organic matter of the surface layer, or the amount of clay in the subsoil) that it is hard to tell them apart except under close examination.
c) Some of the differences are significant, such as the difference between a shallow soil that is 10 inches deep compared to one that is over 72 inches deep, or a soil containing 25 percent clay compared to a soil containing 60 percent clay.

4. Discuss the careers that are available in soil and crop management.

What are career opportunities in soil science?

a) Agricultural production
   1) Farm manager
   2) Land specialists for banks
   3) Technical representatives for fertilizer firms
b) Natural resources
   1) Soil scientist in public service agencies
   2) Technician for recreational industries
c) Environmental science
   1) Government agent
   2) Private consultant for waste management and water quality issues

F. Other Activities

1. Invite a guest speaker from a soil science area.

2. Ask the students to list the ways in which soils affect the quality of their lives.

3. Take a field trip to observe different soils.

4. Bring in soil samples for examination.

G. Conclusion

All life depends on soil; therefore, it is important for people to study the soil so they can learn how to protect it for the future.

H. Competency

Explain the importance of soil.

Related Missouri Core Competencies and Key Skills: None

I. Answers to Evaluation: (Answers may vary.)

1. Soil is a living, naturally occurring dynamic system at the interface of air and rock.

2. Soil is an essential natural resource. A study of soil will increase an understanding of its proper use and protection, how soil supports life, what soil is made of, proper management of the soil, and how soils are different.

3. Some of the differences in soils are slight, like small differences in thickness, the percent of organic matter of the surface layer, or the amount of clay in the subsoil. Other differences are significant, such as the difference between a shallow soil that is 10 inches to bedrock compared to one that is over 72 inches to bedrock, or a soil containing 25 percent clay compared to a soil containing 60 percent clay.

4. a) Farm managers
   Land specialists for banks
   Technical representatives
   Government jobs
   Private institutions
   b) Public service agency job
   Recreational industries
   c) Government agency jobs
   Private consulting jobs

5. Soil supports life. Knowing that, people must study the soil so that they can learn how to protect it for future use.

J. Answers to Activity Sheet

AS 1.1

1. The rocks break or crack as they contract after their expansion by heating.

2. The bubbles are carbon dioxide gas made from carbon and oxygen released from the limestone by a chemical change in the rock caused by the acid in the vinegar.

3. Freezing water expands with tremendous force. Water finds its way into the cracks in the rocks freezes and breaks the rock into smaller and smaller pieces.

UNIT - SOILS

Name _____

Lesson 1: Importance of Soil

Date _____

EVALUATION

Fill in the blank with the correct answer.

1. What is soil?

_____

_____

_____

_____

_____

2. Why should we study soil?

_____

_____

_____

_____

_____

3. How are soils different?

_____

_____

_____

_____

_____

4. There are many career opportunities in soil science. List two careers in each of the following:

   a. Agricultural production

   _____ _____

   b. Natural resources

   _____ _____

   c. Environmental science

   _____ _____

5. Why is soil important?

_____

_____

_____

Soil Definition

Soil is a living, naturally occurring dynamic system at the interface of air and rock. Soil forms in response to forces of climate and organisms that act on parent material in a specific landscape (topography) over a period of time.

UNIT - SOILS NAME: _____

Lesson 1: Importance of Soil

Making Soil Artificially

Objective: Students can show how some of the forces of nature break rocks into soil material.

Activity Length: 2 class periods

Materials and Equipment:

Experiment One: Two pieces of limestone or fine sandstone rock. (If you do not have natural stone, pieces of building rocks or concrete will do.)

Experiment Two: Six pieces of small limestone rock, hot plate, pint of ice water and a small pan.

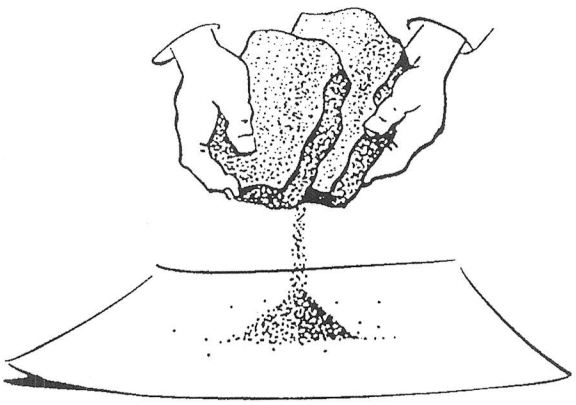
Experiment Three: Small glass jar with cap, water to fill glass jar and refrigerator with freezing compartment.

Experiment Four: Six small pieces of limestone rock, vinegar (one pint), glass container and hot plate.

Experiment One Procedure:

1. Rub two pieces of limestone or fine sandstone together.
2. Notice how long it takes to rub off even a few fine particles.

   Conclusion: Soil is very, very slowly formed from rocks by this same rubbing together action.

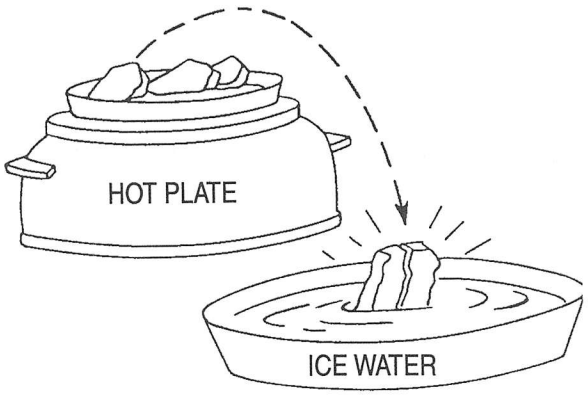


Experiment Two Procedure: (To be conducted by the instructor only. Use extreme caution. Wear safety goggles.)

1. Heat a small piece of limestone over a flame or on a hot plate.
2. Drop the limestone rock quickly into a pan of ice water.
3. Rock should break or crack as it contracts after expansion by heating.

   Conclusion: Changes in temperature help make rock into soil by the heating and cooling conditions found in nature.

   Expansion and contraction chips off particles of rock just as was noted when the hot limestone rock was dropped into icy water.



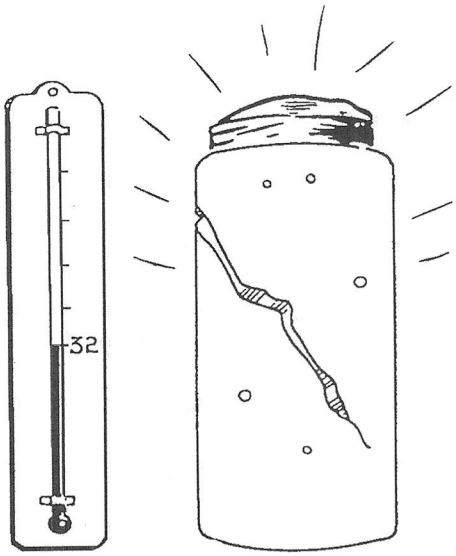
Experiment Three Procedure:

1. Fill a small discarded glass jar with water and cap it tightly.

2. Place the jar in the freezer compartment of a refrigerator and allow to freeze.

3. What happened to the jar?

   Conclusion: Freezing water expands with tremendous force. Water finds its way into cracks in a rock and freezes. Expansion by freezing water causes the rock to crack or break and continues the process of turning rocks into smaller and smaller pieces.



Experiment Four Procedure: (To be conducted by the instructor only. Use extreme caution. Wear safety goggles.)

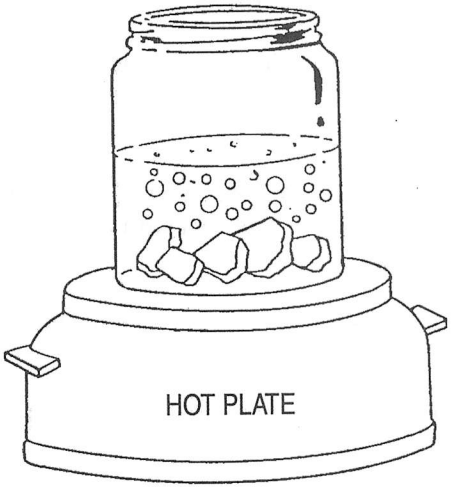
1. Place limestone rocks in a tempered glass container.

2. Fill glass container about half full of vinegar.

3. Heat the vinegar on a hot plate and notice how bubbles form on the pieces of limestone.

   Conclusion: Bubbles are carbon dioxide gas made from carbon and oxygen being released from the limestone by a chemical change in the rock. This chemical change is caused by the acid in the vinegar. By putting limestone into the vinegar, you are duplicating in a small way what plants do in breaking down rocks.

   Carbon dioxide gas released from the plants dissolves in soil moisture creating a weak carbonic acid. This carbonic acid act upon the rocks in a similar way to the vinegar only at a much, much slower manner.



NAME: _____

UNIT - SOILS

Lesson 1: Importance of Soil

Making Soil Artificially

Key Questions:

1. Explain what action takes place when limestone rocks are heated and dropped into ice water.

_____

_____

_____

_____

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_____

2. What chemical reaction takes place when limestone rock is place in vinegar.

_____

_____

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_____

3. Explain how freezing and thawing break up large rocks.

_____

_____

_____

_____

_____

_____

UNIT - SOILS

Lesson 2: Soil Formation

Objective: The student will be able to describe how soils are formed.

Study Questions

1. **How do climate, organisms, parent materials, topography, and time affect soil formation?**

2. **How do the soil-forming processes affect soil development?**

3. **How do the soil-forming processes work together to form soil?**

4. **Why are soils different?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 2.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management.* Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management*, 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 2.1: How Climate Affects Development of Organic Matter
   b) TM 2.2: Why Soils Are Different

5. Activity Sheet

   a) AS 2.1: Life in the Soil

UNIT - SOILS

Lesson 2: Soil Formation

TEACHING PROCEDURES

A. Review

Ask students to review their comparison of soil samples from the previous lesson.

B. Motivation

After reviewing similarities and differences in their soils from home, have the students list what forces might have influenced the formation of their particular soil. Let the students know that although time is an important factor in soil formation, the "age" of a soil is usually measured in development, not in years.

C. Assignment

D. Supervised Study

E. Discussion

1. Discuss how the five soil-forming factors influence soil formation. Discuss the difference between active and passive factors. Of the five soil-forming factors, climate and organisms are active factors. They are catalysts that cause soil to form. The other three factors, parent material, topography, and time, are passive factors. They respond to the forces exerted by climate and organisms. All five factors are closely interrelated and few generalizations can be made about the effect of any factor unless conditions are specified for the other four factors.

How do climate, organisms, parent materials, topography, and time affect soil formation?

a) Climate (Refer to TM 2.1.)
   1) Temperature
      (a) Rate of chemical activity
      (b) Type of vegetation and biological activity
   2) Rainfall
      (a) Leaching
      (b) Movement of clay particles
b) Organisms (Refer to Figure 2.1 in Student Reference.)
   1) Macroorganisms--living and dead
      (a) Source of all organic matter
      (b) Include large plants and animals
      (c) Plants being the largest contributor of organic matter
      (d) Large trees
         (1) Decay slowly
         (2) Break up soil and leave channels
      (e) Soil animals
         (1) Contribute organic matter
         (2) Mix the soil and leave channels

2) Microorganisms (microbes)
   (a) Microscopic plants and animals
   (b) Primary decomposers of organic material
   (c) Humus, produced by microbes, acts as glue for soil aggregates
   (d) Without microbes, inert soil
3) Finely divided nonliving material
   (a) Humus
      (1) Amorphous (formless)
      (2) Dark brown or black

c) Parent material
   1) Original geologic material
   2) Passive
   3) Residuum--formed in place from bedrock
   4) Transported--deposits of sediments
      (a) Colluvium
      (b) Alluvium
      (c) Loes
      (d) Glacial till

d) Topography
   1) Relief or landscape
   2) Influences soil formation--drainage, runoff, erosion, sunlight, and wind

e) Time
   1) "Young" soils more closely resemble their parent materials.
   2) Some parent materials weather faster than others.
   3) Climates may change with the passage of time.

2. Discuss the four major processes that change parent material into life-sustaining soil. These processes are a result of catalytic influences of the active factors (organisms and climate).

How do the soil-forming processes affect soil development?

a) Additions
   1) Organic matter gives black or dark brown color to the surface layer.
   2) Rainfall adds nitrogen.
   3) Acid rain may change the rate soil processes.
   4) Flooding adds new sediment.

b) Losses
   1) Leaching
      (a) Free lime or salts
      (b) Fertilizers (especially nitrogen)
   2) Slowly dissolving minerals--Residual effects of weathering
   3) Gases
      (a) Oxygen from organic decay
      (b) Water vapor from organic decay
      (c) Nitrogen changed to gas by wetness
   4) Solids (mineral and organic)--Solids lost by erosion is the most serious loss.

c) Translocations
   1) Movement of particles from the surface soil to subsoil
   2) Caused by water
      (a) This movement carries clay particles.
      (b) Incomplete leaching leaves mineral deposits.

d) Transformations
   1) Changes that take place within the soil
      (a) Microorganisms
      (b) Chemical weathering
   2) Changes of elements
      (a) Reduction of iron oxide
      (b) Mottling caused by repeated cycles of wetting and drying

3. Obtain samples of common soil-forming rocks and minerals. Discuss what processes must happen to change these parent materials to soil. Discuss how the different layers in a soil profile might have been formed.

How do the soil-forming processes work together to form soil?

a) Climate acts immediately.
b) Physical weathering decreases size of parent material.
c) Weathering changes minerals.
d) Leaching removes salts and limes.
e) Plants add organic matter.
f) Biological activity increases (humus is formed).
g) Increased porosity allows more leaching and weathering.
h) Chemical weathering and leaching continue to change and remove minerals.
i) More horizons develop beneath the surface.
j) The soil becomes more acid.
k) Clay minerals begin to form.
l) Clay is translocated and clay films become visible.
m) Rate of water movement through the soil decreases.
n) Weathering continues, but leaching is not as rapid.
o) Changes continue at a very slow rate.

4. Observe differences in Missouri soil. Discuss why soils are different. Discuss what might have caused the differences. Refer to TM 2.2. Discuss how these causes may have interacted.

Why are soils different?

a) Factors are closely interrelated in the effects on soil. Five factors interact with each other and the four major soil forming processes.
b) Process are also closely interrelated in the effects on soil. Four major soil-forming processes interact with each other and the five factors.

F. Other Activities

1. Take a field trip and study the history of local soils to see how different soils are formed.

2. Demonstrate the effects of heat in the soil-forming process. Explain what will be done and ask students for predictions. Heat a rock and drop it into ice water. Observe the results. Draw conclusions. USE EXTREME CAUTION.

3. Demonstrate the effects of cold in the soil-forming process. Explain what will be done and ask students for predictions. Put wet clay in a jar or plastic bag so it is full and is a tight fit. Freeze. Observe results. Draw conclusions.

4. Demonstrate the effects of wetting and drying in the soil-forming process. Explain what will be done and ask students for predictions. Take a moist clod of clay. Cut it square. Put 2 pins in it and measure the distance between them. Put the clay (with the pins) in the oven to dry. Take out it of the oven and measure the distance between the pins. Compare the two measurements. Draw conclusions.

G. Conclusions

The active factors of soil formation (climate and organisms), together with the passive factors (parent material, topography, and time) are so closely interrelated in their effects on the soil that few generalizations can be made unless conditions are known for all of them. The soil-forming processes (additions, losses, translocations, and transformations) may add further variability.

H. Competency

Describe how soils are formed.

Related Missouri Core Competencies and Key Skills

Science 9B-1: Describe the roles of organisms in the formation of topsoil.

I. Answers to the Evaluation

1. b
2. e
3. c
4. d
5. f
6. a
7. i
8. h
9. g
10. j

J. Answers to Activity Sheet

AS 2.1

1. To be determined by the student.

2. Yes

3. Earthworms feed on fresh organic matter, making the nutrients available to plants. Earthworms bring soil from lower levels to the surface, thus mixing the soil. Earthworms improve aeration and internal drainage of the soil.

UNIT - SOILS

Lesson 2: Soil Formation

Name _____

Date _____

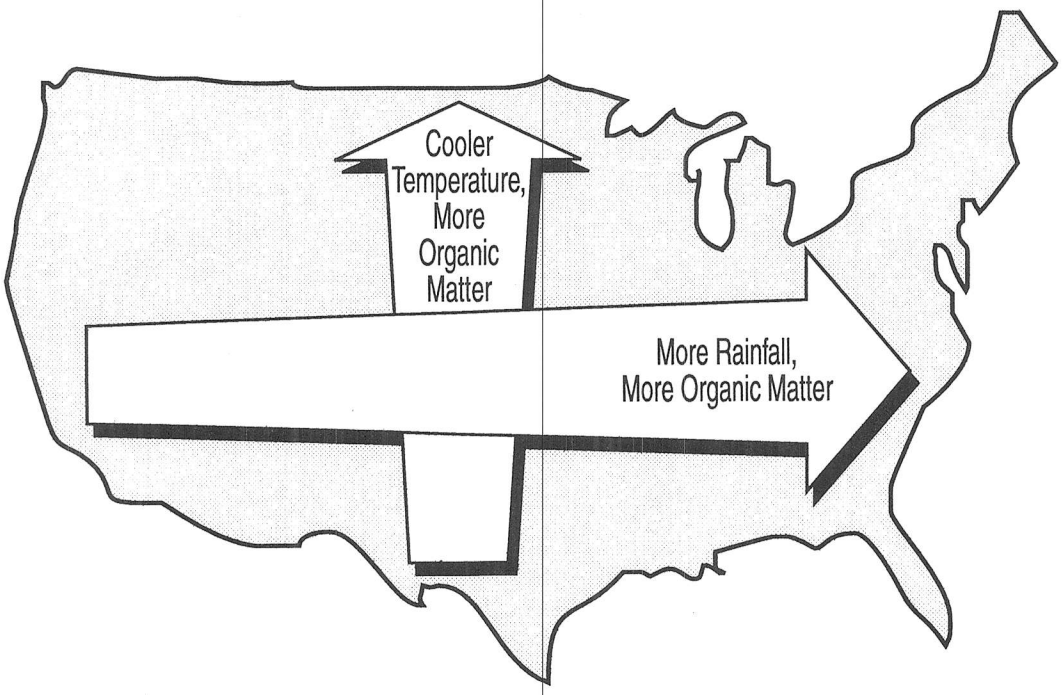
EVALUATION

Match the definition on the left with the term on the right.

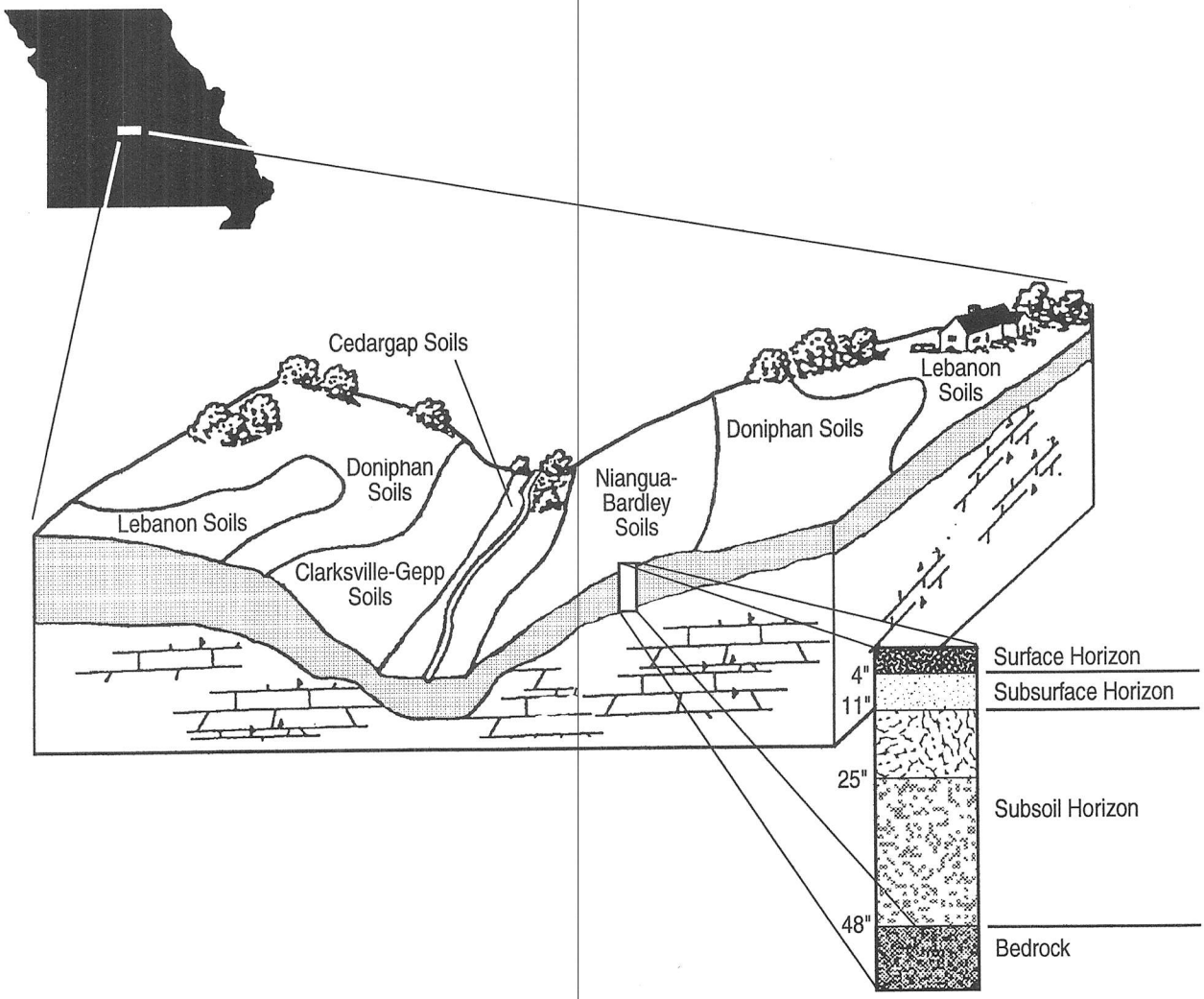
1. _____ Any microscopic animal or plant that is beneficial in decomposing plant and animal residue.
2. _____ Large plants and animals living or dead
3. _____ Soil material formed in place from bedrock
4. _____ One of the active factors in soil formation
5. _____ The removal of soluble constituents from soils by water
6. _____ Solid rock that is underneath the soil
7. _____ The portion of organic matter remaining after the major part of plant and animal residues have decomposed
8. _____ Plant and animal residues at various stages of decomposition
9. _____ The original geologic material that has been changed into the soil
10. _____ The best known animal conditioners of the soil

a. Bedrock
b. Microorganism
c. Residuum
d. Climate
e. Macroorganism
f. Leaching
g. Parent material
h. Organic matter
i. Humus
j. Earthworms

How Climate Affects Development of Organic Matter



Why Soils Are Different



Lesson 2: Soil Formation

Name _____

Life in the Soil

Objective: Students carefully examine the three soil samples for living creatures.

Activity Length: 2 periods

Materials and Equipment:

Three large buckets
Measuring tape
Shovel
Six to eight small bottles with lids
A small magnifying glass
Small hand spade

Procedure:

1. Measure off an area one-foot square and collect the soil to a depth of three inches from each of the following places.

   a. Ungrazed woodland
   b. Pasture
   c. Cultivated field

2. As you remove the soil, watch for burrows of worms and other animals.

3. Carefully place the soil sample in the three containers.

4. Examine the samples, either indoors or outdoors.

5. Pour out the samples on separate sheets of white paper.

6. Carefully sort the soil, watching closely for small living things. One-foot squares of ¼-inch hardware cloth or window screen will be helpful in making this examination.

7. Place the different kinds of animal life in the separate bottles.

8. Observe the three soil samples and count the animal life belonging to each of the following groups.

Table 1.1

	Soil Sample #1	Soil Sample #2	Soil Sample #3
Worms (such as earthworms having no legs)			
Grubs (any wormlike animal with legs)			
Snails (without shells are called slugs)			
Insects (hard-shelled, soft bodied, or winged)			
Spiders, mites, ticks (animals with four pairs of legs)			
Animals with more than four pairs of legs			
Others (any animal not falling into one of the above groups)			

Key Questions:

1. Which soil sample has the most small animal life? _____

2. Does the amount of animal life and the burrows the animals make appear to have any relation to the looseness of the soil? _____

3. What value are earthworms to the soil?

_____

_____

_____

Adapted from: U.S. Department of Agriculture-Soil Conservation Service

UNIT - SOILS

Lesson 3: Soil Color

Objective: The student will be able to explain the importance of soil color.

Study Questions

1. **What is the importance of soil color?**
2. **How is matrix color of soil identified?**
3. **How does organic matter affect soil color?**
4. **What other factors affect soil color?**
5. **What is soil mottling?**
6. **What causes soil mottling to occur?**
7. **How are mottles identified?**
8. **What does a Munsell color notation indicate?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 3.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Munsell color charts, available in sets or individual pages from Forestry Supply, Inc., 205 West Ranken Street, P.O. Box 8397, Jackson, MS 39284. The three Munsell color charts recommended most often are the 10YR, 7.5YR, and 5YR. Three additional charts are used periodically: 5Y, 2.5Y, and 2.5YR.

UNIT - SOILS

Lesson 3: Soil Color

TEACHING PROCEDURES

A. Review

In Lesson 2, the factors and processes that affect soil formation were discussed. This lesson will discuss how these and other factors affect soil color.

B. Motivation

Show the Munsell color chart. Examine again the samples from home. Have the students predict what the different colors in their samples might mean.

C. Assignment

D. Supervised Study

E. Discussion

1. Discuss the importance of soil color. Ask the students if color affects soil or is an indicator of soil condition and composition.

What is the importance of soil color?

a) Color is one of the most noticeable properties.
b) Color gives clues about the nature of the root zone.
   1) Organic matter content
   2) Wetness
   3) Air-water relations

2. Discuss how the matrix color of soil is identified. Refer to the color plates in the student reference. Remind students that soil color is identified using moist (not wet) soil and studied in the brightest light available. Use freshly exposed samples.

How is the matrix color of soil identified?

a) Main body of soil
b) Dominant color of the horizon
   1) Moist soil
   2) Brightest lighting
c) Grouped in four broad classes
   1) Dark brown, very dark brown, black
   2) Light brown, brown, yellowish brown
   3) Red, reddish brown
   4) Dark gray, light gray, white

3. Discuss the importance of organic matter. Is color an indicator we use to determine the amount of organic matter in the soil?

How does organic matter affect soil color?

a) Humus (organic residue) coats soil particles.
b) Causes dark color
c) Dark color increases as humus increases
d) Typical of A horizons
e) Breaks down slower in wet soils

4. Discuss what other factors might affect the color of soil. Ask students what they believe causes the dominant soil color in your area.

What other factors affect soil color?

a) Wetness
b) Aeration--Iron oxide coatings
c) Weathering
    1) Leached
    2) Acidic
d) Mineral color--Naturally gray

5. Discuss what soil mottling is. Discuss the color plates in the student manual.

What is soil mottling?

a) Splotches of soil colored differently than the dominant matrix color
b) Reddish-brown splotches in a gray matrix
c) Gray splotches in a brown matrix

6. Discuss what causes soil mottling.

What causes soil mottling to occur?

a) Seasonal high water tables in landscapes that restrict water movement (drainage mottles)
    1) High water table
        (a) Blocks air circulation
        (b) Removes iron oxide coatings (gray mottle)
    2) Low water table
        (a) Allows air circulation
        (b) Develops iron oxide coatings (yellowish-brown mottle)
b) Chemical weathering
    1) Minerals change color
    2) Rocks fragment
c) Coatings on soil aggregates
    1) Not considered a soil mottle.
    2) Usually dark in color
        (a) Organic coatings
        (b) Clay coatings
        (c) Moisture films

7. Discuss how mottles are identified. Discuss the four properties of mottle patterns. Use Figure 3.1 in the student reference as a guide.

How are mottles identified?

a) Abundance
   1) Few -- less than 2% of exposed surface
   2) Common -- 2 to 20% of exposed surface
   3) Many -- more than 20% of exposed surface
b) Size
   1) Fine -- diameter less than 5 mm
   2) Medium -- diameter 5 to 15 mm
   3) Coarse -- diameter more than 15 mm
c) Contrast
   1) Faint -- evident only on close examination
   2) Distinct -- readily seen though not striking
   3) Prominent -- conspicuous
d) Color
   1) Dark brown, very dark brown, black
   2) Light brown, brown, yellowish brown (common mottle color)
   3) Red, reddish brown (common mottle color)
   4) Dark gray, light gray, white (common mottle color)

8. Show the students a Munsell color chart in the classroom. The Munsell Color Company makes small color chips for each combination of variables. Use the example 10YR 4/6 listed in the student reference to discuss what this Munsell color notation indicates for this particular soil.

What does a Munsell color notation indicate?

a) Hue (color) indicated by first number and letter--Initials of color name
b) Value (light to dark) indicated by fraction numerator--Scale of 0 (black) to 10 (white)
c) Chroma (brightness or purity) indicated by denominator--Scale of 1 (dull) to 8 (bright)

F. Other Activities

Using the Munsell color chips, examine your local soil for all of the color factors in this lesson.

G. Conclusion

Soil color is one of the most noticeable of soil properties. Soil matrix color also gives clues about the nature of the root zone. Soil mottling gives clues as to seasonal high water tables. To be consistent, samples should always be evaluated using moist soil in the brightest available light.

H. Competency

Explain the importance of soil color.

Related Missouri Core Competencies and Key Skills: None

I. Answers to Evaluation

1. a
2. b
3. d
4. g
5. c
6. e
7. h
8. f

Soil can be grouped into four broad classes:

9. Dark brown, very dark brown, black
10. Light brown, brown, yellowish brown
11. Red, reddish brown
12. Dark gray, light gray, white

UNIT - SOILS

Name _____

Lesson 3: Soil Color

Date _____

EVALUATION

Match the definition on the left with the term on the right.

1.	_____	The main body of soil	a.	Matrix
2.	_____	The purity or strength of a color	b.	Chroma
3.	_____	Actual color of a soil	c.	Organic matter
4.	_____	Splotches of colored soil in a matrix of different color	d.	Hue
			e.	Humus
5.	_____	Material of plant or animal origin that decays in the soil to form humus	f.	Value
6.	_____	Causes the dark color typical of A horizons	g.	Mottles
7.	_____	A system used to identify soil color	h.	Munsell color system
8.	_____	The lightness of intensity of color		

List the four broad classes of soil color.

9. _____

10. _____

11. _____

12. _____

UNIT - SOILS

Lesson 4: Soil Texture

Objective: The student will be able to explain the importance of soil texture.

Study Questions

1. **What is soil texture?**
2. **What are the three major separates in fine earth?**
3. **What are the different soil textures and how are they determined?**
4. **What are rock fragments and how are they identified?**
5. **What is pore space?**
6. **What is the importance of pore space?**
7. **What is the relationship between texture and pore space?**
8. **What other factors are affected by soil texture?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 4.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 4.1: Relative Sizes of Sand, Silt, and Clay
   b) TM 4.2: Textural Triangle
   c) TM 4.3: The Soil Triangle
   d) TM 4.4: Flowchart for Estimating Textural Class

5. Activity Sheet

   a) AS 4.1: Are All Particles the Same Size?

UNIT - SOILS

Lesson 4: Soil Texture

TEACHING PROCEDURES

A. Review

In Lesson 3, color, the most noticeable of soil properties, was discussed. This lesson will include discussion of texture, which is the major influence on soil behavior.

B. Motivation

Illustrate how texture influences the workability of soil. Compare working clay and sandy soil.

C. Assignment

D. Supervised Study

E. Discussion

1. Have students assist you in doing a demonstration on soil texture. Perform the ribbon or feel test to determine how easily the soil can be molded. Refer to TM 4.4.

What is soil texture?

a) Refers to the percentage by weight of sand, silt, and clay in a soil.
b) A balanced mixture is called loam.
c) Texture affects soil behavior.
d) Texture classifications also refer to the presence of gravel or cobblestones.

2. Show TM 4.1 to the students. Have the students demonstrate the surface area of soil particles by pouring water over a pile of marbles. Most of the water runs quickly away. Droplets clinging to the surface of the marbles are the only water retained in the pile, since water cannot soak into the marbles. Using the rule about particle size, a pile of small beads holds more water than a pile of marbles because it has more surface area.

What are the three major separates in fine earth?

a) Sand
   1) Particles are large and can be seen with the naked eye.
      (a) Range in size from .05 mm to 2 mm
      (b) Feels gritty
      (c) Will not stick together when wet
      (d) Low capacity for holding moisture and storing nutrients
b) Silt
   1) Particles are smaller than sand and cannot be seen without a hand lens or microscope.
      (a) Range in size from .002 mm to .05 mm
      (b) Feels smooth (like flour or corn starch)
      (c) Not sticky
      (d) Holds large amounts of water in a form plants can use

c) Clay
   1) Particles are very small and flat and can be seen only with high-powered microscopes.
   2) Less than .002 mm in size
   3) High water holding capacity
   4) Feels sticky; can be molded into ribbons or wires

3. Discuss the fact that all soil contains a mixture of the three major separates of sand, silt, and clay. Show the students TM 4.2; explain that loam is a balanced mixture of the three separates. Discuss how soil texture can be thought of in terms of one of nine steps from this balanced mixture. Using the soil samples, have the students feel and discuss the soil texture of each sample. Refer to TM 4.3.

What are the different soil textures and how are they determined?

a) Textural names give clues as to the soil's combinations of the three major separates (sand, silt, and clay), as well as clues to its position on a soils triangle.
   1) Sand
   2) Loamy sand
   3) Sandy loam
   4) Sandy clay loam
   5) Clay loam
   6) Loam - contains all three separates though slightly less clay
   7) Silt
   8) Silt loam
   9) Silty clay loam
   10) Clay
   11) Sandy clay
   12) Silty clay

b) Laboratory analysis shows exact percentages of sand, silt, and clay--Mark points on the soil triangle corresponding with the percentage of at least two soil separates.

c) Field estimates are determined by working the soil between the thumb and fingers to estimate the amounts of sand, silt, and clay by the feel and behavior of the soil.
   1) First estimate the percentage of sand by noting grittiness.
      (a) More than 50% sand: Textural name contains the word sand.
      (b) Less than 20% sand: Textural name usually contains the word silt.
   2) Next estimate the percentage of clay by the length of ribbon formed.
      (a) More than 40% clay: Name usually contains only the word clay.
      (b) Between 27% and 40% clay: Name contains both the words clay and loam.
      (c) Below 27% clay: Textural name doesn't contain the word clay.
      (d) Assume the rest of the content is silt.

4. Discuss rock fragments found in local soils.

What are rock fragments and how are they identified?

a) Rock fragments include all fragments larger than 2 mm.
   1) Gravel - rounded rock fragments with a diameter between 2 mm and 7.5 cm (3 inches)
   2) Cobbles - rounded or partly rounded with diameters from 3 inches to 10 inches
   3) Channer - more flat than round with diameters from 2 mm to 13 cm (6 inches) in length
   4) Flagstones - more flat than round with diameters from 6 inches to 15 inches in length
   5) Stones and boulders - round fragments more that 10 inches in diameter and flat fragments larger than 15 inches, considered a site characteristic (See Lesson 11.)

b) Textural names based on fine earth must be modified if soil contains a significant amount of gravel, cobbles, channer, or flagstone.
c) Modifier names depend on the volume of the soil mass occupied by rock fragments. (See Figure 4.2 of student reference.)
   1) The percentage of rock fragments by volume is estimated to be equal to the percentage of rock fragments on the surface of a vertical soil profile.
   2) If a soil contains both gravel and cobbles, at least 60% of the rock fragments must be gravel to use the term gravelly.
   3) Use the term cobbly if more than 40% of the rock fragments are cobbles.
   4) Use the same calculations for channers or flagstones.

5. Discuss how soil texture affects the distribution of pore space.

What is pore space?

a) Pore space is the space between the soil particles.
b) Pore space contains either air or water.
c) The A horizon contains about equal amounts of solids and pore space.
d) The B and C horizons usually contain more than one-half pore space because of finer soil particles.

6. How does pore space (soil porosity) influence water retention in the soil? Discuss pore space as it relates to root penetration.

What is the importance of pore space?

a) Pore space influences the behavior of soil for maximum plant growth.
   1) Infiltration
   2) Percolation
   3) Available water capacity
   4) Aeration

7. Discuss why it is important to have good balance of particle sizes to incur maximum plant growth.

What is the relationship between texture and pore space?

a) Sandy soil has the largest pore spaces but cannot hold water as it passes, leaving soil droughty.
b) Clayey soil holds too much water in a thin film of hygroscopic water unavailable to plants and does not allow air flow.
c) A balanced soil texture will have a balanced mixture of large and small pores that will have the best soil properties for maximum plant growth.
d) Excessive tillage reduces pore space.

8. Discuss physical properties and how they affect soil texture.

What other factors are affected by soil texture?

a) Soil texture affects the shrink-swell potential of a soil. It affects how buildings and highways are designed to prevent damage from cracking.
b) Content of rock fragments affects the load-bearing capacity for construction of roads, buildings, and earthen dams.

c) Soil texture affects soil behavior concerning water.
   1) Functioning of septic tank filter fields and sewage lagoons
   2) Affects the available water capacity
   3) Leaching of pesticides

d) Soil texture affects the tillage of crops.

F. Other Activities

1. Mix silt, sand, and clay particles together. Fill a jar half full from the mixture. Add water, cover with the lid and shake vigorously. Set aside and allow the particles to settle out for one day. Record how the different particles sizes separated.

2. Each student is asked to bring in a soil sample. Have each student estimate soil texture by feel. Have students trade soil samples for more practice.

G. Conclusion

Soil texture is the percentage by weight of sand, silt, and clay. Soil texture is important to the aspects of soil behavior. Texture affects the amount of water a soil will hold, the rate of water movement through the soil, and the ease of root development. Texture also determines the porosity of a soil, shrink-swell potential, and the bearing capacity for roads, buildings and dams.

Soil texture can be determined by laboratory analysis or by field estimate (working the soil between the thumb and fingers.) Textural class names (based on fine earth) are determined using textural triangle and are modified if the soil contains a significant amount of rock fragments.

H. Competency

Explain the importance of soil texture.

Related Missouri Core Competencies and Key Skills:

Science 10I-1: Observe samples of various soil types and indicate differences and similarities.

I. Answers to the Evaluation

1.	b	7.	g
2.	f	8.	e
3.	h	9.	c
4.	j	10.	a
5.	d	11.	Loam
6.	i		

J. Answers to Activity Sheet

1. The sample with the most silt.

2. The sample with a favorable proportion of sand, silt, and clay.

UNIT - SOILS

Name _____

Lesson 4: Soil Texture

Date _____

EVALUATION

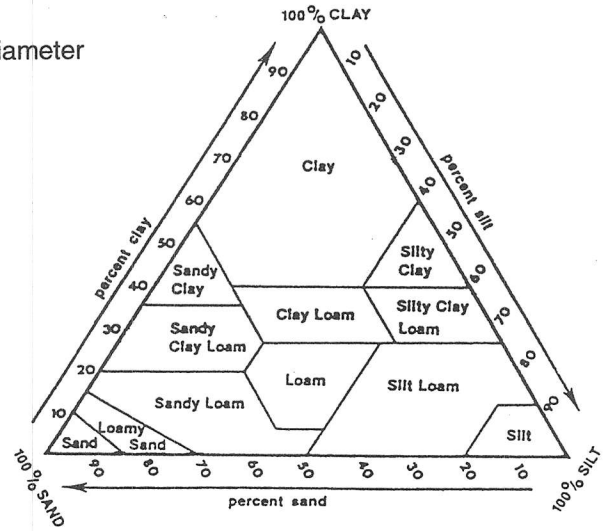
Match the definition on the left with the term on the right.

1. _____ Relative percentages of sand, silt, and clay in the soil
2. _____ Inability of a soil to store enough water to meet plant requirements
3. _____ The total amount of pore space in a soil
4. _____ Portion of soil not occupied by solid material but which is filled with water or air
5. _____ Largest of the soil separates, between 0.05 and 2.00 mm in diameter
6. _____ Medium-sized soil separate, particles between 0.05 and 0.002 mm in diameter
7. _____ The class of smallest soil particles, smaller than 0.002 mm in diameter
8. _____ Individual particles that are larger than 2 mm in diameter
9. _____ A coarse fragment, or piece of rock in the soil, which is between 3 and 10 inches in size
10. _____ All particles smaller than 2 mm in diameter

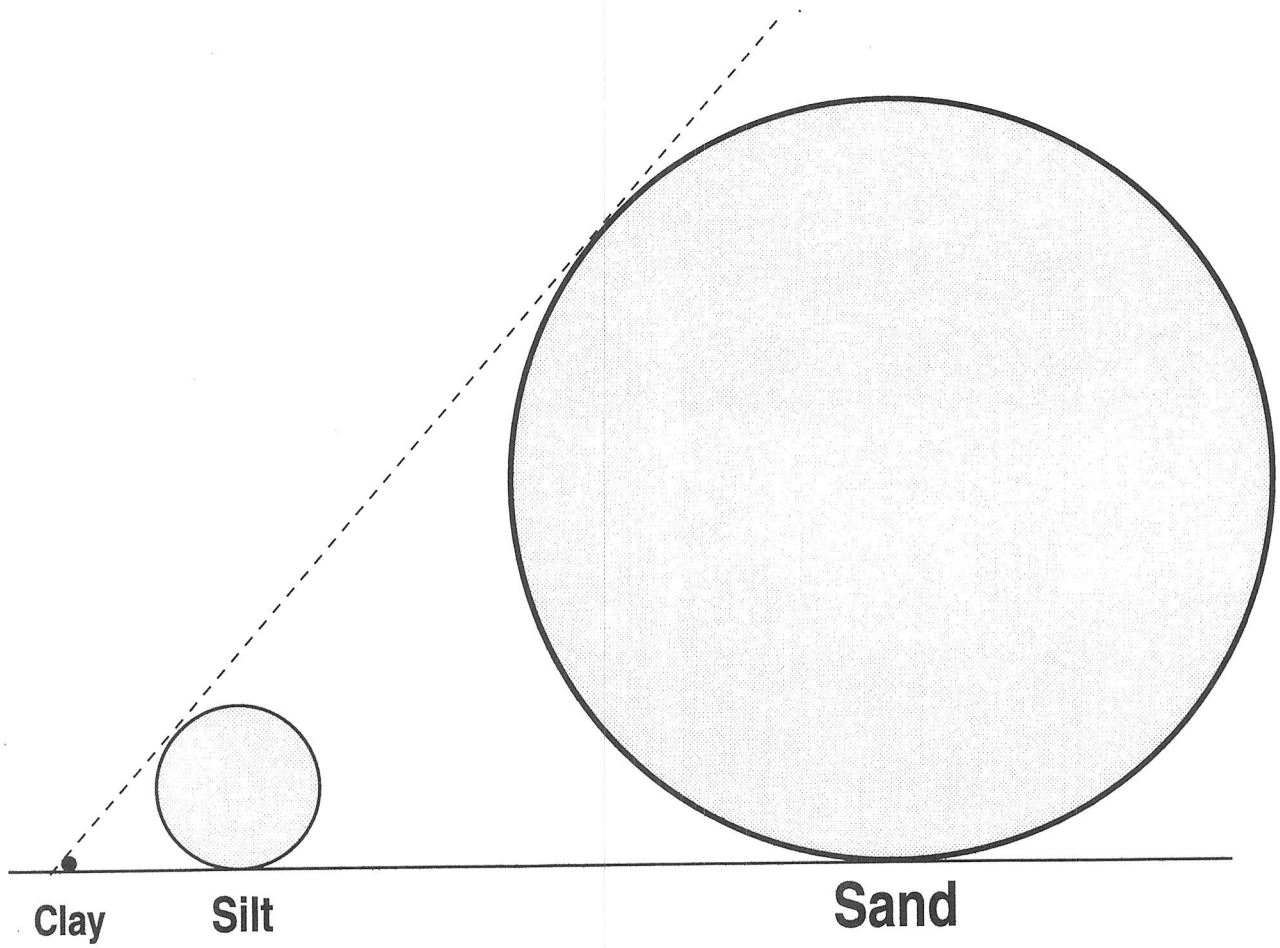
a. Fine earth
b. Texture
c. Cobblestone
d. Sand
e. Coarse fragment
f. Droughty
g. Clay
h. Porosity
i. Silt
j. Pore space

11. Use the soil triangle to determine the correct name for the texture of a soil sample that is 40% sand, 15% clay, and 45% silt.

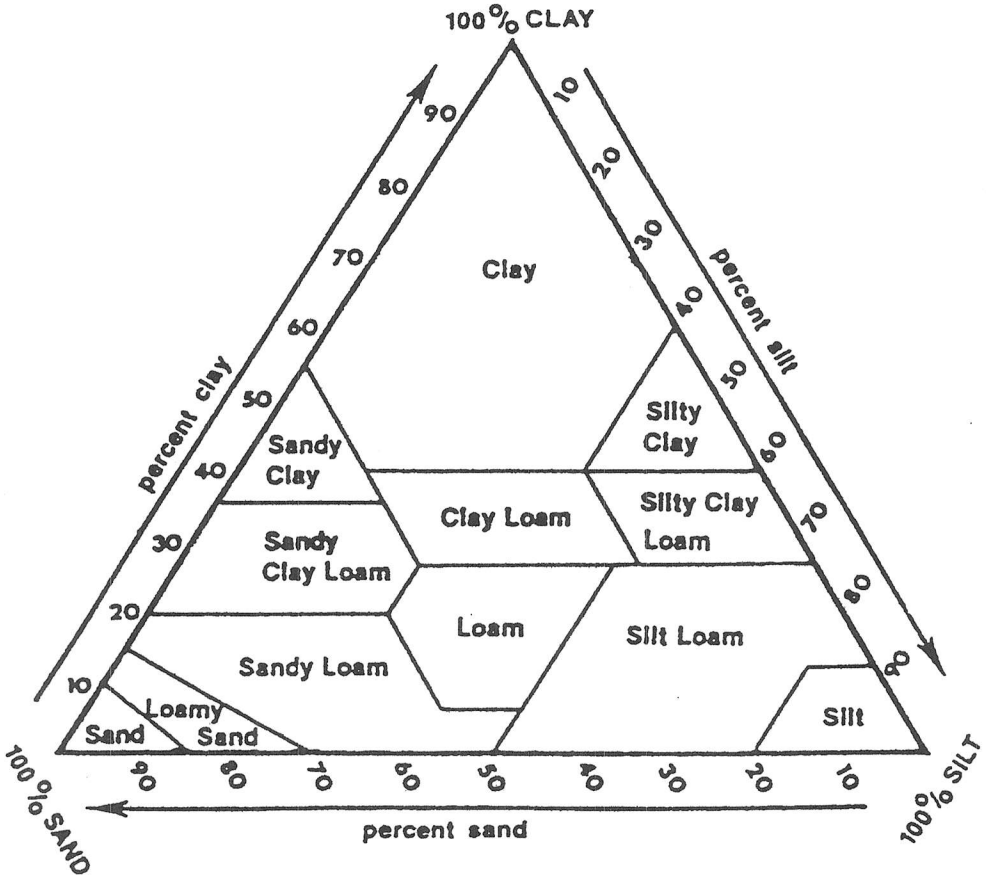
The soil is a _____.



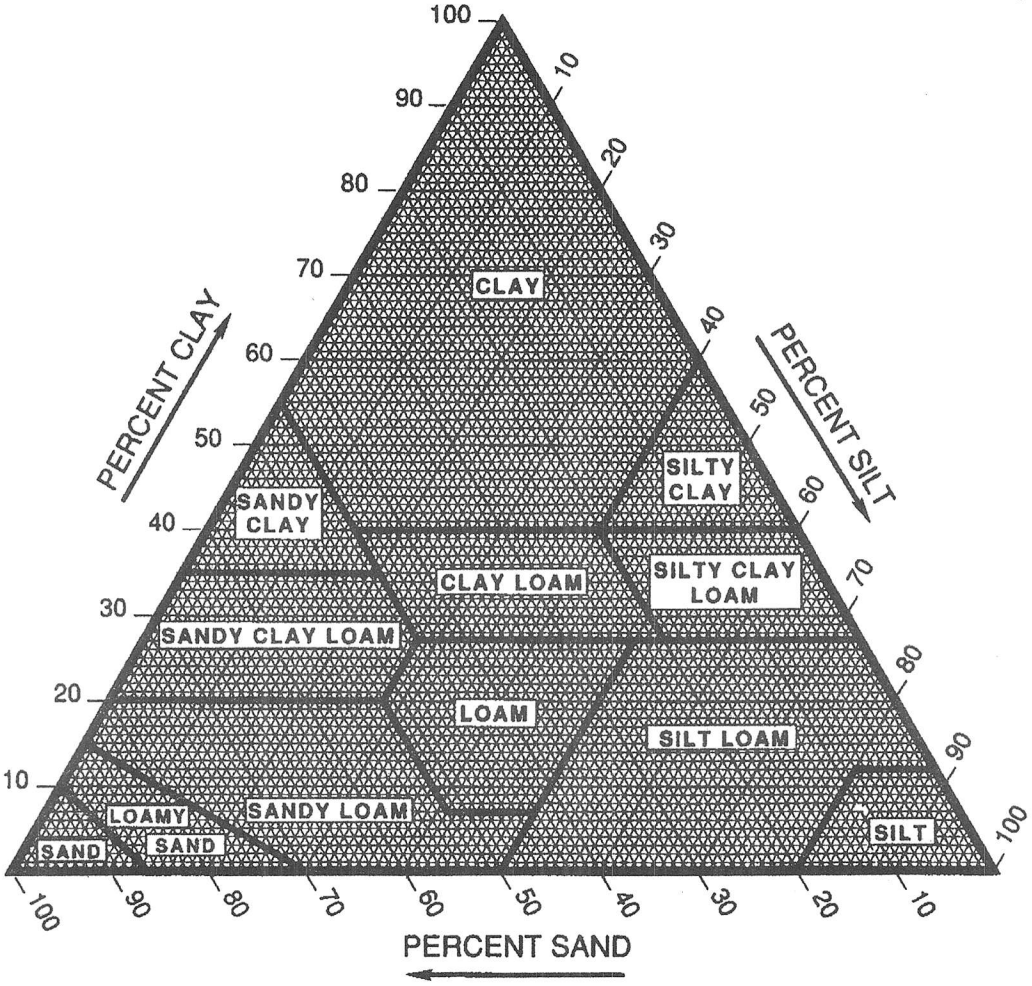
Relative Sizes of Sand, Silt, and Clay



Textural Triangle



The Soil Triangle



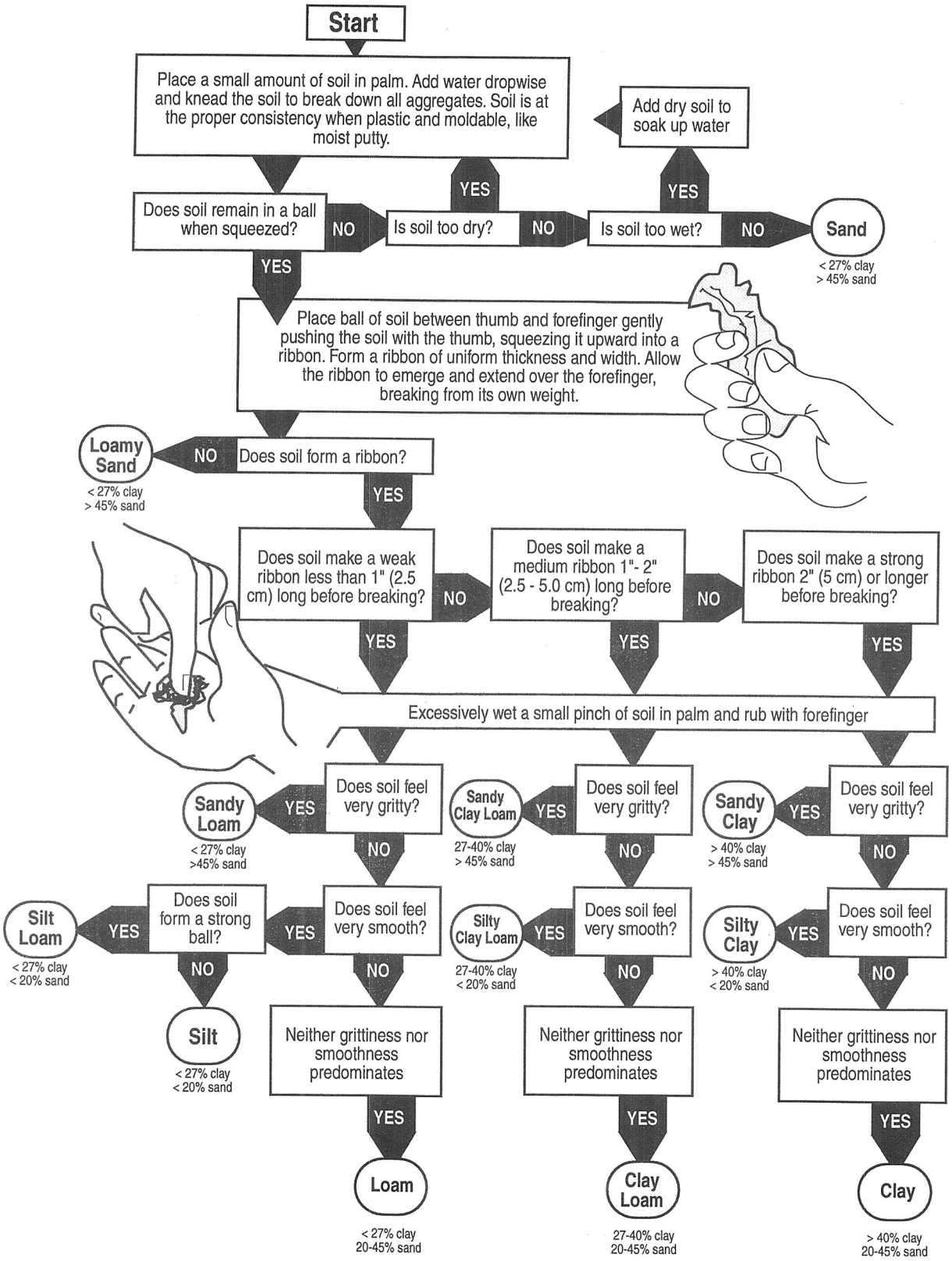
Name: _____
Date: _____

Soil Triangle Texture Quiz

(10 points)

	% Sand	% Silt	% Clay	Soil Texture
1	55	26	19	
2	32	12	56	
3	12	58	30	
4	28	55	17	
5	6	40	54	
6	36	48	16	
7	86	4	10	
8	96	3	1	
9	33	33	34	
10	27	60	13	

Flowchart for Estimating Textural Class



UNIT - SOILS

NAME: _____

Lesson 4: Soil Texture

Are All Soil Particles the Same Size?

Objective: To observe the amount of sand, silt, and clay in three soil samples.

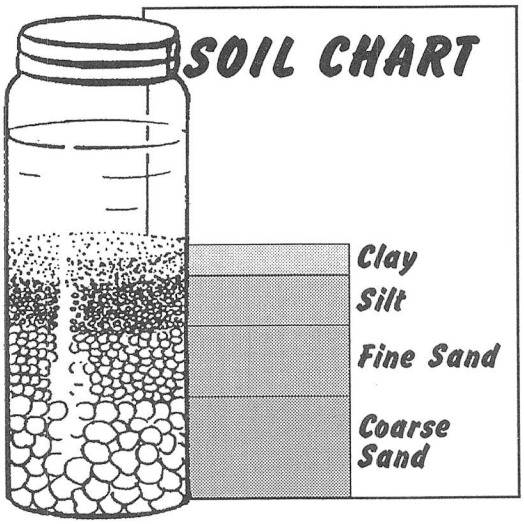
Activity Length: 2 class periods

Materials and Equipment:

Three quart jars with lids
Soil samples
Water
Paper and pencil or markers

Procedure:

1. Obtain three soil samples from different locations.
2. Fill three quart jars about two-thirds full of water.
3. Place one soil sample in each jar; place lid on jars and hand tighten.
4. Shake each jar vigorously.
5. Place jars on table and let the soil settle.
6. Allow a twenty-four-hour period of time for the soil to completely settle.
7. Place an index card or heavy stock paper beside each jar and draw a diagram showing different layers for each soil sample.
8. Label each layer of each sample.



9. Observe each soil sample and record the information in Table 1.1. Measure and record the amount of sand, silt, and clay.

SOIL TYPE	SAMPLE #1	SAMPLE #2	SAMPLE #3
Coarse Sand			
Fine Sand			
Silt			
Clay			

NAME: _____

UNIT - SOILS

Lesson 4: Soil Texture

Are All Soil Particles The Same Size?

Key Questions:

1. Which samples will hold the most water?

_____

_____

_____

_____

_____

_____

2. What sample has the most open space between the soil particles?

_____

_____

_____

_____

_____

_____

UNIT - SOILS

Lesson 5: Soil Structure

Objective: The student will be able to explain the importance of soil structure.

Study Questions

1. **What is soil structure (ped)?**
2. **What is the importance of soil structure?**
3. **How are soil structures formed?**
4. **What are the different types of soil structural units?**
5. **What is the difference between structure grade and type?**
6. **How can soil structure be improved?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1994. Chapter 5.
2. Donahue, Roy L., and Follet, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc., 1990.
3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
4. Transparency Master
   a) TM 5.1: Types of Soil Structure

UNIT - SOILS

Lesson 5: Soil Structure

TEACHING PROCEDURES

A. Introduction

Review the previous lesson.

B. Motivation

1. Use soil samples to demonstrate the different types of structure.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss how soil structure facilitates movement of water.

What is soil structure (ped)?

a) Soil structure forms when individual grains of sand, silt, and clay are bound together physically and/or chemically into larger units called peds.
b) A ped is a single unit of soil structure.
c) Peds range in size from 1 mm to 10 cm depending on their shape.

2. Discuss the soil samples on display. Which soil sample has good structure and will provide ideal environment for plant growth?

What is the importance of soil structure?

a) Soil structure modifies some of the effects of texture on soil behavior by creating relatively large pores.
   1) Provides for water infiltration
   2) Provides for good aeration
   3) Provides for good soil tilth
   4) Provides ideal environment for plant root growth
b) Soil structure can be destroyed.
   1) Over-tilling
   2) Tilling while soil is wet

3. Ask the students why organic matter is essential if you want to maintain good soil structure.

How are soil structures formed?

a) Weathering converts original (structureless) parent material into soil.
b) Soil is loosened and pore spaces are formed when shrinking and swelling occur.
   1) Wetting and drying

2) Freezing and thawing
3) Root penetration

c) Organic matter produces cementing agents that bind and stabilize soil into small clumps with definite shapes (aggregates). Soil then resists breakdown.

4. Show the students TM 5.1 and discuss the different types of soil structures.

What are the different types of soil structural units?

a) Structured
   1) Granular
      (a) Roughly spherical
      (b) Usually 1 to 10 mm in diameter
      (c) Common in surface (A) horizons
   2) Platy
      (a) Flat peds that lie horizontally
      (b) Most less than 2 cm thick
      (c) Occur mostly in subsurface (E and Bx) horizons
   3) Blocky
      (a) Roughly cube-shaped with generally flat surfaces
         (1) Angular (sharp edges and corners)
         (2) Subangular (rounded edges and corners)
      (b) Sizes from 5 to 50 mm in diameter
      (c) Typical of subsoil (B horizons)
      (d) Formed by expansion and contraction of clay minerals
   4) Prismatic
      (a) Peds taller than wide
      (b) Often have 5 sides
      (c) Most common in lower part of subsoil (B and BC horizons)
      (d) Columnar prisms with rounded tops and corners
         (1) Found in strongly developed soils
         (2) Caused by eluviation (downward movement of material)

b) Compound structures -- Large aggregates can be broken into smaller aggregates of a different shape

c) Unstructured
   1) Single grain
      (a) Unit found in very sandy soils.
      (b) Each grain act independently.
      (c) Permeability is rapid.
      (d) Fertility and available water low
   2) Massive
      (a) Compact, coherent soils
      (b) Not separated into peds
      (c) Small pores
      (d) Slow permeability
      (e) Poor aeration

5. Demonstrate soil structure by holding a clod of soil in both hands and applying gentle pressure. If the soil breaks easily along a natural plane of weakness, it is breaking into units of soil structure. Discuss the difference between structure grade and type.

What is the difference between structure grade and type?

a) Structure grade refers to the strength and stability of structural peds. (The ease with which the soil mass breaks into peds and the amount of unaggregated soil that remains indicate the structural grade.)
   1) Strong
      (a) Peds are distinct in undisturbed soil.
      (b) Peds separate cleanly into whole units when disturbed.
      (c) Peds have stable structures.
      (d) Peds provide favorable air-water relationship.
      (e) Peds have good soil tilth.
   2) Moderate
      (a) Well formed and evident in undisturbed soil
      (b) Separate into a mixture of whole peds and broken units when disturbed
   3) Weak
      (a) Barely observable
      (b) Become broken when disturbed
      (c) Unstable structures
      (d) Readily slake (break down)
      (e) Readily seal (form a crust)
      (f) Slow water movement
      (g) Increase erosion hazard

b) Structure type refers to the shape of the soil peds that are broken out of the soil mass.
   1) Granular
   2) Platy
   3) Blocky
   4) Prismatic (columnar)
   5) Unstructured (lack of soil peds)

6. Discuss the advantages of using deep rooted legumes to improve soil structure. Have students suggest other ways to improve soil structure.

How can soil structure be improved?

a) Time
   1) Soil structure gets stronger and more distinct
   2) It takes several years to improve very weak structures.

b) Residue management
   1) Adding organic matter
      (a) Deep rooted legumes
      (b) Barnyard manure
      (c) Green manure crops (plowed under grasses or legumes)
   2) Using minimum tillage (or no-till)
      (a) Avoid over-tilling
      (b) Avoid tilling when wet
   3) Rotating crops, including hay crops

F. Other Activities

1. Have students bring in soil samples and observe the difference in structure.

2. Invite the county extension agent or soil conservation representative to visit your class and discuss the importance of soil structure.

3. Use the soil judging pit to examine the structure of the subsoil.

G. Conclusion

Soil structure is important because it modifies some of the effects of texture on soil behavior. Structure is related to water infiltration, aeration, soil tilth, and the environment for plant root growth. The type and grade of soil structure can be determined by observing the soil and gently breaking it apart. Soil structure can be improved by increasing organic matter content, using minimum tillage or no-till, and applying good residue management. Soil structure is broken down by over-tilling or tilling when the soil is wet.

H. Competency

Explain the importance of soil structure.

Related Missouri Core Competencies and Key Skills: None

I. Answers to the Evaluation

1. b
2. d
3. f
4. g
5. h
6. i
7. j
8. e
9. c
10. a
11. b
12. c
13. b

UNIT - SOILS

Lesson 5: Soil Texture

Name _____

Date _____

EVALUATION

Match the definition on the left with the term on the right.

1. _____ A soil that has a relatively high content of clay particles
2. _____ Arrangement of individual grains of sand silt, and clay into larger units called aggregates, or peds
3. _____ Structure is roughly spherical, like Grape Nuts. Usually 1-10 mm in diameter
4. _____ Structure consists of flat peds that lie horizontally in the soil
5. _____ Structure consists of peds that are roughly cube-shaped with more less flat surfaces
6. _____ In the structure, the peds are taller than they are wide, often with five sides
7. _____ Every grain acts independently and there is no binding agent to hold the grains together into peds
8. _____ This type is compact, coherent soil not separated into peds of any kind
9. _____ Improves soil structure
10. _____ A single unit of soil structure

a. Aggregate
b. Clayey
c. Adding organic matter
d. Structure
e. Massive
f. Granular
g. Platy
h. Blocky
i. Prismatic
j. Single grain

Circle the letter that corresponds to the best answer.

11. Which of the following improves soil structure?

    a. Continuous cultivation

    b. Adding organic matter

    c. Cultivating the soil when wet

    d. Compaction

12. What do we call the aggregation of different soil particles?

    a. Soil texture

    b. Residue

    c. Soil structure

    d. All of the above

13. The soil structure that forms when individual grains of sand, silt, and clay are bound together is called:

    a. Blocks

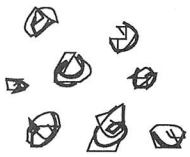
    b. Peds

    c. Aggregate

    d. Structureless

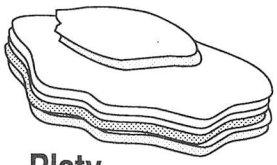
Types of Soil Structure

STRUCTURED



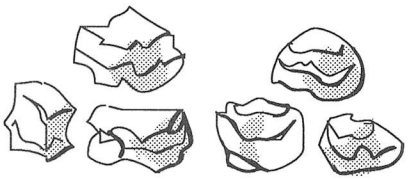
Granular

GRANULAR
- Roughly spherical like Grape Nuts cereal
- Usually 1-10 mm in diameter
- Most common in surface horizons (A horizons)



Platy

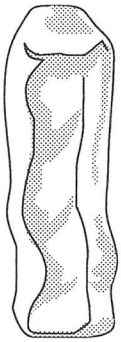
PLATY
- Consists of flat peds that lie horizontally in the soil
- Most are less than 2 cm thick
- Platy structure is not common
- Occurs mostly in subsurface horizons or dense layers (E and Bx)



Angular Subangular

BLOCKY
- Consists of peds that are roughly cube-shaped with flat surfaces
- Two types:
  Angular blocky has edges and corners that remain sharp
  Subangular blocky structure has edges and corners that are rounded
- Sizes commonly range from 5-50 mm across
- Typical in the subsoil (B and Bt horizons)

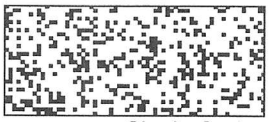
Prismatic



Columnar

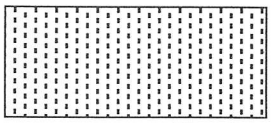
PRISMATIC
- Peds are taller than they are wide, often with five sides
- Sizes are commonly 10-100 mm across
- Most common in lower part of subsoil (B and BC horizons)
- Columnar peds have more rounded corners and edges

STRUCTURELESS



Single Grain

SINGLE GRAIN
In some very sandy soils, every grain acts independently and there is no binding agent to hold the grains together into peds. Permeability is rapid. Fertility and available water capacity are low.



Massive

MASSIVE
Compact, coherent soil is not separated into peds of any kind. Massive claylike soils usually have very small pores, slow permeability, and poor aeration.

UNIT - SOILS

Lesson 6: Soil Horizons

Objective: The student will be able to describe a soil profile.

Study Questions

1. **What is a pedon?**
2. **What is a soil profile?**
3. **What is a master soil horizon?**
4. **What are horizon boundaries?**
5. **What are transitional horizons?**
6. **What are subordinate divisions of master horizons?**
7. **What are subdivisions of thick horizons?**
8. **What are lithologic discontinuities?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1994. Chapter 6.

2. Donahue, Roy L., and Follet, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc., 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 6.1: Soil Pedons - How They Relate to Landscape
   b) TM 6.2: Master Horizons
   c) TM 6.3: Transitional Horizons

UNIT - SOILS

Lesson 6: Soil Horizons

TEACHING PROCEDURES

A. Introduction

B. Motivation

Use soil monoliths for observing the different horizons.

C. Assignment

D. Supervised Study

E. Discussion

1. Arrange a field trip to observe how different soils are formed. Show slides of soil profiles or actual soil profiles so the students may observe the factors in soil formation. Discuss how soil horizons are formed. Discuss how a soil pedon is formed.

What is a pedon?

a) The smallest volume that can be called "soil" is a pedon.
b) A pedon is three-dimensional and large enough to permit study of all horizons. (See TM 6.1.)
c) The area of a pedon may vary from 10 to 100 square feet (1 square meter to 10 square meters) depending on how much the soil changes.

2. Have students observe the several soil profiles. Point out the different soil horizons until the students can identify the horizons themselves.

What is a soil profile?

a) A soil profile is a vertical section of a soil pedon from the surface through all of its horizons including parent material. (See TM 6.2.)
b) A single soil profile never has all the horizons that are possible.

3. Discuss the six master horizons. Discuss management strategies as they relate to different soils.

What is a master soil horizon?

a) A soil horizon is a layer of soil parallel to the earth's surface.
b) A master soil horizon is one of the six general kinds of horizons that occurs in soil profiles with a distinct set of properties.
c) Each is named with capital letters O, A, E, B, C, or R. (See TM 6.2.)
   1) O Horizon (O = organic)
      (a) This horizon has a layer of organic debris.
      (b) O horizons are nearly 100% organic matter material.
      (c) Forest soils have thin organic horizons.

(d) Wet soils in bogs or drained swamps often have O horizons of peat or muck.
(e) Most soils in Missouri have only thin O horizons.
(f) O horizons are destroyed by plowing and do not occur in cultivated areas.

2) A Horizon
   (a) Surface horizon of mineral soil
   (b) Usually dark color from the accumulation of humus
   (c) Thickness ranges from a few inches (most forested soils) to over 30 inches (some upland prairie soils and some alluvial soils in flood plains)
   (d) Every cultivated agricultural soil with an A horizon
   (e) Extremely important in maintaining soil fertility and providing a favorable environment for root growth
3) E Horizon (E = eluviation)
   (a) Strongly leached horizon
   (b) Occurs immediately beneath an O or an A horizon
   (c) Grayish-brown to white in color--nearly all the iron and organic matter removed
   (d) Occur in most forested soil that have not been cultivated and in several of the prairie soils in Missouri
   (e) Contains noticeably less clay than the B horizon beneath it
4) B Horizon
   (a) The subsoil layer that generally changes the most because of soil-forming processes
   (b) Has the brightest yellowish-brown or reddish-brown colors
   (c) Has more clay than other horizons
   (d) Clay films visible
5) C Horizon--Weathered unconsolidated geologic material below the A or B horizon. Anything that is soft enough to dig with a spade but which has not been changed very much by soil forming processes is considered C horizon.
6) R Horizon (R = rock)--Hard bedrock that you can not dig with a spade

4. Discuss what horizon boundaries are. Use sample profiles or judging pits to illustrate horizon boundaries.

What are horizon boundaries?

a) A horizon boundary is the division line between two distinct horizons, where one horizon ends and the other begins.
b) Terms used to describe boundary distinctness and the nature of the boundary may provide clues to soil development and behavior.
   1) **Abrupt** - boundary is less than 1 inch (2.5 cm) wide
      (a) Sudden change to another kind of material or texture
      (b) May limit root penetration
      (c) May signal a different rate of water movement
   2) **Clear** - boundary 1 to 2.5 inches (2.5 to 6 cm) wide
   3) **Gradual**- boundary is 2.5 to 5 inches (6 to 12.5 cm) wide--may indicate very young or highly weathered old soil
   4) **Diffuse** - boundary more than 5 inches (12.5 cm) wide
c) The form or shape of horizon boundaries requires careful examination to determine the true relationship between soil horizons.
   1) **Smooth** - nearly a plane
   2) **Wavy** - shallow pockets wider than their depth

3) **Irregular** - pockets deeper than their width
4) **Broken** - parts of the horizon unconnected with other parts

5. Discuss what transitional horizons are. Talk about how soils have formed in more than one kind of parent material. Discuss how a flooding river deposits fresh silt on top of older sands and gravels. Refer to TM 6.3.

What are transitional horizons?

a) Areas between master horizons where changes occur gradually throughout a zone that may be 5 or 10 inches thick.
b) Transitional horizons are named with two letters, three of which are common in Missouri soils.
   1) AB horizon
      (a) This occurs between the A and B master horizons with dominant A properties, but some properties of the B are evident.
      (b) Dark colors associated with organic matter are fading because organic matter is decreasing.
      (c) Structure often changes from granular to subangular blocky.
   2) BA horizon
      (a) This also occurs between the A and B, but it has more characteristics of the B.
      (b) Structure will generally be the same type as the B, but less strongly expressed.
      (c) Colored darker than the B or the clay content may be less than the maximum in the B.
   3) BC horizon
      (a) This horizon has a transition from the B to C with dominant B horizon properties, but some influence of the C horizon is evident.
      (b) Often the clay content will be less than the maximum in the B, but more than in the C, or the color will be fading.
      (c) The C is massive, and the BC has structure, but it may have larger units and more weakly expressed than the B.

6. Have students observe profiles and assist them in determining subordinate distinctions in each horizon. Discuss what the subordinate divisions of master horizons are.

What are subordinate divisions of master horizons?

a) Subordinate divisions of master horizons are horizons resulting from unique processes that leave a distinct mark on the horizon.
b) Subordinate divisions within master horizons are named by adding lowercase letters immediately following the master horizon symbol. Over 25 letters and combinations of letters are possible.
c) Eight subordinate divisions are common in Missouri.
   1) Oi horizon--The organic layer covering the A horizon with a layer of slightly decomposed twigs and leaves
   2) Ap horizon (p = plow layer)
      (a) The surface horizon of soil in which cultivation has mixed the upper 8 to 12 inches and destroyed natural horizons

(b) Plowing an exposed B or C horizon would automatically making the surface horizon an Ap

3) Bt horizon (t = translocated clay)
   (a) Has distinctly more clay than the horizons above or below it
   (b) Clay usually moved from horizons above by water carrying fine clay particles with it
   (c) Clay possibly coming from the weathering of original minerals in the Bt horizon
   (d) Has well-developed blocky or prismatic structure
4) Bg Horizon (g = gleyed)
   (a) Horizon gleyed (wet for long periods of time)--Indicates poorly drained soil
   (b) Iron chemically reduced by leaching leaving soil dark gray
   (c) Not restricted to Bg--Other gleyed horizons: the Ag, Eg, BAg, BCg, and Cg
5) Bw Horizon (w = weathered)
   (a) This horizon has been changed by weathering, but not enough to form a Bt, or Bg.
   (b) In Missouri soils, the Bw differs from the C by having weak or moderate blocky structure.
   (c) The Bw may also have a brighter color and it may be more leached than the C.
   (d) Bw horizons are common in young soils of flood plains and low stream terraces.
6) Bx Horizon
   (a) This refers to a fragipan.
   (b) Horizon is a massive, dense, but not cemented soil horizon.
   (c) It is often mottled and has seams of gray silt scattered throughout.
   (d) The fragipan is so dense that neither plants roots nor water can readily penetrate, except in the gray silt seams.
   (e) In Missouri, fragipans occur mostly in gently sloping upland soils and some high terrace soils in southern Missouri.
7) Bk Horizon
   (a) This horizon has an accumulation of calcium carbonate, or free lime, leached from upper horizons and redeposited in the Bk.
   (b) White streaks or nodules of lime visible and can be tested with hydrochloric acid (HCl).
   (c) Use the k only to indicate horizons enriched in visible deposits of carbonates by translocation (not for soils on the Missouri River flood plain and uplands of northwest Missouri that have free lime in original amounts).
8) Cr Horizon (r = bedrock)
   (a) Weathered bedrock, or rock that is soft enough to slice with a knife or a spade.
   (b) Original rock structure is often visible
   (c) Not hard enough to be designated R

7. Discuss what subdivisions of thick horizons are.

What are subdivisions of thick horizons?

a) Very thick master horizons or subordinate divisions need to be classified into special subdivisions
b) Vertical sequences within any single horizon indicated by small changes in texture, color, or structure
c) Indicated by using Arabic number, as in A1, A2, or Bw1, Bw2, and Bw3

8. Observe soil horizons to see if they are developed in more than one material. Discuss what lithologic discontinuities are.

What are lithologic discontinuities?

a) Soil horizons developed in more than one parent material
b) Indicated by a number placed in front of the horizon name showing its position from the top down
   1) The geologic material at the surface is always assumed to be the first one, and the number 1 is never used.
   2) The second geologic material is indicated by a 2, the third by a 3, and so on.
   3) An example of soil developed in silt over gravel could have the following set of horizons: A-AB-B-2BC-2C.

F. Other Activities

1. Study the history of the soils in your vicinity and state.

2. Prepare a soil pit and have students determine the soil horizons.

G. Conclusion

The smallest volume that can be called "soil" is a pedon. A soil profile is a vertical section of a soil pedon beginning at the surface and continuing down through all of the horizons, including the parent materials. Six master horizons may occur in soil profiles. The distinctness of boundaries, special features of horizons, subdivisions of thick horizons, and lithologic discontinuities further define the soil horizons.

H. Competency

Describe a soil profile.

Related Missouri Core Competencies and Key Skills: None

I. Answers to Evaluation

1. a
2. b
3. c
4. d
5. e
6. f
7. g
8. h
9. i
10. j
11. b
12. d
13. f
14. e
15. c
16. a

UNIT - SOILS

Lesson 6: Soil Horizons

Name: _____

Date: _____

EVALUATION

Match the definition on the left with the term on the right.

1. _____ The smallest volume that can be called soil
2. _____ A vertical section of soil that allows you to see all the horizons that are present
3. _____ A layer of soil that is approximately parallel to the earth's surface
4. _____ The sum of all plant and animal material, living or dead, that is mixed into the soil
5. _____ Gradual changes from one master horizon to another
6. _____ The original geologic material from which the horizons of a soil is formed
7. _____ The changing of rocks into soils
8. _____ Loss of valuable topsoil by the action of wind or water
9. _____ Removal of soluble minerals from the soil by movement of water through the soil over long periods of time
10. _____ When all the pores of a soil are full of water

a. Pedon

b. Profile

c. Horizon

d. Organic matter

e. Transition horizon

f. Parent material

g. Weathering

h. Erosion

i. Leaching

j. Saturated

Match the correct horizon to the soil profile.

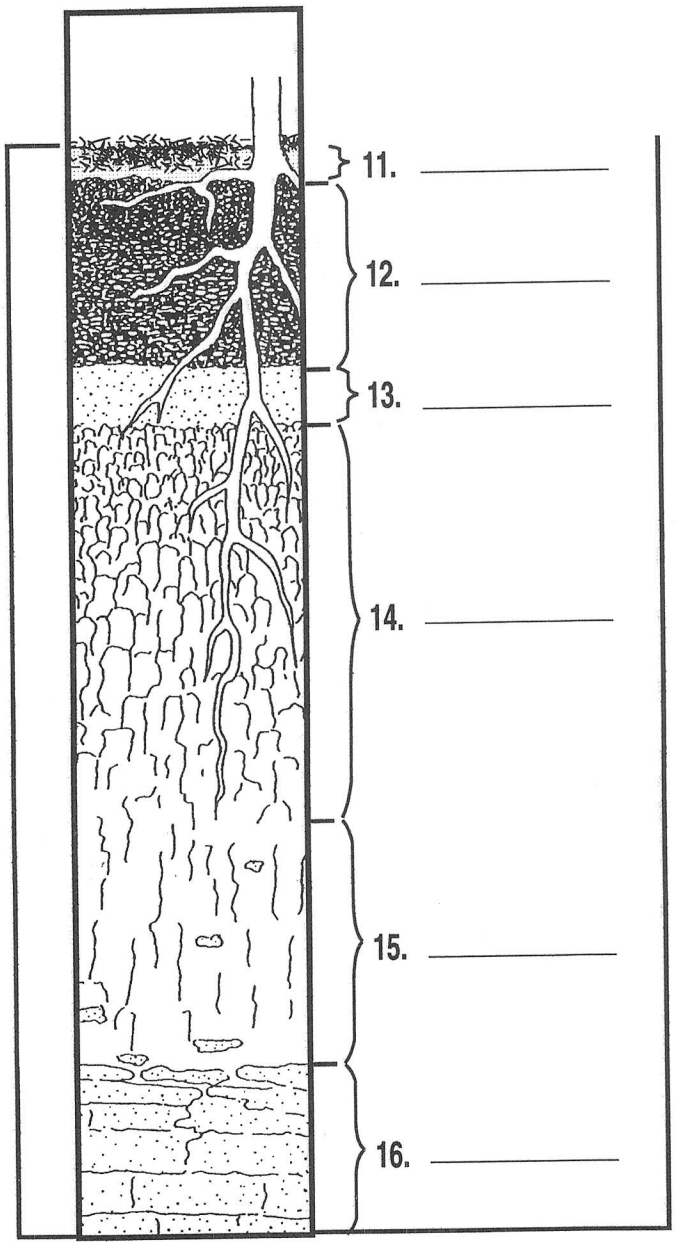
a. R horizon

b. O haorizon

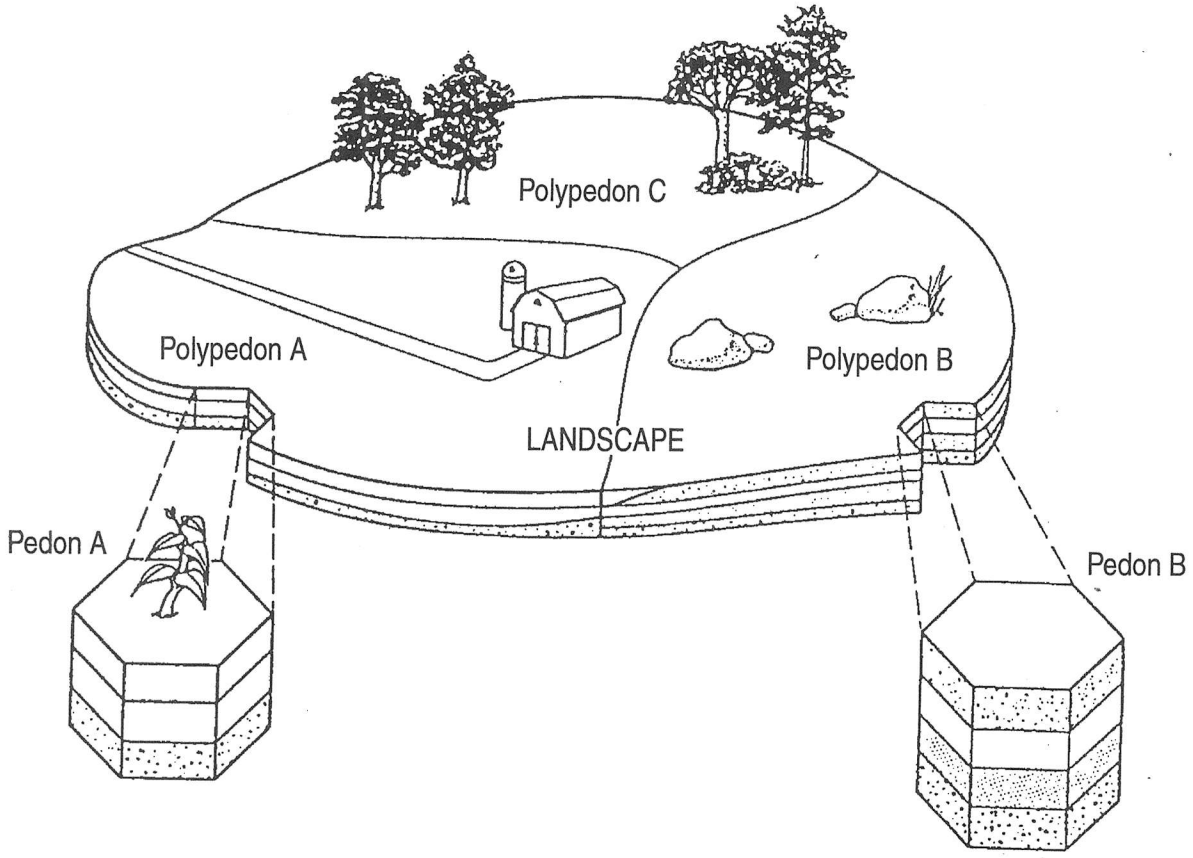
c. C horizon

d. A horizon

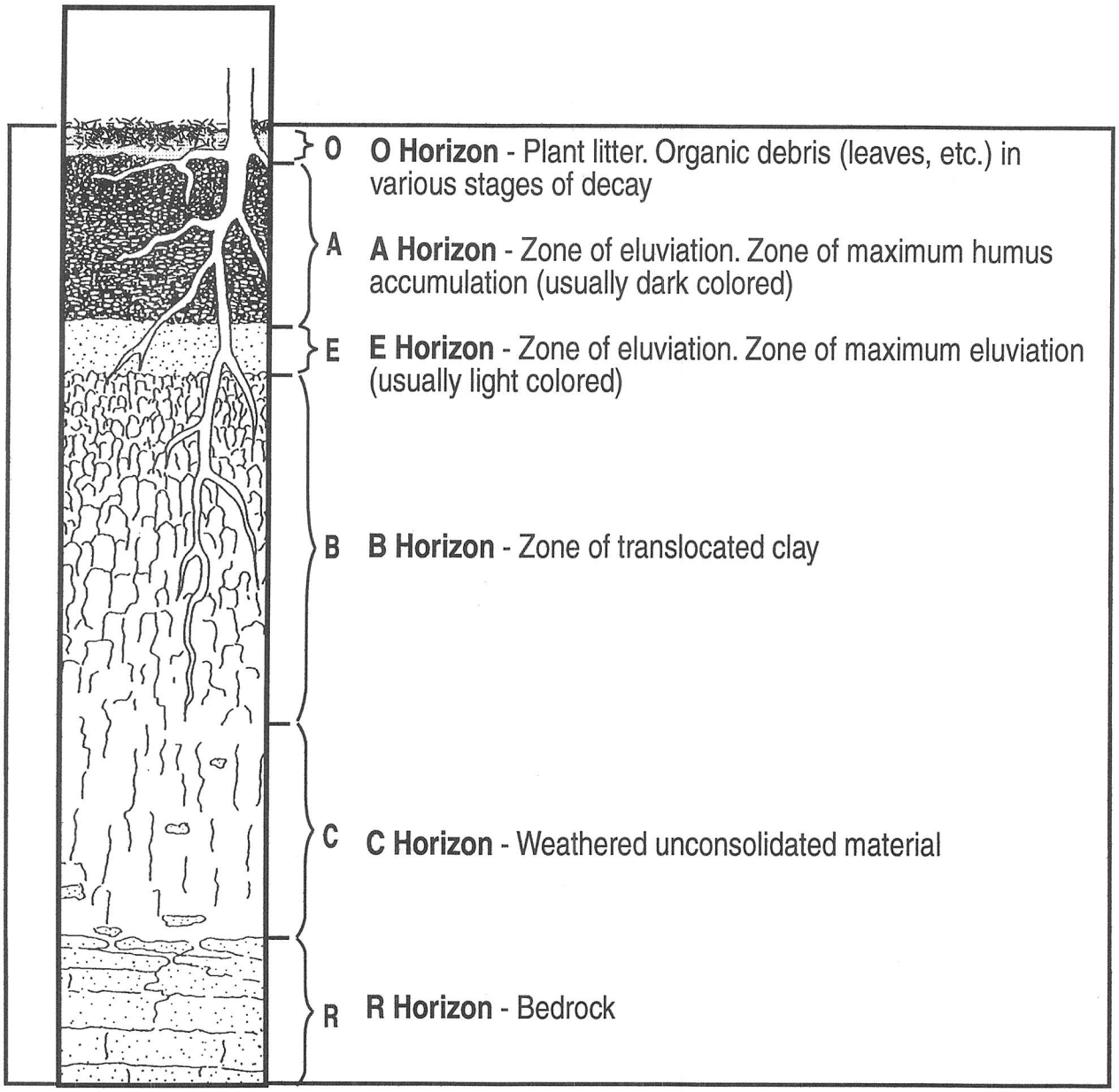
e. B horizon



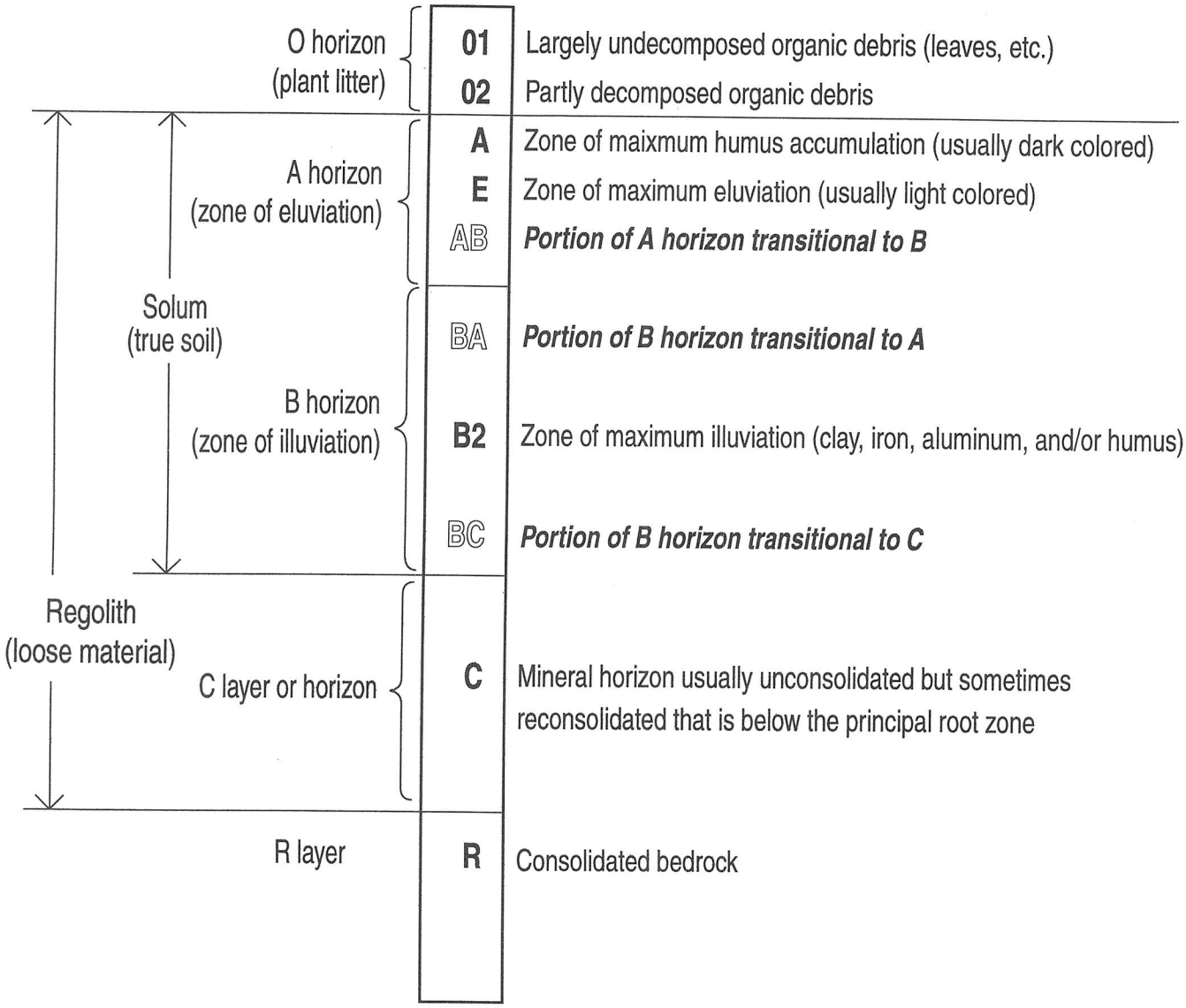
Soil Pedons - How They Relate to Landscape



Master Horizons



Transitional Horizons



UNIT - SOILS

Lesson 7: Soil Chemical Properties

Objective: The student will be able to explain how plants exchange anions for cations.

Study Questions

1. **What is the importance of CEC?**
2. **What is CEC?**
3. **How is CEC calculated?**
4. **What soil properties affect CEC?**
5. **What is soil pH?**
6. **How does pH relate to productivity?**
7. **What factors cause pH to change?**
8. **How can soil pH be adjusted?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 7.
2. Donahue, Roy L., and Follet, Roy Hunter. *Our Soils and Their Management,* Danville, IL: Interstate Publishers, Inc., 1990.
3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
4. Transparency Masters
   a) TM 7.1: Negatively Charged Clay Particle (Micelle)

UNIT - SOILS

Lesson 7: Soil Chemical Properties

TEACHING PROCEDURES

A. Review

Review previous lesson.

B. Motivation

Why are some soils more productive than others? Use the bank account approach to illustrate this. As the plants grow they draw checks from the bank. Thus, if the total amount of calcium carbonate in the soil was 1200 lb per acre and if alfalfa removed 120 lb each year, there would be enough lime to last 10 years.

C. Assignment

D. Supervised Study

E. Discussion

1. Ask students why soils with high CEC (cation exchange capacity) are more fertile than low CEC soils. Discuss the importance of soil chemistry and its effect on crop yields.

What is the importance of CEC?

a) Soil chemistry has a significant effect on crop yields.
b) Soil chemistry involves the relationship between clay minerals, water, and other elements in the soil.
c) Quantity and balance of nutrient elements are important factors in soil fertility.
d) CEC of the soil determines what amounts of plant nutrients are needed.

2. Use TM 7.1 to illustrate how cations are exchangeable. Use magnets to reinforce the fact that like charges attract. Discuss how this compares to soil's capacity to hold essential nutrients.

What is CEC?

a) CEC is the soil's capacity to hold and exchange essential cations. Oxygen, silicon, and aluminum make up about 85% of the earth's crust, and greatly affect the CEC of soil.
b) Essential soil elements are made up of atoms. Atoms are the smallest portion of an element that can take part in a chemical reaction.
c) Atoms that have become electrically charged are called ions.
   1) Positively charged ions are called cations.
   2) Negatively charged ions are called anions.
   3) Ions usually have from one to four positive or negative charges.
d) In chemical systems, there is always an equal balance of positive and negative charges.
   1) For example, two positively charged hydrogen ions attract one oxygen ion, which has two negative charges.

2) Negatively charged clay minerals attract and hold positively charged ions of elements.
3) The phenomenon of cations being attracted and held by the soil particle surfaces is called adsorption.

e) Bases tend to make the soil alkaline (Ca^{++}, Mg^{++}, K^{+}, and Na^{+})
f) Acid cations tend to make the soil acidic. (H^{+} and Al^{+++})
g) The very small soil particles are not ions but have several negative charges per particle.
   1) Micelle is a term used for a negatively charged solid particle composed of clay or organic matter.
   2) Colloid is a term used to describe clay particles.
   3) Water surrounding micelles contains many positive charges.
h) Cation exchange is the process of micelles and plant roots exchanging ions.
   1) Micelles exchange acid H^{+} ions for Ca^{++}, Mg^{+}, and K base ions. The chemical attraction of the bases is much greater than the attraction of hydrogen H^{+} ions.
   2) Plant roots exchange H^{+} acid ions for Ca^{++}, Mg^{++}, and K^{+} base ions. These bases are some of the most important plant nutrients.

3. Have students use the soil test data to calculate the CEC of the soil and determine the amount of fertilizer needed. Use Tables 7.1, 7.3, 7.4, and 7.5 of the student reference to assist in explaining and figuring CEC of the soil.

How is CEC calculated?

a) Obtain the results of a soil test. Soil contains various amounts of each of the exchangeable cations.
b) Add the milliequivalent weights of only K, Mg, Ca (bases) with H and Al (neutralizable acids or NA).
   1) Determine how many grams of each cation are contained in 100 g of soil (milliequivalent) by dividing its atomic weight by the number of positive charges on each ion.
   2) Calculations used in determining the CEC are based on the upper 7 in. surface layer of earth (which weighs about 2,000,000 lb per acre).
c) CEC is the total of these cations in milliequivalents. The sum of the bases divided by the total sum of the cations is the percent of base saturation.

4. Discuss how texture affects the exchange capacity of the soil. Discuss the importance of organic matter in the exchange capacity of the soil.

What soil properties affect CEC?

a) Amount of clay
   1) Low clay content indicates low CEC.
      (a) Sand
      (b) Sandy loam
   2) High clay content indicates high CEC.
b) Kind of clay--Montmorillonite clay has a larger CEC than kaolinite.
c) Organic-matter content--Average organic-matter content has medium CEC, loam, and silt loam
d) Textural differences
   1) Severely eroded soils have more clay and a higher CEC.
      (a) Contain less organic matter
      (b) Poorer tilth

(c) Lower available water capacity

2) Organic matter has good exchange capacity.
   (a) Soils containing 4% organic matter may have as much as 8 meq per 100 g of soil.
   (b) Silt loam with high organic matter content is most ideal.
   (c) Loam and silt loam have a high available water capacity.

5. Have students discuss the meaning of pH. Refer to Figure 7.3 of the student reference as pH is discussed.

What is soil pH?

a) pH is a scale from 0 to 14 that measures acidity to alkalinity. The pH increases ten times between each unit of the scale.
b) Neutral pH of 7 on the scale is neither acid nor alkaline. It occurs when the concentration of H^+ ions and OH^- ions are equal (in pure water at 75° F)
   (a) Pure water at 75° contains 1.0 x 10-7g of H^+ or 0.0000001N.
   (b) The pH scale simplifies the -7 exponent to pH 7.
c) Acid or lower pH occurs when the concentration of H^+ ions increases.
d) Alkaline or higher pH occurs when the concentration of OH^- ions increases.
e) Two methods are used to determine soil pH.
   1) Water pH (pH_w)--A measure of the H^+ ions in the soil solution and the H^+ ions that were attached to soil particles.
   2) Salt pH (pH_s)
      (a) More precise method
      (b) About ½ unit lower than water pH
      (c) Reflection of neutralizable acidity (NA)
      (d) Calcium chloride releases the H^+ ions from the soil particles to they can be measured

6. Discuss the effect of pH on plants. Ask the students how pH affects the nutrient availability of soil. Discuss the relationship of pH and soil organisms. Use Figure 7.4 in the student reference to illustrate the pH range in which crops will grow best.

How does pH relate to productivity?

a) Soil pH governs relative nutrient availability. It indicates balance between plant nutrient elements (K, Mg, and Ca) and non-nutrient elements (H and Al).
b) Strongly acidic soils have low amounts of CEC occupied by K, Mg, and Ca.
c) Soil pH, CEC, and the neutralizable acidity (NA) value indicate the need for agricultural lime (Ca) for a particular crop.
   1) Legumes require more neutral soils of pH_w 6.8-7.3.
   2) Corn, small grain, and grass need pH_w of 6.0-6.8.
   3) Blueberries require acid soil to grow best.
   4) Trees grow better in soils below pH_w of 7.
d) Soil pH_w may also change the effect of pesticides and herbicides may become overactive and burn crops.

7. Discuss with the students the factors that change soil pH.

What factors cause pH to change?

a) Depletion of Ca cause increased acidity
b) Leaching--removal of bases by water
c) Absorption--removal of bases by growing plants

8. Discuss with the students how pH can be adjusted by adding Ca back into the soil through the use of lime.

How can soil pH be adjusted?

a) Lime application can raise soil pH to a desirable level.
   1) Lime causes the H^+ on micelles surface to be replaced by Ca^{++}.
      (a) H^+ and CO^3 ions form carbonic acid, which further breaks down to carbon dioxide gas and water.
   2) Lime helps release other non-base plant nutrients.

F. Other Activities

1. Use pH paper to test a number of household solutions, such as tap water, ammonia, vinegar, and lemon juice.

2. Check a soil sample for pH by mixing 20 g of soil with 20 ml of distilled water. Mix the sample well and let stand for 15 minutes. Use pH paper to determine the pH.

3. Place a few drops of a strong acid on a piece of limestone rock and observe the fizz. Discuss this reaction with the students.

4. Perform a cation exchange experiment. Place a filter paper in a funnel, add several grams of soil, then pour a solution of ammonium acetate through the soil. Catch the filtrate in a container and run a test for magnesium, calcium, potassium, sodium, and hydrogen. The filtrate should contain at least traces of all of the cations. The ammonium acetate replaced the calcium, magnesium, potassium, sodium, and hydrogen ions on the surface of the clay crystals and humus particles. These cations were released to the soil solution and were moved down into the filtrate.

5. Have students bring in actual soil tests for CEC evaluation.

G. Conclusion

Soil chemistry and the cation exchange capacity (CEC) are important to crop yields. Soil chemistry involves the relationship between minerals, water, and other soil elements. CEC is the soil's capacity to hold and exchange essential nutrients with plants. The surfaces of clay minerals attract and hold positively charged ions, called cations, in exchange for negatively charged ions, called anions. Soil pH gives an estimate of the balance between plant nutrient elements (bases) and non-nutrient elements (acids). The two kinds of soil tests for pH are water (pH_w) and salt (pH_s). The pH values indicate the need for agricultural lime, but the exact quantity required is a function of CEC. Each crop has its own level of pH for good production. After nutrients have been used by plants, they need to be replenished by fertilization to maintain a high level of production.

H. Competency

Explain how plants exchange anions for cations.

Related Missouri Core Competency and Key Skills:

Science 9E-5: Identify the basic and acidic ranges and the neutral point on the pH scale.

I. Answers to Evaluation

1. b
2. c
3. i
4. e
5. g
6. d
7. h
8. f
9. a
10. K = .5
11. Mg = 1.5
12. Ca = 6.0
13. NA = 4.0
14. Total CEC = 12
15. K = 240
16. Mg = 288
17. Ca = 3600
18. No additional K needed
19. No additional Mg needed
20. 1200 lbs./A of additional Ca is needed

UNIT - SOILS

Lesson 7: Soil Chemical Properties

Name _____

Date _____

EVALUATION

Match the definition on the left with the term on the right.

1. _____ Smallest portion of an element that can take part in a chemical reaction
2. _____ A measure of the soil's ability to hold nutrients that are cations in the soil
3. _____ Negatively charged solid particle composed of clay or organic matter
4. _____ Measure of the acidity or alkalinity of a soil
5. _____ A soil that contains more hydrogen ions than hydroxyl ions; soil pH is less than 7.0
6. _____ A soil that contains more hydroxyl ions than hydrogen ions; pH is greater than 7.0
7. _____ An ion with a negative or minus charge
8. _____ An ion with a positive charge
9. _____ Materials used to neutralize acidity

a. Lime
b. Atom
c. Cation exchange capacity (CEC)
d. Alkaline soil
e. Soil pH
f. Cation
g. Acid soil
h. Anion
i. Micelle

Use the following soil test data and calculate the cation exchange capacity (CEC) milliequivalent weights of potassium, magnesium, and calcium - K - 780 lb Mg - 240 lb Ca - 400 lb.

SITE No. 1	O.M. (%)	P_2O_5 (lb/Ac)	K (lb/Ac)	Mg (lb/Ac)	Ca (lb/Ac)	N.A. (meq)	pH
Soil test results	2.5	180	390	360	2400	4.0	5.2

10. K = _____
11. Mg = _____
12. Ca = _____
13. NA = _____
14. Total CEC = _____

Use the following soil test data and calculate the amount of exchangeable nutrients that the soil should contain. Optimal amount of nutrient per acre - K = 20 Mg = 24 Ca = 300.

SITE No. 2	O.M. (%)	P_2O_5 (lb/Ac)	K (lb/Ac)	Mg (lb/Ac)	Ca (lb/Ac)	N.A. (meq)	pH
Soil test results	2.5	180	390	360	2400	4.0	5.2

Amounts of exchangeable nutrients that the soil should contain

15. K = _____

16. Mg = _____

17. Ca = _____

Compare the results of the soil test and make recommendations of the nutrients needed.

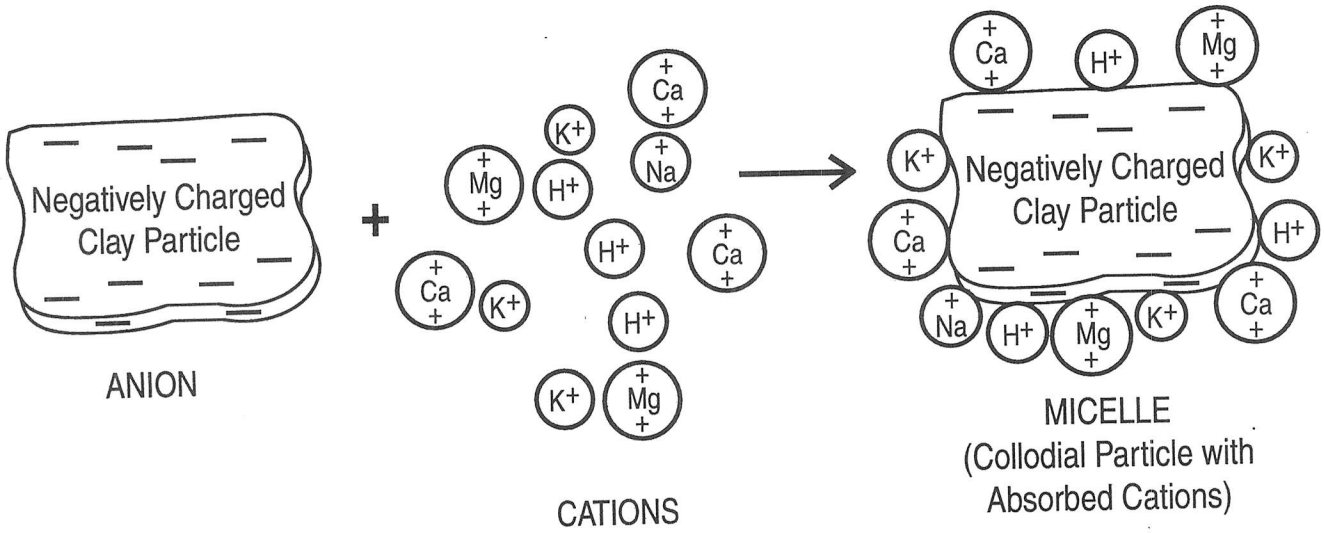
a. The soil should have 240 lb/A of K - amount of K needed _____.

b. The soil should have 288 lb/A of Mg - amount of Mg needed _____.

c. The soil should have 3600 lb/A of Ca. What is the recommendation for Ca? _____

_____.

Negatively Charged Clay Particle (Micelle)



UNIT - SOILS

Lesson 8: Soil Fertility

Objective: The student will be able to identify what plants get from the soil to be healthy and what gives maximum yields.

Study Questions

1. **What are the plant's essential macronutrients?**
2. **What are primary functions for plant growth of the macronutrients?**
3. **What hunger signs can be observed in crops that lack the major elements?**
4. **What are the plant's essential micronutrients?**
5. **What is the importance of organic matter?**
6. **What major nutrients are supplied by organic matter?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 8.
2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.
3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters
   a) TM 8.1: Contents of a Bag of Fertilizer
   b) TM 8.2: Nitrogen Cycle
5. Activity Sheet
   a) AS 8.1: How Organic Matter Builds Soil Structure

UNIT - SOILS

Lesson 8: Soil Fertility

TEACHING PROCEDURE

A. Review

Review previous lesson.

B. Motivation

Show examples of fertilizer grades, rations and formulations. Take students to visit a fertilizer manufacturer if possible or invite a sales person to speak to the class.

C. Assignment

D. Supervised study

E. Discussion

1. What is a fertile soil? Discuss the 17 elements necessary for plant growth. Discuss the nitrogen cycle illustrated by Figure 8.2 in the student reference.

What are the plant's essential macronutrients?

a) There are nine essential macronutrients (out of 17 elements necessary for plant growth).
   1) Three are supplied by water and air.
      (a) Carbon (C)
      (b) Hydrogen (H)
      (c) Oxygen (O)
   2) Six are available in the soil.
      (a) Available mainly in mineral solids
         (1) Calcium (Ca)
         (2) Magnesium (Mg)
         (3) Potassium (K)
      (b) Available in mineral solids and organic matter
         (1) Phosphorus (P)
         (2) Sulfur (S)
      (c) Available primarily in organic matter
         (1) Nitrogen (N)

2. Discuss the primary functions of each macronutrient for adequate plant growth.

What are primary functions for plant growth of the macronutrients?

a) Nitrogen (N) (Refer to TM 8.2.)
   1) Nitrogen provides critical elements for plant growth.
      (a) Needed for photosynthesis
      (b) Needed for plant and root cells
      (c) Needed for dark green, lush growth

2) Many compounds in plants contain nitrogen.
   (a) Amino acids
   (b) Enzymes
   (c) Chlorophyll
3) Soils need nitrogen to produce crops.
   (a) Helps the breakdown of organic material
   (b) Needed by microbes to decompose matter

b) Phosphorus (P)
   1) A component of every living cell
   2) Concentrated in seeds and growing parts of plants
   3) Needed for root development
   4) Aids in the maturing of crops

c) Potassium (K)
   1) Helps in the uptake of other nutrients
   2) Assists in enzyme systems affecting metabolism and photosynthesis
   3) Helps regulate the opening and closing of stomata in the leaves
   4) Important in the formation of carbohydrates
   5) Helps regulate the uptake of water in the root cells
   6) Important for strong brace roots

d) Calcium (Ca)
   1) Exchangeable calcium aids in the availability of other elements
   2) Essential for building cell walls, new roots, and leaves

e) Magnesium (Mg)
   1) Chlorophyll contains magnesium, which is vital in the photosynthesis process.
   2) Magnesium is contained in the seed.

f) Sulfur (S)
   1) Sulfur is a vital part of all plant proteins and some hormones.

3. Grow nutrient-deficient plants and observe the symptoms. Show slide series on plant deficiency symptoms. Discuss why most soils are likely to be deficient in nitrogen, phosphorus, and potassium. Discuss the fertilizer 12-12-12 and explain its meaning. Use TM 8.1.

What hunger signs can be observed in crops that lack the major elements?

a) Nitrogen deficiencies symptoms
   1) Pale green color and poor growth and shortage of chlorophyll are evident.
   2) Leaves may turn yellow and die during extended dry periods.
   3) Crop residue will not decompose within a year.
   4) Soil will not produce.

b) Phosphorus deficiencies symptoms
   1) Stunted growth
   2) Late maturity
   3) Purple spots and streaks in leaf tissues indicate excess sugar caused by slow conversion to starch and cellulose.

c) Potassium deficiencies symptoms
   1) Edges and areas between veins on older leaves turn yellow, then brown.
   2) Small brown spots develop while the veins remain green.
   3) Brace roots may not fully develop.

4. Discuss how micronutrients or trace elements may affect the process of chlorophyll development.

What are the plant essential micronutrients?

a) The eight micronutrients are trace elements found in the soil that are essential to plant health.
   1) Boron (B)
   2) Chlorine (Cl)
   3) Copper (Cu)
   4) Iron (Fe)
   5) Manganese (Mn)
   6) Molybdenum (Mo)
   7) Cobalt (Co)
   8) Zinc (Zn)

b) Other elements are such as sodium (Na) are absorbed but not essential.

5. Compare two soil samples, one high in organic matter and the other low in organic matter. Discuss the importance of organic matter in the soil.

What is the importance of organic matter?

a) Improves soil structure
   1) Enhances aeration
   2) Enhances healthy root development.

b) Adds to the total CEC of the soil

c) Supplies essential nutrients

6. Discuss the decomposition of organic matter. Discuss ways to maintain organic matter in the soil.

What major nutrients are supplied by organic matter?

a) Supplies most of the naturally occurring nitrogen in soil

b) Accounts for about half of phosphorus found in the soil

F. Other activities

1. Grow nutrient-deficient plants as a class project. Make note of the deficiency symptoms observed. Use construction sand as it contains less nutrients. Plant several inch-tall seedlings of corn, beans, and tomatoes into moist sand in individual pots. Fertile them with water- soluble fertilizer. Each pot should receive all the elements except the nutrient you choose to have deficient.

2. Use a newspaper article citing nutrient deficiencies in crops planted on land damaged by the "Flood of '93." Refer to: Associated Press, "Hot, dry weather wilts crops across Missouri," *Columbia Daily Tribune*, 21 June 1994, p. 6B.

G. Conclusions

A fertile soil produces high-yielding, healthy crops. Although a fertile soil has nutrient balance and quantity, nutrients alone are not sufficient to make a soil fertile. Fertile soil depends on soil texture, structure, rooting depth, organic-matter content, available water capacity, aeration, length of growing season, and physical support.

H. Competency

Identify what plants get from the soil to be healthy and what gives maximum yields.

Related Missouri Core Competency and Key Skills: None

I. Answers to the Evaluation

1.	b	6.	l
2.	a	7.	j
3.	e	8.	h
4.	c	9.	g
5.	d	10.	f.

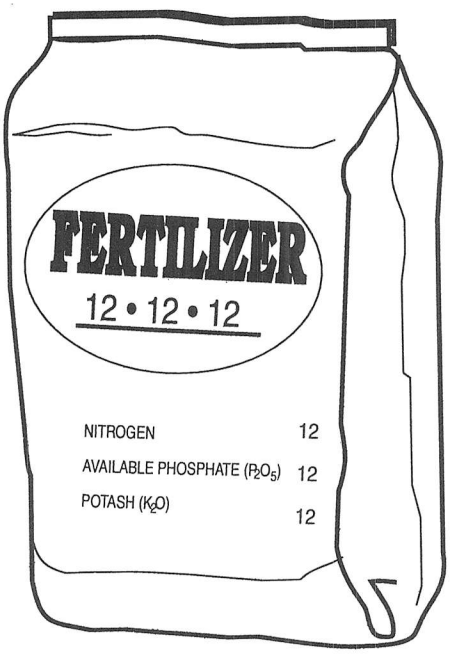
J. Answers to Activity Sheet

AS 8.1

1. The cultivated field has a higher percent of organic matter and improved the soil tilth. This helps soil hold water and therefore decreases the amount of water runoff.

2. The undisturbed fence row is low in organic matter.

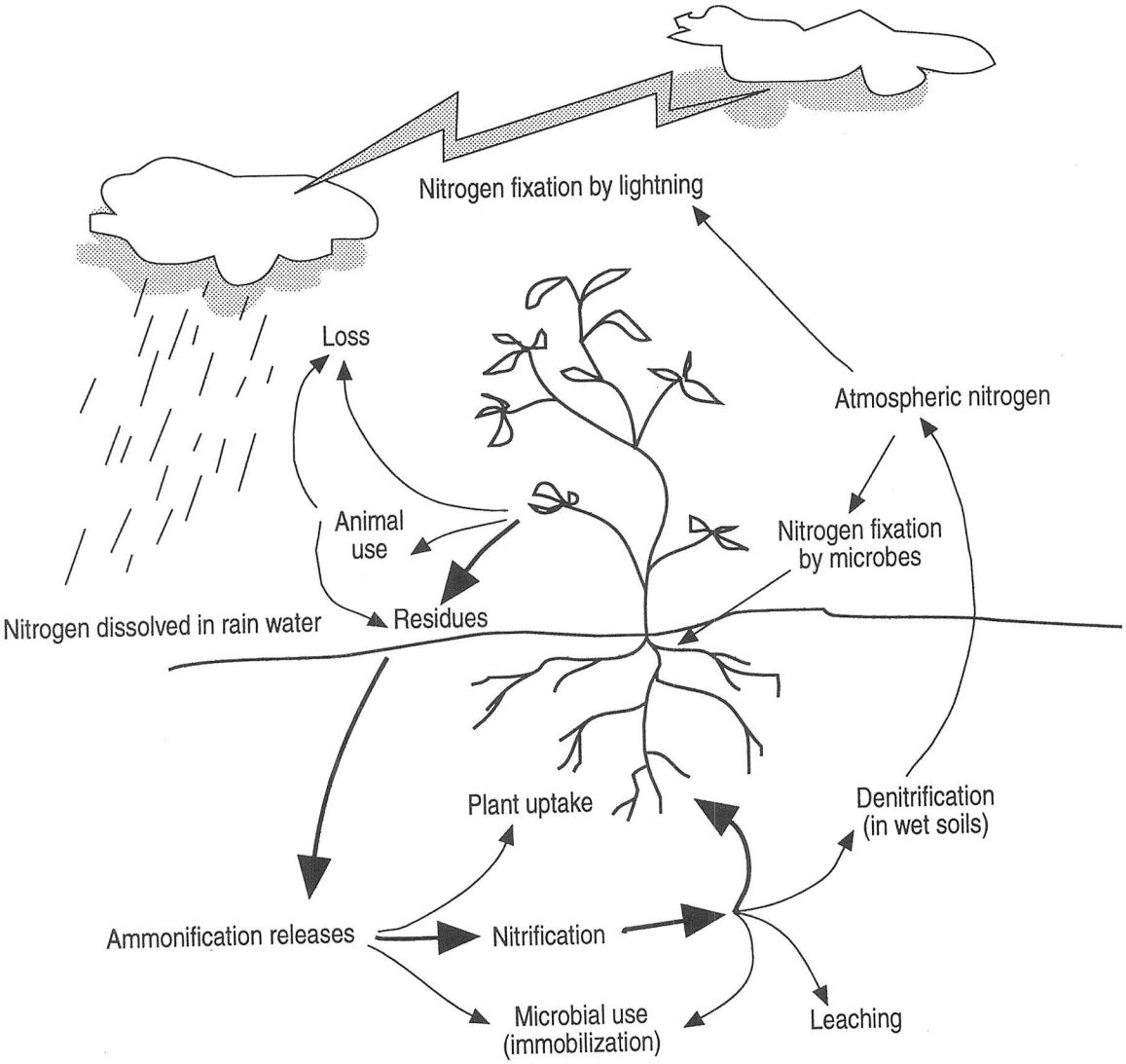
Contents of a Bag of Fertilizer



Nitrogen	12
Phosphorus	5.28
Potassium	9.96

Actual Plant Nutrient Percentages for 12 • 12 • 12 Fertilizer

Nitrogen Cycle



UNIT - SOILS

NAME: _____

Lesson 8: Soil Fertility

How Organic Matter Builds Soil Structure

Objective: To determine why the organic matter content is so important to improving the tilth of the soil and water holding capability.

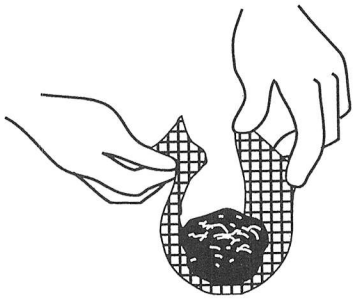
Activity Length: 2 periods

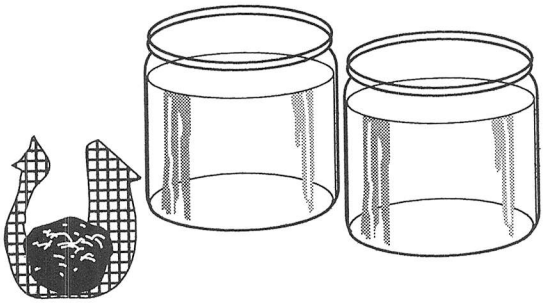
Materials and Equipment:

Two wide mouth glass jars

Procedure:

1. Bend the wire as shown in the illustration, so that it extends basketlike down into the jar..
2. Collect lumps of soil (not sandy) just under the sod from (1) an undisturbed fence row and (2) a cultivated field.
3. The lumps should be about twice the size of an egg.
4. Fill the jars with water to within an inch of the top.
5. Place the lumps of soil in the basket and lower them gently into the jars.
6. Watch closely and make notes of what happens.





SAMPLE	Time for Sample to Fall Apart	Which Sample Took Water Faster
Cultivated Field		
Undisturbed Fence Row		

UNIT - SOILS

NAME: _____

Lesson 8: Soil Fertility

Key Questions:

1. Why did the soil from the heavily cultivated field fall apart?

_____

_____

_____

_____

_____

_____

2. Why did the soil from the undisturbed fence row hold its shape and not fall apart?

_____

_____

_____

_____

_____

_____

UNIT - SOILS

Lesson 9: Soil Sampling and Interpreting Soil Test Results

Objective: The student will be able to prepare a soil sample for analysis.

Study Questions

1. **Why do we take a soil sample?**
2. **What factors influence the number of samples taken?**
3. **When and how often should a soil sample be taken?**
4. **What procedure should be followed to obtain a good soil sample?**
5. **How do you take a soil sample for a cultivated field, no-till field, and a lawn or garden?**
6. **What are some pitfalls to avoid when obtaining a good soil sample?**
7. **What soil testing services are locally available?**
8. **Why is information about crop history included with the sample?**
9. **What data can be obtained from a soil test report?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 9.
2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.
3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.
4. Transparency Masters
   a) TM 9.1: Methods of Taking a Soil Sample
   b) TM 9.2: Taking a Soil Sample from a Cultivated Field
5. Activity Sheet
   a) AS 9.1: Take a Soil Sample

UNIT - SOILS

Lesson 8: Soil Fertility

Name _____

Date _____

EVALUATION

Match the definition on the left with the term on the right.

1. _____ Contains all three of the primary macronutrients: nitrogen, phosphorus, potassium
2. _____ Soil that has a pH higher than 7.0
3. _____ Essential elements used in large amounts by plants - including nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur.
4. _____ Materials used to neutralize acidity of the soil.
5. _____ Browning starts at the tips of the leaves and proceeds down from the edges and usually leaves the veins green.
6. _____ Nutrient most beneficial to vegetative growth.
7. _____ Soil pH is less than 7.0.
8. _____ Nutrient deficiency shows up as a purple coloration in the leaf tissue.
9. _____ Essential elements used in small quantities by plants.
10. _____ Measure of the acidity or alkalinity in the soil.

a. Alkaline soil

b. Complete fertilizer

c. Lime

d. Potassium

e. Macronutrients

f. Soil pH

g. Micronutrients

h. Phosphorus

I. Nitrogen

j. Acid soil

UNIT - SOILS

Lesson 9: Soil Sampling and Interpreting Soil Test Results

TEACHING PROCEDURES

A. Review

Review Lesson 7 for information on determining the actual nutrients for a particular soil and Lesson 8 for information concerning the C:N ratio.

B. Motivation

Discuss why soil tests are important. Compare the analysis of a soil test to your doctor taking your blood pressure and reading your X-rays. Order actual Soil Sample Information sheets for each student or refer to the example on AS 9.I. Review the blanks of this form with the students to gain clues as to proper soil sample collecting procedures.

C. Assignment

D. Supervised Study

E. Discussion

1. Evaluate the importance of a soil test. Discuss why we should have a soil test made after each crop. What time of year is the best for taking a soil sample?

Why do we take a soil sample?

a) To produce healthy, high-yielding plants at minimal cost
b) To determine the percentage of the organic matter
c) To determine the pH
d) To determine the amount of available nutrients in the soil

2. Explain why it is necessary to limit the number of acres included in the soil test. Refer to Figure 9.1 of the student reference.

What factors influence the number of samples taken?

a) Size of area to sample (20 acres or fewer)
b) Areas of different soil
c) Areas growing different crops
d) Various surface textures
e) Eroded areas
f) Wet areas

3. Discuss how often a soil test should be made.

When and how often should a soil sample be taken?

a) Can be taken at any time of the year

b) When soil is dry enough to till or slightly wet--not when soil is muddy
c) Retest every three to four years

4. Demonstrate the proper procedure for taking a soil sample. Use TM 9.1. Have students complete AS 9.1. Explain why it is necessary to include the top seven inches of soil. Refer to Figure 9.1 of the student reference.

What procedure should be followed to obtain a good soil sample?

a) Use a soil auger, probe, or spade.
b) Include the top 7 inches of soil in each subsample.
c) Samples should be taken from different areas of the field and mixed thoroughly.
d) Place about a quart of the sample material in a small box or bag.
e) Identify each sample by field number and field map.
f) Air-dry sample in a dust-free area.
g) Take the sample to local University Extension Center for analysis.

5. Discuss how to sample soils correctly. Ask students what problems they have in taking a soil sample from a cultivated field. Show TM 9.2.

How do you take a soil sample for a cultivated field, no-till field, and a lawn or garden?

a) Press freshly cultivated soil down slightly to obtain a natural depth--take 10-20 subsamples in a cultivated field.
b) Two samples are needed from a no-till field.
   1) Take 10-20 subsamples from the top three inches.
   2) Take another 10-20 subsamples from the next four inches.
c) A garden requires 4-10 subsamples from the top seven inches of soil.

6. Discuss the importance of obtaining a good soil sample. Ask the students what areas to avoid when taking soil samples.

What are some pitfalls to avoid when obtaining a good soil sample?

a) Do not take samples from areas that are not representative of the entire field.
   1) Field boundaries, dead furrows, and end rows
   2) Areas near limestone gravel roads
   3) Severely eroded areas
   4) Wet spots
   5) Old barn lots
b) Do not dry samples by oven or microwave.

7. Ask students what soil testing services are available in your area.

What soil testing services are locally available?

a) University Extension Center
b) Fertilizer companies
c) Independent laboratories

8. Discuss the importance of crop history. Compare your bank account to the soils account of your fields or garden.

Why is information about crop history included with the sample?

a) Helps explain test results
b) Helps in making future crop recommendations

9. Discuss an actual soil test for a garden and a cropping field.

What data can be obtained from a soil test report?

a) Percentage of organic matter content
b) pH
c) CEC
d) Calcium
e) Magnesium
f) Phosphorus
g) Potassium
h) Available neutralizable acidity (NA)
i) Available nitrogen is not tested because it is quickly exhausted and replenished as needed for each crop

F. Other Activities

1. Invite an agent from the University Extension to explain soil test data or tour a soil testing facility.

2. Demonstrate the proper technique in taking a soil sample from a test area. Send the sample to a lab for analysis. Use the data to have the students make recommendations.

G. Conclusions

Soil samples are needed every three to four years to determine the organic matter content, the pH, and the amount of available nutrients in the soil. Samples should be representative of the field or plot. Ten to 20 subsamples should be taken from large fields when the soil is dry enough to cultivate. Subsamples should be thoroughly mixed together, air-dried, and taken to an independent laboratory.

H. Competency

Prepare a soil sample for analysis.

Related Missouri Core Competencies and Key Skills: None

I. Answers to Evaluations

1. Can be taken anytime of the year. The soil should be dry enough to till.

2. a) Use a soil auger, probe, or spade.
b) Include the top seven inches of soil in each subsample.
c) Samples should be taken from different areas of the field and mixed thoroughly.
d) Place about a quart of the sample material in a small box or bag.
e) Identify each sample by field number and field map.

f) Air-dry sample in a dust-free area.
g) Take the sample to local University Extension Center for analysis.

3. Crop history helps to explain unusual test results and present nutrient levels. It also helps in making recommendations for future crops.

4. To produce healthy, high-yielding plants at minimal cost by determining the percentage of the organic matter, the pH, and the amount of available nutrients in the soil.

J. Answers to Activity Sheet

AS 9.1

No questions

UNIT - SOILS

Name _____

Lesson 9: Soil Sampling and Interpreting Soil Test Results

Date _____

EVALUATION

Complete the following short answer questions.

1. When should a soil sample be taken?

_____

_____

_____

_____

2. What is the correct procedure in taking a soil sample?

_____

_____

_____

_____

_____

_____

_____

_____

3. List two reasons for keeping crop history records.

_____

_____

_____

_____

4. Explain why we take a soil sample.

_____

_____

_____

_____

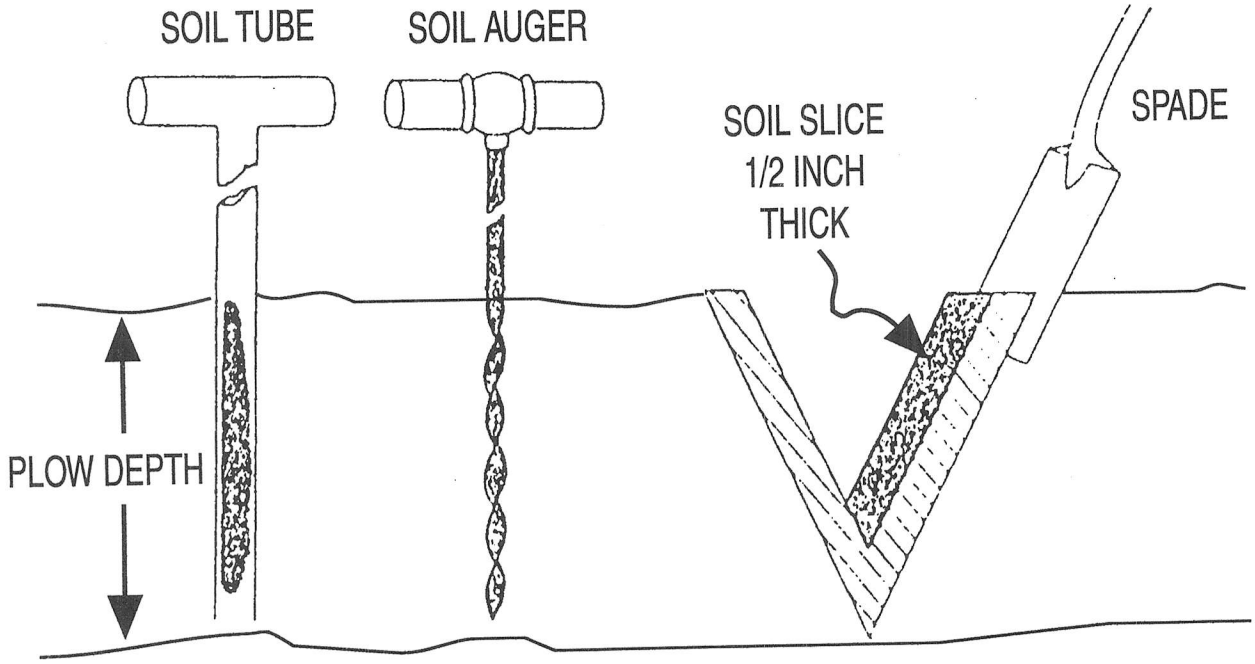
_____

_____

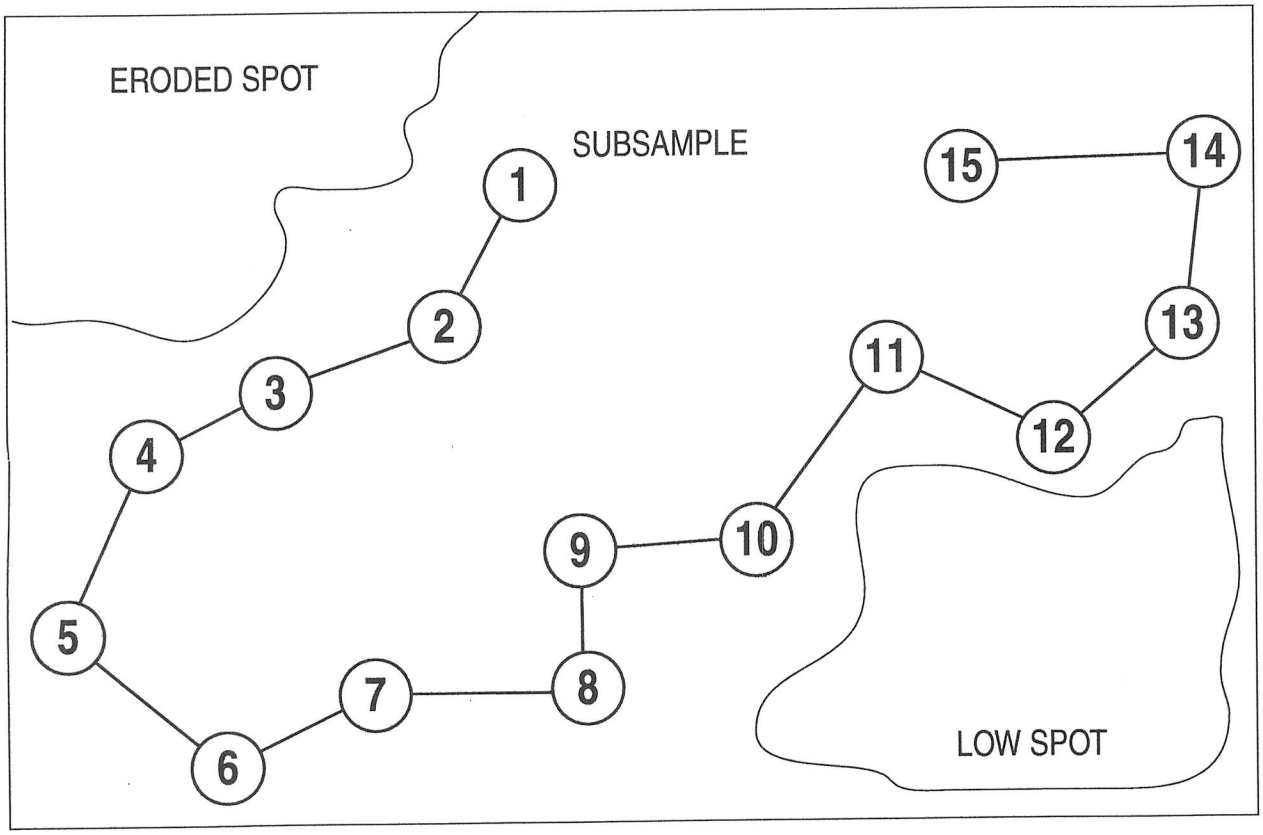
_____

_____

Methods of Taking a Soil Sample



Taking a Soil Sample from a Cultivated Field



Lesson 9: Soil Sampling and Interpreting Soil Test Results Name _____

TAKE A SOIL SAMPLE

Objective: To determine the proper technique in taking a soil sample.

Activity Length: 2 class periods

Materials and Equipment:

Soil tube, soil auger, or spade
Plastic bucket
Soil Sample Information sheet from University Extension

Procedure:

1. Scrape away any surface mat of grass or litter.
2. Each sample should include the top seven inches of soil. (NOTE: Avoid taking samples in areas like borders, low spots, near trees, or near buildings.)
3. Place each sample in a clean bucket.
4. Take number of soil samples according to size of field or garden.
5. Mix samples of soil well to make a composite sample.
6. If samples are wet, air-dry before submitting soil samples.
7. Fill out the soil sample information sheet with the aid of your instructor.
8. Enclose the information sheet and the soil sample in a special bag or sturdy carton.
9. Send the package to the soil testing laboratory.

University Extension
UNIVERSITY OF MISSOURI
COLUMBIA

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone: (314) 882-0623

or: **Soil Testing Laboratory**
P.O. Box 160
Portageville, MO 63873
Phone: (314) 379-5431

Soil Sample Information

Serial No. M5768

Grower _____ Date ____/____/19____

Address _____ Account No. Firm _____ (if applicable) Outlet _____ (if applicable)

City _____ State _____ Zip _____ **Dealer** _____

County _____ Copy for ASCS? _____ Address _____

County Code _____ Agronomy Area _____ City _____ State _____ Zip _____
(if unknown, check with County Extension office)

Guidelines for Major Crops: Codes and Common Yield Goals (additional crops listed on back)

Crop Code	Forage Establishment	Common Yield Goals
1	Alfalfa or alf/grass establishment	0
2	Birdsfoot Trefoil/grass establishment	0
3	Clover or clover/grass establishment	0
4	Cool season grass establishment	0
5	Lespedeza/grass establishment	0
6	Overseeding legumes into grass	0
7	Warm season grass establishment	0
8	Wildlife Food Plot	0

Crop Code	Forage Production	Common Yield Goals
10	Alfalfa or alf/grass hay	3-7 ton/a
11	Alfalfa or alf/grass pasture	100-250 cow days/a
16	Clover or clover/grass hay	2-5 tons/a
17	Clover or clover/grass pasture	100-250 cow days/a
18	Cool season grass hay	2-6 tons/a
19	Cool season grass pasture	100-250 cow days/a
22	Lespedeza/grass hay	1-4 tons/a
23	Lespedeza/grass pasture	100-250 cow days/a
26	Warm season grass hay	2-5 tons/a
27	Warm season grass pasture	100-250 cow days/a

Crop Code	Row Crop & Small Grains	Common Yield Goals
102	Cotton (lint)	500-1500 lbs/a
103	Corn (grain)	80-250 bu/a
104	Corn (silage)	10-25 tons/a
105	Wheat/Soybean double crop*	30-80 bu/a
111	Rice	3000-7000 lbs/a
113	Grain Sorghum	4000-10000 lbs/a
114	Sorghum silage	12-30 tons/a
115	Soybeans	30-70 bu/a
119	Wheat	40-100 bu/a

*Indicate yield goal for wheat only

For Instructions see Back of Form

Lab No. (lab use only)	Sample	Field / Sample ID (No more than 12 letters or numbers)	Acres	Irrigated (Y/N)?	Topography	Last Limed	Soil Region	Previous Crop Code no.	Cropping Options (1-4): 1 Crop Code	1 Yield Goal	2 Crop Code	2 Yield Goal	3 Crop Code	3 Yield Goal	4 Crop Code	4 Yield Goal	Check (✔) Test(s) Desired: Regular	Zn	S	Fe,Mn,Cu	Salts	Na	pHw	NO3-N	Sampling Depth (for NO3 test only) (inches) Top	Sub
	1																									
	2																									
	3																									
	4																									
	5																									
	6																									
	7																									
	8																									

University of Missouri System, Lincoln University, U.S. Department of Agriculture & Local University Extension councils Cooperating
equal opp institutions

White Cc) Yellow-File

UNIT - SOILS

Lesson 10: Effects of Soil on Water Movement and Retention

Objective: The student will be able to evaluate the effects of soil on water.

Study Questions

1. **What is the importance of available water to plant growth?**
2. **What are the different types of soil waters?**
3. **What is available water capacity?**
4. **What effect does soil texture have on available water capacity?**
5. **What effect does effective rooting depth have on AWC?**
6. **What effect does rock fragment content have on AWC?**
7. **What other factors affect available water capacity?**
8. **How is available water capacity determined?**
9. **What is permeability and what soil properties affect permeability?**
10. **What factors affect the internal drainage of soil?**
11. **How are seasonal high water tables determined?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil*, (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 10.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management*. 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 10.1: Water Removal by Plants
   b) TM 10.2: Kinds of Soil Water

5. Activity Sheet

   a) AS 10.1: Effects of Soil on Water Management and Retention

UNIT - SOILS

Lesson 10: Effects of Soil on Water Movement and Retention

TEACHING PROCEDURES

A. Review

Review Lessons 4 and 5.

B. Motivation

Select three tomato plants of the same size but grown in different soil textures. Water all of the plants the same amount to start the observation. See how long it takes each plant to wilt. After wilt is observed, water the plants and see how quickly they respond to the water. Have students observe how the soil texture affects the water retention of the soil.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the importance of water retention and movement. Use TM 10.1 to illustrate water use by plants.

What is the importance of available water to plant growth?

a) All plants need water to survive. Too much or too little can be harmful.
b) Actively growing plants are 90% water.
c) Plants need water to take up nutrients and release moisture through transpiration.
d) Plants use 300-500 lb of water for every pound of dry weight.
e) Soils with high available water have a greater productivity potential than soils with low available water.

2. Discuss what happens in the soil after a heavy rain. Show TM 10.2.

What are the different types of soil waters?

a) Gravitational water
   1) Fills large pores when soil is saturated
   2) Drains away quickly
   3) Plants cannot use
b) Capillary water
   1) This is held in smaller soil pores (capillaries)
      (a) Gravity
      (b) Cohesion
   2) Most is available to plants

c) Hygroscopic water
   1) This is held tightly in tiny soil pores.
      (a) Adhesion
      (b) Roots cannot remove it
   2) Clayey soils contain large amounts.
   3) Plants cannot use this unavailable water.

3. Discuss field capacity of the soil. Discuss the difference between available water capacity (AWC) and the wilting point. Show TM 10.2.

What is available water capacity?

a) The potential of a soil to hold water in a form available to plants -- The amount of water held between field capacity and the wilting point
b) Reservoir of water within the soil which plants can use

4. Use the soil samples with different soil textures for the earlier lessons. Have the samples moist and let the student handle the samples. Ask the students to describe the water-holding capacity. Discuss Figure 10.3 in the student reference.

What effect does soil texture have on available water capacity?

a) Soil texture has the greatest effect of the soil properties that influence AWC.
b) Water is held on the surfaces of soil particles.
c) Surface areas per volume of soil are dependent on the soil particle size.
   1) Clay has a large surface area per volume.
   2) Sand has a small surface area per volume.
   3) Silt has a medium surface area per volume.
d) Texture of different soil layers influences the downward movement of water.
   1) Clay can delay downward movement if it is close to surface.
   2) Clay in a lower layer can pull water from layers above.

5. Discuss the limiting factors in the soil that affect the rooting depth of plants. Have students give ideas on the effects of rooting depth on AWC.

What effect does effective rooting depth have on AWC?

a) Density of soil layers that limit rooting depth also limit AWC.
   1) Fragipans
   2) Gravelly or cobbly layers
   3) Bedrock
b) Soils allowing deep rooting are potentially very productive.
   1) Greater volume of soil for water and nutrients
   2) Good drainage and good aeration favor root penetration
c) Soils with restricting rooting depths are more susceptible to drought and have lower available water capacity.

6. Discuss the soil in your area. Ask the students to estimate the water storage capacity of soils containing rock fragments.

What effect does rock fragment content have on AWC?

a) Horizons containing rock fragments contain less AWC.
b) Rock fragments cannot store water.

7. Discuss the influence of soil structure and organic matter content on AWC. Ask the students what other factors might affect the available water capacity.

What other factors affect available water capacity?

a) Structure and organic matter
   1) Influence the size of aggregates
   2) Affect the amount of pore spaces between particles
b) Structure and density
   1) Dense layers with poor structure inhibit rooting depth
   2) Fragipans
c) Abrupt changes in soil texture from one horizon to another

8. Discuss what soil properties provide clues for determining available water capacity. Ask students how they would calculate the AWC of a particular soil. Refer to Figure 10.6 of the student reference.

How is available water capacity determined?

a) Multiply AWC rate x horizon thickness x percent fine earth.
   1) Determine AWC rate for a particular soil texture using Figure 10.6.
   2) Measure the thickness of the horizon.
   3) To find percentage of fine earth, subtract the percentage of rock fragment from 100%.
b) Repeat calculation for each horizon within the effective rooting depth.
c) Add together the AWCs for all horizons within the effective rooting depth.

9. Discuss texture of the soil as it relates to permeability. Discuss Table 10.3 and Table 10.4 of the student reference.

What is permeability and what soil properties affect permeability?

a) Permeability is affected by the rate at which water moves through a saturated soil. Least permeability layer is used.
b) Porosity, size of pores, and interconnection of pores influence permeability.
   1) Texture
   2) Structure
   3) Density
   4) Organic matter content
   5) Mineralogy

10. Refer to Figure 10.7 of the student reference to discuss classes of internal drainage. Discuss what factors might indicate or affect the internal drainage of soil.

What factors affect the internal drainage of soil?

a) Height of the water table
b) Length of time that soil remains saturated

11. Explain that a seasonal high water table is the highest average depth of a saturated zone during the wettest season. Analyze the water resources in your area. When do you expect seasonal high water in your area?

How are seasonal high water tables determined?

a) By evidence of reduction
   1) Grayed colors
   2) Gray mottles
b) By using boreholes to measure depth and duration of water table
   1) Apparent water table stands in a freshly dug borehole
   2) Perched water table levels fall when bore is extended

F. Other activities

1. Grow several pepper plants in pots until each has several leaves. Then divide the plants into three groups, watering each differently. Water one group so often that the soil stays wet. Water a second group when the soil surface dries. Water the third group only when the plants wilt. Have the students observe the difference in plant growth and discuss the importance of water. Have the students explain field capacity and available water.

2. Have ready for class soil samples of texture ranging from sandy to clay. Take three one-gallon cans and cut out both ends and set them on the ground. Fill each can with a different soil sample. Pour a half-gallon of water through each sample and discuss the results.

G. Conclusions

Plants need water to survive, although the amount of water needed varies widely. There are three kinds of soil water: gravitational water; available water; and unavailable water. Available water capacity (AWC), the capacity of soil to hold water in a form available to plants, is largely determined by soil texture. Soil permeability, internal soil drainage, and effective rooting depth (based largely on soil texture and structure) all work together to influence the available water capacity of a particular soil.

H. Competency

Evaluate the effects of soil on water.

Related Missouri Core Competencies and Key Skills:

9J-2: Study the causes of soil erosion in an area, analyze the problem(s), and choose the action(s) to be taken to prevent further erosion.

I. Answers to Evaluations

1.	b	6.	j
2.	d	7.	c
3.	g	8.	f
4.	l	9.	e
5.	h	10.	a

J. Answers to Activity Sheet

AS 10.1

1. The crumbly soil will have more air spaces between the particles. Soils high in humus have high water-holding capacity and act like a sponge.

2. Lack of organic matter

3. Organic matter increases water-holding capacity of the soil and helps prevent soil erosion.

UNIT - SOILS

Name _____

Lesson 10: Effects of Soil on Water Movement and Retention

Date _____

EVALUATION

1. _____ Process whereby plant wastes are released in water vapor through plant pores.

2. _____ The potential of a soil to hold water in a form available to plants.

3. _____ The point at which all available water is depleted.

4. _____ Refers to water movement through the soil.

5. _____ All the pores of a soil are full of water.

6. _____ Is one that exists in the soil above an unsaturated zone.

7. _____ Naturally occurring hard, brittle soil layer high in clay with high bulk density.

8. _____ Water that moves through the soil under the influence of gravity.

9. _____ Spots of different colors in a soil.

10. _____ Spaces between the mineral grains of a soil.

a. Pores

b. Transpiration

c. Fragipan

d. Available Water Capacity (AWC)

e. Mottling

f. Gravitational Water

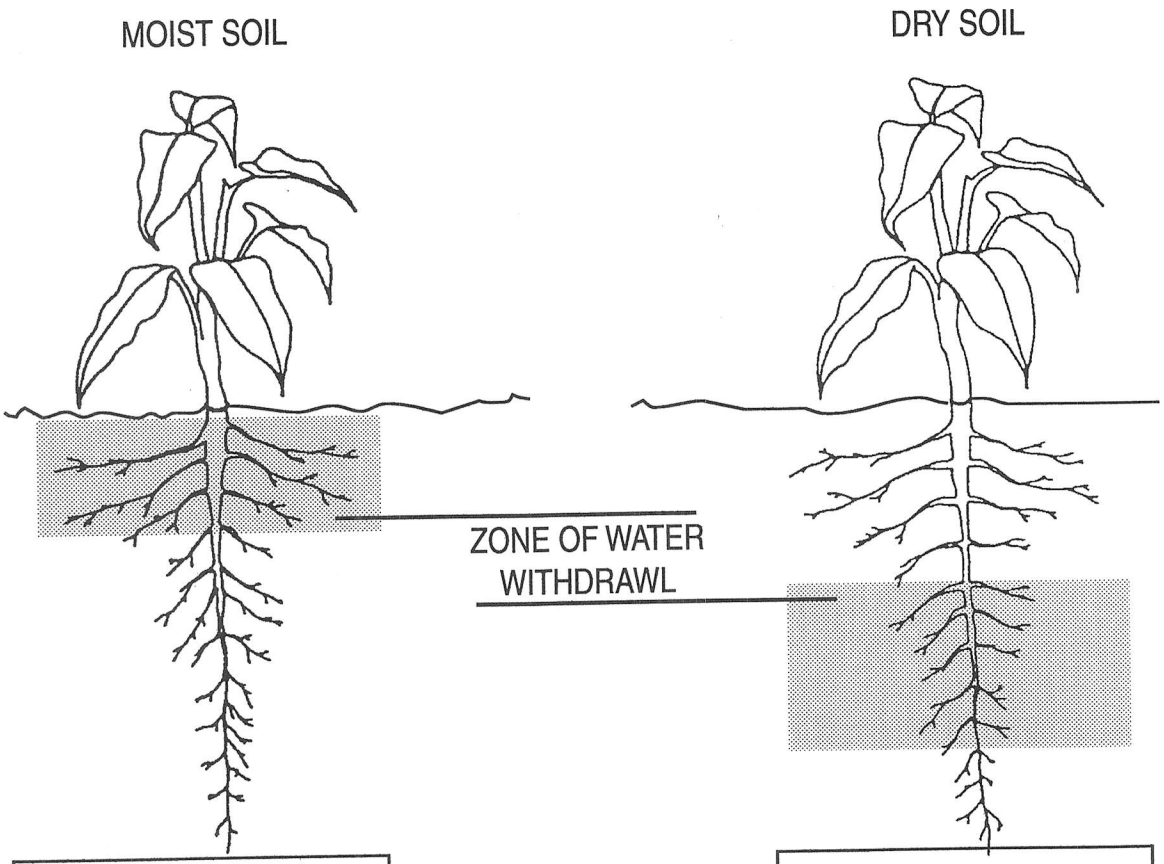
g. Wilting Point

h. Saturated

I. Permeability

j. Perched water table

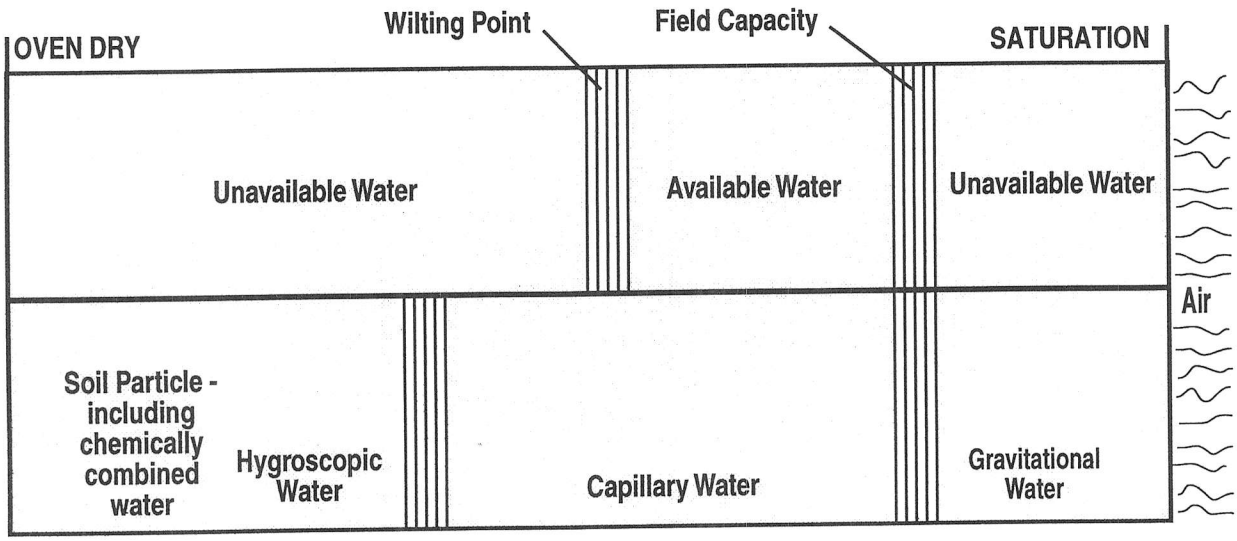
Water Removal by Plants



When soil is moist, the plant draws moisture near the surface.

As moisture is depleted, the plant begins to draw moisture from deeper soil.

Kinds of Soil Water



Name: _____

UNIT - SOILS

Lesson 10: Effect of Soil on Water Management and Retention

Water Retention in Different Soils

Objective: To determine why water retention is different in the two soil samples.

Activity Length: 2 class periods

Materials and Equipment:

Two 1-quart jars
Two pieces of heavy string or twine
Two lamp chimneys or cylinders
Two pounds of soil samples from two sites

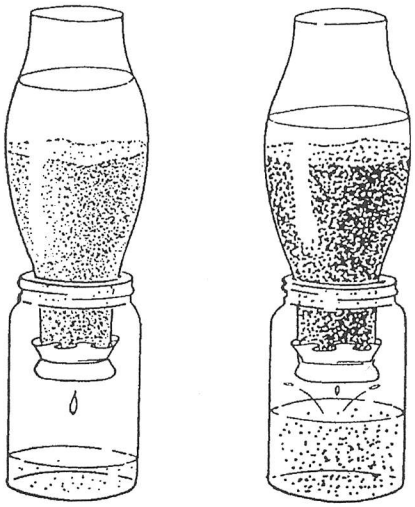
Procedure:

1. Take one soil sample from a garden.
2. Take second soil sample from a field that shows lack of organic matter.

   NOTE: Be sure the soils are equally dry.

3. Tie a cloth over the top of each chimney.
4. Turn chimneys upside down and fill each about two-thirds full with each of the collected soil samples.
5. Place chimneys in the jars as shown in illustration 10.1.
6. Pour a pint of water into each chimney.
7. Observe the two soil samples and record how long it takes the water to begin to drip into the jars and how long the water continues to drip.
8. Measure the amount of water that passes through each soil sample.

Illustration 10.1



ACTIVITY	SAMPLE #1	SAMPLE #2
How long did it take for water to begin to drip into the jars?		
How long did the water drip from each sample?		
How much of the original water passed through the soil sample?		

Name: _____

UNIT - SOILS

Lesson 10: Effect of Soil on Water Management and Retention

Water Retention in Different Soils

Key Questions:

1. Does crumbly soil take in water faster than cloddy soil? Explain why or why not.

_____

_____

_____

_____

_____

_____

2. What causes soil to pack together?

_____

_____

_____

_____

_____

_____

3. Why is organic matter important in preventing erosion?

_____

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_____

_____

_____

_____

UNIT - SOILS

Lesson 11: Site Characteristics

Objective: The student will be able to describe the various site characteristics.

Study Questions

1. **How does landform affect land use?**
2. **What are the major landforms?**
3. **How is percent slope determined?**
4. **What is the relationship between percent slope and water erosion?**
5. **How do you identify parent material?**
6. **What is the effect of stoniness on land use?**
7. **What factors affect water erosion?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 11.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 11.1: Reading Slope with an Abney Hand Level or Clinometer
   b) TM 11.2: Judging Soil Slope
   c) TM 11.3: Slope Diagram Showing Feet Fall Per 100-Foot Distance

UNIT - SOILS

Lesson 11: Site Characteristics

TEACHING PROCEDURES

A. Review

Review Lessons 2 and 10.

B. Motivation

Discuss site evaluation as it relates to soil judging. Introduce the soil judging scorecard and explain the section on Site Characteristics.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss why site evaluation is just as important in soil judging as a description of each horizon. Take a field trip and evaluate a landform.

How does landform affect land use?

a) Site characteristics
   1) Runoff
   2) Erodibility
   3) Internal drainage
b) Management decisions
   1) Choice of crops
   2) Tillage systems
   3) Mechanical practices
   4) Drainage systems
   5) Irrigation

2. Discuss landforms in your area and procedures for evaluation.

What are the major landforms?

a) Uplands
b) Foot slopes
c) Alluvial fans
d) Flood plains
e) Stream terraces
f) Sinkholes

3. Discuss the importance of slope and how it affects the use and management of the soil. Demonstrate the use of an Abney level or a clinometer to measure slope. Since your students will not have instruments to judge slope, estimate the slope gradient within a percent or two. Show TM 11.1, TM 11.2, and TM 11.3.

How is percent slope determined?

a) Place two stakes a certain distance apart (run) on the slope.
b) Calculate the difference in the two elevations (rise).
c) Divide the rise by the run.
d) Change fraction to percentage.

4. Discuss with students how a slope's length, shape, and gradient determine erodibility. Also discuss how the aspect of a slope influences moisture and plant growth as it relates to erosion.

What is the relationship between percent slope and water erosion?

a) The greater the percent slope (gradient), the higher the erosion rate.
b) The steeper the slope, the greater the runoff.
c) As length increases, so does volume and speed of runoff water.

5. Discuss parent material and how they are developed.

How do you identify parent material?

a) Parent material is determined by comparing upper horizons with C and R horizons.
   1) C horizons usually represent original parent material.
   2) Landforms of a soil indicate the kind of parent material.
   3) Geology of an area provides clues to parent material.
   4) Abrupt changes may indicate two parent materials.
b) Six types of common parent materials have their own characteristics.
   1) Residuum - unconsolidated, weathered mineral material
   2) Alluvium - sand, silt, and clay sediments deposited by flooding
   3) Loess - clays and silts deposited by wind
   4) Eolian sand - sand dunes deposited by wind action
   5) Glacial till - clay, silt, sand, and gravel transported by glaciation
   6) Colluvium - loose soil and rocks transported down steep slopes

6. Explain that stoniness is defined in terms of its impact on agricultural management. Discuss classes of stoniness. Ask the students how each class of stoniness might affect land use.

What is the effect of stoniness on land use?

a) Stoniness interferes with tillage
b) Can make cultivated crops impractical -- Could still work for hay crops or improved pasture
c) Can prevent any agricultural improvements -- Use as native pasture or range
d) Rockiness also limits cultivation

7. Discuss the hazards of soil erosion by water. Talk about damages erosion does to productivity and water quality. Refer to Table 11.2 in the student reference.

What factors affect water erosion?

a) Slope
   1) Steepness of slope
   2) Length of slope

b) Runoff
   1) Soil texture
   2) Permeability and infiltration
   3) Soil depth
   4) Vegetative cover
   5) Climate

F. Other activities

1. Tour local farms and observe the six general landforms that are common in the state.

2. Invite your Natural Resources Conservation Service (NRCS) representative to speak to your class.

3. Show a slide set of soil erosion to illustrate types and effects of erosion.

G. Conclusion

Land forms have characteristic shapes and are produced by natural geologic processes. The six general landforms that commonly occur in the state are uplands, foot slopes, alluvial fans, flood plains, stream terraces, and sinkholes. There are five major characteristics used in a site evaluation: landform, slope, aspect, parent material, and stoniness. Both slope steepness and slope shape are important considerations in a site evaluation.

H. Competency

Describe the various site characteristics.

Related Missouri Core Competencies and Key Skills:

9J-2: Study the causes of soil erosion in an area, analyze the problem(s), and choose the action(s) to be taken to prevent further erosion.

I. Answers to Evaluation

1.	c	6.	g	11.-15.	Rise ÷ Run = % Slope
2.	b	7.	h	16.-20.	10%
3.	d	8.	e	21.	a. Uplands b. Flood plain
4.	i	9.	j	22.	a. Convex b. Concave c. Linear
5.	f	10.	a	23.	Slope shape
				24.	Slope length
				25.	Slope gradient

UNIT - SOILS

Lesson 11: Site Characteristics

Name _____

Date _____

EVALUATION

Match the definition on the left with term on the right.

1. _____ Occurs at the junction between uplands and nearly level flood plains
2. _____ Flat or without curvature
3. _____ Saucer-shaped
4. _____ Slopes are like mounds
5. _____ Soils formed in place
6. _____ Soils deposited on a flood plain
7. _____ Soil transported by gravity
8. _____ Soil transported by ice
9. _____ Are at the base of upland hillslopes
10. _____ Abandoned flood plains

a. Stream terrace
b. Linear
c. Alluvial fan
d. Concave
e. Glacial till
f. Residual soils
g. Alluvial soils
h. Colluvium
i. Convex
j. Foot slope

11-15 Write the formula for calculating percent of slope _____

_____

_____

_____

_____

_____

_____

_____

_____

16-20 If two points are 100 feet apart (the run) and one point is 10 feet higher than the other (the rise), what is the percent of slope?

_____

Short Answer: Complete the following short answer questions.

21. The two categories of landforms are:

a. _____

b. _____

22. Name the three shapes of landforms.

a. _____

b. _____

c. _____

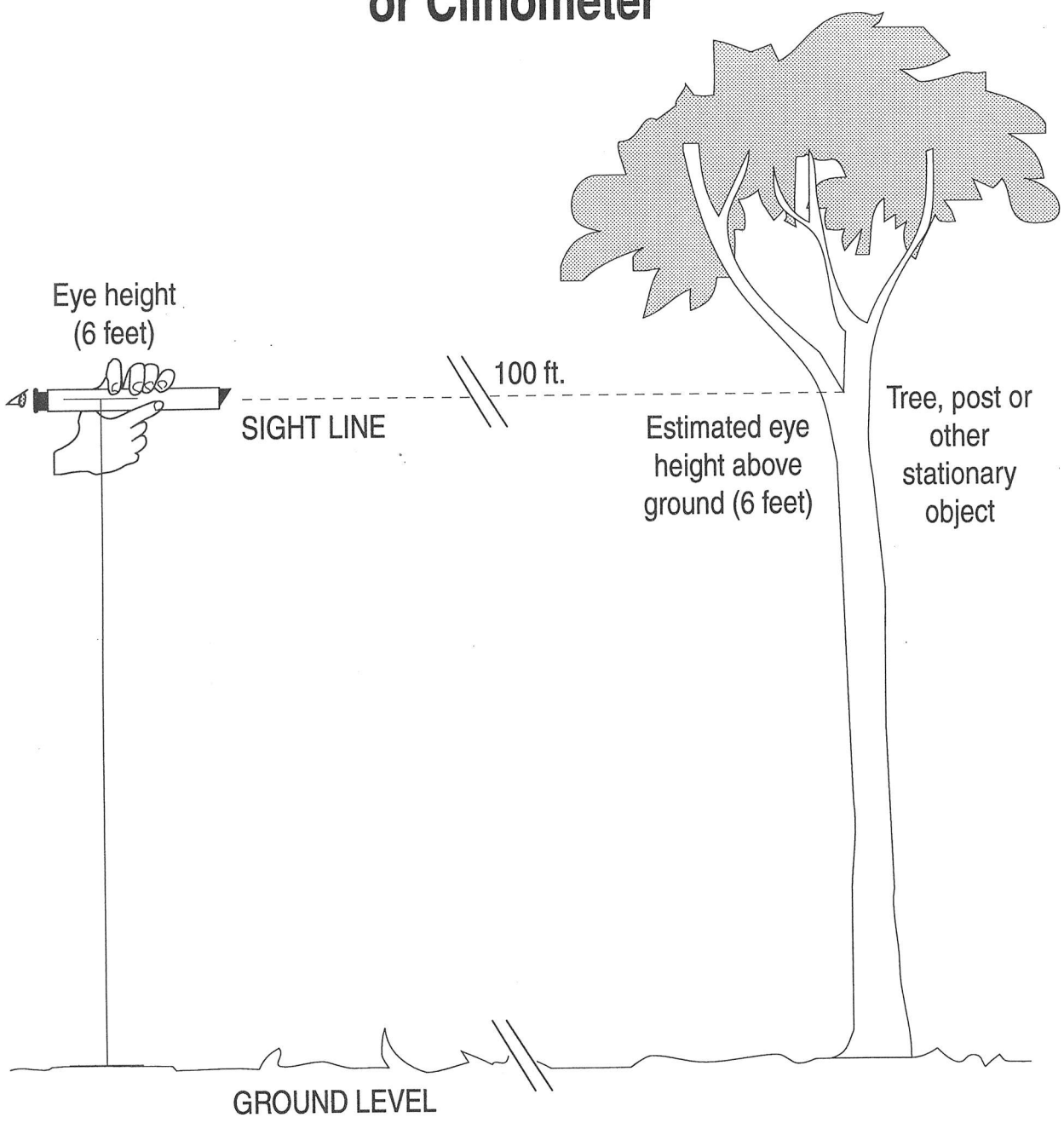
Name three characteristics that determine landform.

23. _____

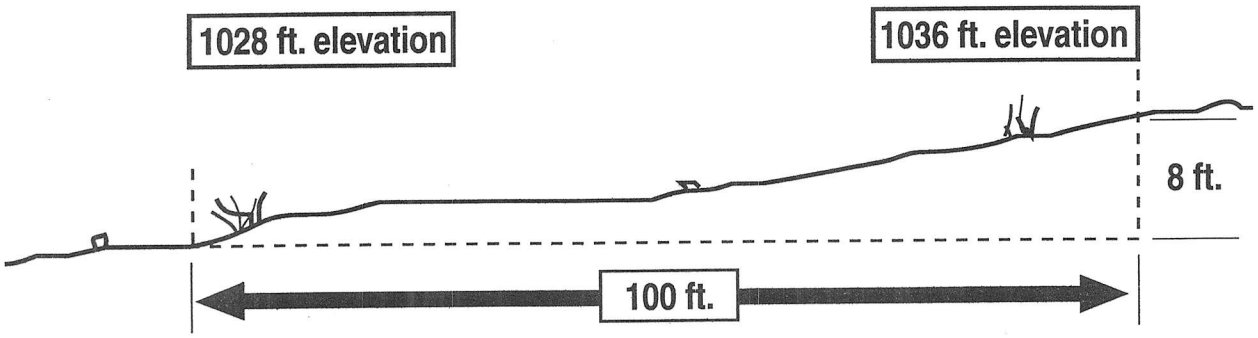
24. _____

25. _____

Reading Slope with an Abney Hand Level or Clinometer

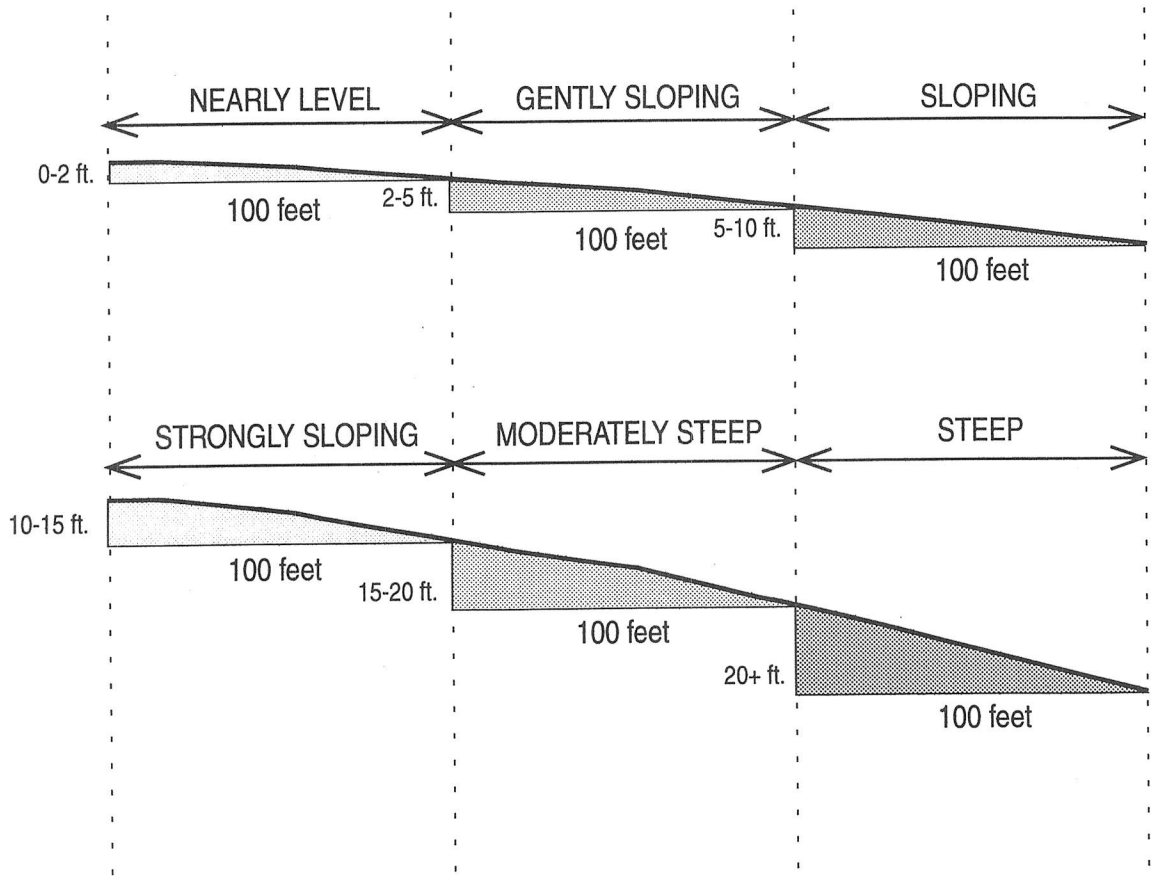


Judging Soil Slope



$$\% \text{ Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{1036' - 1028'}{100'} = \frac{8'}{100'} = 8\%$$

Slope Diagram Showing Feet Fall Per 100-Foot Distance



UNIT - SOILS

Lesson 12: Management and Interpretations

Objective: The student will be able to identify ways to conserve and manage the soil.

Study Questions

1. **What site characteristics and soil properties determine the need for artificial drainage?**

2. **What soil properties determine the suitability for irrigation?**

3. **What management practices are used to control erosion?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 12.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

4. Transparency Masters

   a) TM 12.1 Types of Terraces
   b) TM 12.2 Cross Section - Steep Backslope Terrace
   c) TM 12.3 Cross Section - Broad-based Terrace

5. Activity Sheet

   a) AS 12.1: How Cover Crop Affects Soil Loss

UNIT - SOILS

Lesson 12: Management and Interpretations

TEACHING PROCEDURES

A. Review

Review previous lesson.

B. Motivation

Invite prominent farmers to visit the class to explain proper management of the soil.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the feasibility and cost of artificial drainage in your farming community. Discuss areas where drainage may be prohibited by wetland regulations. Discuss site characteristics and soil properties that indicate the need for surface drainage. Refer to Figure 12.1 in the student reference.

What site characteristics and soil properties determine the need for artificial drainage?

a) Somewhat poorly drained, poorly drained or very poorly drained soils that are nearly level with depressional spots
   1) Sites on which surface water stands for continuous periods of 8 hours or more
b) Sloping soils below seepy spots
   1) Hillsides and foot slopes

2. Have members of the class do a survey of the different systems of irrigation used in our community. Discuss cost figures for the systems mentioned. Ask students to name local areas they believe need irrigation. Discuss the suitability of irrigation for those areas. Refer to Table 12.1 in the student reference.

What soil properties determine the suitability for irrigation?

a) Evaluate these properties as an asset or a liability
   1) Surface texture
   2) Slope
   3) Available water capacity (AWC)
   4) Depth to high water table
   5) Permeability
   6) Percent of rock fragments
   7) Depth to bedrock

3. Discuss the amount of topsoil lost to erosion each year. Discuss erosion control measures such as no-till, terraces, and contour farming. Show TM 12.1 and TM 12.2.

What management practices are used to control erosion?

a) Tillage practices
   1) No-till
   2) Conservation tillage
b) Cropping practices
   1) Contour planting
   2) Contour strip cropping
   3) Grassed waterways
   4) Conservation cropping sequence
c) Terraces can be either gradient or parallel
   1) Broad-base terraces
   2) Narrow-base terraces
   3) Steep backslope terraces

F. Other Activities

1. Conduct field trips to observe irrigation practices.

2. Invite NRCS or Water Conservation District representative to speak to the class about ways a farmer can solicit assistance in developing a conservation plan.

3. Show videos covering additional types of drainage and conservation. These are available through the Department of Conservation.

G. Conclusion

The first steps in evaluating soils involve learning how to identify horizons and site characteristics. The next steps examine the use and management of the soil. Management practices include the suitability of artificial drainage and irrigation, water erosion, evaluating the erosion hazard, conservation practices for erosion control, and hazards or limitations for cropping systems.

H. Competency

Identify ways to conserve and manage the soil.

Related Missouri Core Competencies and Key Skills:

9J-2: Study the causes of soil erosion in an area, analyze the problem(s), and choose the action(s) to be taken to prevent further erosion.

I. Answers to Evaluation

1. a) How to identify horizons and site characteristics
   b) Examine the use and management of the soil

2. a) Texture b) slope

3. a) broad-base b) narrow base c) steep backslope

4. No-till

5. Contour strip cropping

J. Answers to Activity Sheet

AS 12.1

1. Water rushed off the bare soil into the jar, taking soil with it. The jar will contain muddy water. The experiment proves the importance of a cover crop.

2. The water that flows from the sod will be reasonably clear. It will take longer for the flow to start and it will continue longer.

UNIT - SOILS

Name _____

Lesson 12: Management and Interpretations

Date _____

EVALUATION

1. The first steps in evaluating soils involve:

   a.

   b.

2. What are two important characteristics to determine the feasibility of irrigation?

   a.

   b.

3. Name the three basic types of terraces.

   a.

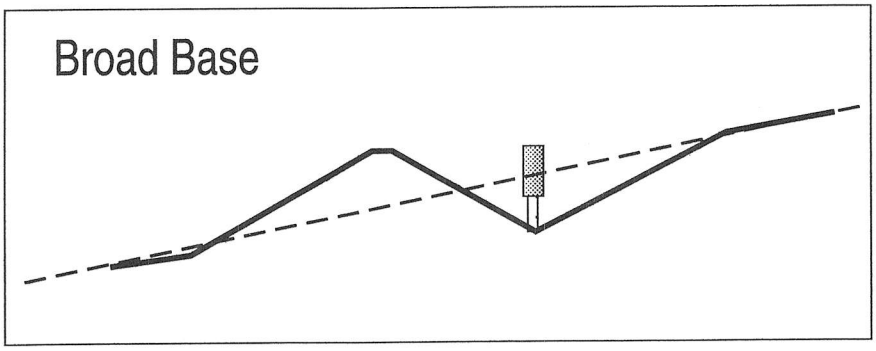
   b.

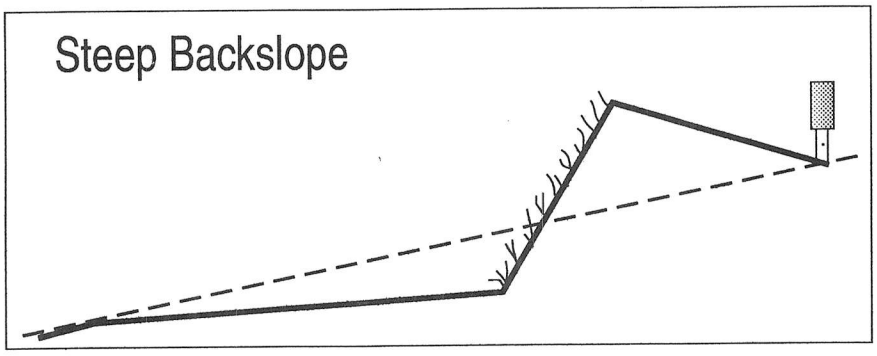
   c.

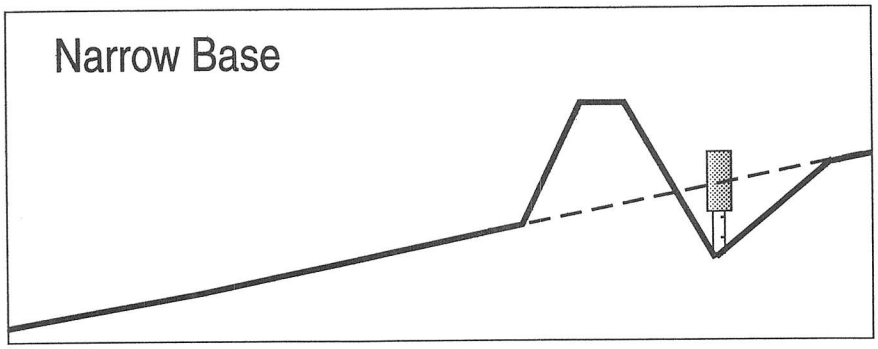
4. _____ is very effective for erosion control because bare soil is never exposed at the surface.

5. A systematic arrangement of crops planted in strips or bands that provide barriers to control erosion are called _____.

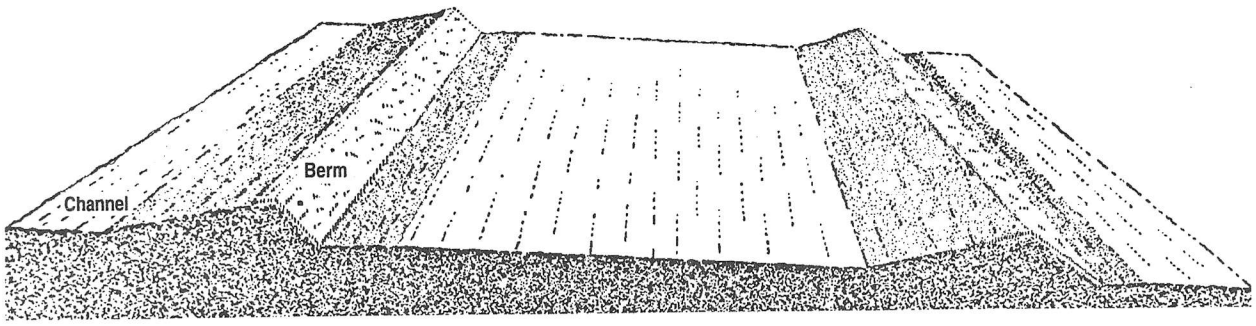
Types of Terraces

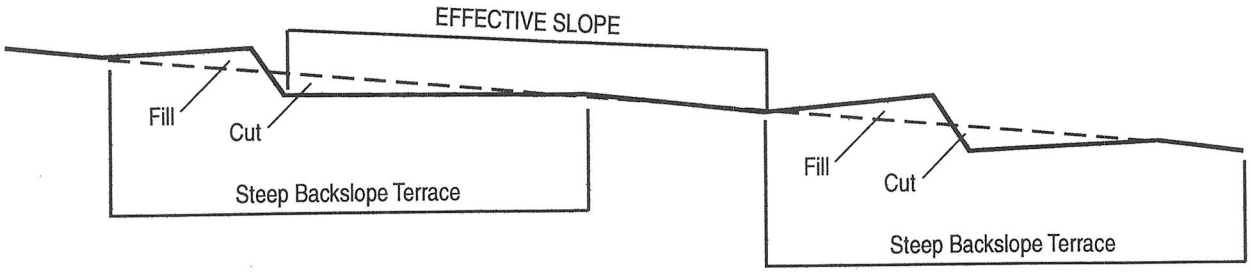




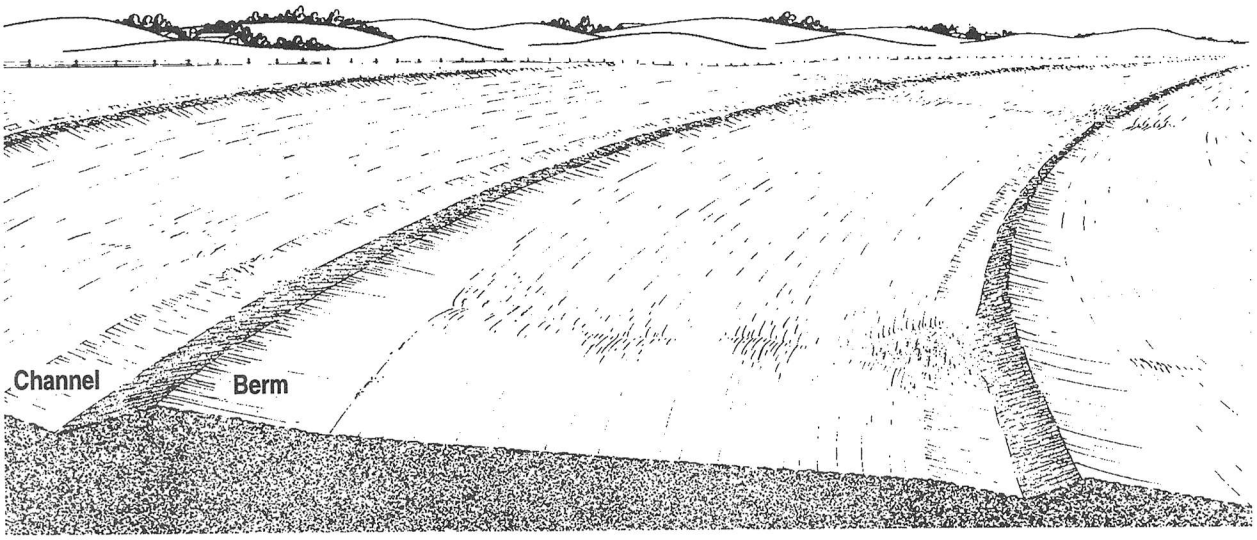


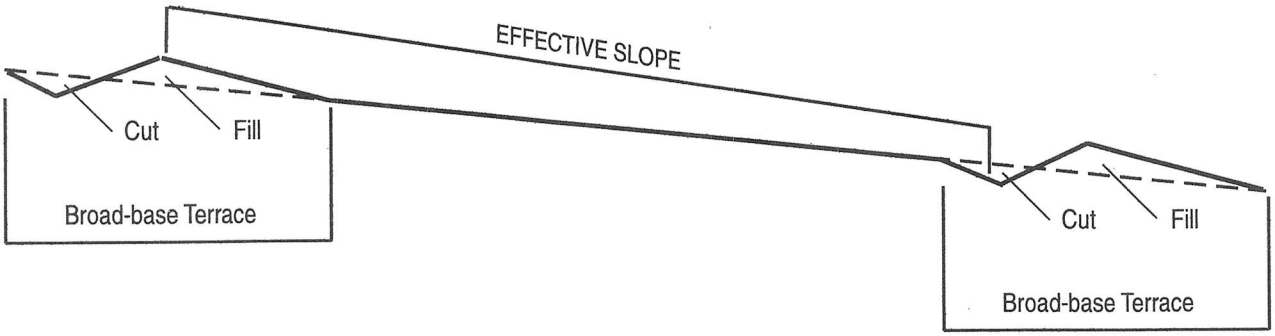
Cross Section - Steep Backslope Terrace





Cross Section - Broad-based Terrace





Unit - Soils

Name: _____

Lesson 12: Interpretation and Management of Soil

How Cover Crop Affects Soil Loss

Objective: To illustrate the effects of a cover crop.

Activity Length: 2 class periods

Materials and Equipment:

- Two small boxes approximately 16" long x 12" wide x 4" deep. Make them watertight by lining with plastic, tin or tar paper. At one end of each box, cut a V-notch 1" to 1 1/2" deep and fit with a tin spout to draw runoff water into a container (See illustration 12.1)
- Two flower sprinklers, half-gallon size
- Two half-gallon wide-mouth fruit jars
- Two one-inch thick sticks of wood, 12 inches long

Procedure:

1. Cut a piece of sod from a pasture, lawn, fence row, etc., to fit into one of the boxes. Trim the grass to about 1-inch high.

2. Fill the other box with soil from the same location, but without grass - just the soil. The strategy is to have the same kind of soil in the boxes, one with grass and one bare.

3. Set the boxes on a table so that the spouts extend over the edge.

4. Place the sticks under the inside end to create a downward slope toward the edge of the table.

5. Place the empty jars under the spouts to catch runoff.

6. Fill the two sprinklers with water and pour the water on both boxes at the same time. Pour steadily and at the same rate for both boxes.

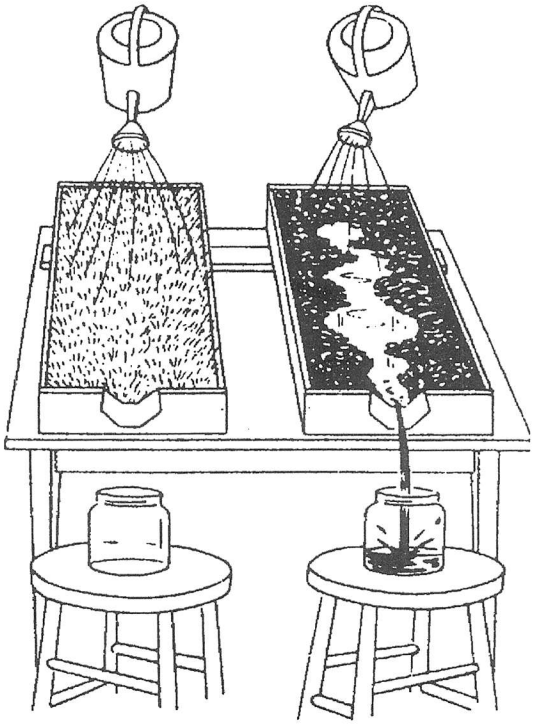


Illustration 12.1

Name: _____

UNIT - SOILS

Lesson 12: Interpretation and Management of Soil

How Cover Crop Affects Soil Loss

Key Questions:

1. What resulted when water was applied to the box with bare soil?

_____

_____

_____

_____

_____

_____

2. What did you notice about the box of sod as water was applied?

_____

_____

_____

_____

_____

_____

3. What conclusions can you draw from this comparison?

_____

_____

_____

_____

_____

_____

UNIT - SOILS

Lesson 13: Environmental Impact of Soil and Water Management

Objective: The student will be able to describe the environmental impact of soil and water management.

Study Questions

1. **What soil properties affect leaching of pesticides and fertilizers?**

2. **What soil properties affect water runoff?**

3. **What soil properties affect site selection of water holding structures?**

4. **What soil properties are important for determining building sites?**

5. **What soil properties are important for on-site waste disposal?**

References

1. Minor, Paul. *Soil Science: Evaluation, Interpretation, and Management of Soil,* (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1995. Chapter 13.

2. Donahue, Roy L., and Follett, Roy Hunter. *Our Soils and Their Management*, Danville, IL: Interstate Publishers, Inc. 1990.

3. Plaster, J. Edward. *Soil Science & Management.* 2nd ed. Albany, NY: Delmar Publishers, Inc., 1992.

UNIT - SOILS

Lesson 13: Environmental Impact of Soil and Water Management

TEACHING PROCEDURES

A. Review

Review previous lesson.

B. Motivation

Discuss soil in your area. Ask the students to evaluate the environmental impact on soils as it relates to water management.

C. Assignment

D. Supervised study

E. Discussion

1. Discuss the effects of pesticide leaching onto your garden or crop.

What soil properties affect leaching of pesticides and fertilizers?

a) Surface infiltration
   1) Texture
   2) Permeability
   3) Restrictive layers
   4) Shrink-swell potential
b) Permeability
   1) Soil structure
   2) Particle size distribution
   3) Bulk density
   4) Restrictive layers

2. Discuss how pesticides and fertilizers are carried off by water runoff. Discuss the importance of water quality and its effect on your health. Discuss how reducing leaching and water runoff losses would improve the overall water quality.

What soil properties affect water runoff?

a) Rate of runoff
   1) Slope
   2) Texture (surface layer)
   3) Permeability
   4) Restrictive layers
   5) Soil depth
   6) Shrink-swell potential
   7) Internal drainage

b) Erodibility
   1) Particle size distribution
   2) Soil structure
   3) Permeability

3. Discuss the guidelines in selecting a site to construct a pond. Refer to Table 13.1 in the student reference.

What soil properties affect site selection of water-holding structures?

a) Low seepage potential in upper 60 inches
   1) Permeability
   2) Depth of bedrock
   3) Depth of highly permeable material
b) Percent slope

4. Discuss the soil features that will determine construction of dwellings with a basement. Refer to Table 13.2 and Table 13.3 in the student reference.

What soil properties are important for determining building sites?

a) Depth to high water table (WT)
b) Flooding
c) Shrink-swell potential
d) Slope
e) Depth to bedrock
f) Rock fragments

5. Discuss regulations concerning the construction of a water disposal system. Ask the students what soil characteristics they would look for. Also mention any approval required by governing agencies. Refer to Figures 13.1 and 13.2 as well as Tables 13.4 and 13.5 in the student reference.

What soil properties are important for on-site waste disposal?

a) Soil properties that affect absorption fields
   1) Permeability
   2) Depth to seasonal high water table
   3) Depth to bedrock or restrictive layer
   4) Slope
   5) Flooding
   6) Rock fragments greater than 3 inches to a depth of 40 inches
b) Soil properties that affect sewage lagoons
   1) Permeability
   2) Slope
   3) Flooding
   4) Seasonal high water table or internal drainage
   5) Depth to bedrock
   6) Rock fragments (percentage of cobbles and stones)

F. Other activities

Have a local planning and zoning official or health inspector speak to the class on soil and site characteristics they have encountered.

G. Conclusion

Pesticides and fertilizers can be lost from the soil by leaching and water runoff and can pollute underground and surface water supplies. Soil properties can be evaluated to determine the potential to transmit water-soluble contaminants and to determine potential water runoff. The soil properties that affect permeability and erodibility impact the environment and need to be evaluated when determining land usage.

H. Competency

Describe the environmental impact of soil and water management.

Related Missouri Core Competencies and Key Skills:

Science 8D-4: Predict the effects of pollution (e.g., acid rain, smog, oil spills, excess pesticides, and fertilizer run-off) on the environment.

I. Answers to Evaluation

1. a. high water table b. flooding c. shrink-swell potential
   d. slope e. depth of bedrock

2. a. permeability b. seasonal high water table c. shallow soil
   d. slope e. flood plains or rock fragments

3. a. soil texture b. permeability c. restrictive layers
   d. soil depth e. shrink-swell potential

4. a. leaching b. water runoff

UNIT - SOILS

Name _____

Lesson 13: Environmental Impact of Soil and Water Management

Date _____

EVALUATION

1. What soil properties are important in determining building sites?

   a.

   b.

   c.

   d.

   e.

2. What soil properties are important for on-site waste disposal?

   a.

   b.

   c.

   d.

   e.

3. What soil properties affect water runoff?

   a.

   b.

   c.

   d.

   e.

4. What soil properties affect leaching of pesticides and fertilizers?

   a.

   b.

Appendix I

How to Organize and Manage a Soil-Judging Contest

Competency: Evaluate the soil landscape.

Appendix I: How to Organize and Manage a Soil-Judging Contest

This information is intended primarily to help those who may be asked to organize a soil-judging contest, prepare the pits at the site, and do the official judging and scoring. Instructors and students, however, may wish to read this section so they will have a better idea of what to expect when they arrive at a contest.

Locating a Contest Site

An official contest has three or four soil pits. One pit could be used as practice or demonstration pit. At least three are used as contest pits. Each pit should represent a distinctly different soil. If at all possible, the pits should all be within a short (5-10 minute) walk from each other. However, buses could be used to transport students several miles if necessary.

Local soil scientists from the Natural Resources Conservation Service, the U.S. Forest Service, or university extension services should be able to provide assistance in suggesting possible contest areas and in selecting precise locations for each pit.

These same people or other area experts may be willing to serve as official judges as well. They should not be asked to arrange for the pits to be dug.

What Shape Should the Pits Be?

Ideally, pits should be large enough for five to eight people to get into the pit at the same time. An ideal pit would be 3-6 feet wide, 10-12 feet long at the bottom, and deep enough to see all the horizons that are to be judged.

Pits should be dug in a T-shape (see Figure A-1) with the tail of the T pointing southwest for an afternoon contest and southeast for a morning contest. This positioning takes advantage of the best light on the fact of the pit to be judged. If pits are dug on steep slopes, the tail of the T should point downhill for ease of entry. This situation, however, does not make use of the best light for viewing. Slope the tail of the T so contestants can walk down into the pit. The other two ends and sides of the pit can be vertical for observation. The pit should be 48 inches deep with a small area in one end that is at least 72 inches deep, for safety precautions.

When digging pits, try to keep both walls as straight as possible and the bottom as level as possible. If the pit has water in it, use suction plumps to keep it dry while it is being judged. Wooden pallets placed in the bottom provide a good surface to stand on while judging wet soils.

Circumstances often require the use of pits, road cuts, or stream banks that are smaller than ideal. If this is the case, there are a couple of things you can do to make it easier for the students to judge the soil.

One helpful technique is to place soil from each of the horizons to be judged into large pans. Label all pans clearly, and place them on the ground near the pit.

Students can use the soil in these pans to judge color and texture, and they can do this while others are examining the soil in the pit. They will still have to get into the pit to determine structure, coarse fragments content, horizon names and effective depth.

Rotate groups of students into and out of the pit at 5 to 10 minute intervals to give each student an equal judging opportunity. With large groups, it may be necessary to allow a longer total judging time in order to make sure that everybody has adequate time to study the soil profile.

Setting Up and Judging the Official Profile

The official judge(s) should select a single area on the face of the pit within which all decisions regarding scorecard entries will be made. This area should be about 1 1/2 to 2 feet wide, and should be plainly marked with colored ribbons on each side running from the top to the bottom of the pit. Each boundary between horizons should be marked with a tag, card, ribbon, or string.

If more than four horizons are present, place a small numbered card in the middle of each horizon for which the students are to record answers on their scorecards.

Suppose, for example, a soil has an Ap-A-E-B-C-Cr-R profile, and the students are to judge the first, third, fifth, and sixth horizons. Place card number 1 in the Ap, card number 2 in the E, card number 3 in the C, and card number 4 in the Cr.

If fewer than four horizons are present, students will normally judge each horizon in the profile. In any case, the official judges always have the right to specify which horizons are to be judged if, for any reason, they do not want students to judge a particular horizon.

It is imperative, however, that students be able to easily determine which horizons the are to judge and how the horizons marked in the soil profile correspond to the four horizons listed on the scorecard.

Contestants should use only the same kinds of resources for making decisions as are available to all students. That is, colors should be estimated according to the guidelines in the *Soil Science Student Guide* without the aid of a Munsell soil color chart. Coarse fragments should be estimated by eye rather than using a sieve, and percent slope should be estimated without the use of instruments.

The judge(s) may decide to allow more than one correct answer if the texture, color, structure, or any other property or interpretation is very close to the boundary between two choices.

Information that Must be Provided at Each Pit/Site

Each pit needs to be clearly identified, either with a letter, number, or color-coded scorecard. Post this identification in a prominent place, to minimize the possibility that students will record their answers on the wrong card for that pit/site.

Additional information that the students need for judging each pit/site include the following:

1. the upper and lower depth limits for each horizon;
2. mark off an area 100 feet by 100 feet for making slope determinations and percentage of surface fragments;
3. whether or not irrigation water is available; and
4. whether or not drainage outlets are available.

Finally, the elevations could be given for slope determination. Select an area near the pit that is to be used for judging the slope of the site. Drive two stakes into the ground, one directly down slope from the other, at a horizontal separation distance of 25, 50, or 100 feet.

Write the lower elevation on a card and tack it to the lower stake. Write the higher elevation on a card and tack it to the upper stake. Be sure that the elevation difference, when divided by the separation distances, does, in fact, calculate out to be the slope gradient intended.

Supplies and Equipment

The host should provide materials such as stakes, posters, ribbons, pumps, and pallets needed to set up the contest pits, and make arrangements for digging the soil pits. They should also have enough Scorecards and Interpretation Help Sheets on hand to provide four scorecards and one help sheet for each student. Scorecards and Interpretation Help Sheets are located in Appendix II in this guide. Additional scorecards are available from Instructional Materials Laboratory at 1-800-669-2465.

Students should come dressed for the weather and should bring field equipment necessary to judge the soil. A suggested list is:

1. warm clothing and a warm coat
2. rain gear
3. rubber boots
4. clipboard
5. clear plastic bag to cover clipboard and keep scorecards dry
6. two no. 2 pencils (don't use harder pencils, the judges won't be able to read the answers)
7. pocket knife or probing utensil
8. water bottle for moistening texture samples
9. nonprogrammable caluclator (If rules allow)

Ground Rules

At the beginning of the contest, remind all students of the rules and announce any special conditions that may also apply. Ground rules include (but aren't necessarily limited to) these eight:

1. The time allowed for judging each pit/site is 30 minutes. Local officials may extend this limit if it is necessary to allow enough time to rotate small groups into and out of the pits.
2. Allow time after each pit/site has been judged (and the scorecards have been collected) for an official judge to review the correct answers for that pit, or to review each pit with all students after the contest is completed.
3. Allow necessary time for rotation between pit/site after student judging at each pit has been completed.
4. The official profile, between the ribbons, is reserved as a reference area. It is not to be disturbed in any way by any of the contestants.
5. Discuss local conditions, and/or local deviations from the guidelines in the *Soil Science Student Guide* with each group at each pit, if necessary. Examples include specific kinds of landforms and parent materials, exceptions to drainage class criteria, etc.
6. Students must record their answers on the scorecard for each question. *Enter one and only one answer.* The official judge(s) may decide to accept more than one answer, but in no case should the students give more than a single answer.
7. If the correct answer splits a class boundary (for example, 15 percent coarse fragments, 6 inches AWC, 9 percent slope), always mark the next higher class.
8. Scorecard and Interpretation Help Sheets will be provided. Students aren't expected to memorize all the criteria required to reach a correct decision. However, they should be familiar with the proper way to *use* the tables.

Scoring

The most important rule in scoring is to do it consistently. The official judge(s) should provide a completed card for each of the contest pits, from which additional keys can be made up. The scorecards are designed so that the edge of the key card can be placed right alongside the column of answers on a contestant's card.

It doesn't matter whether you mark right answers or wrong answers, as long as everyone who is helping with the scoring does it the same way. Similarly, it doesn't matter if you total up right answers or wrong answers, as long as everyone does it the same way. In any case, each answer, on both sides of the scorecard, is worth one point.

Scorecard graders usually enter the number of points earned in each of the boxes on the scorecard. Some may prefer, however, to enter the number of points missed, and determine the outcome of the contest on the basis of the lowest, rather than the highest, score. Again, it doesn't matter, as long as it is done consistently.

If you have enough time, it is a good idea to double-check some of the scoring. After all cards have been graded and team scores have been compiled, you could rescore all cards for the top ten teams and check the arithmetic. This ensures that the ranking of the winning teams is not affected by inadvertent errors in scoring.

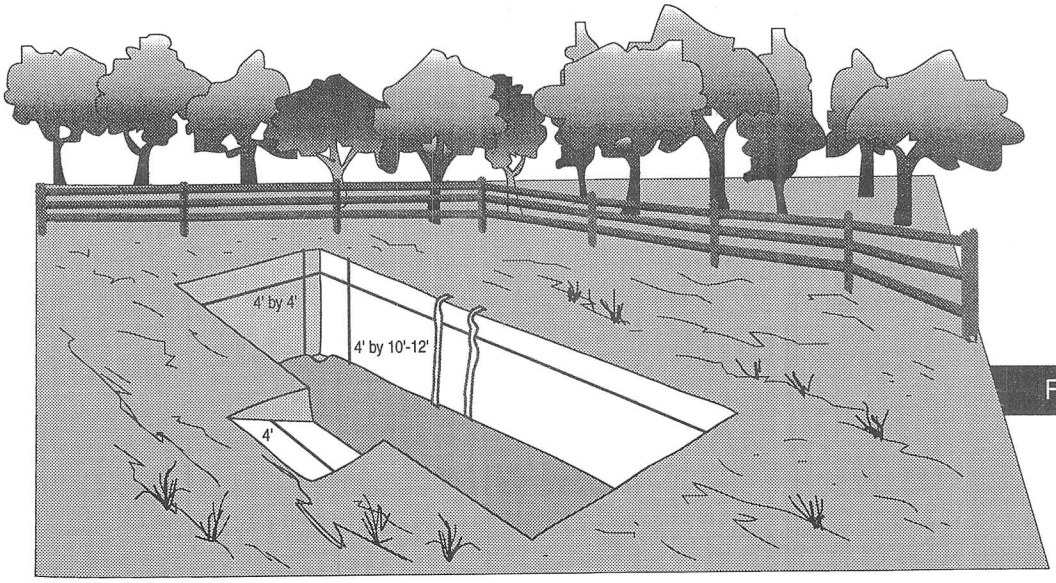


Figure A-1

Appendix II

Evaluating and Interpreting the Landscape and Soil Pedon

Competency: Evaluate the soil landscape.

Appendix II: Evaluating and Interpreting the Landscape and Soil Pedon

The first thing soil scientists do in describing a soil profile is to locate the boundaries of major horizons. Then they list the color, mottles, texture, structure, volume of rock fragments, special features and the horizon name. Except for soil texture, these are soil properties that are most obvious and can be seen. The texture, in most cases, is the most difficult soil property to determine, but can be estimated with a keen sense of feel.

To describe a soil profile:

1. Locate boundaries of major horizons. (See Chapter 6.)
2. For each horizon, determine:
   - —soil color (See Chapter 3.)
   - —mottles (See Chapter 3.)
   - —texture (See Chapter 4.)
   - —structure (See Chapter 5.)
   - —percentage of rock fragments (See Chapter 11.)
   - —special features (See Chapters 4 and 6.)
   - —name the horizon. (See Chapter 6.)

1. Locating Boundaries of Major Horizons

For most soil judging contests, the horizon boundaries will be located by the judges. This is because it is very difficult to be exact on field estimates. In differences of 1 to 3 inches, one may be as correct as another, but this would make scoring very difficult. However, students can learn how to locate horizon boundaries by following the steps listed below.

1. Look for color changes. Where there is an obvious color change, there is also a horizon change, but it may not be a master horizon change. For example, the change may be to a subordinate division of a master horizon. Color alone, however, is not sufficient to separate all horizons. Several soils in Missouri have nearly uniform colors extending all the way through the B and into the C horizon.

2. Take a knife and gently poke the soil every few inches from the surface down to the lower part of the pit. Often you can "feel" that the soil gets firmer in the subsoil and restrictive layers. You may even be able to locate a contact between B and C horizons this way.

3. Starting at the top, you should check the soil texture with your fingers every 2 to 4 inches. If there is a marked increase in clay from the A to the B horizon, or a decrease in clay from the B to the C horizon, it can be detected this way.

4. With a knife, remove a handful of soil from the upper 4 inches of soil. Carefully break it apart and observe the size, shape, and strength of the structural aggregates. Repeat this process every 4 to 6 inches down through the profile. Structural changes may be good clues to the boundaries between horizons and the presence of transition horizons.

5. Each time a tentative boundary is located, mark the depths on a scorecard or with nails on the soil profile. As more characteristics are considered, boundaries can be adjusted up or down.

6. When the initial set of boundaries has been determined, start looking more carefully at the color, texture, structure, pores, clay films, etc., of each horizon. With a complete set of information, a final adjustment in location of each horizon boundary can be made.

2. Determining Soil Properties for Each Horizon

Color - Determine the matrix color of each horizon using the four basic color groups listed. Access to a Munsell soil color book would be useful for each team to have for practice.

Mottles - Determine the abundance of all mottles: gray, brown, red, etc.

Texture - Carefully determine the texture of each horizon. This is very important because several other interpretations will be based on the texture.

Structure - Structure may be difficult to see. If in doubt, remember most cultivated A horizons are granular unless high in clay and organic matter. Most E horizons are platy, most B horizons are blocky or prismatic. C horizons are massive or single grain if sandy.

Percentage of rock fragments - Give percentage of rock fragments, 2 mm to 10 in, then give only those 3-10 in.

Special features - Fragipan or abrupt textural change.

Name the Horizon - Use the classifications of Ap, A, E, B, C, Cr, and R.

PROPERTIES OF THE WHOLE SOIL

1. **Effective rooting depth.** Cr or R horizons and fragipans are the major features.
2. **Available Water Capacity.** Use the chart for finding AWC for each texture. Do not add for fragipans or horizons below a fragipan.
3. **Permeability.** Determined by texture on the permeability chart.
4. **Internal drainage.** Determined by depth to a water table (gray matrix or gray mottles) and texture for excessively and somewhat excessively drained soils.
   a. Excessively and somewhat excessively drained soils generally are sands or sandy loams and often extremely gravelly or cobbly and the permeability is rapid or moderately rapid.
   b. Well drained to very poorly drained soil may have any texture. The drainage class is determined almost entirely by the depth to a water table. (See "Guide for internal drainage" and "Depth to water table.")
5. **Shrink-swell potential.** Determined by texture and type of clay. (See "Guide for determining shrink-swell potential.")

SITE CHARACTERISTICS

When judging the site characteristics, be very careful with slope, stoniness, and rockiness, as several management interpretations are affected by them. (See Chapter 10.)

MANAGEMENT INTERPRETATION

Match the answers given for the profile description on page 1 of the scorecard, properties of the whole soil and site characteristics with the guides for each management interpretation. If the correct answer splits a class boundary, give the next highest answer.

Figure 10.6 — Determining available water capacity (AWC)

Field Procedure for Estimating Available Water Capacity

1. Identify the horizons present in the soil profile.
2. Measure the thickness of each horizon.
3. Determine the effective depth of rooting.
4. For each horizon:
   a. Determine the texture and the rock fragment (2 mm–25 cm) content.
   b. Find the percent fine earth by subtracting:
      100% – percentage rock fragment content = percent fine earth.
   c. Use the AWC rate that corresponds to the texture of each horizon.
   d. Multiply the AWC rate by thickness of horizon by percent fine earth to determine the AWC.
5. Total the AWC for all horizons within the effective rooting depth.
6. Determine the correct AWC class.

Soil Texture	AWC Rate in Inches of Water/Inch of Soil
Sand, loamy sand	.06
Sandy loam	.12
Loam, silt loam	.20
Silty clay loam, clay loam	.20
Clay, silty clay, sandy clay, sandy clay loam	.15

AWC Class (Rates to 60 in.)	
Very low	— < 3 in.
Low	— 3 - 6 in.
Moderate	— 6 - 9 in.
High	— 9 - 12 in.
Very high	— 12 in.

Table 10.4 — Guide for Determining Soil Permeability

Texture	Structure	Permeability (inches of water/inch of soil)
Sand, loamy sand	Single grain	Rapid to very rapid (>6.0 in/in)
Sandy loam	Granular	Moderately rapid (2.0–6.0 in/in)
Loam, silt loam	Granular	Moderate (0.6–2.0 in/in)
Sandy clay loam	Blocky	Moderately slow (0.2–0.6 in/in)
Clay loam, silty clay loam	Blocky	Moderately slow (0.2–0.6 in/in)
Sandy clay	Blocky	Moderately slow (0.2–0.6 in/in)
Silty clay, clay**	Blocky	Very slow to slow (<0.2 in/in)
**NOTE: If the horizon is a fragipan, use the guide below.*		
Fragipan (weak)	Platy	Slow (0.6–0.06 in/in)
Fragipan (strong)	Platy	Very slow (<0.06 in/in)
***NOTE: If the horizon is kaolinite, use the guide below.*		
Clay, silty clay	Blocky	Moderate (0.6–2.0 in/in)

Table 10.3 — Permeability Class

Permeability Class	Water flow in moist soil (in/hr)
Very rapid	>20.0
Rapid to very rapid	6.0 – 20.0
Moderately rapid	2.0 – 6.0
Moderate	0.6 – 2.0
Moderately slow	0.2 – 0.6
Slow	0.06 – 0.2
Very slow	0.06 – 0.01
Extremely low	<0.01

Table 10.5 — Guide for Internal Drainage and Depth to WT

Drainage Class	Subsoil Color	Mottles	Depth to WT
Excessive (E)/ Somewhat excessive (SE)	Brown, red	No gray colors or mottles	>6 ft
Well (W)	Brown, red	Gray mottles below a depth of 40 in	3.5–6 ft
Moderately well (MW)	Brown, red	Gray mottles at depths of 24–40 in	2–3.5 ft
Somewhat poorly (SP)	Grayish brown, gray	Gray mottles below the A horizon	1–2 ft
Poorly (P)	Gray, black	Gleyed colors or gray mottles in the lower part of the A horizon	0–1 ft
Very poorly (VP)	Gray, black	Gleyed colors or gray mottles to the surface, depressional areas, and evidence of long periods of ponding	+1 ft

Table 13.2 — Guide for Determining the Shrink-Swell Potential

Soil Texture	Percent Clay	Shrink-Swell Rating
Sand, loamy sand, sandy loam, loam, silt loam	0–27%	Low
Silty clay loam, clay loam, sandy clay loam	27–40%	Moderate
Silty clay, clay, sandy clay	>40%	High

*Kaolinite clay loam — Low rating
** Kaolinite clay — Moderate rating

Figure 12.1 - Guide for determining artificial surface drainage

Drainage is needed for:

1. Soils that are somewhat poorly drained, poorly drained or very poorly drained, and are nearly level with depressional spots.
2. Sloping soils below seepy areas.

Table 12.1 — Irrigation Guidelines

Soil Characteristic	Asset	Liability
Surface Soil Texture	Loam, silt loam, silty clay loam, clay loam	Sands and clays
Slope	0–3%	>3%
AWC	>6 in	0–6 in
Depth to High WT	> 2 ft	0–2 ft
Permeability	>0.2 in/hr	<0.2 in/hr
Rock Fragments >3 in (surface layer)	<15%	>15%
Depth to bedrock	>40 in	0–40 in

Table 12.2 — Guide for Determining Hazards or Limitations for Cropping

Possible Hazard or Limitation	Soil Characteristics That Indicate A Hazard or Limitation Exists
Slope or Erosion	1. All land slopes longer than 90 ft in excess of 2% slope. 2. Any eroded area where the upper 6–7 in is either mixed topsoil and subsoil, mostly subsoil, or has gullies. (See Plate 32, p. 50h**.)
Available Water Capacity	Less than 10 in of available water in the upper 60 in of the profile.
Surface Drainage	High water table <2 ft and nearly level with depressional spots. Also, sloping areas below seep spots.
Internal Drainage	High water table <3.5 ft.
Rock Fragments (volume upper 10 in)	>15%
Stoniness (surface)	<100 ft apart
Rockiness	

Table 13.1 — Guide for Rating Limitations for Pond Reservoir Area

Property	Slight	Moderate	Severe
Permeability	<0.6/hr	0.6–2.0 in/hr	>2.0 in/hr
Depth to hard bedrock	>60 in	20–60 in	<20 in
Depth to soft bedrock	>60 in	40–60 in	<40 in
Slope	<3%	3–8%	>8%

Table 13.3 — Guide for Rating Limitations for Dwellings with Basements

Property	Slight	Moderate	Severe
Depth to WT	>6.0 ft	2.5–6.0 ft	<2.5 ft
Flooding	None	—	Any flooding
Shrink-Swell (thickest layer 10–60 in)	Low	Moderate	High
Slope	<8%	8–15%	>15%
Depth to Bedrock	>60 in	40–60 in	<40 in
Rock Fragments (percent > 3 in) (avg. percent volume to a depth of 40 in)	<15%	15–35%	>35%

Table 13.4 — Guide for Rating Limitations for Septic Tank Absorption Fields

Property	Slight	Moderate	Severe
Permeability (24–60 in)	2.0–6.0/hr	0.6–2.0 in/hr	<0.6 or >6 in/hr
Depth to WT	>6 ft	4–6 ft	<4 ft
Depth to Bedrock	>60 in	40–60 in	<40 in
Slope	<0–8%	8–15%	>15%
Flooding	None	—	Any flooding
Rock Fragments > 3 in (avg. percent volume to a depth of 40 in)	<15%	15–35%	>35%

Table 13.5 — Guide for Rating Limitations for Sewage Lagoons

Property	Slight	Moderate	Severe
Permeability	<0.6 in/hr	0.6–2.0 in/hr	>2.0 in/hr
Slope	<2%	2–8%	<8%
Flooding	None	—	Any flooding
Depth to WT	>5 ft	3.5–5 ft	<3.5 ft
Depth to Bedrock	<60 in	40–60 in	<40 in
Rock Fragments > 3 in (avg. percent volume to a depth of 40 in)	<15%	15–35%	>35%

INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA • COLUMBIA, MISSOURI

ATTENTION

January 1997

Re: Soil Science, Student Reference 10-5050-S

The following list contains corrections to various charts in the Soil Science student reference. Please advise your students of these changes in their books.

FIGURE		LOCATION
10.6	Determining available water capacity (AWC)	Chapter 10, Page 59

TABLES		LOCATION
10.3	Permeabliliy Class	Chapter 10, Page 60
10.4	Guide for Determining Soil Permeability	Chapter 10, Page 61
12.2	Guide for Determining Hazards or Limitation for Cropping	Chapter 12, Page 82
13.1	Guide for Rating Limitations for Pond Reservoir Area	Chapter 13, Page 86
13.2	Guide for Determining the Shrink-Swell Potential	Chapter 13, Page86
13.4	Guide for Rating Limitations for Septic Tank Absorption Fields	Chapter 13, Page 89
13.5	Guide for Rating Limitations for Sewage Lagoons	Chapter 13, Page 90

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*Figure 10.6 — Determining available water capacity (AWC)

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   a. Determine the texture and the rock fragment (2 mm–25 cm) content.
   b. Find the percent fine earth by subtracting:
      100% – percentage rock fragment content = percent fine earth.
   c. Use the AWC rate that corresponds to the texture of each horizon.
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6. Determine the correct AWC class.

Soil Texture	AWC Rate in Inches of Water/Inch of Soil
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Sandy loam	.12
Loam, silt loam	.22
Silty clay loam, clay loam	.17
Silty clay, sandy clay	.12
Sandy clay loam	.15
Clay	.09

AWC Class (Rates to 60 in.)	
Very low	— < 3 in.
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Sandy clay loam	Blocky	Moderately slow (0.2–0.6 in/hr)
Clay loam, silty clay loam	Blocky	Moderately slow (0.2–0.6 in/hr)
Sandy clay	Blocky	Moderately slow (0.2–0.6 in/hr)
Silty clay, clay**	Blocky	Very slow and slow (<0.2 in/hr)
**NOTE: If the horizon is a fragipan, use the guide below.*		
Fragipan (weak)	Platy	Slow (0.6–0.06 in/hr)
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***NOTE: If the horizon is kaolinite, use the guide below.*		
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Rapid	6.0 – 20.0
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Moderate	0.6 – 2.0
Moderately slow	0.2 – 0.6
Slow	0.06 – 0.2
Very slow	.01 – .06
Extremely slow	<0.01

* Figure or Table has been adjusted and may not match the IML curriculum guide and student handbook.

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** Kaolinite clay — Moderate rating

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AWC	>6 in	0–6 in
Depth to High WT	> 2 ft	0–2 ft
Permeability	>0.2 in/hr	<0.2 in/hr
Rock Fragments >3 in (surface layer)	<15%	>15%
Depth to bedrock	>40 in	0–40 in

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Available Water Capacity	Less than 10 in of available water in the upper 60 in of the profile.
Surface Drainage	High water table <2 ft and nearly level with depressional spots. Also, sloping areas below seep spots.
Internal Drainage	High water table <3.5 ft.
Rock Fragments (volume upper 10 in)	>15%
Stoniness (surface)	Stones <100 ft apart
Rockiness	10 sq. ft. of rock outcrop per 10,000 sq. ft. of area

Table 13.1 — Guide for Rating Limitations for Pond Reservoir Area

Property	Slight	Moderate	Severe
Permeability	<0.6 in/hr	0.6–2.0 in/hr	>2.0 in/hr
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Slope	<8%	8–15%	>15%
Depth to Bedrock	>60 in	40–60 in	<40 in
Rock Fragments (percent > 3 in) (avg. percent volume to a depth of 40 in)	<15%	15–35%	>35%

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Property	Slight	Moderate	Severe
Permeability (24–60 in)	2.0–6.0 in/hr	0.6–2.0 in/hr	<0.6 or >6 in/hr
Depth to WT	>6 ft	4–6 ft	<4 ft
Depth to Bedrock	>60 in	40–60 in	<40 in
Slope	<0–8%	8–15%	>15%
Flooding	None	—	Any flooding
Rock Fragments > 3 in (avg. percent volume to a depth of 40 in)	<15%	15–35%	>35%

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Property	Slight	Moderate	Severe
Permeability	<0.6 in/hr	0.6–2.0 in/hr	>2.0 in/hr
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