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The Ground We Walk On: An Effective Analogy for Exploring Soil Characteristics

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THE GROUND WE WALK ON

Photo by Joe Taylor

An Effective Analogy for Exploring Soil Characteristics

by **Sally Wilson** and **Meher Vani Bojja**

ABSTRACT: Soil is common to all of us, so common that few people think about it and its importance in our everyday lives. The activity presented here provides an analogy useful for helping students design experiments and explore how soil particle size affects its behavior. Originally a simple "cookbook" demonstration for community college students, we restructured it to be more inquiry oriented so that it mentally engages students and promotes several important goals for science teaching. We believe the modified activity is applicable across a broad grade/age range, perhaps from upper elementary to some introductory post-secondary science courses. This activity promotes National Science Education Content Standards A,B,D, and E, and Iowa Teaching Standards 2, 3, 4 and 6.

Everyone knows something about soil, but how many of us really care about what's underneath our feet? About one fourth of our planet Earth is covered with diverse types of soil from which almost all our food is derived. Soil is home to many organisms, and is an integral component of most ecosystems and their many cycles - hydrologic, geologic, nutrient, and others. Because soil is something that everyone has some familiarity with, this topic is accessible to students with a broad range of experiences and abilities. Soil is user friendly.

Most people, regardless of background, have made mud pies or sand castles or played in the dirt at some time in their life. These simple experiences are enough to equip them for the suggested activities in this article. This activity also demonstrates that science can be made less complex and helps students understand that investigations can be done with materials easily within their reach.

The original idea for this activity came from a demonstration we found on-line at http://www.conservationinformation.org/publications/EdibleSoilCompactionDemo.pdf. We restructured this activity into an inquiry-based experience that reflects the learning cycle (Colburn & Clough, 1997), starting instruction with a concrete experience, moving into concept development and finally applying new knowledge. The modified activity more effectively encourages mental engagement and promotes a deeper understanding of the targeted content.

Engaging Students

We begin "exploring" with a group discussion. We ask the question, "What types of things would you look for when observing and trying to describe soil?" To engage students and keep them involved, teachers must use positive non-verbal behaviors and wait-time I & II to illicit as much information from the group as possible (Rowe, M.B. 1974a, 1974b, 1986). By assessing students' prior thinking, teachers can identify misconceptions, evaluate the experience level of the students and gain student "buy-in" by encouraging more students to participate. This information will also help teachers ask questions at appropriate levels of difficulty to help build or scaffold student understanding (Clough, 2007). We find it valuable to write down information the students share on the board. Be careful to use the words that students are using rather than paraphrasing what they say. Using students' words conveys that you value their contributions and it begins instruction at their current level of vocabulary. This invariably leads to more sharing of ideas, and future scaffolding can improve and extend students' vocabulary and expression of ideas.

After noting and discussing students' initial ideas, have students look at a variety of actual soil samples. You can provide these samples, invite students to bring in a sample that they are interested in investigating, or you can go out for a little field trip and collect some soil samples. Make sure you have a variety of textures including the four basic texture types, sand, clay, silt and loam. Use guiding questions to remind them of the ways they can make observations about soil, using all their senses. By guiding students toward ways to observe the soil, rather than simply telling students what to do, students must think! Encourage the students to handle the soil. Listen carefully to how students describe the samples. We think you will be amazed at how this "exploratory" experience along with effective questions and wait-time will generate more participation, precise observations, and information from students.

Challenge the students to make comparisons with a question such as "What differences do you notice in these samples?" Some students may suggest color, moisture content, feel or texture. Some might even come up with particle size. Any of these ideas can lead to further learning, but we are focusing on particle size in this activity. If they don't hit on particle size, try some guiding questions, such as "What else can you tell me about the way soil feels?," or "How do you explain the differences in the texture of our soil samples?" Keep your probing open-ended and thought-provoking by using initiatory words like "how," "what," "explain" and "elaborate," rather than "can," "is," "did," or "will."

Developing Concepts through Student Investigations

Creating and observing "soils"

Begin the investigation by having students consider the following questions:

- If you were going to try to identify soils or classify them, what criteria would you use?
- What characteristics would allow you to differentiate these samples?
- What is the purpose of soil?
- Who would want to know about soil and why?
- What are some things that are affected by soil?

Have students write their ideas in their notebooks or science journal. You might then choose to have students share their initial ideas in a class brainstorming session. To engage students in answering these kinds of question we offer them some materials to “create” a soil and learn about its behavior. We provide cocoa rice crisp cereal, clear plastic containers (9 oz. drink tumblers work well), milk, water, graduated cylinders, or measuring cups (e.g. watering cans, baby powder bottles with small holes in the lids, etc.), rolling pins, zipper plastic bags, scales, and spoons.

We tell students, “Here are materials you can use to create a 'soil' to learn about how soil behaves.” And then we ask, “What characteristics do these materials have that make them useful for modeling soil?” Some answers we often hear include, “The cereal is dark colored like soil,” “The milk is white so it is easier to see it when you pour it on “cereal soil,” “Cereal soaks up milk like soil soaks up water,” and “The cereal can be crushed to make it different textures”.

Next have students form pairs to “create” some soils and observe how they behave. We ask them to note their observations on white boards or large pieces of newsprint for sharing with the other groups. Encourage students to perform inquiries with their “cereal” soil that they might do with a real soil – crushing the soil, mixing the soil with liquids, packing the soil, etc. Walk around observing and listening to students, and encourage purposeful investigations by asking students to explain their rationale for particular actions and decisions. Provide at least 15 minutes and check often with each group on their progress. Probe students’ thinking by asking questions such as “What characteristics are you observing?”, or “How are you 'creating' or changing your soil?” Provide as much time as you deem necessary for students to complete their work.

Now begin a whole class discussion by asking students “What are the characteristics of your samples?” You may hear them note that the crushed cereals are soggier and stickier. This observation brings up a good opportunity to focus students on particle size by asking a question such as, “What difference might explain the change in behavior of your cereal?” Have students share other observations about their “cereal soil” and be sure to encourage all groups to contribute. Ask the students what characteristics of the “cereal soil” can be manipulated or modified to show how real soil might behave. Teachers might also add to the list of observations students made about real soil by asking, “What new insight have you gained about soil from this experience you could not or would not have gained with real soil?” Write these ideas on the board.

Investigating “soil” behavior

Next we have the students suggest some further experimental designs to collect even more data on “cereal soil” behavior. By having students first investigate their “cereal soil” and then discuss more or new ways to go about investigating, we illustrate how science builds on prior work and is affected by what scientists currently think and what is currently known about a subject.

We want students to notice that cereal particle size has an impact on “cereal soil” behavior. Usually some groups will have crushed some cereal to see what happens. Use guiding questions to make sure that at least one group looks at the effects of particle size on “cereal soil” interactions with either milk or water. Others may prefer to look at types of liquids and how they interact with the soil, or compare two types of different cereals. With effective questions by the teacher, these students can be encouraged to connect their observations to particle size as well. Try to focus the group on the variable of particle size by asking questions like, “Why do you think a crushed cereal will interact differently with liquids than a whole cereal? What kind of an investigation would help you answer that question?”

At some point the group should discuss establishing parameters for their experiments. Ask the students what things they need to keep in mind when doing experiments and collecting data. These kinds of questions encourage students to mentally engage in and practice the process of scientific inquiry. Depending on their past experiences in your class, students may suggest things such as use of a control, variables, dependent and independent variables, ways to *record* data such as tables, ways to *display* data such as charts and graphs, quantitative and qualitative data, etc. We take this valuable opportunity to reinforce the multitude of decisions scientists must make when investigating natural phenomena, the creativity required, and that no universal step-by-step scientific method exists.

This is a convenient stopping point if you need to wait until another class meeting time to complete this exercise. Before permitting students to begin their investigations, emphasize the expectations of proper laboratory conduct. Ask students to summarize the purpose of the activity, and make clear the importance of their investigations for learning about the behavior of soil. These proactive steps, along with consistent monitoring and interaction with students, maintain the desired productive learning environment.

Now the ground is set for students to investigate. Students enjoy the freedom to explore and are engaged mentally and physically setting up and running tests, and recording results on their whiteboards or newsprint to share with their "colleagues" when done. Again, teachers must visit groups, observing and listening to what they are doing and interject when necessary to promote further needed investigation. Where appropriate, using relevant professional vocabulary helps to establish the validity and seriousness of the activity, and conveys to students the value of their investigations.

Once again return to the large group format and have students share their results, interpretations of the data they collected, and possible conclusions. At this point, students will often have begun noticing finer differences that result from varying particle sizes. We have heard students say that "the 'cereal soil' in this plastic bag feels like clay" when commenting on the cereal that had been finely crushed and mixed with milk or water. Other comments relate information about the rates of flow for milk or water in "cereal soil." For example:

- "Uncrushed cereal allowed liquids to pass through rapidly and some uncrushed cereal floated on the surface of the liquid."
- "Semi-crushed cereal had a more even distribution of liquid."
- "Finely crushed cereal forming layers didn't allow liquid to absorb for a long time and was sticky and soggy. After the finely crushed cereal had absorbed the liquid, it didn't appear that it would dry out for a long time."

These observations create the perfect opportunity to introduce soil science concepts and terminology and to discuss some applied soil science. Ask, "What types of environments or soils would behave like the uncrushed cereal?" The students may respond, "sandy or gravel-like soils" or they may say "deserts or beaches". A follow-up question might be, "In what ways is the uncrushed 'cereal soil' like a sandy soil?" A possible student response might be, "The particles are the largest, and spaces between are the biggest so fluids flow right through." Help the students identify more characteristics of these "cereal soils" based on particle size.

During this concept development phase, teachers should strive to ask questions that help students make connections between what they are observing and the desired learning outcome. Through use of questions, wait-time, positive non-verbal behaviors, and follow-up probing questions, teachers can gain insight into the connections students are making and where they are struggling. From this insight, teachers can help students make desired connections and, use their concrete experiences to target persistent misconceptions.

Connecting Students' Knowledge to Scientific Knowledge

Now is the time to introduce information and terminology relevant to what students have experienced and learned. Presenting accepted scientific ideas to students is important, and should be done purposefully when students are in a position to make sense of that information. For instance, students' experiences and the teacher's effort to help them make sense of those experiences has prepared students to understand a Piper Diagram of Soil Textures (Figure 1), and terms such as sand, clay, silt and loam to describe soil particle composition. This diagram may be found in many textbooks and on-line by searching with the key words of *soil texture*. Seeing how their observations and interpretations are connected to accepted scientific knowledge builds both understanding and confidence.

After you have engaged students in interpreting Figure 1, you might have them conduct a standard soil texture test, such as a ribbon test, thread or roll test. These tests are also easily found in soil, environmental, and agricultural textbooks and web sites. We like the diagram in Figure 2, but several others exist. You might have students practice a texture test on some of the real soil samples. A possible extension activity might be to have students create a diagram similar to Figure 2 for their "cereal soils."

Mentally engage students with these new ideas by asking them questions such as the following, “How would different soils behave in a light drizzle, moderate rain, or heavy downpour?,” “Why might some soils wash away and others not?,” “Why would some soils hold more moisture than others?,” and “What texture of soil would be best for gardens or farms?” Have them elaborate on their answers. Some may have the insight that vegetation will affect soil erosion. Getting students to the idea of building soil with organic matter is a bit more difficult, but when the idea of vegetation emerges, use questions to guide them toward the idea of the living components of soil - decomposing matter and organisms that help form soil materials.

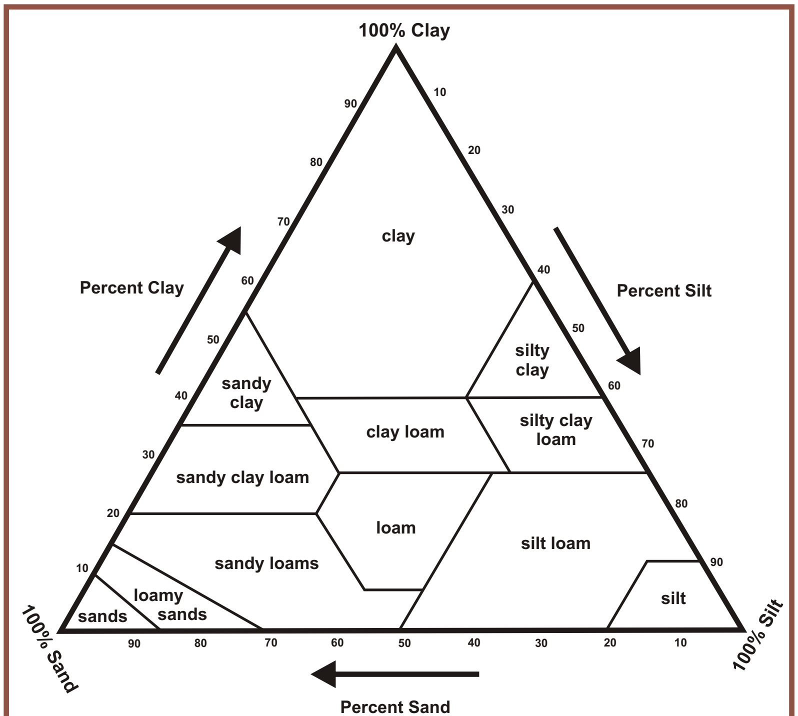

Figure 1. Piper Diagram of soil textures.

Graphic by Joe Taylor

To extend learning at this point, a good video to use is *Life in the Soil*. The video is a bit difficult to get, but worth the effort. You might request your Area Education Agency purchase the video if you don't have the resources. There are also some excellent vermiculture (worm composting) videos available (see the reference section). We recommend that you stop the videos periodically as they touch on terms or concepts you particularly want the students to grasp, asking questions and drawing students' attention to key details. Many other valuable resources are available by searching on-line.

Application to Real World Issues

Discussion should now turn to connecting students' emerging understanding of soil to relevant societal issues. To begin, you might ask questions such as, “What are some ways that real soil particle sizes might change?,” “What are some natural and unnatural occurrences that might affect soil texture and/or behavior?,” “What are ways people manipulate or change soil?,” “What are some negative and some positive consequences of changing soil particle size?” The students may be inclined to only refer to their experiences in the activity, but application means using what they learned in new situations. Help them make the connection to authentic everyday issues such as run-off, erosion, hard-pan, etc. Encourage students to dig deeper with questions such as, “What might happen if top soil is washed off?,” “After being washed off what stays behind?,” “What comprises the topsoil?,” “Why do you think topsoil is important?,” or “What are some ways we can build soils or help ecosystems build soil?” Planting pits or “zai holes” is an interesting project relevant to soil quality that is taking place in the Sahel Region in Africa. Information about zai hole plantings and their associated insect communities is at http://www.salon.com/tech/htww/2006/10/04/zai_holes/index.html. Teachers might tie the zai hole project in Africa to the many factors that make for healthy soil.

Final Thoughts

This learning cycle approach to teaching about soil engages students, promotes understanding of important concepts, and opens minds to the importance of soil and humanity's role as soil stewards. This activity lays the groundwork to discuss current issues such as corn-based ethanol as a fuel. What consequences might we face for mining our soils for fuel instead of food? While this subject sounds simple, soil underlies many issues that concern humanity. Soil composition directly connects with many basic problems that we are facing today soil erosion, landslides, drought, climate effects, ground water contamination, land use issues and conflicts, food and fuel production, etc. There is much more to soil than meets the eye. Instead of saying the sky's the limit; we could actually say the soil's the limit.

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Life in the Soil Video. World Sustainable Agriculture Association. 3510 Nuuanu Pali Drive. Honolulu, HI 96817. (808) 595-6344. (808) 595-8014 FAX . E-mail: moahawaii@lava.net

Wormania, 26 minutes with 48 p. teacher guide or Worm Bin Creatures Alive Through a Microscope Videos. Http://www.wormwoman.com. ISBN: 0-942256-09-3.

Testing Soil Texture

Take a good teaspoon of soil from a representative part of the garden or field. Remove any stones, roots, or other pieces of unrotted organic matter. Moisten the sample until it reaches its maximum cohesion. In other words, if it will form into a ball, get it to the moisture content and consistency at which it will form the strongest ball possible.

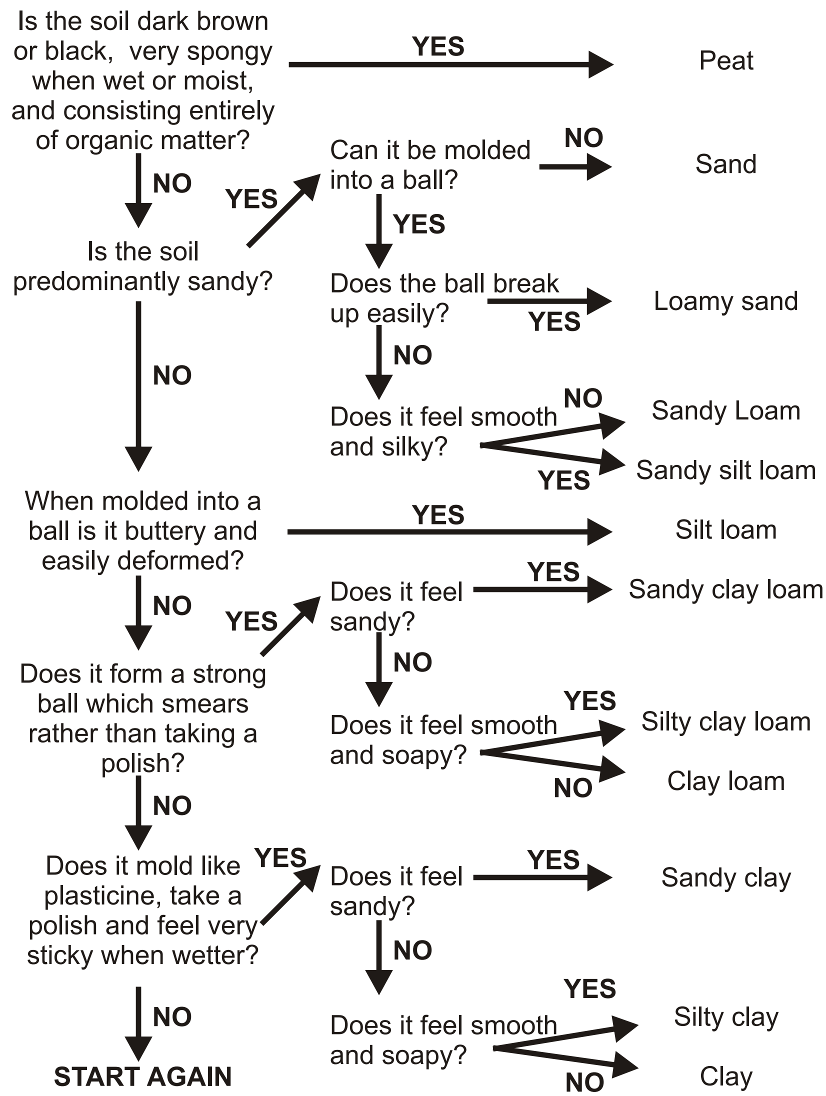

Figure 2. **Soil Textures Test**

Graphic by Joe Taylor

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