POROSITY – Teacher Notes

Grade Level Appropriateness

As presented in this set of activities, the lessons are designed for middle school or high school. With a little imagination, teachers of younger students can make some modifications that still teach the concepts.

- For porosity tests, younger students could fill clear cups or beakers with sand (or pea gravel, etc.). Next, they can measure a volume of water, and then carefully pour the water into the cup until the sand is covered. This can be repeated for each size particle. Then, students can compare the amounts of water it took to cover the same volumes of these different materials.
- For permeability tests, a short plastic column or a clear plastic cup with its bottom cut out will suffice. Glue a screen or piece of muslin cloth over the bottom opening. Have one student hold the cup over a catch pan while another student pours a measured amount of water (standard or non-standard measure) into the earth material. As soon as the pouring begins, have students begin counting, and continue counting until no more water drips from the cup. Students can then compare their "counts" for fine sand to their counts for pea gravel, etc.
- For retention tests, you can have students repeat the procedures for the porosity test, but then pour out water (through a screen, for example) and compare the amount of water that was poured into the earth material with the amount that was poured out. The younger students may not be able to measure this accurately, but should be able to easily see the differing amounts of water that is poured out from each earth material cup.
* For capillarity tests, a short plastic column or a clear plastic cup with its bottom cut out will suffice. Glue a screen or piece of muslin cloth over the bottom opening. Have students fill the column/cup with earth material, and then lower the screened end into a pie pan or beaker of water and hold it for a couple of minutes and observe what happens. The students should be able to see the water wicking up through the particles of the earth material, and then compare how far up into the column/cup the water seems to move.

Related Activities to Consider

A related activity looking at sedimentation rates can easily be done by filling the plastic columns with water and having students carefully drop particles (beads or sand, etc.) in the tops and timing how long it takes for the particles to settle to the bottom of the tube. If students pour in 10 mL amounts of sediments of differing sizes, it is easy to see how the materials self-sort and separate to form distinct layers in the bottom of the column. This can be modified for use with younger students by having them do essentially the same thing with soil, sand, pea gravel, etc. in clear plastic cups or tumblers.

The Model

Remember that the plastic columns (or their alternatives) are models of soil and rock profiles in the actual earth. You may find it helpful to guide students to view photos of actual soil profiles, or to see some exposed profiles, where you can point out the different layers and how the characteristics of those layers differ (e.g. coarseness of particles, size of particles, kinds of particles, etc.). It is important that students relate what they are seeing in the plastic columns with what goes on in the surface layers of the earth.

Cost Considerations

The versions we are sharing of the activities on porosity, permeability, retention, and capillarity of earth materials make use of some commercially-produced materials such as the plastic column kit. You can obtain plastic column kits from various science suppliers either through hard copy or internet catalogs. Commercially-available plastic column kits typically include the heavy duty (thick-walled) plastic column (82.55 cm long), a flexible end cap with a short hose extension, a small screen that fits inside the column (to prevent small particles from escaping the bottom when drained), a pinch clamp for the drain tube, and plastic beads of varying sizes (4 mm, 7mm, and 12 mm diameters). Costs for a single column set without

any of the beads is typically less than $20 USD, and with the beads is about $65 USD. If you order the kits with the beads, you receive 500 mL of each size of bead. Individual canisters of beads cost around $25 to $65, depending upon the size of beads you want. The manufacturer often tells buyers that one 500 mL container of beads is sufficient to supply the needs of 5 plastic columns. A class set of columns and beads (n = 15 units) costs around $375 USD.

There are alternatives to consider when seeking the equipment for these activities, and these alternatives can save you money, but require you to do some advanced legwork.

- **Beads Versus Earth Materials:** First, the beads can be replaced with actual earth materials, such as very fine white silica sand, coarse sand, pea gravel, etc. Some teachers have even used small and large marbles in lieu of the beads. The advantages of these substitutions include the fact that students are working with the same kind of earth materials that are actually found in the ground and near aquifers. This eliminates another cognitive step for students in mentally need to correlate the plastic beads with corresponding earth materials. Another advantage is their ready availability on short notice, and their cost. A disadvantage is that the plastic beads are easily dried and can quickly be reused, whereas the earth materials (sand, pea gravel, etc.) may require days to dry once used.

- **Plastic Column:** The commercially-made plastic column is very sturdy. However, there are suitable substitutes available, but they are not nearly as sturdy. For example, you can go to a home improvement or lighting store and purchase plastic tubes used to protect expended tube fluorescent light bulbs. These are clear plastic, and the ends can be cut off to eliminate the holes in the tube sides near the ends. The diameter of these tubes is also suited to fit larger sized rubber stoppers you may already have in your science supplies. Hardware stores sell screen repair kits, and you can cut the screen to size and shape to fit the end of one of these tubes. A similar alternative is plastic mailing tubes, although most mailing tubes tend to be cardboard nowadays. Both of the tubes mentioned above can be held in burette clamps on a ring stand. Yet another alternative is to make use of one liter (even two liter) clear plastic soda bottles. Simply cut the “bubble” or bottom end off the bottle. A piece of screen can be glued into the inside of the bottle to cover the neck. The bottle’s neck is narrow enough so that they likely fit rubber stoppers you already have on hand. This configuration can be attached to a ring clamp by using a burette clamp to hold the neck and using a ring clamp to steady the upper (cut-off) end of the bottle. For any of these alternative column ideas, the stopper used needs to be a one-hole stopper into which you can insert a short piece of glass or plastic tubing, onto which you can then connect a 10 cm length of rubber or vinyl tubing (that you can clamp closed using a pinch clamp). The advantages of these alternatives include their much-reduced cost compared to the commercial columns. Their disadvantages include the extra work you must do to make them, their thinner wall sides (less sturdiness), and sometimes a shorter length.