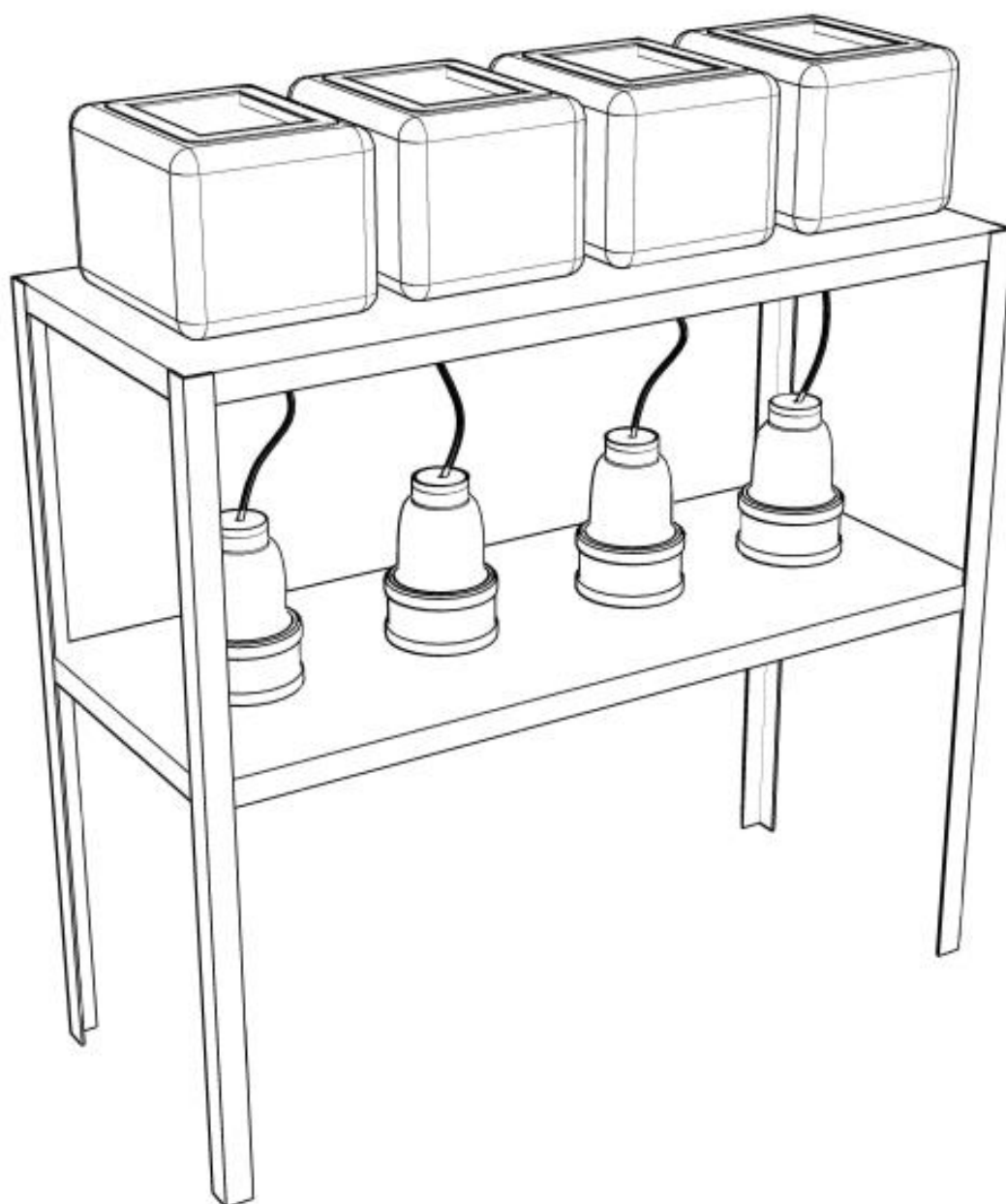


Building the Cool City Lab



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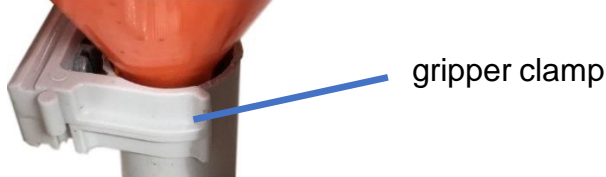
1. The Cool City Lab

Even during short walks in the city, you can experience that it feels differently warm at different places. With the Cool City Lab, we want to explore this. It is about the question "Why does it feel warmer or colder in some places in the city than in others?". If you look at different places in the city, you notice that the ground also looks different. Sometimes the surface it is almost white, as for example light-colored stones, sometimes it is black, as for example a tarred surface. With the Cool City Lab, we can investigate whether and how the temperatures are related to the surfaces sand, stones, tar and grass. This manual explains how to build the Cool City Lab.



2. List of materials

1. 4 Polystyrene **boxes**, external dimensions: length 26 cm, width 21 cm height 18 cm.
2. Metal **shelf**, roughly in the proportions: width 100 cm, depth 40 cm, height 90 cm. In this manual, it is a boltless shelf from the hardware store.
3. 4 simple plastic **funnels**: diameter at the top about 7.5 cm.
The outlet at the bottom must have a suitable dimension to either fit into the hose from point 9. or onto it.
4. **Bolts**: 4x M4x20 with 4 nuts, 8x M8x40 with 8 nuts and 8 suitable washers.
5. 4 plastic **tubes** (e.g. cable conduit), dimension: length 7 cm, outer diameter 2 cm.
6. 4 gripper **clamps**, fitting the outside of the plastic tube in point 5.

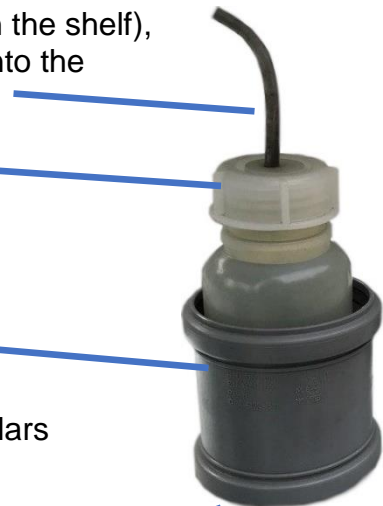


7. 4 **wood strips**, measures depending on the polystyrene box: length 30 cm, width 2 cm, thickness 0.5 cm.
8. **Wire**: 4 pieces of simple florist wire: length ca. 10 cm.
9. 4 **hoses**, dimensions: length 40 cm (depending on the shelf), outer diameter about 1 cm (suitable to fit into or onto the outlet of the funnel from point 3).

10. 4 wide-mouth **bottles** with a capacity of 1 liter.

11. 4 sewer pipe **collars**

12. 4 sewer pipe **socket plugs**, for the sewer pipe collars in point 11.



13. 12 aluminum take-away **containers**, dimensions of about: length 22 cm, width 17 cm, height 3 cm. The base area must be smaller than the lid of the polystyrene boxes from no. 1.

14. Acrylic **paint** in black, red, and green.

15.4 **temperature probes.**

16. Light **stones** (often named decorative or ornamental gravel in a hardware store), they can be relatively large.

17. Potting **soil** and grass **seeds**

18. **Asphalt** (often you can get it from a road construction site if you ask nicely; asphalt may also be bought at a hardware store but make sure, it is really asphalt and not bitumen)

19. **Sand** (e.g. playground sand from the hardware store)



3. The Boxes

In the end, the four boxes will be placed on the top shelf. They will be covered with different materials (grass, asphalt, stones, sand). Inside the boxes, effects of the different coverings will be measured.

You need:

Material: The 4 polystyrene boxes, the aluminum take-away containers and the acrylic paint.

Tools: A sharp knife, a pen, a tape measure or folding rule, a brush, and a cordless screwdriver with an 8 mm drill bit.

You do:

At first, you paint the boxes.

1. You take the brush and paint the first box black, the second one green, and the third one red. In between, you have to wash the brush. The last box stays white.

After the paint has dried, the aluminum containers will be placed in the lid of the polystyrene boxes.

2. Measure an aluminum container. Since it will be placed in the lid of the polystyrene box, you only measure the container itself, without the folded edge.
3. Draw a rectangle in the measured dimensions on the lid of a polystyrene box. You can also use the bottom of the aluminum container as a template and draw its outline (note that the containers usually get bigger towards the top). Then cut out the opening for the container with a knife.
4. Stack three aluminum containers to give them more stability. Drill a hole through the bottom in the middle of the containers with the 8 mm drill bit or use the knife.
5. Place the stack of three aluminum containers in the hole in the lid of the polystyrene box.

Repeat steps 3 through 5 with all four boxes. The lids will look like in the picture.



4. The inside of the boxes

The next step is to prepare the inside of the boxes. The water that comes through the hole in the aluminum container will be collected with a funnel and stored in a bottle.

You need:

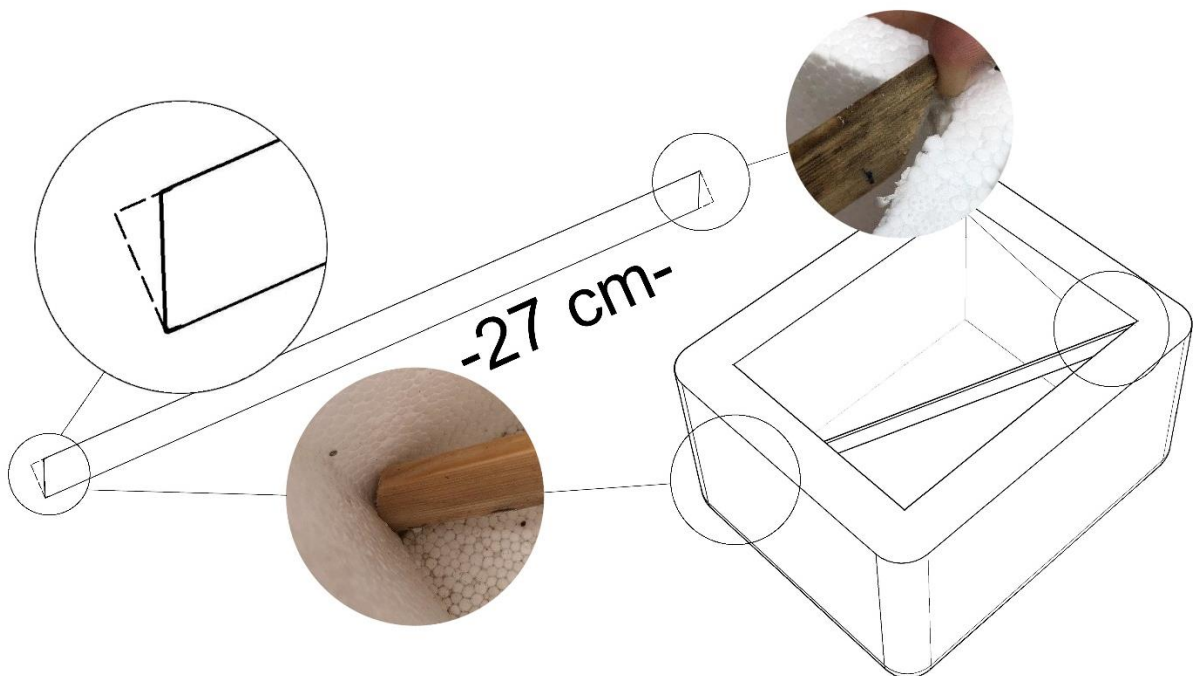
Material: The funnels, the fitting plastic hoses, the wood strips, the bolts M4x20 with nuts, the 2 cm plastic tubes, the fitting gripper clamps, and the wire.

Tools: A saw, a pen, a tape measure or folding rule, a cordless screwdriver with 4 mm and 10 mm drill bits (or with the same diameter as your hose), and a fine saw.

You do:

1. Measure the diagonal of your polystyrene box, i.e. from the bottom front corner to the top back corner, diagonally through the whole box. This is the longest distance you can measure in the box.
2. Saw the wooden strip on this length.
3. Saw off a corner on both sides of the wooden strip, as shown in the picture below, so that it has the shape of a parallelogram and fits into your polystyrene box.

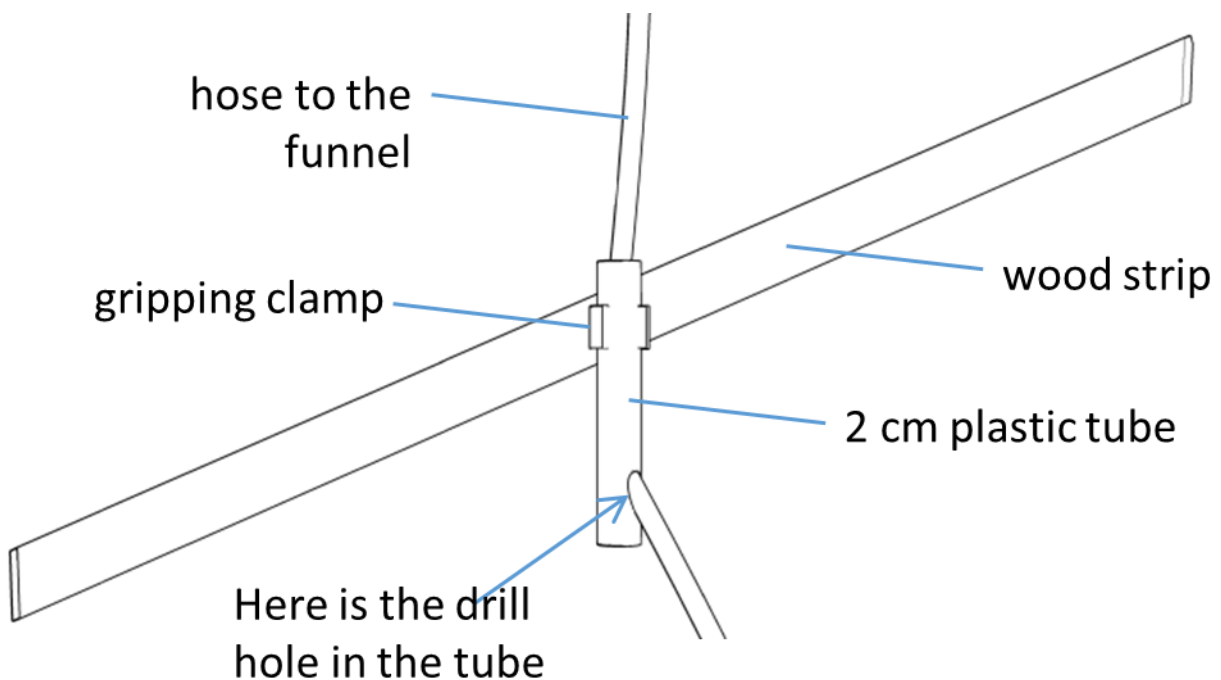
Repeat steps 2 and 3 until you have strips for all four boxes.



The tube that will hold the funnel, will be attached to the wooden strip

4. Drill a hole in the middle of the wooden strip with a 4 mm drill bit and attach the gripper clamp with the M4x20 bolt and the appropriate nut at this point.
5. Cut the 2 cm plastic tube to a length of about 7 cm with the fine saw. You might have to adjust the length a bit later.
6. Drill a hole in the bottom part of the tube with the 10 mm drill bit (or with a drill bit that suits the diameter of you hose) and thread the hose through this hole. Look at the illustration and the photo below to understand better, what is meant.
7. Put everything together, i.e. put the hose into the plastic tube and through the hole, the tube into the gripping clamp and then the wooden strip with the plastic tube into the polystyrene box.
8. On the bottom of the polystyrene box mark where the hose that comes out of the tube will go through the bottom of the box.
9. Drill a hole with the 10 mm drill bit (or with a drill bit that suits the diameter of you hose) through the bottom of the box. Thread the hose through the hole so that it sticks out of the box at the bottom.

Repeat these steps with all four boxes.



Then, the funnel will be attached to your construction.

10. Insert the outlet of the funnel into or onto the hose that sticks out of the top of the plastic tube. If the diameters are fitting correctly, the connection will be tight and firm.

Again, repeat this step for all four boxes.

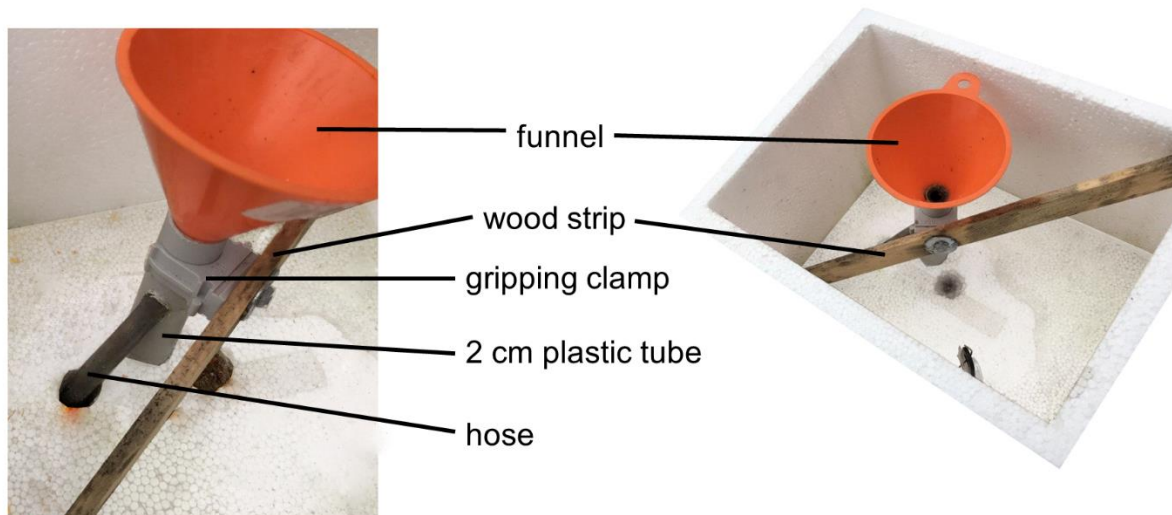
Finally, you have to build the hanger for the temperature probe.

11. Bend a piece of wire so that you can insert one end into the wall of the polystyrene box from the inside. In the other end of the wire, you bend a small hook so that you can hang the temperature probe on it.

The important thing is that the temperature probe itself hangs in the air and does not touch anything so that it measures the air temperature and not the temperature of a surface.

Repeat this step for all four boxes.

Now you can assemble everything, it should look somehow like in the picture below.



5. Mounting the boxes to the shelf

The completed boxes can now be mounted to your metal shelf. The boxes will be attached to the shelf with a bolt going right through the bottom of the box and the shelf.

You need:

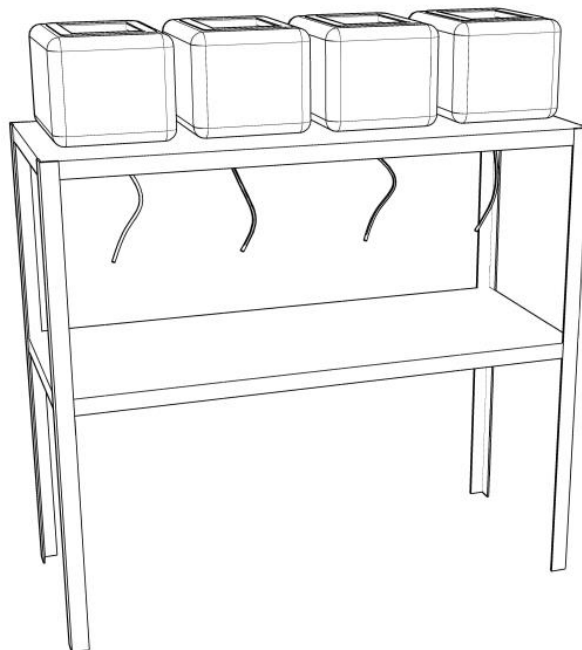
Material: The metal shelf and the M8x40 bolts with nuts and washers.

Tools: An 8 mm wrench for the M8x40 bolts and a cordless screwdriver with 8 mm and 10 mm (or with the same diameter as your hose) drill bits. Use metal drill bits to drill through the shelf.

You do:

1. Assemble the shelf according to the manufacturer's instructions. It should look similar to the picture below.
2. Place the boxes at equal distances on top of the shelf. To do this, you have to pull the tubes out of the hole in the bottom of the boxes again.
3. Drill a hole through the bottom of the polystyrene box and the metal shelf with the 8 mm drill bit, but not too close to the position where the plastic tube rests.
4. Thread the washer onto the M8x40 bolt and insert it from above into the hole you have just drilled.
5. Fix the box to the shelf with the bolt and the matching nut from below.
6. Use the 10 mm drill bit (or with the same diameter as your hose) to extend the hole for the hose in the bottom of the box through the shelf.
7. Put the hose back through the hole so that it now sticks out of the bottom of the shelf.

Repeat steps 2 to 7 for all four boxes.



6. The seepage water collection bottles

The water that seeps through the content of the aluminum container into the funnel will be collected in bottles on the bottom shelf.

You need:

Material: The wide-mouth bottles, the sewer pipe collars and socket plugs, and the M8x40 bolts with nuts and washers.

Tools: A wrench for the M8x40 bolts and a cordless screwdriver with 8 mm and 10 mm (or with the same diameter as your hose) drill bits. Use metal drill bits to drill through the shelf. You will need a measuring cup and a waterproof foil pen if the wide-mouth bottles do not have scales for reading the amount of water.

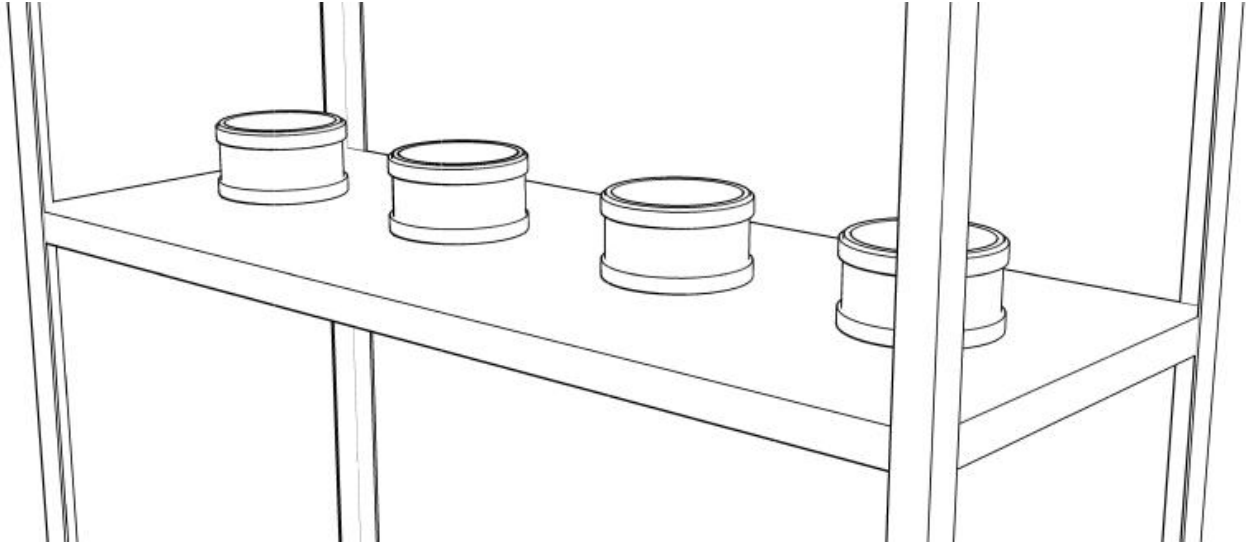
You do:

The sewer pipe collars and socket plugs become bottle holders for the seepage water collection bottles as shown on the illustration below.

1. First, check whether the wide-mouth bottles have scales for reading the amount of water. If not, fill in water from the measuring cup in steps of 50 ml and mark the water level with a line on the bottle using the waterproof foil pen. Note the amount of water next to the line. You might have to use a different amount of water per filling step. This depends on the size and shape of the bottle.
2. Drill a hole in the middle of the sewer pipe socket plug with the 8 mm drill bit.
3. On the lower shelf, mark the position in middle under one of the boxes.
4. Drill through the shelf at the mark using the 8 mm drill bit.
5. Put the sewer pipe collar onto the lower shelf so that the holes align. Thread a washer onto the M8x40 bolt and insert it through the socket plug from above into the hole you have just drilled. Tighten the bolt with a nut from below.
6. Put the sewer pipe collar on the socket plug. The rubber seal should keep them quite tight together.

Repeat these steps for all four boxes.





After finishing the preparation of the bottle holders, the bottles have to be prepared.

7. Take the lid of a wide-mouth bottle and drill a hole in the middle with the 10 mm drill bit (or with the same diameter as your hose).
8. Thread the end of the hose through the lid.
9. Shorten the hose so that it almost reaches the bottom of the bottle when it is in the bottle holder. The hose must be loose but must not have any loops where the water may accumulate.

Repeat these steps for all four bottles.

The experimental setup is now finished and should look similar to the illustration on the first page.

7. Filling the containers

The aluminum containers are now ready to be filled.

You need:

Material: The potting soil and grass seeds, the light stones, the asphalt, the sand, and a piece of cloth, filter paper, or something similar that prevents sand from trickling through a hole.

You do:

The **green box** will be covered with grass in the aluminum container to simulate a lawn.

1. Fill the stacked aluminum containers with potting soil.
2. Sow the grass seeds in the potting soil.
3. Now you have to wait and water regularly. You also have to water the grass when the Cool City Lab is finished and it has not rained for some days or when it is indoors, otherwise the grass will dry up. Always note exactly how much water you used to water the grass. Pour the same amount of water on the other boxes so that they can be compared at the end of the experiment. You can also install a self-watering system as shown in section 8.
4. Put the container into the lid of the green box.

The **black box** will be covered with asphalt to simulate a street or a square.

5. Fill asphalt into the stacked aluminum containers. If the asphalt is from a hardware store, follow the given instructions supplied.
6. Put the container into the lid of the black box.

The **white box** will be covered with light stones.

7. Fill the stones into the stacked containers and put them into the lid of the white box.

Now only the **red box** remains. It will be filled with sand.

8. Cover the hole in the stacked aluminum containers with a piece of cloth or something that prevents sand from trickling through.
9. Fill the sand into the containers.
10. After filling the sand into the containers, put them into the lid of the red box.



8. Optional: Capillary watering

If you do not water the grass regularly, it will dry out quickly. To avoid this, you can build a watering system with a watering wick. During the experimental phase, however, watering should be done manually so that you know the exact amount of water for the analysis of the results.

This works like the wick of a candle but it sucks water instead of wax. The water is sucked from a container by capillary force. You can get the required material in the hardware store or on the internet.

You need:

Material: A capillary wick or simply a cotton cloth or socks and a container, e.g. a wide-mouth bottle with a lid or simply a jam jar.

You do:

1. Remove the lid from the container and put a hole in it large enough for the capillary wick to fit through.
2. Thread one end of the capillary wick through the hole in the lid and bury the other end in the soil of the green box. Make sure that a good proportion of the capillary wick is in the soil.
3. Fill the container with water and screw the lid on so that a good proportion of the wick is in the water.
4. Place the water container in a position at the same height or higher than the grass.

Make sure that there is always enough water in the water container. If it gets very hot, your watering system may not be able to supply enough water. Then you have to water the grass manually to keep it from drying out.

