Pot-in-Pot

Mohammed Bah Abba is from northern Nigerian. He won the 2001 Rolex Awards for Enterprise for his invention of a simple cooling system that can help preserve food in rural areas where there is no electricity. Eggplants stay fresh for 27 days, instead of the usual three. Tomatoes and peppers last for up to three weeks. The Pot-in-Pot system works by putting a smaller clay pot inside a larger one. The two are separated by constantly moist sand. Evaporation causes a cooling affect in the inner pot.

At a recent SEED workshop in Malaysia we decided to try this for ourselves. We also replicated the experiment later with different pots.

Tools and Materials

- Two clay pots, one larger than the other
- Sand
- Water
- Cloth to cover the pots
- Clay, cork or other material to plug holes in the pots if they have them
- Thermometer
- GoGo Board with temperature sensors (optional) http://padthai.media.mit.edu:8080/cocoon/gogosite/home.xsp?lang=en

What to Do

1. The smaller pot should fit inside the larger one with a space of one to three centimeters. If the pots have holes in the bottoms, as flower pots usually do, plug them with clay, cork or some other suitable substance. This prevents the sand from running out of the larger pot and keeps water from flowing into the inner pot.
2. Put a small amount of sand into the larger pot. The layer should be thick enough so that when you put the small pot inside the larger one, the tops of the two pots are at the same level.

3. Fill the space between the pots with sand.

4. Pour water on the sand until it can absorb no more.

5. Dampen the cloth and cover the inner pot.

6. Use a thermometer to check the temperature inside and outside the pot every few minutes and keep track of your results. We used a digital thermometer, but an alcohol one will do as well.

7. If you have a GoGo Board, click, go to page 5 to find out how to use it with the Pot-in-Pot Refrigerator.

Our Results

The Pot-in-Pot refrigerators we built at the workshop in Malaysia did not work. The inside of the pot was actually warmer than the air outside! At first we thought it might be because the sand we started with was hot since we got it from the beach, which was in the sun. So we dug below the surface and got cooler, wet sand. We also tried garden soil instead of sand. Still no luck.

We believe the problem was that the pots we used were glazed. The glaze forms a glass-like surface on the surface of the pot. This would seal the water inside the pot and prevent it from evaporating.

When we replicated the experiment we used unglazed clay flower pots. This time the inside of the Pot-in-Pot was definitely cooler than the air outside. Here is the record we kept:

Time after setting up the Pot-in-Pot Refrigerator	**Temperature inside the pot (degrees Celsius)**	**Air temperature outside the pot (degrees Celsius)**
15 minutes	23.7	23.8
20 minutes	23.6	24.0
30 minutes	23.2	23.8
40 minutes	21.7	24.7
1 hour	21.0	24.8
1 hour 15 minutes	20.4	25.0
1 hour 30 minutes	20.1	24.7
1 hour 40 minutes	19.9	24.7
2 hours 30 minutes	19.5	24.0
2 hours 40 minutes	19.4	24.4
13 hours	19.4	25.0

That may not be enough to keep your ice cream frozen, but it is cooler inside than outside.

Digging Deeper

Why evaporation causes cooling (http://www.seed.slb.com/en/scictr/lab/cool_clay/index.htm)

More Ideas to Try

- We want to try this with larger pots. In particular, a larger outside pot. We think the cooling effect will be greater if there is more outside surface from which water can evaporate.
- We think humidity may also be a factor. If humidity is low, evaporation should be greater. We want to try the experiment under different humidity conditions.

Related Links

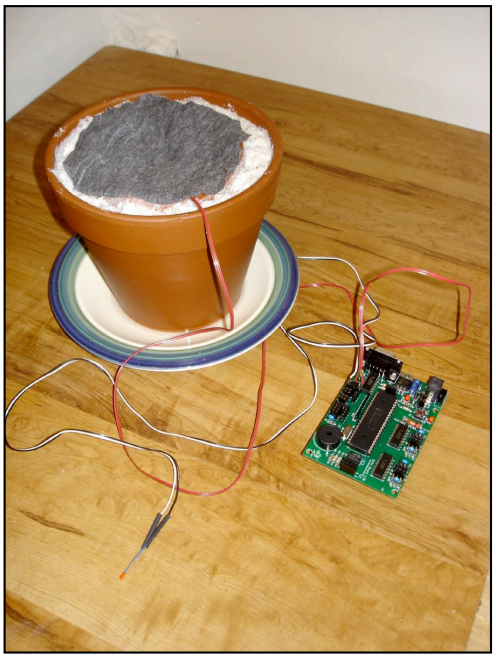
Cool Clay
http://www.seed.slb.com/en/scictr/lab/cool_clay/index.htm
The same process of evaporation that kept our Pot-in-Pot refrigerator cool can work for an entire house. Find out how.

The Pot-in-Pot Refrigerator
http://www.itdg.org/html/agro_processing/docs29/FC29_34.pdf
More information about the Pot-in-Pot cooling system.

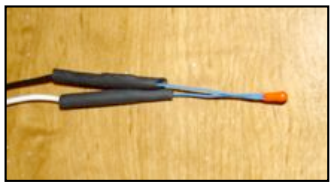
Cool: Fridge Without Using Electricity!
http://www.newmediaexplorer.org/chris/2004/04/14/cool_fridge_without_using_electricity.htm
An article by Chris Gupta with photos.

Keeping Cool in the Heat
http://www.rolexawards.com/special-feature/inventions/abba.html
A beautiful animation of the system by Mohammed Bah Abba.

Using a GoGo Board with the Pot-in-Pot Refrigerator



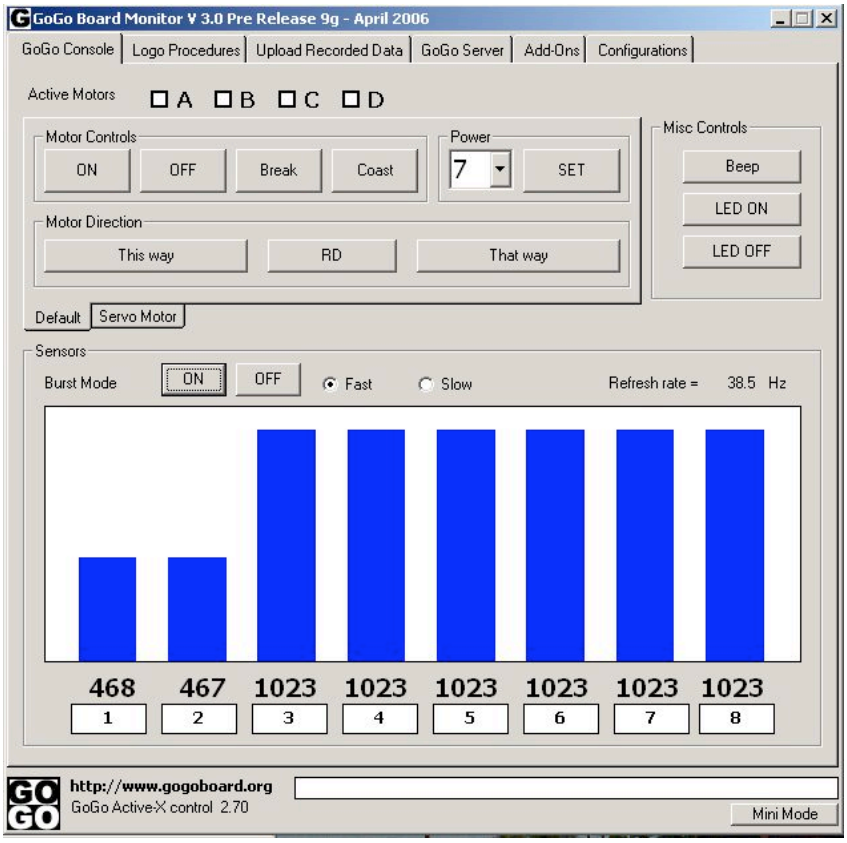
If you have a GoGo Board (http://www.gogoboard.org) you can use it to keep track of the temperature inside and outside your Pot-in-Pot refrigerator. We used two temperatures sensors so we could track temperature inside and outside the Pot-in-Pot at the same time.



For more information about how to use a GoGo Board go to the GoGoBoard web site (http://www.gogoboard.org).

The GoGo Board does not record actual temperature. Rather, it reports a value between 0 and 1023 for each sensor reading. A reading of 0 indicates a closed circuit, such as you would get if you used a switch for a sensor and put the switch in the "on" or closed position. A reading of 1023 indicates an open circuit, such as you would get with a switch in the "off" or open position. If there is no sensor connected to a given port on the GoGo Board, the reading will be 1023.

Because of the way in which the temperature sensor works – higher temperature results in lower electrical resistance – lower numbers mean higher temperature. We used two temperature sensors, one in sensor port 1 and the other in port 2. Before setting up the Pot-in-Pot refrigerator we tested our GoGo Board with the two sensors. Using the Console on the GoGo Monitor, the image here is what we saw.

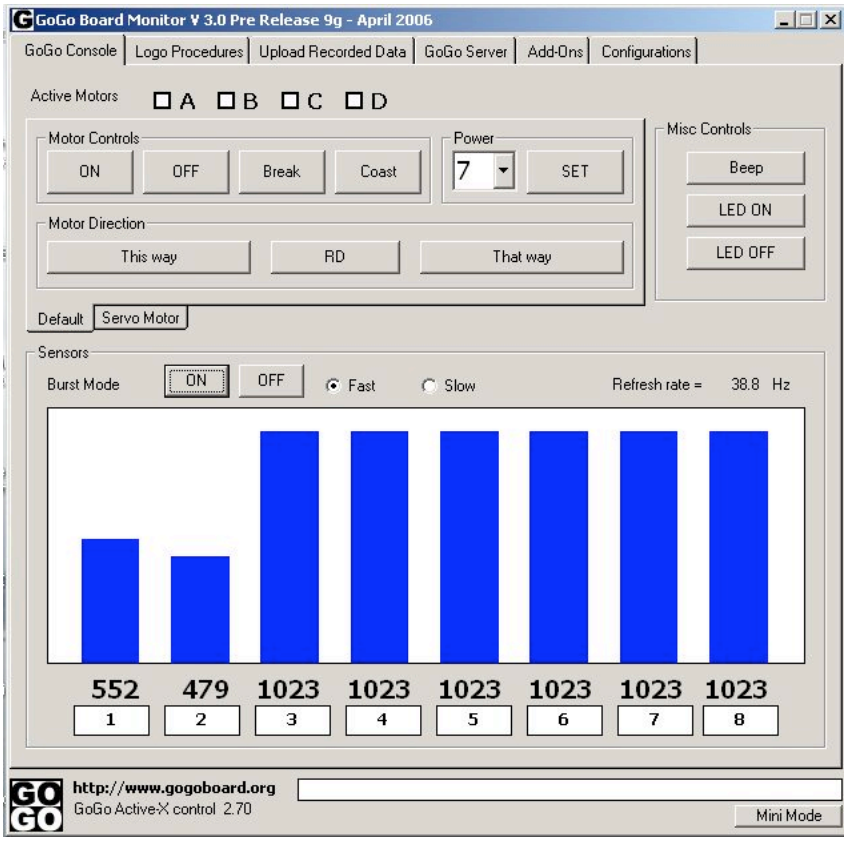


The two sensors reported almost exactly the same value.

Then we set up the Pot-in-Pot refrigerator. After it had been set up for a few hours we tested it with **sensor1** inside the pot and **sensor2** outside. Here's what we saw:

Sensor 1 reports a higher value indicating that it is cooler inside the pot.

After a few days the Pot-in-Pot had dried out. We decided to set it up again and use the GoGo Board to track changes over a long period of time.



We wrote a program to record sensor readings once an hour for 24 hours.

```
to test
resetdp
repeat 25 [
        record sensor1
        record sensor2
        wait 36000]
ledon
end
```

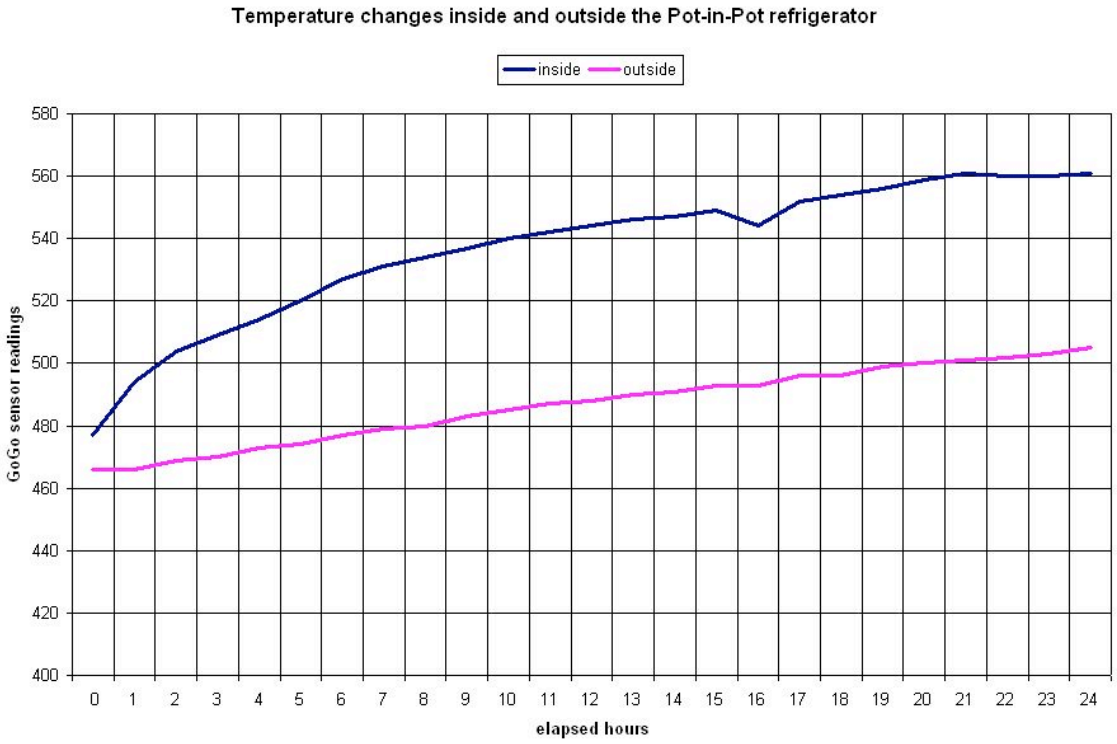
The program records sensor data as soon as it starts and then once an hour for the next 24 hours.

Resetdp sets the data pointer to the starting position. **Record** is used to gather the data into the GoGo Board memory.

Wait 36000 causes a pause of 36000 tenths of a second. (One minute is 10*60. One hour is 10*60*60, or 36000.)

Ledon turns on the green LED on the GoGo Board so we know the program has finished its job.

After 24 hours we uploaded the data from the GoGo Board to our computer in two columns. We then saved the data as a text file, opened it in Excel and made this chart.



During the 24 hours we collected data it became a bit cooler both inside the pot and outside. You can see that both sensor readings increased, meaning lower temperature, during that period. During the entire time it was cooler inside the pot than outside. But, the difference increased in the first few hours. It takes a while for the Pot-in-Pot to cool down.

More things to try

- It would be interesting to collect data for an even longer period of time. We predict that as the Pot-in-Pot dries out over time the temperature inside would rise and become close to the outside temperature.
- Once the Pot-in-Pot had dried out, we could add water while still recording data. We would expect that it would again become cooler inside.
- The idea of the Pot-in-Pot it to keep food cool. We tried it with an empty pot. What if we put some vegetables inside? Would that affect the temperature?