How to Keep Food on the Table in a Changing Climate

Water Management and Healthy Soils

engineering FOR CHANGE

Contents

Healthy Soil and Irrigation on Small Farms Mean More Money and Less Risk in a Changing Climate

Healthy Soil and Irrigation on Small Farms Mean More Money and Less Risk in a Changing Climate

By Alan Spybey and Marion Moon

In many areas of Africa, South and Central America, India, Myanmar, Thailand, Cambodia, and Vietnam rain is seasonal. It rains for a couple of months then stops. Since crops cannot survive the dry period, this natural rhythm drives agriculturalists to plant and harvest synchronously. The result is a glut of similar crops that fight it out in the markets, driving down prices and demand.

While natural rain cycles are making the food supply irregular, climate change is making these cycles themselves more irregular. Changing conditions are endangering traditional yields.

The only effective way to break out of this vicious wave is to irrigate. Irrigation shifts the growing season ahead or behind the conventional rainfed cycle and helps smooth the effects of climate change. This means that harvests are sold at times of higher prices; higher value crops can be grown; and irregularities in rainfall can be bridged. This methodology has been proven to be an effective income multiplier for hundreds of thousands of smallholder farmers, but strangely it is little promoted by large organizations.

Water is as essential to the life of a plant as blood is to humans. But once that need is met, other challenges threaten farmers' livelihoods and the health of their farms.

Across Africa, smallholder families are struggling to make more productive use of their farmland. Most are unable to produce enough, either to feed their families an adequate nutritional diet, or to sell in the market and generate sufficient income to meet other needs.

Population growth exerts continuous pressure on arable land, resulting in shrinking family shambas, or plots of land. Shambas shrink with each generation, often triggering local migration from agricultural zones that have high potential but too many people into more marginal land in semi-arid areas.

Whether farming with plenty of rain or in the drylands, farmers need the right technologies to grow more food more often. They also need the right tools to produce crops of higher nutritional and market value.

Introduction

One of the topmost priorities is the health of the soil. African farmland soils are badly depleted. Under continuous farming, the land is not allowed to rejuvenate. The problem is worsened by nutrient mining without replenishing soil nutrients. The smallholder's challenge is either to produce more food and more income from less and less land with rapidly deteriorating soils, or to turn drylands into productive farms.

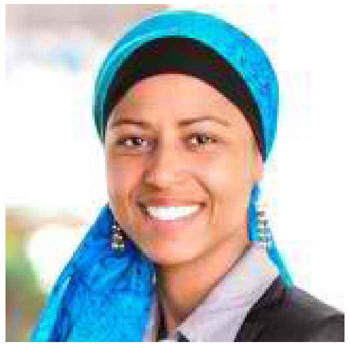
So, the right technologies must include those which can restore and improve soil health and fertility. Examples include crop rotation, intercropping two or more types of crops together in the same field, building furrows to prevent water runoff and erosion, and composting for fertilizer.

Compost is a good example of an organic fertilizer. But the most widely known and available type of fertilizers are inorganic. They are not matched to the particular needs of specific soils or agro-economic zones. The lack of knowledge and access to organic fertilizers hinders farmers' uptake of sustainable agricultural practices.

Introducing irrigation and organic fertilizers to the world's smallholder farms could go a long way to improve their yields, longevity, financial sustainability, and their resilience to changing climates.

Alan Spybey

Director of Product Intelligence and Development at Kickstart in Nairobi, Kenya.



Marion Moon

Organic farmer and Managing Director of Wanda Organic in Nairobi, Kenya.

Ten Low-Cost Ways to Irrigate Crops

Ten Low-Cost Ways to Irrigate Crops

Irrigating a farm can double the amount of food it produces. But even with that potential, 80 percent of farmland worldwide is not irrigated, says the UN Food and Agriculture Organization. Part of the problem may be the high cost of irrigation equipment. Also, the prospect of wasteful irrigation techniques raises the specter of environmental damage including water shortages, erosion and soil salinization. Small-scale watering systems can circumvent those issues: Low-cost, low-tech and efficient irrigation is possible. These are ten technologies that work.

Photo by Stuck in Customs / Flickr

Flood irrigation

Flooding fields with water from buckets or pumps is one of the simplest methods of irrigation. The advantage is that it requires little energy or equipment. Done improperly, however, it can waste water and erode and salinize the soil. To do it right, try three tricks that the US Geological Survey suggests:

- Time the floods to reduce runoff
- Catch the runoff in ponds or ditches at the edges of the field
- Level or grade the field with a gentle slope

Without accurate instruments, getting the land level or graded accurately can be a challenge. Farmers who don't have a laser handy can try surveying their land with a DIY water level. With little more than a hose, plastic tubes, stakes and measuring tape, the device measures the height difference between two points. Here's a construction guide.

Depending on the crops planted, farmers may want to choose from among these types of flood irrigation, from a guide by the FAO:

- Basin
- Furrow
- Border

Watering and flooding fields by hand is simple, cheap and hard work, but leveling the field can help conserve water. Photo by Bread for the World / Flickr

Ten Low-Cost Ways to Irrigate Crops

Buried Clay Pot Irrigation

Unglazed clay pots buried at intervals in a field can water crops efficiently and drastically cut water consumption. When the pots are buried up to their openings and filled with water, the water seeps through the clay into the soil, drawn out at the rate at which the soil dries. The upshot is that the pots provide just the amount of water that the crops need. The video explains one method.

Watch the video about buried terracota pot irrigation

Drip irrigation

Drip irrigation is quickly gaining popularity as a low-cost and water-saving technique. At its core, it is a network of perforated tubes linked to a water source.

The water flows through the tubes and trickles out of the perforations onto the soil. Many versions installed on small farms are gravity-driven, with the water stored in a tank raised above the farm so the water can flow through the tubes below.

Variations abound. A handful of organizations have refined and simplified the hardware to reduce costs.

Notably, among its contingent of acclaimed designs, iDE, has developed a low-cost drip system explained in detail in this technical manual (pdf).

Drip system innovators:

- iDE
- DripTech
- EOS

Here's an Alternative!

Chameleon Soil Moisture Sensor

Help farmers determine where the roots are actively taking up water giving farmers insight on when to irrigate and how much water to apply

Suitable in these locations:
16 African Countries

Photo by DripTech

Ten Low-Cost Ways to Irrigate Crops

Solar Drip

The Solar Electric Light Fund, based in Washington, DC, has installed award-winning solar-powered drip irrigation systems in Benin, West Africa. The systems use solar panels to power electric pumps that move water from the source to the field. Farming families in Benin have used the systems to boost crop yields and earn more money, SELF says. Stanford researchers involved with the organization published this paper (pdf)on the pumps in the journal PNAS.

Watch the video about Solar Drip Irrigation Project - Benin, West Africa

Sprinklers

Sprinklers are sometimes derided as water wasters, but like flood irrigation, if done right, they can be efficient on small farms. iDE developed an interesting pedal-powered low-pressure system that sprinkles water over the crops using a treadle pump.

Here's an Alternative!

MoneyMaker Hip Pump

Portable, manually operated pump. Kickstart aims to help small-holder farmers to start family enterprises using the pump.

Suitable in these locations:
16 African Countries

Treadle Pumps

Part of the challenge of irrigation is often how to draw water from a well or a nearby stream to the field. Diesel pumps are expensive, but fortunately, people have been pumping water since long before the advent of the diesel engine. Low-cost, human-powered designs are at work on farms worldwide.

Photo by World Resources / Flickr

Ten Low-Cost Ways to Irrigate Crops

Farmers bobbing up and down in their fields on a machine that looks like a stair stepper are treadle-pumping water onto their crops. The pumps use leg power to move pistons and create suction that draws water through a hose from a well, a stream or another source. Some are compact, steel machines and others are handmade with treadles cut from local woods such as bamboo and other materials.

Kickstart is one of several noteworthy organizations that design and sell the pumps. Kickstart's pumps cost $35-100, depending on the region. And, the organization says, the pumps can help small-plot farmers earn an average of $1000 more per year.

Treadle pump innovators:

- Kickstart
- iDE
- Practica Foundation

Modular Treadle Pumps

The BYU team behind the human-powered water well drill has created a modular treadle pump. The device allows farmers on a tight budget to buy a hand pump and then pay for upgrades over time. The first upgrade available converts the hand pump into a treadle pump, and the second upgrade adds a second cylinder to the treadle pump and lengthens the treadles. Farmers can pay for more irrigating power as they earn money from their investments.

Watch the video about Grower Pump

Photo by KickStart

Ten Low-Cost Ways to Irrigate Crops

Rope Pumps

This ancient technology is still at work on farms and in water wells today. The pump is a wheel at the top, a tube in the water below and a long loop of cord with washers or some other kind of disc tied on at intervals. When the operator turns the wheel at the top, the cord snakes through the tube and the discs draw water upwards to an outlet. The video by Pump Aid shows an animation of the process.

Watch the video about Pump Aid: Elephant Pump Animation

Appropedia's depth-adjustable rope pump

Akvo
Pump Aid

Here's an Alternative!

Futurepump SF1 Solar Pump

Solar-powered irrigation pump. Robust and portable.

Suitable in these locations: Kenya, Uganda, Rwanda, Tanzania, Malawi, Zambia, Nepal

Bicycle Rope Pumps

Linking a rope pump to bicycle parts boosts the pump's efficiency and saves the operator's arms. iDE is developing a low-cost pedal-powered design, but it's the first that we've seen that might be manufactured. Designs we've found have been DIY, but if readers know of a manufactured product or a construction guide, please let us know.

Photo by Akvopedia

Ten Low-Cost Ways to Irrigate Crops

Thermal Solar Pumps

Solar steam pumps are an interesting concept with a handful of prototypes on fields now. They use solar thermal energy – just the heat of direct sunlight – to heat water and power a small steam engine. iDE and the Practica Foundation are developing designs.

Ten Low-Cost Ways to Treat Water

Ten Low-Cost Ways to Treat Water

Having money helps, but clean water doesn't have to be expensive. Celebrities like Bill Gates and Matt Damon have helped clean rivers, dig wells and install pumps, pipes and other hardware to deliver clean water. Their time and money are well spent because the problem is huge. As we've reported before, as many as 1.8 million people die each year from diarrhea linked to bad water and sanitation, most of them under age 5.

Community-wide water infrastructure is as good as it gets. But until everyone has that, there are other, cheaper clean water solutions. Boiling water over a wood fire is one of the most widely used methods, but it is also a health hazard for those working in poorly ventilated kitchens, and it exacerbates deforestation. Instead, we've rounded up ten low-cost ways to treat water, and not one requires boiling. Do you know of other methods? Please let us know in a comment below.

Ceramic filters

Clay, sawdust and a plastic bucket can make a water filter that catches dirt and disease-causing microbes. In the classic design, mix clay with a combustible material like sawdust or rice husks, give it a flower pot shape and fire it in a kiln.

The sawdust or rice husks burn away, leaving tiny pores in the ceramic through which water filters. Organizations around the world have been using this kind of ceramic filter to reduce disease in impoverished communities for years.

This prototype is the predecessor of bone-char filters that will strip heavy metals from drinking water on a South Dakota reservation. Photo courtesy of Jacob Becraft

Bone Char Filtration

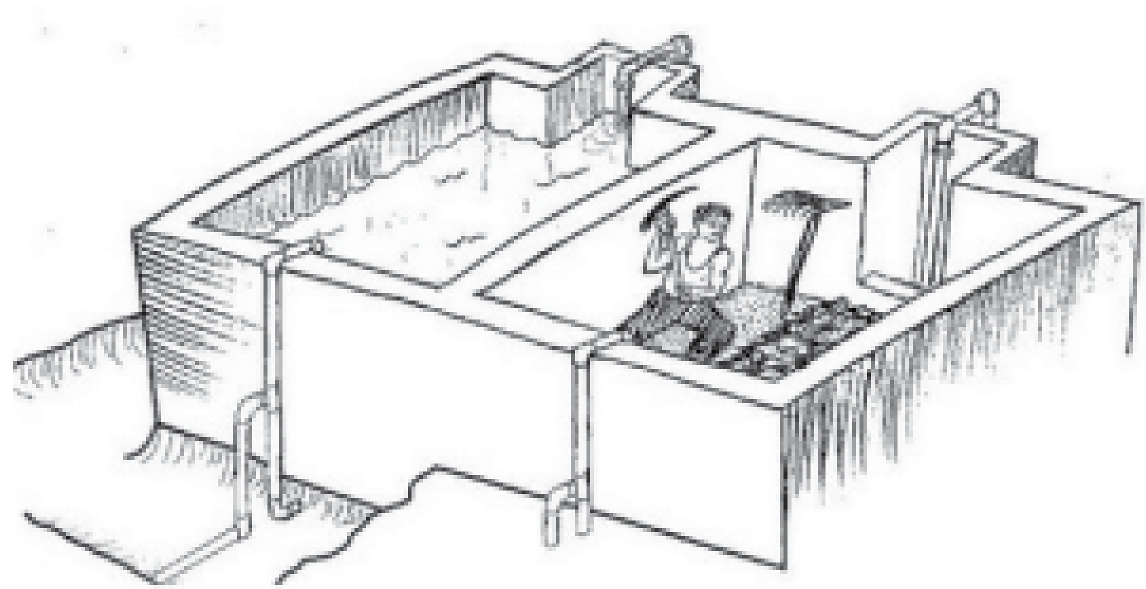
Not all filters remove heavy metals or other toxins from the water, but crushed and charred animal bone can. And in areas where they occur in the water, removing them is a good idea. Chronic arsenic exposure, for example, can cause skin cancer, bladder, kidney and lung cancers, gangrene and possibly diabetes, high blood pressure and reproductive disorders. Uranium in the drinking water is linked to nephritis (pdf)—inflammation of the kidneys. As they inflame, the kidneys dump proteins that the body needs into the urine stream, a condition that is lethal at its worst.

When a US Geological Survey study found high levels of arsenic and uranium in wells in the Ogala Lakota tribe's US reservation at Pine Ridge, students at the University of Illinois at Urbana-Champaign had an idea: Bone char. Crushed and charred cattle bones are cheap and locally available. With the right design, filters can clean drinking water right in the home. It's a solution that can work in Pine Ridge or anywhere arsenic contamination is rampant (bearing in mind potential cultural aversions to ingesting cow products).

Slow Sand Filtration

Slow sand filtration has the advantage of working on an entire community's water source, not just individual households. Practical Action put together a technical manual for slow sand filtration systems, a complete guide to their construction and maintenance. Follow the link above to see the manual.

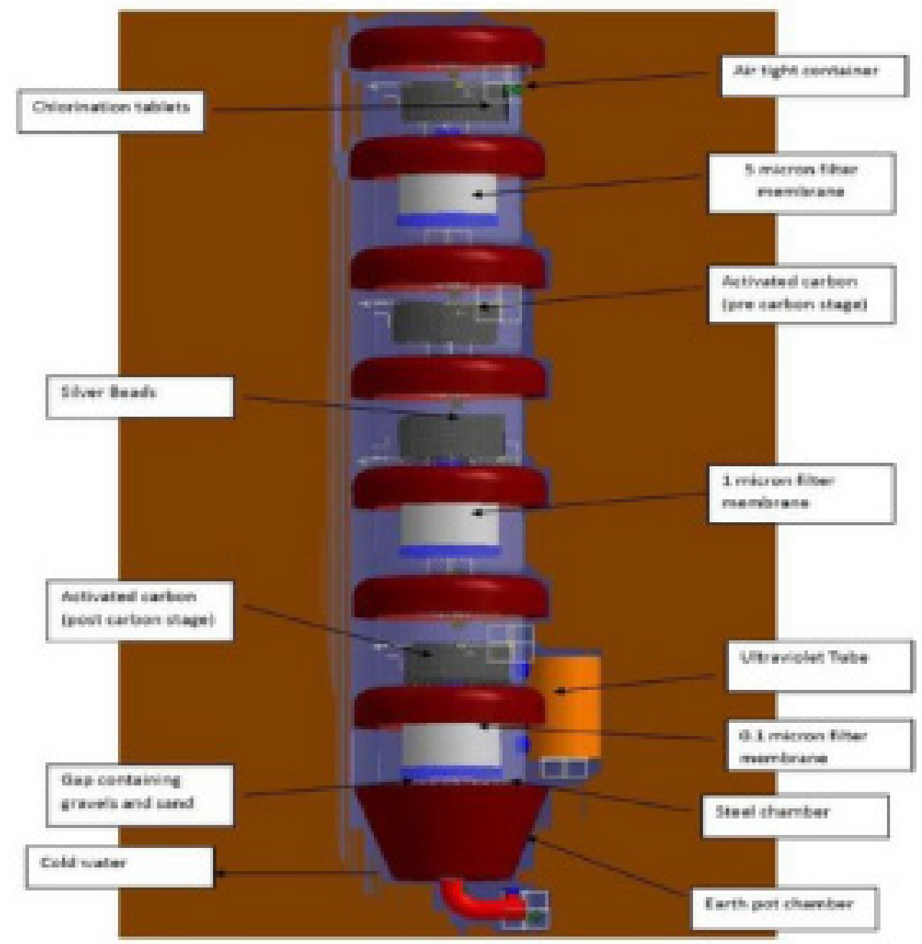
A slow sand filtration system is a combination of several parts: water storage tanks, an aerator, pre-filters, slow sand filters, disinfection stages, and filtered water storage tanks. The number of filters and filter types that are used in a given slow sand filtration system will depend on the quality of the source water and will be different for each community.



Everything-but-the-sink Portable Filter

This portable filter design proposed in response to a call for better water filtration at taps in India uses chlorine, silver beads, activated charcoal and sand. Honeybee Network posed the original problem and an E4C member posted this solution. It includes a detailed guide to the specifications, materials and construction of a portable filter built from everything but the kitchen sink.

Honeybee Network also proposes the development of new mobile applications that employ a phone's camera to sense impurities in water. We Googled up two that are in development: The H2O Mobile Water Testing Lab and Aquatest, though it's not clear if the latter will be phone based or not.



Ten Low-Cost Ways to Treat Water

Bamboo Charcoal

In this spin on the charcoal filter, a team of E4C members in Bangalore propose a filter made of locally available materials including charred bamboo, gravel and natural adsorbents. "The process we propose is indigenous, eco-friendly, low cost and entails minimum maintenance," the team writes in their workspace. They estimate that their filter can handle 30 liters of water per hour, and it would be affordable for average households in the region.

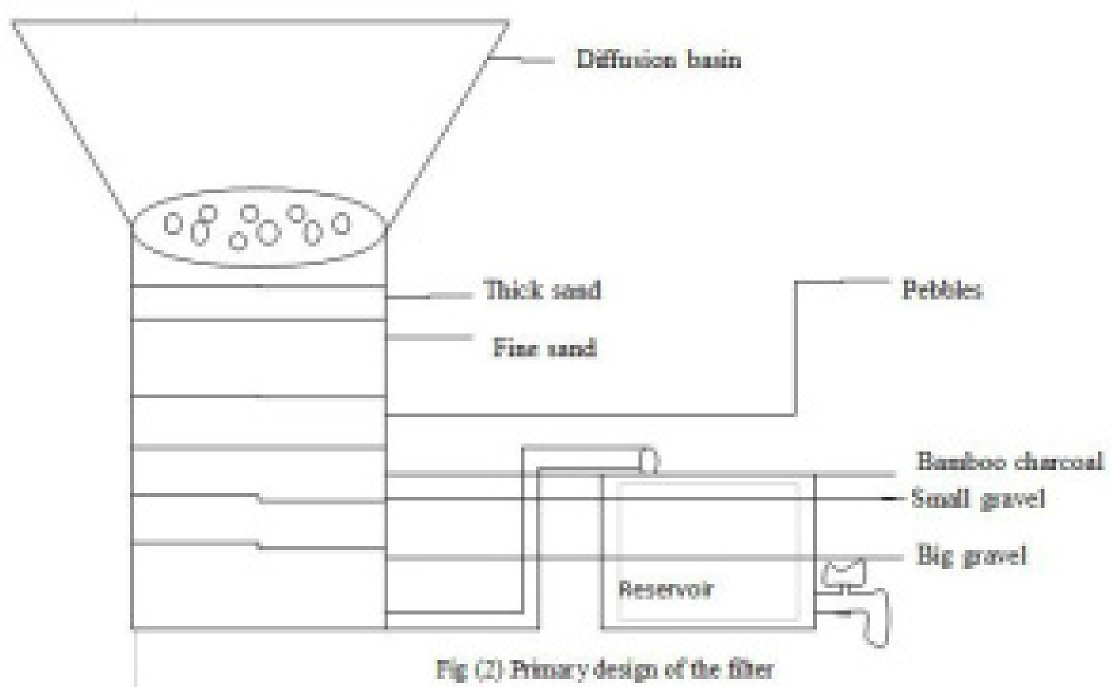


Fig (2) Primary design of the filter

Solar Sterilization

If cost is a bigger concern than time or convenience, the cheapest way to treat water is to leave it in a plastic bottle in the sunlight. Leave clear bottles in the sun for a few hours and the UV radiation and heat kills the microbes that cause diarrhea and other waterborne illness. The Sodis (for solar disinfection) method was deployed in some parts of Haiti after the earthquake in 2010, and it is used in emergencies and impoverished regions worldwide.

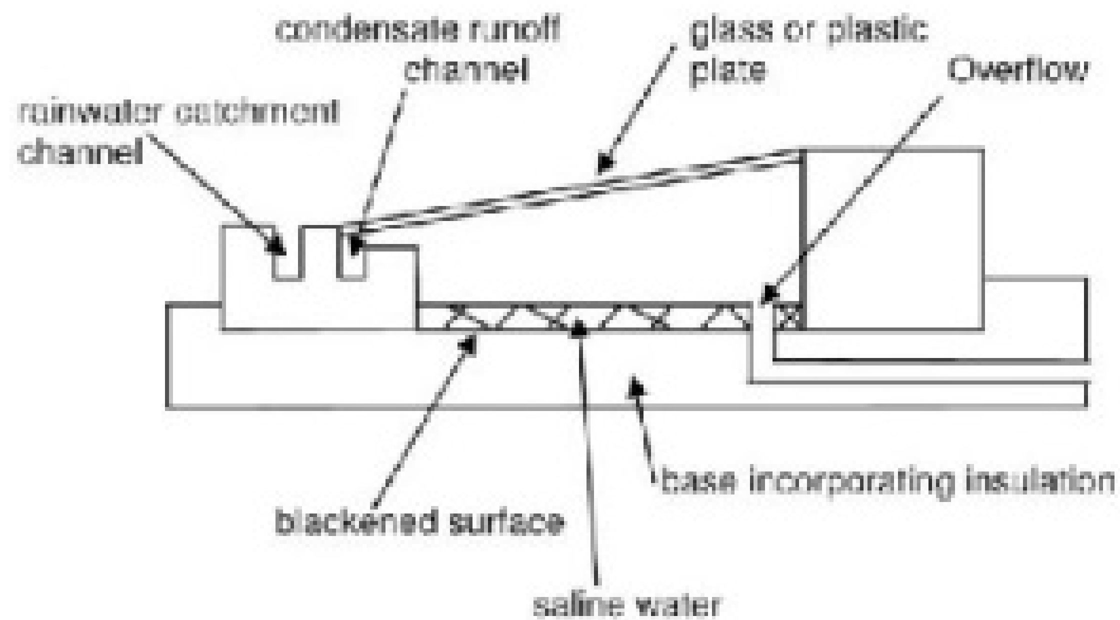
Ten Low-Cost Ways to Treat Water

If the bottle is too basic or prone to error, Solvatten sells a more highly designed solar disinfection device. It's a jerry-can-like container with a built-in thermal indicator that lets drinkers know when the water is safe to drink. The Solvatten container opens like a book to expose the water inside to sunlight through clear plastic panels. Its black backing helps it absorb more sunlight.

The amount of sun exposure that a bottle needs varies by the amount of sunlight available (it takes longer to sterilize water on a cloudy day). To take the guess work out of the solar method, a disinfection indicator can measure light exposure and signal when the germs are dead. We came across this prototype of a solar indicator at IEEE's Global Humanitarian Technology Conference in Seattle, Wash., last year. And there's also Helioz, a similar concept with a top-mounted design.

Solar Distillation

Not to be confused with solar sterilization or disinfection, solar distillation purifies even muddy, salty or otherwise undrinable water through evaporation and condensation. The power of distilation to purify saltwater makes it unique among the treatment methods featured on this page. A solar still can actually be a cheap and simple piece of shaped plastic or glass, or they can be more highly designed devices. To work, the still allows sunlight to shine through a clear panel onto the impure water. The water heats and evaporates, then condenses on the underside of the panel and runs off into a container of some kind. This simple process takes huge amounts of energy, which is why solar stills can make more sense than stills powered by other fuels. Our Solutions Library links to a technical brief and construction guide to several different still designs from Practical Action.



Ten Low-Cost Ways to Treat Water

Bicycle Filter

Bicycles in all their glorious versatility and simplicity have got to be one of our favorite devices, and we were pleased to find not just one, but two bicycle-powered water filters. Nippon Basic Co. invented Cyclo Clean, a bicycle rigged with a pump to draw water from a river or well and a robust, three-filter system to purify the water. The filters are designed to last without replacement for two years, and the tires are puncture-proof. It can filter three tons of water in 10 hours.

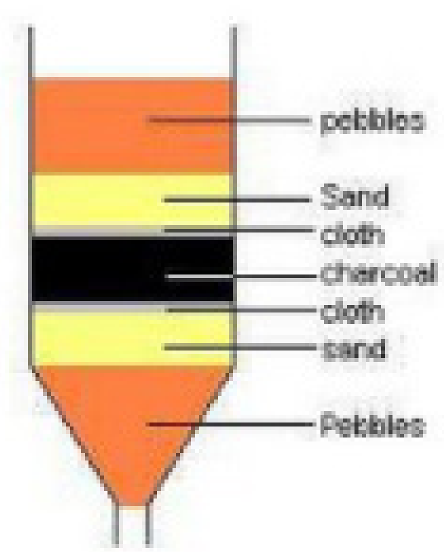
Then there's the Aqueduct, which is like Cyclo's whimsical little brother. It's a tricycle with bubbly curves and a sky-blue paint job that pumps up to two gallons of water through a filter while the rider pedals. Cyclo handles much greater volumes of water, but Aqueduct's one advantage is that it can do its job on the move.

Watch the video about Innovate or Die - Aquaduct: Mobile Filtration Vehicle

Emergency Homemade Filter

The plastic bottle makes yet another appearance as a water treatment device, this time as a simple filter that can remove sediment and even disease-causing microbes. Simply cut the bottom from the bottle, fill it with layers of gravel, sand cloth and charcoal, filter the water through it and hope for the best.

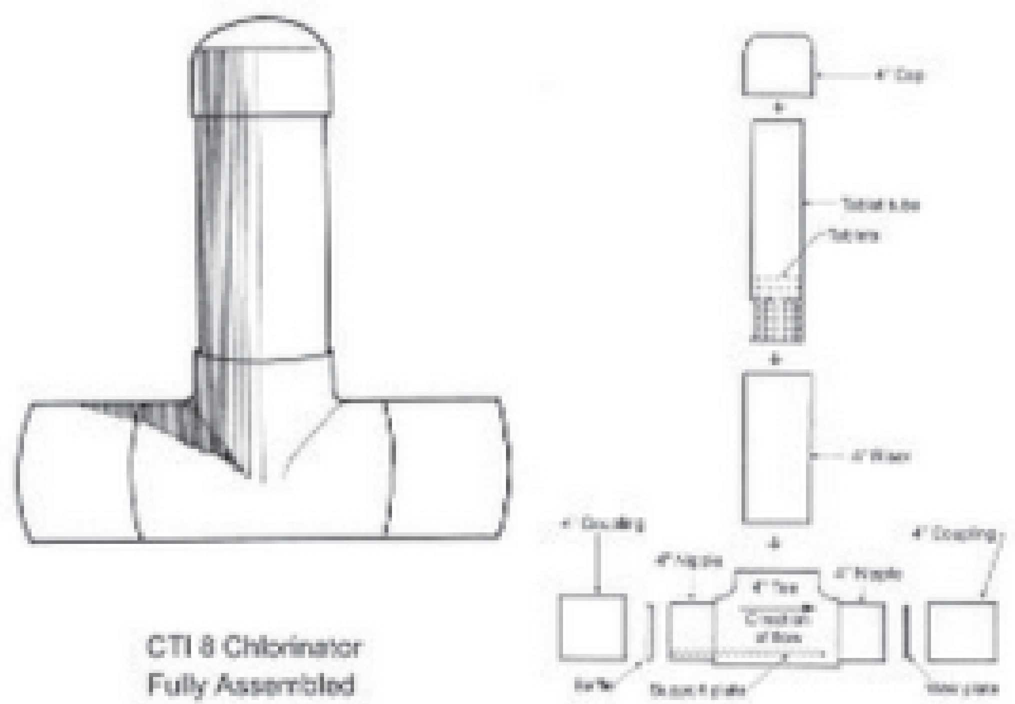
This design is also featured in our list of the best appropriate technology DIY plans



Chlorine

We saved the most obvious and probably the most reliable treatment method for last. Chlorine can work in the community water supply to kill microbes before it enters people's jerry cans or home water supplies. And it keeps the water safe from new contaminations long after it is added.

We've seen several interesting chlorination methods at work in resource-poor regions. Compatible Technology International developed this tested and proven device that chlorinates water in gravity-fed systems that fill a community water cistern. And these four experimental designs have worked in field tests to dose water accurately after people fill their buckets at a community well, stream or other source. The chlorinator, shown here fully assembled and broken down, attaches to a loop in the water pipe that feeds into the community tank. Image courtesy of CTI.



Technologies for Rural Water Supplies

Technologies for Rural Water Supplies

Safe drinking water saves lives, and fortunately, technologies to deliver it to rural communities abound. It can be tough to navigate the mounds of information, however, so we've compiled a list of important resources here. Many of these suggestions come from USAID's WASHPlus blog, and others come from our Solutions Library and news blog. For more devices and case studies, please see the Water section of our Solutions Library. These are ten technologies for clean water systems in rural communities.

Know-How

Educational resources are a must-have for building a sustain-able, long-term water supply and treatment system. Here's a short list of links to get started.

E4C Webinars: Experts in the Water, Sanitation and Hygiene (WASH) sector worldwide lead E4C Webinars to deepen our understanding of issues in rural and underserved communities. We recommend Professional Water Well Drilling in Africa: Incentives and Support, a presentation by Dr. Kerstin Danert at the Rural Water Supply Network and José Gesti at UNICEF.

Guidelines and Tools for Rural Water Supplies: The Rural Water Supply Network provides this directory of guidelines and manuals on delivering rural water services.

Rural Water Supply Design Manual: The World Bank issues this manual on basic waterworks facility design. It is non-technical, aimed at managers and operators of small water supply systems, not engineers, to provide background information to inform their decisions.

Hand-washing Stations

Hand washing limits the spread of waterborne and other disease. A few simple devices can make it easier to lather up with soap and rinse hands where there are no taps.

Enabling Technologies for Handwashing database: Leave the search fields blank and choose "Handwashing stations/stands" in the first sub-menu called "Purpose." When you hit "enter" you'll see 16 hand-washing devices, including Tippy Taps like the one pictured above.

Happy Tap: Designed with customers in Vietnam, the Happy Tap is a home hand-washing station that costs very little and looks stylish and manufactured, not homemade like Tippy Taps.

Children Design Hand Washing Stations: For more design inspiration, see this video of winning entries in a student competition hosted by UNICEF in Togo. Students made their own hand-washing stations.

Household Water Treatment

We rounded up 10 devices in this chapter's section called Ten Low-Cost Ways to Treat Water: They include, chlorine dispensers, solar stills, and more.

Technologies for Rural Water Supplies

Innovations for Poverty Action's chlorine dispenser system: IPA has installed chlorine dispensers in communities with no water treatment system. The fixed dispensers treat jugs that people take to them for household use. For more background information, see WASHfunders Blog, which published an article on the dispensers as they are used in Kenya.

WASHplus Household Drinking Water Quality Updates: The WASHPlus blog is a wealth of resources on household water treatment, including manuals, peer-reviewed studies and videos.

Community Water Treatment

Water treatment systems large enough for a community can include technologies such as slow sand filtration and chlorination. A newer set of devices comes from Healing Waters International, the Gravity Pure UF gravity-driven filtration system and the Solar Pure UF solar purification and bottling system.

Measured chlorinator for community water supplies: Compatible Technology International helps rural communities in Latin America install low-cost automatic chlorinators on their community water supply.

Rainwater Harvesting

Instructables offers guides for do-it-yourself rainwater harvesting. We suggest these three:

Rainwater harvesting: Self-sufficient home

How to build a rainwater collector

DIY 275-gallon rainwater collection

Rainwater Harvesting Technical Brief: Most roofs can channel rainwater into catchments for use as drinking water (or for irrigation). WaterAid reports on the performance of different roof materials and designs.

How to Make a Model Rainwater Harvester: Sometimes a visual aid can sell an idea best. WaterAid wrote up this guide to making a model of a rainwater harvester to demonstrate its benefits.

Technologies for Rural Water Supplies

Life-Cycle Costs of Rainwater Harvesting Systems: The IRC International Water and Sanitation Centre compares the costs and benefits of rainwater harvesting technologies to other water supply systems.

How to Make Ferrocement Tanks: Akvopedia explains how to make ferrocement cisterns that can be used as a septic tank or rainwater catchment.

Instructables has step-by-step how-to guides to building rainwater harvesting systems. Photo by iPodGuy / Instructables

Wells and Sand Dams

Hand-Dug Wells: The Water Channel shot this video on well digging in the Tigray Province of northern Ethiopia, where the water table has risen after 20 years of conservation work.

A Guide for Water Well Drilling Supervisors: The Rural Water Supply Network's guide informs geologists and engineers who supervise borehole drilling.

Sand dams: Properly damming a dry river bed can retain groundwater and water underground when it rains. Kurtis Unger on E4C's Linked In group reports that sand dams can partially filter water for drinking and they raise the water table, which turns the riverbanks into arable land for agriculture. Besides the link above, Unger provides this from the Guardian: Sand dams voted best solution in water crisis debate

Human-powered drill: A team at Brigham Young University in Provo, Utah has developed a human-powered drill for making boreholes in places where fuel is too expensive.

Manual Pumps

Rope pumps and bicycle-powered rope pumps: Rope pumps are an ancient technology that is still at work today lifting water through a tube on discs fastened to a rope. The operator turns a wheel at the top of the well. There are hand-powered and even bicycle versions.

Rope pump designs:

- iDE
- Appropedia
- Practica Foundation
- Akvo

Treadle pumps: A machine on some farms that looks like a stair stepper is actually a foot-operated treadle pump. The pumps use leg power to move pistons and create suction that draws water through a tube. Kickstart International makes popular treadle pumps in its Moneymaker line.

Photo by Akvopedia

Technologies for Rural Water Supplies

Powered Pumps

Ram pumps: For off-grid water pumping where there's downward-flowing water, ram pumps can channel the water's force to move it upward to where it's needed.

"With an available 'drop' of one to five meters, some water can be lifted up to 100 meters or more," says Michel Maupoux at Green Empowerment. "The largest irrigation installation I have seen uses six large ram pumps in parallel, which lift 440 cubic meters (110,000 gallons) of water 35 meters (120ft) to irrigate 35 rice fields. It allowed the 35 farmers to double their yearly harvest."

This AIDFI animation explains how ram pumps work. Here's a clip of a transparent pump that shows the valves moving. And here are some general videos on AIDFI's work and village installations.

Solar pumps: Solar pumps have come a long way in a short time. A steep drop in the price of photovoltaic panels has seeded a new crop of low-cost solar pumps for small-holder farmers and other underserved markets.

See our analysis, As Costs Fall, Designers Take a New Look at Solar. And you will find Sun Pump and SHURFlow's submersible solar pumps in our Solutions Library.

Multi-function platforms [link pending new Solutions Library]: The MFP project takes small diesel engines that run on locally available vegetable oil and outfits them with attachments that mill grains, generate electricity and pump water.

Water Storage

An Engineer's Guide to Domestic Water Containers: WEDC's booklet outlines different domestic water containers found in low-income countries.

PackH2O Water Backpack: This pack makes it easier for people to carry water – up to 20 liters – in regions where other methods are hard to come by.

Safe Storage of Drinking Water in Developing Countries: The US Centers for Disease Control & Prevention reports on jerry cans, the Oxfam Bucket, and other hygienic water storage methods.

Technologies for Rural Water Supplies

Hippo Water Roller: Grant Gibbs' project allows one person to carry up to 90 liters (24 gallons) of water by rolling it.

How To Make A Biochar Gasifier

How To Make A Biochar Gasifier

Add biochar to a garden or farm to improve the soil's ability to hold and retain water and increase the crop yield. Biochar can also filter contaminants out of drinking water, including agricultural chemicals that may have leached into the water supply.

You make biochar by burning wood at high temperatures in a low-oxygen chamber. The process is similar to making charcoal, except that the biochar material burns at a much higher temperature. The biochar gasifier that we show here burns at 750 to 900 C and can yield 6 to 12kg of char.

This top-lit, updraft gasifier design, including the photos and diagrams, come courtesy of Josh Kearns the science director at Aqueous Solutions, a non-profit water, sanitation and hygiene development organization.

The design is open architecture, so feel free to improve upon it and adapt it to your needs. For questions, and to offer tips and comments, please contact Josh Kearns at josh (at) aqsolutions (dot) org.

For more information, see Aqueous Solutions' instructional videos in English and Thai, and downloadable handbooks in English, Thai, Burmese and Spanish.

How To Make a 200L (55gal) Top-lit Updraft Gasifier

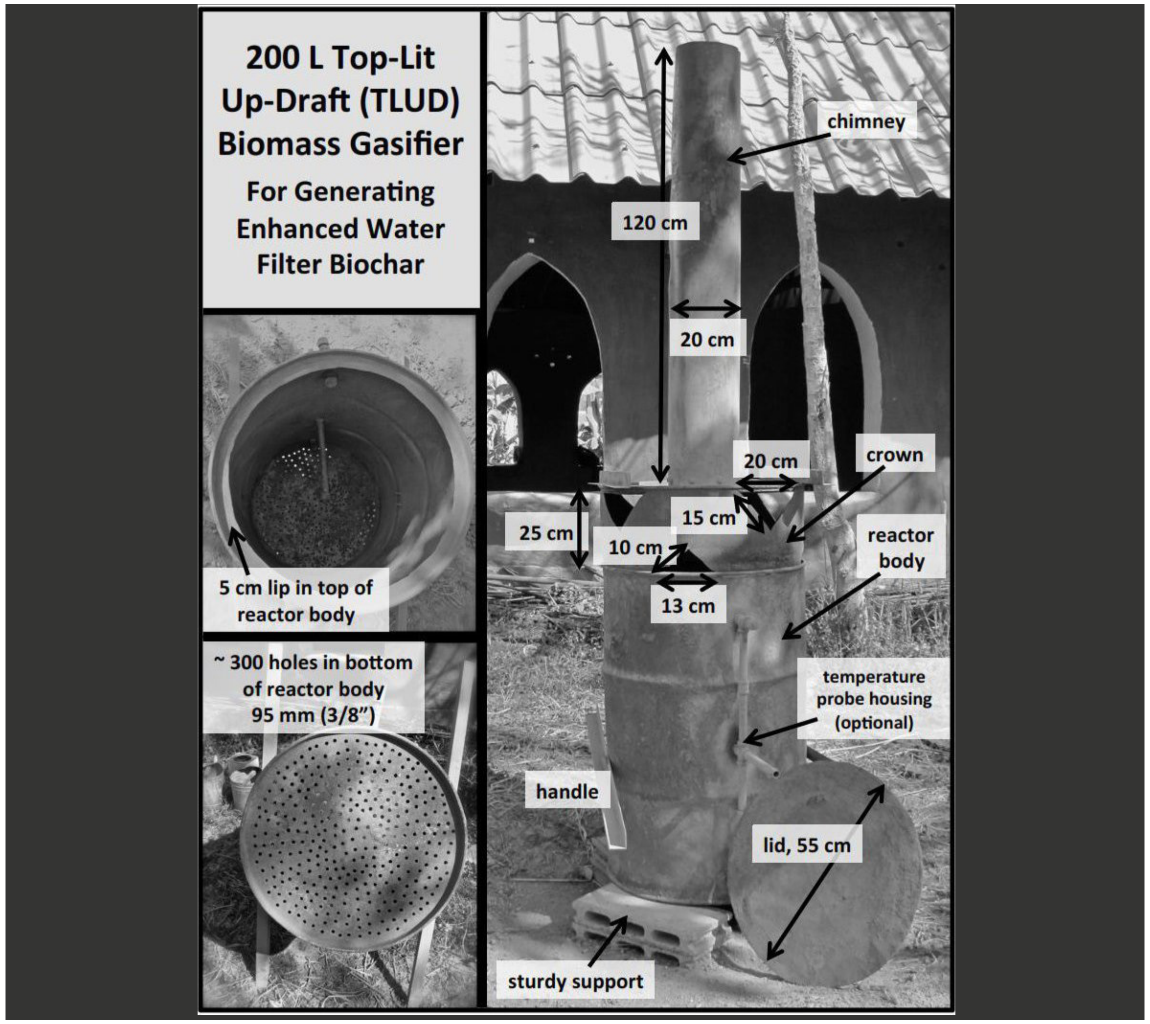
Materials

- Two 200L (55gal) steel drums
- Square tubular steel or angle iron scrap
- Sheet metal or flue pipe (not tin, aluminum or thin galvanized steel)
- Concrete blocks or bricks or something comparable
- Bolts, nuts, washers

Tools

- Angle grinder
- Drill with bits
- Cold chisel
- Basic welding setup

How To Make A Biochar Gasifier



The image above shows most of the construction process. Select one of the two drums for the reactor body. In that drum, cut a circle out of the top leaving a 2in (5cm) lip around the edge (upper left in the image above).

Drill roughly 300 holes, evenly spaced, each just shy of 1/2 in (10mm) in diameter into the bottom (bottom left). Or, if you prefer, cut radial slits into the bottom of the drum (see the photo on the right).

How To Make A Biochar Gasifier

To make the handles, cut two lengths of angle iron or square tubular steel at least 50in (125cm) long, then weld or bolt them to the sides of drum.

To make the chimney, either use a flue pipe or roll a piece of sheet steel into a cylinder, clamp the edges and weld them closed.

Now, onto the second drum. This will become the lid and the crown placed on top of the reactor (the first drum), and it will support the chimney. The crown is where the combustion will happen.

To make the crown, measure 10in (25cm) from the bottom and, from that point, cut evenly around the perimeter to make a cylinder. Cut eight triangular vents, four in the top and four in the bottom. The four upper vents should be 6x8in (15x20cm) and the four lower vents should be 4x5in (10x13cm). Stagger the vents so that the lower four fall between the upper four.

To attach the chimney, cut a tabbed hole in the top of the crown, right in the center. Bend the tabs outward and attach the chimney with bolts or welds. The photo on the left shows the tabbed attachment in a view through the top of the chimney looking down.

Photo by Lyse Kong

How To Make A Biochar Gasifier

Cut the lid out of the other end of the second drum. The lid should have a diameter of about 22in (55cm), large enough to place snuggly onto the lip that you left in the first drum, plush against the inside rim.

Now cut two 6ft (2m) lengths of steel tubing or angle iron that you will use to remove the crown when it is hot after combustion.

Arrange the cement blocks, bricks, or other material into a stable base for the gasifier. Leave a large enough gap between the bottom of the reactor and the ground to allow for airflow.

Set the crown with the chimney attached onto the lip that you left around the inside top edge of the reactor. Try for a snug fit. Make sure it is stable and will not wobble or tip during the burn.

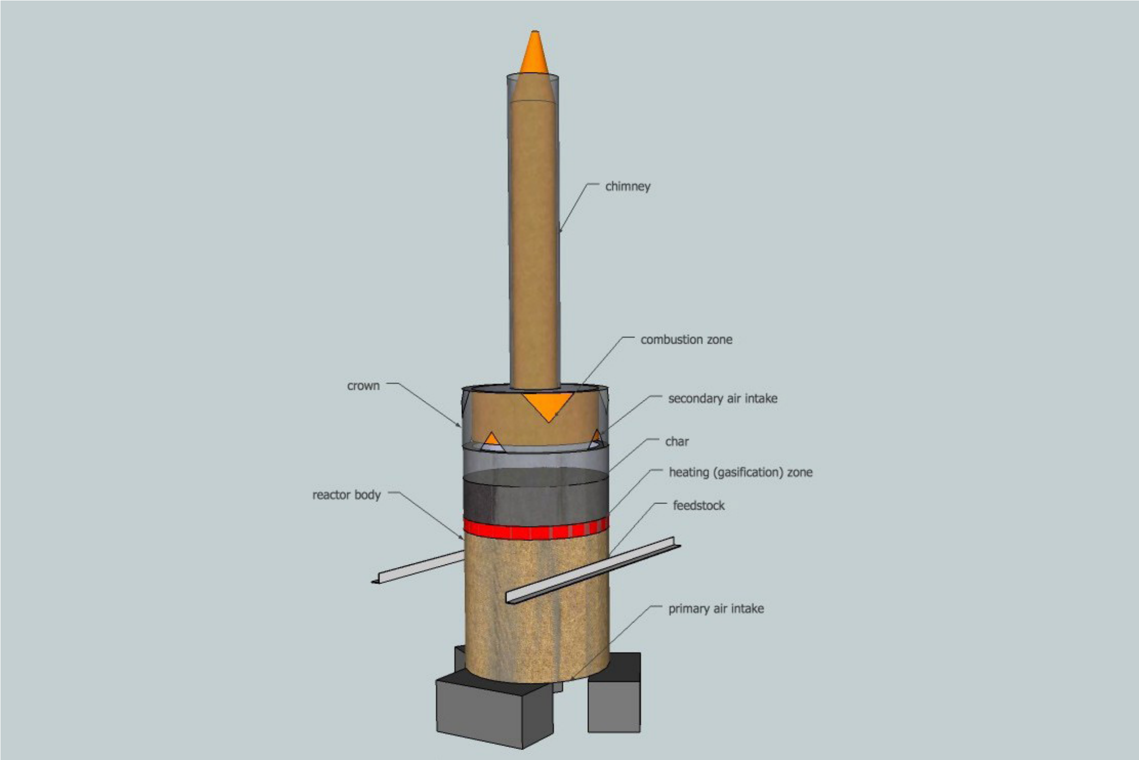


Photo by Lyse Kong

How to use the gasifier

Pack the reactor full of biomass. That can be any woody or plant-based cellulosic material. Kearns recommends materials such as corn cobs, lumber scrap and coconut husks. For details on what works best, please see the handbook.

Photo by Lyse Kong

Photo by Lyse Kong

Place the crown and chimney on top, then light the biomass through one of the vents in the crown. You can use straw or other kindling, but no lighter fluid or gasoline or anything like that is necessary. As the material pyrolizes (releases and burns off gases) it will burn with an orange flame that you can seen through the vents in the crown, as shown in the photo on the left. When the gases are burned off, the orange flame will fade to a clear, bluish color. At that point, the material is combusting and you need to shut down the reactor before it burns up.

How To Make A Biochar Gasifier

Remove the crown by inserting the poles into the vents and set it aside. This is a two-person job, as you can see in the photo below.

Place the lid on the reactor and, using the handles, move it to a nearby mud pit. Seal the edge of the lid with mud. Wait a couple of hours for it to cool and then enjoy your biochar!

Photo by Lyse Kong

An Ancient Filtration Material Removes Pesticides from Drinking Water

An Ancient Filtration Material Removes Pesticides from Drinking Water

Charcoal has been a part of water treatment for at least 4000 years, but can it remove modern synthetic pesticides from drinking water? Farmers in northern in Thailand, concerned about agricultural runoff, put the question to Josh Kearns, an environmental engineering doctoral candidate at the University of Colorado in Boulder and the science director at Aqueous Solutions, a non-profit water, sanitation and hygiene development organization.

"I didn't know the answer, and searching the scientific literature revealed that, in fact, no one knows the answer," Kearns told E4C.

The answer, Kearns discovered through his own tests, is that it can. But a lot depends on how you make the char.

Gasifiers and Char

Charcoal removes impurities from water by a process called adsorption, meaning that the contaminants adhere to the charcoal's surface. Because it is porous, however, water can flow through and permeate the charcoal. That permeation is the better-known process of absorption. Dropping the prefixes gives the word "sorption," which covers both processes.

The Thai communities make their charcoal in traditional kilns that, when burning well, heat the material to 350 to 500 C. In contrast, simple gasifiers burn at 900 C.

An Ancient Filtration Material Removes Pesticides from Drinking Water

At that temperature, the wood and agricultural waste that they burn converts more completely into char. The biomass releases gases as it heats, and those are burned as fuel. The release of gases and combustible material leaves behind char that is highly porous with a greatly increased surface area.

"Gasifier char may therefore be an optimal choice for sorption of pesticides, industrial and fuel compounds, human and livestock pharmaceuticals, and other synthetic organic compounds of increasing concern to water quality," Kearns says.

Design Principles

One problem with introducing new technology is that people might not use it if it doesn't feel comfortable to them.

"Don't fight culture; if people cook by stirring their stews, they're not going to use a solar oven, no matter what you do to market it," says Ethan Zuckerman, founder of Global Voices.

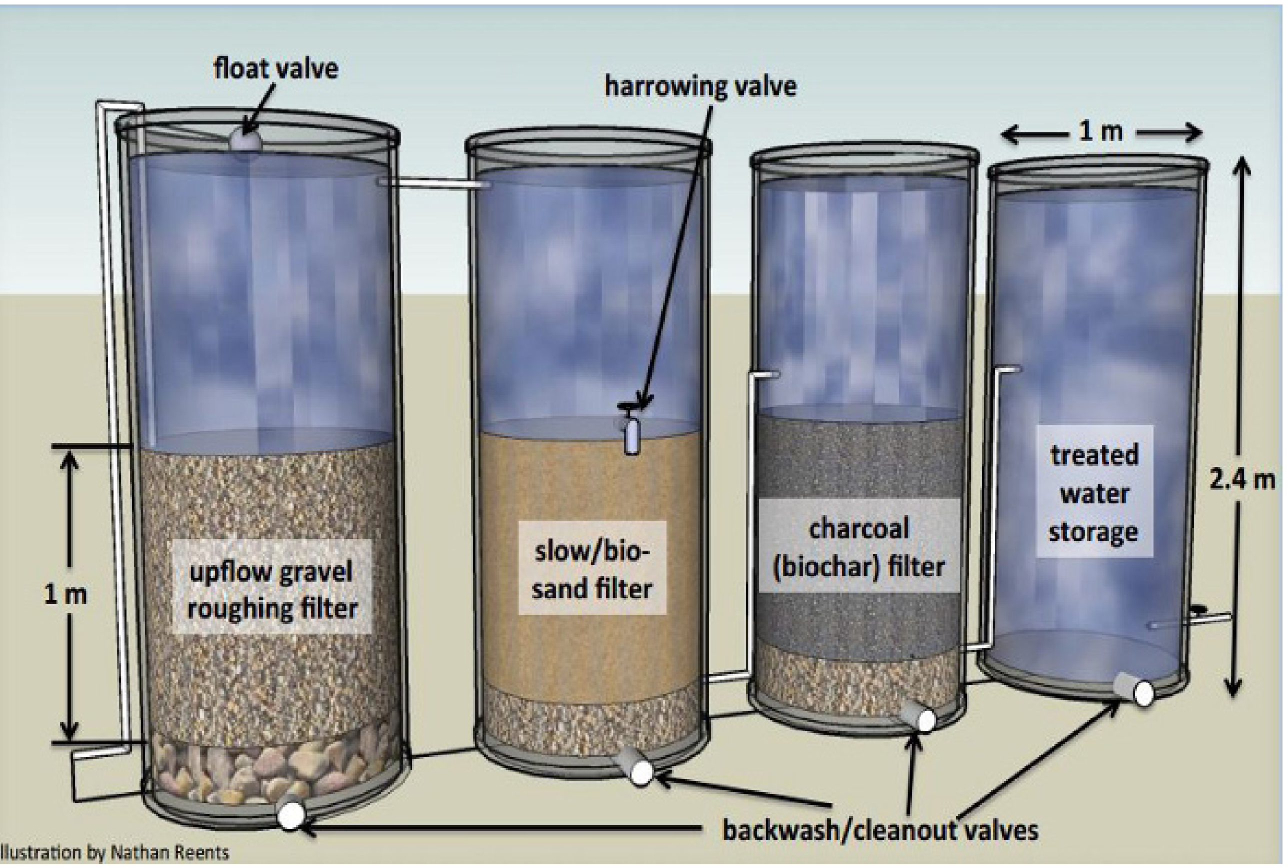
Zuckerman's advice and the maxim "consider context" is one of the design principles included in our complimentary online course, Introduction to Engineering for Global Development.

Gasifiers seem like a match. They operate in a way that is similar enough to kilns, and after a demonstration, they proved to be superior. Kearnes has built gasifiers with the help of people in the community. Gasifiers seem like a match. They operate in a way that is similar enough to kilns, and after a demonstration, they proved to be superior. Kearnes has built gasifiers with the help of people in the community.

"In regions around the world where charcoal filtration is still a known practice, there would presumably not be strong cultural barriers to uptake," Kearnes says. "However, for many traditional charcoalers, the design and operation of a gasifier for char production are not immediately intuitive." To help, Kearns spent six months on a farm in Thailand over the winter of 2011 developing the 55-gallon (200L) gasifier drum featured in this handbook.

"After seeing several batches of char made this way, they were won over because, one, it was less work to make gasifier char than traditional kiln char; two, it only took two hours for a burn as opposed to all day for a similar sized traditional kiln; and three, there was no smoke to beleaguer the operator," Kearns says.

An Ancient Filtration Material Removes Pesticides from Drinking Water



How to treat water with four containers in a series. Image courtesy of Josh Kearns

Water Treatment with Local Materials

Working with the farmers, Kearnes built a water treatment system that includes 35 cubic feet (one cubic meter) of biochar.

It's hard to overstate the importance of using locally available materials, and the water treatment systems Kearns and the farmers are developing are entirely local. One proven system links four containers in a series, the first three filled with filtering materials such as sand, char and stone, and the final container holds the pure water. This handbook explains the build: Constructing a multi-barrier water treatment system (pdf).

An Ancient Filtration Material Removes Pesticides from Drinking Water

Sanskrit and Nerve Gasses

Charcoal may have been used to treat water as early as 4000 years ago. A line translated from Sanskrit in a collection of Indian medical documents called the Ousruta Sanghita reportedly reads, "It is good to keep water in copper vessels, to expose it to sunlight, and filter through charcoal." And other documents offer similar glimpses into the use of charcoal in the region.

Biochar has been known to remove sediment and even chlorine from water, but, as Kearnes discovered, its usefulness on pesticides was less clear.

Pesticides in agriculture may predate even charcoal filters, but synthetic chemicals are relatively new. Their discovery stemmed from research into nerve gas weapons in World War II, when scientists realized that the compounds also kill insects. The proliferation of agents like DDT in the 1930s and 1940s reduced malaria and improved crop yields. The damage they inflicted on insects, however, was not limited to insects.

Detail on a gasifier. Photo courtesy of Josh Kearns

It is good to keep water in copper vessels, to expose it to sunlight, and filter through charcoal.

An Ancient Filtration Material Removes Pesticides from Drinking Water

Toxic Trouble

Today, "pesticide pollution" makes two appearances in the top 10 of The World's Worst Toxic Pollution Problems Report 2011 by the Blacksmith Institute.

Kearns calls drinking water contamination with pesticides and similar chemicals a "major worldwide problem." He cites a paper in the journal Science that points out two alarming facts. The first is that 5 million tons of pesticides and 300 million tons of synthetic organic compounds in general are produced every year and they are major contaminants. The second is that farmers in developing countries often lack training in the use of agricultural chemicals. They tend to overuse them, and they sometimes buy from a "black market" of illegal agents.

"In South and Southeast Asia where my colleagues and I work, for example, around 75 percent of the pesticides used are banned or heavily restricted in the West due to deleterious ecological and human health effects," Kearns says.

From Organ Damage to Birth Defects

Agricultural chemicals lurk in drinking water all over the world, including in developed countries. The US Environmental Protection Agency regulates chemicals and establishes maximum amounts of each that can run from the tap. Those limits are based on estimates of a potentially harmful dosage, and those doses are estimated from evidence gathered in epidemiological studies and from laboratory animals and other research (EPA's health risk assessments for many pesticides). Legal wrangling, new evidence and shifting political pressures can lower and raise those limits. In developing countries, scarce resources can prevent adequate regulatory control.

Drinking water laced with pesticides and other chemicals on a regular basis is linked to cancer, organ damage and reproductive defects in lab animals. And pesticide exposure in the workplace, through breast milk and in food and water is linked to sperm and fertility defects, spontaneous abortion, fetal growth retardation, developmental problems and possibly childhood leukemia.

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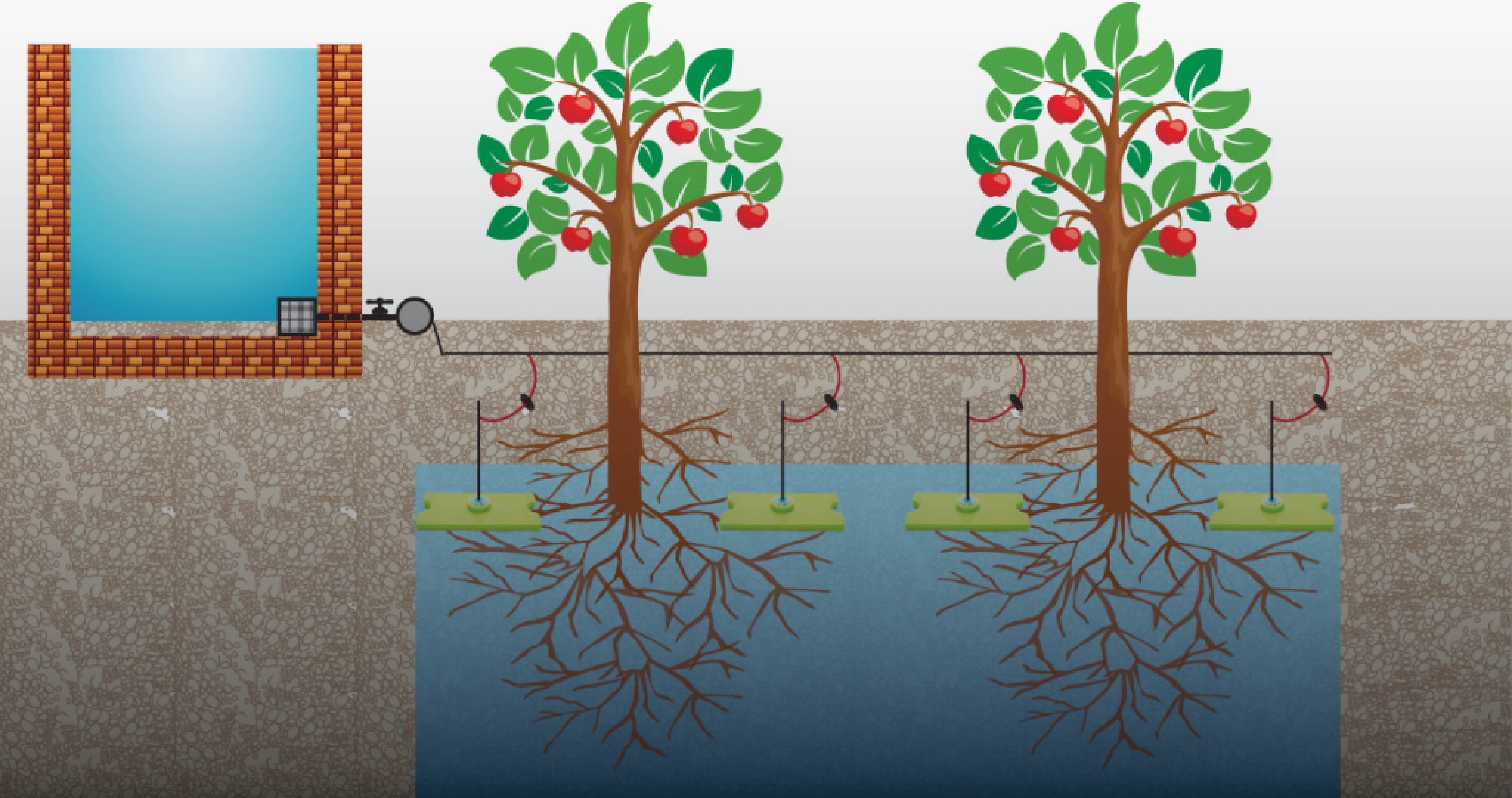
A Local Solution

In the absence of water treatment infrastructure in many rural communities, the Blacksmith Institute recommends small-scale filtration in people's homes. Kearns agrees. He and Aqueous Solutions have created a series of handbooks in English and Thai to explain gasifier and water filter construction.



Ten Technologies for Farming in Dry Climates

Ten Technologies for Farming in Dry Climates

Farmers in dry climates manage to coax crops from sandy soil and water them with rain and even fog. We mined our Solutions Library and network of experts for proven tools and even a couple of prototypes that are helping farmers grow food with little water. These are 10 tools that enable farming in dry climates.

Zero-Emission Fridge

Subsistence farmers in Mozambique have to endure a dry season from October to January that they call the "hunger period." Families eat less to get through the drought. As the world's climate changes, the dry season is lengthening. Low incomes and limited or no electricity make refrigerators scarce in these communities. But storing food is more than just a convenience, it can alleviate hunger. The Zero-Emission Fridge for Rural Africa (ZEFRA) can help. Also known as Silo Tehetere, the fridge is a seed storage silo built with local materials, and it doesn't require power.

The fridge (or silo) is made of woven bamboo encased in clay. It seals seeds in a nearly hermetic chamber which also contains herbal insect repellents, all standing on a base with built-in mouse traps.

Learn more in our Solutions Library.

HESE Affordable Greenhouses

Greenhouses are essential to productive farming in dry climates, and this one is created for low-income farmers in developing countries. The Humanitarian Engineering and Social Entrepreneurship program at Pennsylvania State University tests and distributes these Affordable Greenhouses in Kenya and Tanzania and the team is branching into drier African climates. The greenhouses can be made from locally available materials, they are tough and they can expand with the needs of the farmers.

HESE's research shows that the greenhouses cut water loss by up to 30 percent and water usage by 50 percent if used in tandem with a drip irrigation system.

Learn more at HESE Affordable Greenhouses.

Lotus Solar Pump

U Myat Kyaing and his son U Nyein Hlaing stand by the solar panel that powers their new Lotus Solar Irrigation System. The farmers in Myanmar were the first customers to buy Proximity Designs' pump after its launch in October 2015. Proximity calls it "radically affordable" for its retail price of $345, making it one of the most low-cost solar pumps on the market. Powered by 260W of solar panels, the lotus is a submersible pump that fits into the 50mm (2in) tube wells common in rural Myanmar. At a depth of 7.3 meters (24ft), the pump can yield 15,000 liters (4000 gallons) of water per day.

Thanks to the Autodesk Foundation, which provided funding for Lotus, for recommending it to our list. Learn more at Proximity Designs. And compare it to the Sun Pumps SDS Submersible Solar Pump in our Solutions Library.

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Moisture Sensors

Moisture sensors tell a farmer when to irrigate and when the crops have had enough. Researchers are developing devices that give intuitive visual readouts that reduce the complexity of using a new digital tool. IDEO.org is testing sensors like the one picture above in Africa and in Myanmar, where the organization has teamed with Proximity Designs to test sensors in the country's dry region.

A day of measurements reveals the land's drainage rate, soil type and the farmer's behavior.

In the longer term, weather pattern data emerges.

Thanks to The Autodesk Foundation for recommending this prototype to our list. Learn more at IDEO.org.

The Chameleon is another sensor prototype in testing now in Mozambique. The device, funded in part by the Australian Centre for International Agricultural Research, also gives a visual readout, changing color to indicate moisture levels.

Hand and Treadle Pumps

"The use of low-lift pumps in SSA has had a hugely significant adoption rate," Roberto Lenton, the founding executive director of the Robert B. Daugherty Water for Food Institute at the University of Nebraska, said in the E4C Webinar Managing Water for Food Security.

Rope pumps like the one by iDE pictured here, other hand pumps, treadle pumps, ram pumps and more make irrigation affordable. Learn more in our Solutions Library.

"The use of low-lift pumps in SSA has had a hugely significant adoption rate."

- Roberto Lenton,
founding executive director of the Robert B. Daugherty Water for Food Institute at the University of Nebraska

NBD Nanotechnologies' Fog Nets

Fog nets work where fog is abundant, but they aren't quite up to the task in drier climates. To capture water from the air for irrigation, the engineering firm NBD Nanotechnologies is giving the nets an upgrade. NBD is testing its superhydrophobic coating on nets in the semi-arid hills of San Francisco. Data suggest that the coated nets yield five times as much water as uncoated nets. And 50 of them in heavy fog may capture up to 19,000 liters (5000 gallons) of water per day.

Oil Expellers and Other Added Value

Ten Technologies for Farming in Dry Climates

The Piteba Oil Expeller can make olive oil from olives, increasing the value of a crop that grows in dry climates. A farmer can add value by making olive oil on the farm instead of selling the olives to a third party to make the oil. That extra money, managed wisely, improves the farm's chances of weathering droughts and market fluctuations.

An oil press is just one example of how farmers can add value. In our Solutions Library you'll find presses, solar driers and nut and maize shellers, all with specifications and prices for side-by-side comparison.

Groasis Waterboxx

The Groasis Waterboxx mimics animal excrement by protecting seeds, locking moisture into the soil as they sprout. Birds and other animals excrete seeds and the dung adds and retains moisture in the soil around the seed. Groasis, invented by Pieter Hoff, is a 20 liter (5 gallon) barrier placed around the seedlings of fruit trees and shrubs in desert and semi-arid farms. The device gathers rain and dew in a reservoir under the plant, preventing its evaporation and allowing it to nurture the plant over time.

The device is an awardee of Securing Water for Food: A Grand Challenge for Development. Thanks to SWFF for the recommendation to our list. Learn more at SWAR.

Image courtesy of Groasis

Ten Technologies for Farming in Dry Climates

The Buried Diffuser

The Buried Diffuser is a square or rectangular plastic plate with a 5mm layer of silica that is connected to an underground drip irrigation system. The plate is buried near the roots of the crops and diffuses water from the drip system around and underneath it. The plates can last up to 30 years without maintenance.

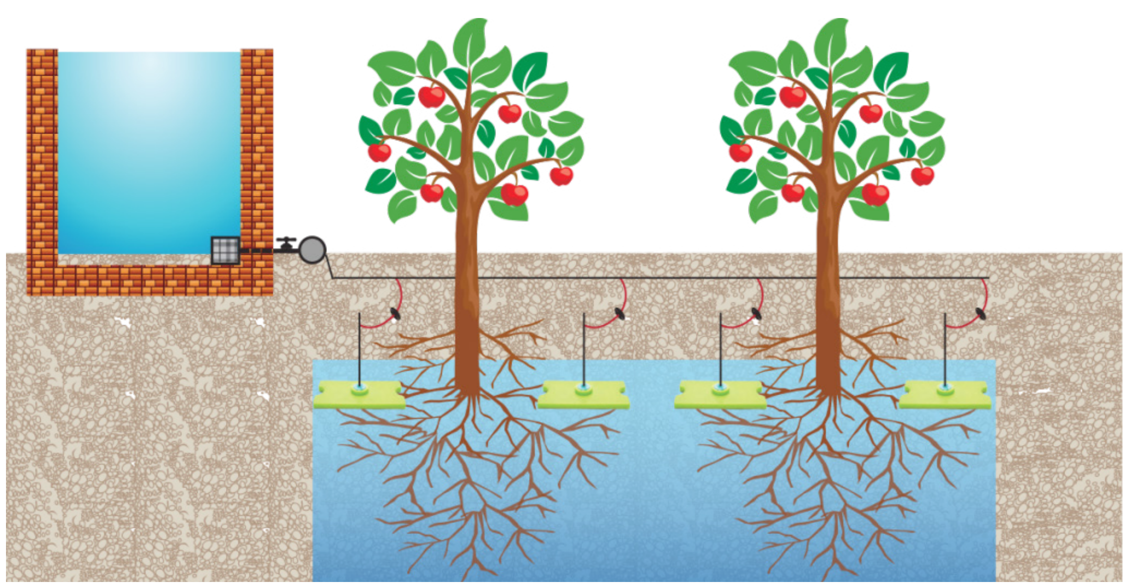
In tests on farms in Tunisia, the system increased crop yields. It also reduced the cost of crop production and the amount of water needed by 30 percent compared to traditional drip systems.

The device is an awardee of Securing Water for Food: A Grand Challenge for Development. Thanks to SWFF for the recommendation to our list. Learn more at Chahbani Technologies.

SWAR Root Moisture Control System

The SWAR system allows orchards to flourish in the dry regions of Andhra Pradesh near India's southeastern coast. The process begins with rainwater catchment. Then, using a treadle pump, the farmer pushes the rainwater up to a holding tank above the field. Gravity draws the water down through PVC piping to sealed plastic jugs placed inside of ceramic pots. The pots are buried near the trees. Water drips slowly out of the jugs into the pots where it seeps into the soil. Tests suggest that it reduces water by 80 percent compared to above-ground drip systems.

The device is an awardee of Securing Water for Food: A Grand Challenge for Development. Thanks to SWFF for the recommendation to our list. Learn more at SWAR.



Urine is Fertilizing Crops and Saving Money in India

Urine is Fertilizing Crops and Saving Money in India

Consider these facts about urine: Adults produce 1-2 liters (4-8 cups) per day; it's a reservoir of nitrogen, potassium and phosphorus, the same elements that nourish crops; and it's cheap to make.

That's the kind of information that Sridevi Govindaraj, an Indian agriculture expert, had in mind when she proposed that dousing fields with urine could improve sanitation and boost farmers' incomes.

"Human urine is indeed not an unwanted waste, but it is a useful resource," Sridevi wrote to E4C.

Urine, it turns out, is a huge and mostly untapped reserve of crop fertilizer. If Indians collected and applied 40 percent of their urine, the country could save $26.7 million (1.2 billion rupees) in fertilizer costs, Sridevi calculates.

Sridevi Govindaraj tours a banana plantation, which is one of the crops that she tested with human urine as a fertilizer. Photo courtesy of Sridevi Govindaraj

A Unique Field

Those figures are from her doctoral thesis at the University of Agricultural Sciences, Bangalore in 2009, with research funded by the Arghym foundation. Sridevi may be the only person in India with a doctorate in ecological sanitation.

Urine is Fertilizing Crops and Saving Money in India

The Urine Proposal

She proposes using urine in conjunction with regular fertilizers. People would collect it in specially rigged latrines, like Blue Box's urine-diverting dry toilets. Or, in lieu of a commercial product, DIY attachments to toilets in the men's room are cheap and easy to make.

The Experiment

Sridevi tested urine on maize, bananas, radishes, tomatoes, millet and French beans, all with encouraging results. In nearly all cases, urine outperformed chemical fertilizers, she says.

"Now many farmers adopted our technology and implemented it in their own field," Sridevi says.

More Tips and Fun Facts

Application to the fields works best with a diluted mixture of five parts water to one part urine. A drip irrigation system can help avoid health hazards. And Sridevi suggests using airtight containers to store the urine and gloves to transport and apply it.

Urine is packed with the nutrients plants need. In 22 gallons (100 liters), there are more than 10oz (300gm) of nitrogen, 6oz (170gm) of phosphorous, and 5.6oz (160gm) of potassium. Plus, it has almost every other essential and secondary nutrient that plants can use, Sridevi says.

Human urine can be used in agriculture for food production and it could lessen our dependency on commercial fertilizer.

10 Ways to Put Human Waste to Use

10 Ways to Put Human Waste to Use

It was hard to limit the list to just ten. With a mix of proven technologies, award- winning prototypes and an eye-catching entry at Maker Faire Africa this year, we present ten ways to put poop and pee to good use.

1. Urine-powered Generator

Four young Nigerian women ages 14 and 15 made interesting headlines when they debuted their urine-powered generator at Maker Faire Africa in Lagos this month. The device uses electrolysis to separate hydrogen from the water in urine and then fuels a generator with the gas. Water might work just as well, but saying your phone charged on urine just makes more of a splash, so to speak.

2. Fertilizer

If 40 percent of the people in India stored their urine to use it on their crops, the country's farmers could save $26.7 million (1.2 billion rupees) in fertilizer expenses, Sridevi Govindaraj calculated when she completed her doctoral thesis in ecological sanitation at the University of Agricultural Sciences in Bangalore. Incidentally, she may be the only person in India with a doctorate in ecological sanitation.

Sridevi Govindaraj tours a banana plantation, which is one of the crops that she tested with human urine as a fertilizer. Photo courtesy of Sridevi Govindaraj

10 Ways to Put Human Waste to Use

Our bodies make about four to eight cups (one to two liters) of urine per day, and it's rich in nitrogen, potassium and phosphorus, the same elements that crops love. It's also pretty cheap to make. Urine, Sridevi told E4C, is a useful resource.

Resources

E4C news: Urine is fertilizing crops and saving money in India

Appropedia: Liquid fertiliser system

3. Drink It

NASA is developing a complex, expensive and, as it turns out, somewhat buggy machine that purifies human urine to recycle the water for astronauts to drink. Rex Walheim, a NASA mission specialist, tests the Forward Osmosis Pump Syringe in the photo, injecting a colored "Challenge Liquid" into the Forward Osmosis Bag on the middeck of the Atlantis.

It may be much easier to purify urine for drinking here on the ground, however.

We've heard of the theory that drinking urine has health benefits, and fresh urine can be sanitary (although it could pick up pathogens on its way out of the body if the person has a disease). But for the select few who are trapped in a desert with no water and can't stomach the thought of drinking straight urine with no chaser, we suggest making a solar still. The still uses the sun's radiation to evaporate water from the urine, collecting the condensate on a surface, such as plastic wrap, and channeling it into a container to drink.

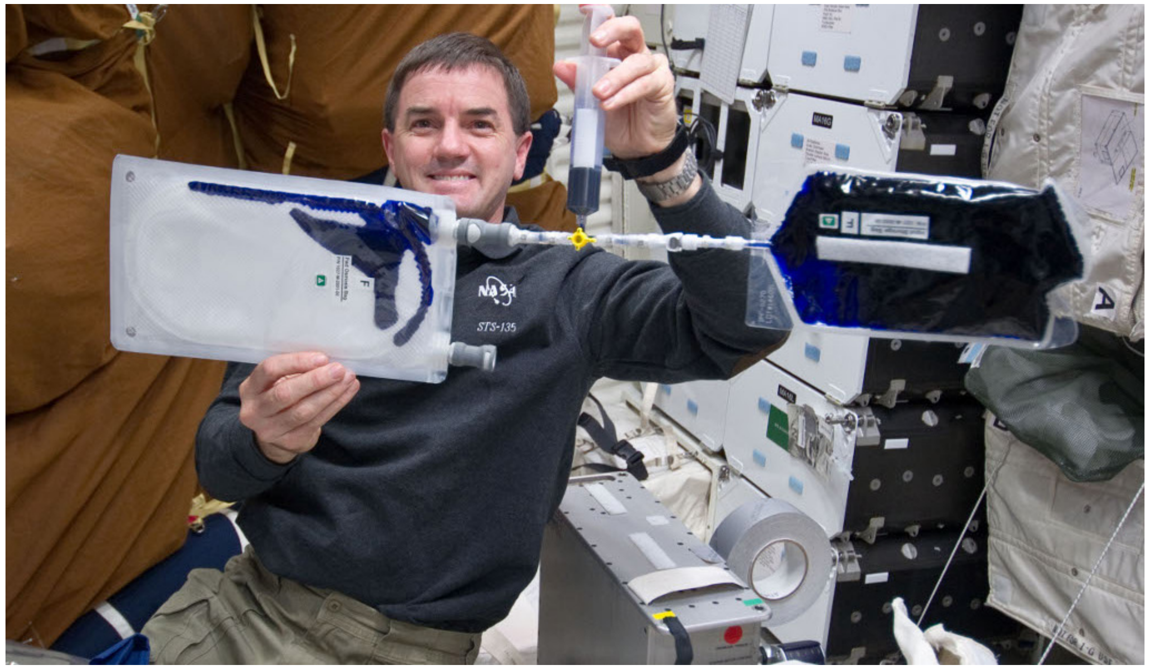


Photo courtesy of NASA

Resources

YouTube: How to make a solar water distiller

4. Animal Feed

Black soldier fly larvae thrive in feces, and after processing, they make for nutritious farm animal and fish feed, and also biodiesel. A research team at the London School of Hygiene and Tropical Medicine is looking into how to raise them in central facilities on a diet of waste collected from latrines. An earlier, alternate version of the plan is a fly-catching latrine that lures the pests in but prevents their escape, turning the latrines into fly killers and possibly even larvae producers.

Field tests are underway now in Cape Town, South Africa.

Photo by Thomas Shahan / Flickr

Resources

Sanitation Ventures: Black soldier fly additives

Sanitation Ventures newsletter: Toilets and fly larvae project, pg. 13

5. Compost

Composting latrines turn a sanitation problem in an agricultural solution. In fact, Jason Kass, founder of Toilets for People, recently called a variant of a composting latrine the "toilet of the future," in a guest column for E4C.

The basic ecological composting latrine design is two pits, one covered with a semi- mobile structure that is the actual toilet and walls. You mix the human waste with materials such as ash and yard clippings or agricultural waste. When the pit is full, you move the structure to the second pit, cover the first and let natural bacteria and the animal agents of decomposition do their work. When the waste is naturally processed, dig up the compost and spread it as a safe fertilizer on crop fields.

Variations of the design collect the waste in removable drums for off-site composting. Toilets for People and SOIL are two organizations promoting this method in Haiti.

Resources

E4C news: High-tech toilets? What we need is a low-tech toilet revolution

Five questions with Sasha Kramer (SOIL)

Simple, effective toilet designs like this one, the CRAPPER, are more likely than more expensive devices to become the "toilet of the future" that serves the developing world, Jason Kass says. Photo courtesy of Jason Kass

6. Grow Mushrooms or Watercress

Rural Bolivia has a toilet shortage. Fewer than half of rural Bolivians have regular access to a toilet, according to the World Health Organization. But with such scarcity, by definition toilets are strange, foreign objects, and many people there are not inclined to try them out. Aid organizations have given away composting latrines to communities in the region, but studies show that only one-fifth to half of them are used correctly. Instead, people defecate on the open ground. To entice better use of the free toilets, Water for People is experimenting with a composting business venture. Compost from correctly used latrines is spread on reforested land planted with Monterrey pine saplings. The pine trees provide a habitat for expensive bolete mushrooms, which can generate relatively high incomes for the communities.

We see evidence of some creative problem solving in that experiment, but the general concept of cashing in on compost is not unique to Water for People. SOIL and other organizations, some mentioned here and elsewhere on E4C, are also turning poop into profit with some encouraging results.

Not to leave out number two, an example of the fertilization powers of urine is an odd experiment in raising watercress. A Web page that is enthusiastically named drinkpeedrinkpeedrinkpee offers a kit and a how-to guide to growing (supposedly) edible watercress in a bowl full of urine.

A bolete mushroom. Photo by Vicki & Chuck Rogers / Flickr

Resources

E4C news: Toilets for mushrooms: An experiment to improve sanitation

7. Biogas Production

One of the gases that lends human waste its stench is methane, which, as 13-year-old boys with matches worldwide must know, burns. A biogas digester collects methane as microbes produce it inside a closed container (oxygen can be deadly to microscopic methane-producers). With the right equipment, gas channeled from a container of waste could generate electricity, heat water for homes and industry and cook food on a gas range. Sanergy, the organization behind the useful bicycle modification that converts it into a latrine pump, also promotes biogas production from waste collected from urban communities in developing countries.

Resources

E4C news: A bike-powered poop pump is redefining low-cost sanitation

E4C Solutions Library: Biogas Pit Latrine

Biogas generators and biogas-powered products

8. Hydrogen Gas Production

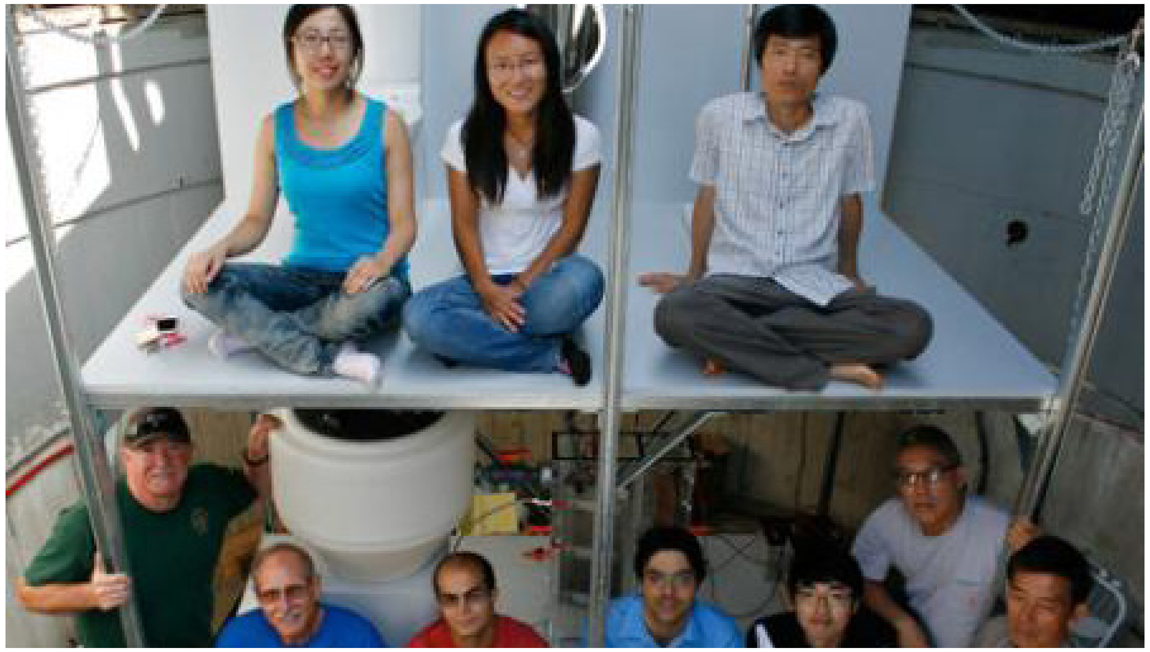
Michael Hoffmann's Gates Foundation award-winning toilet prototype uses solar power to break human waste into hydrogen gas and leftover solids. Hoffman and his team at Caltech showed how the toilet could store hydrogen in fuel cells as an energy source. The toilet treats waste on the spot and syphons off hydrogen for later use as energy.

9. Generate Power on the Spot

In a unique variation of biogas production from human waste, researchers at Delft University of Technology have worked out a way to produce synthetic gas – "syngas" – which is a mixture of carbon monoxide and hydrogen.

Their Gates Foundation award- winning design dries the waste on the spot and zaps it with microwaves to heat it into a plasma for gasification (all proprietary technology). Then the toilet stores the gas in a solid state fuel cell stack to produce electricity.

The design is affordable, the researchers say. Like other prototypes on this list, we mention this as a point of interest while we're waiting to see if the end products are also practical. No photo is available.



The Caltech team poses around their hydrogen-gas producing toilet design.
Photo courtesy of Caltech

Treat Jellyfish Stings

False. It turns out that urinating on a jellyfish sting will do little to alleviate the burn and could actually exacerbate it. Thanks to Scientific American, About.com and other sources for this important exposé. This new information raises a question, though: If it doesn't work, then who spread this rumor to begin with?

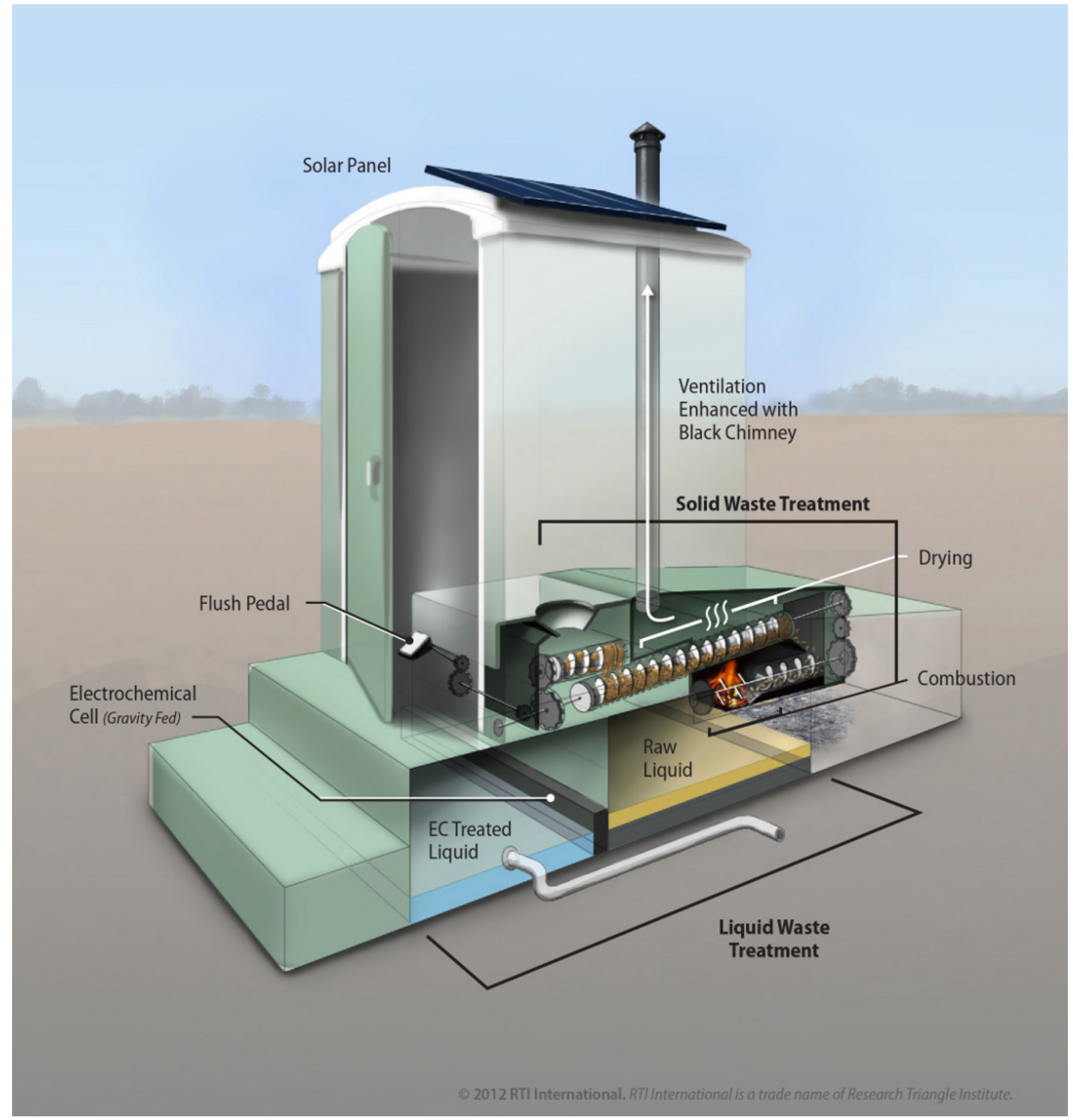


Image courtesy of RTI International

10. Burn it as Fuel Briquettes and Biochar

With the last use debunked, we'd like add a final use for human waste: Fuel briquettes. Not compost, not biogas or hydrogen fuel cells, but actual, burnable fuel made from treated human waste. Researchers from the University of Colorado in Boulder won a Gates Foundation grant to develop a solar-powered toilet that turns waste into biochar.

And researchers from RTI International in North Carolina won a Gates Foundation grant for their toilet design that converts waste into fuel briquettes that it burns for storable energy. It also churns out treated, but non-potable, water.

We came across other uses for human waste: Urine has been used as a disinfectant, invisible ink and dye for cloth, and both urine and feces are necessary to diagnose certain illnesses and parasitic infections, for example. If you have other tips on how to put waste to use, please share in the comments below.