Purifying Water Using Sustainable Methods

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www.sustainlife.org

The Ploughshare
Institute for Sustainable Culture

INSPIRE. INFORM. INSTRUCT

We all need water

Beautiful, clean water!

Is This Water Safe to Drink since the stream is running?

What Do you think?

Assumptions About Water Quality are Dangerous

Drink from this stream without treating the water and you might die, or be so sick that you are unable to do anything.

Why Water Treatment?

- **Preventable** waterborne diseases — 80% of all illnesses and deaths in the developing world.
- Children — nearly **two million deaths** each year.
- Chemical contamination — illness, death and birth defects.

What are Pathogens?

- **path·o·gen** [path-uh-juhn, -jen]
- *noun*
- any disease-producing agent, especially a virus, bacterium, or other microorganism.

Sources of Waterborne Disease

- **3 Main Sources of waterborne disease**
- Protozoa (parasites, amoebas, cryptosporidium, giardia, etc.)
  - Bacteria (botulism, cholera, E. Coli, salmonella, legionella, typhoid, etc.)
  - Viral Pathogens (SARS, Hepatitis A, Polio)

Safe and Clean Water

- **Long-term Storage Issues**

- Stale, bad-tasting water
- Some containers leach
- Algae growth
- Dirt, soil or pollen
- Anaerobic conditions

Safe and Clean Water

- What sustainable methods are available to treat water?
  - **Chemicals**
  - **Filtration**
  - **Heating or vapor distillation**
  - **UV light**
  - **Ozone**

Pros and Cons of Chemicals

Good:

- Easy to use
- Chemicals are fairly cheap
- They usually keep well over time
- Long lasting effects in the water-even during storage

But:

Pros and Cons of Chemicals

Bad:

* Chemicals are toxic
* Chemicals can taste bad
* Chlorine does not work well in high pH-most ground water is high pH
* Chlorine's effectiveness decreases as temperature increases
* There are new mutated forms of pathogens that are becoming increasingly resistant to these chemicals
* Disinfection byproducts are formed when pathogens are killed

* ...water needs to be disinfected to inactivate (or kill) microbial pathogens. However, disinfectants can react with naturally-occurring materials in the water to form byproducts including:
*

- Trihalomethanes (THM),
- Haloacetic acids (HAA),
- Chlorite, and
- Bromate.

www.epa.gov/dwreginfo/stage-1-and-stage-2-disinfectants-and-disinfection-byproducts-rules

Filtration

- **Filtration** is the next major method of water treatment and it is used in two main ways:

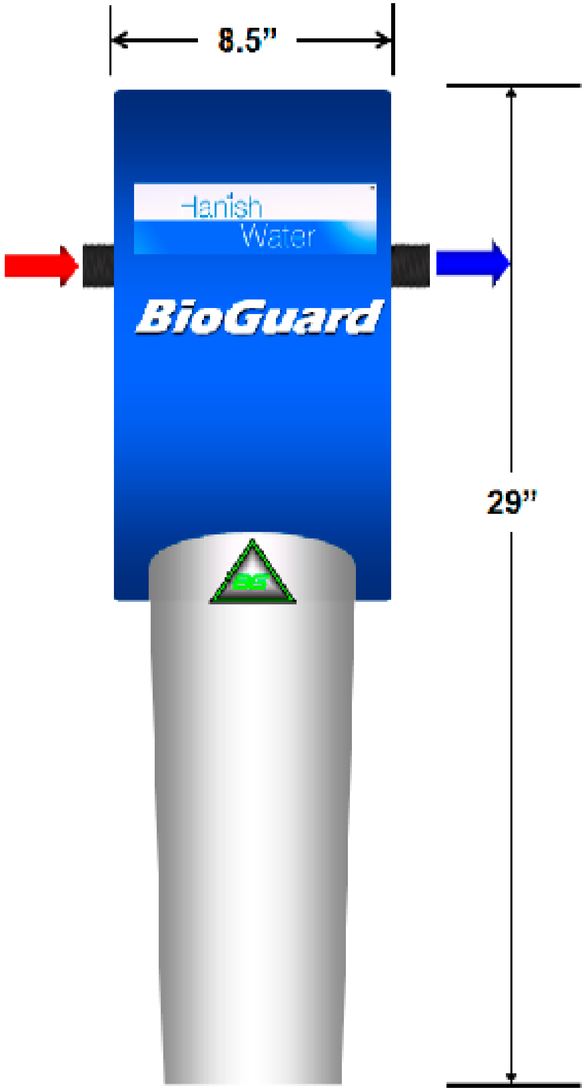
- Taste and sediment filters
- Filters that either adsorb, kill or block pathogens

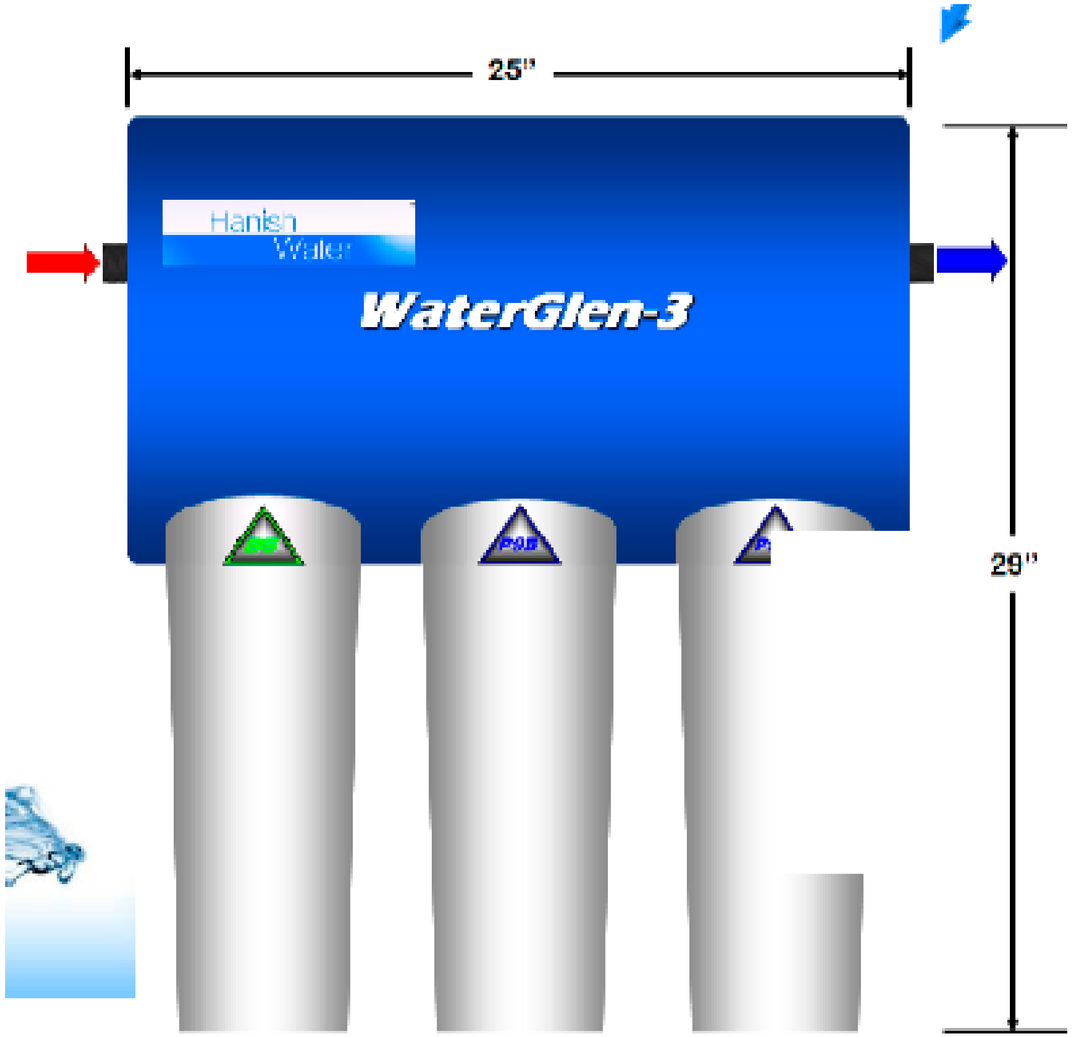
Nano Alumina Filters

- They come in two basic configurations:
  - Standard filter cartridges under the name **NanoCeram®**
  - Special cartridges and assemblies under the name **Bioguard®**

- The standard **NanoCeram®** cartridges **do not** meet the standards of safety to be used as disinfection units of contaminated water due to the lack of fail-safe seals in the standard water filter housing.

Single Cartridge BioGuard®





Three Cartridge WaterGlen® System

- The systems with multiple cartridges consist of various filtration levels and one BioGuard®

Pros and Cons of Nano Alumina

- **Good:**
  - Very good filtering-equal to the Reverse Osmosis
  - Very fast flow-no slow down in home water system even if filtering all the water for the home
  - Easy to maintain-owner can change out the filter easily
  - The filter cartridges are fairly inexpensive
  - There is no back flushing or water waste
- **Bad:**
  - The filter must be changed every 6 months to 1 year in normal use
  - The units can only be purchased from authorized dealers
  - The units are about the same price as UV lights at first purchase
  - Care must be taken to pre-filter the water
  - There must be at least 1.5 psi of pressure for the filter to function-water source would be at least 3.5 ft. above filter for a gravity feed

New Filters Available

- Activated Alumina and Granulated Activated Charcoal filter for removing Fluoride, Chlorine, and Chemicals from tap water.
- These fit a standard 10” under-counter filter base.
- This filter is rated for 500 gallons.

New Filters Available

- Personal sized adsorption filters
- These are good for emergencies or hiking.
- Shown is the GRAYL Ultralight Water Purifier.
- It uses nanoalumina filtration It is rated for 300 gallons. This filter will also filter chemicals due to the activated charcoal mixed within the filter cell-the orange device pictured at right.

New Filters Available

- Personal sized ultra fine membrane filters
- These are good for emergencies or hiking. This filter is rated for 100,00 gallons. It is back washed to clean.
- Shown is the Sawyer Mini

History of the Slow Sand Filter

- Egyptians 2000 BC.

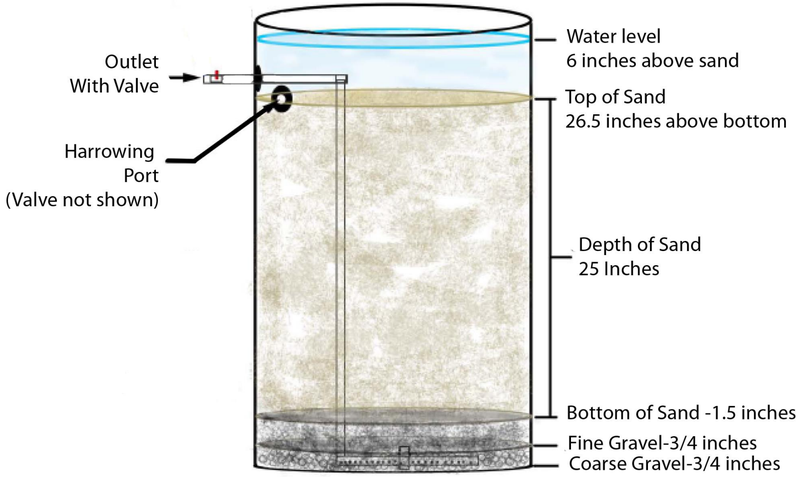
- In Paisley Scotland in 1804, John Gibb invented the 1st modern SSF

- The first drinking water supplies for cities:
- In Paris, France in 1806
- In London, England in 1827,
- The first SSF built in the US was in Richmond, VA in 1832.
-
- The Metropolis Water Act of 1855 in Britain, was the first law concerning water treatment and it required all water supplied to London to be treated by SSF.

History of the Slow Sand Filter

- Hamburg and Altona, Germany in 1892 experienced a cholera outbreak.
- Hamburg did not filter the water taken from the river while Altona used SSFs.
- Hamburg suffered 30% of the population infected with 7500 deaths and Altona was almost totally unaffected.
- In the light of this development, all Europe began using Slow Sand filters to treat drinking water.

Slow Sand Filter



Building a Slow Sand Filter

SSFs are very easy to build

Preparing the Vessel

Drilling hole for grommet seal for the harrowing valve

Installing Ports

Installing grommet seal

Outlet Plumbing

Clean water outlet

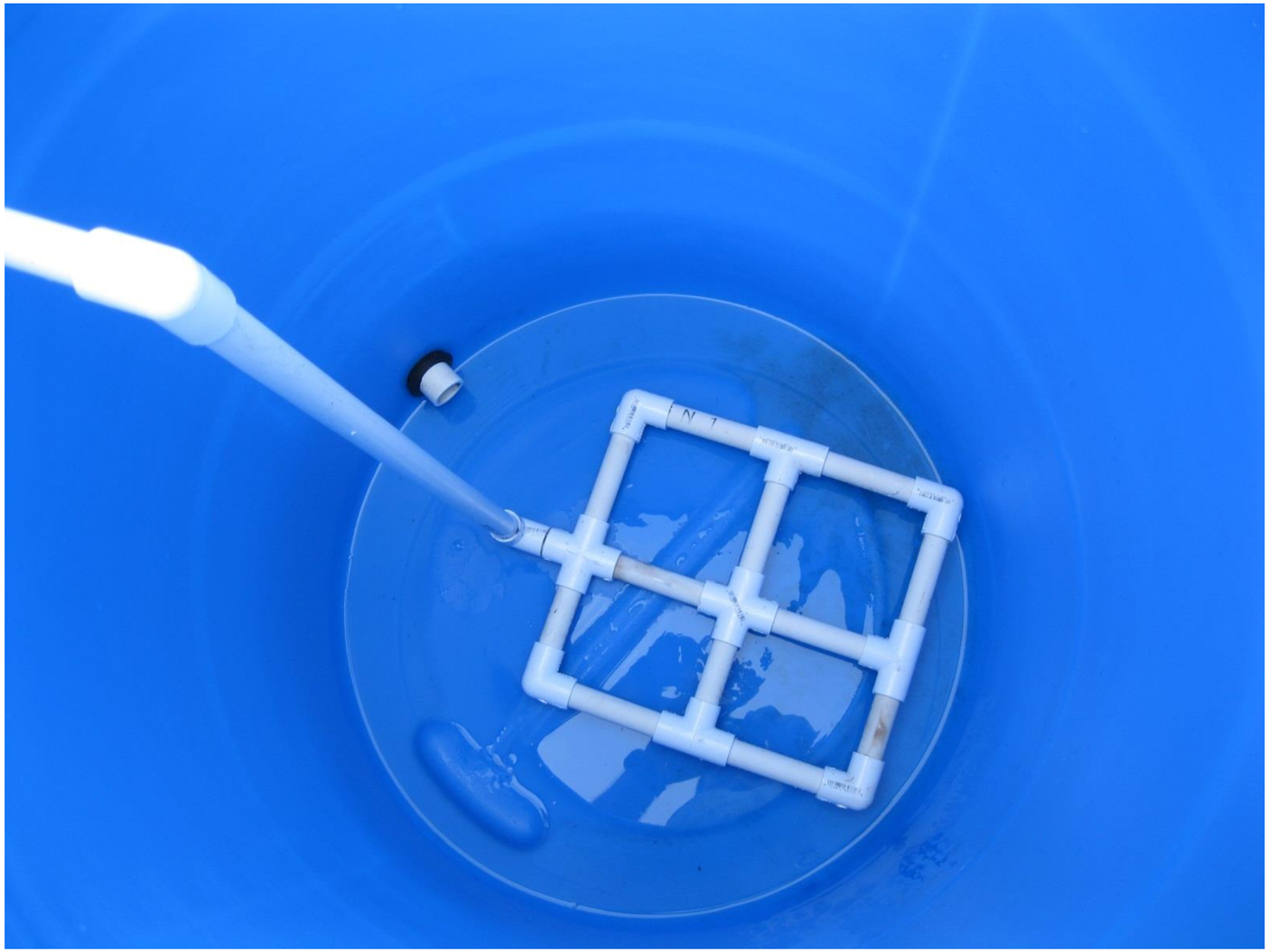
All Three Outlets

All the openings: Drain on bottom. Harrowing valve on left.
Clean water outlet on right.

Clean Water Manifold

Manifold goes in the bottom to take water from various positions. Notice the tiny holes.

Installing Manifold



Manifold placed in the bottom of the filter. Drain on the left.

Installing Gravel Media

Gravel covering the manifold at the bottom of the filter

Installing Sand Media

Notice the downpipe is not against the wall of the filter

Flushing Silt at First Fill

The brown color in the water is silt from construction

Contaminated Water Level

About 6-6.5 inches of water sits over the sand layer

Slow Sand Filter Delivery at Maximum Safe Flow Rate

Filter surface in Sq.Ft	Gallons at 7.4 gal/hr/sq.ft.	Gallons per 24 hours	Gallons per minute	Oz/minute
0.25	1.85	44.4	0.03	3.95
0.5	3.7	88.8	0.06	7.89
0.75	5.55	133.2	0.09	11.84
1	7.4	177.6	0.12	15.79
1.5	11.1	266.4	0.19	23.68
2	14.8	355.2	0.25	31.57
2.5	18.5	444.0	0.31	39.47
3	22.2	532.8	0.37	47.36
3.5	25.9	621.6	0.43	55.25
4	29.6	710.4	0.49	63.15
4.5	33.3	799.2	0.56	71.04
5	37	888.0	0.62	78.93
5.5	40.7	976.8	0.68	86.83
10	74	1,776.0	1.23	157.87
10.5	77.7	1,864.8	1.30	165.76
11	81.4	1,953.6	1.36	173.65
12	88.8	2,131.2	1.48	189.44
13	96.2	2,308.8	1.60	205.23
14	103.6	2,486.4	1.73	221.01
15	111	2,664.0	1.85	236.80
Do not exceed these numbers!				
Minimum Safe Depth of Media is 15.75 inches!				

Sand Filter Calculations

Known Items:	Diameter	Height
30 gal drum	19.5	29.5
55 gal drum	23.75	34.5

Convert feet to inches	feet	inches
	0	0

play sand	$ 3.47
filter sand	$ 5.48
size-cu.ft.	0.5

Choose if cylinder or rectangle	cylinder

	Diameter	Height	
Enter drum dimensions	23.75	34.5	inches

	length	width	height	
Enter rectangle				inches

Choose head height	8	choose gravel height	5	inches

Enter size of gravel bag	0.5	price:	$ 3.47	each
Enter size of sand bag	0.5	price:	$ 5.48	each

Choose sand Type	filter sand

Enter data in green cells only

Blue cells are results of calculations

Yellow cells are known data

Calculating safe daily flow rate		
Enter maximum need	100	gal/day
Required sq.ft.	0.28	sq.ft for low flow
	0.57	sq.ft for Maximum flow
Chosen sq. ft.	3.08	safe

There is no lower limit on flow. Lower is better.

Materials	
Number of gravel bags:	3
Number of sand bags:	11
Cost of gravel:	$ 10.41
Cost of sand:	$ 60.28
Total media cost:	$ 70.69

Sieving play sand is hard labor

Play sand has loss from sieving it.

Filter sand is cleaner and more uniform

Filter sand should be used if possible

Range of safe flows				
Low flow	15.10	Gal/hr	0.25	Gal/min
Maximum flow	22.65	Gal/hr	0.38	Gal/min
Low flow	60.4034	quarts/hr	32.22	oz/min
Maximum flow	90.61	quarts/hr	48.32	oz/min

Do not exceed maximum flow rates!

Media Depth:	26.5	inches
Tap height from bottom:	28	inches
Sand height from bottom:	21.5	inches
Head in ft:	0.67	inches
pressure:	0.29	PSI

Minimum sand safe height:	15.75	safe	by	5.75	inches

Pros and Cons of the SSF

- **Good:**
  - Once the filter is constructed, it is the most sustainable water treatment device available and will last forever if maintained properly.
  - It is time-tested since 1804 to be very reliable and safe.
  - Thousands, if not millions, are using SSFs today to prevent waterborne diseases.
  - Smaller units can be made for less capacity if attention to the specifications is observed.
- **Bad:**
  - It is very heavy and is a permanent fixture unless you remove the sand.
  - Inattention to details on the specifications could result in unsafe conditions
  - There is no secondary disinfection

Blocking Filters

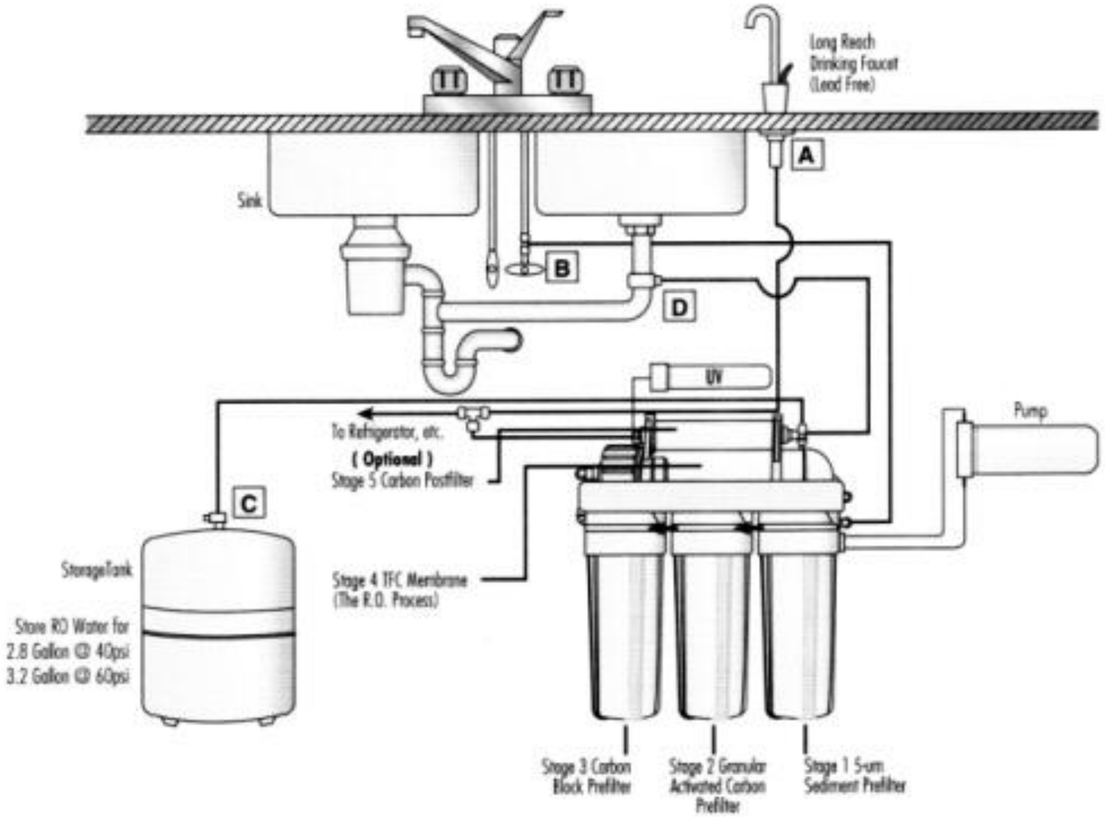
- We will look at two types of filters that block pathogens:

- **Reverse Osmosis**
- **Ceramic filters**

Reverse Osmosis

- The Good:
  - Very pure water-the purest water except laboratory distillation
  - Water is softened by removing minerals

- The Bad:
  - Very high ratio of wastewater to filtered water—about 4-10 gallons of waste per gallon of filtered water-much too high for situations where there isn't an abundance of water.
  - Pressure is required for the system
  - The process is slow-perhaps 1-1.5 gallons per hour or longer
  - The water is too soft in some cases to the point the water will pull minerals from your body as distilled water will.
  - There is no secondary disinfection so you must exercise care in storing the drinking water



Typical Reverse Osmosis Unit

Ceramic filtration

- **Examples: Berkey, Katadyn, Doulton, etc.**
- The Good
  - Very effective filter
  - Can be small and carried into zones with contaminated water for individuals or larger ones used by families for drinking water needs
- The Bad
  - Extremely slow
  - Ceramic element clogs over time
  - The elements are expensive
  - Does not remove chemicals unless combined with activated charcoal
  - Undetectable, hairline cracks <u>can</u> develop in the ceramic
  - Some people do not like the taste of the water after it has been used many times
  - There is no secondary disinfection

Ceramic Filters

These are true blocking filters

Other Treatment Methods

- These methods kill or de-activate pathogens
  - Boiling
  - Distillation
  - Pasteurization
  - UV Treatment
  - Ozone Treatment

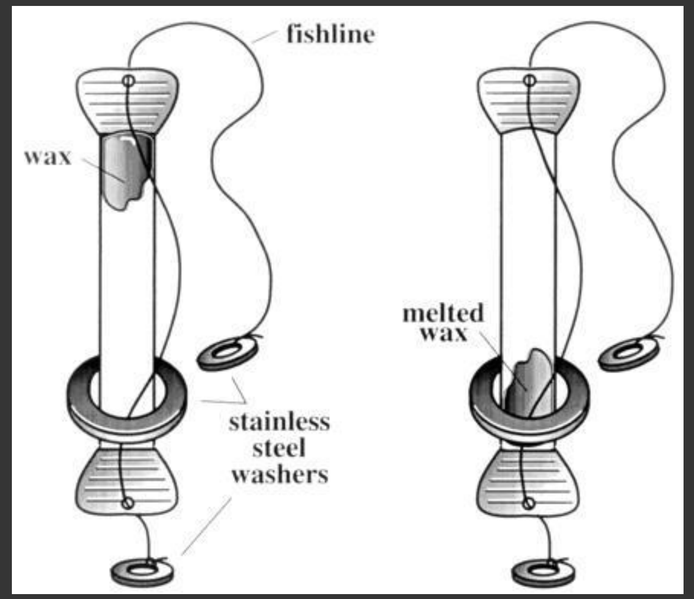
Solar Still

Solar Pasteurization in Africa

- Pasteurization will not remove inorganic nor most organic compounds. It does not provide secondary disinfection.

Solar Pasteurization Tools

•Water Pasteurization Indicator. Developed in 1992. Low cost. Reusable, indicates when the water reached the necessary temperature even after the water has cooled



UV Light

- UV light deactivates pathogens as long as the light can reach all the water and it is not moving too fast.

UV Light

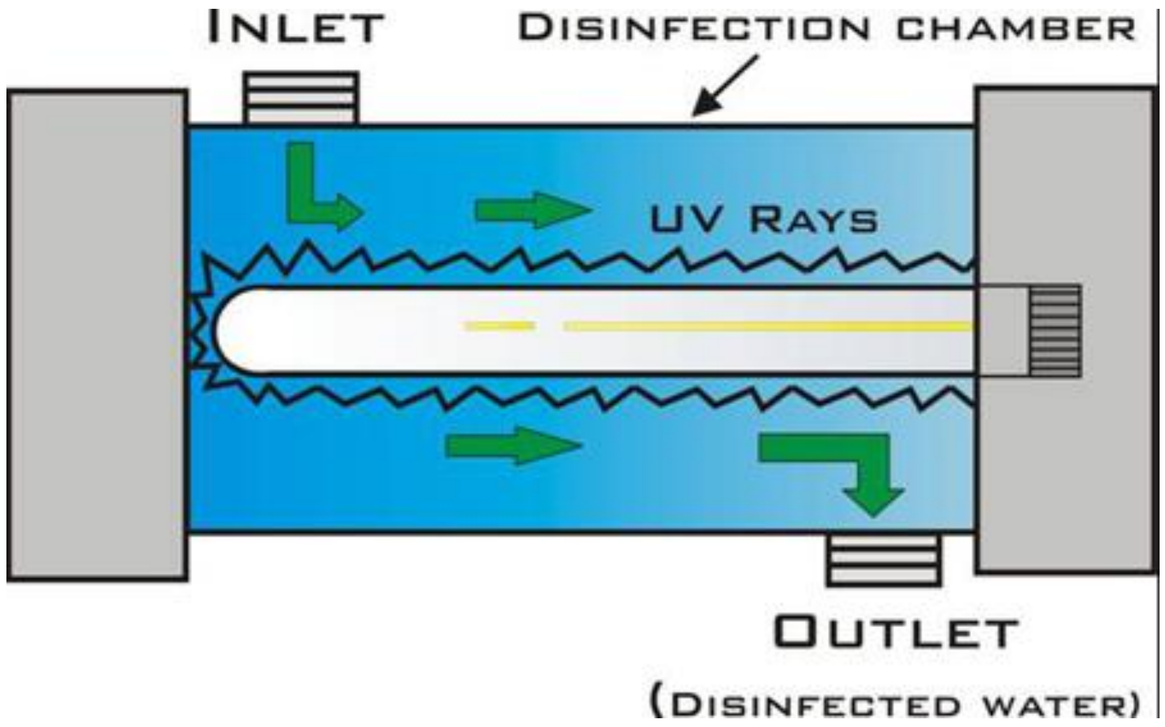
Good:

- The water flows through at normal rates of speed
- The units make the user feel like he is actively treating his water
- As long as all the conditions are met and the lamp is still strong enough to treat the water, the result is ok

Bad:

- They require diligent maintenance
- The lamps and sheaths break easily
- They use power
- If you don’t buy a Class A you will not know when your water ceases to be treated

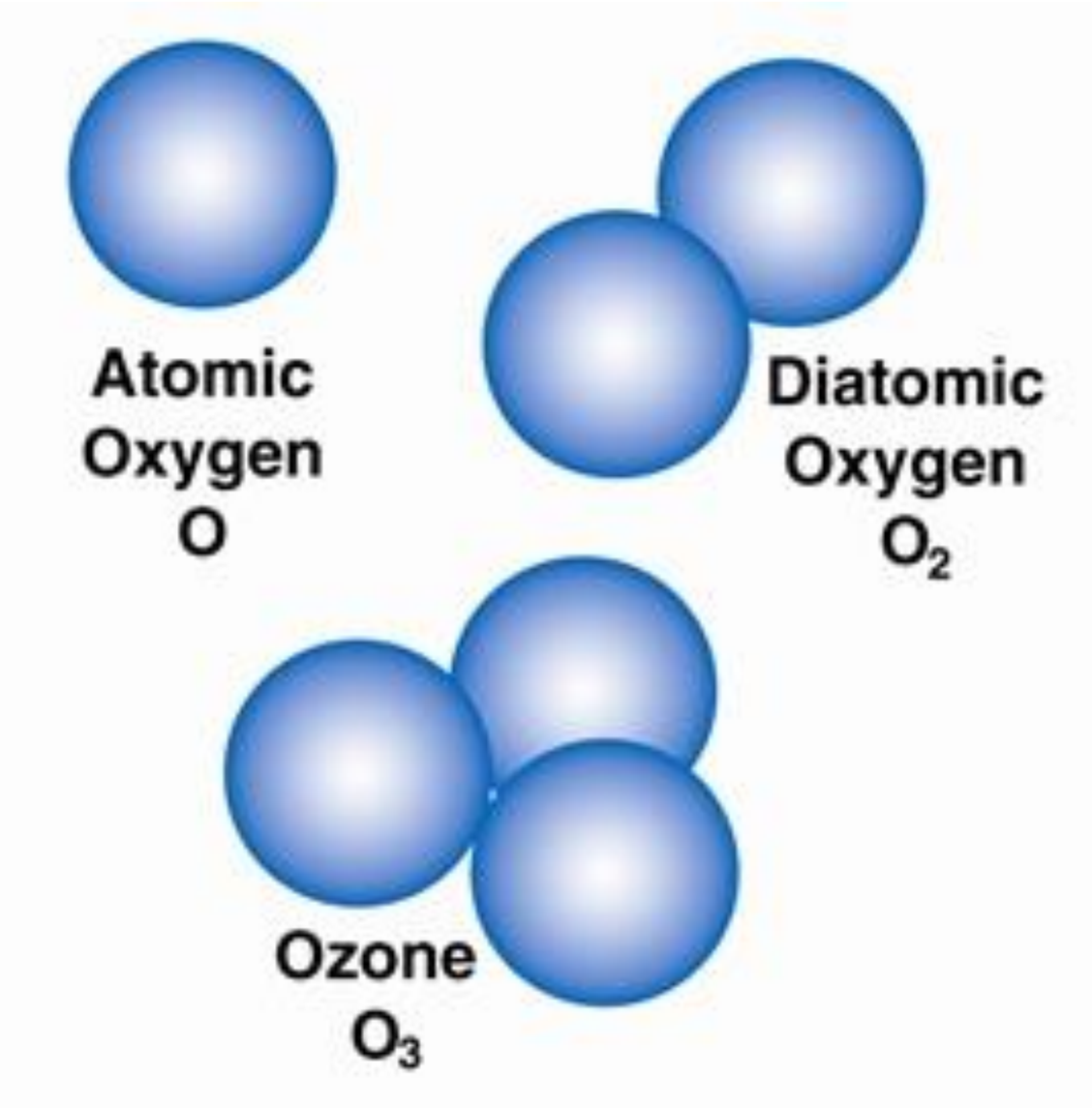

UVSS-10
UVSS-6
C
US


INLET
DISINFECTION CHAMBER
UV RAYS
OUTLET
(DISINFECTED WATER)

UV Light

Understanding Ozone Molecules

- This diagram shows Ozone (O_3), a normal Oxygen molecule (O_2) and a free Oxygen atom (O)

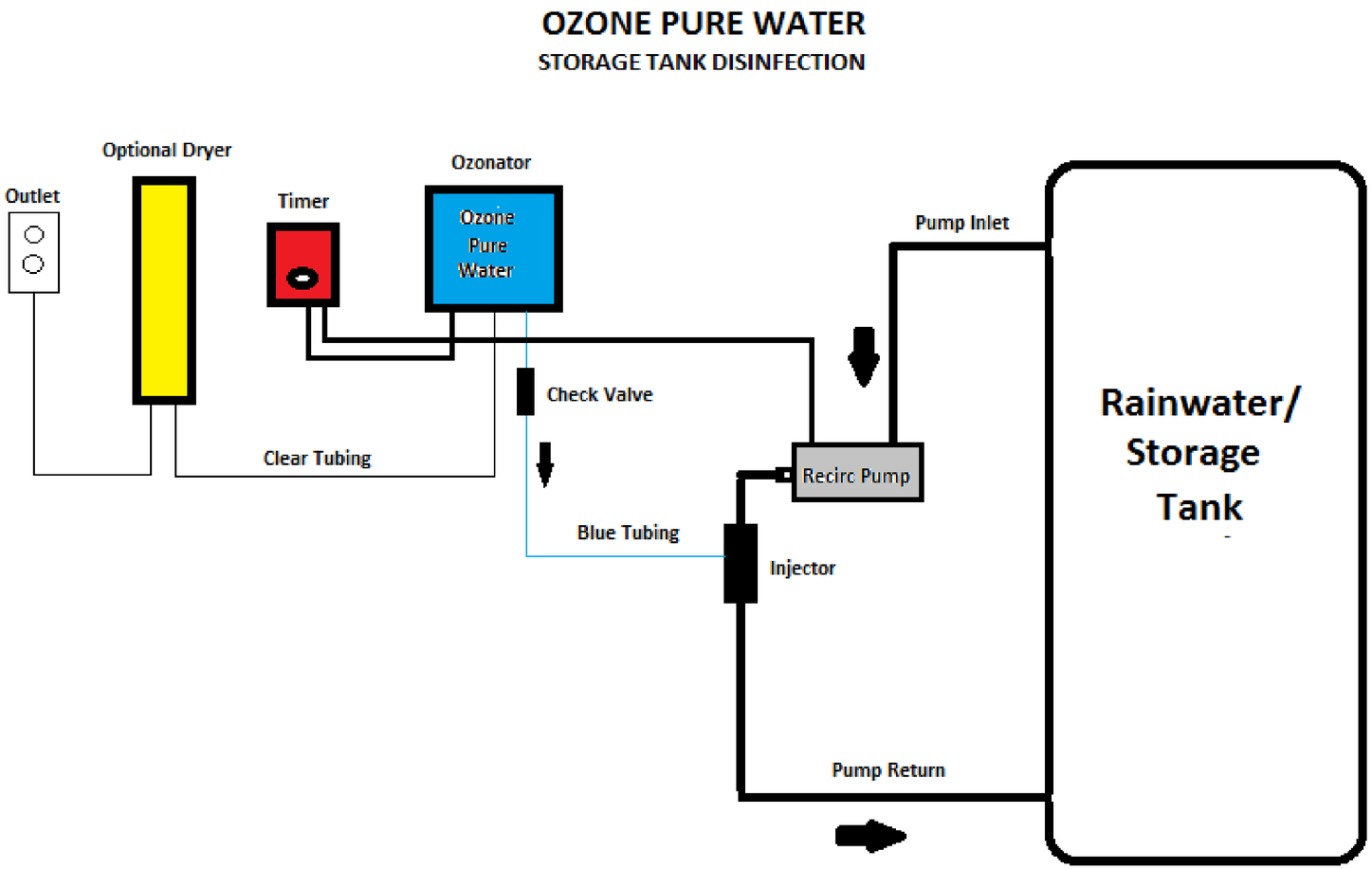


Ozone in a Rainwater System

- This ozone generator ran only 10 minutes and took the rainwater on the left from contaminated to crystal clear on the right.

- Nothing else was done and this was the best tasting water I ever tasted!

Ozone in a Rainwater System



Pros and Cons of Ozone

Good:

- Destroys all organic materials and leaves water extremely pure
- Brings a freshness to the water like nature

Bad:

- Care must be exercised to prevent breathing concentrated ozone
- It is so unstable that there is no lingering effect after 15 minutes
- It requires modest power resources

Do You Want More

- There is much more to be covered in water treatment. Please let us know if you would like to have more seminars concerning this topic.

- Please attend the companion seminar
- *Collecting and Storing Water for the Small Homestead*

Contact Information

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Notes, PowerPoints and Spreadsheets found at:

www.chesneyservices.com/2013-fair.html

The Sustainable Water For Homesteads seminar will be held here in the Red Barn