Purifying Water Using Sustainable Methods

The words "sustainable" and "sustainability" are now buzzwords that are becoming over-used and losing their meaning.

In our context, sustainability means to meet the essential needs of the present without compromising the ability of people in the future to meet their own needs. A sustainable practice must endure in value and worth. It should be comprehensive and embrace all areas of our life. It should not be easily lost or damaged.

The three main areas we are concerned with are:

- Environmental sustainability—use and stewardship of natural resources, conservation, renewable energy and agriculture
- Economic sustainability—provide for the needs of the family for food, water, income or products
- Social sustainability—sustain the needs and values of the family and community that are beyond the material and physical

3 areas of Sustainability in our water resources

- Self-sufficient water sources
- Self-sufficient storage
- Self-sufficient treatment of water resources

How important is a sustainable water supply?

Please attend the 10:00AM seminar: Collecting and Storing Water for the Small Homestead where we cover water sources and water storage.

Is water found in a flowing stream safe to drink since it is running water? Don't they say that you should only drink running water?

Assumptions about water quality are dangerous. If you don't remember anything else in this seminar, please remember this statement.

Drink from a polluted stream like this and you may die or be so sick you can't do anything.

What are you planning for with your homestead?

- Total self-sufficiency off the grid?
- Better stewardship with resources?

In light of your goals, is water purity and safety important?

Preventable waterborne diseases are responsible for approximately **80%** of all illnesses and deaths in the developing world.

Children are especially susceptible, with **nearly two million** deaths each year.

Chemical contamination causes illness, death and birth defects.

How can we supply our water needs and maintain good health and safety?

First we need to understand what causes the diseases

Pathogens—any disease-producing agent

There are 3 main Sources of waterborne disease:

- Protozoa (parasites, amoebas, cryptosporidium, giardia, etc.)
- Bacteria (botulism, cholera, E. Coli, salmonella, legionella, typhoid, etc.)
- Viral (SARS, Hepatitis A, Polio)

Long-term storage

Some methods of storage require various water treatment options

- Ponds and streams are contaminated with plant and animal waste and possible chemical contamination. (Cholera can be found in standing water.)
- Rain water catchment may be contaminated by roofing materials or dust and bird droppings or creatures falling into the cisterns.
- Ground water wells may be contaminated by surface water contamination
- Stale, bad-tasting water is not desirable. It is important that the container does not contaminate the water. Some containers leach harmful chemicals. Translucent containers can grow algae.

Taste—is this <u>important</u>?

Yes, when people need to drink enough water to maintain adequate hydration, it is not easy to drink water that does not taste good. In fact, the beginning of the quest for safe water began with the desire for good-tasting water.

- Some containers may leach chemicals.
- Translucent containers grow algae—block light
- Dirt, soil or pollen can cause a foul taste. Some rainwater experts stop collecting during pollen season
- Anaerobic conditions, especially near the bottom, can cause sour or dangerous water

What methods are available to treat water? For the homestead, we will focus on these main methods.

Chemical treatment

- Mainly Chlorine, but also some other chemicals, are added to the water to destroy pathogens.
- The chemicals provide both primary and secondary disinfection. (Secondary is long-term and lasts longer than the original treatment—for example disinfection continues while the water is stored or piped to the end use.)

Good:

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

Bad:

- Chemicals are toxic—it is now known that there are by-products formed every time chlorine effects a pathogen. These toxic chemicals have NO SAFE limit from the EPA!
- Chemicals can taste bad
- Chlorine does not work well in high pH-most ground water is high pH
- Chlorine's effectiveness decreases as the temperature increases
- There are new mutated forms of pathogens that are becoming increasingly resistant to these chemicals

Filtration—two main categories

1. Taste and sediment filters with mechanical filtration combined with activated charcoal
2. Removal of pathogens by adsorption, destroying them, or blocking them
    a. NanoAlumina (adsorption)
    b. Slow Sand Filter (kills with a biological layer)
    c. Blocking filters-Reverse Osmosis or ceramic filters

Nano Alumina filters

These filters are manufactured in the USA by Argonide and are <u>only sold</u> by approved dealers through the C.Hanish company.

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 **<u>do not</u>** 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.

These filters were developed for NASA for recycling water in space. Water can't be carried up—too heavy. It can't be found, so it has to be recycled. No water is wasted.

Pros and Cons of Nano Alumina

Good:

- Very good filtering-equal to the Reverse Osmosis
- Very fast flow-no slowdown 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 for a whole house configuration (40,000 gallons)

- 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 for particles
- 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

Slow sand filter—we will focus on these filters—they are the **most sustainable** water treatment method. We are not talking about the fast sand filter that is used with swimming pools. Those filters are for making water crystal clear. We are talking about SLOW sand filters. They are very special in what they do and how they do it.

According to the World Health Organization, the SSF is "The best, most economical, primary method of purifying water and they are accepted by the EPA as "a safe, effective method of primary disinfection."

SSF are recognized by the WHO, Oxfam, United Nations and the EPA as a superior technology for the treatment of surface water. This is interesting because it is the first widespread water treatment method.

Here is a quote from The World Health Organization in the document, *Slow Sand Filtration* published in 1974:

"Under suitable circumstances, slow sand filtration may be not only the cheapest and simplest but also the most efficient method of water treatment. Its advantages have been proved in practice over a long period, and it is still the chosen method of water purification in certain highly industrialized cities as well as in rural areas mid small communities."

And further:
"…it is still the most useful all-round treatment process. Within a single unit it incorporates settlement, straining, filtration, organism removal, organism inactivation, chemical change, and (to some extent) storage…It probably represents the nearest approach, in each of its functions, to the processes that occur in nature. Perhaps because of this, it has unusual powers to suffer misuse without failure, and a capacity for self-regeneration after such misuse."

"No other single process can effect such an improvement in the physical, chemical, and bacteriological quality of normal surface waters as that accomplished by biological filtration. The delivered water does not support after growth in the distribution system, and no chemicals are added, thus obviating one cause of taste and odor problems."

History

The earliest record of use is in Greek and Indian writings from 2000 BC. Along with heating water to purify it, sand filters and gravel filtration.

In 1804, the first drinking water supply for a city was built in 1804 in Paisley, Scotland by John Gibb. He was trying to mimic the way God cleans water and makes it taste good as it comes from springs. People did not want to drink water in the cities because it tasted bad. They did not understand water-borne disease was caused by pathogens yet.

By 1806, Paris operated a large water treatment plant.

In 1827, James Simpson built a sand filter in England for safe drinking water.

The first SSF built in the US was in Richmond, VA in 1832.

The Metropolis Water Act of 1852 in Britain was the first law concerning water treatment and it required all water supplied to London to be treated by SSF.

Their concern up to this point was still the taste of water until something dreadful happened:

In 1892, two neighboring cities, Hamburg and Altona, which drew their drinking water from the River Elbe, experienced a cholera outbreak. Hamburg did not filter the water taken from the river while Altona used SSF. Hamburg suffered 30% of the population infected with 7500 deaths and Altona was almost totally unaffected.

Description of the SSF

Slow Sand Filters are essentially a container filled with one or more layers of graduated media (usually sand). At the top there is a chamber of raw water. Gravity forces the water through the sand to the bottom where there is a drain.

As the water passes through the first few inches of the top, it is affected by a biologically active layer called the ***schmutzdecke*** (dirt blanket in German).

Various biological activities continue to consume pathogens down to around 15.5 inches.

Examples today

Many philanthropic and mission organizations are providing SSFs and SSF building training for developing nations.

The US Navy has distributed thousands of SSFs in Haiti and in Southeast Asia

Being used again
SSF have been widely used in Europe since the early 1800s. In the US primarily small cities in New England continue to use them. However, the recent *Surface Water Treatment Rule* by the EPA has caused renewed interest in SSFs for communities.

The Pros and Cons for the Slow Sand Filter

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 and stored filtered water can become contaminated

Blocking filters

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

- Reverse Osmosis using a membrane and flushing the membrane to unclog when it fills. This was considered the best possible method until the Nano Ceramic filter equaled its ability.
- Ceramic filters that use very fine ceramic filters to let water pass through slowly as a drip.

Reverse osmosis

Good

- Very pure water
- softened from minerals

Bad

- Very high ratio of waste water to filtered water—about 4-10 gallons of waste per gallon of filtered water
- 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 and stored water can become contaminated.

Ceramic filtration—example: Berkey, Katadyn

Good

- Very effective filter
- Can be small and carried into zones with contaminated water or larger and used by families for drinking water needs

Bad

- Slow drip
- Ceramic clogs over time
- Does not remove chemicals unless combined with activated charcoal (which will clog over time also)
- Undetectable, hairline cracks can 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

Other treatment methods

Using heat:

Boiling or distillation

Boiling will destroy or deactivate pathogens in the water. It will not remove minerals. Most people do not like the taste of boiled water.

Distillation is defined as capturing the water vapor from steam by condensation. It is free from pathogens and inorganic compounds, such as metals and minerals. However, inorganic compounds, such as petroleum products, will vaporize as well as the water.

Boiling or distillation is not needed if the contamination is biological. Neither are considered the best long-term water treatments due to high energy use and the difficulty of processing the water.

Solar stills are an exception. Solar pasteurizers are preferred to actually boiling the water.

Pasteurization

Disease-causing organisms in water are killed by exposure to heat in a process called pasteurization.

It is not necessary to boil water to make it safe. The WHO recommends bringing water up to a rolling boil, but this is merely a good visual indicator that the water has reached high enough temperatures to kill the pathogens.

Water that has been heated to 65ºC (150ºF) for 6 minutes is free from microbes including E coli, Rotaviruses, Giardia and the Hepatitis A virus. (Hepatitis A is the most heat resistant pathogen.)

At around 70ºC (160ºF), milk and other foods are pasteurized.

The Water Pasteurization Indicator was developed in 1992. Low cost. Reusable, indicates <u>after</u> the water has cooled. This way, it is known that the water was hot enough, long enough to pasteurize.

Pasteurization <u>will not remove inorganic</u> and most organic compounds.

UV light and Ozone treatment

These methods are very similar. In fact, UV light forms ozone in water. UV deactivates pathogens as long as the light can reach all the water and it is not moving too fast. <u>De-activation</u> means the organisms are not able to reproduce after being exposed to UV light. Pathogens are not killed by UV light. Ozone kills pathogens.

UV treatment is rather high-tech and requires several important things to be functioning in order to do its work as a disinfectant.

- It must be serviced whenever the bulb begins to fade (about one year)
- It must be serviced when the quartz sheath around the bulb gets covered by residue (about one year)
- The water must not have too many particles in it that limit the penetration of the UV
- The light must come on up to full power before water begins to move through the unit or else must be left on at all times
- The power must not fail or else the water must be shut off if it fails to come on or is not up to full power.
- The Class A units that automatically sense whether enough UV has penetrated the water are very expensive

Pros and Cons of UV light treatment

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

Ozone oxidizes pathogens in the water (as it does in the air). The O3 molecule is very unstable and the extra oxygen atom tries to jump from this molecule to return to being the highly stable H2O (water)molecule and the organic molecules the oxygen atom bonds to is oxidized and neutralized. It is similar to burning organic things like wood which leaves ash.

Because ozone is so unstable, it rapidly dissipates and releases oxygen and returns to water. For this reason, even though it is 80 times more powerful than chlorine, it can't be used for secondary disinfection.

Ozone, and particularly ozone water, has unique qualities. A strong concentration of ozone dissolved in water can be used to disinfect surfaces for about 15 minutes. Then it becomes plain water. The strong ozone water can be drunk with no ill effects.

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 power—however modest amounts
- Not many sources of generators are currently available

Iron and manganese removal and ozone

Iron will leave the tell-tale orange residue and can be tasted in high concentrations. It is not considered a health hazard, but iron taste will hinder the desire to drink the water and high concentrations can stain clothes in the wash. Bleach can make the stains darker.

Most people find drinking a concentration of .3 ppm of iron and .05 ppm of manganese objectionable. It is rare to find water with levels higher than 10 ppm of iron and 2 ppm of manganese.

Most iron filters rely on oxidizing the iron to cause it to drop out of the water. There are various filter media used such as: greensand and manganese dioxide.

Some filtration requires dissolved oxygen in the water. Ozone can be used to oxidize the water. This is usually done for high concentrations of iron. Ozone is also a disinfectant and this proves to be a beneficial combination of methods for water treatment.

Contact information

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.

Pat Chesney
Accredited Professional (**AP**) by the American Rainwater Catchment Systems Association (**ARCSA**)

254-716-3568
pat@sustainablelivingconsultants.com