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Enhancing Seychelles' Freshwater Assets



*Seven Additional Approaches for
Addressing our Drinking Water Problem*

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Enhancing Seychelles' Freshwater Assets

Seven Additional Approaches for Addressing our Drinking Water Problem

Introduction

Fresh water is a scarce resource of great value.

Seychelles has limited natural fresh water resources. Mean annual rainfall in Mahé averages 2,880 millimeters at sea level and as high as 3,550 millimeters on the mountain slopes.

Precipitation is somewhat less on the other islands, averaging as low as 500 millimeters per year on the southernmost coral islands.

Because catchment provides most sources of fresh water in the Seychelles, yearly variations in rainfall or even brief periods of drought can produce water shortages.

Small dams have been built on Mahé since 1969 in an effort to guarantee a reliable water supply, but drought can still be a problem on Mahé and particularly on La Digue.

This proposal suggests 7 additional ways (besides desalination) to enhance Seychelles' freshwater assets, and solve the recurring drinking water crisis.

Six of these proposed solutions are scientifically tested, and one is entirely speculative. Even if one or two of these seven approaches prove to be practical / economical, they can serve to alleviate the recurring fresh water shortages.

Why would an SMB manager, and member of our corporate Task Force, brainstorm solutions for enhancing Seychelles' freshwater assets, and addressing the recurring drinking water problem? There are three reasons: (1) SMB has interests in drinking water: we produce bottled drinking water at our BDR factory, and are affected by freshwater shortages. (2) Our MD is also Chairman of the Public Utilities Corporation. (3) SMB's corporate mission statement is *Building the future for the people of Seychelles*.

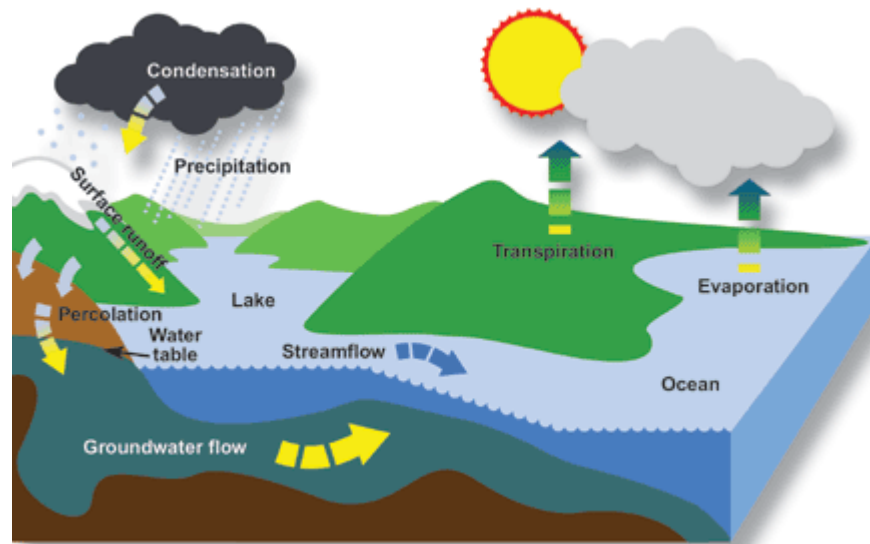
Executive Summary

The seven approaches for enhancing Seychelles' freshwater assets, and addressing the recurring drinking water problem described in this proposal are:

1. Rainwater harvesting
2. Constructing micro-reservoirs
3. Cloud seeding over catchment areas
4. Solar distillation
5. Water recycling
6. Allowing market forces to facilitate water conservation by regulating demand.
7. Sand-filtration as pretreatment for desalinated water

These solutions can be financed by private investments and government subsidies for household level units, as well as public investments for community level and national initiatives.

The Hydrologic Cycle



Solution 1: Rainwater Harvesting

For centuries, people have relied on rainwater harvesting to supply water for household, landscape, livestock, and agricultural uses.

Before large centralized water supply systems were developed, rainwater was collected from roofs and stored on site in tanks known as cisterns.

With the development of large, reliable water treatment and distribution systems and more affordable well drilling equipment, rain harvesting systems have been all but forgotten, even though they offer a source of pure, soft, low sodium water.

A renewed interest in this time-honored approach has emerged due to:

- the escalating environmental and economic costs of providing water by centralized water systems or by well drilling;
- health benefits of rainwater;
- potential cost savings associated with rainwater collection systems

The harvesting of rainwater simply involves the collection of water from surfaces on which rain falls, and subsequently storing this water for later use.

Normally water is collected from the roofs of buildings and stored in rainwater tanks. This is a common practice in many parts of the world (...and was actively promoted by environmentalist friends and colleagues of mine at Kodaikanal, a hill resort in India that faced period water shortages despite having a sizeable lake).

The collection of rainwater from the roofs of buildings can easily take place in the Seychelles. All that is necessary to capture this water is to direct the flow of rainwater from roof gutters to a rainwater storage tank. By doing this, water can be collected and used for various uses.

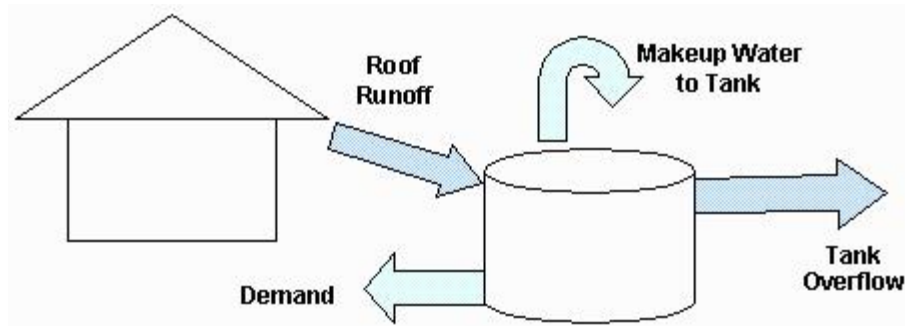
What are the Benefits in Rainwater Harvesting? By capturing water directly, we can significantly reduce our reliance on water storage dams. This places less stress on these water storages and can potentially reduce the need to expand these dams or build new ones.

Collecting and using your own water can also significantly reduce water bills.

By capturing water, the flow of stormwater is also reduced and this minimises the likelihood of overloading the stormwater systems in our neighbourhoods.

What About Dirty Roofs? There are a number of devices (first flush devices) which allow for the first flow of water to the rainwater storage tank to be diverted from the tank. By doing this, any dirt on the roofs of buildings that has built up prior to the rain can be excluded from the tank.

Sizing of Rainwater Storage Tanks. The most appropriately sized rainwater storage can be chosen by quantitatively assessing the performance of various sized storage capacities.



Water Balance for Estimation of Rainwater Storage Capacity

The size of the area of capture or roof area must also be known when estimating the amount of rainfall that is able to be collected. The larger the roof area, the more rainfall that is able to be collected.

Solution 2: Construct Micro-Reservoirs

The concepts of rainwater harvesting are not only applied to roof catchments. Water can also be collected in small check dams and micro-reservoirs from rain falling on the ground and producing runoff. Either way, the water collected is precious.

Besides providing additional storage sites for fresh water runoff, these small check dams and micro-reservoirs will facilitate the replenishment of the water table.

Solution 3: Cloud Seeding Over Catchment Areas

"Weather modification" is the general term that refers to all human attempts to exercise some control over the weather. From the late 1940s into the 1960s, the term "weather control" was sometimes used. But, scientists know that no one can "control" the weather. The best that can be done is to change

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the weather in small ways, such as squeezing a little more precipitation out of clouds than would have otherwise fallen.

Cloud seeding refers to using silver iodide or other materials to increase the amount of precipitation from clouds. It is the one technique of planned weather modification that has been shown to work.

Cloud seeding over catchment areas could help 'wring the moisture' from the atmosphere / passing clouds and fill our reservoirs.

Sometimes precipitation only occurs in small amounts, or not at all, because certain required conditions are not present. Of prime importance for determining both the initiation and amount of precipitation from the cloud system are (1) the vertical and horizontal dimensions of the clouds, (2) the lifetime of the clouds and (3) the sizes and concentrations of cloud droplets and ice particles.

Under proper conditions, one or more of these three factors can be favorably modified by seeding the cloud with appropriate nuclei.

There are two basic mechanisms by which precipitation forms in clouds. These are called the "warm rain" and the "cold rain" processes. The term "warm rain" was derived after scientists noticed that rain in tropical regions often fell from clouds with temperatures never colder than 32°F (0°C). Rain is formed in these warm clouds when larger droplets collide with and absorb smaller cloud droplets in a process known as coalescence.

Compared to the amount of water that is visible as clouds or that falls to the ground as precipitation, the atmospheric reservoir of water above the earth is large. The sizes, types and concentrations of nuclei present in the atmosphere play an important role in determining the efficiency with which a cloud system forms and ultimately produces rain or snow.

For instance, salt crystals acting as giant condensation nuclei are abundant in the oceanic regions. These allow larger cloud droplets to form and the subsequent coalescence process initiates rainfall well within the lifetime of the clouds.

Conversely, the atmosphere over continental regions usually contains much smaller and more numerous condensation nuclei. Medium-sized clouds formed in these regions normally dissipate before the coalescence mechanism has had a chance to initiate rain.

The technology may best be described as simply *lending nature a helping hand*. Man can assist nature by furnishing appropriate types and numbers of

nuclei through "seeding" the clouds at the proper time and place. Seeding with very large condensation nuclei (hygroscopic particles such as salt crystals) can be done to accelerate the warm rain process.

Flares mounted on a cloud seeding aircraft are shown below.



Solution 4: Solar Distillation

Solar distillation for purifying water is one of many processes available for water purification, and sunlight is one of several forms of heat energy that can be used to power that process. Sunlight has the advantage of zero fuel cost.

To dispel a common belief, it is not necessary to boil water to distill it. Simply elevating its temperature, short of boiling, will adequately increase the evaporation rate. In fact, although vigorous boiling hastens the distillation process it also can force unwanted residue into the distillate, defeating purification. Furthermore, to boil water with sunlight requires more costly apparatus than is needed to distill it a little more slowly without boiling.

Many levels of purification can be achieved with this process, depending upon the intended application. Sterilized water for medical uses requires a

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different process than that used to make drinking water. Purification of water heavy in dissolved salts differs from purification of water that has been dirtied by other chemicals or suspended solids.

The present dollar cost of solar-distilled drinking water is several times that of water provided by most municipal utilities, but it costs less energy-wise. On the other hand, solar-distilled water is much less expensive than bottled water purchased in the store.

For people concerned about the quality of their municipally-supplied drinking water and unhappy with other methods of additional purification available to them, solar distillation of tap water or brackish groundwater can be a pleasant, energy-efficient option.

Solar distillation systems can be small or large. They are designed either to serve the needs of a single family, producing from $\frac{1}{2}$ to 3 gallons of drinking water a day on the average, or to produce much greater amounts for an entire neighborhood.

In some parts of the world the scarcity of fresh water is partially overcome by covering shallow salt water basins with glass in greenhouse-like structures. These solar energy distilling plants are relatively inexpensive, low-technology systems, especially useful where the need for small plants exists.

Solar distillation of potable water from saline (salty) water has been practiced for many years in tropical and sub-tropical regions where fresh water is scarce.

Natural fresh water often cannot be diverted for direct human consumption without substantial environmental damage. The economic feasibility of solar desalination of ocean water will, therefore, improve considerably as energy costs continue to escalate and population pressure exerts more stress on available fresh water supplies.

There are several acceptable designs for small solar stills for the individual family; however, there is still much room for innovation and improvement. Solar desalination is particularly well-suited for backyard experimentation by individuals with little or no technical training.

Basic Principles

The basic concept of using solar energy to obtain drinkable fresh water from salty, brackish or contaminated water is really quite simple. Water left in an open container in the backyard will evaporate into the air. The purpose of a

solar still is to capture this evaporated (or distilled) water by condensing it onto a cool surface, using solar energy to accelerate the evaporation.

The rate of evaporation can be accelerated by increasing the water temperature and the area of water in contact with the air. A wide, shallow pan painted black makes an ideal vessel for the water. It should probably be baked in the sun for a while before it is used in order to free the paint of any volatile toxicants which might otherwise evaporate and condense along with the drinking water. The pan is painted black (or some other dark color) to maximize the amount of solar energy absorbed. It should also be wide and shallow to increase the surface area, assuming the availability of a substance with good solar absorbing properties and durability in heated salt water. (This is a very harsh environment for materials to survive in over prolonged periods.)

To capture and condense the evaporated fresh water, we need some kind of surface close to the heated salt water which is several degrees cooler than the water. A means is then needed to carry this fresh water to a storage tank or vessel. The evaporating pan usually is covered by a sheet of clear glass or translucent plastic (to allow sunlight to reach the water) which is tilted at a slight angle to let the fresh water that condenses on its underside trickle down to a collecting trough. The glass also holds the heat inside.

Other possible configurations and materials are discussed in the Manual on Solar Distillation of Saline Water, available for \$10.75 (using order no. PB 201 029) from the National Technical Information Service, Order Department, Springfield, VA 22161.

Another excellent publication is *Solar Distillation as a Means of Meeting Small-Scale Water Demands*, published in 1970 by the United Nations. It is available for \$6 from the United Nations, Publications Sales Section, Room A-3315, New York, NY 10017 (order no. E70.11.B.1.). These two publications are recommended for individuals interested in building a solar water still. In addition, the Office of Water Research and Technology, U. S. Department of the Interior, Washington, DC 20240, offers an extensive bibliography of relevant reports available from the National Technical Information Service.

Economics

For families interested in building a solar still, a good design should be capable of producing 1/2 to 1 gallon of fresh water per day for each square meter (10.7 square feet) of still area. Material costs generally do not exceed about \$20-\$30 per square meter for large solar distillation plants. For smaller, backyard models, the material costs are likely to be somewhat higher.

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The per-gallon cost of solar-distilled water can be calculated as follows: (a) estimate the usable lifetime of the still; (b) add up all the costs of construction, repair and maintenance (including labor) over its lifetime; and (c) divide that figure by the still's total expected lifetime output in gallons (or liters).

Such a cost estimate is only approximate since there are large uncertainties in both the lifetime and the yield estimates. Costs are usually considerably higher than current water prices – which explains why solar backyard stills are not yet marketed widely.

However, as times change, water prices rise. The quality of "city water" is deteriorating in many parts of the world and some people are buying expensive water filters or drinking only bottled water. Consequently, a more favorable evaluation of solar-produced fresh water costs would involve a comparison with bottled drinking water prices. For example, a 1970 United Nations report cites costs of \$3 to \$6 per 1,000 gallons of solar-distilled water. Using a 10 percent annual inflation rate, this translates into about \$6 to \$12 per 1,000 gallons at today's prices, excluding labor costs. This can be contrasted with a price of .50 to \$1 per 1,000 gallons for utility-supplied water, and from .50 to \$1 per gallon for bottled water sold in supermarkets (equivalent to \$500 to \$1,000/1,000 gallons).

We see that the solar-distilled water costs much less than bottled water and somewhat more than utility-supplied water. Small solar stills capable of producing pure drinking water even for as much as \$20 to \$30 per 1000 gallons might find many buyers who are unhappy with the quality of the water they are presently getting. As the cost of purifying polluted groundwater and delivering it to the home continues to rise, the solar distillation market should continue to grow significantly—especially if someone comes up with a unit that produces good drinking water at a reasonable price.

Water Quality

On August 22, 1978, the St. Petersburg Times stated that published reports of impurities in some water systems and national concern over carcinogens in drinking water had created a growing market for what are called "home water purifiers."

The article quoted Paige Geering of the U. S. Environmental Protection Agency as saying that "the problems they (home water purifiers) create may be far worse than the benefits".

During discussions with this author, Ms. Geering emphasized that her published comments were primarily directed at the use of the word "purifier" with home water treatment devices. She said that these products can provide

some improvement in drinking water, especially if the filter is changed frequently, but that one should be cautious of manufacturers' "purity" claims.

In principle, the water from a solar still should be quite pure. The slow distillation process allows only pure water to evaporate from the pan and collect on the cover, leaving all particulate contaminants behind.

Since a clean glass cover plate and storage vessel should produce no contaminants, the catch basin, or trough, remains as the potential source of direct contamination.

The catch trough should be made of material unlikely to degrade water flowing through it, even at the moderately elevated temperatures which might be encountered. PVC (polyvinyl chloride) plastic plumbing pipe is commonly available at relatively low cost. Since vinyl chloride has been identified as a carcinogen potentially harmful to workers in plants manufacturing PVC products, one should be very careful about using this material in a drinking water system.

Fortunately, some PVC formulations have been designed for use in potable water systems; however, other formulations are not so-designed and could pose a problem.

It is possible that a chemical in the feed water (or in the still itself) which evaporates along with the water could condense on the underside of the cover and be carried into the catch basin. There are several ways to minimize contamination from the materials in the still itself. Preconditioning of the distiller by "baking" it under the sun for several days may be sufficient to drive off most volatiles. Non-volatile materials left behind in the concentrate may be discarded. Avoiding use of materials containing known toxicants is another way to ensure condensate water purity.

With care in design and operation, the solar still should, therefore, be capable of producing good drinking water free of cancer-causing pollutants and other harmful substances – water that is colorless, odorless and, unfortunately, tasteless. When the minerals common to drinking water are removed, taste goes, too. One flavor recommendation is to add small amounts of minerals or salts to the distilled water maybe a good idea, since the minerals found in water may be healthful. Lost minerals also can be replaced by trickling the distilled water through a bed of marble chips.

Summary Comments on Solar Distillation

In principle, solar energy can be used to separate pure water from most of the natural contaminants, such as dissolved solids (salts) and particles (dirt and algae). Solar distillation is most economically effective when sunlight is

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allowed to pass through a transparent cover and into a black evaporating pan with little or no concentration of the sun's rays.

A reasonable production rate would be about one gallon of water per day per square meter (10.7 square feet) of still area. If it costs about \$40-\$60 per square meter to build the still and if this water is worth roughly \$15 per 1,000 gallons, the still should pay for itself in 2,500 to 4,000 days, or 7 to 11 years. As the value of solar-distilled water increases, the payback time shrinks. If one values this water at .60 a gallon, about what distilled water costs at the supermarket, then the payback time is only 60-100 days.

Solar distillation of water is not quite competitive with utility-supplied drinking water in Seychelles, but it is highly competitive with bottled water. Rising energy prices seem bound to create an early market for small manufactured solar water distilling units. In a few more years, large-scale solar distillation may also become economically viable for utility use in the country.

Solution 5: Water Recycling

Water can be recycled by means of membrane filtration and membrane bio reactors (MBR), ozone disinfection, UV-disinfection and sand filtration.

1. Tap and well water

The cost of tap water is constantly increasing. One pays now on average 1 - 1,50 EURO per cubic meter (1000 litres). This is a 20 % increase from 1990. When extracting groundwater, a levy of EURO 0,15 - 0,20 must be paid in the Netherlands e.g., due to a drop in the ground water level.

Concessions are rarely granted for the extraction of ground water anymore. This has resulted in more and more drinking water companies having to use surface water for the preparation of drinking water and companies changing to water recycling. It is therefore expected that drinking water will soon double in price. In the countries neighbouring the Netherlands, high water tariffs are already in use. (Germany: EURO 2, - per m3, Denmark: EURO 2,50 per m3)

2. Energy savings with the water recycling

Many industrial processes require the process water to be heated or cooled. Well water and tap water have an average temperature of 10 °C and 13 °C respectively. On average, every degree rise in temperature costs around EURO 0,05 per m3. Every degree lowered in temperature costs around EURO 0,07per m3.

By re-using process water, the energy requirement demands are lowered and therefore savings can be made on energy expenses.

3. Further cost savings when re-using process water

When preparing process water, certain elements are removed to increase the performance of the system (e.g. the removal of iron from well water and the softening of water by the removal of carbonates).

Apart from the removal of unwanted elements, other substances are usually added to improve the water quality and promote the effectiveness of the process (e.g. nutrients for plants in a horticultural nursery). When this water is re-used, it is free of unwanted elements and already contains those elements that are needed by the process, therefore lowering costs.

4. Stricter demands on water usage

Stricter demands are being made on the quality of the water flowing through processes. Disinfection by means of environmentally friendly products is highly recommended.

5. The costs of wastewater

The cost of draining off wastewater has risen by 20% in the past 5 years. This cost is expected to rise even more. Some companies have therefore already placed pre-treatment units for treating wastewater. In many cases, post treatment of the water is also possible, therefore making it suitable for water recycling in the process. The effluent water can also undergo a less effective treatment and be used as cooling or cleaning water.

Solution 6: Let Market Forces Facilitate Water Conservation

Allowing market forces to facilitate water conservation by moderating demand (through higher prices), and encourage investments in new technologies and production facilities may help enhance Seychelles' freshwater assets and alleviate the drinking water problem.

The growing demand for bottled drinking water is evidence that a market exists.

Market forces alone, however, cannot regulate the production and distribution of water, which is essential to the sustenance of life itself and therefore cannot be permitted to be priced beyond the reach of the poor.

Solution 7: Sand-filtration as Pre-Treatment for Desalination

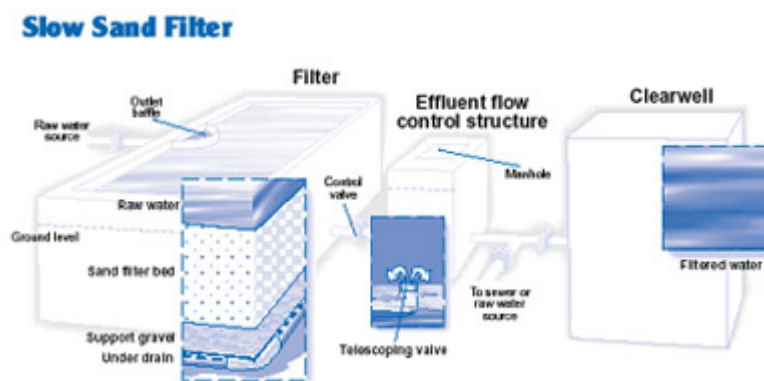
Can sand-filtration be used as a pre-treatment for desalination ? If so, why not sink a borehole into the sea bed: *Even marginal reductions in salinity and other impurities (inexpensive tests can be carried out by drilling at various depths) can reduce desalination costs, and increase the output of treated water...*

Slow Sand Filtration Makes a Comeback

In the early 1800s, a Scotsman named John Gibb needed a way to provide his bleachery with clean water. Taking matters into his own hands, Gibb built a water treatment plant that utilized the slow sand filtration technique, which is now regarded the oldest type of municipal water filtration. The facility he built was so successful that it not only supplied water to his bleachery and his town, but within three years, filtered water was piped directly to customers in nearby Glasgow.

Since that time, slow sand filters have continued to provide potable water to consumers throughout the world. In fact, some experts claim that slow sand filtration currently is experiencing a resurgence in North America - especially in smaller communities - primarily because it is a cost-effective and reliable method of purification. Specialists say it may also be a suitable treatment choice for rural homeowners who depend on private water sources for household use.

How It Works



In a slow sand filter, a combination of physical straining and biological treatment effectively purifies the raw water. The process itself is relatively

slow- filtration rates ranging from 0.015 gpm/ft.² to 0.16 gpm/ft.² are common. Because of their rather lethargic filtration rates, slow sand filtration systems often must take up a large amount of space to produce substantial amounts of filtered water. (Smaller systems do not require such extensive physical space.) Extensive pilot testing during the design stage is critical to ensure that the filter performs up to par.

In the system, untreated water percolates through a bed of uniformly graded porous sand that overlies a gravel bed (see Figure 1 for diagram). The water enters over the surface of the filter and is drained from the bottom. In a mature filter, a rich, sticky, mat-like biological layer called a Schmutzedecke forms in the top layers of the sand, where particles tend to settle because of the slow rate of filtration. The Schmutzedecke is composed of biologically active microorganisms, including bacteria, algae, and other single- and multiple-cell organisms. The microorganisms break down and feed off of organic matter in the water that is passing through the Schmutzedecke, and inorganic particles are trapped and strained by this layer, as well. The Schmutzedecke assumes the dominant role in slow sand filtration because it allows the process to remove particles smaller than the sand could trap on its own. To ensure that the biological community in this layer remains effective, the filters should operate at a constant rate.

Eventually, flow becomes reduced because the filtered material and debris begin to block up the Schmutzedecke. To increase the flow rate, the filter must be cleaned by scraping and removing the top layer of sand. Until the biological layer replenishes itself, the filtered water should not be used.

Advantages

While there are many other monitoring and operational tasks that need to be performed (some daily), the scraping of the top layer probably is the most time-consuming maintenance-related task that the slow sand filter requires. However, even if one does not clean this top layer on a regular basis, the quantity of filtered water will be reduced, but the quality of the water will not suffer.

This limited maintenance to-do list is just one of the major advantages that slow sand filters offer. However, cost is probably the biggest benefit of slow sand filtration method. Materials used to build the system may be locally found, making the cost of construction relatively inexpensive. Also, since close, constant supervision is not necessary, the cost of operation also is reasonably low.

Another benefit of the filtration technique is that there is no known negative impacts of using this technology on the environment. In fact, because it is a low-energy consuming process, slow sand filtration can actually help protect

the environment, as compared to other water disinfection techniques.

Other advantages of slow sand filtration:

- No pre-treatment chemicals, are required
- The system has great adaptability in components and applications
- Problems handling sludge are minimal

Limitations

Nothing is perfect in this world, and slow sand filters are no exception. The systems have several limitations that one should consider before investing in them. As mentioned previously, slow sand filters need a great deal of land, as well as filtration materials, to produce significant amounts of treated water. Therefore, if a large amount of water is needed, substantial space needs to be set aside for the system, which may not be feasible in some environments. A lengthy testing period - preferably a year - also must be reserved to ensure adequate performance throughout the four seasons.



Work is done on a slow sand filter. Courtesy of Dr. N. Nakamoto, Shinshu University.

There are some limitations in regard to condition of the raw water that these filters can treat, as well. For example, the raw water turbidity must generally be low because high turbidity levels tend to plug up the sand quickly. Also, the filters treat cold water less effectively because chilly temperatures tend to discourage the biological growth that needs to occur in the system. Water with too much algae is unfavorable in a slow sand filter, as is water with too low a nutrient count or water mixed with very fine clay.

Furthermore, while slow sand filters are effective in reducing the levels of many undesirables, they are not capable of removing all of them. Color removal is only fair to poor, and according to the National Drinking Water Clearinghouse, "slow sand filters do not completely remove all organic chemicals, dissolved inorganic substances, such as heavy metals, or trihalomethane (THM) precursors - chemical compounds that may form THMs when mixed with chlorine." Please see Table 1 for data concerning slow sand filters' removal capacity of other contaminants.

Is Slow Sand for Us?

Slow sand filtration has many advantages, especially for small communities and rural homeowners, but like every purification technique, it has its limitations.

Table 1. Typical Treatment Performance of Conventional Slow Sand Filters

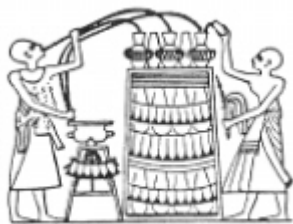
Water Quality Parameter vs. Removal Capacity

Turbidity <1.0 NTUU
Coliforms 1-3 log units
Enteric Viruses 2-4 log units
Giardia Cysts 2-4+log units
Cryptosporidium Oocysts >4 log units
Dissolved Organic Carbon <15-25%
Biodegradable Dissolved Organic Carbon <50%
Trihalomethane Precursors <20-30%
Heavy Metals
Zinc, Copper, Cadmium, Lead >95-99%
Iron, Manganese >67%
Arsenic <47%

Brief History of Drinking Water

The history of water treatment is still being written, as discoveries continue to document its origins.

Early Egyptian paintings from the **13th and 15th centuries B.C.** depict sedimentation apparatus and wick siphons, and it is speculated that the ancients utilized alum to remove suspended solids.



Historically, water was considered clean if it was clear. Hippocrates, the Father of Medicine, invented the "Hippocrates Sleeve", a cloth bag to strain rainwater, in the **5th century B.C.**

Skilled Roman engineers created a water supply system that delivered 130 million gallons daily through aqueducts between **343 B.C. to 225 A.D.**

Public Water Supply Systems were born at the end of the **3rd century B.C.** in Rome, Greece, Carthage and Egypt.

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Storage or settling cisterns were constructed to remove silt by plain sedimentation.

From about **500 to 1600 A.D.**, there was little progress in water treatment and its connection to public health.

Sir Francis Bacon, the great Elizabethan philosopher, chronicled only 10 scientific experiments in the preceding 1,000 years which related to water treatment.

Drinking Water in the 17th and 18th Centuries

In 1680 the microscope was invented by Anton van Leeuwenhoek, and in 1685 an Italian physician named Lu Antonio Porzio designed the first multiple filter. These two unrelated events were to play important parts in the future of water treatment.

Van Leeuwenhoek was accused of inaccuracy. **The scientific community regarded his sketches of microscopic organisms as unimportant curiosities.**

Then 200 years later, the scientists of the 19th century made the connection between these "animacules," water, and health.

Porzio's filter used plain sedimentation and straining followed by sand filtration. It contained two compartments (one downward flow, one upward).

In 1746, Parisian scientist Joseph Amy was granted the first patent for a filter design, and by 1750 his filters for home use could be purchased. *The filters consisted of sponge, charcoal, and wool.*

Drinking Water in the 19th and 20th Centuries

The first water facility to deliver water to an entire town was built in Paisley, Scotland in 1804 by John Gibb to supply his bleachery and the town, and within three years, filtered water was even piped directly to customers in Glasgow, Scotland.

In 1806 a large water treatment plant began operating in Paris. The plant's filters were made of sand and charcoal and were renewed every six hours. Pumps were driven by horses working in three shifts. Water was settled for 12 hours before filtration.

In the 1870's, Dr. Robert Koch and Dr. Joseph Lister demonstrated that microorganisms existing in water supplies can cause disease. Since then,

America has relied on several processes of water treatment to progressively ensure the best water quality.

The Civil War interrupted the development of filtration in the United States; however once the North and South were reunited, the U.S. became a leader in the art of water treatment.

The year 1906 saw the use of ozone as a disinfectant in Nice, France. Because of the equipment's complexity and cost, ozonation was less prevalent in the U.S. Jersey City Water Works became the first utility in America to use sodium hyperchlorite for disinfection in 1908, and the Bubbly Creek plant in Chicago instituted regular chlorine disinfection.

The initial treatment process utilized slow sand filters to provide a more aesthetic product. Within several years filtration was recognized for removal of undesirable particles and deadly bacteria, as those communities that utilized it had fewer outbreaks of typhoid.

William Stipe, superintendent of water works at Keokuk, Iowa, organized a meeting of all persons concerned with water-works at Washington University in 1881. The 22 participants founded the American Water Works Association.

Significant improvements to water treatment in the latter part of the 19th century included the development of rapid sand filters, filters, improved slow sand filters, and the first applications of chlorine and ozone for disinfection. At the turn of the century, chlorination became the most popular method in the United States and numbers of typhoid dysentery and cholera case plummeted.

In 1914, the U.S. Department of The Treasury promulgated the country's first drinking water bacteriological standard, a maximum level of 2 coliforms per 100 mL.

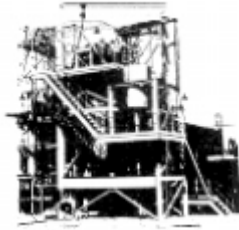
By the 1920's , the use of filtration and chlorination had virtually eliminated epidemics of major waterborne diseases from the American landscape. These two decades also saw the development of dissolved air flotation, early membrane filters, floc blanket sedimentation, and the solids-contact clarifier.

Late 20th Century

Desalination Equipment 1940

A major step in the development of desalination technology arrived during World War II when various military establishments in arid areas required water to supply their troops.

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In 1942 the U.S. Public Health Service adopted the first set of drinking water standards, and the membrane filter process for bacteriological analysis was approved in 1957.

By the early 1960's, more than 19,000 municipal water systems were in operation throughout the U.S. Since the 1974 enactment of the Safe Drinking Water Act, the government, the public health community, and water utilities

throughout the country have worked together to safeguard the nation's drinking water supplies and to ensure that law protects public health in the best possible ways.

Today, the AWWA leads the effort to advance science, technology, consumer awareness, management, conservation and government policies related to drinking water.

Imon Ghosh

Friday, August 20, 2004