CCWF Part 3
Cabin Clean Water Filter
Comparison to Other
Household BioSand Water Filters
for use in the developing world

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1.0 Characteristics of BioSand Water Filters.

There are several designs for household BioSand Water Filters (BSF) that appear to function quite well. There are a few filter designs that claim to be a variation of the BSF but do not have the required design characteristics and cannot be considered types of BSF technology. A BSF must have the following characteristics:

1. The filter container, diffuser, standpipe, lid and media are constructed using food grade quality materials.
2. The filter will contain a filtering layer consisting of a minimum of 15 cm of clean rock particles, also known as media, as measured down from the top surface of the media. Layers of larger diameter rock particles may underlie the filtering media to provide support for the filtering layer and drainage of filtered water.
3. The rock particles comprising the filtering layer will have a mean diameter less than 0.35 mm.
4. The filter outlet system is normally a pipe that should be located such that it removes filtered water from the bottom of the filter into a vertical pipe, called the standpipe, that is located inside the filter container wall or securely attached to the filter on the outside the filter wall. The standpipe must not be located inside the filter media to avoid accidental occurrence of untreated water reaching the bottom of the media by flowing along the outside of the standpipe. Filtered water must flow freely from the filter when in operation (no valves or anything else that might restrict the flow of filtered water). When the flow of filtered water stops, there must be a layer of water at least 5 cm deep above the filter media – known as the paused depth. There should be no extensions to the standpipe outlet that would result in siphoning action that might drain all of the water from the filter.
5. A diffuser plate or basin with a flat bottom must be located 10 cm above the top of the filter media when leveled. All water that is poured into the filter must pass through the diffuser. The holes in the bottom of the diffuser must be no smaller than 3 mm diameter spaced no closer than 25 mm (so as not to disturb the surface of the media when water is added to the filter). The number of holes is dependent on the diameter or width of the filter container (must cover more than one-half the area of the bottom of the diffuser). The space above the paused depth of water in the filter should be large enough to allow convenient addition of water to the filter with minimum user attendance.
6. Filter height must be one meter or less (convenient for household use).
7. Filter can be used as required without reduction in filter effectiveness to remove bacteria and viruses.
8. Routine cleaning of the media should not require removal of any media from the filter.
9. Only the top 5 cm or less of the media should be disturbed during cleaning using surface agitation methods.

10. Maximum surface loading of a BSF used to remove bacteria and viruses is 400 Liters per square meter of media surface.

Filters that do not exhibit any one of the features 1 to 10 cannot be called a variation of the BSF technology.

11. All types of BSFs will all remove 99.99% of parasites and larger organisms from the moment the filters are put into operation. This performance is not affected by the presence of chlorine in the raw water.
12. **None of the BSFs will remove 100% of the bacteria or viruses that may be in the raw water supply.** Post filtration disinfection is required to kill or deactivate bacteria and viruses which have not removed by the filtration process. Maximum removal of bacteria and viruses will occur when the biofilm develops around the media particles in the top 25 mm of media. This may require anywhere from one to three weeks depending on the nature of the raw water supply and is not visible to the naked eye. Experience indicates that BSFs will remove up to 70% bacteria (ecoli) from the moment it is put into production. Bacteria and viruses may be killed or deactivated using post-filtration disinfection such as chlorine or chlorine tablets.
13. Routine cleaning of the media should not reduce filter effectiveness to remove bacteria and viruses immediately after cleaning.
14. The effectiveness of the BSF to remove bacteria and viruses will vary depending on the quality and variability of the raw water supply, weather and how the filter is operated, cared for and cleaned. (This assumes that the filters have been produced using designs from reputable organizations and using appropriately prepared and installed media.)
15. Most practical experience with BioSand water filters is in developing countries in rural disadvantaged communities around the world. This is the most demanding use for any household water treatment technology.

2.0 Effectiveness of the BSF Technology to Treat Water

The effectiveness for the BSF technology to treat water is a function of untreated water quality including variation in quality, weather and use. It is generally understood that BSF technology produces water that may contain bacteria and viruses and the filtered water will require disinfection if it is to meet WHO guidelines.

A BSF will exhibit 99.99% removal of all parasites and complete removal of organisms such as bilharzia, Guinea worm and amoebae.

BSFs produce very little wastewater. It is not dangerous. The wastewater is safe to dispose of.

BSFs are not complex and are simple to operate. If located where the filtered water is produced near where it will be used, the BSF becomes a valued, protected household appliance.

Since they are usually manually operated, their operating cost is negligible. Maintenance costs are also negligible since the media is not intended to be replaced, and if it is, the cost of replacement is very low.

If properly cared for, the useful life of a BSF is in greater than twenty years.

Millions of BSFs are in use around the world. Thousands of BSFs are being constructed every day.

3.0 Comparison of BioSand Water Filters

Since its introduction to households in developing countries in 1992 (Nicaragua being the first) many variations in the design of household water filters using BSF technology have been developed. Table 1 compares the basic variations that are being constructed around the world. The differences between the designs and use of the filters can be very important.

The original design is the original concrete version named the Manz BioSand Filter (or Manz Concrete BSF). Details of its construction and use are described in https://manzwaterinfo.ca/biosand-filter. The filters were easy to construct with good quality control, functioned very well, and were accepted by intended users. Several community scale installations using the Manz BSF became the subject of several health impact studies (epidemiological studies) conducted by reputable universities. Initial studies were on community scale installations (large field studies) that used the Manz BSF. Those using this filter experienced up to 60% decrease in gastrointestinal disease. No other intervention has matched this performance. Cholera was completely eliminated (as were reported in the original Nicaragua community scale installation) as were diseases causing eye and other infections, parasites and skin penetrating organisms such as bilharzia and Guinea worm (verbal reports from Peace Corps volunteers). Health impact studies are not common because of their sophistication and expense which could easily approach seven figures. The original design of the HydrAid plastic filter carefully followed the Manz Concrete Filter Design and independent studies of its performance were similar to the Manz Filter. The design of the HydrAid filter has since been modified.

There have been a several research programs in universities around the world producing numerous masters and PhD theses. Most of this research was performed in laboratories where conditions and filter use could be controlled. Field studies are very difficult to perform because of variations in quality of the water supply and consumer behaviour and the results can be inconclusive. The results of the laboratory studies coupled with field experience with the BSF technology led to the development of several other designs, each one hoping to solve a particular problem or using new found science that might improve performance and enhance acceptance and funding.

The World Health Organization has never fully accepted the BSF technology despite its demonstrated positive impact on health because the technology could never guarantee that the treated water would meet its Guidelines. This is unfortunate. It is an example of "the perfect being the enemy of the good".

Use of the BSF technology has been confined to poor rural and peri-urban communities where it is readily accepted (because it is usually a gift or heavily subsidized); but more important, it performs well and is valued. The 'rustic' appearance of the filters has limited appeal when aesthetics and convenience become important considerations.

Table 1 presents a comparison of water filters using the BioSand Water Filter technology for use in households in developing countries since 1992. A description of each of the filters follows.

Table 1. Comparison of water filters using BioSand Water Filter technology 2021.

Filter Name[5]	Cost per Unit	Method of Construction	Ht/W/D cm	Weight Empty/Full including water kg	Method of Operation	Max. Prod. L/h L/day	Method of Cleaning	Frequency of Filter Media or Filtering Component Replacement	Portability when Operat*ing*	Life Expectancy years	Limitations on Quality of Untreated Water [1]	Quality of Filtered Water [2,3]	Need for Technical Support/ Replacement Parts	Commercial Potential (for profit in rural or urban retail market)[4]
Manz Concrete	**Local cost of material and labour**	**Steel mold using concrete 12.5mm pvc pipe.**		**Est.125/ 225**	**Manual**	**40 320+**	**Surface agitation with decant with possibility of using backwash**	**If it gets plugged it will need replacement (unless backwash feature is used)**	**Not**	**20+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
CAWST Concrete	**Local cost of material and labour**	**Steel mold using concrete 12.5mm pvc pipe.**		**Est 75/ 175**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement.**	**Not**	**20+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
Bushproof Concrete	**Local cost of material and labour**	**Steel mold using concrete 12.5mm pvc pipe.**		**Est. 75/ 175**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement.**	**Not**	**20+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
Samaritan's Purse Concrete	**Local cost of material and labour**	**Steel mold using concrete 12.5mm pvc pipe.**		**Est. 125/ 225**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement.**	**Not**	**20+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
Clear Cambodia Concrete	**Local cost of material and labour**	**Steel mold using concrete 12.5mm pvc pipe.**		**Est. 125/ 225**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement.**	**Not**	**20+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
HydrAid	**Unknown**	**Plastic and 12.5mm pvc pipe**		**3.5/ 150**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement.**	**Not**	**10+**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
Manz Found Filter BSF Design	**Local cost of material and labour**	**Plastic and 12.5mm pvc pipe**		**-**	**Manual**	**12 100+**	**Surface agitation with decant**	**If it gets plugged it will need replacement**	**Not**	**?**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**

Adapted Designs	**Local cost of material and labour**	**Typically, plastic pipe or bucket of unknown size**		**-**	**Manual**		**Surface agitation with decant**	**If it gets plugged it will need replacement**	**Not**	**?**	**Sediment load that penetrates media**	**A, AA, B, BB and C**	**Limited**	**Limited**
Davnor Cabin Clean Water Filter	**Retail CD $200 or as low as CD $50 retail.**	**Plastic and 12.5mm pvc pipe.**		**5/ 15**	**Manual or automatic**	**12 96**	**Surface agitation with decant and backwash**	**Should not be necessary**	**Yes**	**20+**	**Not limited by sediment plugging media.**	**A, AA, B, BB and C**	**Limited**	**Significant**
Manz BSF60	**CD $1200**	**Plastic and 12.5 mm and 50 mm pipe and valves**		**10/ 150**	**Automatic**	**60/ 1200**	**Backwash**	**Should not be necessary**	**Not**	**20+**	**Not limited by sediment plugging media.**	**A, AA, B, BB and C**	**Some**	**Significant**

1. Sediment that penetrates and collects in media cannot be removed by manual cleaning and the media will eventually stop filter flow. It needs to be removed and replaced with clean media. BioSand filters cannot remove or have limited capability to remove dissolved solids (toxins). Very fine colloidal material might not be removed and the filtered water may still have high turbidity. All BioSand water filters would be able to remove parasites from piped urban water supplies.

2. All BioSand water filter produce water that requires some disinfection to kill/ deactivate bacteria and viruses remaining after filtering. All organisms 5 µm or larger are removed. Treatment technologies such as ceramic candle filters, or ceramic pot filters, would provide long term, non chemical removal of any bacteria or viruses left in water after BioSand filtration. WHO Guidelines can only be met with final disinfection. (See 'Market for the Household Water Treatment'.)

3. In all but exceptional circumstances such as when treating water with very high turbidity or sediment load filtered water from BioSand Water Filters is safe to drink without disinfection. All of the epidemiological studies performed by very reputable organizations and universities in communities around the world support this conclusion. All BioSand water filters produce water that is easily disinfected using chlorine; and if the produced water has a low turbidity, using ultra violet disinfection.

4. Occasionally, retail sales for locally manufactured BSFs develops. This has happened in almost every region where the technology has been introduced. The demand is very limited except to satisfy demands from locally operated NGOs. The HydrAid filter is only marketed to NGOs. To my knowledge none of the adapted or found filters have a retail market. The Davnor Cabin Clean Water Filter is intended for both the retail market and volume sales to governments and agencies and NGOs. The Manz BSF60 is strictly retail market.

5. Only those filters which exhibit all of the minimum characteristics of BioSand Water Filters, use materials suitable for contact with potable water, and do not use pseudo or mystery technology are considered.

4.0 Information on BSF Filters

The history of the BioSand Water Filters has its origins in the late 1980s with first visits to Kwazulu Natal, South Africa and Mindanao, the Philippines. The real development of the BSF started in the 1990 and continues to this day with the development of the Cabin Clean Water Filter and the Manz BSF60. There are two power point presentations that describe this journey (parts of it anyway). They are parts of a larger presentation I gave at the time I was designated a Legend of Engineering by the Association of Professional Engineers and Geoscientists of Alberta in 2018. They may be found on the bottom of the home page of www.manzwaterinfo.ca. The development of the BSF technology and discoveries of its use continue to this day.

4.1 Early development of the Manz filters at the University of Calgary.

The development of the Manz concrete BSF was the result of considerable effort by myself, many graduate and undergraduate students and staff in the Department of Civil Engineering of the University of Calgary. See bottom of home page, www.manzwaterinfo.ca. Photos of the evolution, found filters to concrete filters, follow.

An important observation is that much of the journey in the development of the BSF technology is still being rediscovered today. Several of these designs shown would not meet the required characteristics of a BSF.

Sadly, many who wish to bring safe drinking water to the disadvantaged communities they wish to help design their own filters. My first experience with this was when a member of the Division of International Development at the University of Calgary introduced, without my knowledge, what she called a BioSand Filter (strange interpretation of the technology) to a clinic in Bolivia, and it didn't work. This not only set the Bolivian initiative back (could have helped a great deal) but also the filter lost value in the eyes of others in the University who ultimately obstructed its support for use in other projects (eventually overcome with the help of none other the person who launched the technology in the Dominican Republic, Jan Tollefson). Ad hoc designs should be avoided. Found filters are inexpensive and easy enough to make correctly.

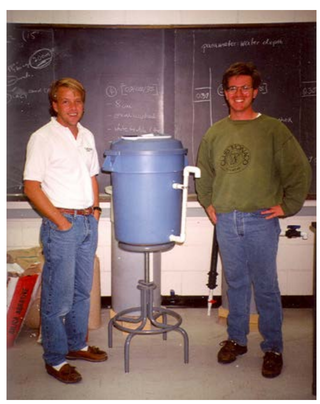
Note that early ideas evolved to the BSF technology that is used today. Changes in any aspect of the design of the BSF often have unintended consequences. This possibility doesn't seem to deter the fearless. There are many sand filters out there that are said to use BSF technology but don't. Unfortunately, this includes many of the larger versions of the filters intended to provide safe water to communities and schools and they don't – at least not to the standard possible if they implemented the BSF technology correctly.

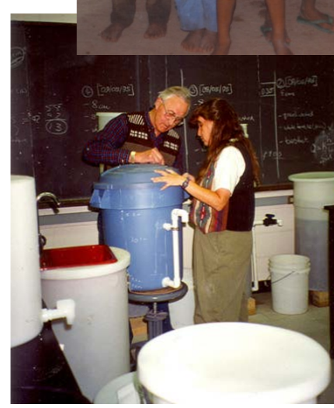
First filter, 1991.

Second and third filters, 1991 -92.

Fourth filter Nicaragua 1993.

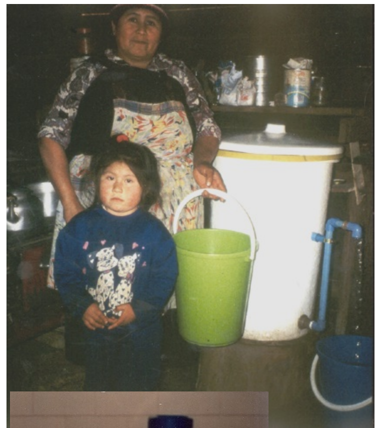
First short courses found filter,1994.





Fibre glass found filter in Chile, 1994.

Plastic found filter in Honduras, 1994.



Another plastic garbage can filter, 1995.

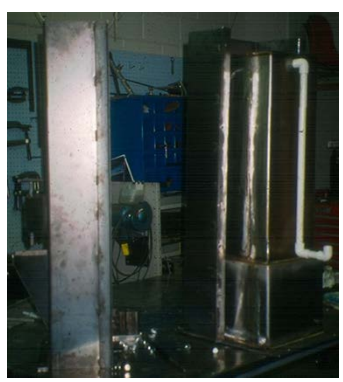
Found filter in Costa Rica, 1995.

Steel barrel filter. Fill orange barrel with water to be treated. Open valve to allow water into actual filter which produces filtered water to a third barrel.

Experiments at University 1992 - 1993.

Wood mold Nicaragua 1994. Wood mold proved not durable and was replaced by the more durable steel mold.

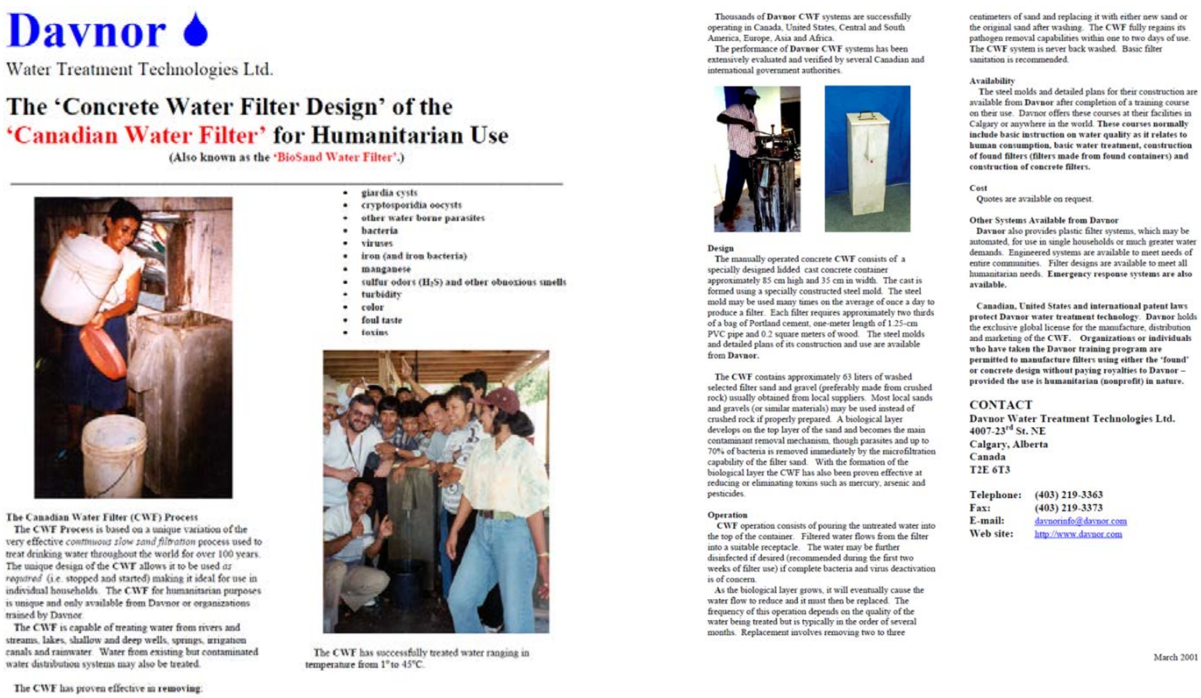
First steel mold, clam shell design, at the University of Calgary, 1995.



4.2 Manz concrete filter.

The Manz concrete filter was the original concrete filter design. Design details may be found in https://manzwaterinfo.ca/biosand-filter. This also includes a description of the development and use of the BSF, drawings needed to manufacture and use the steel mold, numerous manuals and guides describing how to construct and use the filter and some case histories. Short courses on the use of the filter started in 1994. Ultimately, short courses on the construction and use of the Manz concrete filter were provided by Davnor Water Treatment Technologies Ltd. The Davnor brochure dated 2001 is shown below. At this time the filter was named the 'Canadian Water Filter'. Shortly after its name was changed to the BioSand Water Filter. Despite the 'official' name change it has always been known as the Manz concrete BSF.

Davnor stopped offering the courses when it became a public company, 2001, at which time the Centre for Affordable Water and Sanitation was founded to assume this role.



Davnor

Water Treatment Technologies Ltd.

The 'Concrete Water Filter Design' of the 'Canadian Water Filter' for Humanitarian Use

(Also known as the 'BioSand Water Filter'.)

The Canadian Water Filter (CWF) Process

The **CWF Process** is based on a unique variation of the very effective *continuous slow sand filtration* process used to treat drinking water throughout the world for over 100 years. The unique design of the **CWF** allows it to be used *as required* (i.e. stopped and started) making it ideal for use in individual households. The **CWF** for humanitarian purposes is unique and only available from Davnor or organizations trained by Davnor.

The **CWF** is capable of treating water from rivers and streams, lakes, shallow and deep wells, springs, irrigation canals and rainwater. Water from existing but contaminated water distribution systems may also be treated.

The **CWF** has proven effective in removing:

- **giardia cysts**
- **cryptosporidia oocysts**
- **other water borne parasites**
- **bacteria**
- **viruses**
- **iron (and iron bacteria)**
- **manganese**
- **sulfur odors (H_2S) and other obnoxious smells**
- **turbidity**
- **color**
- **foul taste**
- **toxins**

The CWF has successfully treated water ranging in temperature from 1° to 45°C.

Thousands of **Davnor CWF** systems are successfully operating in Canada, United States, Central and South America, Europe, Asia and Africa.

The performance of **Davnor CWF** systems has been extensively evaluated and verified by several Canadian and international government authorities.

Design

The manually operated concrete **CWF** consists of a specially designed lidded cast concrete container approximately 85 cm high and 35 cm in width. The cast is formed using a specially constructed steel mold. The steel mold may be used many times on the average of once a day to produce a filter. Each filter requires approximately two thirds of a bag of Portland cement, one-meter length of 1.25-cm PVC pipe and 0.2 square meters of wood. The steel molds and detailed plans of its construction and use are available from **Davnor.**

The **CWF** contains approximately 63 liters of washed selected filter sand and gravel (preferably made from crushed rock) usually obtained from local suppliers. Most local sands and gravels (or similar materials) may be used instead of crushed rock if properly prepared. A biological layer develops on the top layer of the sand and becomes the main contaminant removal mechanism, though parasites and up to 70% of bacteria is removed immediately by the microfiltration capability of the filter sand. With the formation of the biological layer the CWF has also been proven effective at reducing or eliminating toxins such as mercury, arsenic and pesticides.

Operation

CWF operation consists of pouring the untreated water into the top of the container. Filtered water flows from the filter into a suitable receptacle. The water may be further disinfected if desired (recommended during the first two weeks of filter use) if complete bacteria and virus deactivation is of concern.

As the biological layer grows, it will eventually cause the water flow to reduce and it must then be replaced. The frequency of this operation depends on the quality of the water being treated but is typically in the order of several months. Replacement involves removing two to three centimeters of sand and replacing it with either new sand or the original sand after washing. The **CWF** fully regains its pathogen removal capabilities within one to two days of use. The **CWF** system is never back washed. Basic filter sanitation is recommended.

Availability

The steel molds and detailed plans for their construction are available from **Davnor** after completion of a training course on their use. Davnor offers these courses at their facilities in Calgary or anywhere in the world. **These courses normally include basic instruction on water quality as it relates to human consumption, basic water treatment, construction of found filters (filters made from found containers) and construction of concrete filters.**

Cost

Quotes are available on request.

Other Systems Available from Davnor

Davnor also provides plastic filter systems, which may be automated, for use in single households or much greater water demands. Engineered systems are available to meet needs of entire communities. Filter designs are available to meet all humanitarian needs. **Emergency response systems are also available.**

Canadian, United States and international patent laws protect Davnor water treatment technology. **Davnor** holds the exclusive global license for the manufacture, distribution and marketing of the **CWF. Organizations or individuals who have taken the Davnor training program are permitted to manufacture filters using either the 'found' or concrete design without paying royalties to Davnor – provided the use is humanitarian (nonprofit) in nature.**

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Others are essentially the same but have modified the shape of the filter body, design of the standpipe and depth of media.

The 12.5 mm diameter standpipe and limited surface area of the filter allows for the use of commissioning using a backwash-type process – eliminating need to ever replace media.

4.3 Centre for Affordable Water and Sanitation, CAWST

https://www.cawst.org/services/expertise/biosand-filter/more-information

Initially, 2001, CAWST used the Manz concrete filter design. Later CAWST adopted a modified design of the concrete filter which used a much smaller diameter standpipe and required walls that were about half the thickness. The filter weight was reduced by approximately one-half. The media depth was increased in response to research performed at the University of North Carolina and they recommended limiting filter use each day with a view to enhance the ability of the filter to remove bacteria and viruses. It was in fact improved but the filters will never exhibit 100% removal of bacteria and viruses. Use of the filter alone will not meet WHO Guidelines and post-filtration disinfection is still required. The difficulty with the protocol introduced by CAWST to limit filter use is the negative effect of limiting the amount of filtered water produced to below what daily household requirements might be. There is a very strong possibility that this protocol would be ignored.

4.4 Bushproof

https://bushproof.com/ and https://www.biosandfilter.org/

Bushproof has provided BSF technology and training since mid 2000s. They immediately 'improved' the filter design by changing the shape of the filter to a cylinder and using a mold forming the front and back of the filter. (Similar to the clam shell design of the original steel mold used to form the Manz Filter.) Otherwise, the filter technology is still the same as the Manz concrete filter design.

4.5 Samaritan's Purse, SP

https://www.samaritanspurse.ca/what-we-do/water-sanitation-hygiene/

Initially, 1995, Samaritan's Purse used the Manz concrete filter design but with a larger 'nose' – the result of efforts to use the steel mold more effectively. (This was later resolved through minor design changes.) Ultimately, SP adopted the same media depth and operation protocol as recommended by CAWST.

4.6 Clear Cambodia

https://www.clearcambodia.org/home/

Clear Cambodia was supported SP initiatives in Cambodia in the late 1990s. Since then, it has become a major supplier of concrete BSFs in Cambodia building and installing water filters funded by several other doners as well as SP. The design of the filter is the same as that originally introduced by SP, that is, the same design as the Manz concrete filter. It has since moved into the large BSF filter market for provision of filtered water for schools.

4.7 Hydraid

http://wishingwellintl.org/hydraaid/

The Hydraid BSF is a plastic version of the BSF technology originally manufactured and distributed under license from a Canadian company. This license has not been in effect for several years. Originally, the Hydraid filter was similar to the Manz concrete BSF except that it had it has a circular cross-section that tapers to allow for efficient transportation. The area of the surface of the media is significantly larger than the Manz filter, the standpipe is 12.5 mm in diameter; and recently, the media depth has been increased similar to CAWST recommendations.

4.8 Manz Found Filter

The Manz found filter was developed by Davnor for inclusion in its filter workshops. This design was eventually abandoned by Davnor because of the design invited poor quality control and inappropriate innovation – the internet is full of these types of innovations which have the real potential of giving the BSF technology a bad reputation.

The Davnor brochure follows:

Davnor

Water Treatment Technologies Ltd.

The 'Found Filter Design' of the 'Canadian Water Filter' for Humanitarian Use

(Also known as the 'BioSand Water Filter'.)

The Canadian Water Filter (CWF) Process

The **CWF Process** is based on a unique variation of the very effective *continuous slow sand filtration* process used to treat drinking water throughout the world for over 100 years. The unique design of the **CWF** allows it to be used *as required* (i.e. stopped and started) making it ideal for use in individual households. The **CWF** for humanitarian purposes is unique and only available from Davnor or organizations trained by Davnor.

The **CWF** is capable of treating water from rivers and streams, lakes, shallow and deep wells, springs, irrigation canals and rainwater. Water from existing but contaminated water distribution systems may also be treated.

The **CWF** has proven effective in **removing**:

- **giardia cysts (beaver fever)**
- **cryptosporidia oocysts**
- **other water borne parasites**
- **bacteria**
- **viruses**
- **iron (and iron bacteria)**
- **manganese**
- **sulfur odors (H_2S) and other obnoxious smells**
- **turbidity**
- **color**
- **foul taste**
- **toxins**

The **CWF** has successfully treated water ranging in temperature from 1°to 45°C.

Thousands of **Davnor CWF** systems have been successfully operating in Canada, United States, Central and South America, Europe, Asia and Africa.

The performance of **Davnor CWF** systems has been extensively evaluated and verified by several Canadian and international government authorities.

Design

The 'found filter design' of the **CWF** consists of a plan and procedure for making properly functioning **CWF's** out of suitable 'found' containers often available at little or no cost. These filters exhibit exactly the same performance as other filters using the **CWF** design.

The container should be approximately .8 m to 1 m in height and .3 m to .5 m in diameter. Containers can be made of any food grade material. Containers with a non-circular cross section can be used if they don't deform when filled with sand.

The amount of selected and prepared filter sand and gravel used to construct the filter will depend on the size of the container used. Ideally, the filtering media will be made from crushed rock available from local suppliers; however, local sands and gravel are often successfully used.

A biological layer develops on the top layer of the sand and becomes the main contaminant removal mechanism, though parasites and up to 70% of bacteria is removed immediately by the microfiltration capability of the filter sand. With the formation of the biological layer the CWF has also been proven effective at reducing or eliminating toxins such as mercury, arsenic and pesticides.

Operation

CWF operation consists of pouring the untreated water into the top of the container. Filtered water flows from the filter into a suitable receptacle. The water may be further disinfected if desired (recommended during the first two weeks of filter use) if complete bacteria and virus deactivation is of concern.

As the biological layer grows, it will eventually cause the filter water production to reduce and it must then be replaced. The frequency of this operation depends on the quality of the water being treated but is typically in the order of several months. Replacement involves removing two to three centimeters of sand and replacing it with either new sand or the original sand after washing. The **CWF** fully regains its pathogen removal capabilities within one to two days of use. **The CWF** system is never back washed. Basic filter sanitation is recommended.

Availability

Detailed plans and procedures are available from Davnor upon completion of **a training course on the filter's use.** Davnor offers these courses at their facilities in Calgary or anywhere in the world. **These courses normally include basic instruction on water quality as it relates to human consumption, basic water treatment, construction of found filters and construction of concrete filters.**

Cost

Quotes are available on request.

Other Systems Available from Davnor

Davnor also provides concrete filters for humanitarian use, manually operated plastic filter systems, which may be automated for use in single households or filter systems capable of satisfying much greater water demands. Engineered systems are available to meet needs of entire communities. Filter designs are available to meet all humanitarian needs. **Emergency response systems are also available.**

Canadian, United States and international patent laws protect Davnor water treatment systems. **Davnor** holds the exclusive global license for the manufacture, distribution and marketing of the **CWF. Organizations or individuals who have taken the Davnor training program are permitted to manufacture filters using either the 'found' or concrete design without paying royalties to Davnor – provided the use is humanitarian (nonprofit) in nature.**

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4.9 Found and Adapted Filter Designs

The development and construction of found and 'adapted' filter designs has been taking place since the first communication of the BioSand Filter technology to the world. People can't stop trying to improve stuff and more often than not they get it wrong. The BSF technology is very robust and deviations that might considered fatal appear to be accommodated without loss of performance, at least in the field applications where it counts the most. The ability of these products to treat water is rarely if ever evaluated (likely because there is no knowledge of how to perform this exercise or the budget and willingness to do it).

There are numerous problems with the found filter concept including the myth that it is somehow less expensive and will do the same job. The filters are constructed with little or no quality control in most circumstances (something like a grade school project of which there also many). The filter containers often have uncertain provenance – used to hold toxic chemicals comes to mind. The media used of comes from a questionable source. Some of the creativity demonstrated, in the spirit of cost cutting, simplifying construction, easier transportation, easier sourcing of materials, etc. may result in a filter but not one that can be called a BSF. The performance of resulting products is never evaluated. Something is not always better than nothing. I remain opposed to the encouragement to construct any sort of adapted or found filter products that are intended to possess the performance of carefully constructed and evaluated concrete and plastic versions of the BSF.

4.10 Davnor Cabin Clean Water Filter, CCWF

The Davnor Cabin Clean Water Filter or simply Clean Water Filter is best described in the following brochure and in the dedicated web site www.cabincleanwaterfilter.ca.

The CCWF is able to treat most water to a quality satisfactory for human consumption similar to all other quality BSF technology. With the addition of post-filtration disinfection, the produced water may be able to meet WHO Guidelines. The caveat is; the raw water may have characteristics that require advanced treatment technologies if the objective is to meet WHO Guidelines. Typical urban and peri-urban water has undergone treatment at a central treatment facility and is distributed or is obtained from deep wells. This water may reach households with dangerous pathogens but is otherwise very high quality and easy to treat by the CWWF. Rural water supplies that have elevated sediment loads would normally plug the filter media in ALL BioSand Filters including the CCWF. However, the CCWF is simply recommissioned, (5 to 10 minutes) and it is back in operation. Other filters will need media replacement.

The performance of the CCWF has been independently evaluated in laboratory environments typical of the use expected in households in both the developing and developed world.

The results of the Giardia and Cryptosporidium Removal evaluation indicated better than 99.99% removal rates when both unchlorinated and chlorinated water were considered.

The results of the bacteria removal challenge indicate removals greater than 90%, typical of other BSFs. Post-filtration disinfection is expected in the households where the CCWF is to be marketed.

The CCWF is intended to be distributed in commercial markets which do not have access to BSF technology at this time. The price point is very competitive and multi-level marketing appears feasible.

This is the ONLY biosand water filter that can be considered portable when fully charged with media and water. Once the moving process is complete and the filter located it is simply re-commissioned and its in back in operation.

The CCWF may be automated and used as part of quite sophisticated treatment technology including GAC and reverse osmosis to deliver treated water throughout a household by with the turn of a tap.

The technical support required is well within the capability of the supplier.

CABIN 'Clean Water Filter' Manual and Automatic

www.cabincleanwaterfilter.com

The CABIN Clean Water Filter treats water so that it is safe for human consumption and is aesthetically pleasing. It is designed for use in isolated homes or cabins, homes in communities without access to safe drinking water, camps, emergency supplies, boats, barges and recreational vehicles. Electrical power is not required for the manual operation. Automatically operated filters may use any available power supplies as required to provide raw water, operate valves, distribute treated water and power UV disinfection.

The CABIN Clean Water Filter is effective, compact, lightweight and portable. It is used to remove particulate matter (including iron) and disease-causing organisms from surface water (rivers, ponds and lakes), groundwater (wells and springs), captured rainwater and unsafe municipal supplies (piped or delivered). The CABIN Clean Water Filter can produce up to 12 litres of filtered water in one hour. The basic filter is manually operated and simple to clean. It is used as required. The automatic version may be used as part of a completely automated system including management of raw water supply, filter production, disinfection and treated water distribution as required by user.

Water produced by the CABIN Clean Water Filter is free of all types of water borne parasites such as Giardia and Cryptosporidium, and larger organisms such as Bilharzia and Guinea Worm and spores of infectious fungi. Most bacteria and viruses are also removed. Cholera is completely removed because it only survives in the gut of larger organisms that are easily removed. It is strongly recommended that filtered water be disinfected using chlorine tablets or household bleach or UV disinfection if available. The treated water should be safely stored and dispensed to provide treated water that is free of disease-causing organisms. The ability of the CABIN Clean Water Filter to remove disease causing organisms has been verified by independent laboratory testing.

The CABIN Clean Water Filter will not remove most dissolved substances but does provide excellent pre-treatment for filters that do remove dissolved substances such as micro filters and reverse osmosis. The filter will remove oxidized iron (typical form) and dissolved arsenic with the iron (co-precipitation). The biosand filtration process has been proven to reduce concentration of organic pesticides.

The manual version of the Cabin Clean Water Filter is intended to be placed on a counter-top safe from unwanted disturbance. Manual operation consists of removing the lid and pouring water to be treated directly into the top of the filter Filtered water is immediately produced from the filter outlet. Automatic versions may be placed and used where convenient including under counters, in cabinets or other locations where it is not conspicuous or uses counter space. Commissioning may be manual using the kit provided with the filter or using a small pump selected specifically for the commissioning purpose.

The CABIN Clean Water Filter is constructed using food grade plastic and media that are all NSF 61 certified. The filter is 50 cm tall and 30 cm wide at the lid. When filled with media the filter and accompanying commissioning kit weigh approximately 15 kg.

The filter construction is very durable and should provide satisfactory service for many years. With normal use the media will never require replacement.

The treatment and cleaning processes used by the CABIN Clean Water Filter are similar to those used by the millions of BioSand Water Filters in use around the world for more than twenty-five years. For more technical information and for information regarding price, availability, shipping costs and conditions of sale contact manzcabin@shaw.ca.

Davnor

Davnor Water Filters Ltd., 2703 Cannon Rd. NW., Calgary, AB, Canada, T2L 1C5 2020B

Giardia and Cryptosporidium Removal

Performance Evaluation MEL-BF and MEL-PF Technology, MEL Technical Bulletin No. 2

The performance evaluation was conducted by Lethbridge College (Lethbridge, Alberta) [1] and Hyperion Research Ltd. (Medicine Hat, Alberta) [2] on behalf of Manz Engineering Ltd. using pilot filters provided by Manz Engineering Ltd. (See Technical Bulletin No. 1 for description of pilot filter.) Details of the MEL-BF and MEL-PF technology may be found in www.manzwaterinfo.ca. The performance evaluation is unique in that live parasites were used in the testing procedure.

Objective

The objective of the study was to assess the ability of MEL-BF and MEL-PF technology to remove *Cryptosporidium* oocysts and *Giardia* cysts from both chlorinated and dechlorinated municipal water (considered worst case scenarios but also typical of urban water supplies in developing countries where municipal water often alternates between chlorinated and unchlorinated.)

Methodology

Three separate inoculation tests were performed using the pilot filter provided by Manz Engineering Ltd. with surface loading rates of 400 $L/h/m^2$, 600 $L/h/m^2$, and 1000 $L/h/m^2$. Both chlorinated and dechlorinated water were used in the tests.

Each test required the inoculation of approximately 1.0×10^6 *Cryptosporidium* oocysts and *Giardia* cysts. The live oocysts and cysts were supplied by Hyperion Research Ltd. (Medicine Hat, Alberta). The two selected lab strains were, *Cryptosporidium* oocysts (AZ-1 strain, lot C48025b) and the *Giardia* cysts (environmental isolate associated with an outbreak of human giardiasis, lot G54005). The oocysts and cysts in the filter effluent were captured using an Envirochek HV filter (Pall Canada, Mississauga, ON. The concentration of oocysts and cysts in the filtered water was determined using the EPA 1623 method for isolating *Cryptosporidium* (and *Giardia*) in water by filtration, immunomagnetic separation and immunofluorescence.

All testing was performed in the Hyperion Research Ltd. laboratory in Medicine Hat, Alberta.

Results

The MEL-BF and MEL-PF technology demonstrated 4 log removal of both *Cryptosporidium* oocysts and *Giardia* cysts at all surface loading rates considered. (99.99% removals.)

Contacts

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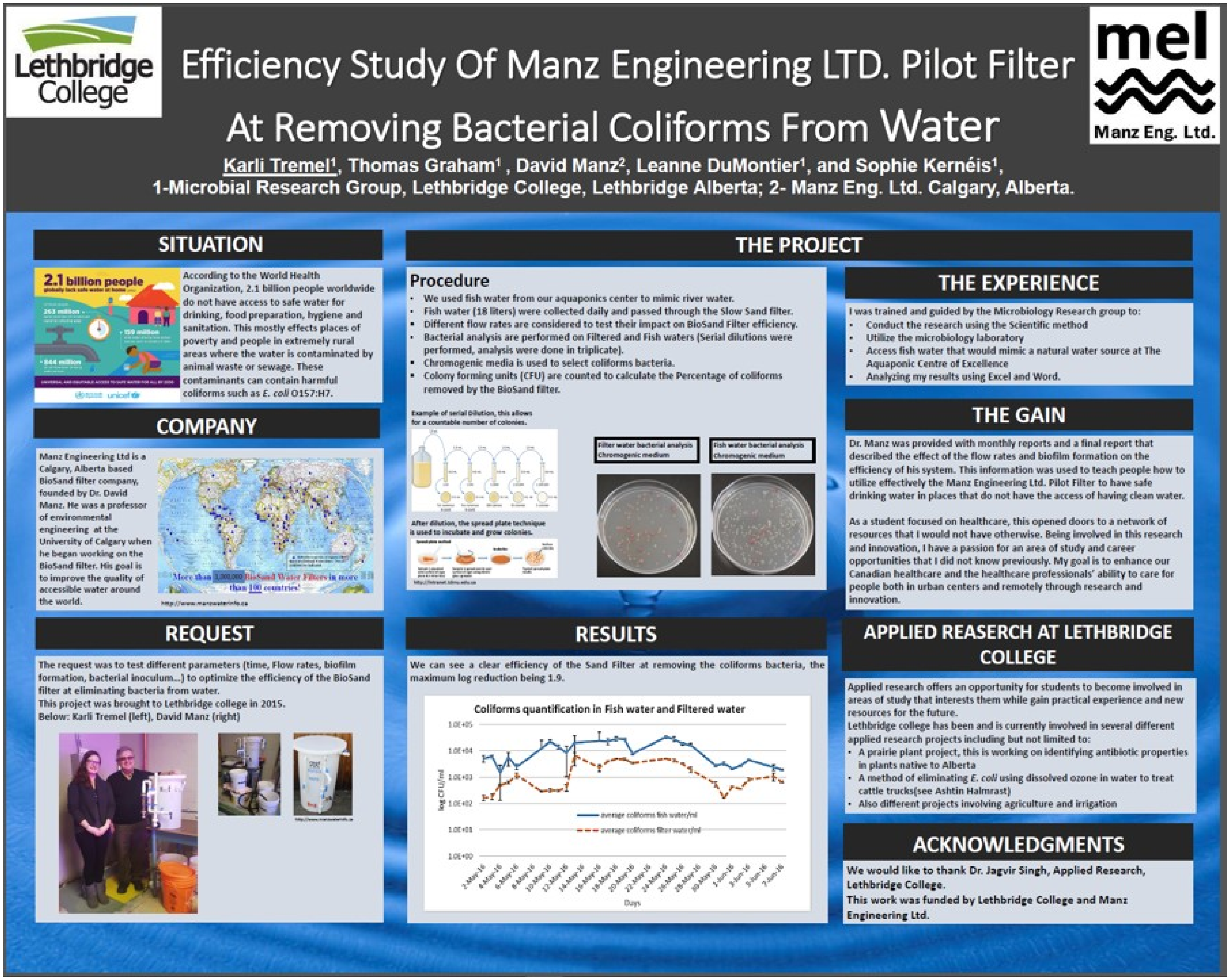
2. Dr. Peter Wallis, Hyperion Research, 1008 Allowance Ave. SE, Medicine Hat, AB CANADA T1A 3G8, www.hyperionlab.ca, hyperion@telusplanet.net (403 529 0827).


Lethbridge College
Efficiency Study Of Manz Engineering LTD. Pilot Filter At Removing Bacterial Coliforms From Water
mel
Manz Eng. Ltd.
Karli Tremel[1], Thomas Graham[1], David Manz[2], Leanne DuMontier[1], and Sophie Kernéis[1],
1-Microbial Research Group, Lethbridge College, Lethbridge Alberta; 2- Manz Eng. Ltd. Calgary, Alberta.
SITUATION
2.1 billion people
According to the World Health Organization, 2.1 billion people worldwide do not have access to safe water for drinking, food preparation, hygiene and sanitation. This mostly effects places of poverty and people in extremely rural areas where the water is contaminated by animal waste or sewage. These contaminants can contain harmful coliforms such as E. coli O157:H7.
COMPANY
Manz Engineering Ltd is a Calgary, Alberta based BioSand filter company, founded by Dr. David Manz. He was a professor of environmental engineering at the University of Calgary when he began working on the BioSand filter. His goal is to improve the quality of accessible water around the world.
than 100 countries!
REQUEST
The request was to test different parameters (time, Flow rates, biofilm formation, bacterial inoculum...) to optimize the efficiency of the BioSand filter at eliminating bacteria from water.
This project was brought to Lethbridge college in 2015.
Below: Karli Tremel (left), David Manz (right)
THE PROJECT
Procedure
We used fish water from our aquaponics center to mimic river water.
Fish water (18 liters) were collected daily and passed through the Slow Sand filter.
Different flow rates are considered to test their impact on BioSand Filter efficiency.
Bacterial analysis are performed on Filtered and Fish waters (Serial dilutions were performed, analysis were done in triplicate).
Chromogenic media is used to select coliforms bacteria.
Colony forming units (CFU) are counted to calculate the Percentage of coliforms removed by the BioSand filter.
Example of serial Dilution, this allows for a countable number of colonies.
After dilution, the spread plate technique is used to incubate and grow colonies.
Filter water bacterial analysis Chromogenic medium
Fish water bacterial analysis Chromogenic medium
RESULTS
We can see a clear efficiency of the Sand Filter at removing the coliforms bacteria, the maximum log reduction being 1.9.
Coliforms quantification in Fish water and Filtered water
log CFU/ml
Days
average coliforms fish water/ml
average coliforms filter water/ml
THE EXPERIENCE
I was trained and guided by the Microbiology Research group to:
Conduct the research using the Scientific method
Utilize the microbiology laboratory
Access fish water that would mimic a natural water source at The Aquaponic Centre of Excellence
Analyzing my results using Excel and Word.
THE GAIN
Dr. Manz was provided with monthly reports and a final report that described the effect of the flow rates and biofilm formation on the efficiency of his system. This information was used to teach people how to utilize effectively the Manz Engineering Ltd. Pilot Filter to have safe drinking water in places that do not have the access of having clean water.
As a student focused on healthcare, this opened doors to a network of resources that I would not have otherwise. Being involved in this research and innovation, I have a passion for an area of study and career opportunities that I did not know previously. My goal is to enhance our Canadian healthcare and the healthcare professionals' ability to care for people both in urban centers and remotely through research and innovation.
APPLIED REASERCH AT LETHBRIDGE COLLEGE
Applied research offers an opportunity for students to become involved in areas of study that interests them while gain practical experience and new resources for the future.
Lethbridge college has been and is currently involved in several different applied research projects including but not limited to:
A prairie plant project, this is working on identifying antibiotic properties in plants native to Alberta
A method of eliminating E. coli using dissolved ozone in water to treat cattle trucks(see Ashtin Halmrast)
Also different projects involving agriculture and irrigation
ACKNOWLEDGMENTS
We would like to thank Dr. Jagvir Singh, Applied Research, Lethbridge College.
This work was funded by Lethbridge College and Manz Engineering Ltd.

4.11 Manz BSF60

The Manz BSF60 is intended to treat large volumes of water as part of a larger treatment system. It is operated automatically (in emergencies it can be manually operated). It is described in the following brochure which contrasts it to the Cabin Clean Water Filter.

Davnor Plastic Filters.

Available capacities when operating as a biological filter are: 12 LPH and 60 LPH. Capacity of the 12 LPH filter is fixed but the capacity of the 60 LPH filter may be increased to 180 LPH when operating as a polishing filter.

Davnor Water Filters Ltd.: Cabin Clean Water Filter and Manz BSF60 filter.

The Clean Water Filter is able to filter 12 litres per hour. The filter is approximately 50 cm tall and 30 cm wide at the lid and weighs approximately 15 kg. The design may be configured to be manually or automatically operated. Water is filtered on an 'as required' basis though daily use is recommended. The manually operated versions were specifically designed for developing country environments (urban and rural) and remote applications typical of Canada (cottages, camps, remote communities, temporary habitation and recreational vehicle). See web site, www.cabincleanwaterfilter.com. The automated version of the Clean Water Filter was designed for use where electricity in some form is normally available and convenience of use is a priority; and, it is significantly more expensive than the manually operated versions.

The filtering media should never need replacement if the filters are used for production of drinking water using sources of water that would normally be considered for potable water use. Operation consists of pouring untreated water into the top of the filter. It passes through several layers of media and leaves through the standpipe outlet. Filtered water is captured in a container suitable for storing and dispensing potable water. Rate of flow of filtered water is controlled internally and cannot be adjusted. Typically, the volume of untreated water added to the filter would not exceed the capacity of the treated water storage vessel. It is recommended that the filtered water be disinfected using chlorine (liquid or tablet form) which ensures that all pathogens have been removed or killed. The manually operated Clean Water Filter may be cleaned using harrowing or by simply repeating the commissioning process. No electrical power is required.

The automatically operated Clean Water Filter employs a float-controlled inlet system that allows filtration as required to fill the treated water storage reservoir. Untreated water may be supplied by a pump or from overhead tanks (gravity). UV disinfection may be used before the treated water storage. Chlorine in liquid or tablet form could be used to disinfect the water in the treated water storage reservoir. Water from the treated water storage could be manually dispensed or distributed to suitably located faucets using an electric demand pump. The automated Clean Water Filter may be cleaned using harrowing and by repeating the commissioning process. A household reverse osmosis system may be added if desired.

The BSF60 would provide up to 60 litres per hour of filtered water when operating as a biological filter and 180 litres per hour when operating as a polishing sand filter. It is intended to be used in automated systems that include an appropriately sized storage reservoir to contain filtered and disinfected water and distribution of treated water directly from treated water storage tanks by gravity or using electric pumps. Detailed technical specifications are available on request. Technical support available to assist in applications.

The BSF60 is 85 cm tall and 55 cm wide at the lid. Installed and operating weight is approximately 250 kg.

Typically, larger treatment systems would employ two or more filters operating in parallel.

All materials used in the construction of the filters meet NFS 61 standards.

Filters operating as slow sand filters meet AWWA Guidelines, EU Standards and can be configured to meet the United States Ten States Standards.

Performance claims related to removal of water borne pathogens have been independently confirmed.

4.0 Concluding Remarks

There are several variations of the BSF technology for use in the rural household market. This is not a large market for the CCWF and would not justify its development. However, it is apparent that the CCWF and Manz BSF60 are able to bring the BioSand Water Filter technology into the very large commercial household market in the developing world. Use of the CCWF eliminates demand for bottled water and associated pollution from the plastic bottles.

The Cabin Clean Water Filter offers many advantages.

1. Produces sufficient water (12 L/h) for drinking, cooking and personal hygiene for more than ten people per day.
2. Eliminates need for bottled water.
3. Able to effectively and efficiently filter most water supplies considered for drinking purposes worldwide.
4. Culturally acceptable worldwide.
5. Aesthetically pleasing.
6. Used as required.
7. Gravity operated - no pumping, electricity or pressure required; or,
8. Gravity operated – automatically operated part of complex treatment system.
9. No replacement components.
10. Minimum technical support required.
11. Portable - easily moved and re-commissioned.
12. Competitively priced.
13. Can be used as part of more complex water treatment systems. Provides ideal pre-treatment for reverse osmosis and carbon filters that may be needed to remove dissolved solids.
14. Rugged.
15. Available worldwide.
16. Delivered ready to use.
17. Indefinite shelf life.
18. Lifetime purchase.