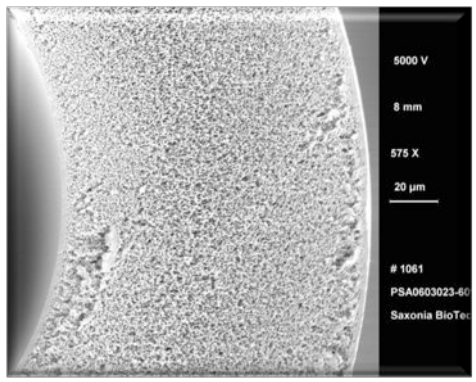
An Introduction: more clean water …..in a world of need.

Mankind's need for clean water….. is growing.

And, for many ……clean water is not available.

Membrane filtration is presently the fastest growing technology for use in the filtration of water. At the everyday level of industry and homes the technology permits one to transform contaminated water into potable water. At the laboratory level, ultra-high purity systems are creating purer water that has ever existed in nature.



A cross-section of the pore structure for a customized hollow fiber membrane

After years of successful and useful medical applications as a product development guide, the new membrane technologies represent a new stage of technical maturity. With this improved technical foundation, new membrane based products have begun to penetrate all primary applications of water filtration, albeit to varying degrees of use thus far.

These applications manifest themselves, for example, as:

1]. large filtration & desalination plants treating up to 400,000 m^3 / day that are now common-place in the industrialized countries;

2]. the first municipal treatment plants that transform sewage water into drinking water are in place; and

3]. globally, small point-of-use filters that are found in tens of millions of homes and in a variety of Institutions.

All together, global water membrane sales per se now exceed $3 billion per year. And though the accumulative clean water related sales have been growing at about 20% per year, this volume still pales in comparison to the 'in-place and still-growing' medical membrane applications.

For example, in 2007, membrane dialyzer sales alone were more than double the size of the industrial applications of membrane for water generation.

Dialysis Units in Operation

Still, if today's current trends are maintained, the overall membrane sales for the generation of clean water are projected to surpass medical membranes sales by 2020.

For perspective, the market's need for the high quality water treatment that membranes could have provided ***has existed for years.***

Since the 1960s, membranes have been used to desalinate water in places that simply have no alternatives ….such as Saudi Arabia and Israel. In the early years of these technologies the production costs were very high. But, when you have inadequate supplies of water, you then pay the price needed to provide the water needed. However, this high cost and demanding applications technologies that persisted throughout the 1960s, 1970s, and 1980s restricted water membranes programs primarily to Middle Eastern desalination operations and certain specialized industrial applications.

But the world changed and the water requirements demand underwent substantial increases in the past 25 years.

During this period as water short-falls continued to intensify and outbreaks of water illness due to pollution began to increase, the demand for the use of water filtering membranes continued to intensify. For example, in 1993 [Milwaukee, Wisconsin, USA] contaminated water resulted in nearly 100 deaths and 400,000 illnesses due to a unique situation where the incoming water supply was inadequately treated by the local, conventional water treatment plant. Situations like this at home and in many countries set the stage plus the growing global needs all fueled the demand for improved products.

Globally we've experienced a very non-linear growth in the global population. Global industrialization growth has been extensive. We're also experiencing adverse climate changes, increased industrial and people based pollution plus we are "over-drawn in our use of natural global clean water supplies. When you total up the bill …..more people in more regions of the world are increasingly more water stressed.

With those facts in place, the market for improved engineering solutions using membrane technologies became increasingly attractive, which precipitated major investments and finally yielded substantial technical improvements….and more water. [These intense technical and engineering efforts by major companies (Dow Chemical, Siemans and G.E.) over the past ten years are now providing a growing array of new and economically affordable membrane-based products.]

Engineered Answers ……clean water at "reasonable" costs

The 1990s represented the breakthrough decade for water membranes …especially in terms of cost reductions, product mix and developing markets. By the end of the 1990s, membranes had become cost competitive with non-membrane technologies for many applications. And, with the ability to offer superior water quality at a competitive cost, water membrane use had and has begun to expand dramatically.

Today, for a refreshed perspective, the following examples reflect some of these new applications.

First Israel's most recent water treatment plant is based on up-to-date Reverse Osmosis membrane technology.

The world's largest reverse osmosis desalination plant was opened this week in the Israeli coastal town of Hadera. This desalination plant is the first to be funded primarily through foreign funds by IDE Technologies who, according to their CEO, Avshalom Felber, raised the entire $463 million from European banks. The desalination plant was built by H2ID and can supply up to 20 percent of Israel's domestic drinking water for a year, about 750 million cubic meters.

Although bigger desalination plants are operating in Saudi Arabia, they use thermal-based technology which is not very energy efficient. The H2ID reverse osmosis plant will only demand 450 gigawatts to operate each year, making the cost per cubic meter of water around $0.57.

The new desalination plant is one of five scheduled to be built in Israel over the next few years. The goal is for these desalination plants to supply up to 100% of the nation's domestic water to supplement the dwindling traditional water sources provided by rainfall, aquifers and the Sea of Galilee — which is having so much water pumped from it that it is reaching (has reached) dangerously low levels.

To provide further perspective, ***R.O. and associated membrane technologies have permitted growth to occur where it has never been…. nor was even thought possible*** …for example in the newly created Dubai City within the United Arab Emirates.

Safe Water ……June 15, 2010

Using Membrane Bio-Reactor (MBR) technology helped Dubai Sports City widen the scope for waste water re-use within the development
By Anoop K Menon

Majd Hamdallah

The waste water plant tour ended inside the Reverse Osmosis (RO) room with Majd Hamdallah, Head of Operations, Eagle Electromechanical Company heading towards his colleague, who held in his hands a large glass tumbler filled with clear water. About time, I murmured to myself, as the long traipse through the plant's innards had left me with a gnawing thirst.

Taking the tumbler in one hand, Hamdallah gestured at its contents with the other and said, "We treat a portion of the treated sewage effluent (TSE) to drinking water quality that meets the Dubai Electricity and Water Authority (DEWA) standards by using RO." He then brought it up and proceeded to take a few swigs from it.

Hamdallah greeted my incredulous look with a big grin. "There is no better way to prove a point than walking the talk," he said, which in this case, was the superior product output of Membrane Bioreactor (MBR) technology increased the scope for wastewater re-use than conventional treatment methods. From somewhere, a voice whispered, "It's your turn now."

This exchange had taken place inside the premises of the largest operating membrane bio-reactor (MBR) wastewater treatment plant (WWTP) in the Middle East, designed, built and operated by Eagle Electromechanical Company. The 25,000 m3/day WWTP, located in the Dubai Sports City development in Dubai-land, stands out from its peers in several ways. It also represents a milestone in engineering excellence for the company, which has always practiced localization and designed its own wastewater treatment systems instead of relying on outside designs, as intended by Mohamed Hijaz, Eagle's founder and General Manager.

"All the things you are going to see inside the plant today were designed in-house by our engineers," stressed a visibly proud Hamdallah at the beginning of the tour. The Dubai Sports City WWTP takes Eagle's wastewater operating capacity in the region to over 100,000m3/day in Dubai alone.

In parallel to these developments, major corporations have been attracted to these "new" regions to set up operations ……places in which they had never thought to operate before. For example, per CH2M Hill's web-site statement:

> *" CH2M HILL operates in all major markets in the Middle East, including the United Arab Emirates, Saudi Arabia, Qatar, Egypt, Kuwait, Bahrain, Iraq, and Afghanistan. Emphasizing water, wastewater, power, transportation, and industrial and government facilities services, our goal is to create lasting value for our clients.*
> *Since 1977, after an urban development project was started in Dammam,*

Saudi Arabia, the firm's Middle Eastern presence continued to grow. Currently, there are nine office locations in this region, with more than 500 staff. By uniting strong local relationships, global resources and alliances, and cost-effective technologies, CH2M HILL has been delivering successful and sustainable projects in this region for over 30 years".

Further, to provide a comparative perspective, let's examine the United States of America's present status as to water quality and supply.

We've long held to the concept that we have a more-than-abundant amount of natural, clean water which will always be available to us (period). Thus our planning of water management has been slowed by this flawed concept….and is still being slowed.

But, there are signs of change. In the US of A the first, radically new water concepts and programs by some cities have begun or are on the drawing boards. For example, three years ago San Diego announced that it would be spending tens of millions of dollars to recover of 7.4 million gallons a day of their own waste water ….their own sewerage…for their own consumption.

"Californians Move to 'Toilet-to-Tap' Water Recycling"

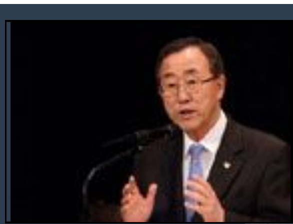
Posted: February 11, 2008

In response to Southern California's dwindling water supply, several California cities are " trying out" new water reclamation technologies that turn wastewater into drinking water.

It states that this effort will focus onto the use of Reverse Osmosis Membranes to generate useful clean water for people plus use in crops, in conservation efforts by planting native vegetation, by collecting rain water, and installing pressurized shower heads & low flow toilets.

One expects that more cities and states will follow.

And finally, one comes to consider the concept of **'The water wars'** as suggested for consideration by Secretary General Ban Ki-moon of the U.N. in 2008.



U.N. Secretary-General Ban Ki-moon said that water shortages have contributed to poverty and other problems in nations around the world.

"California is not the only area to face a water shortage -- in the U.S. or around the world.

The United Nations predicts that severe water shortages affecting at least 400 million people today will affect 4 billion people, more than half of humanity, by 2050".

Prevention of the looming water crisis should receive top priority in 2008, according to UN Secretary-general Ban Ki-moon.

At an economic conference in January, Ki-Moon said the conflict in the Darfur region of Sudan was touched off by drought and that water shortages have contributed to poverty and social hardship in numerous countries, including Somalia, Israel, Sri Lanka, Colombia and Kazakhstan, he said.

"Too often, where we need water, we find guns instead," he said. "Population growth will make the problem worse. So will climate change."

Indeed, when placed in perspective of the needs and corresponding actions, membranes seemingly represent one of the "best" technological solutions to many of the present and projected world's substantial water problems.

Membranes and clean water for people….an engineering look

Membranes are useful water filters because the membranes contain holes ……intelligently selected holes. At the beginning of the 1990s, membrane filtration cost 3-4 times the price of any basic water filtration system and desalination cost over 10 times as much. This meant that engineers generally did not use membrane technology. Today raw sewage water can be transformed into potable quality water more efficiently that alternative filter systems at competitive costs and at significantly lower costs than systems using RO membranes.

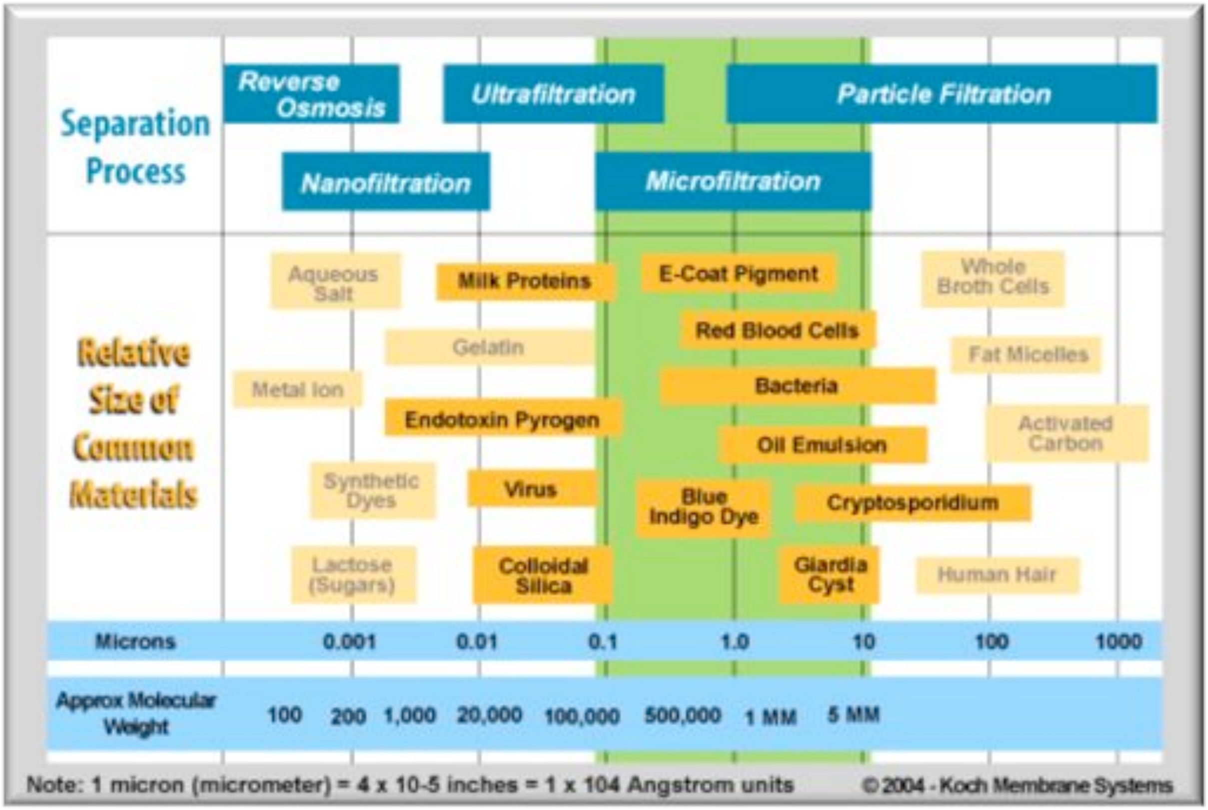
Today you can even select specific classes of membranes …each with different sized holes ….for filtering out different items one does not want in the processed water .

Thus, for example, we have a variety of categories of membranes such as…..ones for micro-filtration[MF], one's for ultra-filtration [UF] and one's for nano-filtration [NF].

For example, MF membranes allow the passage of salts and minerals thru the membrane wall, yet filter out the bacterial specifies that are associated with natural or fouled raw water sources. The resulting output water is microbiologically safe water [free of bacteria] and thus does not support disease in consuming humans.

The following section provides the reader with an industrial overview of membrane applications as presented by one of the leaders ….that of Koch Membrane Systems. Following then are some specific examples of the uses for membrane technologies plus some of the engineering considerations involved for a few specific markets.

" KMS manufactures microfiltration membranes in tubular, hollow fiber, spiral and flat sheet membrane configurations. The following graphic provides a useful perspective of the pore sizes that are available for a variety of membranes and an overview of the materials that are separated.



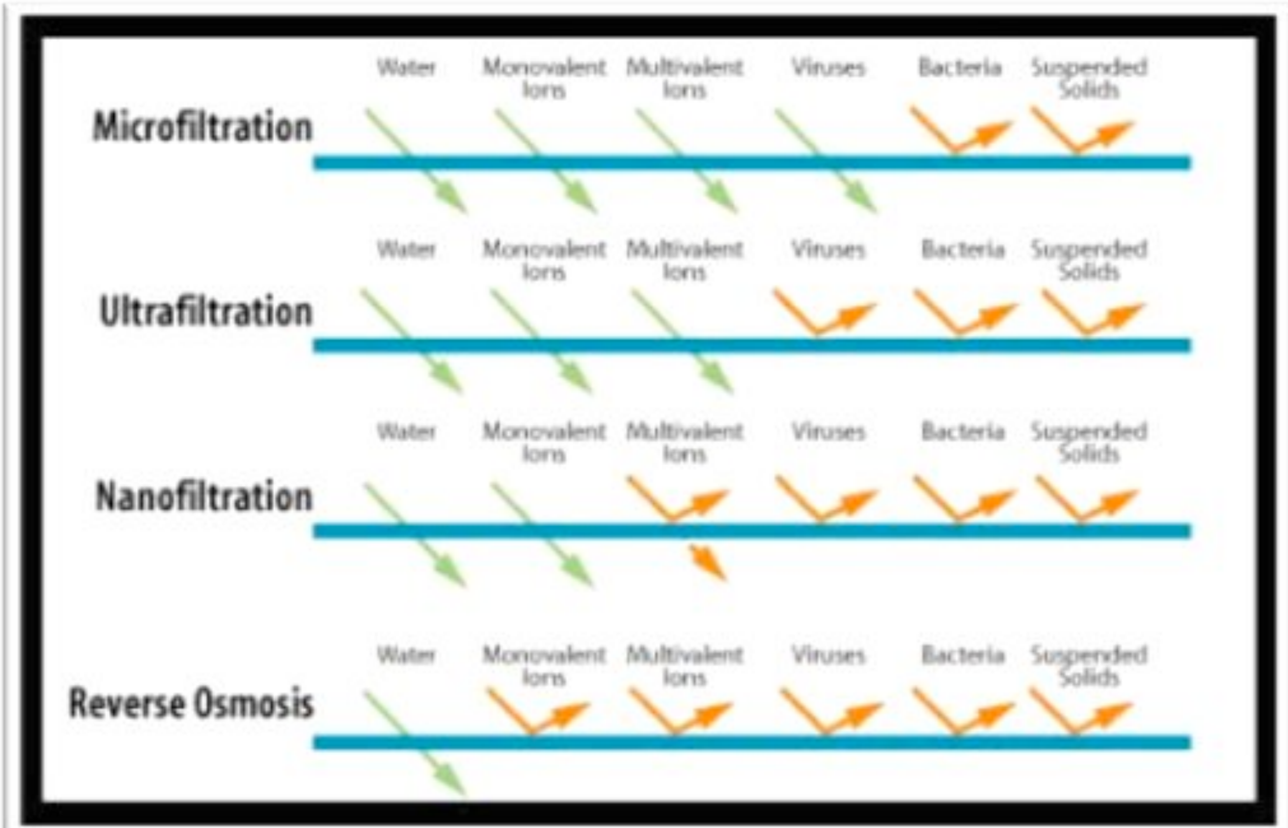
MF [micro-filtration] is a low pressure (10-100 psig) process for separating larger size solutes from aqueous solutions by means of a semi-permeable membrane; the MF process

- retains large suspended solids
- passes some suspended solids and all dissolved material
- pore ranges from 0.1 micron to 3 micron

This process is carried out by having a process solution flow along a membrane surface under a modest pressure. Retained solutes (such as particulate matter) most often leave with the flowing process stream and do not accumulate on the membrane surface.

The MF [microfiltration] based products are designed for cross-flow separation, where a feed stream is introduced into the membrane element under pressure and passed over the membrane surface in a controlled flow pathway. A portion of the feed passes through the membrane and is called the permeate. The rejected materials are flushed away in a stream called the concentrate.

Cross-flow membrane filtration uses a high cross flow rates to enhance permeate passage and reduce membrane fouling.



Membrane Process Characteristics

The MF cross-flow membrane filtration controls the effect of concentration polarization and the gel layer. In turn, this provides the most rapid, and hence economic, continuous membrane filtration.

Applications for MF applications include ***wastewater treatment***, caustic cleaner recovery and clarification of dark juices. For example, in the clarification of wine and dark juices (such as cranberry), MF is employed to separate the suspended solids from the juice to produce a low turbidity juice while allowing the passage of color and flavor.

Examples of MF Applications

Application	Permeate	Concentrate (Retentate)	Benefits of MF
Cranberry juice clarification	Low turbidity, clear juice	Juice, suspended solids, colloidal haze particles.	Removes suspended solids and turbidity while allowing the passage of color, sugar and taste.
Wine filtration	Low turbidity, clear, flavorful wine	Wine, suspended solids, colloidal haze particles.	Removes suspended solids and turbidity while allowing the passage of color, alcohol and taste.
Industrial Waste Water Treatment	Water & dissolved solids	Water, suspended solids, insoluble metal hydroxide solids.	Removes suspended solids and insoluble metal hydroxide solids from wastewater to allow the permeate to be discharged to a local POTW.
Fermentation broth clarification	Water & dissolved solids	Water & suspended solids	Removes suspended solids from the fermentation broth leaving clarified liquid.

NF [nanofiltration] is a higher pressure driven process for separating larger size solutes from aqueous solutions by means of a semi-permeable membrane. This process is carried out by having a process solution flow along a membrane surface under pressure. Cross-flow membrane filtration uses a high cross flow rate to enhance permeate passage and reduce membrane fouling. Retained solutes (such as dissolved salts) leave with the flowing process stream and do not accumulate on the membrane surface.

Pores have not been observed in NF membranes under any microscope, however, water can still pass through the membrane and multivalent salts, low molecular weight organics and even virus bodies are rejected. It is difficult to predict the performance of NF membranes, especially if more than three solutes are present in the solution, since membrane rejection is influenced by the size, structure and charge of the components in solution. As a result, piloting is highly recommended for NF applications, even if a detailed feed water analysis is available."

Examples of NF Applications

Application	**Permeate**	**Concentrate (Retentate)**	**Benefits of NF**
Whey / Whey Permeate	Salty wastewater	Desalted whey concentrate	Allows the recovery of lactose and whey protein concentrate with reduced salt content
Textile	Dyes	Water, salts, BOD, COD and color	NF is used to desalt dyes resulting in a higher value product
Caustic cleaning solutions	Caustic cleaning solution	BOD, COD, suspended solids, caustic cleaner	Allows caustic cleaning solution to be recycled resulting in reduced cleaning chemical costs
Recycle of acid solutions	Acid solution	BOD, COD, calcium, suspended solids, acidic water	Allows acid solution to be recycled resulting in reduced cleaning chemical costs
Water	Softened water	Hard water	**Potable water production.** Softened water reduces scaling on equipment & heat exchange surfaces
Antibiotics	Salty waste product	**Desalted, concentrated Antibiotics**	**NF produces high value pharmaceutical products**

Global markets ……and ACI's hollow fiber product applications

Today, only about 5% of the world's total water treatment capacity utilizes membranes: this is split roughly equally between desalination and MF/NF filtration. Further, only about 1% of all the waste water streams are processed / treated using membranes.

Innovations in design and manufacturing cost reduction from scale-up and automation hold the promise of continuing to reduce the costs of membrane technology for sterile use in medical facilities. Many of these innovations will be borrowed from other industries like municipal water treatment and kidney dialysis manufacturing. This will drive the adoption of membranes for sterile point of use applications not only in institutions and homes, but even pocket based systems for emergencies and travel. And perhaps most importantly of all, these innovations could play a critical role in providing cleaner drinking water to the approximately one billion people that still do not have access to safe drinking water today.

Though the transition to membranes for extensive water filtration programs now seems inevitable, the application to global opportunities to serve people within all the markets has only just begun. Likely the initial engineering efforts and applications will clearly be ….with those who can afford and properly use the technology.

So, whereas all of this is underway, one also expects that in the global market place " the last shall be last". To date, there are no fundamental efforts to be seen on the horizon for applying this water purification technology to support the clean water needs of the poor.

That's where we come in.

It is only thru cheap and clean water can we reach and serve those who are " the last of the last". For perspective 40% of the people on the planet indeed subsist on less than $2 per day; that is somewhat around 3 billion people. Of that number at least one billion people in the developing countries currently drink "water" much of which is equivalent to the "waste water" of developed countries…. or worse. And one-third of this total also lack adequate food.

These conditions create a variety of inter-related outcomes. The overall result: most of the people are sick most of the time. As to their health as it specifically relates to the on-going ingestion of badly contaminated water,

1]. an estimated
    i) two million children die per year
    ii) four million children survive but are permanently impaired / damaged
2]. for everyone, the nutritional effectiveness of the presently available foods is substantially diminished; and
3]. the everyone, the effectiveness of the medicines available for treatment of other diseases is substantially diminished.

Thus, people who are generally sick most of the time simply don't function as efficiently, often do not learn as well and then are less capable in correcting the deficiencies in which they live and operate. So, maintaining a source of clean water for these people ***sets the foundation upon which all other improvements are then brought to bear.***

Ultimately our reference standard within our markets is simply the cost / liter of clean water. Can we indeed utilize the hollow fiber technology to generate cheap, clean water?

With the economics associated with our ACWP units, the resulting cost of clean water in the clients home ranges from $.0005 to 0.001 per liter. So any program that ACI undertakes should, as 'our rule of thumb' provide clean water to our clients at a cost of < $ 0.001 per liter.

Based on our initial engineering work and hollow fiber filter performance estimates, it appears that ***we can learn*** to develop water purifiers that will provide very clean water at or near this cost.

Selecting the distribution technique for reaching families with clean water

The market segment we have chosen is the family unit of the poor. Our distribution system for reaching that market is to work directly in the field with the people with the need. This effort is made possible via the identification and selection of a local structure within which to work. This might be, for example, a school, a church, or an effective local NGO.

Within this framework, ACI's efforts have been and are focused onto the transfer of clean water technology directly to families ….at the lowest possible cost.

As to our present program, what has been learned can be summed up as follows:

1]. this transfer of knowledge is made feasible only by dealing directly with the people in need;
2]. this transfer is functional only if trust relationships are in place thru which the parties can effectively interact;
3]. this transfer is made more effective if it can be implemented via an in-place, operating structure [e.g. a school system];
4]. the water purifier costs are low because they are made by local crafts-people using locally available materials;
5]. when the technology transfer is sound… the performance of the water purifiers meets expectations and clean water is the result; and
6]. the cost of generating clean water from poor water is < $ 0.001 per liter.

ACI's present program has demonstrated that this transfer can and does work. Thus, we expect to follow the principles of this guideline as we apply the hollow fiber technology and develop its applications in our markets.

Selecting the next distribution technique for reaching families with clean water and improved health

The ACWP unit was designed to be simple yet effective ….and its operation is within the capabilities of the family members. However , we believe that by establishing a new distribution system the service to families will be improved ….and other benefits will result.

However, the generation of very clean water via the use of hollow fiber filter based units will require more attention to its operation. But, the rewards are substantial as these units will generate large volumes of very clean water and provide an improved set of benefits. The question then becomes… where to place these units for the greatest benefit of those being served?

We think that the answer is to place these units with the staff of a soundly run, field medical clinic. And, in conjunction with that placement, ACWP units will be placed with all the clients of the medical clinic. This functional model then sets the stage for a series of benefits for everyone involved.

One the strongest trust relationships that exist in almost all countries and in all situations…..is the relationship between each patient and their doctor. Thus with a useful supply of clean water the Medical Clinic takes advantage of an important structure and a useful system that leads to improved health outcome for all the people in their day-by-day living.

Each specific program begins by making available useful volumes of bacteria free water for use by the medical staff of the clinic for their benefit and that of their patients. The point is to reduce general levels of contaminants such that the odds of a successful outcome for the patient within the clinic are improved as well as that of the staff members.

In parallel to this, by placing and using AC water purifiers in each of the client homes that are associated with the medical clinic, the level of contaminants in each home will be reduced. Here the general outcome benefits are:

i) a reduction of illnesses for each family member related to ingested parasites;
ii) a reduced demand on each family member's immune system due to reductions in the general turbidity and bio-load of the water;
iii) a reduced incidence of diarrhea for each child of each family;
iv) a reduction of secondary cases of diarrhea within each family;
v) a reduced work load for each mother due to the reduction of diarrhea cases and their clean up;
vi) enhanced nutrition by each of the family members due to having a more stabilized immune systems; and
vii) a reduction in costs associated with the medications that deal with parasites and diarrhea

Next, the clinic will benefit as their work load will be reduced in direct proportion to the reduced incidences related to parasites and diarrhea cases within the families.

And finally, with improved nutrition and an improved, stabilized immune system, patients that do require medication [such as for HIV and DRTB] the effectiveness of that medication is improved. The net result is a benefit to the clinic operation as adequate medication is achieved with lower dose quantities and a reduced dose frequency.

The stages of this program are:

- I]. stage 1
    - a) daily provide the clinic with a substantial volume of sterile/ bacteria free water
    - b) establish a team for the local production & placement of water purifiers that function under the direction of the clinic staff.
    - c) under the directions of the medical staff place ACWP units
        - i) in each home where diarrhea is most prominent
        - ii) in the schools
        - iii) in the orphanages
        - iv) in all homes where the request has been made by the wife
    - d) the clinic may elect to sell clean water
- II]. Stage 2 ….more to follow

AS TO THESE NOTES ….. TO BE ORGANIZED FURTHER

I]. Organizing Principle …..re: Medical Clinics

- 1]. Improve and Stabilize the clinic's health & hygiene capabilities
    - i) clean water
        - - clinic/hospital [hollow fiber hybrid units]
        - - population served [ACWP POU units]
    - ii) health & hygiene training
        - - clinic / hospital
        - - population served
    - iii) *sanitation*
        - - bio-systems engineering
        - - population served
        - - engineering / composting toilets
    - iv) *nutrition*
        - - agricultural engineering
        - - micro-farms [Haron Wichara]
        - - Amaranth [Partners Worldwide]
    - v) *medications*

<u>OPERATIONAL MODEL</u>

MEDICAL CENTER – HUB
POPULATION SERVED

STEP #1: CHEAP CLEAN WATER
FECAL MATTER MANAGEMENT
- STERILE WATER FOR CENTER
- FAMILY WATER PURIFIERS

HYGIENE TRAINING & EDUCATION

REDUCED CONTAMINATION
- IMPROVED NUTRITION
- IMPROVED DRUG EFFICIENCY

STEP #2: LATRINES

BUSINESS & JOB DEVELOPMENT FOR COMMUNITY ENTREPRENEURS
WATER PURIFIER SALES
WATER SALES
LATRINE SALES
IMPROVED FARMING
ENERGY EFFICIENT STOVES

The desire to sterilize all water in medical institutions is driven by increasing evidence of the risks of contact with water even for brushing teeth or showering by populations with weaker immune systems such as HIV and hepatitis patients or the elderly or small children. Many institutions have even begun to filter water that will not come into direct human contact such as water in air conditioning loops that can become contaminated by Legionella. One of the major challenges to protecting these patients is the need for point-of-use treatment as resilient bio-films on water distribution pipes can quickly re-contaminate treated water making point of entry solutions insufficient.

Historically, the idea of installing and frequently replacing sterilize membrane filters at all points of use as well as on cooling water loops was too costly to be seriously considered. However, with the recent dramatic reductions in the cost of water membrane technology, this approach is now gaining momentum. As we enter a new phase of exponential adoption of water membranes that is bringing them into every municipality, industry, institution, and home, the cost has fallen to the point where easily disposable sterile filtration has become a reality.