Overcoming the *'YUCK'* Factor

Flushing out new water resources: The concept of 'toilet to tap'

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The 'YUCK' factor

There is a tremendous psychological barrier to overcome before someone will drink apple juice out of a bed pan. Such was the finding of the research published by J. Stigler et al. in a study at Cambridge University in 1990.[1] Stigler added that "even when the subjects acknowledged that it was apple juice and that the bedpans had never been used," they still refused to drink the juice. This reaction of disgust one gets from people faced with drinking their own waste water is referred to as the *yuck* factor.[2] Drinking someone else's waste would provoke an even stronger reaction—the *YUCK* factor!

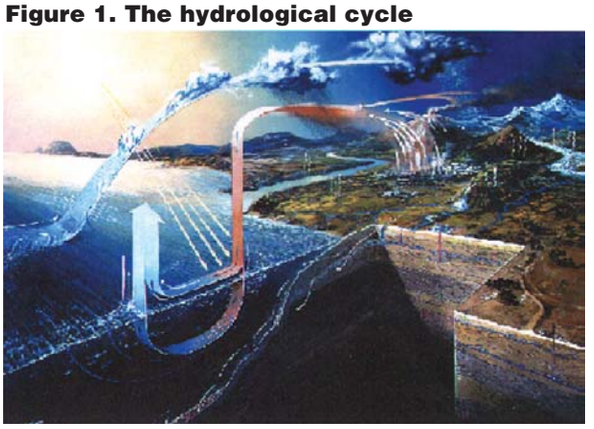
Even though we have the technology to purify any water stream and turn it back into potable water, the *YUCK* factor persists because the association of recycled water with sewage exists independent of our scientific understanding of the purification process.[2] In other words, even though we may believe in the technology and know it already exists to recycle sewage, we still won't accept the idea of putting *filtered toilet water* back into the tap.

The psychological barriers against drinking *used* and reclaimed water are seemingly stronger than the belief in the technology to safely do so.

The need is there

Currently, a number of municipalities recycle highly treated waste water but none for direct supply to the home. The applications are limited to non-potable uses and there are enough large customers for this product (i.e., cities and golf courses for landscape irrigation) that the systems are both practical and inexpensive. Every gallon of water sent to highway landscape irrigation represents the saving of one gallon of *virgin* water prized by consumers.

Figure 1. The hydrological cycle



Recycling waste water is not a new concept

Pure water does not exist on the planet. All water sources are simply dilute solutions of salt…some more dilute than others. Once the salts are removed through filtration, water is water. It always has been that way. *Virgin* water does not exist either. All water is *used*. Some more used than others.

At historical evaporation rates, all the water in the sea is *distilled* every 2,735 years.[3] So over the past 3.5 billion years, water has been used and reused about 1.3 million times. Even that bottle of boutique designer water you've been carrying around has been drunk before. Imagine that! Best we all get used to the idea, because recycled drinking water at the municipal level is right around the corner.

All water on the planet has been used before…many, many times.

While we can accept the fact that Mother Nature is very good at water recycling, we can point out the similarities between the manmade processes and hers. The hydrological cycle chart shown in Figure 1 points out that Nature's primary source of *fresh* water is through evaporation from the sea. We use distillation.

Water vapor rises over land, cools and eventually falls to Earth as rain or snow. We call this condensation. Some of this precipitation soaks into the ground and makes a long and tedious trek back to the sea via underground rivers we call aquifers. Along the journey, it is subject to aerobic and anaerobic bacterial attack which removes organics and other nutrients leached from the air and soil it has passed through. Seeping deeper into the ground, it is subject to layer after layer of micro-filtration. As water passes through the soil there is a mineral exchange (ion exchange) which stores certain minerals for the benefit of plants. Water taken up by plants undergoes osmosis. Plants, in turn, store some water as carbohydrates through the process of photosynthesis. Some is lost back to the atmosphere as transpiration. As rain, it will fall again another day in a different land.

Some water runs off the land and collects in rivers, lakes and streams. Cities and towns use this water for municipal supply. After it is used it is given a primary treatment and dumped back into the river—to be used as virgin water by the next town down the line. The watershed that collected the water through brooks, streams, ponds, lakes and rivers could be considered the latrine for all that live there.[4] Fish don't treat their own waste. Neither do bears, horses, cows, birds nor the hikers that enjoy a trip through the woods. Get the picture? In order to supply safe and potable water, municipalities have to do extensive treatment because they are already recycling waste water.

World water resources

There is a total of 326 million cubic miles of water on the planet.[5] One cubic mile of water is approximately 3.4 million acre feet. One acre foot equals 324,000 gallons, which is enough water to keep about three American families supplied for a year but doesn't grow their food. It is interesting to note that there is 10 times the amount of water in the atmosphere than all the rivers of the world combined. It also ranks as the purest natural source of water.

Americans now have at their disposal 1,350 gallons of water per day per capita (see Table 1) with about 85 percent of that going to agricultural needs.[6] Given the current rate of depletion and the projected population growth, this amount will decrease to 700 gallons by the year 2050. The minimum water required for human needs, including agriculture is considered to be 700 gpd per capita. Many regions of the world are already below that level.[7]

Stretching water resources by recycling

Although employed by NASA, water recycling is not rocket science. Aboard the space station, close to 95 percent of all water is proposed to be recycled using conventional filtration techniques.[8] This includes perspiration, urine, tears, moisture from respiration and any and all sources of evaporation including all the lab specimens living aboard. Without recycling, the four-man crew would require 40,000 lbs of water per year to be ferried up at a tremendous expense.

Many cities across the U.S. and around the world are also recycling water. They sidestep the *YUCK* factor by using direct injection or a short run of river. This is called *indirect* reuse because there is no direct pipe to pipe connection with the city water supply.[9] In other words, they give the treated water back to nature for a period of time and then borrow it back again at a later date. By then it has been *purified* by nature and diluted by *virgin* water sources. This seems to be the most psychologically acceptable way to recycle. Some of the most notable programs include the following:

Goleta, Calif.

The city of Goleta, Calif. (near Santa Barbara, population 55,000) added tertiary treatment to a portion of their secondary treated waste water and now, instead of discharging all of their treated water to the ocean, resells it to large landscapers. This saves the equivalent of 300 million gallons of potable water each year—enough to service 3,000 new homes. Although this water does not find its way back to the tap, it saves the same amount. Many communities have programs of this type.

Orange County, Calif.

Water Factory (WF) 21 in Orange County, Calif. is one of the best-known projects for water recycling.[9] Since 1971, Water Factory has protected groundwater from seawater intrusion by injecting up to 15 million gpd of highly treated reclaimed water that is blend-ed with deep-well water into four coastal aquifers. Half of this water flows inland and supplements potable water supplies to two million people after adequate dwell time underground. WF 21 uses lime clarification, re-carbonation and multi-media filtration followed by GAC and RO plus chlorination. The RO consists of 252 @ 8 inch spiral wound cellulose membranes in a 24/12/6 array. Their permit allows injection of treated water within 2,000 ft. of drinking water wells.

Table 1. World water supply

Water source	Volume (cu. mi.)	Percent of total
Salt water		
Oceans	317,000,000	97.2
Inland seas	270,000	0.008
Fresh water		
Freshwater lakes	30,000	0.009
All rivers	300	0.0001
Antarctic ice cap	6,300,000	1.9
Arctic ice and glaciers	680,000	0.21
Water in atmosphere	3,100	0.001
Groundwater to 2,500 ft.	1,000,000	0.31
Groundwater over 2,500 ft.	1,000,000	0.31
	326,000,000	**100**

Northern Virginia

The Upper Occoquan Sewage Authority (UOSA) in Northern Virginia was established in 1978 to build and operate a state-of-the-art reclamation plant to replace outdated and ineffective treatment facilities believed to be responsible for the deterioration of water quality in the Occoquan Reservoir. Today, the UOSA supplies about 50 percent of the water for the Fairfax Water Authority serving a population of one million people. Their process includes high pH flocculation, settling, re-carbonation, multi-media filtration, regenerable GAC and ion exchange (ammonia for sodium exchange). The processed water is then chlorinated and de-chlorinated before ultimate discharge to the Occoquan Reservoir.

Denver, Colo.

The Denver Potable Water Demonstration Project operated a 100,000 gpd pilot plant from 1985 to 1992. Using multiple barrier technologies it showed that it was feasible to obtain 90 percent recovery with 95 percent TDS reduction, including 15 organic compounds that were spiked at 100 times the normal levels normally found in the reuse plant effluent. The various components of the system included high pH flocculation, sedimentation, re-carbonation, filtration, UV, GAC, RO, aeration, ozonation, chloramination and ultrafiltration.

Los Angeles, Calif.

Groundwater accounts for one third of the domestic water supplied to Southern California. Originally set up in 1948 and expanded to include three reclamation plants, the Montebello Forebay Groundwater Recharge Project now supplies up to 30 percent of the water (191 million gpd) that is recharged to the Central Basin (the main aquifer underlying the greater Los Angeles metropolitan area). Secondary treatment (clarified) water is heavily chlorinated, passed through media filtration and given 90-minute retention time before de-chlorination and subsequent introduction to the basin.

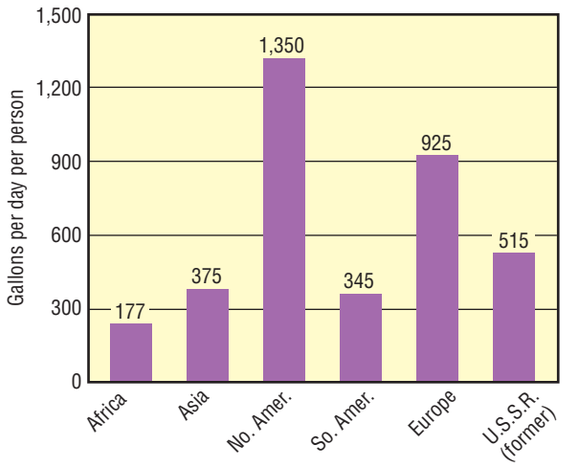
Tampa, Fla.

Facing a probable supply deficit for meeting water needs by the early 2000's, the Tampa Water Resource Recovery Project was begun in 1984 to study several methods of possible water reuse. After two years of study, the city decided to build and operate a pilot plant in 1986. Effluent water from an existing waste treatment facility was used as the source water for study. After a two-year study, the project determined that conventional treatment of the waste with pre-aeration, lime treatment and re-carbonation, gravity filtration, GAC adsorption and ozone disinfection could produce a water resource that met or exceeded the quality of other typical raw water sources. A full-scale project is now being investigated. The only real obstacle is public acceptance.

El Paso, Texas

The Hueco Bolson recharge project is a full-scale operating program using es-

Table 1. Per capita water use internationally



SOURCE: USSR National Academy of Sciences (1987)

sentially 100 percent household waste discharge (less than 0.01 percent industrial discharge) which is treated to potable water quality and injected directly into the primary drinking water source for the city of El Paso. The plant has been operational since 1984 and now consists of two parallel five-million gpd units. Using a 10-step treatment, the process includes screening, de-gritting, primary clarification, equalization, flow equalization, two-stage powdered activated carbon (PAC), lime treatment, two-stage re-carbonation, sand filtration, ozonation, GAC and final chlorination. The water is then sent to clear wells that distribute it to 11 injection wells within the aquifer. The emphasis of the treatment is to obtain better than 96 percent reduction of TOC, de-nitrification, heavy metals removal, phosphate reduction, THMs below 100 ppb and to date, have averaged an impressive plate count of 0 CFU. This aquifer services a population of 250,000 people and represents the case for direct reuse.

Singapore

According to the Center for Water Research, Dept. of Civil Engineering, National University of Singapore, the conversion of municipal waste water into reusable water here uses membrane technology utilizing three main treatment processes: microfiltration, RO and UV. Current production is 10,000 m3/d; by 2010 production is expected to make up 15 percent of the country's water supply. This appears to be possible because of broad cultural acceptance—a distinct lack of the *YUCK* factor.

San Diego, CA

The San Diego Total Resource Recovery Project, which started in 1974, was undertaken to demonstrate the feasibility of using natural systems for the secondary treatment of waste water with subsequent advanced treatment systems to provide water equivalent to or better than the imported water supplied to the region. Coarse filtration followed by a series of large hyacinth ponds provides the secondary treatment which is the bacterial oxygen demand (BOD) and suspended solids (SS) reduction process. The ponds contain fish and other aquatic life to control mosquitoes. Tertiary treatment consisted of filtration, chorination, RO (CA membranes), pH adjustment and aeration with a final 30 minutes EBCT GAC tower. Based on extensive performance data taken during the test program, it was concluded that the combination of systems was effective in reliably producing an effluent that could be safely used as a raw water supply. The implementation of a full-scale treatment system is under development with only one stalling point: the pilot systems demonstrated that with modern technology, municipalities could remove every objectionable contaminant from waste water except for one—the *YUCK* factor.

Summary

Simple conservation of our water resources is not enough to provide for a doubling of the world population over the next 50 years. Experience has shown (through extensive pilot plant and operational plant trials) that waste water from sewage treatment effluent can be a safe and valuable source of *new* water for unlimited use. The ultimate in recycling is to process any and all sources of water, including storm runoff and street drainage back into potable water through the municipal supply channels and simply put that water back into the reservoirs. This would eliminate the need for separate distribution systems and replumbing the whole city. To that end, there would be an inexhaustible supply of drinking water for all societies.

The *YUCK* factor, however, may be too ingrained to make this idea universally acceptable. Then again, any reclaimed waste water used for any application that would normally use potable water as its source saves water and creates an alternative supply. A gallon recycled is a gallon saved. It's like water in the bank.

In the parched western U.S., many municipalities (notably in Southern California) have tried to restrict the use of water softeners under the guise that the added TDS from the salt discharge would make it more difficult to discharge their waste water or recycle that water for the purpose of irrigation. Full-blown recycling addresses the TDS issues and the indirect reuse allows for time and dilution with other water sources which will bring the quality of the reclaim well within the potable water specs. *Waste water* is a misnomer. We should simply think of treatment plant effluent as another valuable natural resource.

The biggest obstacle is public perception; the biggest task their education as to the need, safety and value of water reuse. We have the technology and have demonstrated with confidence that we can connect the toilet directly to the tap.

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