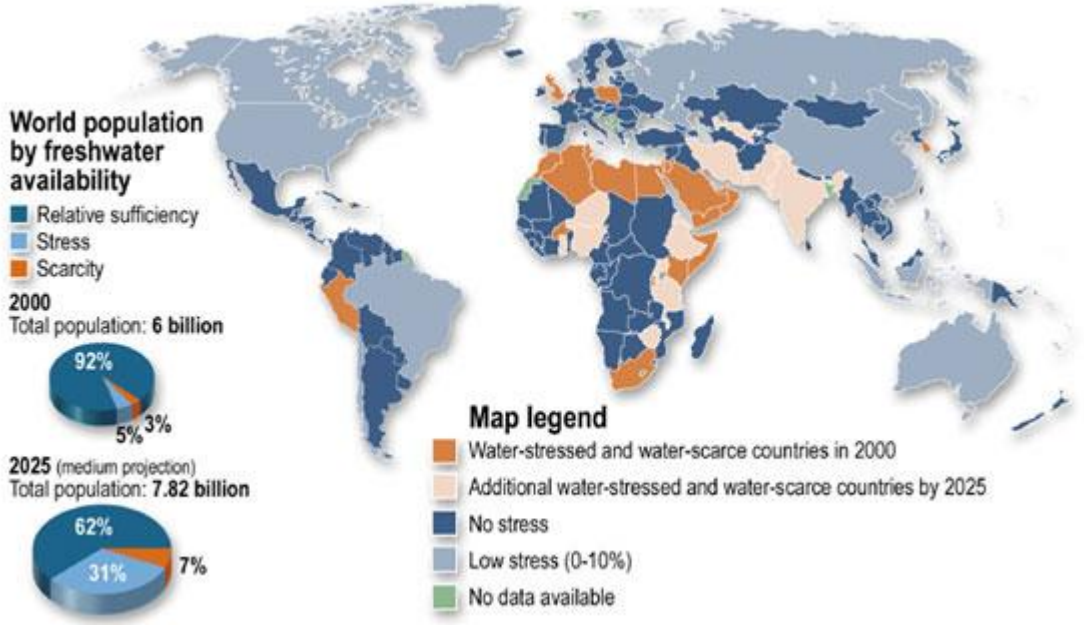
EMERGING TRENDS IN WATER TECHNOLOGY

1. FILTERING WATER WITH NANOTECHNOLOGY



Last year, 2014, Nano Sun of Singapore's Nanyang Technological University developed a multi-functional water filtration membrane. This latest water filter technology uses titanium dioxide nanotechnology instead of the usual polymer-based water filtration membranes.

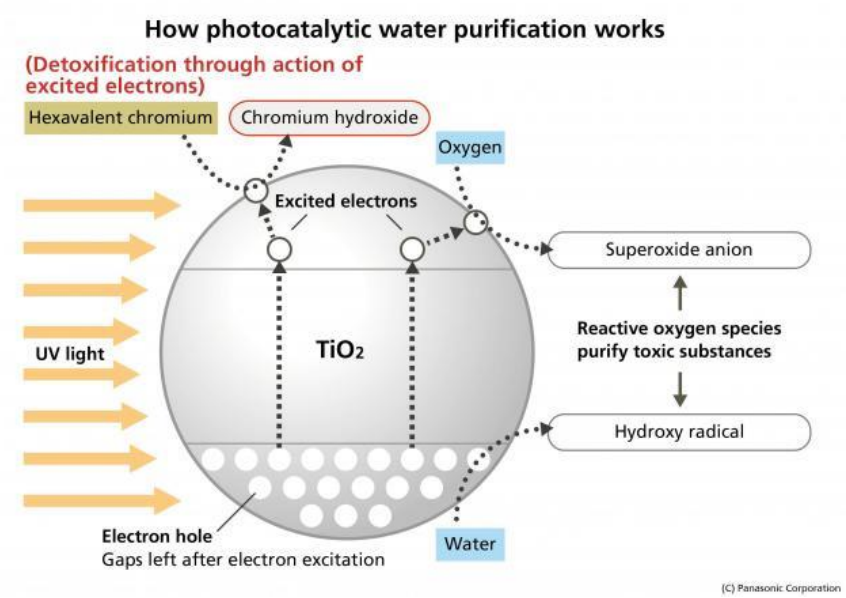
A young startup at Singapore's Nanyang Technological University (NTU) has developed a multi-functional water filtration membrane. Its inventors hope it will render current membranes in the water industry obsolete. Traditional polymer-based water filtration membranes tend to end up clogged up with what they have filtered out. As a result, bio-fouling and organic compounds are a huge problem for the $200 billion global water industry. With the membranes developed by NTU's Nano Sun, bio-fouling is greatly reduced as organic material and bacteria are killed and destroyed when they come into contact with the membranes. Any organic material that does not decompose can also be quickly burnt by putting the membrane in an oven heated to 700 degrees Celsius, since it is able to withstand high heat unlike traditional polymer membranes. Additionally, the new membranes allow for a flow rate of at least ten times faster than current water filtration membranes. Underlying this new invention is a titanium dioxide nanotechnology patented by Nano Sun. Titanium dioxide nanoparticles are proven to kill bacteria and to break down organic compounds in waste water with the help of sunlight or ultra violet (UV) rays. "With more of the world's population moving into urban cities and generating more waste water, there is a real need for cost-effective technology," said associate professor Darren Sun, from NTU's School of Civil and Environmental Engineering, who invented the new membrane. "Traditional polymer-based water filtration membranes are faced with issues such as fouling and high breakage, while the developing countries with high industrial output are generating wastewater which is increasingly harder to treat." "What the world needs—and what we have developed—

is a breakthrough technology which can turn large volumes of polluted or untreated water into drinking water quickly, safely and at a fraction of the cost," said Prof. Sun, who has developed various systems that are used in water treatment plants all over the world. Co-founder and managing director of Nano Sun, adjunct professor Wong Ann Chai, said the applications and implications for their new technology are wide-ranging. "Apart from our capabilities to improve waste water treatment and desalination plants, multinational companies in the food and beverage industry have also expressed interest in using our technologies in their production processes," said Prof. Wong, who teaches finance at NTU. "The scope for our membranes is of benefit to companies in the chemicals, food and biomedical industries." Several water agencies in the region and multinational corporations have already indicated interest in the NTU invention, which is now ready for sale in the market. Nano Sun recently signed deals with PT Pelaksana Jaya Mulia, a large Indonesian company, to provide 10,000 cubic meters of clean water per day. In China, Nano Sun is working with an industrial paper mill in Guangzhou to optimize their wastewater treatment processes, which will lead to savings of S$3 million (~US$2.37 million) over the next five years. In Singapore, Nano Sun is in discussion with local water agencies and companies which own and operate large-scale energy-efficient integrated power and water reclamation plants, to test bed its innovative technologies. Nano Sun is also investing heavily into miniaturizing the membranes into products which can be used for household needs as well as humanitarian aid and disaster relief, said Prof. Wong. This could be through a a low-cost water purification water bottle. It also aims to explore other product possibilities such as air filtration, disinfection (bandages) and solar cell industries. The company is now working to scale up its production of membranes from seven meters per day to 100 meters per day. According to NTU, the two year-old Nano Sun has a valuation of US$80 million.

2. PHOTO-CATALYTIC WATER PURIFICATION TECHNOLOGY

To solve such drinking-water issues worldwide, Panasonic has developed its own photo catalytic water purification technology. This technology uses photo catalysts and the UV rays from sunlight to detoxify polluted water* at high speeds, creating safe and drinkable water.

When photo catalysts are exposed to ultraviolet light, formed reactive oxygen purifies the toxic substances. However, TiO_2, a kind of photo catalyst, comes in extremely fine particles and is troublesome to collect once dispersed in water. Methods of binding TiO_2 to larger matter have hence been used, but they in turn suffered a loss of surface active site. Panasonic developed a way of binding $TiO_2$to another particle, zeolite, which enables photocatalysts to maintain their inherent surface active site. Moreover, since the two particles are bound together by electrostatic force, there is no need for binder chemicals.



Ref: http://news.panasonic.com/global/stories/2014/30520.html

3. ACOUSTICS NANOTUBE TECHNOLOGY

Innovators at NASA's Johnson Space Center have developed a filtration device to eliminate contaminants from water supplies. Originally developed to purify wastewater for reuse aboard the International Space Station, the innovation is applicable to numerous situations on Earth where there is a need to collect potable, medical-grade water from a contaminated water supply. The unique aspect of the technology is its use of acoustics rather than pressure to drive water through small-diameter carbon nanotubes. The invention requires less power than conventional filtration systems and is well-suited to a variety of water processing needs.

Benefits

- **Effective:** Produces clean water by eliminating contaminants
- **Efficient:** Requires less power than conventional filtration systems, enabling remote operation and solar power options
- **Flexible:** Does not depend on gravity for water to flow through the system
- **Scalable:** Allows for use of a single filter or a large bank of integrated filters, depending on filtration needs
- **Widely applicable:** Suits applications for a variety of water processing needs, ranging from industrial to consumer applications

Applications

- Municipal water facilities

- Medical facilities
- Laboratories
- Distilleries
- Desalination plants
- Industrial facilities
- Wastewater treatment facilities
- Consumer markets

Technology Details

This water filtration innovation is an acoustically driven molecular sieve embedded with small-diameter carbon nanotubes. Turning the idea of filtration on its head, this technology pushes water away from contaminants, rather than removing contaminants from water.

How it Work

Water enters the device and first contacts the filter matrix, which can be made of polymer, ceramic, or metallic compounds, depending on end-use requirements. Carbon nanotubes within the matrix allow only water molecules to pass through, leaving behind any larger molecules and contaminants.

The unique aspect of the technology is its use of acoustics to help drive water through the filter. An oscillator circuit attached to the filter matrix propagates acoustic vibration, further causing water molecules to de-bond and move through the filter. This use of acoustics also eliminates dependence on gravity (and thus filter orientation) to move water through the device. When water exiting the system diminishes to a pre-determined set point, a cleaning cycle is triggered to clear the sediment from the inlet of the filter, reestablishing the standard system flow rate. Unlike other filtration systems, flushing of the filter system is not required.

Why it is better

Existing water filtration technologies are generally plagued by limited performance, high energy consumption, and high costs. New filtration and treatment techniques designed to mitigate these problems generally depend on pressure to drive water through the filtration system. The combination of acoustics and small-diameter carbon nanotubes in this innovation make it an effective and efficient means of producing contaminant-free, clean water.

4. SUNSPRING SYSTEM

Colorado-based company Innovative Water Technologies has made a breakthrough in water purification technology, according to Nicholas Sakelaris of the Denver Business Journal.

The company has patented a system that can purify water by using a wind turbine with an attached solar panel. The "SunSpring" system can purify up to 5,000 gallons of water per day running solely on batteries charged by renewable energy. The system works by pumping water from a nearby source, such as a lake, stream or swimming pool. The water then passes through a seven-mile membrane that's .02 microns thick, specifically designed to stop microbiological contaminants. The water comes out from a pair of water spigots. The clean water can also be stored in cisterns with chlorine treatment.
The SunSpring system costs $25,000 and can be deployed in only a few hours. The membrane is good for 10 years and the system automatically backflows, similar to a swimming pool, to clean itself. The newly developed system has already received the Water Quality Association's gold seal certification to the U.S. Environmental Protection Agency standards for microbiological water purifiers. SunSprings are being used in orphanages in remote villages and in the aftermath of earthquakes or hurricanes.

5. EUGLENA BIO FILTRATION SYSTEM

A recent breakthrough, however, shows that Euglena can absorb many different pollutants in water: from phosphates to lead.
Noble Purification has designed a system to use Euglena to treat waste water. The Euglena Bio Filtration System works by creating a controlled algae bloom within waste water and then 'tricking" the Euglena into absorbing minerals, heavy metals, nutrients, and pollutants from the environment. Noble Purification plans to then convert the Euglena biomass produced from the system into biofuel, food and fertilizer.
This year, Noble Purification hopes to complete the first large-scale Euglena Bio Filtration prototype with its partners: The City of Peterborough, The Centre for Alternative Wastewater Treatment, and Drain Brother's excavating. This prototype will treat approximate 100,000 litres of waste water per day at the Peterborough Waste Water Treatment Plant, and will sequester approximately 32 tons of CO2 from the atmosphere.
The company also announced the launch of a Euglena Research Program (ERP) at Trent University. This will be a collaborative research initiative that will bring together the collective abilities of researchers and students at Trent to better understand the untapped potential of Euglena. It will help increase the efficiency of Noble Purification's technology and provide an opportunity to sequence its genome.

6. TiO_2 AND GRAPHENE

Sunlight plus a common titanium pigment might be the secret recipe for ridding pharmaceuticals, pesticides and other potentially harmful pollutants from drinking water. Scientists combined several high-tech components to make an easy-to-use water purifier that could work with the world's most basic form of energy, sunlight, in a boon for water purification in rural areas or developing countries.

The talk was one of more than 10,000 presentations at the 247th National Meeting & Exposition of the American Chemical Society (ACS), the world's largest scientific society, taking place here through Thursday.

Anne Morrissey, Ph.D., explained that the new technology could someday be incorporated into an easy-to-use consumer product that would remove these stubborn pollutants from drinking water as a final step after it has already been treated with conventional methods.

Her group at Dublin City University in Ireland started with a compound called titanium dioxide (TiO_2), a powder used to whiten paints, paper, toothpaste, food and other products. With the right energy, TiO_2 can also act as a catalyst — a molecule that encourages chemical reactions — breaking down unwanted compounds in drinking water like pesticides and pharmaceuticals. Morrissey explained that modifying current water treatment methods to get rid of these potentially harmful species can be costly and energy-intensive, and often, these modifications don't completely eliminate the pollutants.

But Morrissey said TiO_2 is usually only activated by ultraviolet light, which is produced by special bulbs. To access titanium dioxide's properties with the sun's light, Morrissey and her group experimented with different shapes of TiO_2 that would better absorb visible light. She found that nanotubes about 1,000 times thinner than a human hair were best, but they couldn't do it on their own.

That's why she turned to graphene, a material made of sheets of carbon just one atom thick. "Graphene is the magic material, but its use for water treatment hasn't been fully developed," she said. "It has great potential." Morrissey put the TiO_2 nanotubes on these graphene sheets. Pollutants stuck to the surface of the graphene as they passed by, allowing TiO_2 to get close enough to break them down.

Her research group successfully tested the system on diclofenac, an anti-inflammatory drug notorious for wiping out nearly an entire vulture population in India.

"We're looking at using the graphene composite in a cartridge for one-step drinking water treatment," said Morrissey. "You could just buy a cartridge off the shelf and plop it into the pipe where the drinking water comes into your house." The cartridge system would also ensure that the graphene stays immobilized and does its job without contaminating the clean water.

Morrissey noted, however, that the technology will never be strong enough to completely clean drinking water on its own. Rather, she sees it as a polishing step after traditional water treatment processes to mop up the most insidious pollutants.

That could be especially useful in her home country, where she said many rural communities use small water treatment systems that only supply a few dozen homes. Because they don't have the infrastructure that large-scale urban treatment plants do, she thinks that a cartridge that could clean with only the sun's energy could help make their water safer.

Ultimately, Morrissey said there are still many questions to answer before declaring her TiO_2-graphene system a success. One of the biggest is making sure that when it breaks down pollutants, it is producing harmless byproducts. She also wants to make sure that the energy required for the system compares favorably to simply using TiO_2 with ultraviolet light. But so far, she reported, her design seems to be easier to make and dispose of than other visible-light activated TiO_2 purifiers.

Ref: **https://www.acs.org/content/acs/en/pressroom/newsreleases/2014/march/high-tech-materials-purify-water-with-sunlight.html**

7. Automatic Variable Filtration (AVF) Technology

Automated Variable Filtration (AVF) technology is a state of the art technology used for wastewater treatment in which upward flow of influent is cleaned by downward flow of filter media. During the treatment process itself, the filter media is cleaned by the filtered influent thus there is no requirement for any additional filter media cleaning or fresh water. The AVF process comprises two sets of media filters that can be operated in series or in parallel. The two stage series configuration is used to produce very high quality filtrate. This mode is ideal for refining secondary wastewater for reuse. The AVF process is equipped with actuated valves, sensors and programmable logic controllers to automatically switch from serial mode to parallel mode during wet weather conditions or other preset operating conditions.
The key benefits of the system are:

- Higher solids capacity
- Continuously cleaned media beds
- Elimination of ancillary equipment
- Even flow distribution
- Cost effective to install and low operating and maintenance costs
- Average reject of 5-15%
- Extremely low power consumption
- Ease of Operation & Maintenance

8. Fixed Film Systems (FFS)

A biological process that employs a medium such as rock, plastic wood or other natural or synthetic solid material that will support biomass on its surface and within its porous structure. The main applications are that they reduce the biochemical oxygen demand (BOD) and total suspended solids (TSS) from septic tank effluents to meet higher effluent standards.

9. Geotextile Filtration

Geotextile membranes are poly propylene or polyester or from natural fibres like coir and can be used in waste water treatment. These membranes make it amenable for use in flowing water where microorganisms and other contaminants can get attached to the geotextile fibres.

10. UV oxidation Process

By using UV oxidation, the water quality can increase and also help reduce the carbon footprint. Powdered activated carbon (PAC), which was used earlier, could remove the odour and taste but could not remove the MIB (2-methylisoborneol) and geosmin sufficiently. A comparative study was done to replace the PAC, in which it revealed that a PAC dosage of 30 mg/l reduced 55 percent of geosmin concentration. Meanwhile, the UV oxidation system exhibited an 80 per cent reduction in the peak flow and 90 per cent reduction in the average

flow.

11. Deployable Aqueous Aerobic Bioreactor (DAAB)

DAAB is a new finding developed by the Texas Research Institute for Environmental Studies (TRIES) at Sam Houston State University (SHSU), and PCD works. This technology offers a low-cost and highly transportable method for wastewater cleanup. The advantage of this technique is to convert waste water to Environmental Protection Agency (EPA) acceptable standards. This process uses specially selected bacteria to clean wastewater by removing organic and inorganic material. This system is completely autonomous and can be monitored, diagnosed and controlled via the internet.

12. Solar Detoxification

In recent years, it has been found that solar detoxification plays a major role in disinfecting water. The actual process behind this is that waste water collected from bathrooms and kitchens can be stored in the settling tank for primary treatment and passed onto the second tank where it will be mixed with titanium dioxide, which can then be pumped to the solar flat plate.

13. Membrane Bioreactor

Membrane bioreactors (MBRs) are increasingly being specified as the best available technology for all wastewater treatment applications. This process is a combination of ultra filtration and biological treatment. This replaces the traditional clarification process in the activated sludge process. According to Daigger 2003 and Judd 2006, submerged MBRs have proven to be more cost and energy efficient than tubular side stream modules. The most serious problem with this system is membrane fouling as a result of deposition of biosolids, colloidal species and scalants on the membrane surface resulting in flux and permeability decline. The basic need for a waste water process is to speed up the natural process by which water purifies itself. In ancient periods there was no need for water treatment due to a natural process that eliminated contamination. But the increased population and emerging industries have increased the need for treatment processes. As the economy grows, there is demand for upgraded water treatment systems. The character and quantity of contaminants presenting problems today are far more complex than those in the past. In future, more improved technologies will be introduced to overcome waste water treatment process drawbacks.