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Water Purification: New Technologies that Might Change the World

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Abstract
Environment Nanotechnology is making significant improvements in technologies for protecting the environment. Nanoscale devices are being used for enhanced sensing, treating and remediating environmental contaminants. Someday we may be able to prevent pollution with the help of nanotechnology. On the other hand, nanotechnology's unique characteristics may also lead to unforeseen environmental problems. Nanotechnology can clean arsenic contaminated drinking water cheaply and simply enough to use in developing countries. Researchers have developed nanocrystalline photocatalysts that purify water by accelerating a reaction that requires light. Nanoparticles use sunlight to break down organic pollutants, such as those in the oil industry. The performance of the nanocrystals has improved as well as the ability to recover them. Therefore they are more cost effective than previous nanocrystals.A water purification system that uses nanotechnology to remove bacteria, viruses and other contaminants may be able to deliver clean drinking water to rural communities for less than $3 a year per family, according to a new study.
Key words: Nanoscience, Nanocatalyst, nanorust

Introduction:

About 1 of every 6 people around the world has no adequate access to water, and more than twice that number lack basic sanitation, for which water is essential, according to the U.S. National Academy of Engineering. One of the Grand Challenges for Engineering set forth by the academy aims to develop technology that will make polluted water potable.

It's not that the world doesn't have enough water. Globally, water is abundant, but most of it is in the oceans, where it's unsuitable for drinking without expensive desalination.

Description:

"Cleaning Our Water with Nanotechnology" is a public presentation about our drinking water and how we can make contaminated water safe to drink using a variety of technologies – including 3 new nanotechnologies for water purification.

Water is a scarce resource, and for many countries — particularly those in theMiddle East — supplies already fall short of demand. With the pressures of climate change and population growth, water will become even scarcer, especially in developing regions. Moreover, in these regions, what water is available is often unsafe to drink (see Table 1).

884 million	people lack access to safe water supplies — approximately one in eight people
6 kilometres	is the average distance African and Asian women walk to fetch water
3.6 million	people die each year from water-related diseases
98 per cent	of water-related deaths occur in the developing world
84 per cent	of water-related deaths are in children ages 0–14
43 per cent	of water-related deaths are due to diarrhoea
65 million	People are at risk of arsenic poisoning in the Bangladesh, India and Nepal area

Nanotechnology's potential

Nanoscience and nanotechnology involve studying and working with matter on an ultrasmall scale. One nanometre is one-millionth of a millimetre and a single human hair is around 80,000 nanometres in width.

Many researchers and engineers claim that nanotechnologies offer more affordable, effective, efficient and durable ways of achieving this — specifically because using nanoparticles for water treatment will allow manufacturing that is less polluting than traditional methods and requires less labour, capital, land and energy.

Nano catalysts, magnets and detectors

Nanocatalysts and magnetic nanoparticles are other examples of how nanotechnology could make heavily polluted water fit for drinking, sanitation and irrigation. Nanocatalysts owe their better catalytic properties to their nanosize or to being modified at the nanoscale. They can chemically degrade pollutants instead of simply moving them somewhere else, including pollutants for which existing technologies are inefficient or prohibitively expensive. Researchers at the Indian Institute of Science, in Bangalore, have used nano titanium dioxide for this very purpose

Magnetic nanoparticles have large surface areas relative to their volume and can easily bind with chemicals. In water treatment applications, they can be used to bind with contaminants — such as arsenic or oil — and then be removed using a magnet. Several companies are commercialising such technologies and researchers are frequently publishing new discoveries in this area.

For example, scientists at Rice University in the United States are using magnetic "nanorust" to remove arsenic from drinking water. Nanorust's large surface area means it can capture one hundred times more arsenic than larger counterparts. The team projects that 200–500 milligrams of nanorust could treat a litre of water. And it is developing a way of creating nanorust from inexpensive household items. This could significantly reduce production costs, making it a viable product for communities throughout the developing world.

Nanotechnology detect water-borne contaminants.

Researchers are developing new sensor technologies that combine micro and nanofabrication to create small, portable and highly accurate sensors that can detect single cells of chemical and biochemical substances in water. Several research consortia are field testing such devices and some expect to

commercialise these soon. For example, a team at Pennsylvania State University in the United States has developed a way of detecting arsenic in water by using nanowires on a silicon chip.
Jeffrey C. Grossman, MIT associate professor of power engineering, and his graduate students David Cohen-Tanugi and Shreya Dave are developing a filtration material made of a sheet of nanoporousgraphene. The holes in the graphene—a one-atom thick form of carbon—are small enough to block salt ions while letting water molecules through. *Smithsonian* magazine called this nanoporous form of carbon one of the top five surprising scientific milestones of 2012.

Cohen-Tanugi presented their paper, "Water Desalination Across NanoporousGraphene," at the IEEE Conference on Technology for Sustainability, held in August, in Portland, Ore.
"It's essentially a single layer of carbon atoms shaped like a honeycomb," he explains. "Produced with holes in it, graphene is a much thinner, more porous, and efficient membrane than the polymers generally used for filtering water. It's extremely strong and has very interesting physical properties, but it is only now being looked at for water applications."

The most efficient process today for desalination is reverse osmosis, which relies on semipermeable membranes to filter salt from water. But such systems demand high pressure to force water through the membranes, which are about a thousand times thicker than ones made of graphene. The process remains very energy-intensive and expensive, notes Cohen-Tanugi.

Researchers at the Indian Institute of Technology Madras in Chennai, India, developed a purification device that filters water through a specially crafted mixture of nanoparticles to remove harmful contaminants. Their study was published today (May 6) in the journal Proceedings of the National Academy of Sciences.

The device, which is currently being tested in communities in India, could offer an affordable way to provide small families with at least 10 liters (2.6 gallons) of safe drinking water per day, said study co-author ThalappilPradeep, a professor in the department of chemistry at the Indian Institute of Technology Madras. [10 of the Most Polluted Places on Earth]

Silver ions to the rescue

The researchers designed a water filter composed of a grainy mix of nanoparticles — so-called composite nanomaterials — that release a continuous stream of silver ions to destroy microbes in the water.

Silver ions, which flow from nanoparticles when oxidized (a conversion process in which an element or molecule becomes more positively charged), have long been known for their ability to effectively kill bacteria.Other composite materials in the filter cartridge were added to remove arsenic, pesticides, lead and other heavy metals from the water.

Conclusion:

A water purification system that uses nanotechnology to remove bacteria,

viruses and other contaminants may be able to deliver clean drinking water which is more cost effective than previous methods.

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