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Using nano material to make water safe

A technology developed in the IIT Madras lab

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Clean Water: A Mission for All. Clean water is a mission that touches all aspects of society, linking grassroots technology to advanced research.

Affordable clean water is a crucial aspect of development. Yet, it finds less than adequate attention in the overall scheme of things, whether research, technology, or policy.

Over 20 per cent of the Indian population has no access to safe water; about 8 crore people are affected by arsenic poisoning and 10 crore by fluoride. Diarrhoea kills 1,600 people a day. Water-related illnesses keep children away from schools and people from work. Some problems have persisted. Arsenic remains unsolved, even 100 years after its discovery in the environment. Fluorosis was discovered in India in 1937, but the problem persists.

However, technology to make water safe, affordable, and accessible for the majority has been available. The problem arises because the process of development contaminates water sources irreversibly. Unlike fire, water cannot purify itself. Humans can access and use only 0.5 per cent of the planet's water. As we better understand the impact of pesticides or arsenic on health, we are continually revising water quality parameters, and many more chemicals are being regulated.

The limits of regulation can be as small as one in 100 crore water molecules. In other words, a water purifier must remove 1 contaminant from 100 crore molecules in minutes. If we had such efficient sorters to identify terrorists, the world would be a different place. Imagine an airport entrance closing on a terrorist while 100 crore people walk through. Water purifiers must do this level of screening fast, without error, at the lowest power requirement, and with no waste. A demanding task indeed.

Contaminated water requires energy to clean it. Desalination, using reverse osmosis (RO), costs about 4.5 units of electricity per 1,000 litres. It causes concentrated rejects and needs investments in membranes and infrastructure. RO rejects everything, including ions that are needed for biological functions. Many fear that depleting ions, some at ultra-trace amounts, through the universal application of RO could have a disastrous effect on humans. The high energy usage impacts greenhouse gases, global warming, etc.

Reducing Energy Costs

How do we reduce energy costs? One way is to use advanced materials to scavenge contaminants selectively. Another is to use selective catalysis on active surfaces, degrading toxic molecules to harmless species. Besides, there must also be efficient antimicrobial agents that don't cause toxic by-products. One such antimicrobial agent is silver, which has been historically used. Alexander the Great stored water in silver vessels during campaigns to avoid waterborne diseases. Our laboratory work showed that a specific dose of silver ions, about 50 parts per billion, can cause effective antimicrobial activity. How can one do that at room temperature over years? Nanomaterials come to the rescue.

However, nanoparticles have active surfaces and when exposed to normal water, minute impurities, even harmless ones, sit on these surfaces forming thin coatings that prevent silver ion dissolution. The purifier becomes ineffective, even though it contains silver. The lab then developed constant silver ion-releasing materials by confining nanoparticles in nanoscale cages where water alone gets in, but no dirt. No nanoparticle gets out. The effect is a material with extended antimicrobial activity.

A recent twist in the story is that the ubiquitous carbonate ions can enhance the effect of silver. Carbonate causes some of the proteins from the bacterial membranes to be released, enhancing silver ion penetration. Thus, half the silver is enough for effective antimicrobial activity.

Clean water means all contaminants are below permissible limits. Nanomaterials provide a larger surface area per unit mass. They are 'metastable' and tend to acquire stability by reactions with contaminants. They can be contained in nanocages as before, and contaminants such as arsenic can be removed selectively. By creating specific materials with controlled chemistry, a clean water solution for all contaminants can be found.

Deployment and Local Solutions

The solution needs to be deployed in various forms, at the community (school, village, city) level and at the home level. The silver solution is being installed in various parts of India, as small community units. A particularly important success is with arsenic — arsenic-free water is being delivered to over 1,50,000 people at 4 paise per litre. The quality of water changes fast, often within meters, and solutions need to be available as and when the problem is identified. Even without advanced technology, affordable local solutions could be available and must be adopted and used across geographies.

Ultimately nanotechnology and nanomaterials have to learn from nature. Halophytes (plants growing in waters of high salinity) live by filtering water. Coconuts store clean and tasty water even when grown in saline soil. They don't use energy and reject no concentrates, unlike RO. However, there is no water filter yet designed with the technological inputs of coconut trees. Clean water is a mission that touches all aspects of society, linking grassroots technology to advanced research. Clean water must not just be a millennium development goal, but a basic human right that goes beyond national boundaries.

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