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IIT Madras Prof, T Pradeep's AMRIT filters saving lives from arsenic contamination

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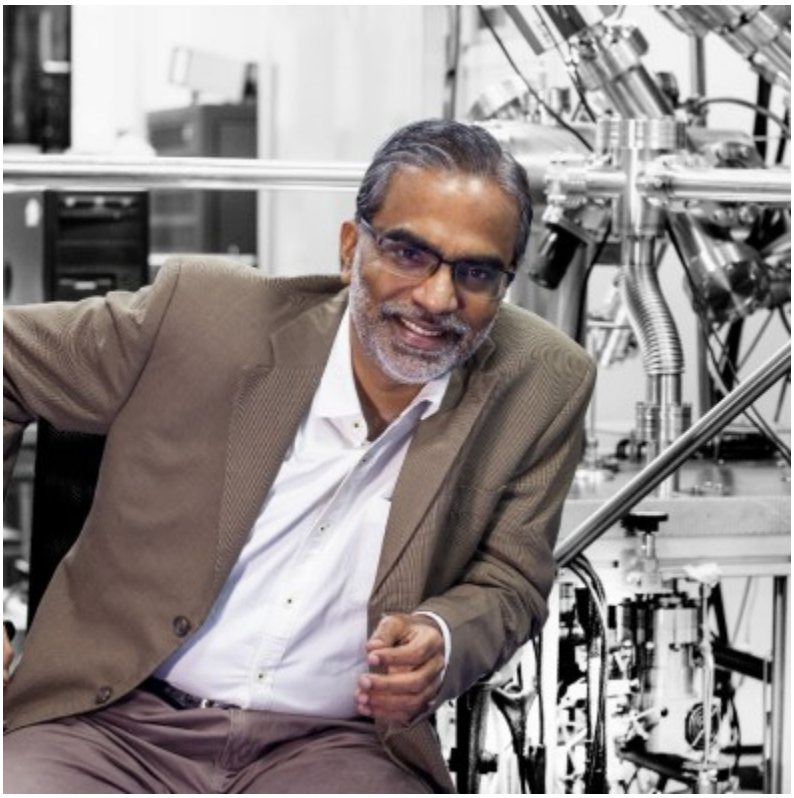
The chemical element of Arsenic is a naturally occurring element found in the earth's crust. However, its presence in drinking water beyond the WHO- mandated maximum permissible limit of 10 ppb is known to have disastrous consequences for human health. Scientists say that over ninety per cent of such arsenic-related contamination is geogenic in origin. This

arsenic has been sitting there and leaching out into the water bodies for ages. Increased groundwater use has now exposed humans to it. Arsenic's presence in low-quality pesticides, which are non-permissible but continue to be used- has further exacerbated the problem in our country. Globally, the knowledge of arsenic's presence in drinking water has been in the scientific community for a long time. Then why have we not been able to provide people with arsenic-free drinking water to this day?
As the contamination threatens millions of lives in the developing world, a pertinent question arises. **"How can India overcome the mammoth arsenic challenege?"** Professor Thalappil Pradeep, an Institute Professor at the Department of Chemistry, IIT Madras, is showing the way. His AMRIT filters bring new hope to millions suffering from the arsenic menace.



How widespread is arsenic contamination?

An estimated 300 million people worldwide, spanning 108 countries, are affected by arsenic contamination in groundwater. That is to say, these people are drinking water that contains arsenic (chemical element) concentration beyond the maximum permissible limit of 10 ppb recommended by the World Health Organization. The situation is grim in India, too. As per the data from the Central Ground Water Board, Arsenic [>10 µg/L(ppb)] has been found in groundwater samples spreading over 221 districts in 25 States/UTs.

A 2021 study by IIT Kharagpur used artificial intelligence (AI)-based prediction modelling to gauge the extent of arsenic contamination in India. The study revealed that almost 20% of

India's total land area has toxic levels of arsenic in its groundwater. This exposes more than 250 million people across the country to the poisonous element.

The problem is particularly acute in the heavily populated states of the country along the Ganga basin – UP, Bihar, Assam and West Bengal. WHO stipulates that inorganic arsenic is the most significant chemical contaminant in drinking water globally. It is highly toxic, and long-term exposure can lead to devastating consequences for human health. It is also a confirmed carcinogen.

Why is dealing with arsenic contamination so tricky?

Professor Pradeep explains to us that three different types of arsenic species exist in water. Two types of ions which are arsenite ions and arsenate ions, are most common. The pre-existing methods of removal did not remove these ionic forms effectively, especially arsenite, which is more difficult to absorb. As a result, arsenic remains in the water.

Owing to this knowledge, the past decades have seen the development of several processes to remove arsenic from drinking water. But, there was simply no "affordable" technology to provide arsenic-free water to the masses.

Professor Pradeep explains what challenges lay in developing an arsenic removal technology suitable for rural areas,

"For the technology to be viable for implementation in rural areas, it had to be very low-cost and affordable. Rural areas also suffer from frequent electricity cuts, so this technology had to be electricity-free. The filters had to be built so that they could be serviced and maintained by local technicians. Another problem was the issue of clogging, maintaining the flow rate of water, and the durability of the material. For logistical reasons, the material saturation must happen after a considerable usage period, at least for a year. Methods to keep the filtered material from being released into water were also equally essential… Particular attention was required to ensure that the technology does not recontaminate the village environment from the material used in the technology. Finally, all of this had to be achieved efficiently while focusing on the primary objective of reducing the arsenic concentration – in the shortest possible time. "

*"My contribution has been to develop **a low-cost, locally serviceable, electricity-free technology that can provide clean water to the masses**," says Professor Pradeep as he starts to talk about AMRIT filters.*

Community water purifier efficiently eliminates arsenic and iron from the groundwater | Photo: IIT Madras

The technology behind AMRIT Filters

AMRIT – an acronym for *Arsenic and Metal Removal through Indian Technology*– was born from the research Professor Pradeep and his team started in 2004. Consequently, InnoNano Research — a nanotechnology-based water-purification firm incubated at the Indian Institute of Technology Madras, was established in 2008. Although, the AMRIT filters are currently being made by Hydromaterials Private Limited, another company incubated at the institution.

The AMRIT filters are a filtration-based absorption technology, based on materials. The process of purification takes place in two stages. The technology makes use of a minimal concentration of silver ions released from silver nanoparticles that kills the microbial impurities in the water. Thereafter, iron oxyhydroxide, an engineered nanostructured material, selectively captures ions like arsenic, iron and fluorides when water passes through it. A matrix of biopolymers called chitosan supports these nanomaterials. Professor Pradeep points out that no synthetic polymers are used in the filters, making them more environmentally friendly.

The process of decontamination takes place by the operation of gravity alone, meaning no electricity is required in the process. Furthermore, he notes that the AMRIT filters are adaptable to local conditions. That is to say, little tweaks can be made to the materials depending on the type of chemical contamination found in a particular area.

How have AMRIT filters impacted people's lives?

As per the PIB press release, the AMRIT systems are currently supplying 80 million litres of water every day. This means, providing safe drinking water to 1.3 million (2% of the affected population) people across several Indian states. *"With the experience we have got, I am hopeful that we can benefit 10 million people in the next two years."*

Professor Pradeep tells us that he initially aimed to provide WHO-recommended arsenic-free drinking water at 5 paise per litre. *"Currently, the AMRIT filters are producing water with an arsenic concentration of fewer than 2 parts per billion (2 ppb) at 2.2 paise per litre,"* he says, beaming with pride.

https://youtu.be/aUc6Fr7btnw

The project has been implemented at various levels – homes, small communities, and large-scale water supply programs. The on-field implementation of the technology has been undertaken by several startups and established companies incubated at IIT Madras.
A documentary by IIT Madras on the subject shows the difference these filters have brought about in the villages of Murshidabad district in West Bengal. Here, the project was first implemented in 2013. Moreover, the team has made continuous improvements in the technology such that it is now capable of removing uranium and manganese as well.

Barriers and Limitations

On being asked how nano-materials saturated with poisonous arsenic are not harmful to dispose of, the Professor explained that the arsenic has to go back to the soil eventually. Hence, these nano-materials also leach the arsenic back to the earth. However, the distinguishing factor is the rate of this leaching. In the case of filter, leaching happens far below and slower than what professor calls the background rate of leaching of arsenic. The saturated nano-particles can go back to the field because they don't release arsenic at excessive levels in the natural condition of the soil (neither acidic nor alkaline). This was established by testing through the Toxicity Characteristic Leaching Procedure (TCLP) to ensure the safe disposal of arsenic-laden material.

Speaking on the barriers in building the entire project, Prof. Pradeep remarks that it was akin to raising a child. And, they learned to address the challenges in the course of time.

"There were numerous barriers in terms of financial constraints, laboratory barriers, governmental barriers, limited resources, infrastructural limitations." Prof. Pradeep notes that the work atmosphere was not as adequate when he started his research 25 years ago.

“But my institute (IIT Madras) gave me the space and freedom to harness the opportunities that lay out there – it allowed me to interact with the industry, and that has been very important for the project to reach this stage.”
His advice for other institutions- *“Get good people and give them freedom”*

Source: AMRIT TECHNOLOGY Arsenic and Metal Removal by Indian Technology

Economics and governmental support

Speaking on the challenges in commercializing the AMRIT technology, Prof. Pradeep spoke about the general resistance that any new technology faces, and the hurdles this resistance creates. Start-ups in India face resistance in the form of procedural issues as well as internal resistance from within the communities. Governmental push on the lines of Make In India is imperative for the technology to reach all people, both in India and aboard, especially in the developing world, he mentions.

Prof. Pradeep notes that a major roadblock comes in the form of the lack of urge to spend the allocated money fast enough. This is especially problematic as the resources allocated are already less than what is required to deal with the situation. He draws attention towards crores worth of money available under Corporate Social Responsibility (CSR), and they should be integrated in the fight against arsenic menace.

The Professor also acknowledged that currently, systems are in place to remove arsenic from drinking water. However, food crops continue to be cultivated using this water. Thus, arsenic

continues to make its way into the food cycle. Research is in progress to seek a sustainable solution for this.

Even with the widespread nature of the contamination, and despite the efficiency, affordability and sustainability of the AMRIT technology, the project is yet to see a national-scale implementation. The government today lacks a dedicated national water policy to tackle arsenic contamination.

President Kovind presents Padma Shri to Prof T. Pradeep for Science and Engineering. A Professor at IIT Madras, he is widely recognised for his pioneering work on material science and nanotechnology commercialization for affordable clean water | Photo: Twitter/rashtrapatibhvn

National and International Recognition

Professor Pradeep's groundbreaking technology and its role in changing people's living standards, especially in rural areas, has been recognized at several levels. He holds the position of an Institute Professor at IIT Madras. This title bestowed only to a handful of people in the institute's history. Besides being a co-founder of half a dozen companies, he has 550 papers and over 100 patents to his credit.

Prof. Pradeep's work has been recognized with many awards. Some of which include the Padma Shri, Prince Sultan Bin Abdulaziz International Prize for Water, the Nikkei Asia Prize, and the VinFuture Prize. The prestigious Eni Award, considered among the top global honours for scientific research in energy and environment, is the latest honour in his list of accolades.

Speaking about his future goals while accepting the Eni Award, Prof. T. Pradeep said,

"Water presents numerous opportunities in cleaning, sensing, distribution, and data analytics. It is the most opportune moment nationally and globally to get into water – for science, industry, or both. There is a career in it where one can get satisfaction besides wealth and fame. We need more youngsters in the area to ensure water security."

Conclusion

"Nanotech has a huge scope in countering the unique problems that India faces today – in healthcare, wastewater, environment, housing, and agriculture. More research and support is required to harness the benefits nanotech has to offer", he tells us

As the interview neared its end, a personal question was put in front of him. *"You are a student of the Bharat Ratna Professor C. N. R. Rao. What influence did he have in shaping your academic life?"*

"Vey big influence. Professor Rao is someone who lives within me," he said, his eyes brimming with tears. Great teachers produce great students, and society reaps its fruits for generations.