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# Water: Gaps and Opportunities

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InnoDI Water Technologies Pvt. Ltd.

VayuJAL Technologies Pvt. Ltd.

Aqueasy Innovations Pvt. Ltd.

Hydromaterials Pvt. Ltd.

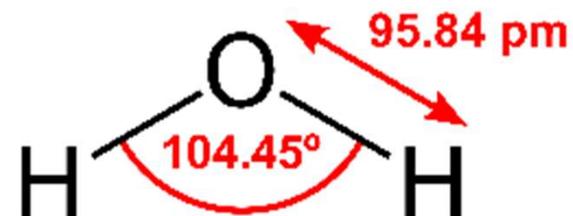
EyeNetAqua Solutions Pvt. Ltd.

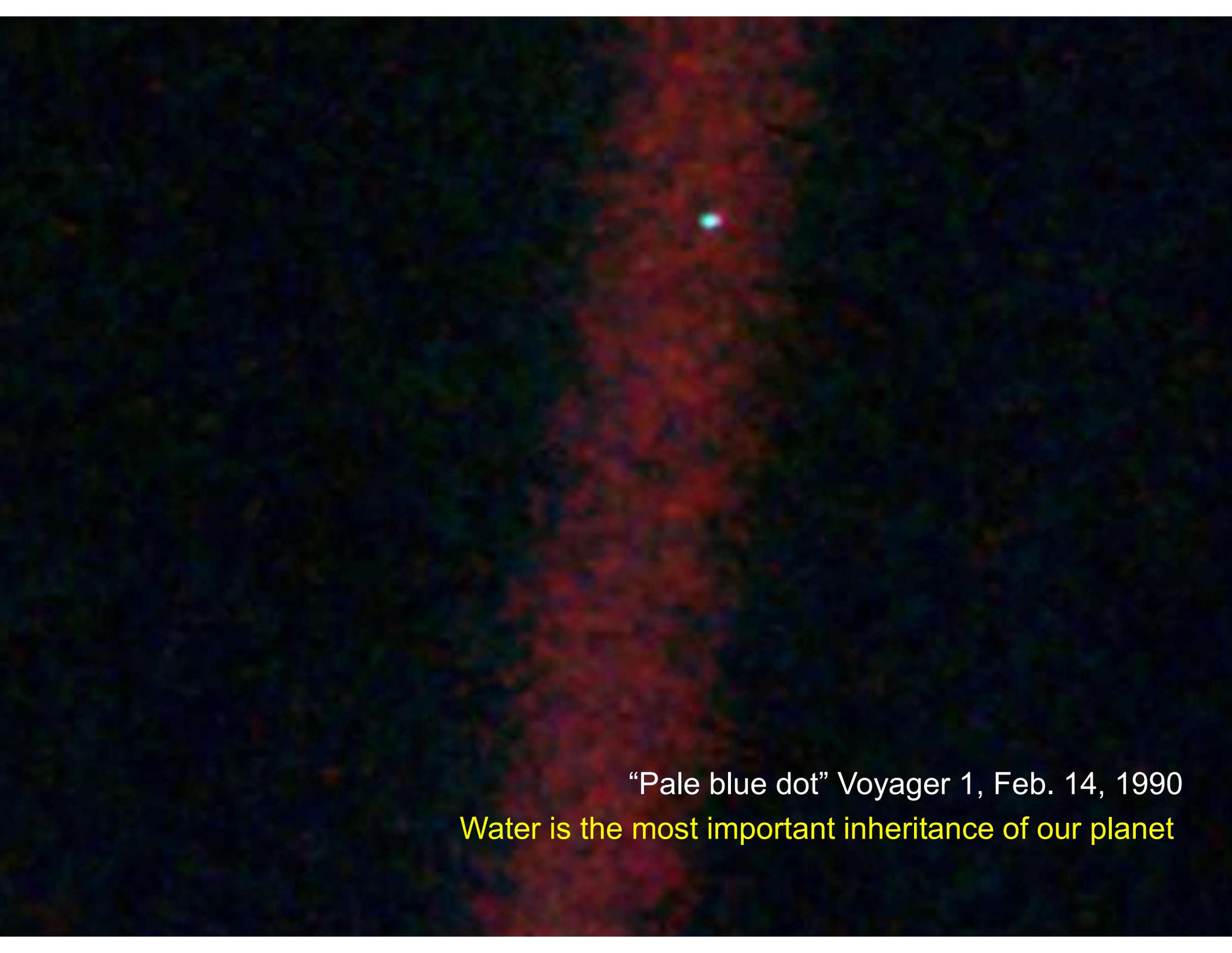
DeepSpectrum Innovations Pvt. Ltd.

Professor-in-charge



International Centre for Clean Water





“Pale blue dot” Voyager 1, Feb. 14, 1990

Water is the most important inheritance of our planet

# Water is at the centre of action

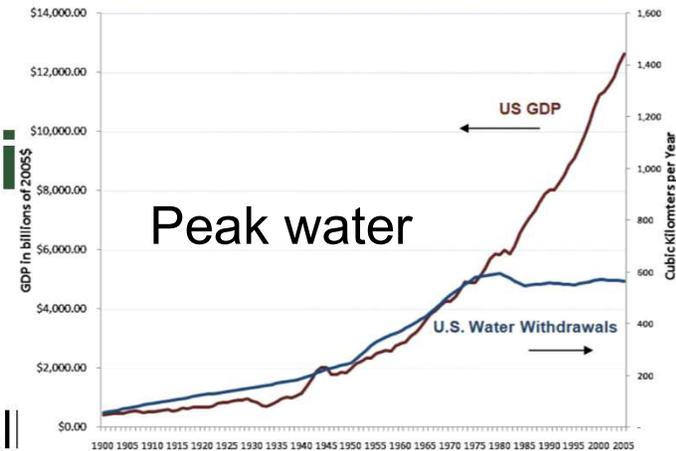


Variety and diversity are part of water, in problems and opportunities

# Water is big and .... India i

Per capita water availability – 1500 CM

That water and its benefits need to reach all



Peter H. Gleick and Meena Palaniappan, PNAS, 2010, 107, 11155–11162

## 3Ss for water **Store – Sensitive – Smart**

Average rainfall 1085 mm, 85<sup>th</sup> in a list of 186 countries

Traditions of storage and conservation – we store just about 8%

Water is for all – for every living form

83% of freshwater species have declined globally in the last 50 years!

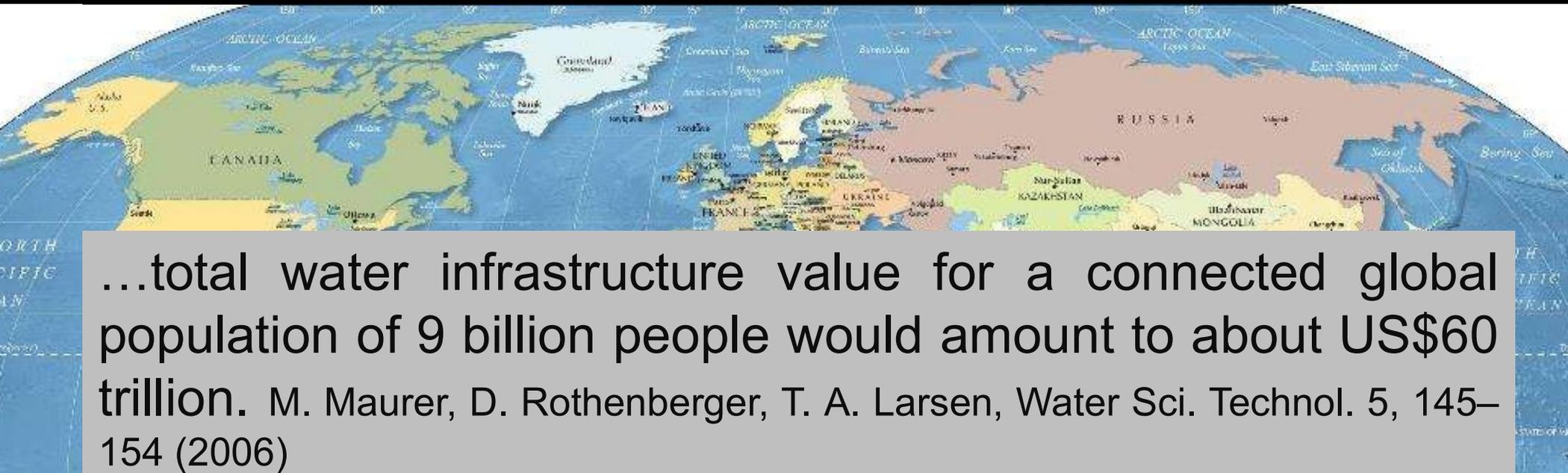
GDP can grow even by capping freshwater withdrawals

We must find technologies of relevance

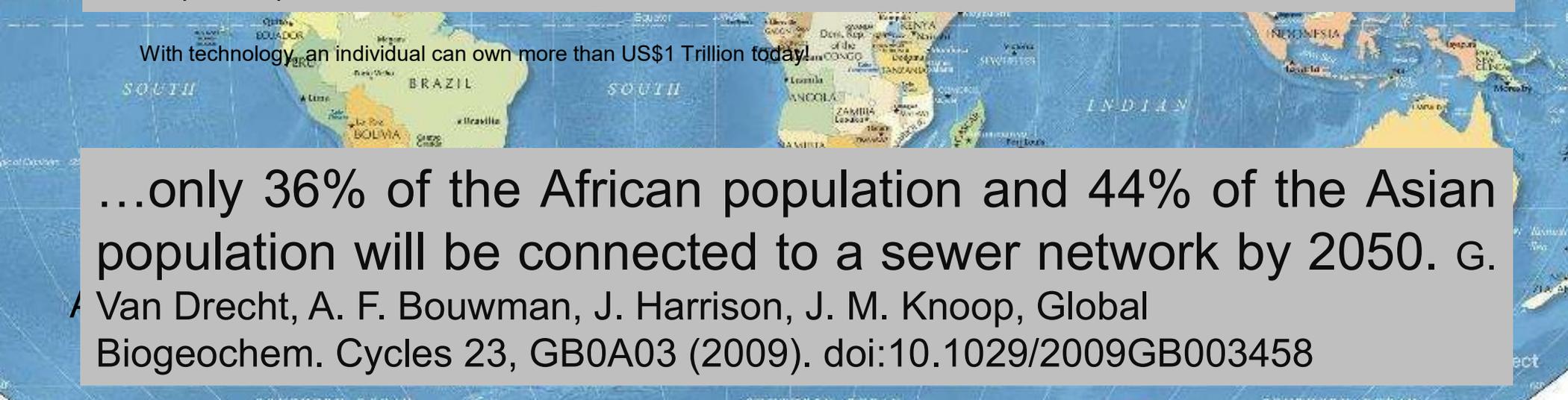
Energy - food – clothing – construction – manufacturing - .....

Water is big in every scale – Gaps, opportunities, wealth, satisfaction

# Water, sanitation and inequality

A world map showing global water infrastructure value. The map is color-coded by region, with North America and Europe in shades of green and yellow, and Russia and parts of Asia in shades of brown and red. The text is overlaid on a semi-transparent grey box.

...total water infrastructure value for a connected global population of 9 billion people would amount to about US\$60 trillion. M. Maurer, D. Rothenberger, T. A. Larsen, Water Sci. Technol. 5, 145–154 (2006)

A world map showing sewer network connectivity by 2050. The map is color-coded by region, with Africa and parts of Asia in shades of yellow and orange, and South America and parts of Europe in shades of green. The text is overlaid on a semi-transparent grey box.

With technology, an individual can own more than US\$1 Trillion today!

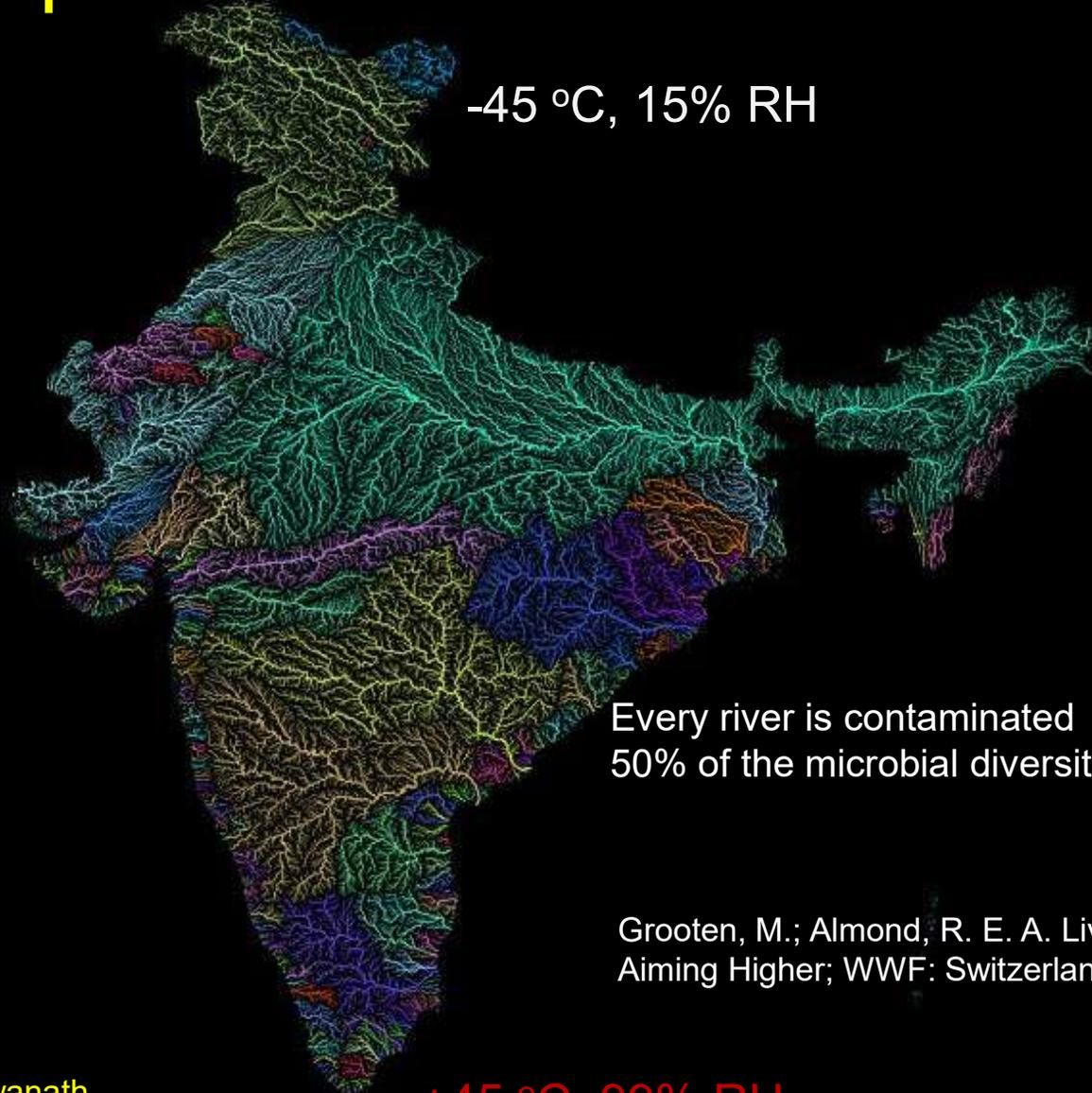
...only 36% of the African population and 44% of the Asian population will be connected to a sewer network by 2050. G. Van Drecht, A. F. Bouwman, J. Harrison, J. M. Knoop, Global Biogeochem. Cycles 23, GB0A03 (2009). doi:10.1029/2009GB003458

**Total wealth of India – US\$12.8 Trillion**  
**Total wealth of USA – US\$126 Trillion**

# Challenges

## Every possible need

Arsenic  
Fluoride  
Uranium  
Mercury  
Chromium  
Perchlorate  
Nitrate  
Pesticides  
Antibiotics  
Plastics  
Detergents  
.....



-45 °C, 15% RH

Every river is contaminated  
50% of the microbial diversity is lost for ever

Grooten, M.; Almond, R. E. A. Living Planet Report - 2018:  
Aiming Higher; WWF: Switzerland, 2018.

+45 °C, 99% RH

From S. Vishwanath

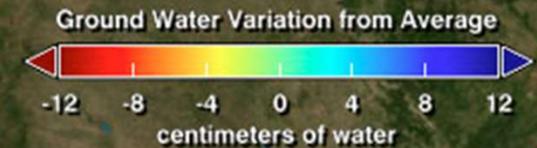
# Indian agriculture

67% of agriculture run on GW

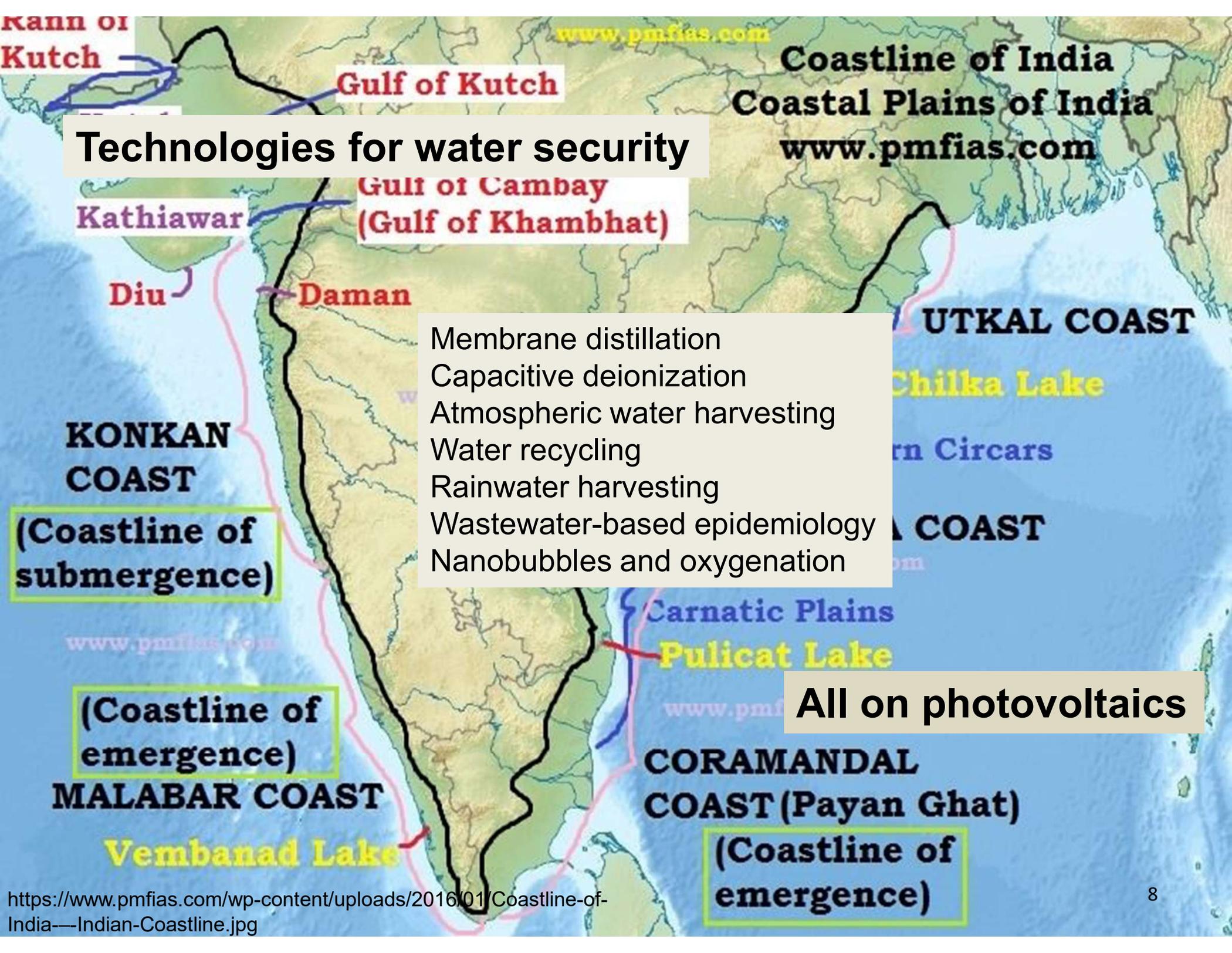
Total districts 742  
Water stressed >300  
256 with critical or overexploited ground water levels  
'India is suffering from its worst water crisis in its history.'

November 2002

November 2008



Data from NASA



# Technologies for water security

- Membrane distillation
- Capacitive deionization
- Atmospheric water harvesting
- Water recycling
- Rainwater harvesting
- Wastewater-based epidemiology
- Nanobubbles and oxygenation

All on photovoltaics

# Nanomaterials can solve real problems



ACS Sustainable Chemistry & Engineering Editorial, December 2016

# Biopolymer-reinforced synthetic granular nanocomposites for affordable point-of-use water purification

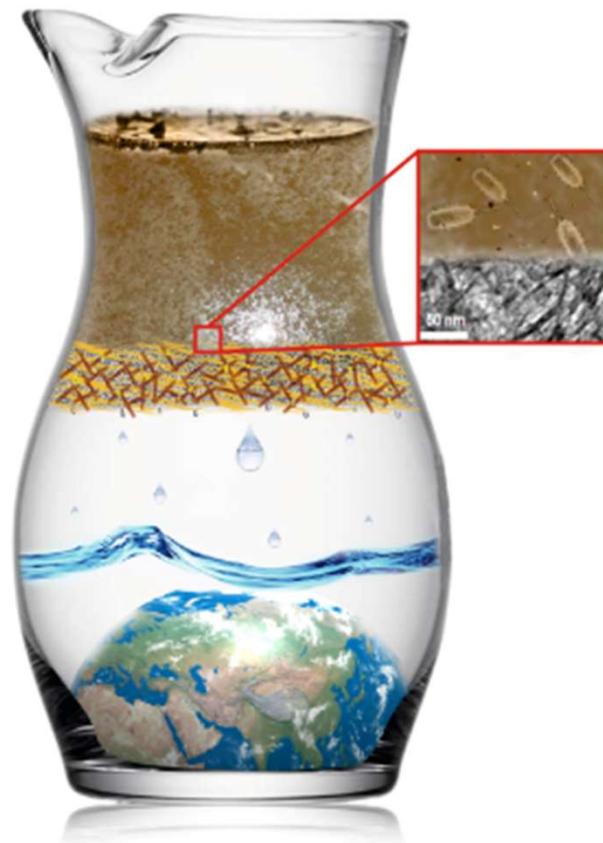
Mohan Udhaya Sankar<sup>1</sup>, Sahaja Aigal<sup>1</sup>, Shihabudheen M. Maliyekkal<sup>1</sup>, Amrita Chaudhary, Anshup, Avula Anil Kumar, Kamalesh Chaudhari, and Thalappil Pradeep<sup>2</sup>

Unit of Nanoscience and Thematic Unit of Excellence, Department of Chemistry, Indian Institute of Technology Madras, Chennai 600 036, India

Edited by Eric Hoek, University of California, Los Angeles, CA and accepted by the Editorial Board April 4, 2013 (received for review November 21, 2012)

Creation of affordable materials for constant release of silver ions in water is one of the most promising ways to provide microbially safe drinking water for all. Combining the capacity of diverse nanocomposites to other contaminants, these materials can be synthesized out of the use of sand-like porous forms. These nanocomposites can be used as a water purifier in rural areas. The ability to purify water at ambient temperature is a significant advantage for water purification in rural areas.

hybrid | green |

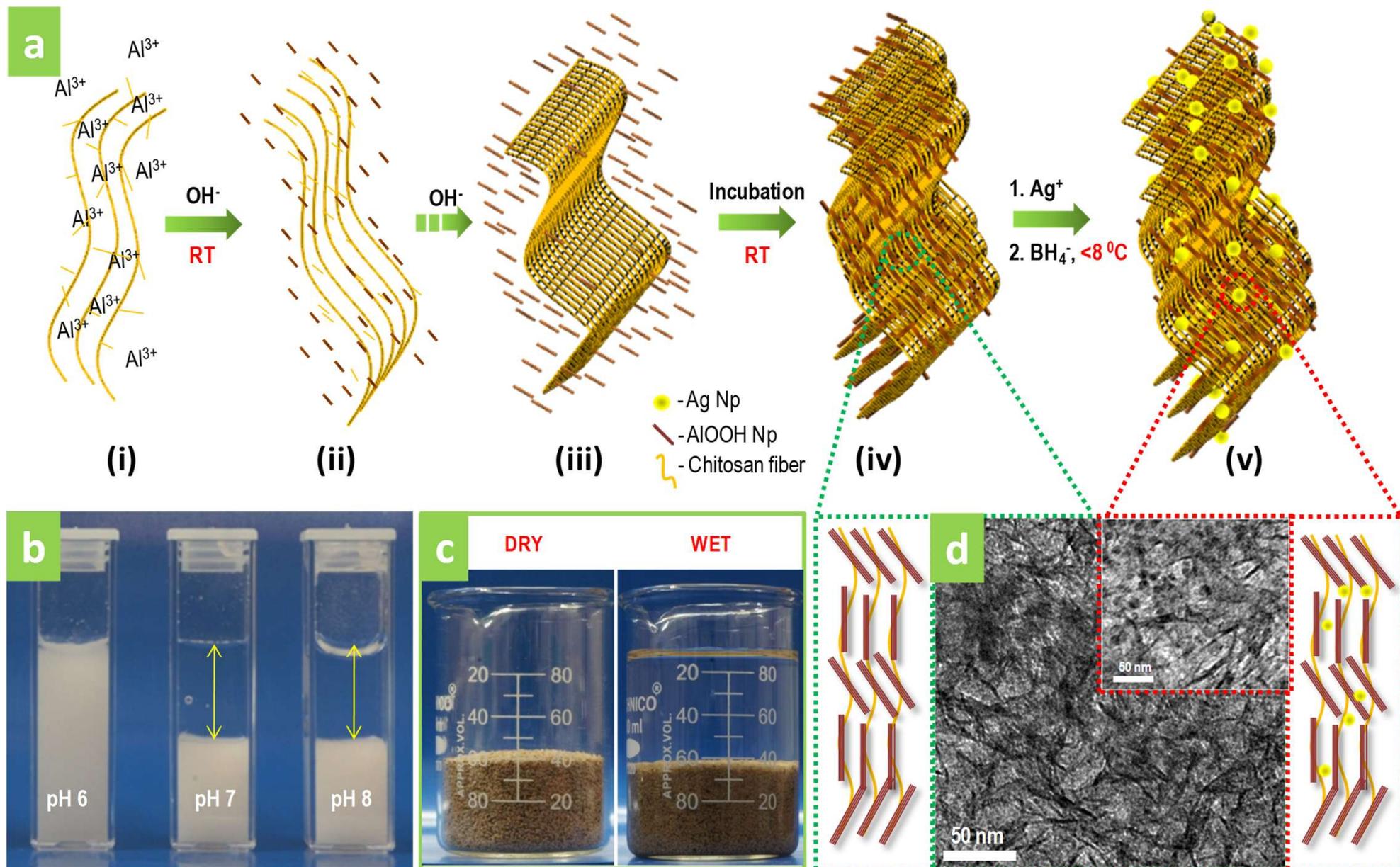


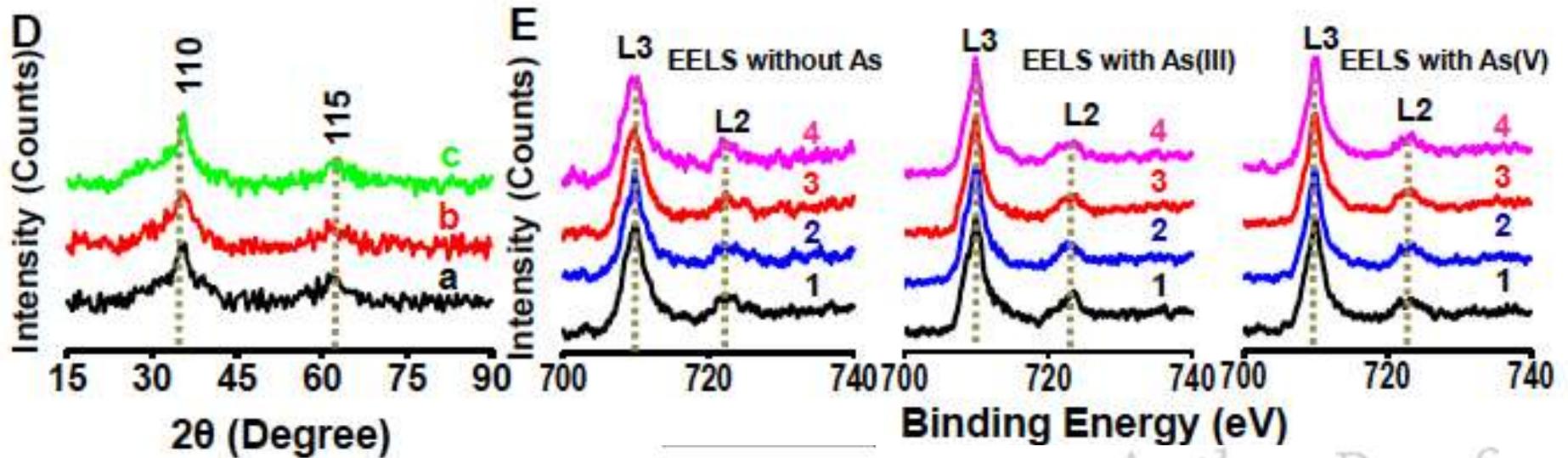
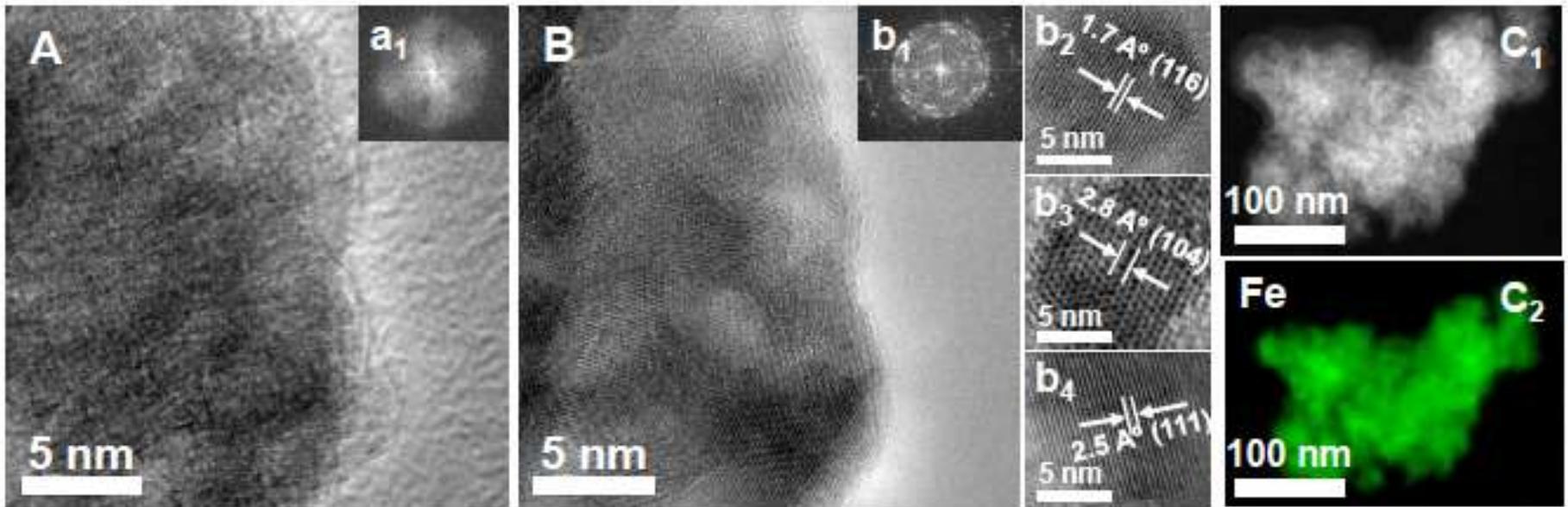
release into water are not available; and (c) continued retention of the nanoparticles in the matrix is difficult.

In this work, we demonstrate a unique family of nanocrystalline metal oxyhydroxide-chitosan granular composite materials prepared at near room temperature through an aqueous route. The degree of crystallinity in the composition is attributed to abundant  $-OH$  functional groups on chitosan, which help in the crystallization of metal oxyhydroxide and also ensure strong covalent binding of the nanoparticle surface to the matrix. X-ray photoelectron spectroscopy (XPS) confirms that the composition is rich in surface hydroxyl groups. Using hyperspectral imaging, the presence of nanoparticle leaching in the water was confirmed. Further, a unique scheme to reactivate the silver nanoparticle surface is used for continual antimicrobial activity in drinking waters. Several other composites have been developed that can remove other contaminants in water. We demonstrate an affordable water purification device based on such composites developed over several years and undergoing field trials in India, as a potential solution for widespread eradication of the waterborne disease burden.

## Results and Discussion

# New materials



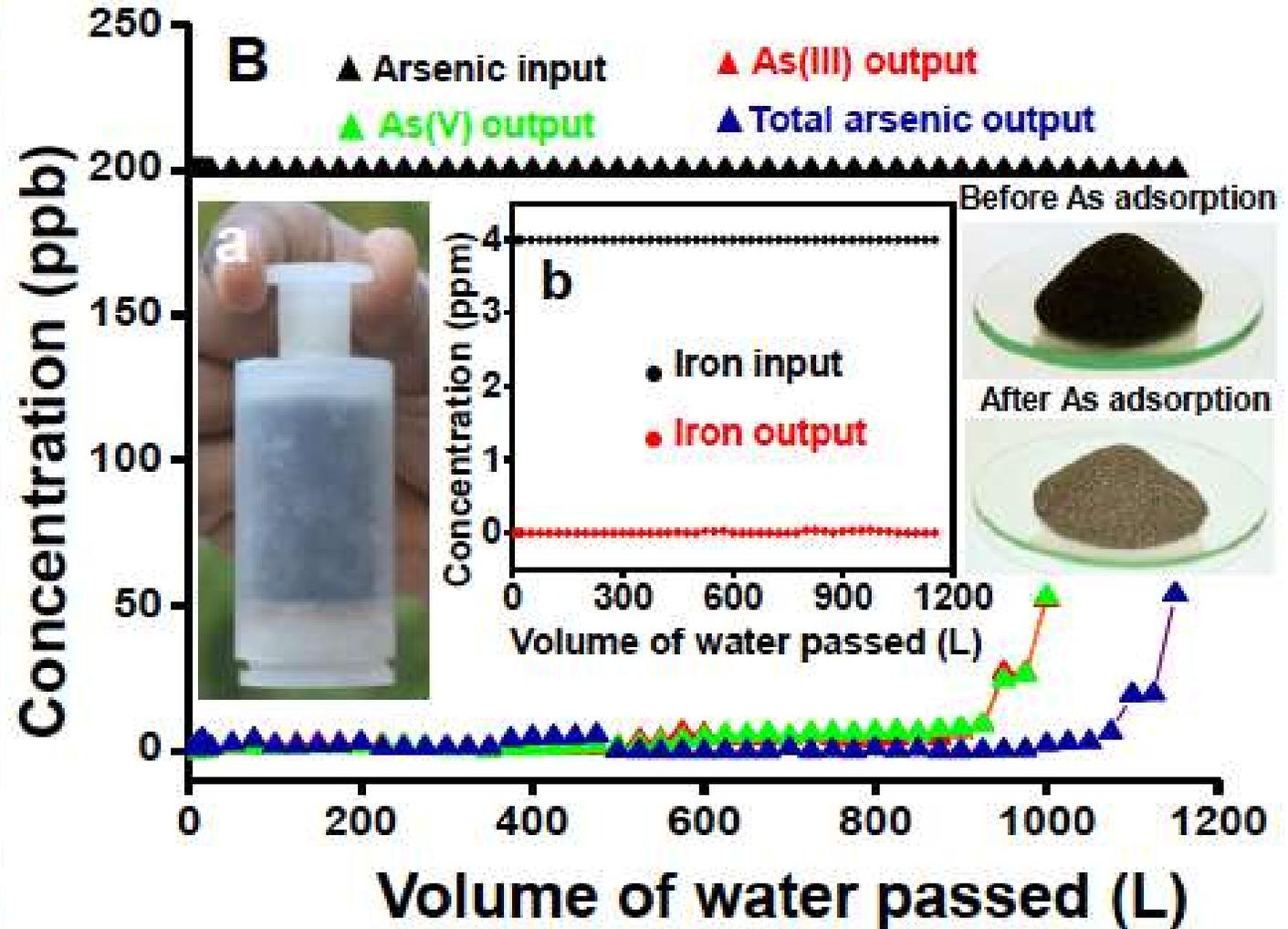


www.advmat.de

Author Pr <sup>6</sup> ADVANCED MATERIALS

## Confined Metastable 2-Line Ferrihydrite for Affordable Point-of-Use Arsenic Free Drinking Water

By Avula Anil Kumar, Anirban Som, Paolo Longo, Chennu Sudhakar, Radha Gobinda Bhuin, Soujit Sen Gupta, Anshup, Mohan Udhaya Sankar, Amrita Chaudhary, Ramesh Kumar, and T. Pradeep\*





# Changing the dynamics in the field



Existing plant in 40 cents



New plant in 3 cents

- Existing unit for iron and arsenic removal – 20 m<sup>3</sup>/h
- Uses activated alumina and iron oxide (old generation of adsorbents)

- Existing unit for iron and arsenic removal – 18 m<sup>3</sup>/h
- Uses iron oxyhydroxide (new generation of adsorbents)
- Input arsenic concentration: 168 ppb
- Output arsenic concentration: 2 ppb

Seeing how the new adsorbents are changing the dynamics at the ground level (type 1 of our efforts)



Name of the scheme: Mahilan Wala (TW9144), District: Amritsar  
Population: 2610, Daily demand@70 LPCD: 188 kLD, OHSR Capacity:  
100 kL

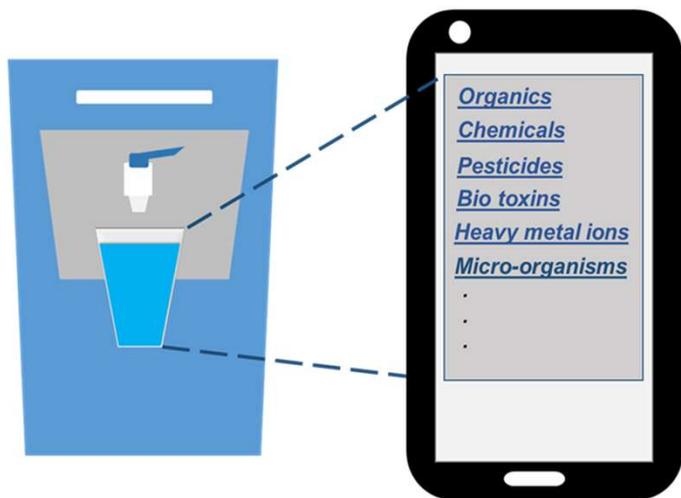
# Cleanwater at 2.1 paise per litre!

## Calculation for the Tariff to be collected for treated water (Revision if Required)

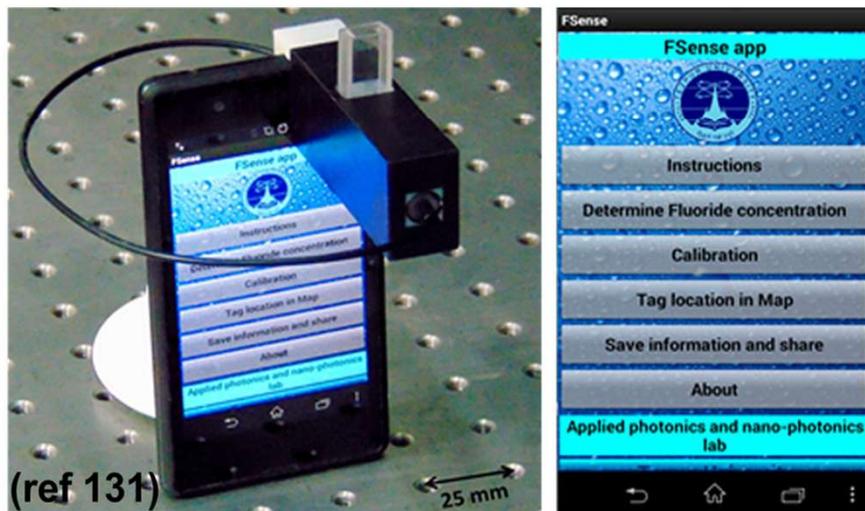
Sr.No	Item/Description	Cost / Quantity	Remarks
	Design population	1,071	Plant capacity/70 LPCD
1	Cost of Replacement of Iron removal media	56400	After minimum two years if Iron concentration is more than 5 ppm. But iron concentration is more than 5 ppm at only two to three places. Therefore media may work for 3 years also.
2	Cost of Replacement of Arsenic removal media	978660	After minimum two years if Arsenic concentration is more than 100 ppb. But arsenic concentration is more than 100 ppb at only two to three places. Therefore media may work for 3 years also.
3	Cost of replacement of Activated Carbon	28560	
4	Total cost of Replacement of media	1063620	After minimum two years.
5	Total cost of Replacement of media for one year	531810	
6	Plant capacity	75000	ltr per day
7	Design population	1,071	Plant capacity/70 LPCD
8	Cost per liter of water	<b>2.1 Paise per ltr</b>	
9	Cost of replacement of media	<b>1.36</b>	Rs. per head per day =Media replacement cost per year/365/Design population
		<b><u>40.80</u></b>	per head per month for 70 LPCD water

# Smart water purifiers and big data

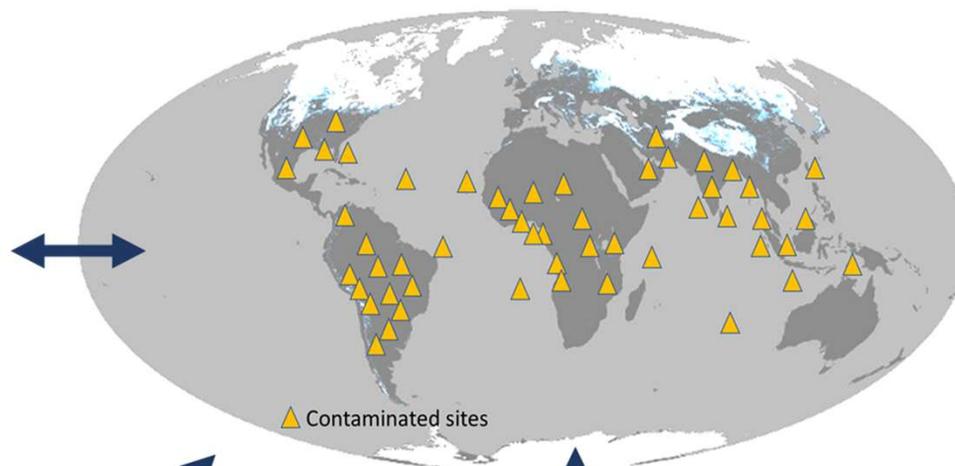
Smart Water Purifiers linked to IoT



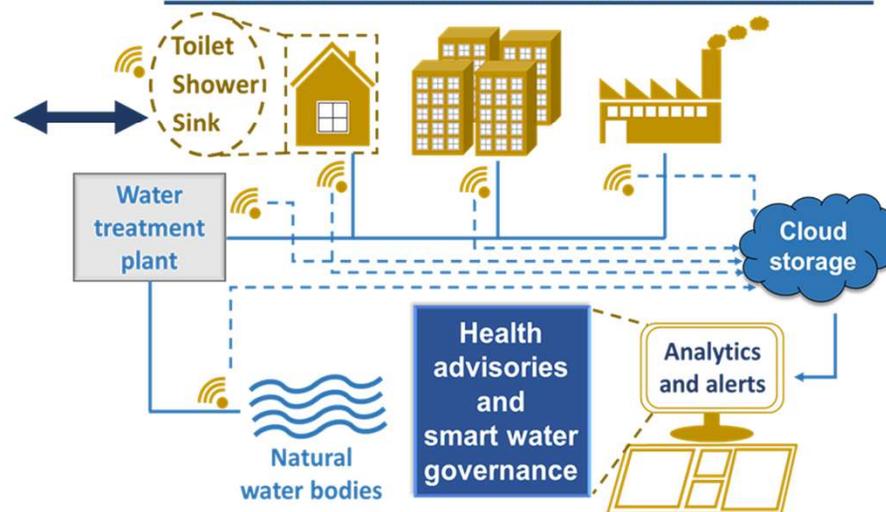
Cost-effective sensor accessory for point-of-use applications



Global Map of Water Health



IoT-enabled sensing for households and distribution networks



## **Waste management**

Adsorbents conform to toxicity characteristic leaching procedure

Elemental waste goes back to local environment

Safe disposal of arsenic (or any other) laden waste

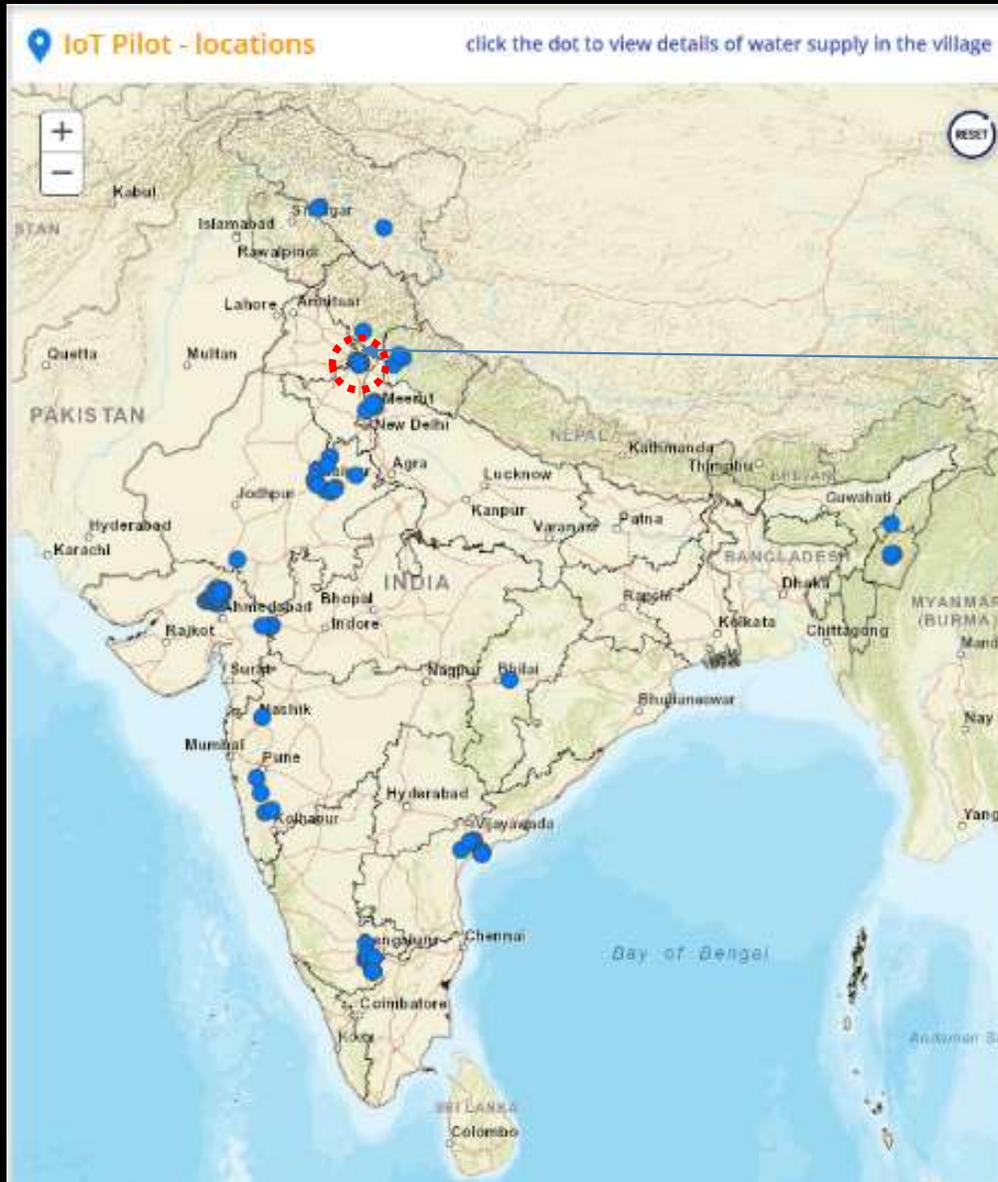
Additional protection could be considered, if necessary

Exploring viable uses



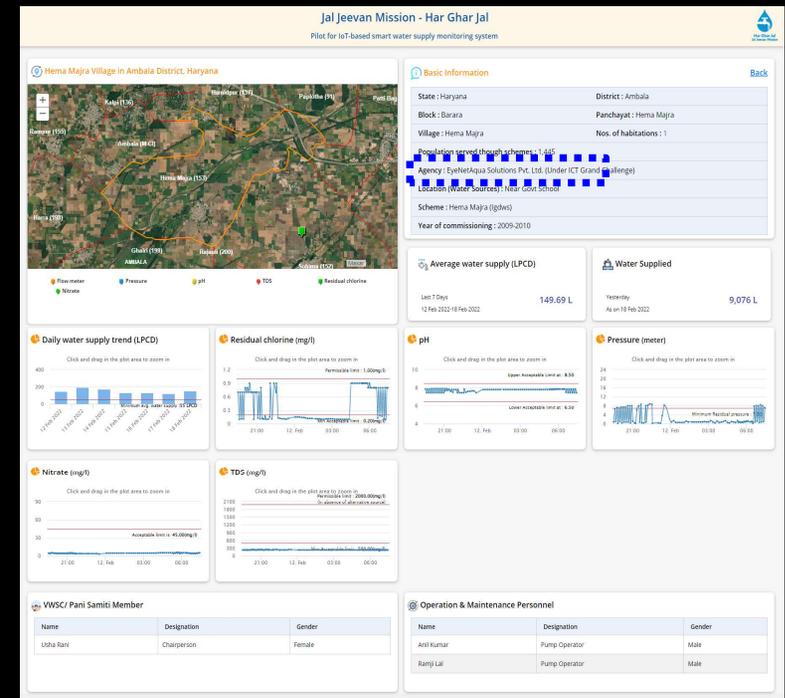


# India's water is being monitored



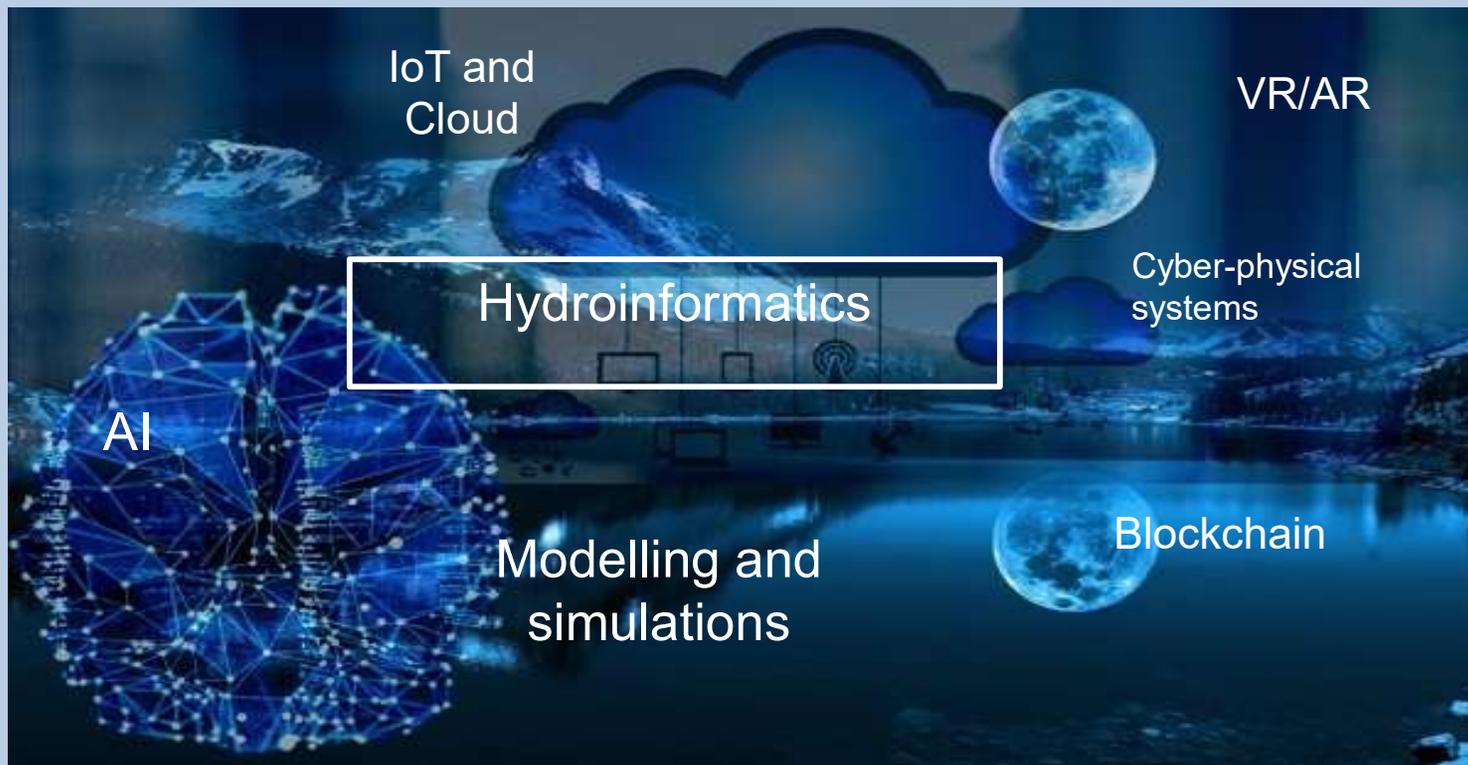
IITM/IISc

Installations made by four companies



# Hydroinformatics

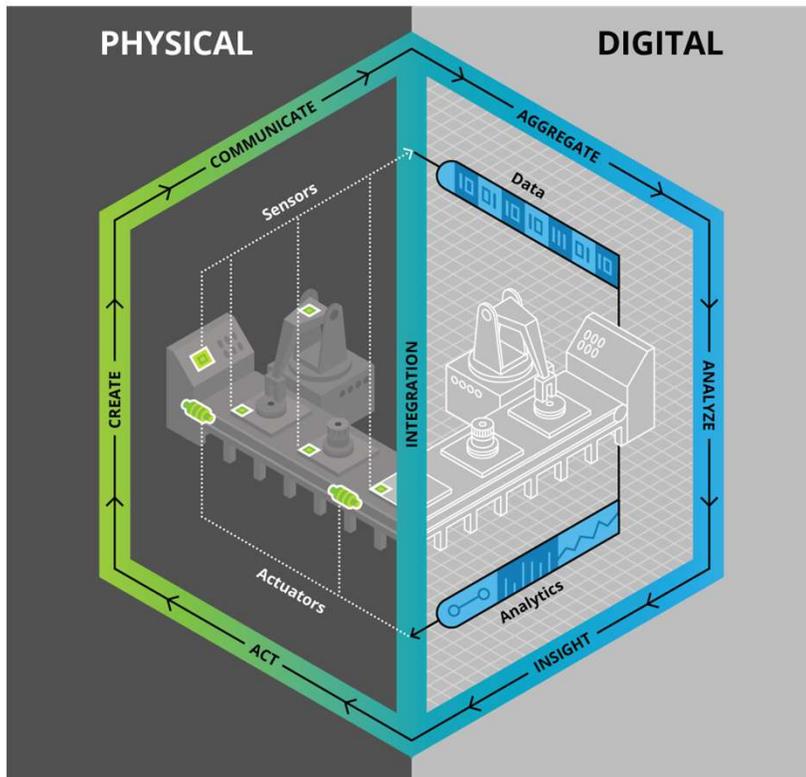
Application of computing technologies for efficient, sustainable and equitable water management.



Water is becoming data and associated opportunities

# Water 4.0

## Digital twin of water resources



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Digital twin is the digital visualization and representation of a physical or natural system, which may gather data continuously from its physical counterpart and interact with it via a control system.

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Create a digital twin of different elements of hydrologic environment – surface water bodies, ground water, rivers, and urban water utilities.

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Data-driven modelling of events such as flood inundation of rural and urban areas with 3D visualization using the digital twin representation of the landscape.

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Integration of real-time modelling of groundwater and surface water, water supply networks and utilities combined with analytics platform more accurate decision making.

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# Traditional knowledge



<https://www.unnatisilks.com/blog/naturally-colored-cottons-a-regain-in-popularity/>

## Arsenic free rice



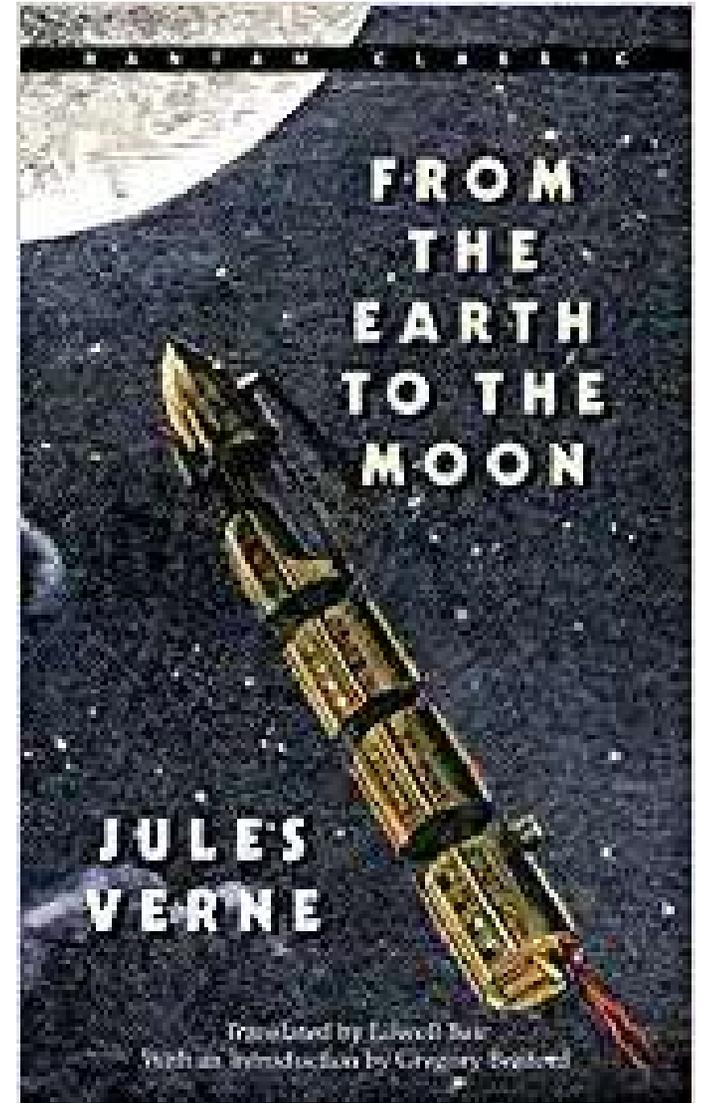
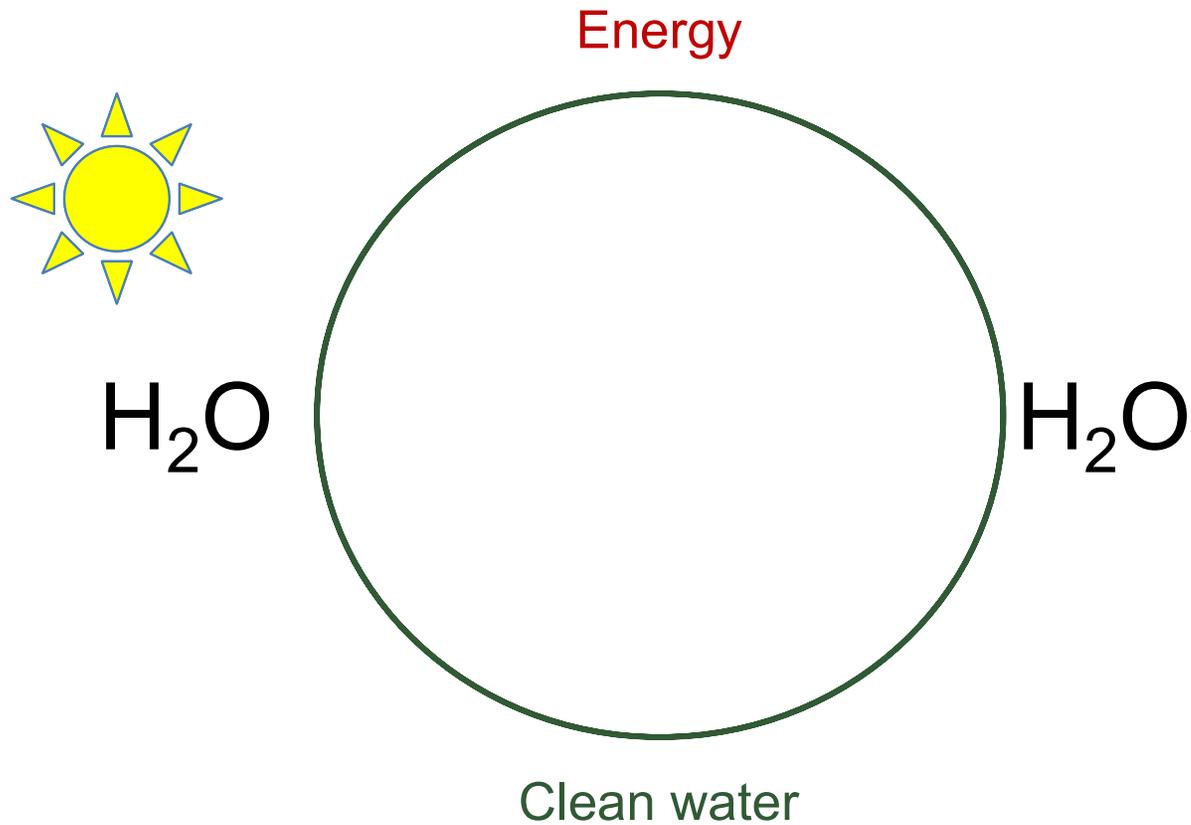
Iron rich, silver rich, etc. rice

So much is happening on the ground



Policy

Our dreams become reality with materials



Affordable, inclusive, sustainable and contextual excellence

## Some simple calculations

Hydrogen + Oxygen → Water + 286,000 joules of energy per mole

1 kg of solar hydrogen is now at Rs. XX and could be Rs. 150 soon.

It can make 143 million J of energy.

Desalination needs 2.4 kWh or 8.84 million joules for 1 CM of water.

1 kg of hydrogen can therefore make 16.56 CM of water.

Or Rs. 9.06 per cubic meter, 0.9 paise per litre!

Well, add efficiency, other costs of plant, transportation, etc.

That world will need water literacy



# Indian Institute of Technology Madras



Directors - past and present

# Thank you all



Associate Editor

ACS  
Sustainable  
Chemistry & Engineering

