Since 1959

Technological Advancements for Achieving Water Sufficient GPs

T. Pradeep

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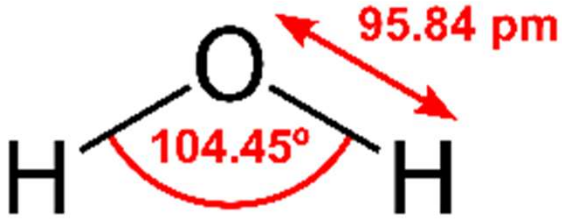
https://pradeepresearch.org

Professor-in-charge

International Centre for Clean Water

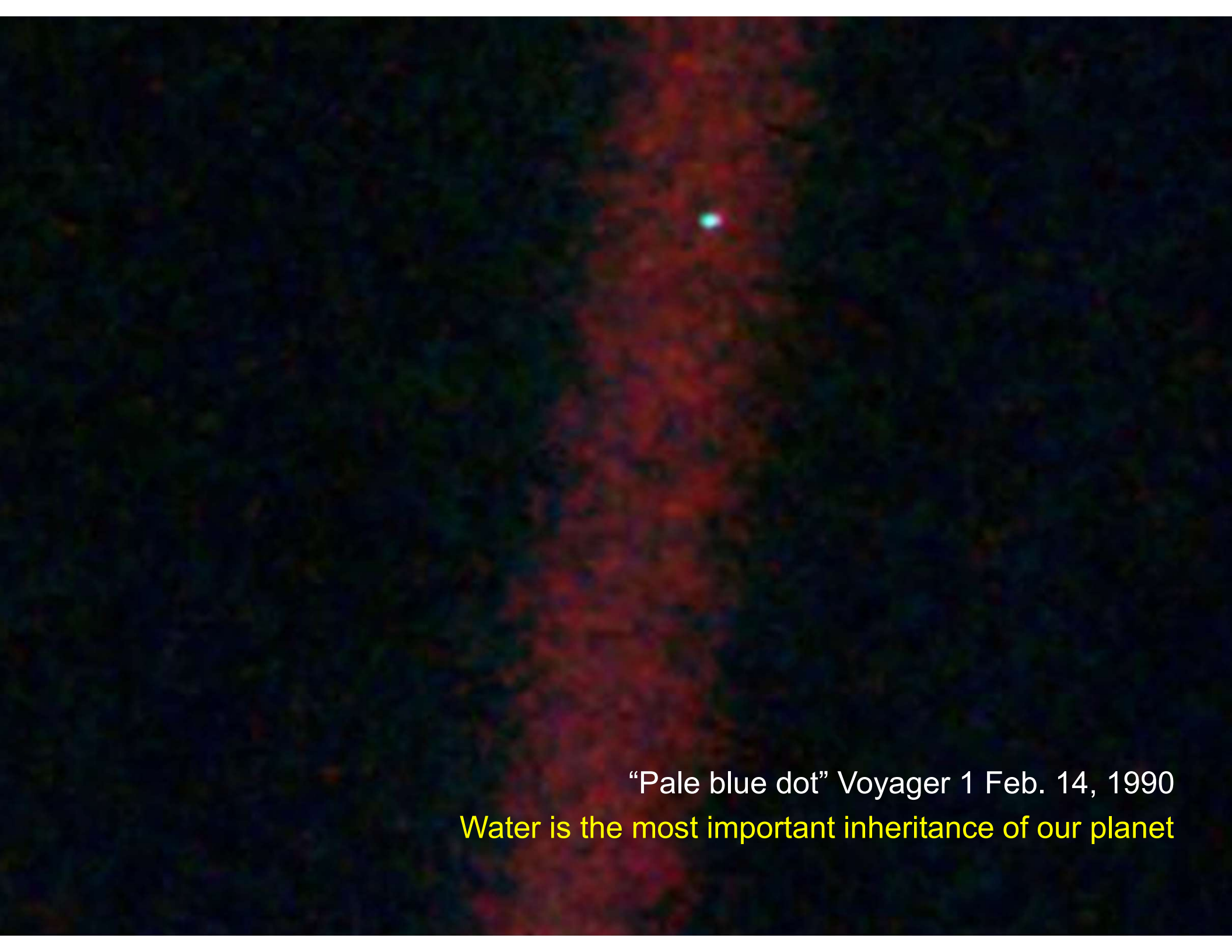
Rekha Yadav, Joint Secretary
Ministry of Panchayati Raj



Azadi Ka Amrit Mahotsav Celebration of ICONIC Week, Government of India Ministry of Panchayati Raj, Vigyan Bhawan, New Delhi, April 11-17, 2022

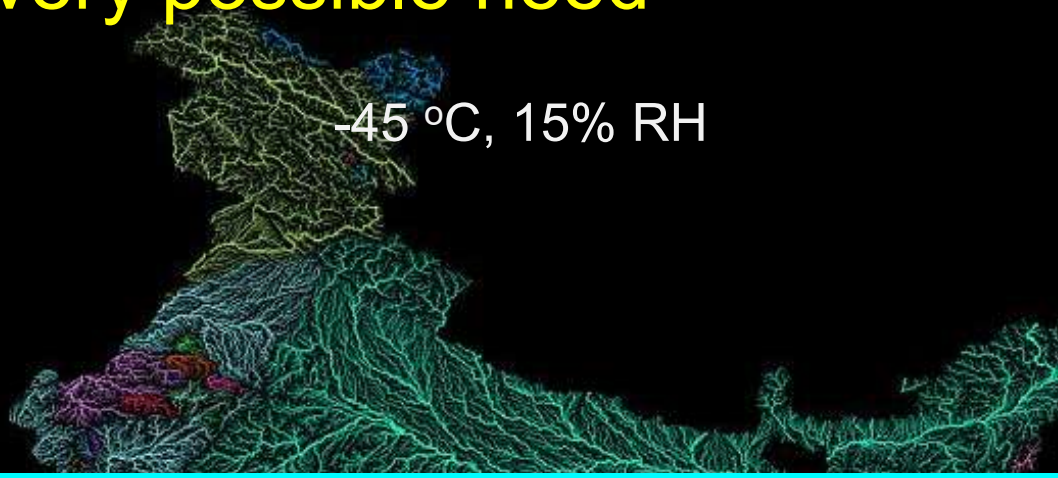
Water is at the centre of action

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


“Pale blue dot” Voyager 1 Feb. 14, 1990
Water is the most important inheritance of our planet

Challenges

We have every possible need



Arsenic
Fluoride
Uranium
Mercury
Chromium
Perchlorate
Nitrate
Pesticides
Antibiotics
Plastics

Issues of sustainability are paramount for villages

Villages need advanced technologies

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.

From S. Vishwanath

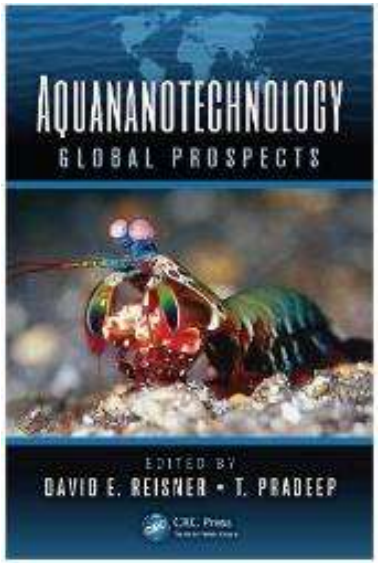
+45 °C, 99% RH

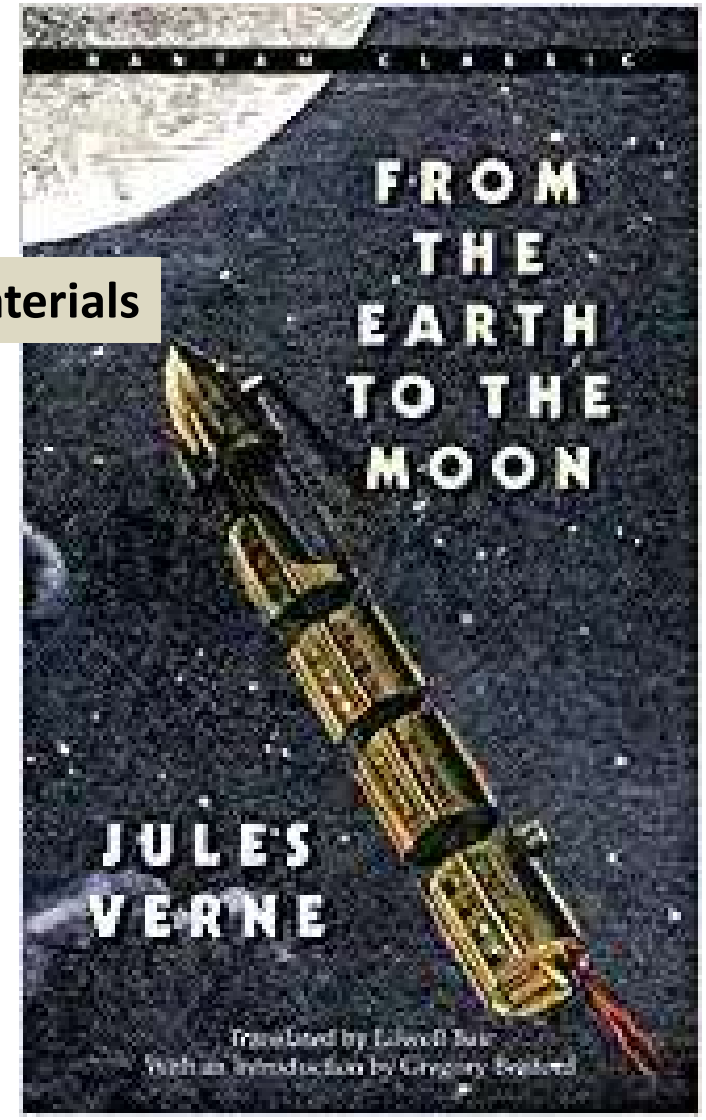
Our dreams become reality with materials

Affordable clean water is a matter of advanced materials

Emergence of nanotechnology

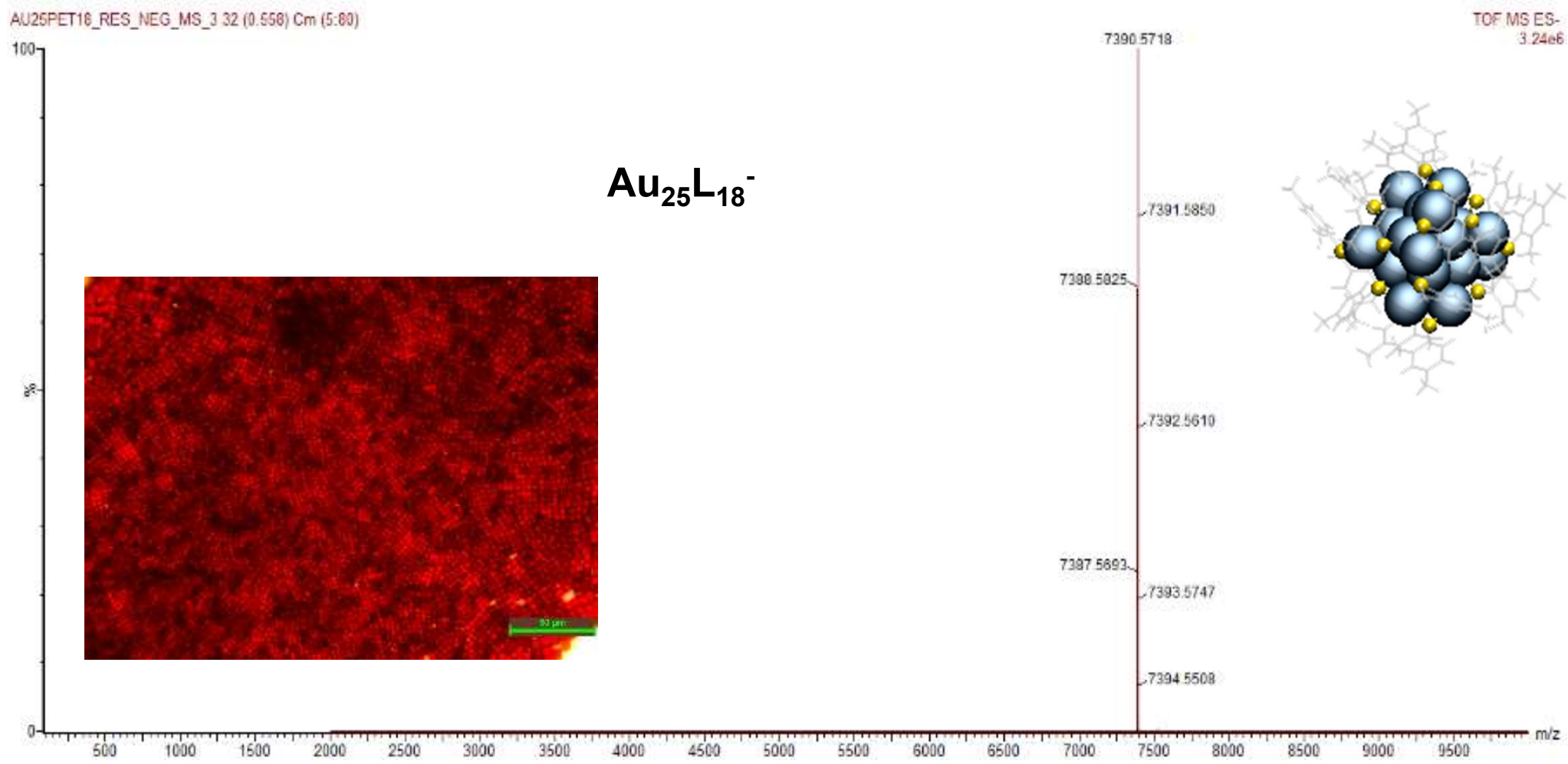
New adsorbents
New sensors
New catalysts
Novel phenomena
New devices





Nanomaterials are now atomically precise

With advanced methods of analysis, we study them in detail



$Au_{25}L_{18}^-$

T. Pradeep et. al. *Acc. Chem. Res.* 2018; 2019.

Nanomaterials can solve real problems

A (Affordable)
S (Scalable)
S (Sustainable)
U (Universal)
R (Rapid)
E (Excellent)
D (Distinctive)

R. A. Mashelkar

Supplying arsenic free water to 1.2 million people, every day

Supplying 60 million litres of clean water every day

ACS Sustainable Chemistry & Engineering Editorial, December 2016

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

Mohan Udhaya Sankar[1], Sahaja Aigal[1], Shihabudheen M. Maliyekkal[1], Amrita Chaudhary, Anshup, Avula Anil Kumar, Kamalesh Chaudhari, and Thalappil Pradeep[2]

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 nano-
composites to
other contami
affordable, all-
without electr
synthesis of st
uously in the
drinking wate
surfaces. Here
be synthesized
out the use of
sand-like prope
forms. These n
water purifier
ily. The ability
ambient temp
water purifica

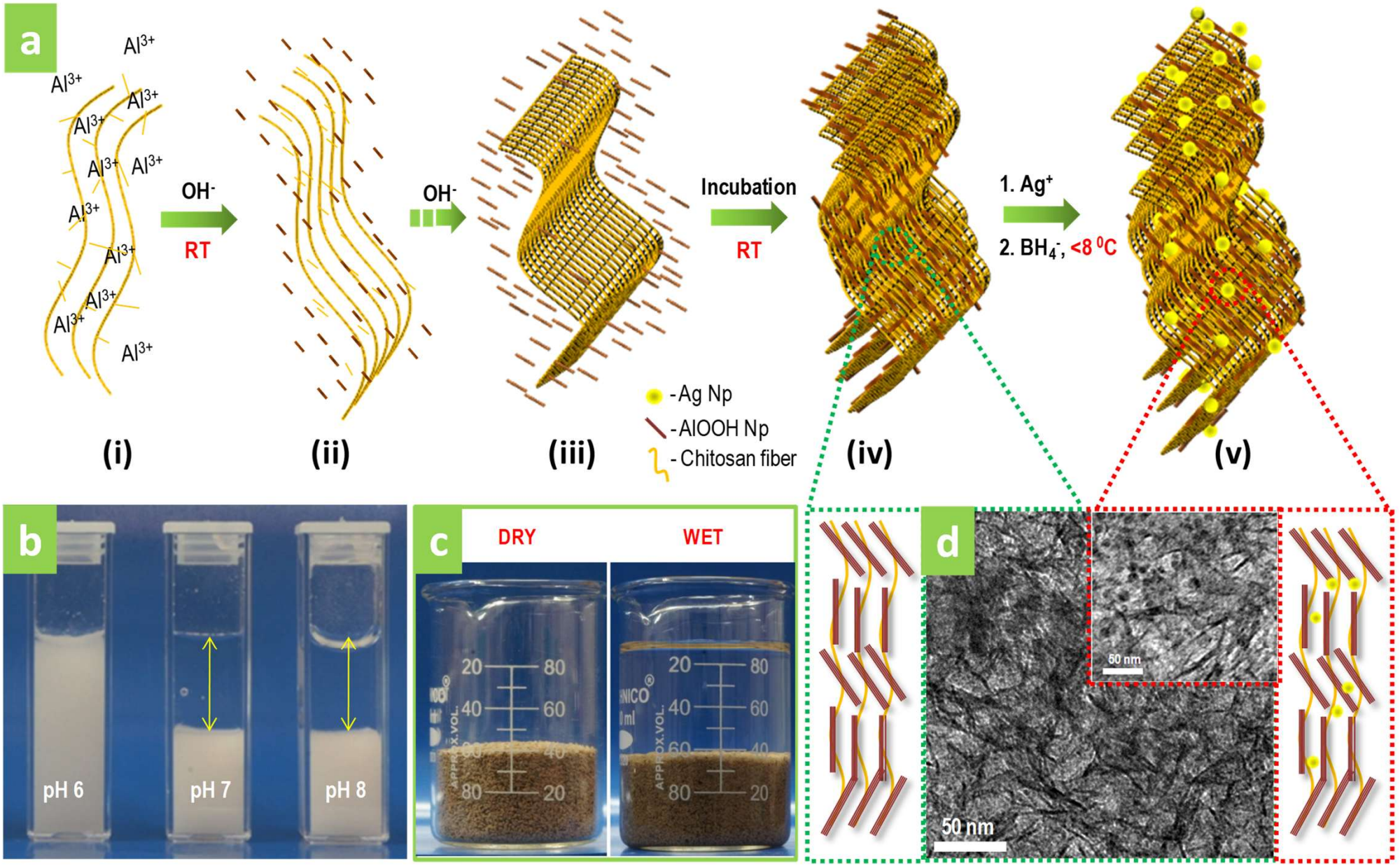
hybrid | green |

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

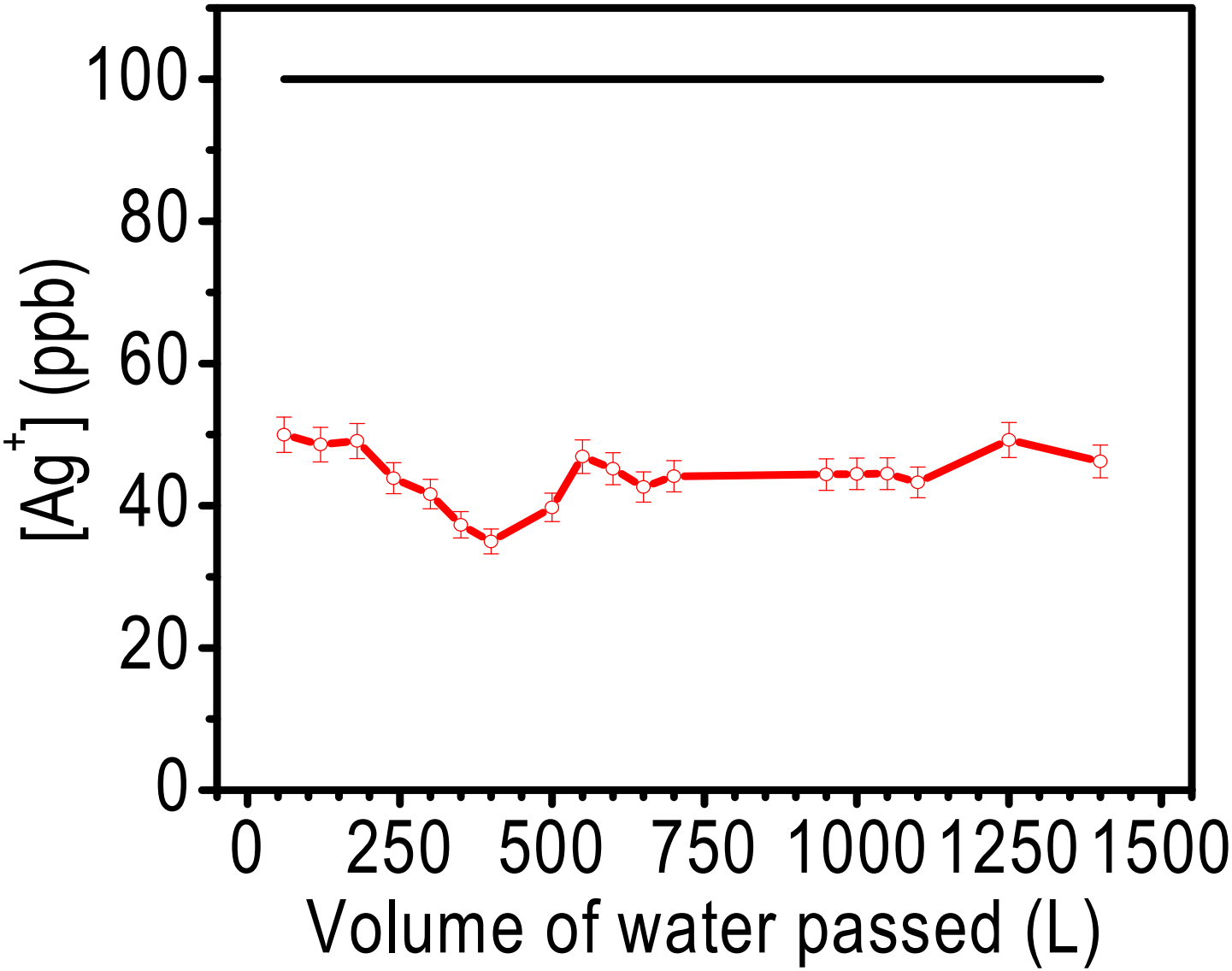
In this work, we demonstrate a unique family of nanocrystalline tal oxyhydroxide-chitosan granular composite materials pre-ed at near room temperature through an aqueous route. The gin of crystallinity in the composition is attributed to abundant -O- -OH functional groups on chitosan, which help in the crys-ization of metal oxyhydroxide and also ensure strong covalent ding of the nanoparticle surface to the matrix. X-ray photo-tron spectroscopy (XPS) confirms that the composition is rich h surface hydroxyl groups. Using hyperspectral imaging, the ence of nanoparticle leaching in the water was confirmed. ther, a unique scheme to reactivate the silver nanoparticle face is used for continual antimicrobial activity in drinking ers. Several other composites have been developed that can venge other contaminants in water. We demonstrate an af-dable water purification device based on such composites de-oped over several years and undergoing field trials in India, as otential solution for widespread eradication of the waterborne ease burden.

ults and Discussion

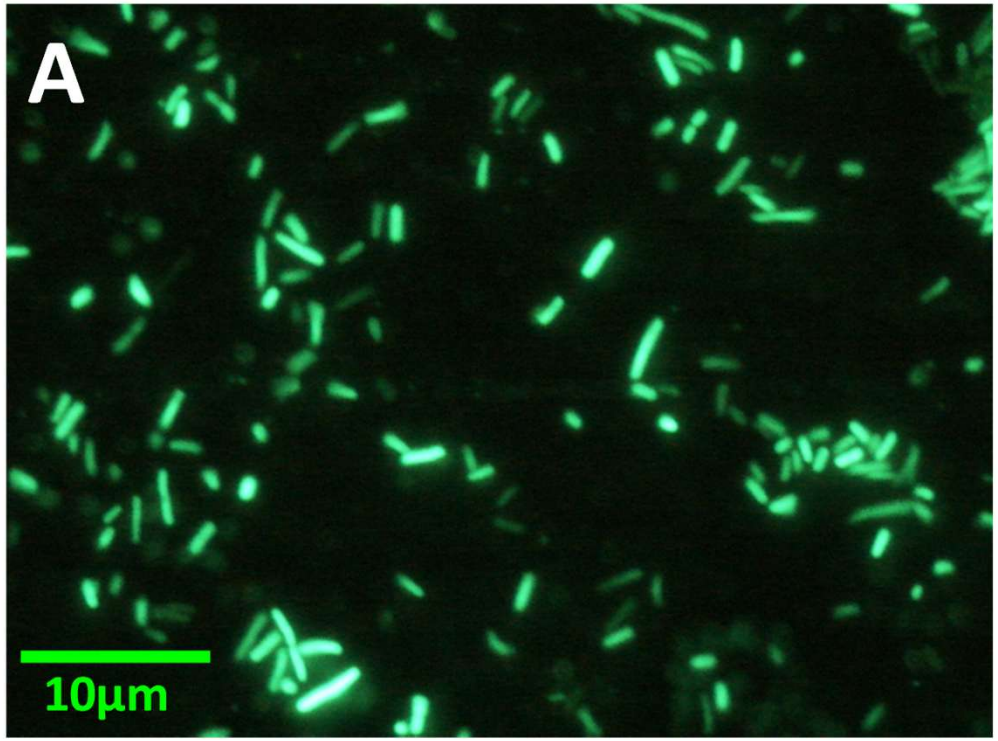
New materials

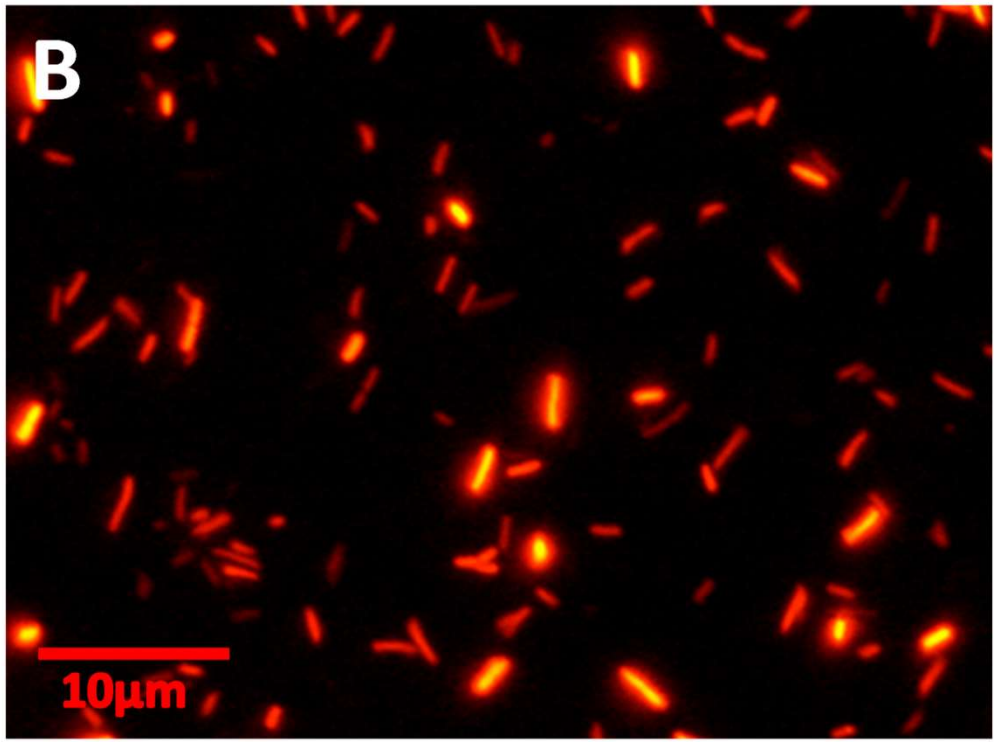


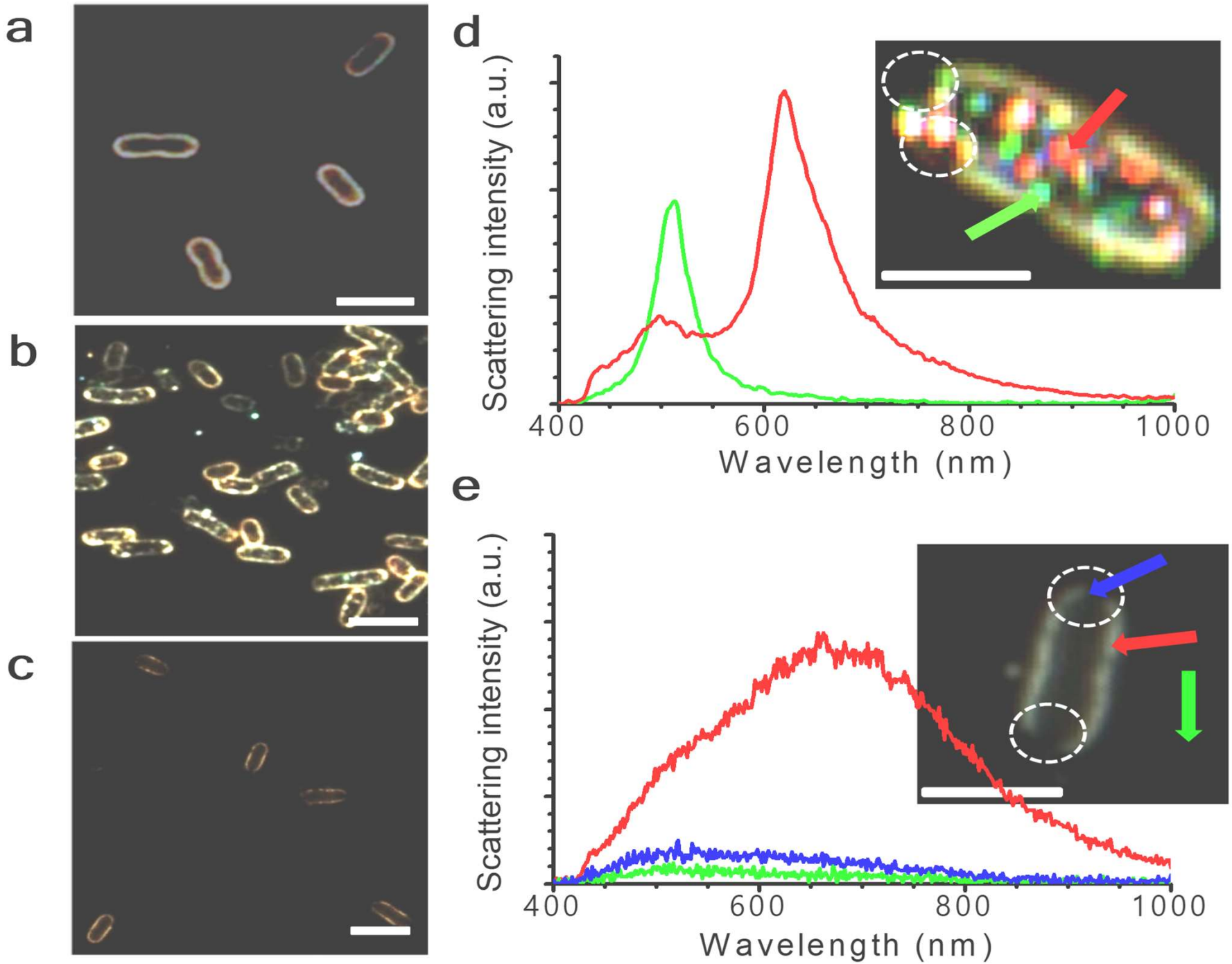
What is special?

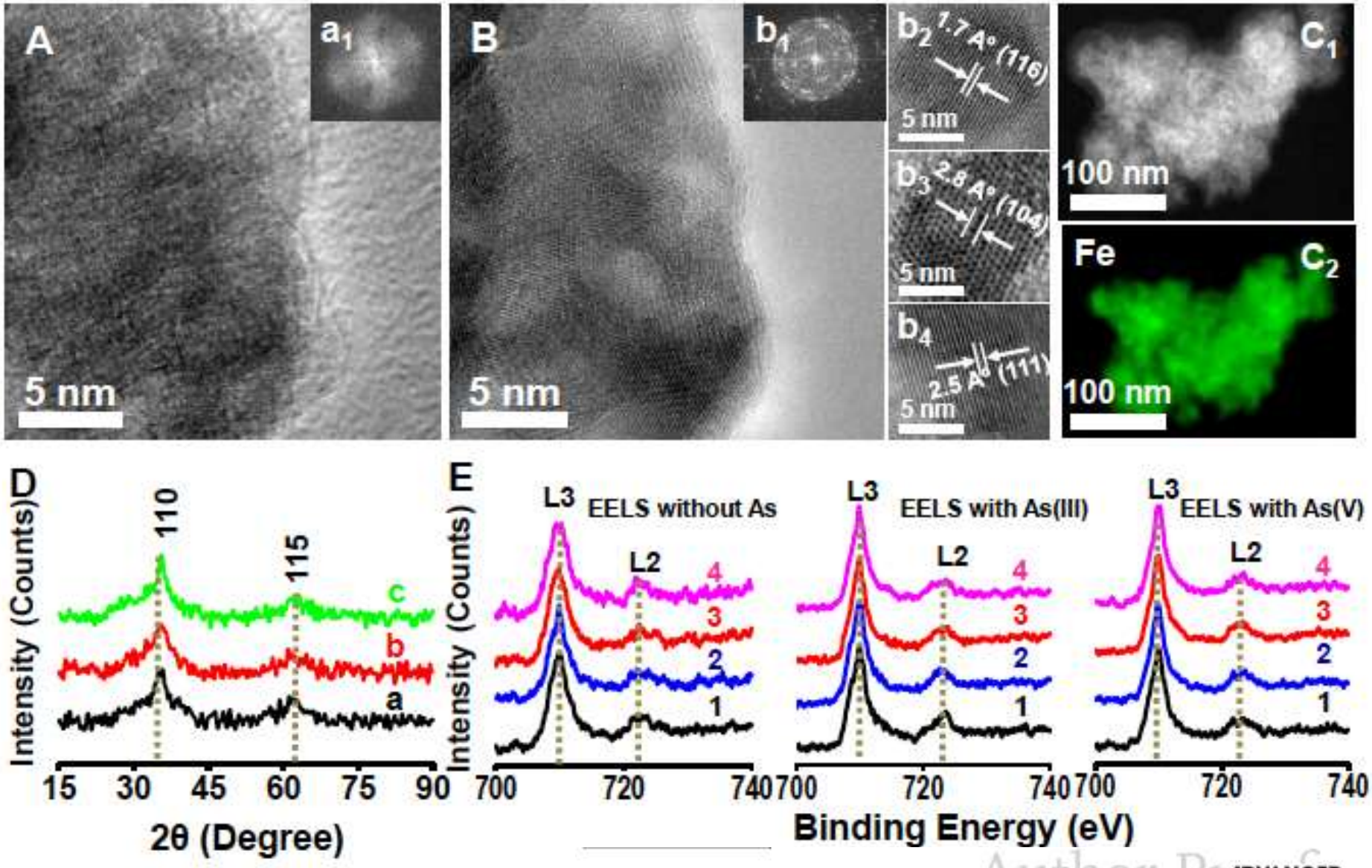


Live/dead staining experiments






a
b
c
d
Scattering intensity (a.u.)
400
600
800
1000
Wavelength (nm)
e
Scattering intensity (a.u.)
400
600
800
1000
Wavelength (nm)

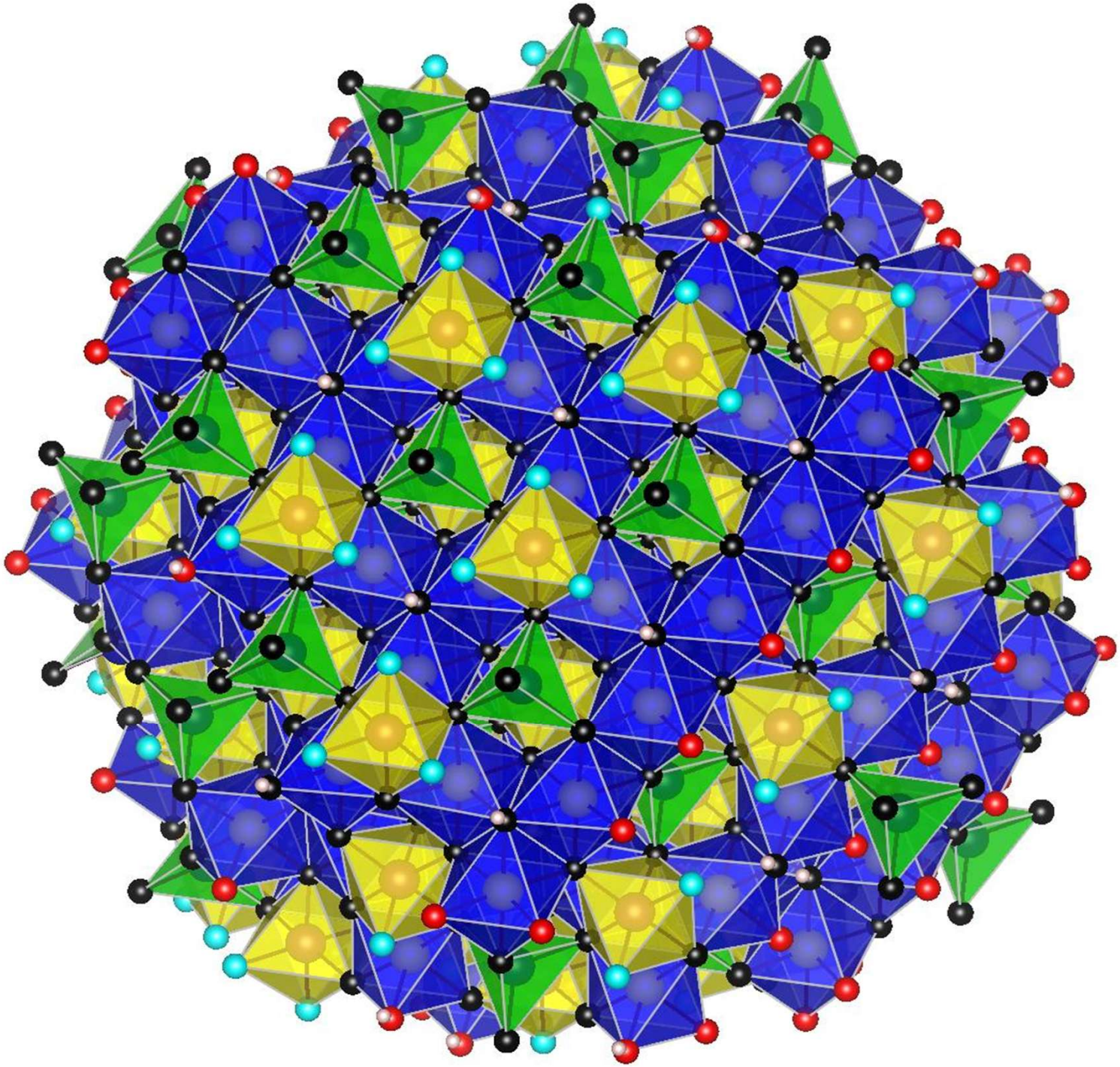


www.advmat.de ADVANCED MATERIALS

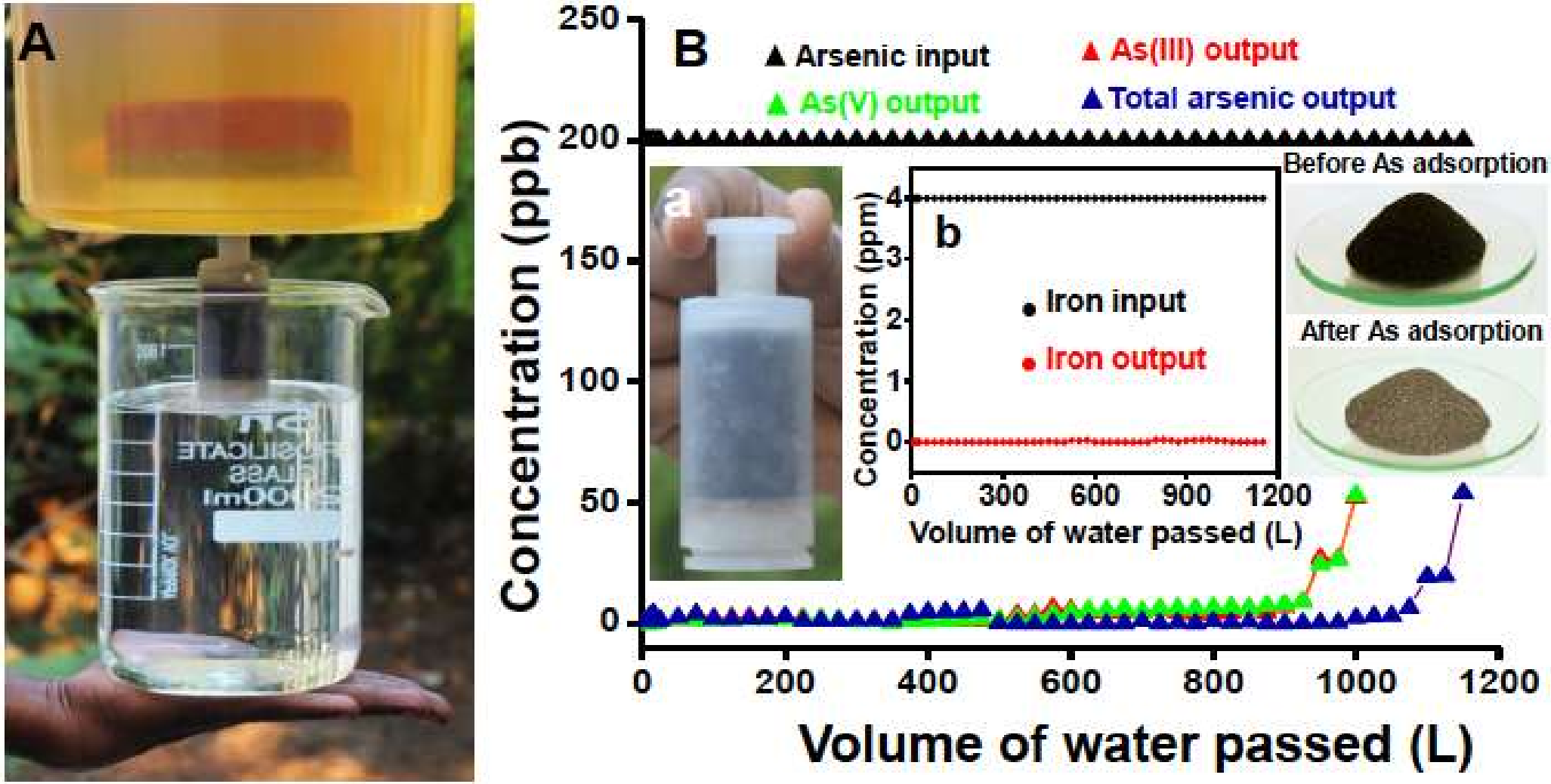
Confined Metastable 2-Line Ferrihydrite for Affordable Point-of-Use Arsenic Free Drinking Water

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**

A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 1604260.



Chennu Sudhakar, et al. *ACS Sustainable Chemistry & Engineering*, 6 (2018) 9990-10000



A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 1604260.

Changing the dynamics in the field

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

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


Completed 3 years maintenance (stipulated: 2 years)
for 330 bamboo unit project in Nadia, WB
03471-250221
Minimum uptime: 91%, Maximum: 98%
Only 4/330 have reported arsenic above 10 ppb
Benefiting over 100,000 children and villagers
Glimpse of Installed units (330 nos)

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

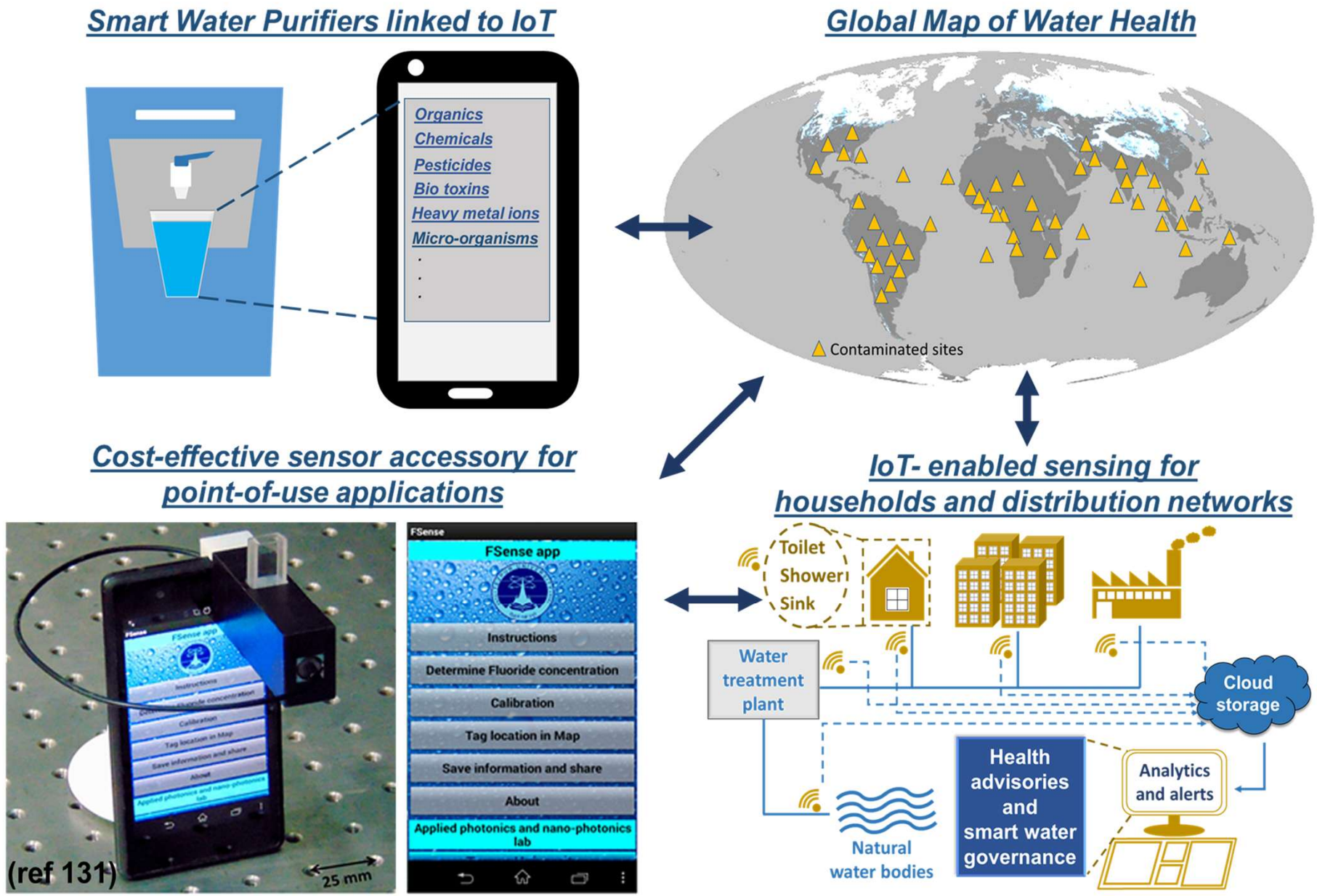
Community units – 25 KL – 1000 KL

Cleanwater at 2.1 paise per litre!

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

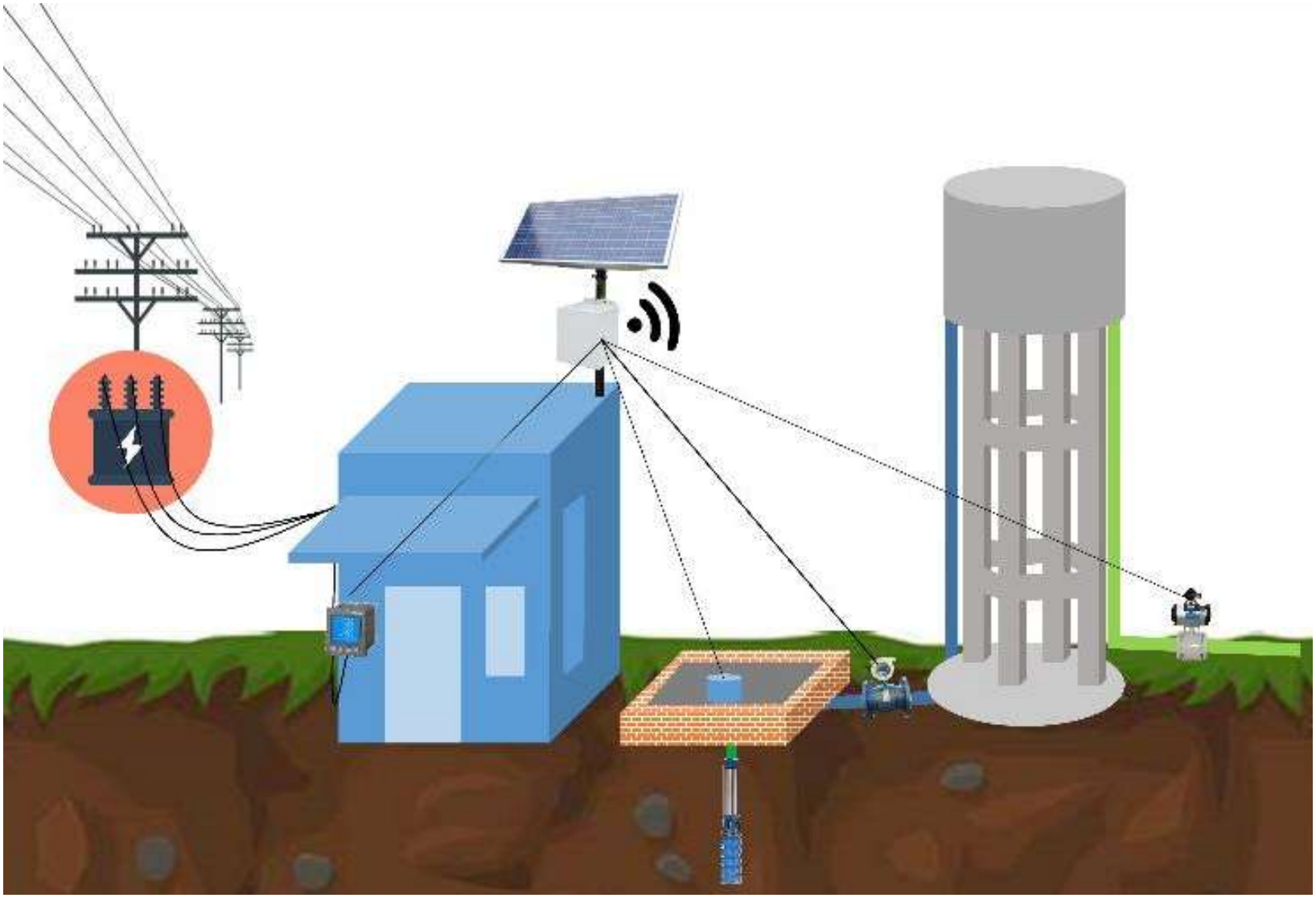
	Design population	1,071	Plant capacity/70 LPCD
Sr.No.	**Item/Description**	**Cost / Quantity**	**Remarks**
1	Cost of Replacement of Iron removal media	56400	After minimum two years if Iron concentration is more than 5 ppm. But iron concentration is more than 5 ppm at only two to three places. Therefore 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 litr of water	2.1 Paise per ltr	
9	Cost of replacement of media	**1.36** **40.80**	Rs. per head per day =Media replacement cost per year/365/Design population per head per month for 70 LPCD water

Smart water purifiers and big data

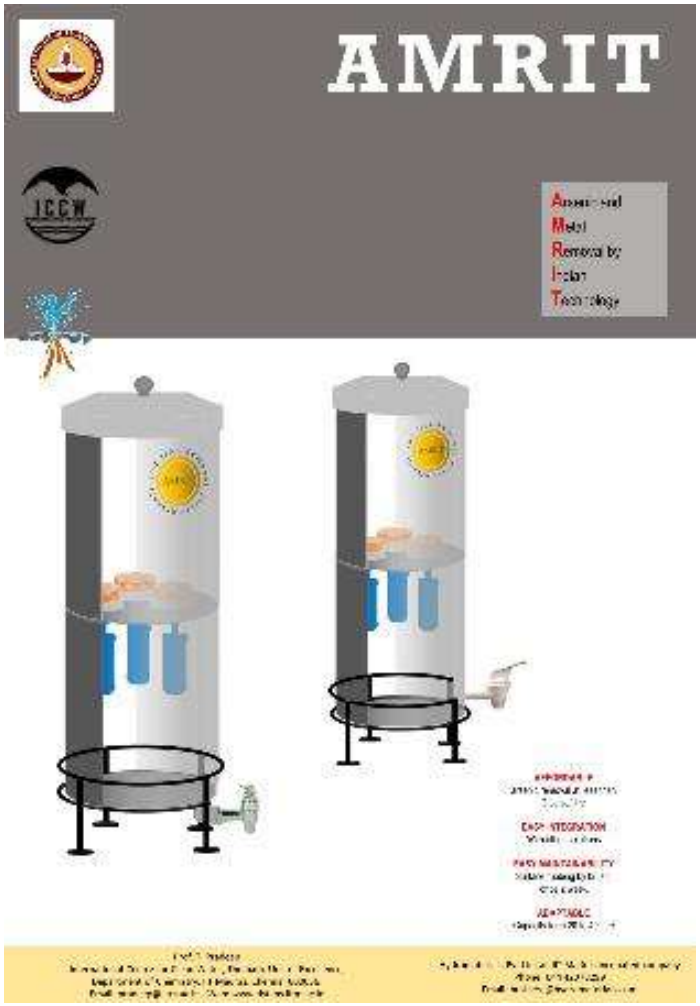


Ankit Nagar and T. Pradeep 14(2020). *ACS Nano*, 6420-6435

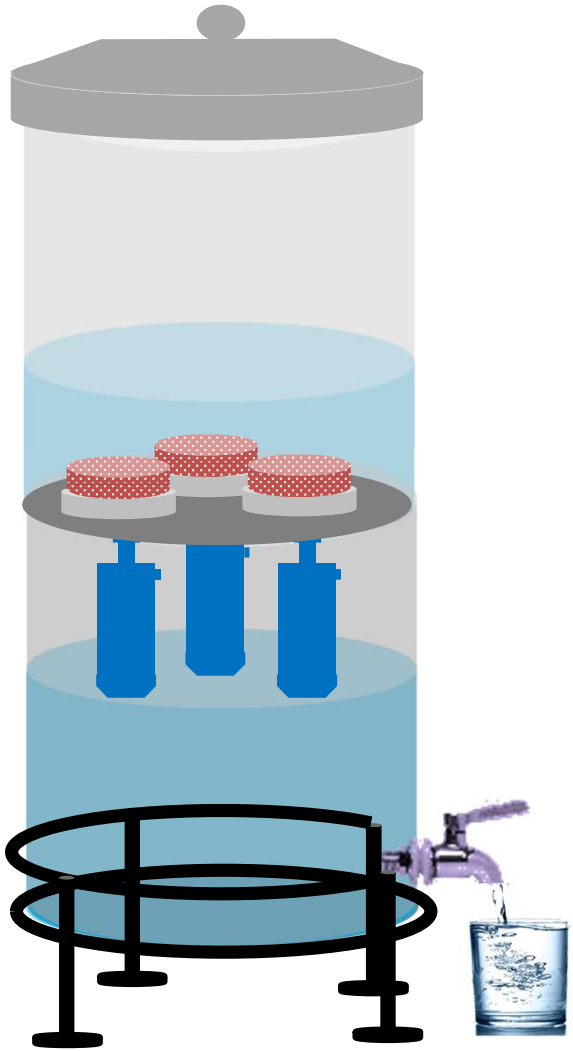
Automation of water supply scheme

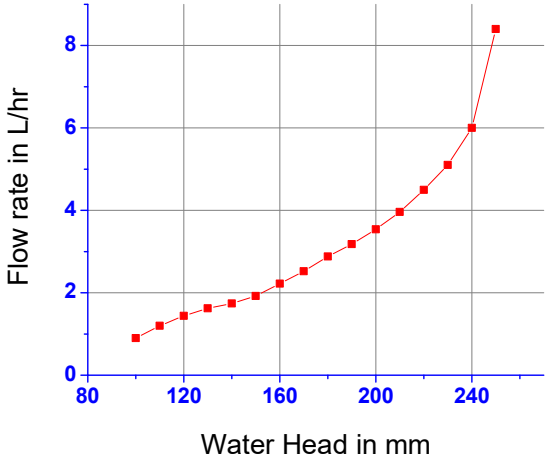


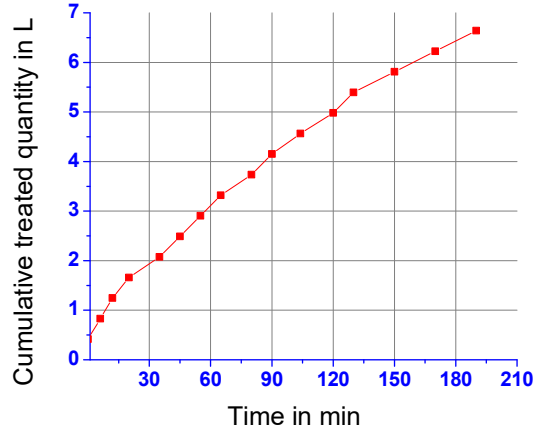
AMRIT – Household Water Purifier



About 12,800 household water purifiers are provided to Arsenic and Uranium affected villages where retrofitted treatment plants are not installed. This water purifier removes turbidity, Iron and Arsenic/Uranium.




Flow rate in L/hr
0
2
4
6
8
80
120
160
200
240
Water Head in mm

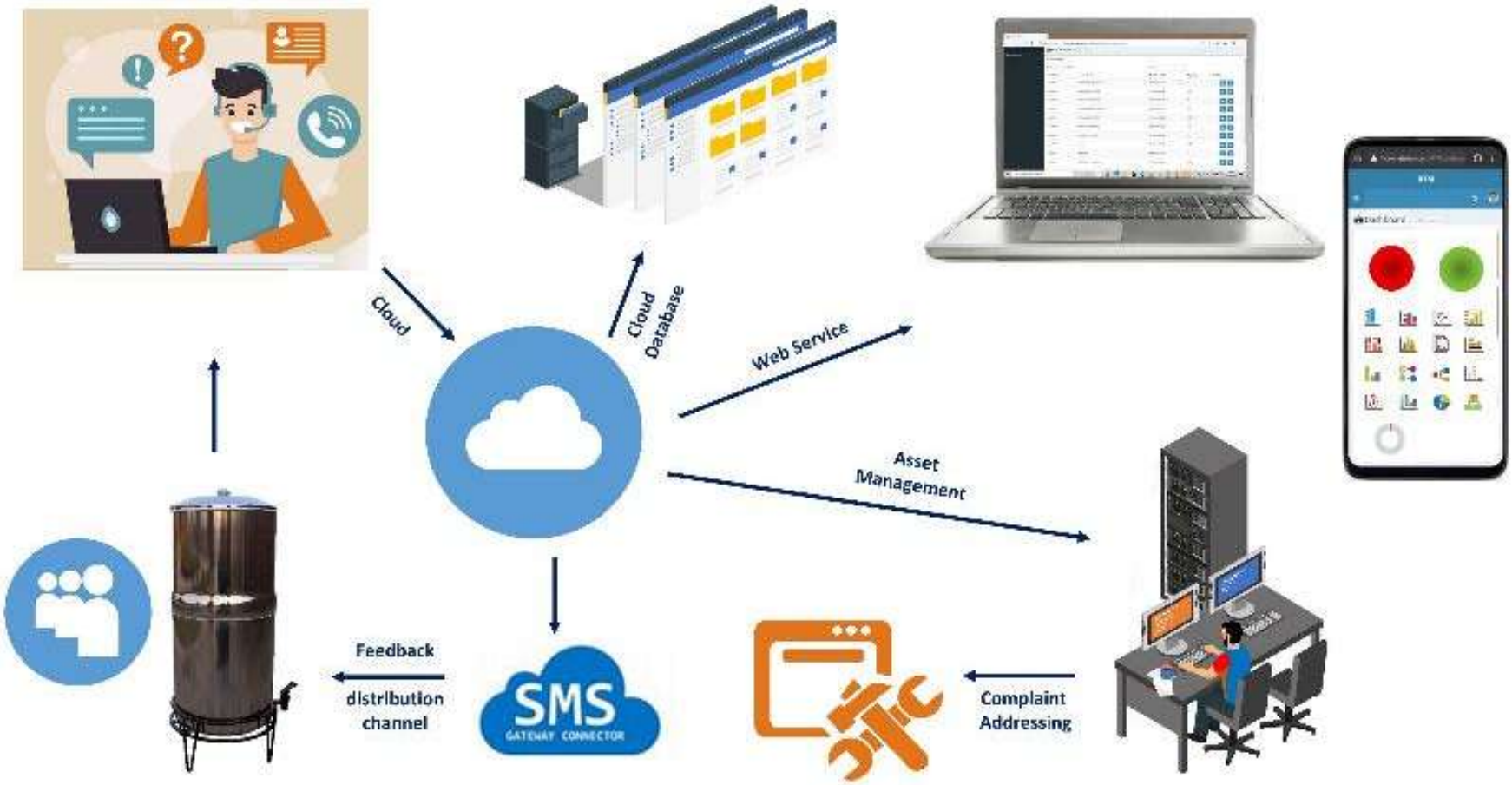

Cumulative treated quantity in L
0
1
2
3
4
5
6
7
30
60
90
120
150
180
210
Time in min

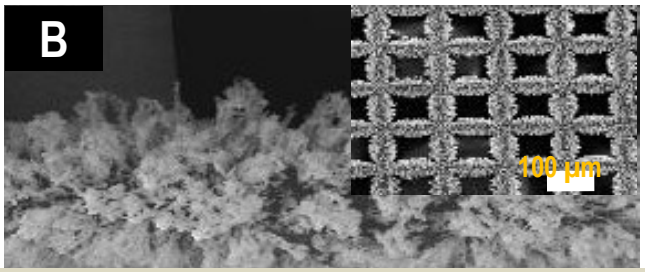

12 : 43 : 13
04-01-2021 Thursday
Mari Nauabad

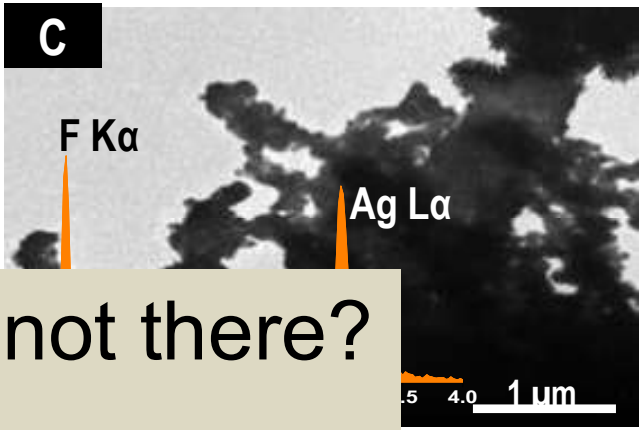
There is no reason for anyone to suffer from water quality – As, U, F, Hg,….

Glimpses of household water purifier

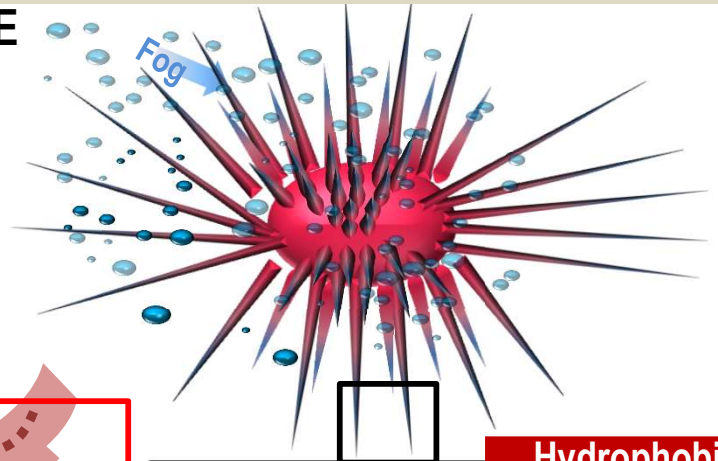
Snapshot view of household water purifier customer care web platform

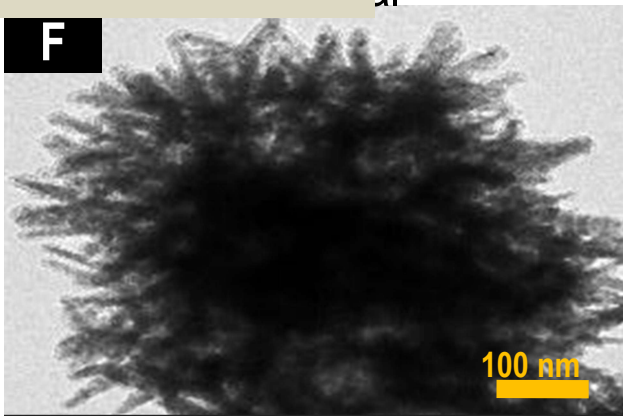


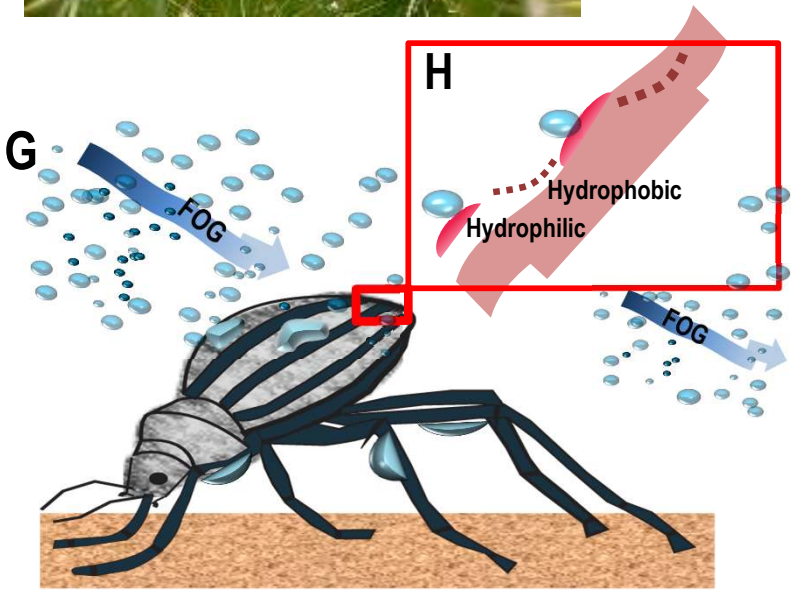


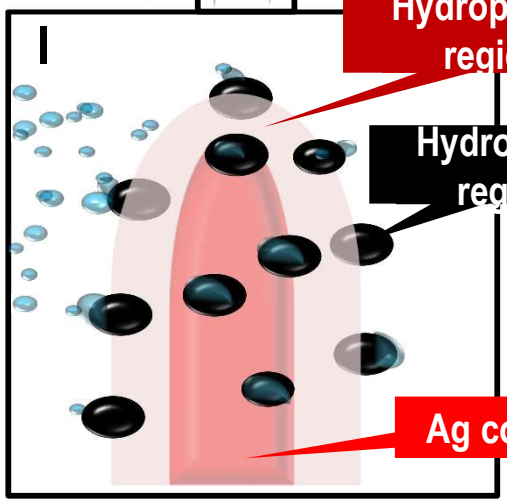


What do we do when water is not there? Harvest humidity!

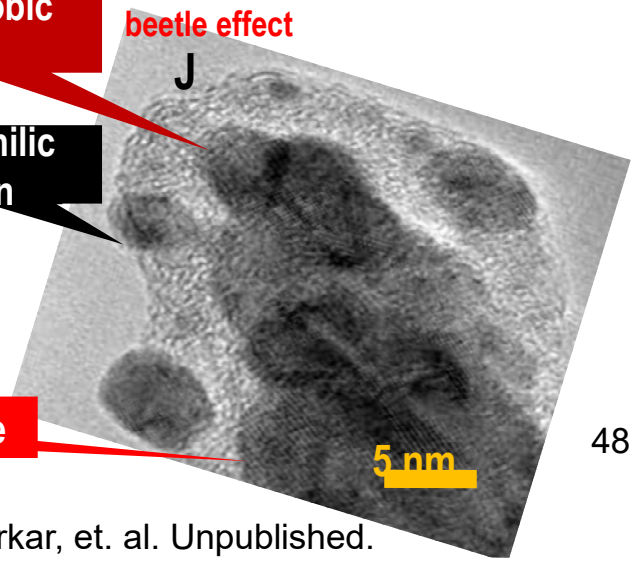




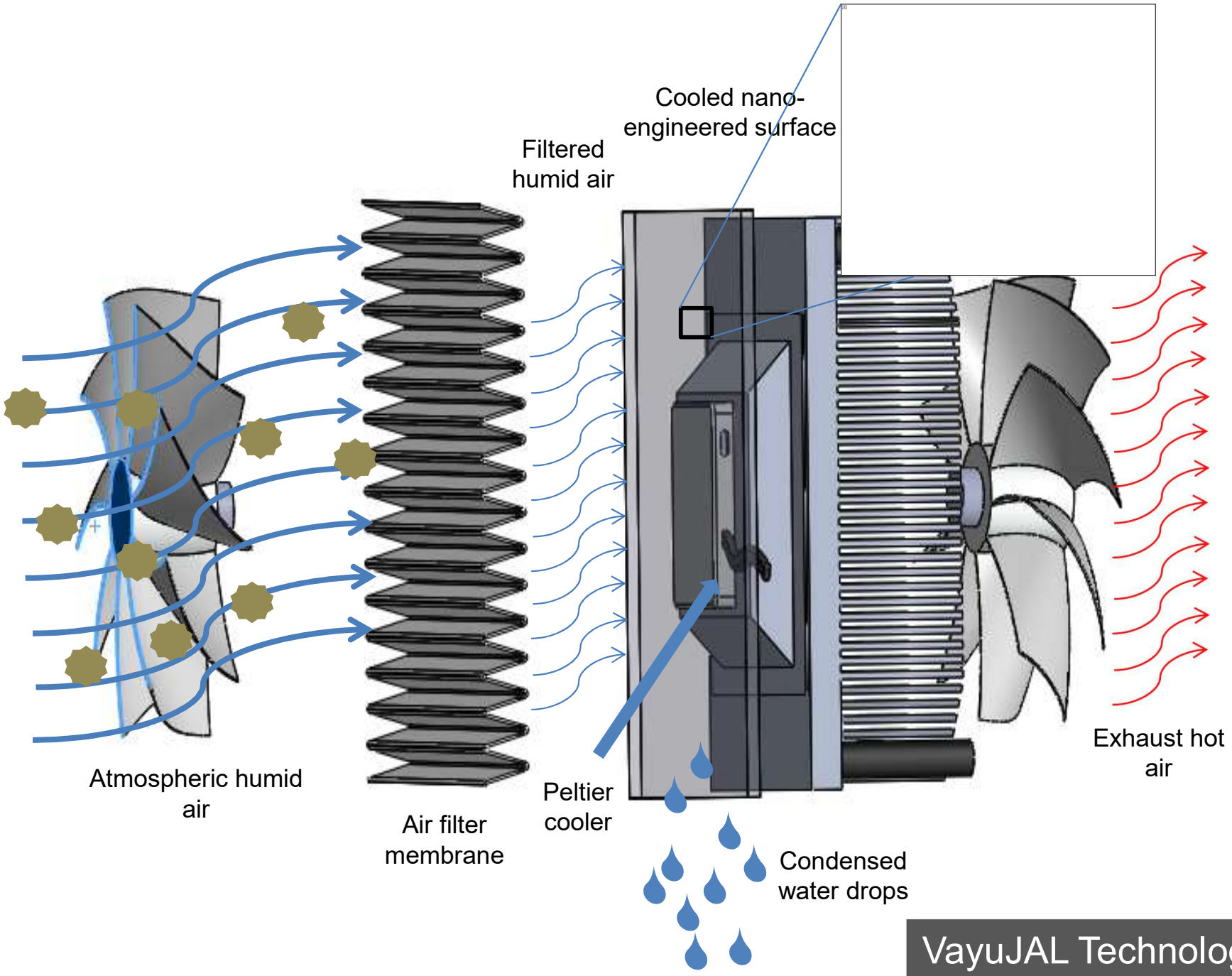




Combination of cactus and Namib desert beetle effect



Depanjan Sarkar, et. al. Unpublished.

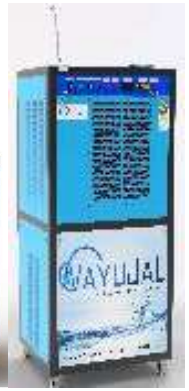


VayuJAL Technologies Pvt. Ltd.

Ramesh Kumar Soni and Ankit Nagar

Products in the field

35 LPD



120 LPD

400 LPD

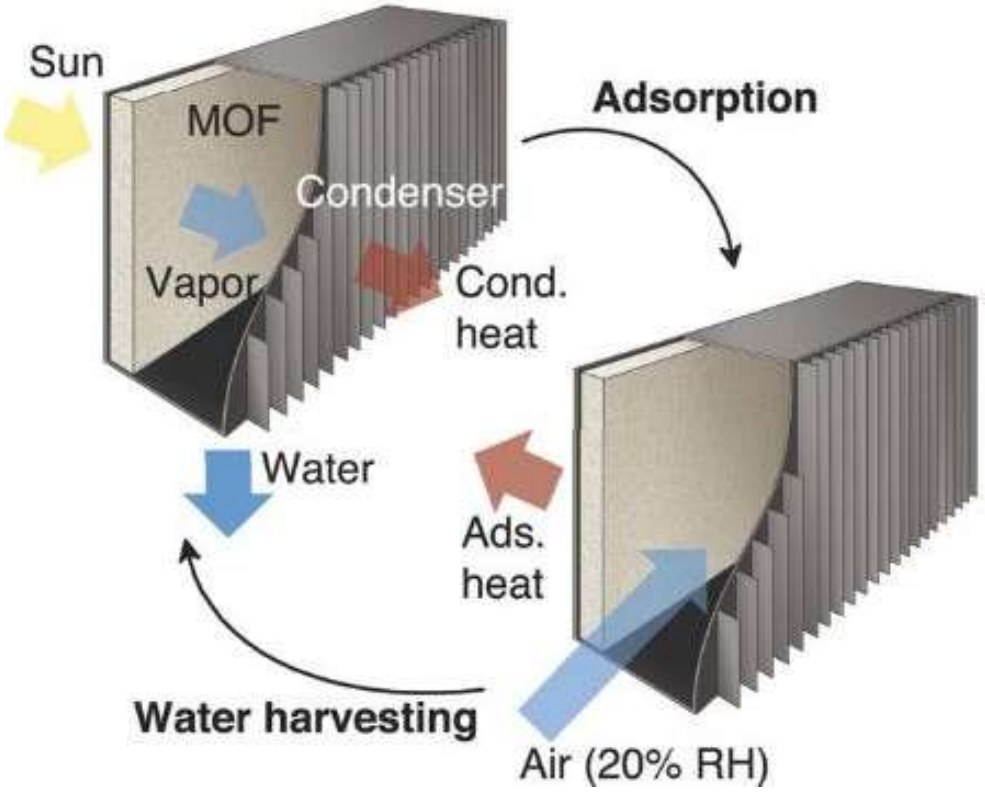
1000 LPD

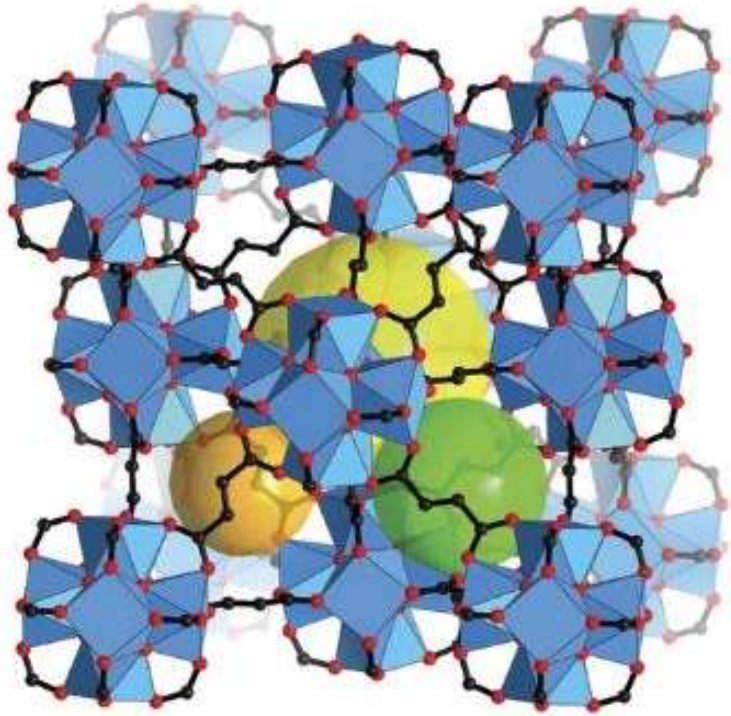
2000 LPD

(LPD: Litres per day)

Sustainable atmospheric water harvesting

Solar- heat-enabled atmospheric water capture at a relative humidity as low as 20%

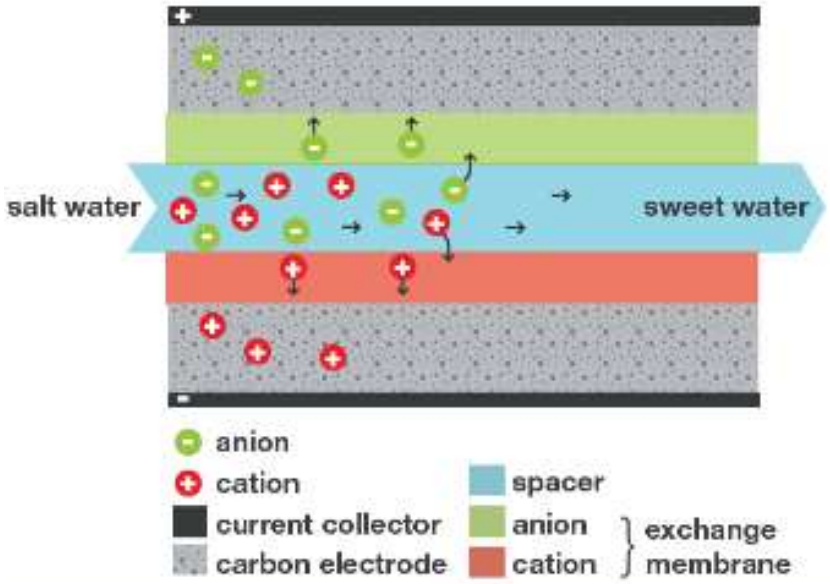


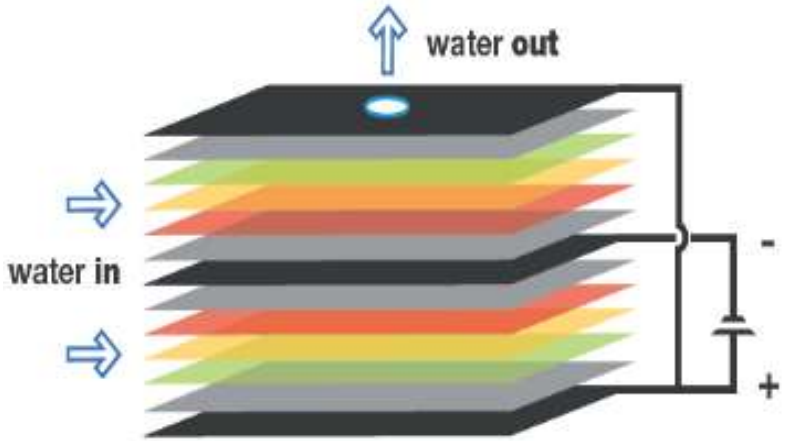


Porous metal-organic framework (MOF-801, $Zr_6O_4(OH)_4(fumarate)_6$)

Kim Hyunho, et al. *Science,* 356 (6336) 2017

Capacitive Desalination (CDI) – brackish water





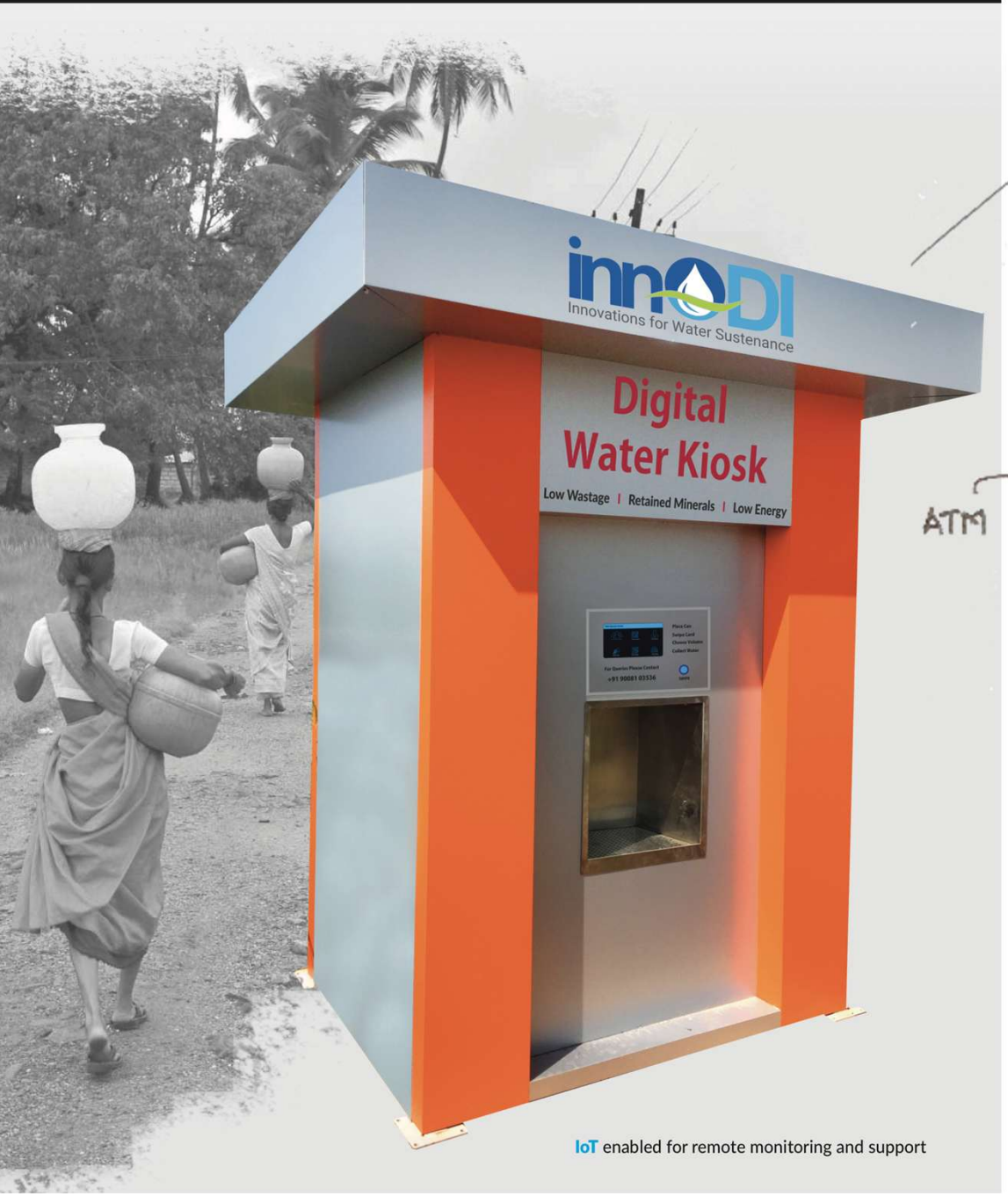
innODI

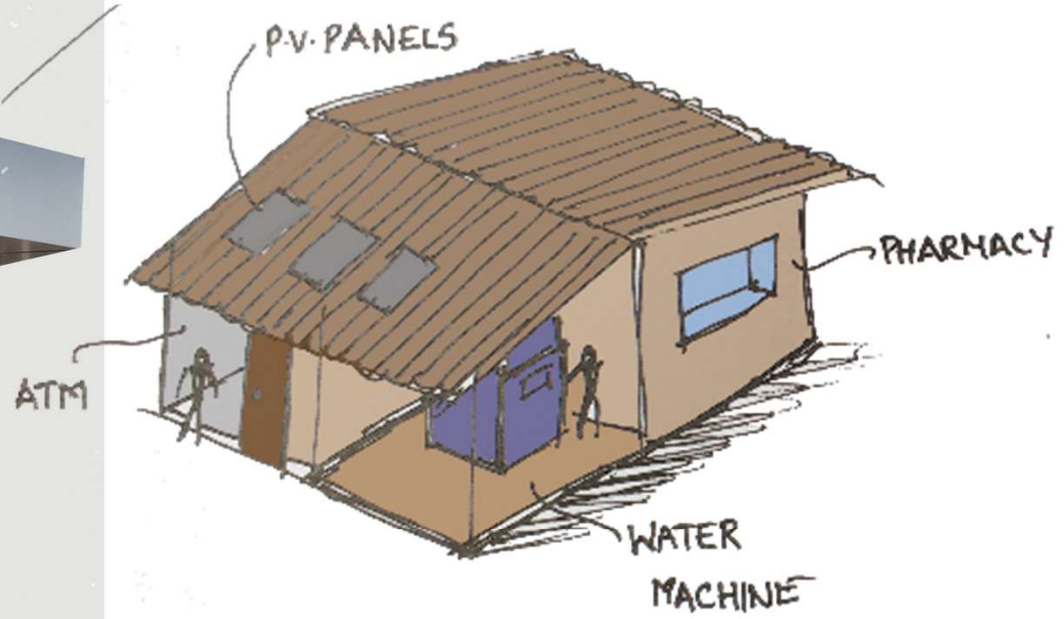
Our new company

Soujit Sengupta, Rabiul Islam and others

DIGITAL WATER KIOSK

for community drinking using CDI Technology

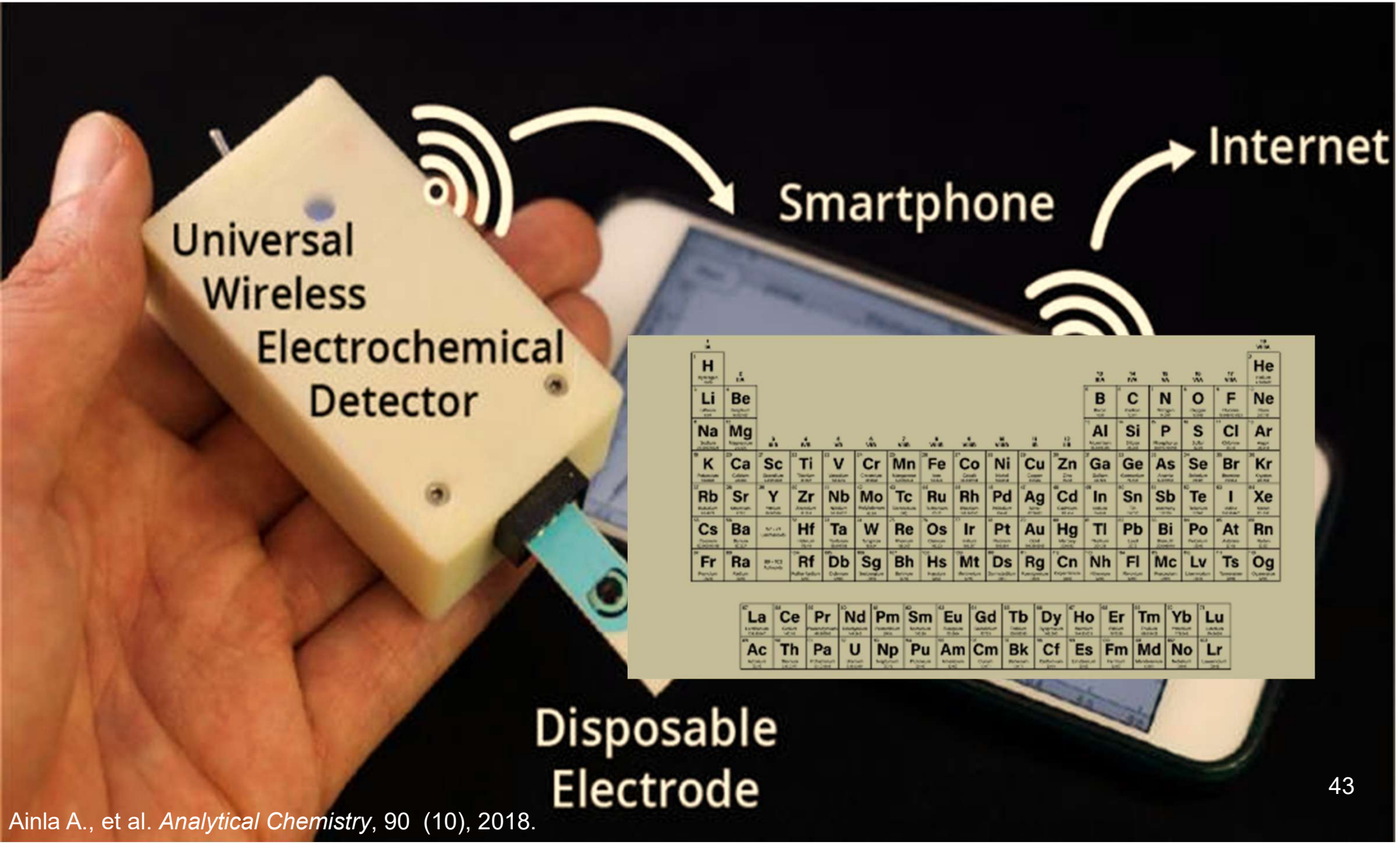




Products under implementation

Vijay Sampath and Tullio Servida

Analytical devices

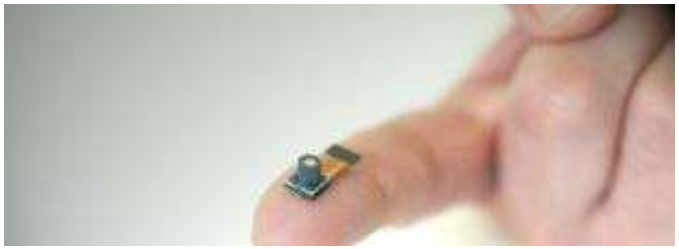


Ainla A., et al. *Analytical Chemistry*, 90 (10), 2018.

Sensors and new opportunities

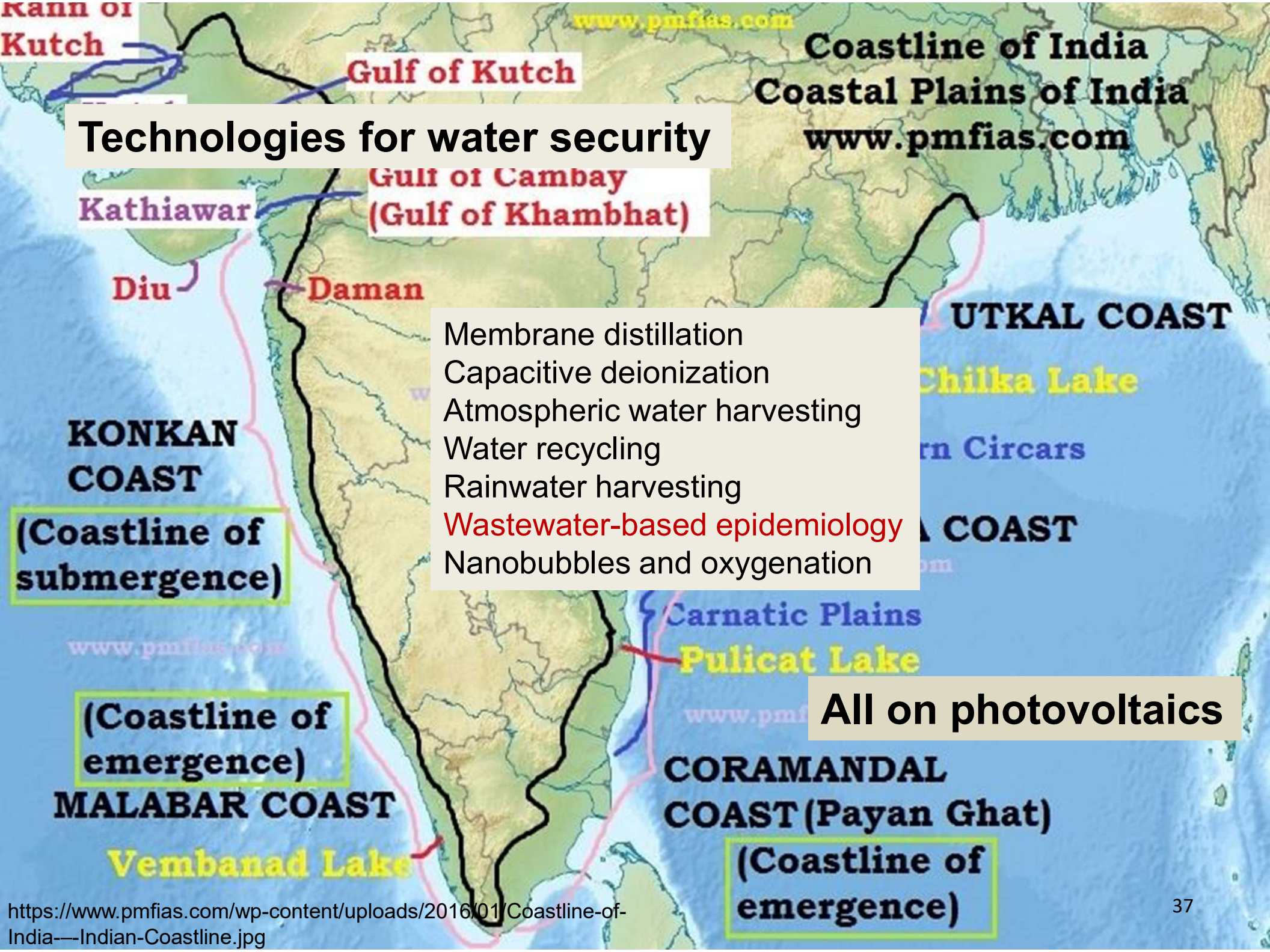
Analog/Grating
Equipment
$ 5~6 Billion (2017)
a few **100k units (2017)**

Ultra compact Low Cost
Spectral Sensor Module
~ Billions units (? 2027)



Water quality measurement – In the pipeline

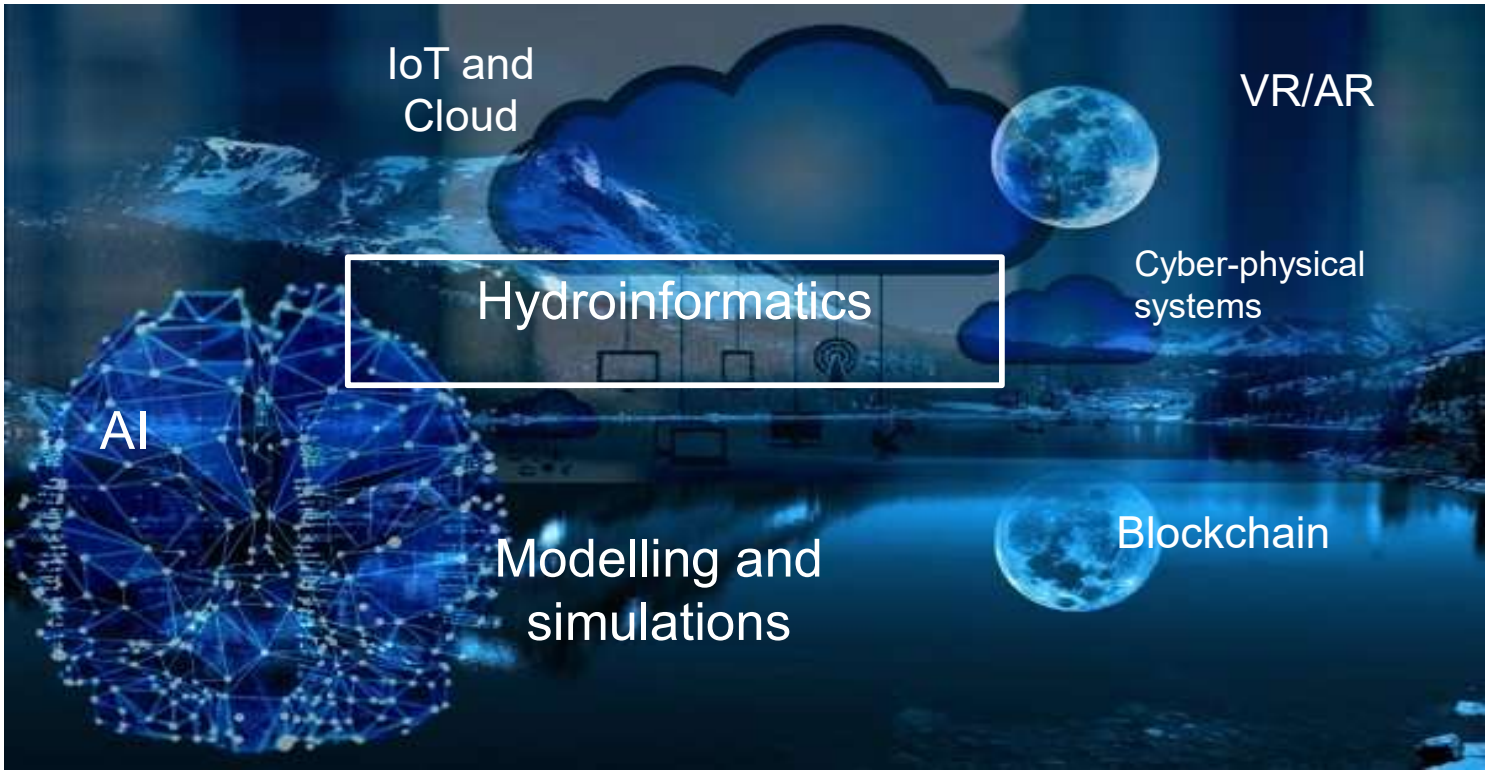
nanoλ



https://www.pmfias.com/wp-content/uploads/2016/01/Coastline-of-India-–-Indian-Coastline.jpg

Hydroinformatics

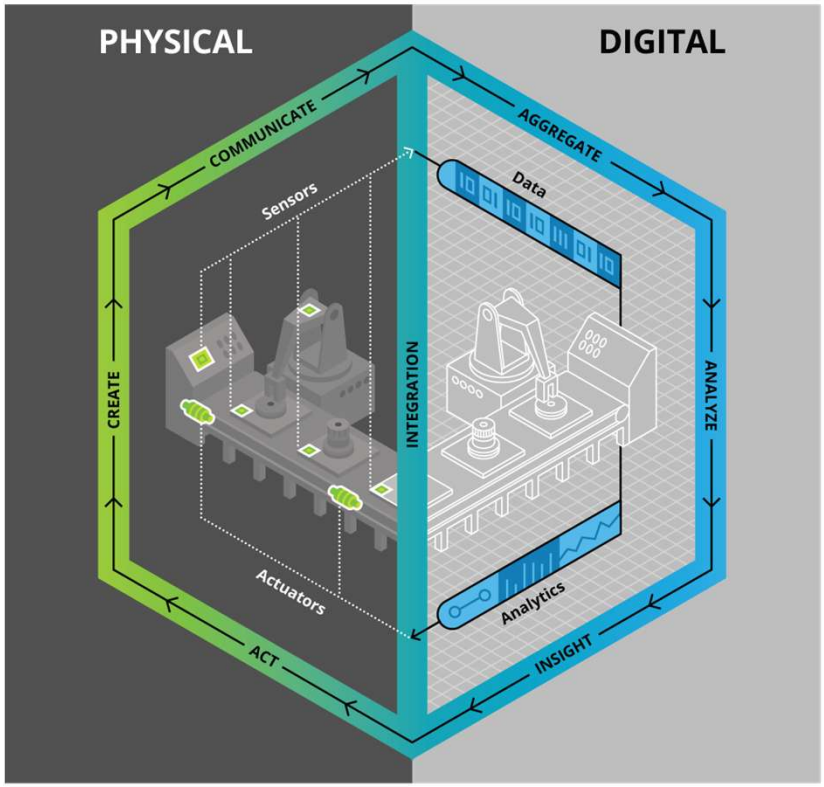
Application of computing technologies for efficient, sustainable and equitable water management.



Digital water or water 4.0 will revolutionize water management.

Water 4.0

Digital twin of water resources



Source: Deloitte University Press.

Deloitte University Press | dupress.deloitte.com

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.

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

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.

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

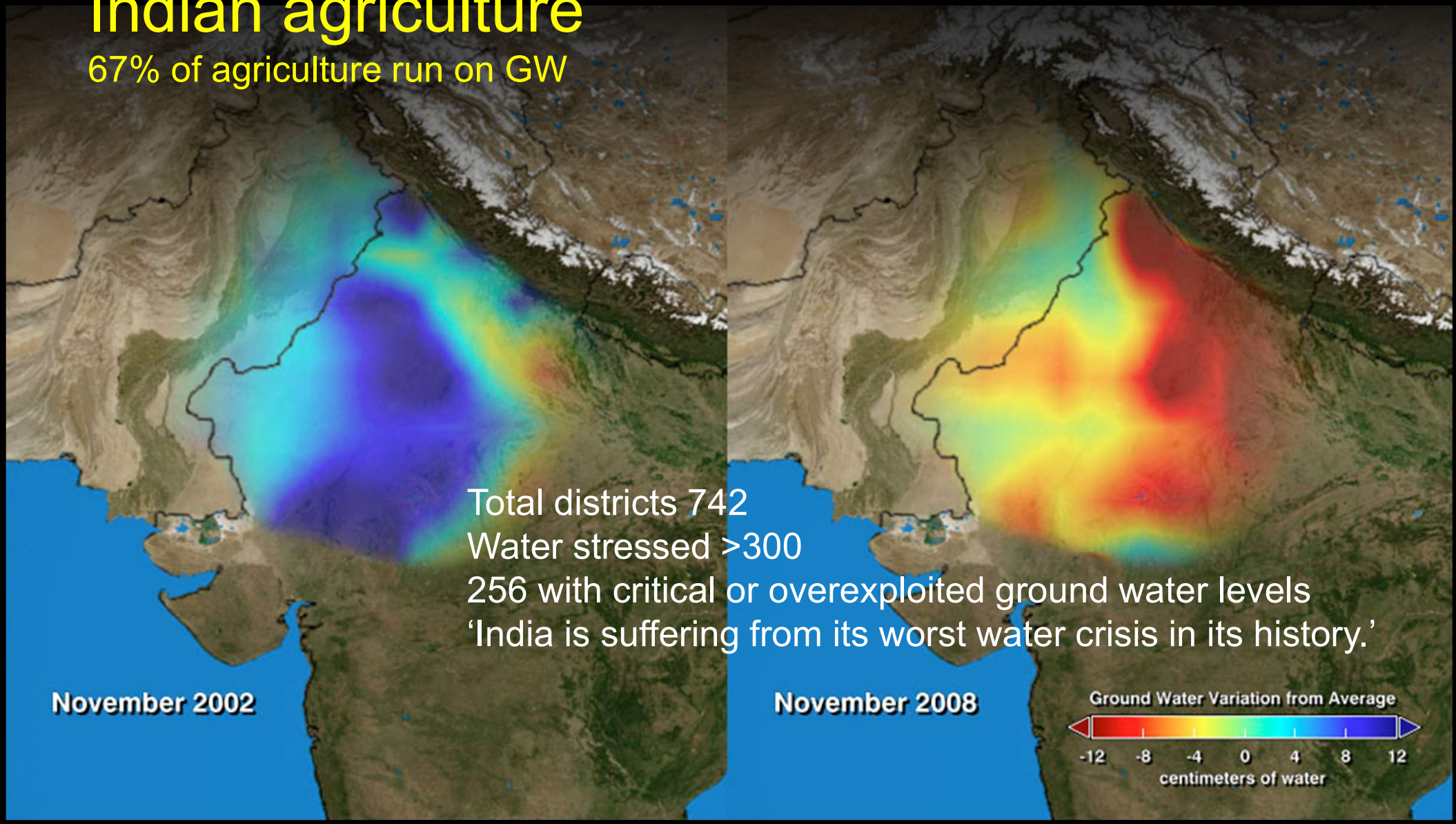
Genetic diversity – opportunities and sustainability

Traditional knowledge

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

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.’

Data from NASA

Arsenic free rice

Iron rich, silver rich, etc. rice

So much is happening on the ground


Policy


International Centre for Clean Water

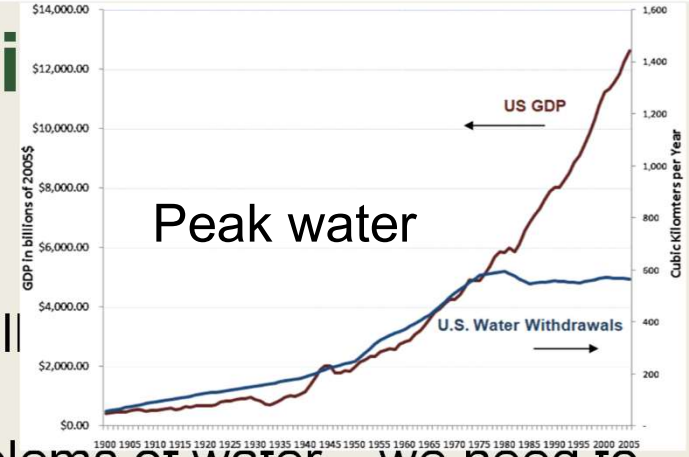

IIT Madras Research Park

Water is big and …. India i

Per capita water availability – 1500 CM

That water and its benefits need to reach all

We have solutions for each one of the problems of water – we need to invest in them - water has to be brought to the living room



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

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

Average rainfall 1085 mm, 85th 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

Building capacity

SYMPOSIUM ON

Imagining India@2047 through Innovation

7th – 9th March, 2022

Organized by

प्रशासनिक सुधार और लोक शिकायत विभाग
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Bringing unlike minds together

People: A. Sreekumaran Nair, Anshup, M. Udhaya Sankar, Amrita Chaudhary, Renjis T. Tom, T. S. Sreeprasad, Udayabhaskararao Thumu, M. S. Bootharaju, K. R. Krishnadas, Kalamesh Chaudhari, Soujit Sengupta, Depanjan Sarkar, Avijit Baidya, Swathy Jakka Ravindran, Abhijit Nag, S. Vidhya, Biswajit Mondal, Krishnan Swaminathan, Azhardin Gnayee, Sudhakar Chennu, A. Suganya, Rabiul Islam, Sritama Mukherjee, Tanvi Gupte, Jenifer Shantha Kumar, A. Anil Kumar, Ankit Nagar, Ramesh Kumar Soni, Tanmayaa Nayak, Shihabudheen M. Maliyekkal, G. Velmurugan, Wakeel Ahmed Dar, Ganapati Natarajan, N. Pugazhenthiran, A. Leelavathi, Sahaja Aigal, S.Gayathri, Bibhuti Bhusan Rath, Ananthu Mahendranath, Harsh Dave, Erik Mobegi, Egor Moses, Hemanta R. Naik

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सत्यमेव जयते

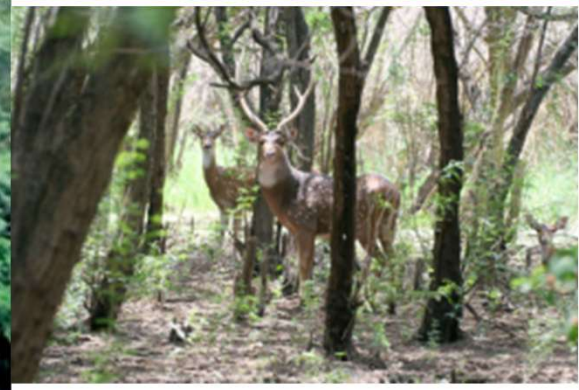
Start-ups and partners:

Mahindra WORLD CITY

Our collaborators

Ministry of Drinking Water and Sanitation, Govt. of Indi

Indian Institute of Technology Madras



Bhaskar Ramamurthi/V. Kamakoti

Associate Editor

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Thank you all