Since 1959

Affordable Clean Water Using Advanced Materials

Himanshu Budhia

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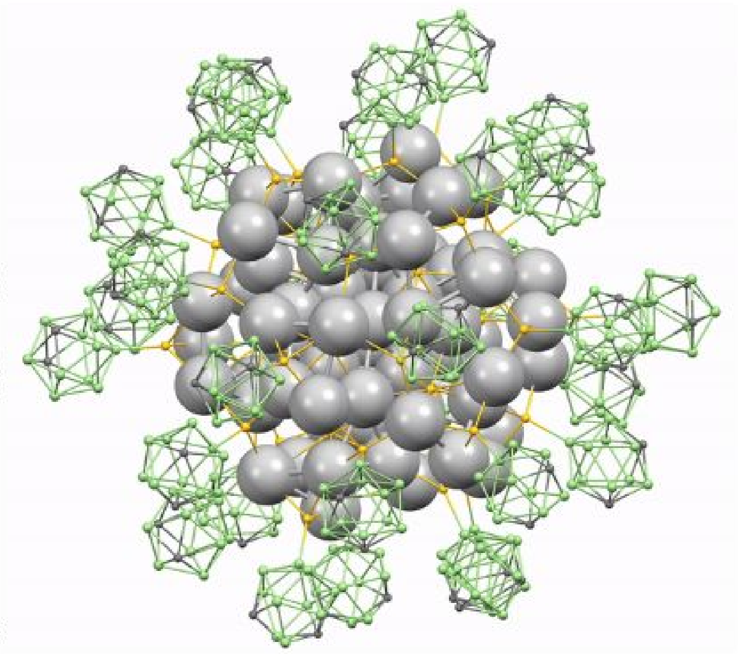
Co-founder

InnoNano Research Pvt. Ltd.
InnoDI Water Technologies Pvt
VayuJAL Technologies Pvt. Ltc
Aqueasy Innovations Pvt. Ltd.
Hydromaterials Pvt. Ltd.
EyeNetAqua Solutions Pvt. Ltc
DeepS

ACS Sustainable Resource Management Associate Editor



Professor-in-charge

ICCW
International Centre for Clean Water

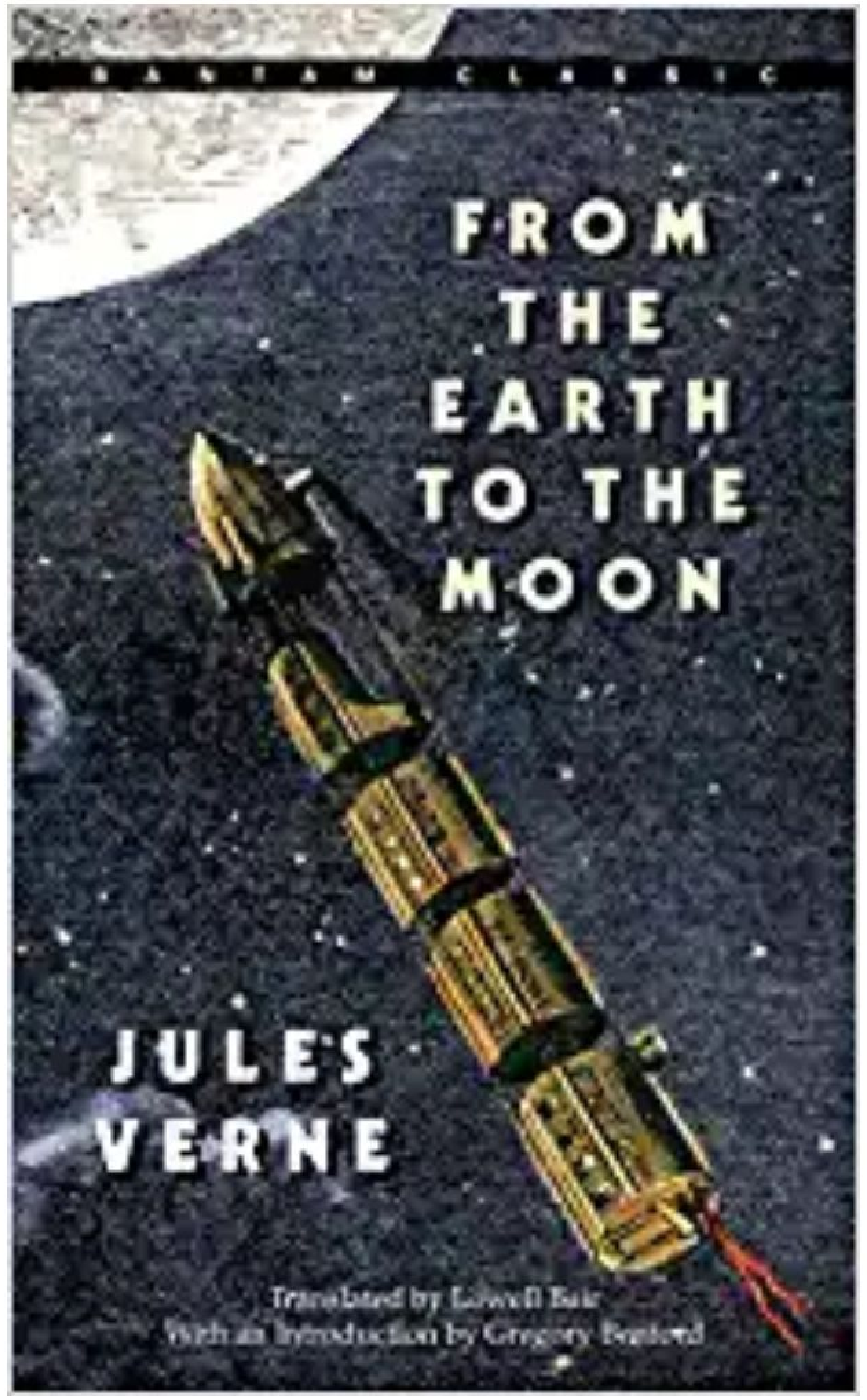
Rotary Club of Madras, August 26, 2025

Water is the most important inheritance of our p
lanet

© Robert Szucs/Grasshopper Geography

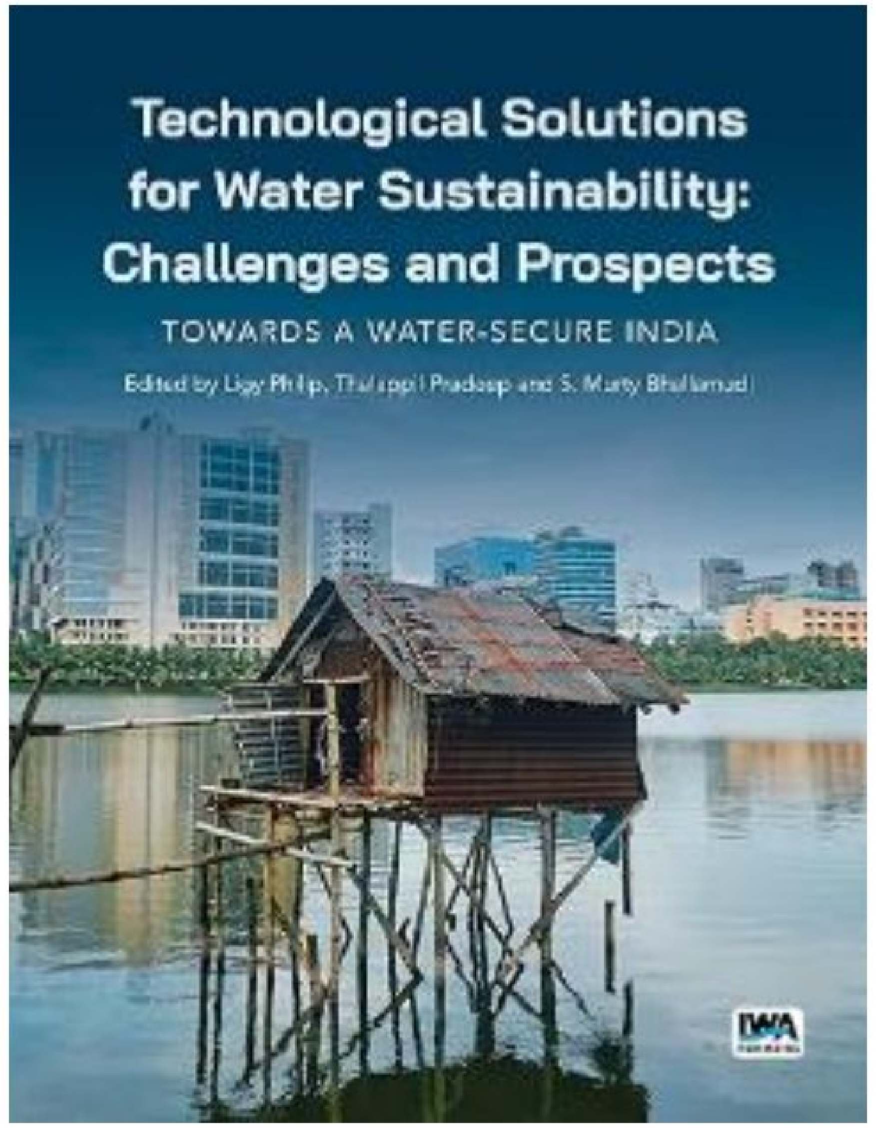
From S. Vishwanat
h

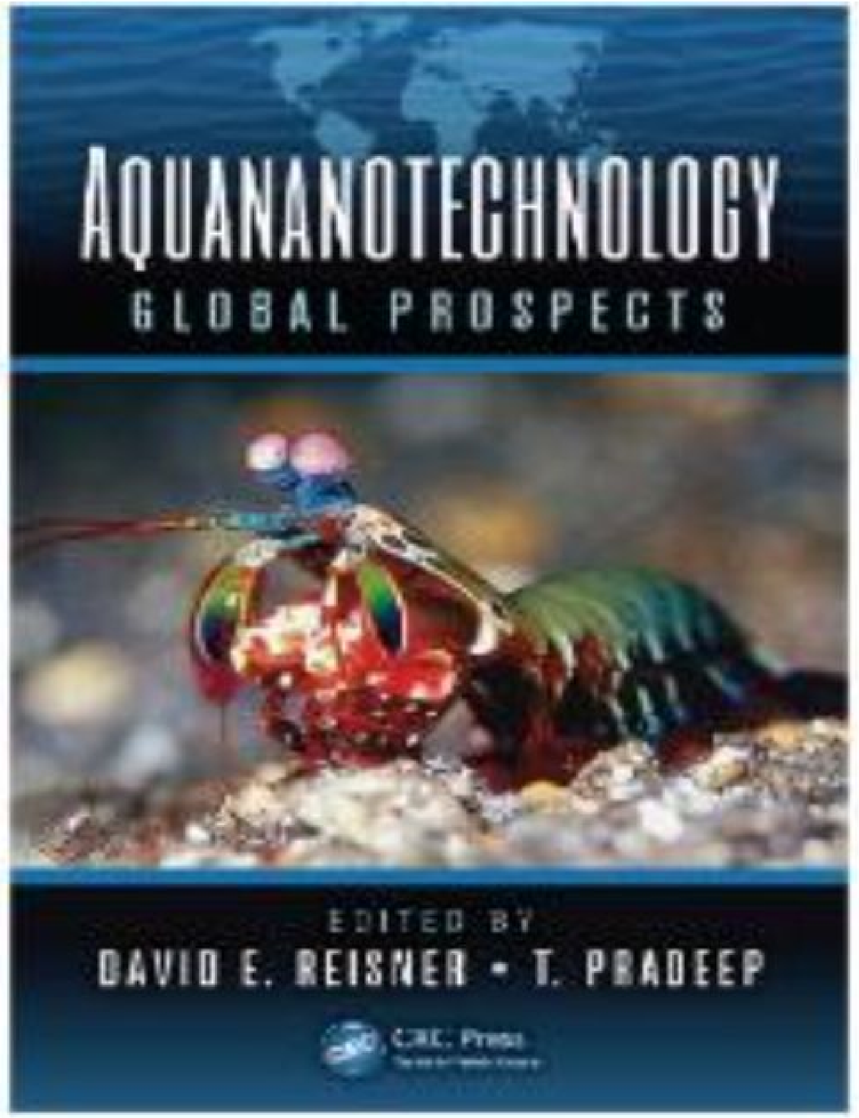
Our dreams become reality with materials



Affordable clean water is a problem of advanced materials

New adsorbents
New sensors
New catalysts
Novel phenomena
New devices

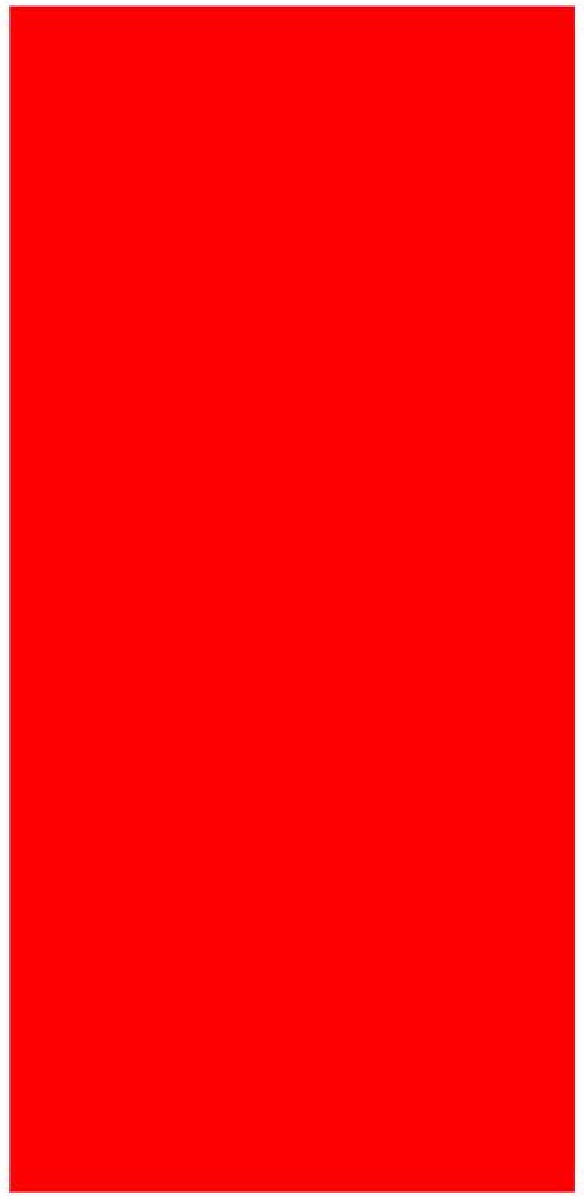




Water purification, history

T. Pradeep and Anshup, *Thin Solid Films*, 2009

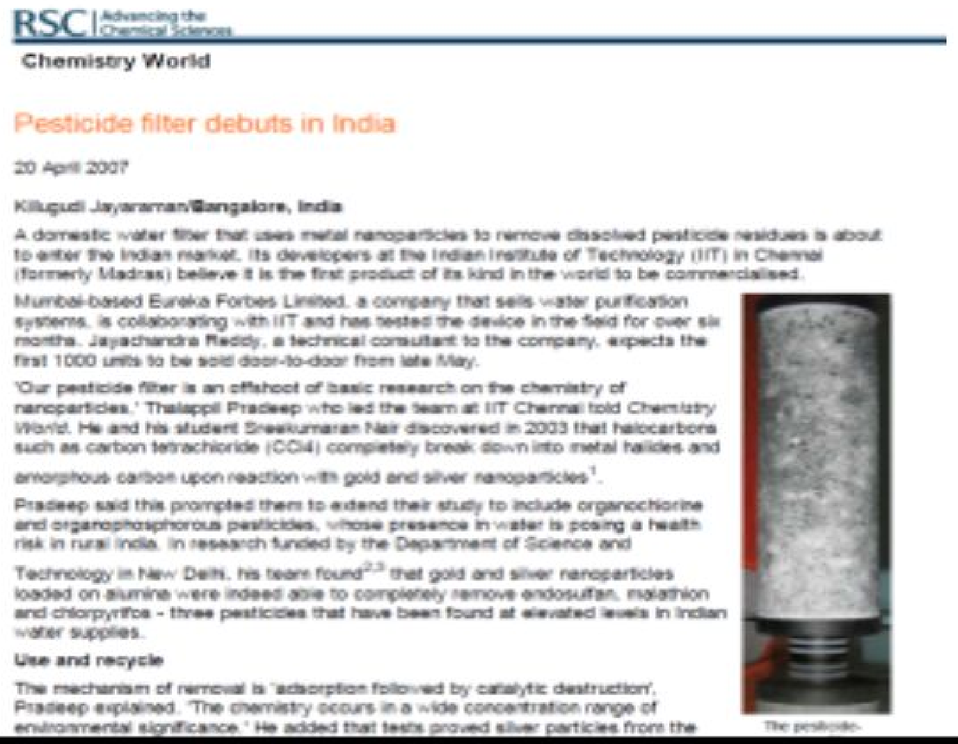
Future of water purification: An enigma with some pointers



Category-wise distribution of contaminants regulated by USEPA and future contaminants

Noble metal nanoparticles for water purification: A critical review, T. Pradeep and Anshup, Invited critical review, Thin Solid Films, 517 (2009) 6441-6478 (DOI: 10.1016/j.tsf.2009.03.195).

World's first nanochemistry-based water purifier



RSC | Advancing the Chemical Sciences

Chemistry World

Pesticide filter debuts in India

20 April 2007

Killugudi Jayaraman/Bangalore, India

A domestic water filter that uses metal nanoparticles to remove dissolved pesticide residues is about to enter the Indian market. Its developers at the Indian Institute of Technology (IIT) in Chennai (formerly Madras) believe it is the first product of its kind in the world to be commercialised.

Mumbai-based Eureka Forbes Limited, a company that sells water purification systems, is collaborating with IIT and has tested the device in the field for over six months. Jayachandra Reddy, a technical consultant to the company, expects the first 1000 units to be sold door-to-door from late May.

'Our pesticide filter is an offshoot of basic research on the chemistry of nanoparticles,' Thalappil Pradeep who led the team at IIT Chennai told *Chemistry World*. He and his student Sreekumaran Nair discovered in 2003 that halocarbons such as carbon tetrachloride (CCl4) completely break down into metal halides and amorphous carbon upon reaction with gold and silver nanoparticles[1].

Pradeep said this prompted them to extend their study to include organochlorine and organophosphorous pesticides, whose presence in water is posing a health risk in rural India. In research funded by the Department of Science and Technology in New Delhi, his team found[2,3] that gold and silver nanoparticles loaded on alumina were indeed able to completely remove endosulfan, malathion and chlorpyrifos - three pesticides that have been found at elevated levels in Indian water supplies.

Use and recycle

The mechanism of removal is 'adsorption followed by catalytic destruction', Pradeep explained. 'The chemistry occurs in a wide concentration range of environmental significance.' He added that tests proved silver particles from the

The pesticide-

[redacted]

A plant to make supported nanomaterials for water purification; with capacity of 4.5 tons per month,

[redacted]

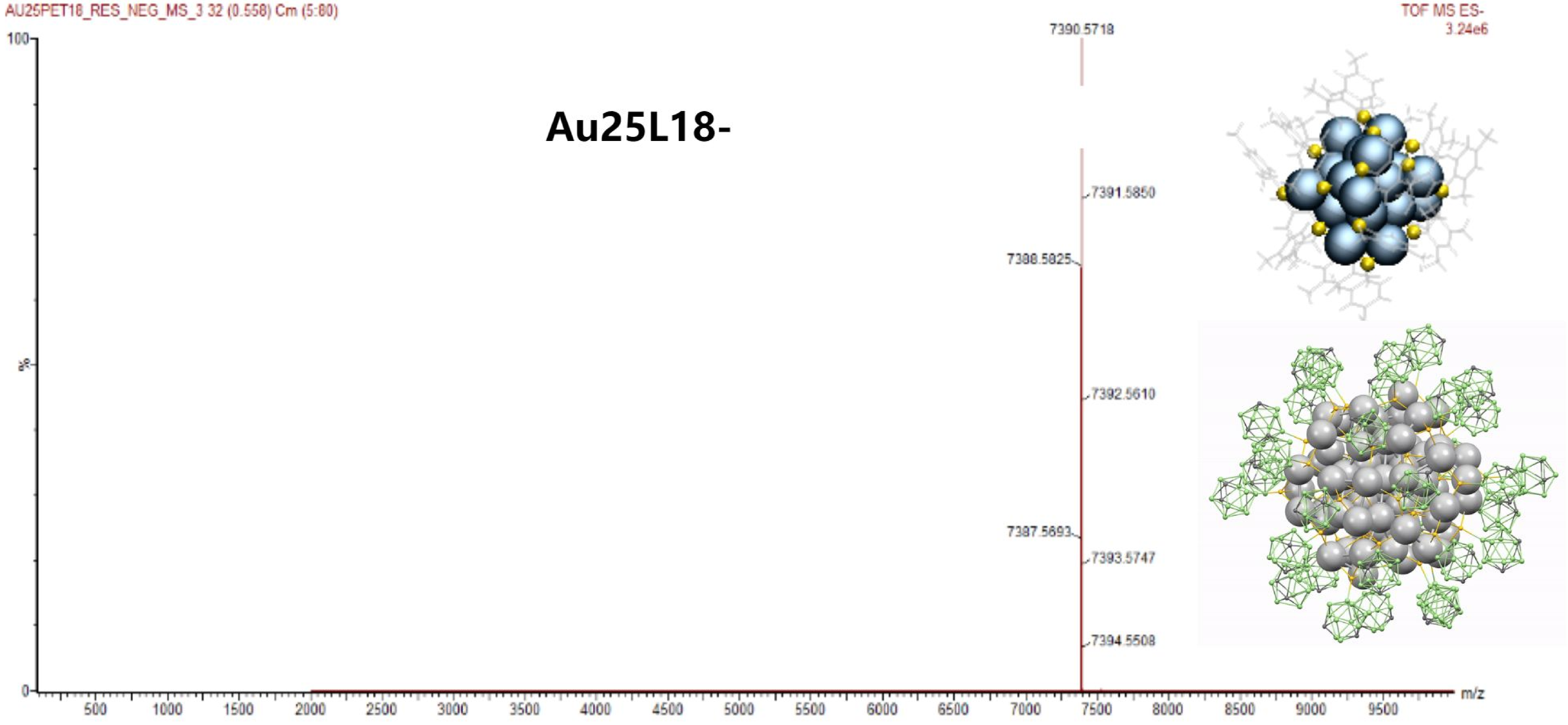
Indian patent 200767

US 7,968,493

EP 17,15,947

Product is marketed now by a Eureka Forbes Ltd

Nanomaterials are now atomically precise



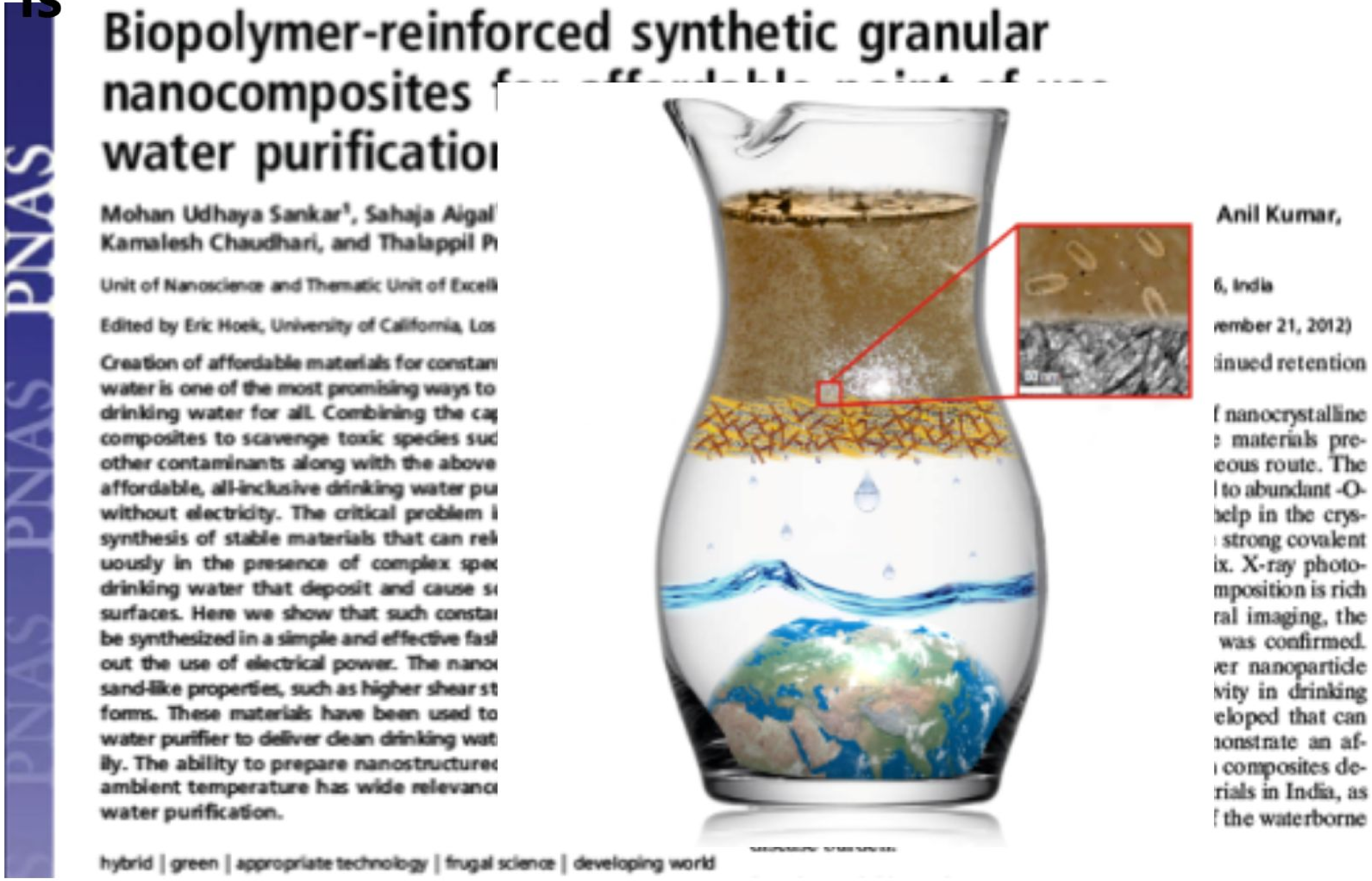
T. Pradeep et. al. *Acc. Chem. Res.* 2018; 2019.

Clean water for everyone



ACS Sustainable Chemistry & Engineering Edito
rial, December 2016

Water positive materia ls



PNAS PNAS PNAS PNAS

Biopolymer-reinforced synthetic granular nanocomposites f... water purificatio...

Mohan Udhaya Sankar[1], Sahaja Aigal... Anil Kumar, Kamalesh Chaudhari, and Thalappil P...

Unit of Nanoscience and Thematic Unit of Excell... 6, India

Edited by Eric Hoek, University of California, Los ... ember 21, 2012)

Creation of affordable materials for constan... water is one of the most promising ways to... drinking water for all. Combining the ca... composites to scavenge toxic species suc... other contaminants along with the above... affordable, all-inclusive drinking water pu... without electricity. The critical problem i... synthesis of stable materials that can rel... uously in the presence of complex spe... drinking water that deposit and cause s... surfaces. Here we show that such consta... be synthesized in a simple and effective fas... out the use of electrical power. The nano... sand-like properties, such as higher shear st... forms. These materials have been used to... water purifier to deliver clean drinking wat... ily. The ability to prepare nanostructured... ambient temperature has wide relevanc... water purification.

...tinued retention ... f nanocrystalline ... materials pre- ... eous route. The ... to abundant -O- ... help in the crys- ... strong covalent ... ix. X-ray photo- ... mposition is rich ... ral imaging, the ... was confirmed. ... ver nanoparticle ... vity in drinking ... eloped that can ... monstrate an af- ... composites de- ... rials in India, as ... f the waterborne

hybrid | green | appropriate technology | frugal science | developing world

M. Udhaya Sankar, et. al. *Proc. Natl. Acad. Sci.,* 110 (2013) 8459-8464.

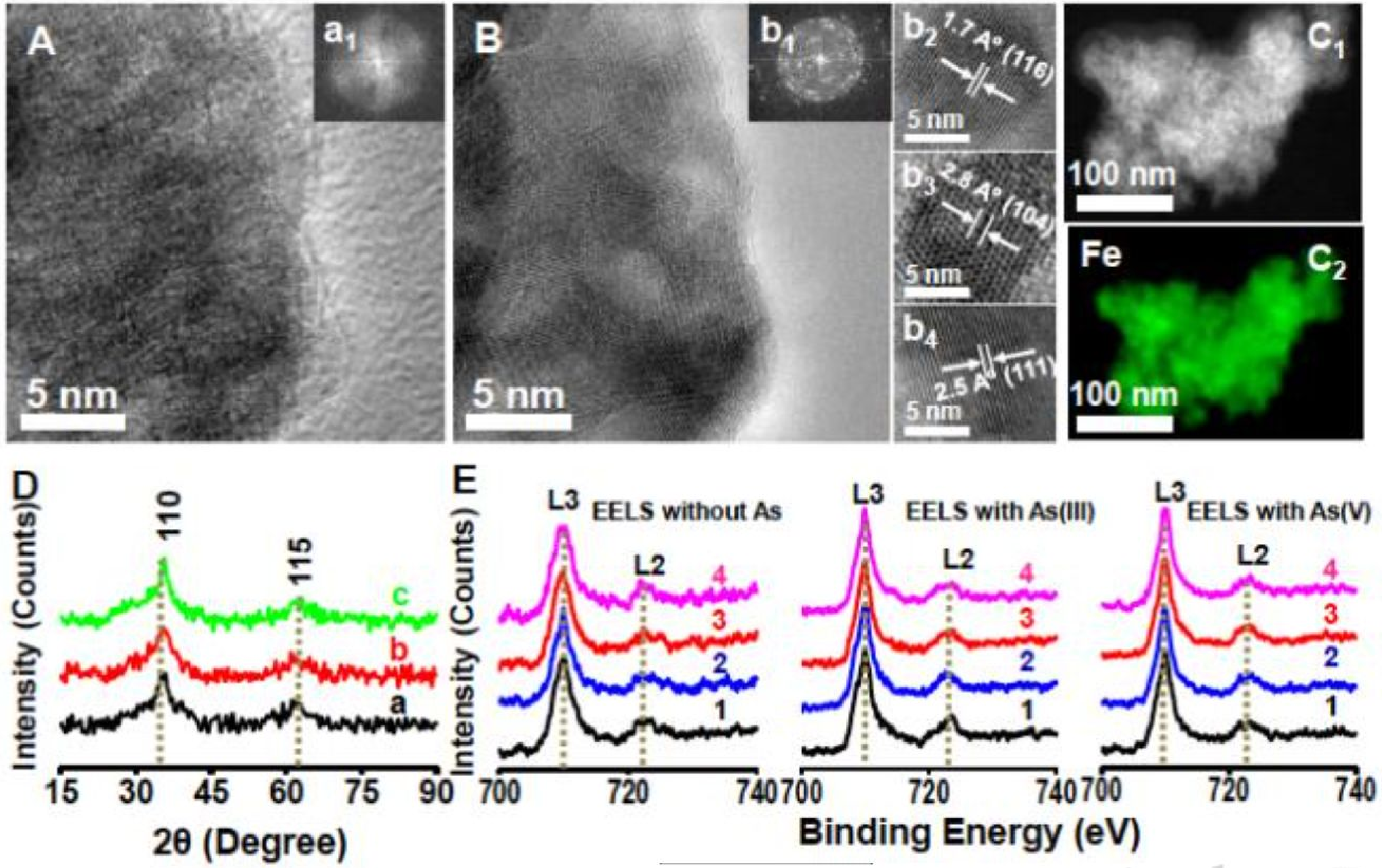
How to make?

What is special?

Live/dead staining experiments

No nanotoxicity

Variety of materials



Author Proof

www.advmat.de ADVANCED MATERIALS

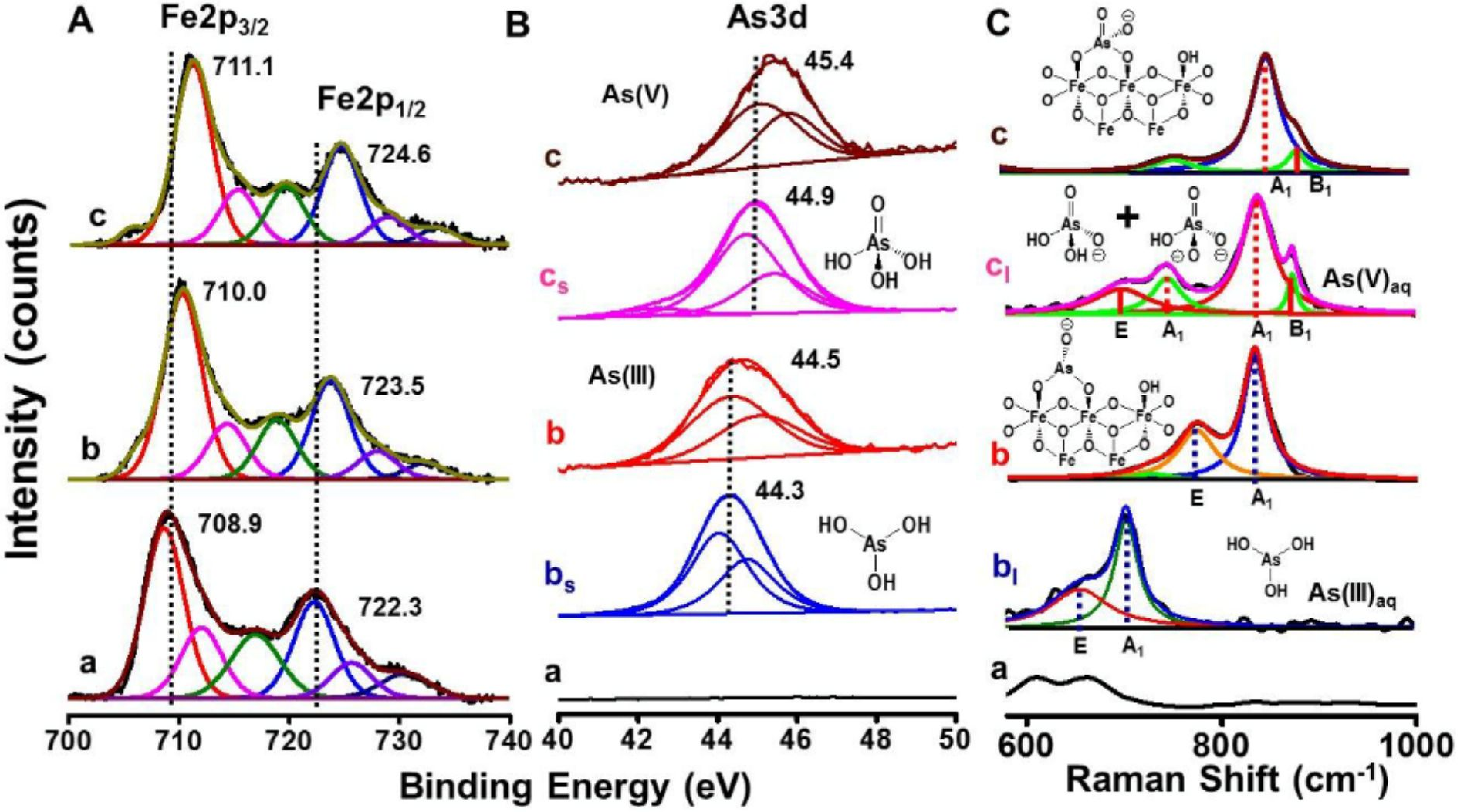
Communication

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

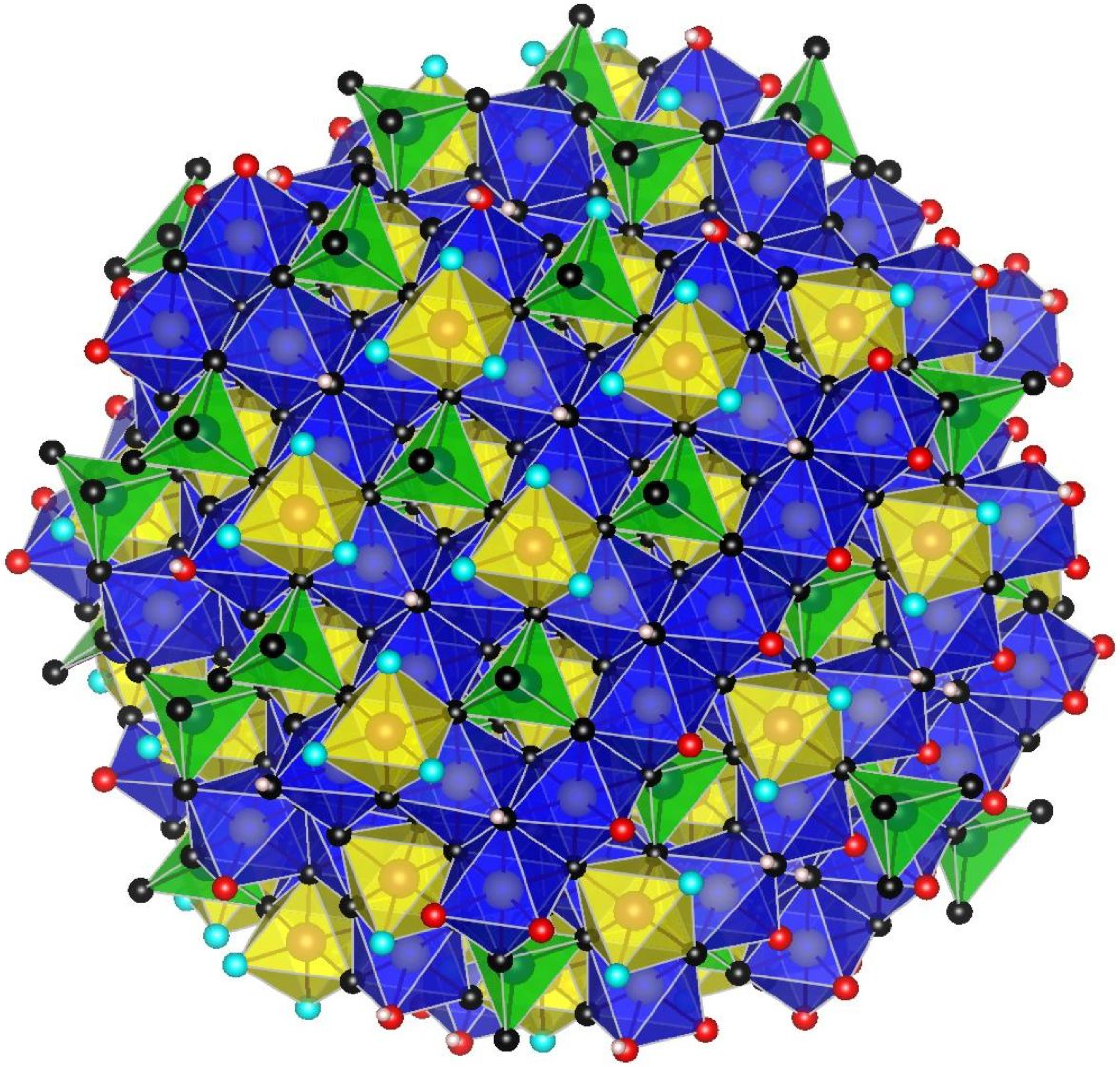
*By Avula Anil Kumar, Anirban Som, Paolo Longo, Chennu Sudhakar, Radha Gobinda Bhuin, Soujit Sen Gupta, Anshup, Mohan Udhaya Sankar, Amrita Chaudhary, Ramesh Kumar, and T. Pradeep**

A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 16042

Mechanism – molecular tools

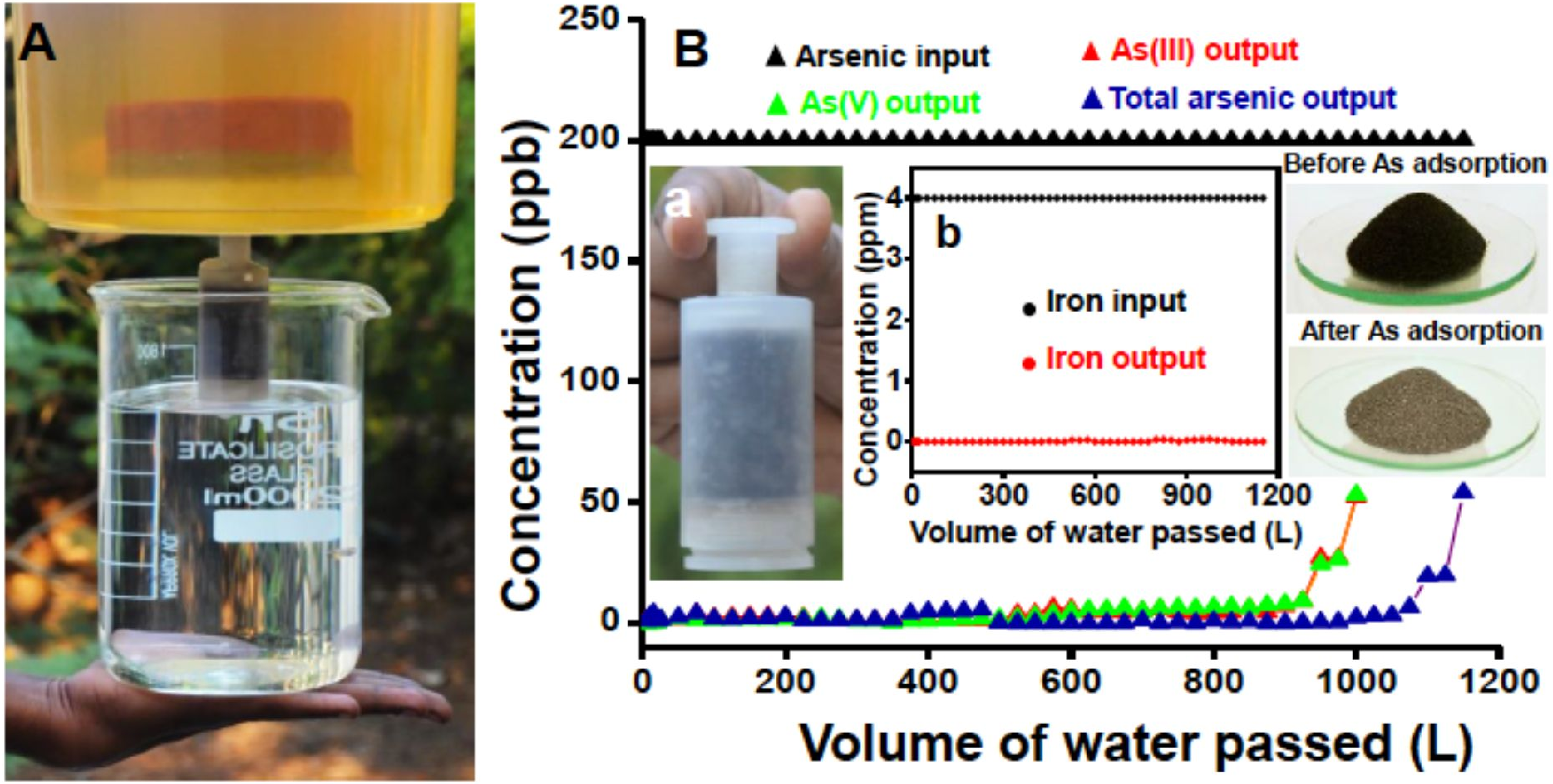


Modeling surfaces



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

Lab studies



A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 16042
60.

Initial pilot studies

Larger pilot studies

Changing the dynamics in the field

[redacted]

t s)

[redacted]

- Output arsenic concentration: 2 ppb

Completed 3 years maintenance (stipulated: 2 years) f or 330 bamboo unit project in Nadia, WB

Minimum uptime: 91%, Maximum: 98%

Only 4/330 have reported arsenic above 10 ppb

Benefiting over 100,000 children and villagers

Implementation - From 25 KLD to 1 MLD

Large water supply schemes

Capacity: above 1 MLD

5 schemes in use across India

Retrofitted Water Purification Plant

Capacity: 0.1-1 MLD

Over 180 units in use across India

Clean water at 2.1 paise per litre!

0.025 cent
s

Smart water purifiers and big data

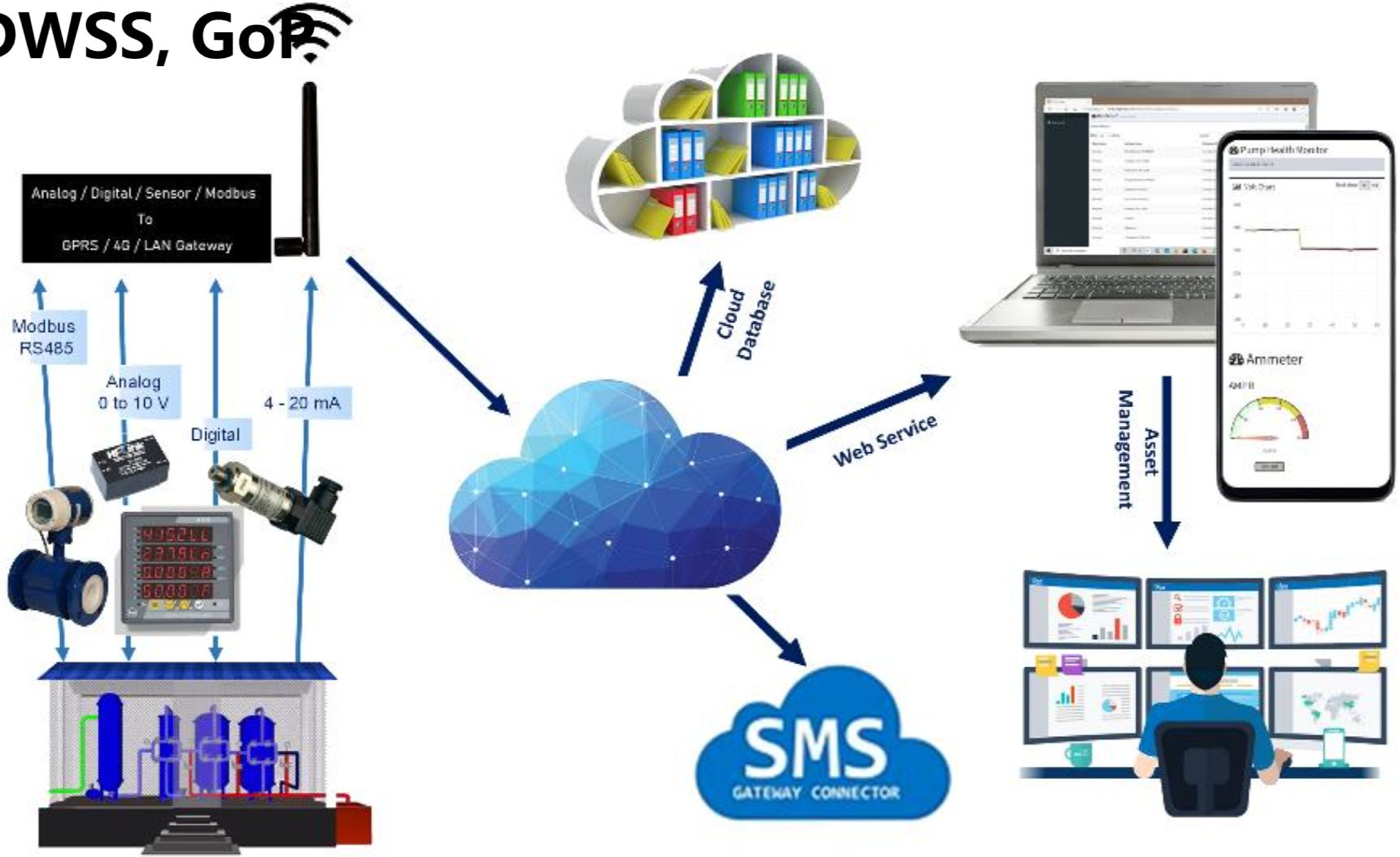
Ankit Nagar and T. Pradeep 14(2020). *ACS Nano*, 6420-6435

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

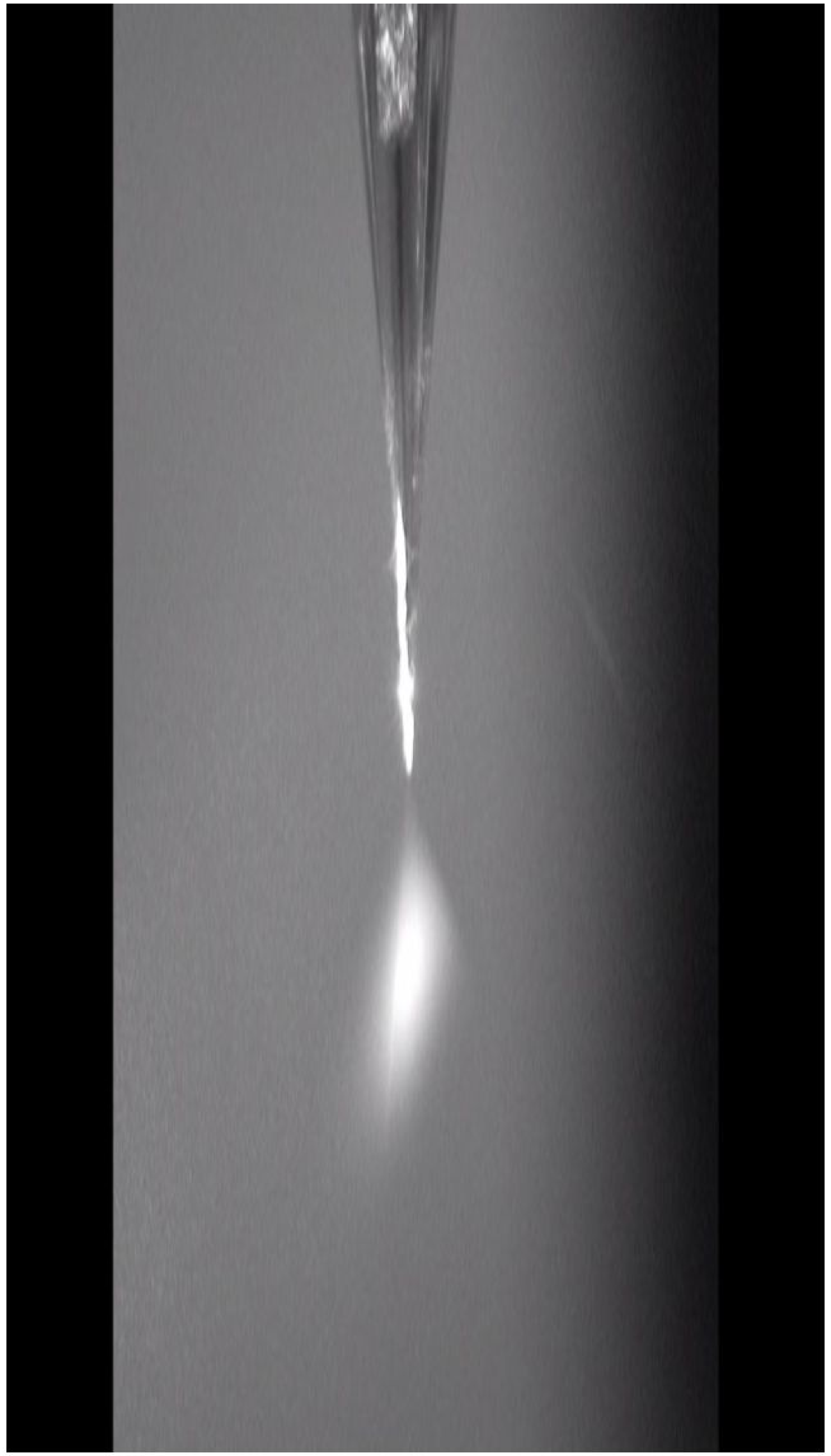
Now they are across the countr y

Components of IoT architecture implemented by DWSS, GoP



Typical IoT architecture comprises various sensors and meters, communication gateway, Cloud Server, SMS gateway, Webservices and mobile phone application for operator

Atmospheric water harvesting



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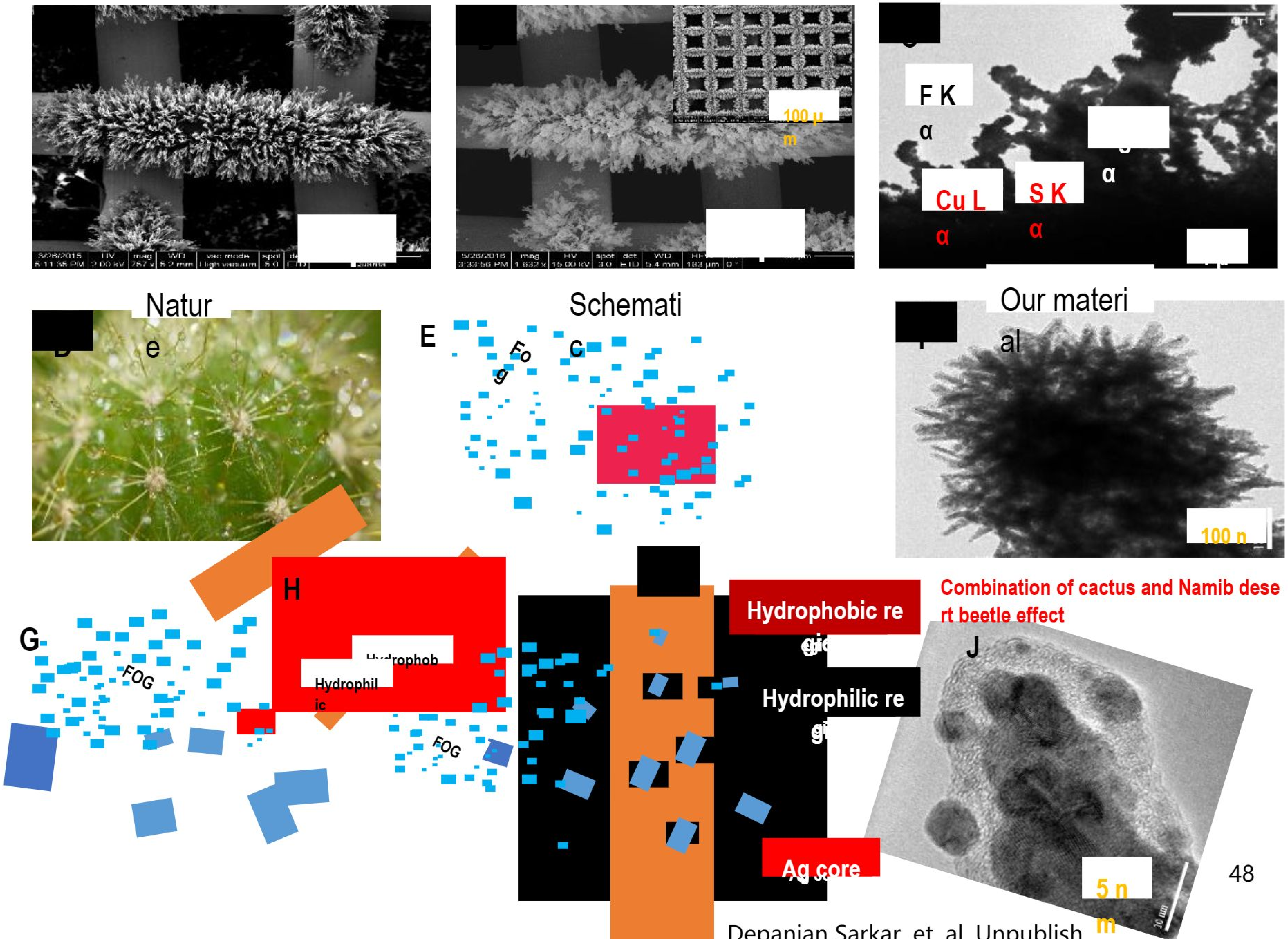
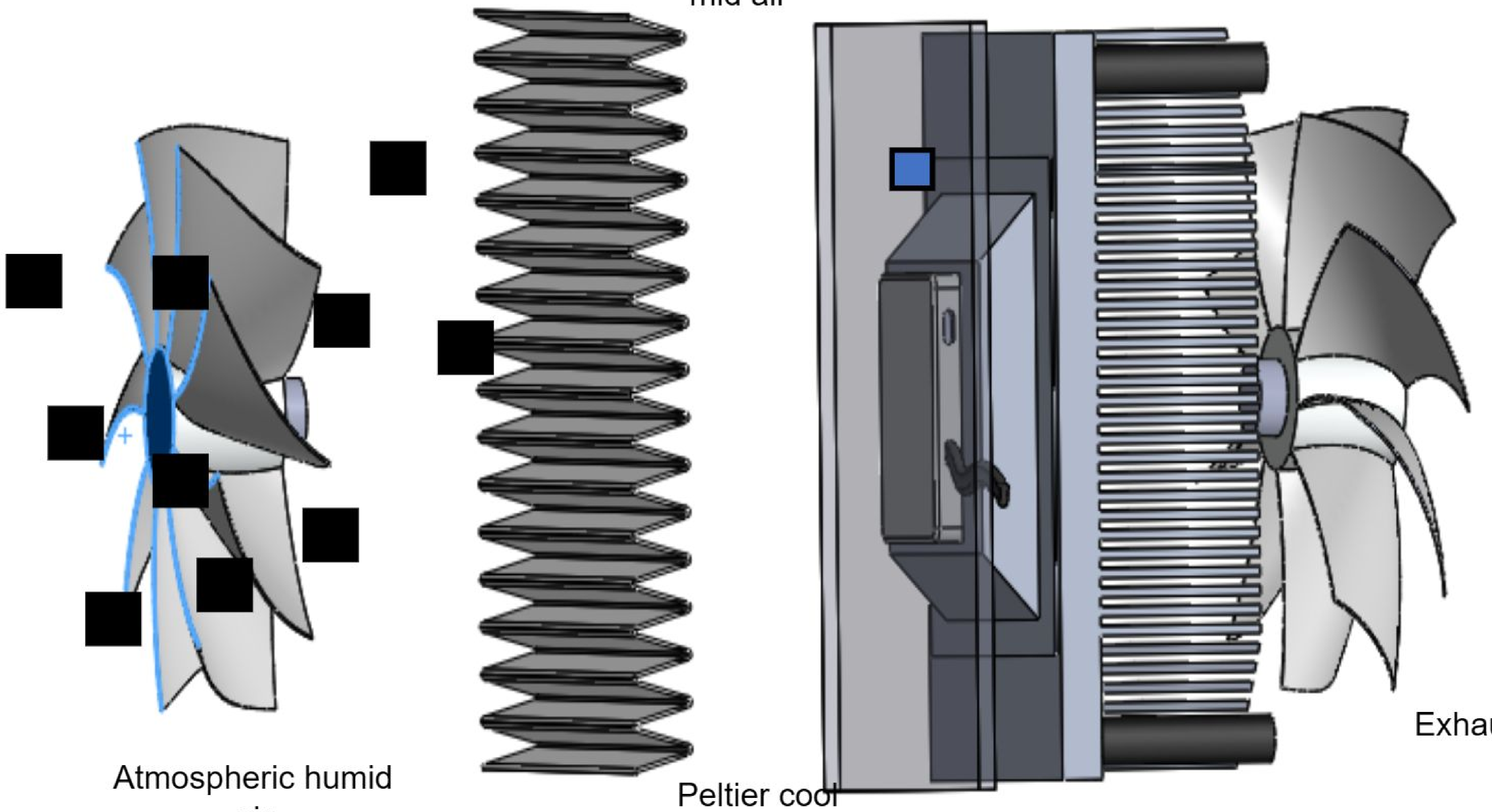
New harvesters

Depanjan Sarkar, et. al. *Advanced Materials*, 28 (11), 2016.



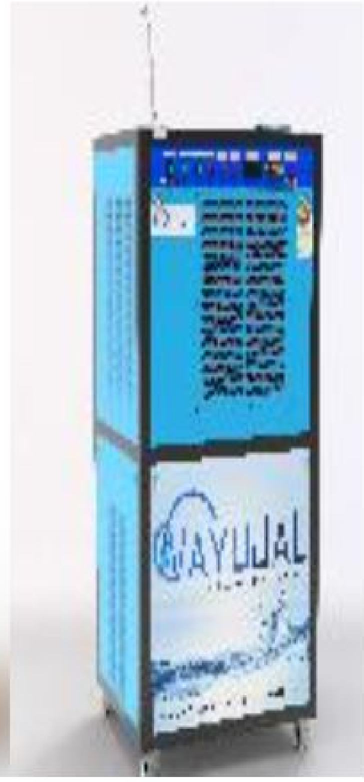
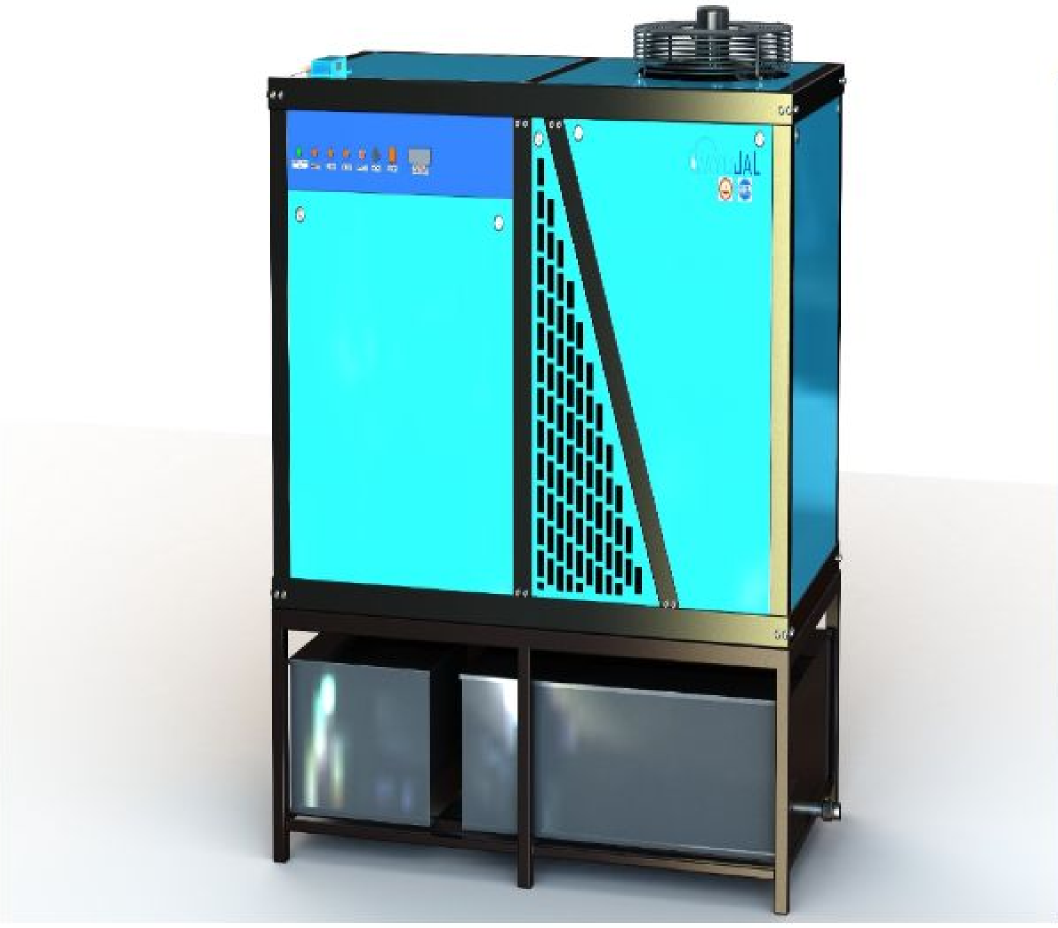
Depanjan Sarkar, et. al. Unpublish



VayuJAL Technologies Pvt. Lt
d.

Ramesh Kumar Soni and Ankit Na

Products in the field

35 LPD
LPD

120 LPD

400 LPD

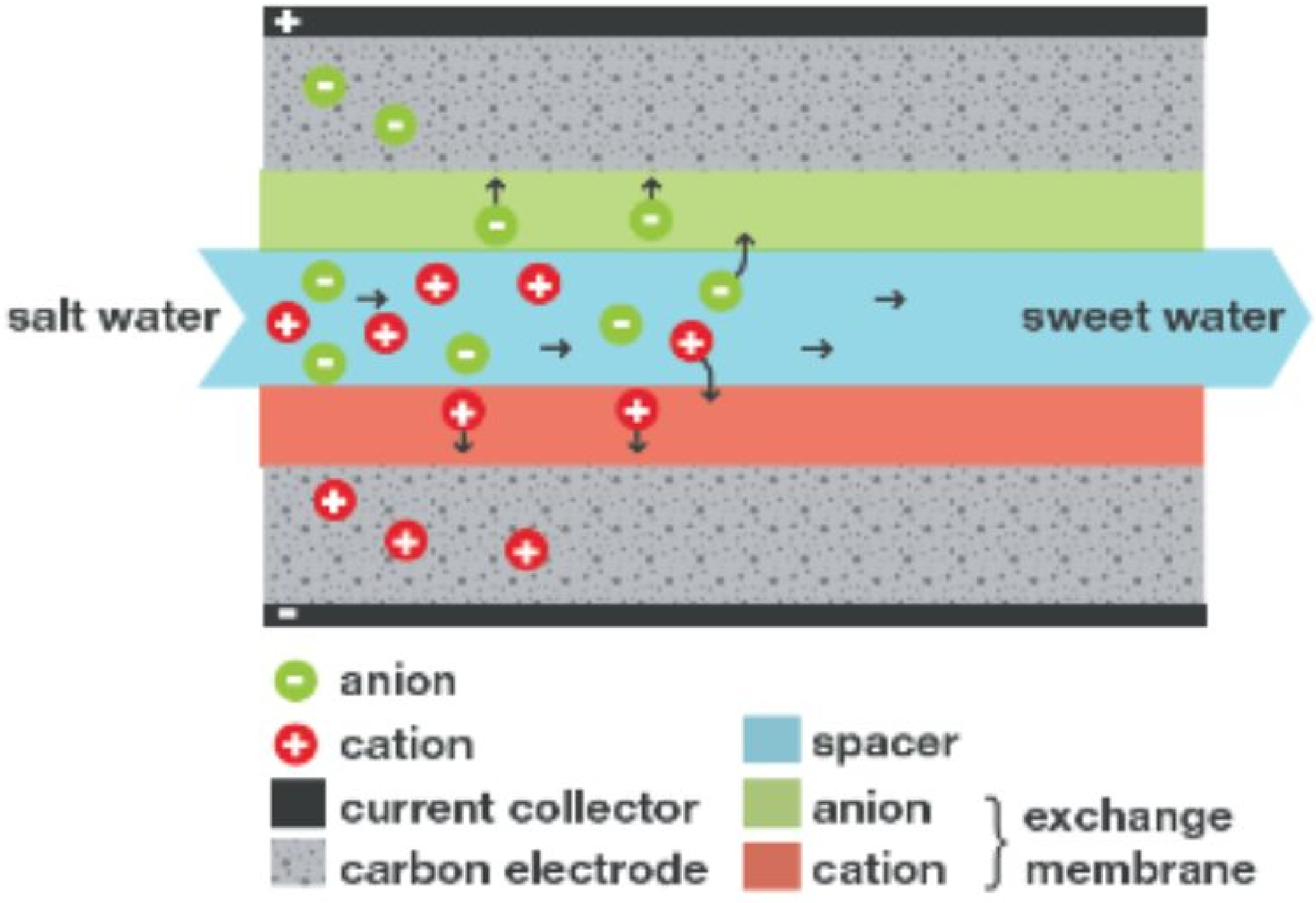
1000 LPD

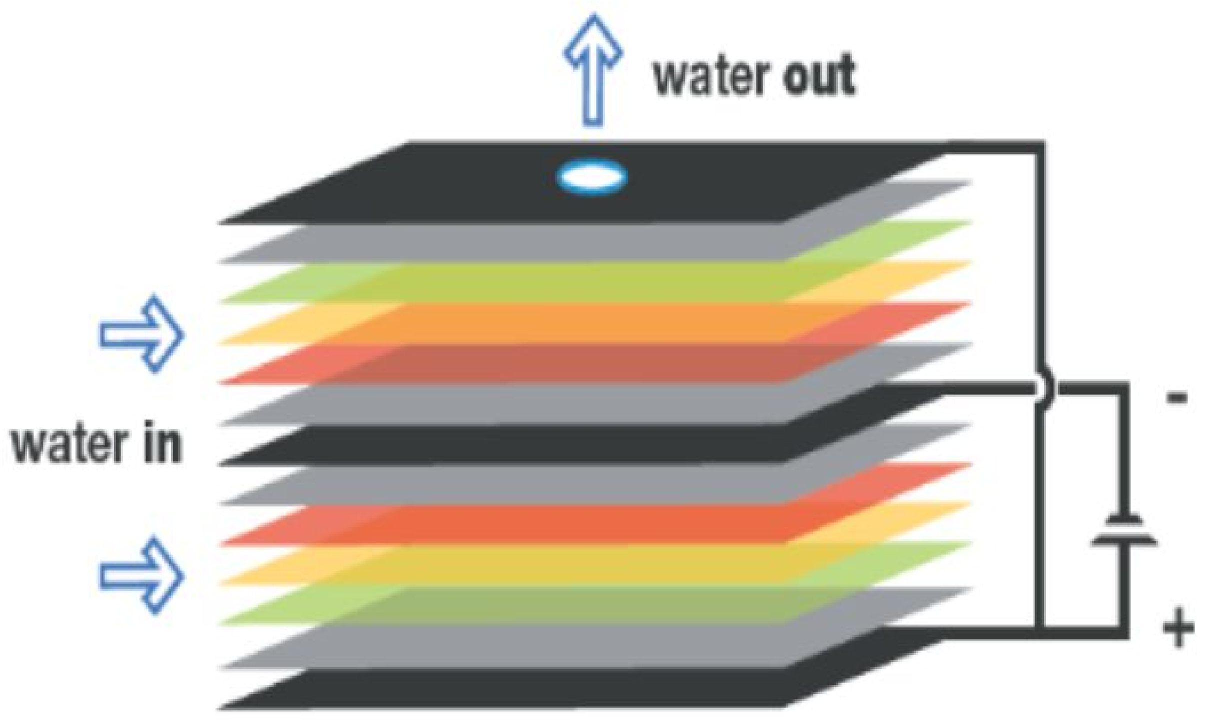
2000

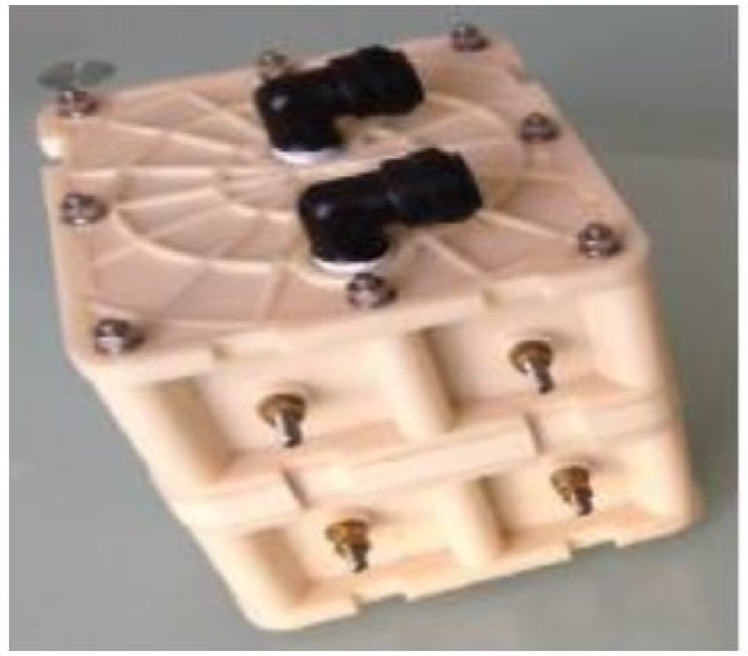

July 202
3

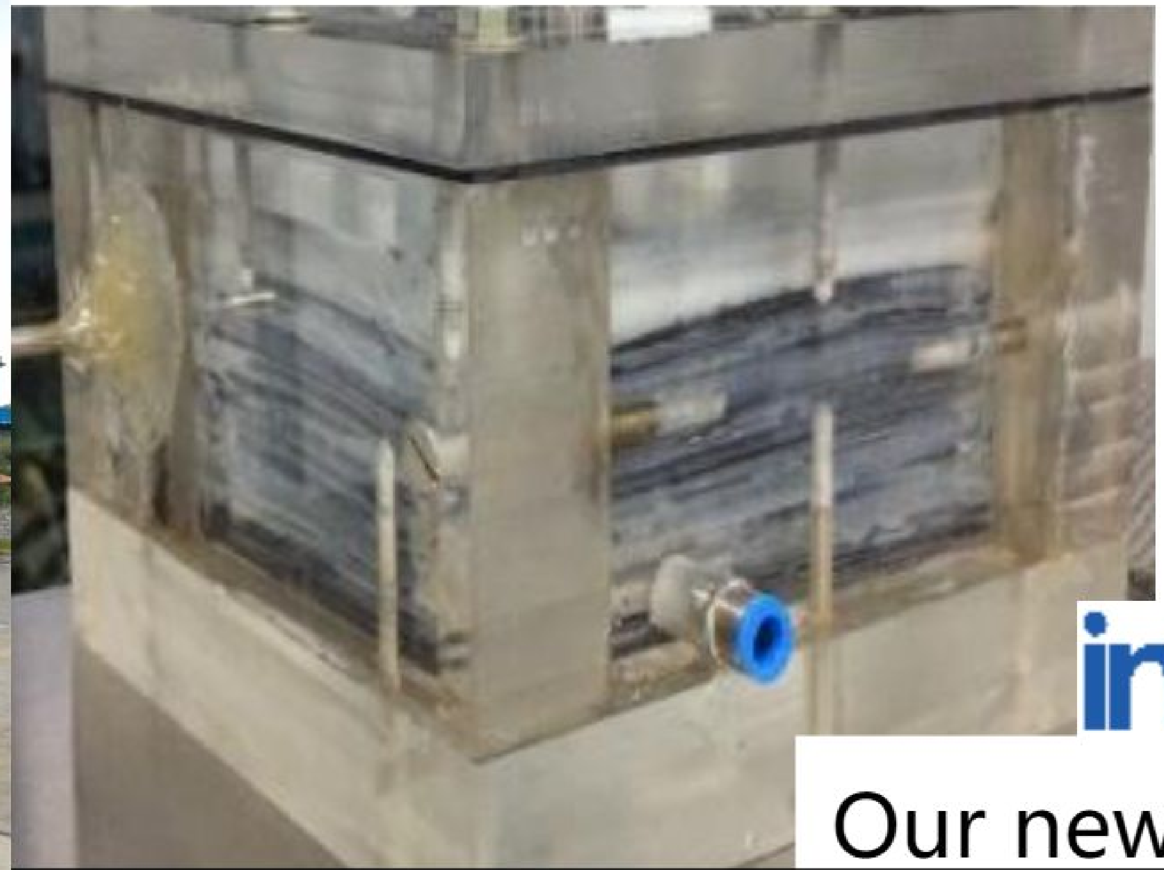
(LPD: Litres per day)

Capacitive Desalination (CDI)



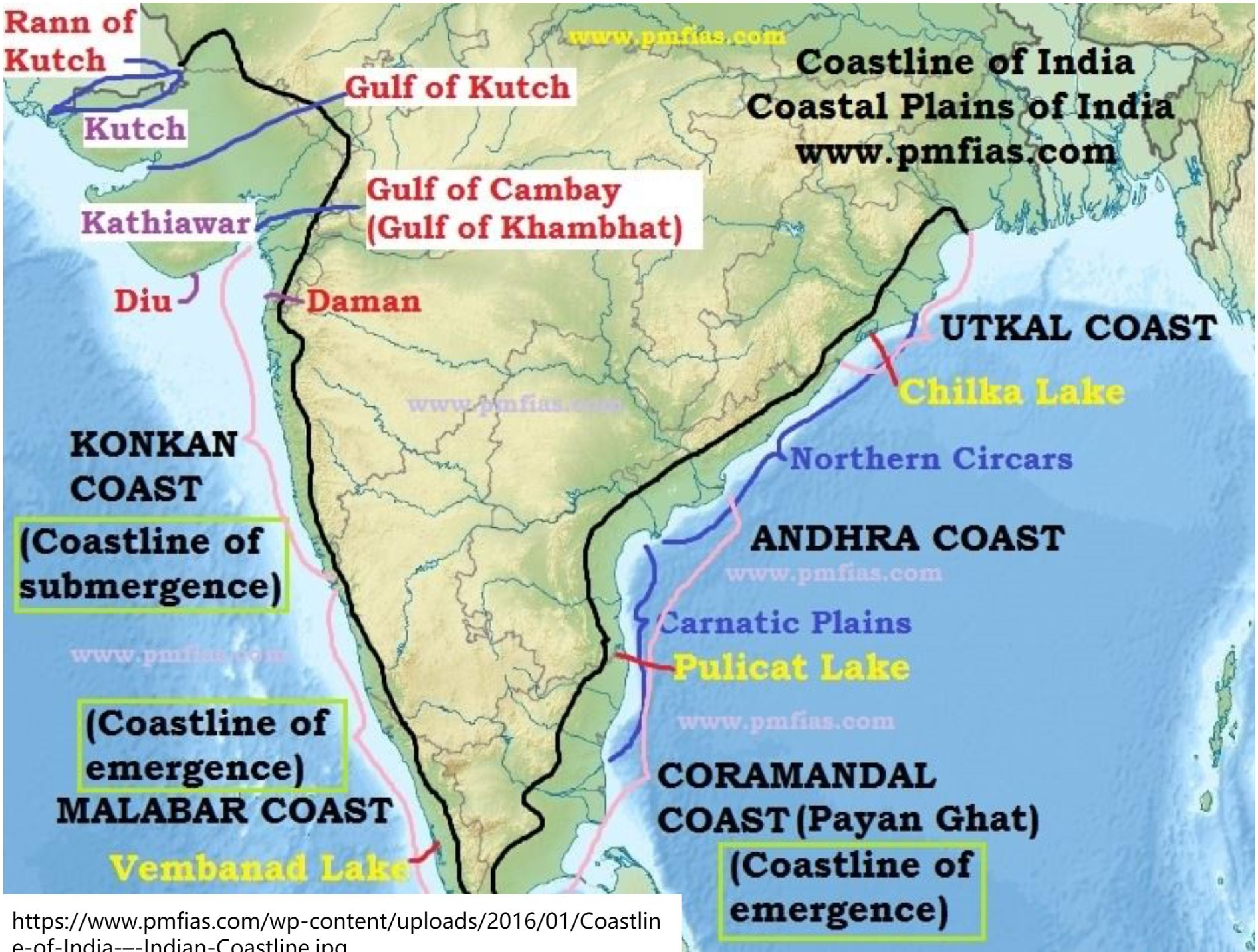




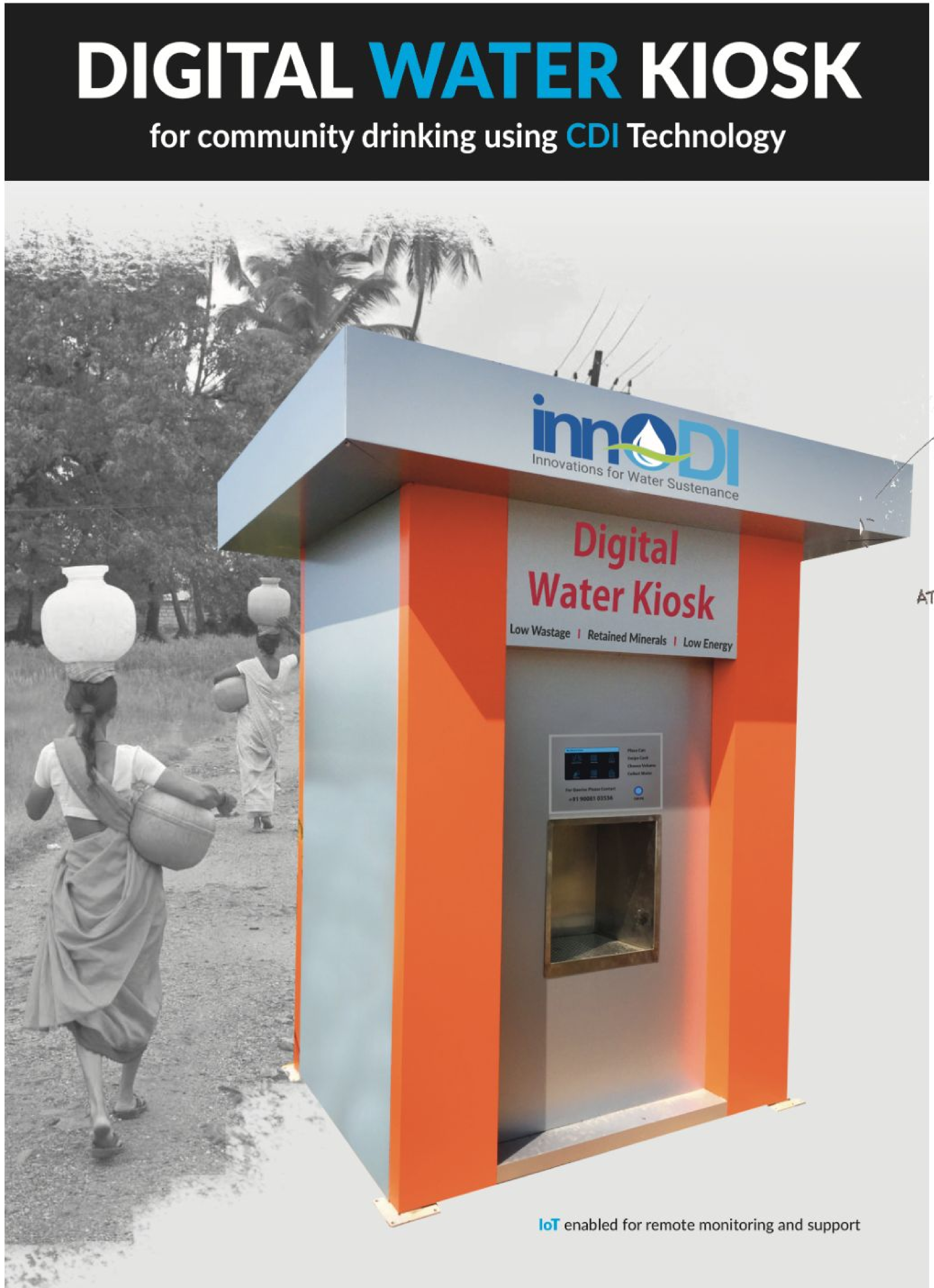


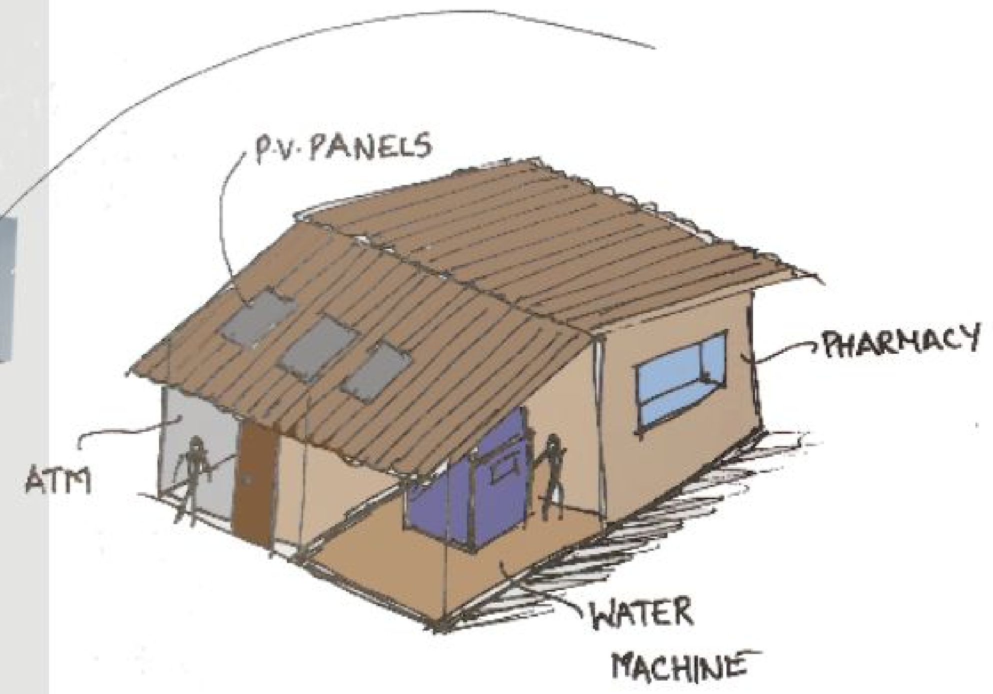
Our new compa

Soujit Sengupta, Rabiul Islam and other



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

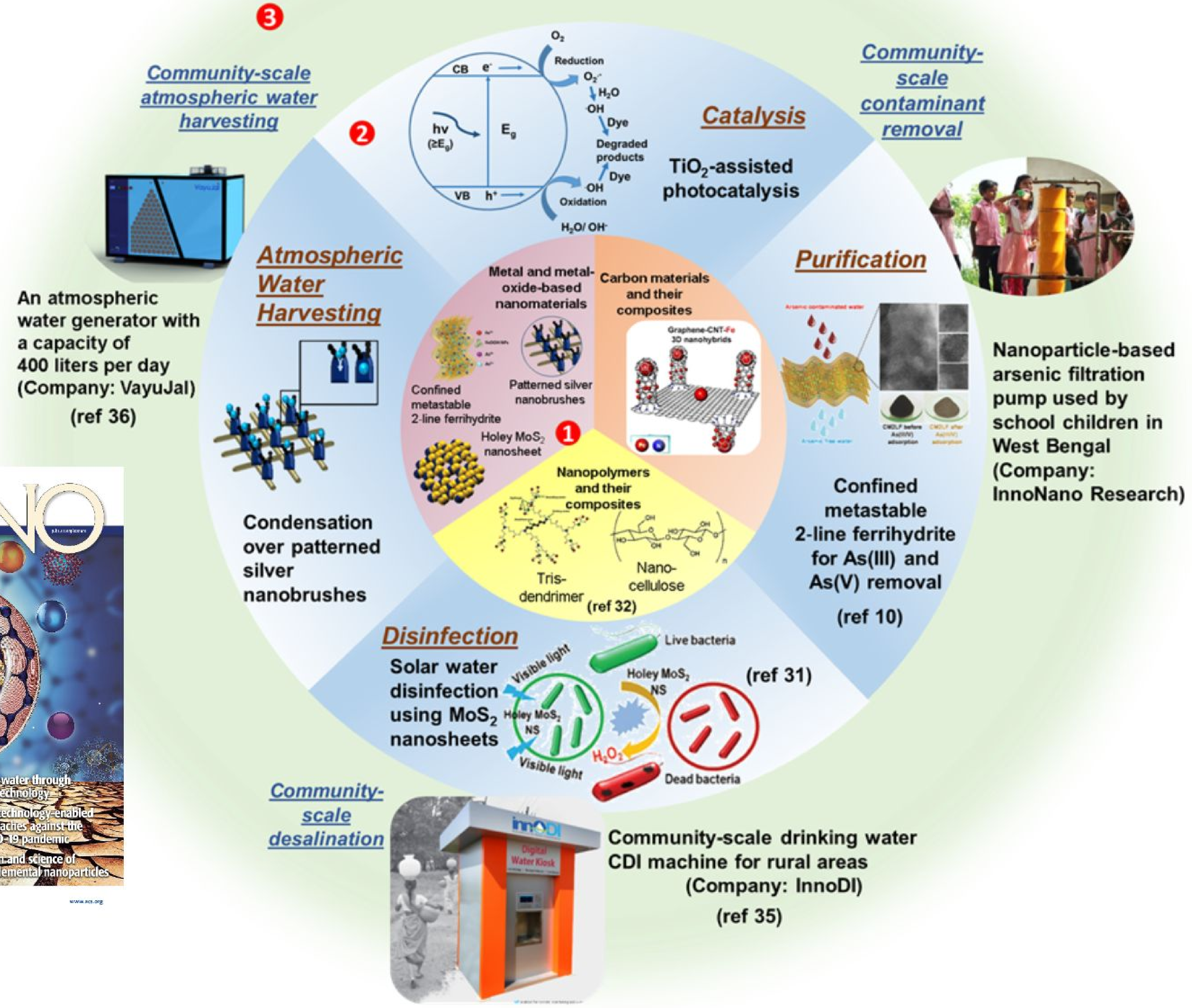


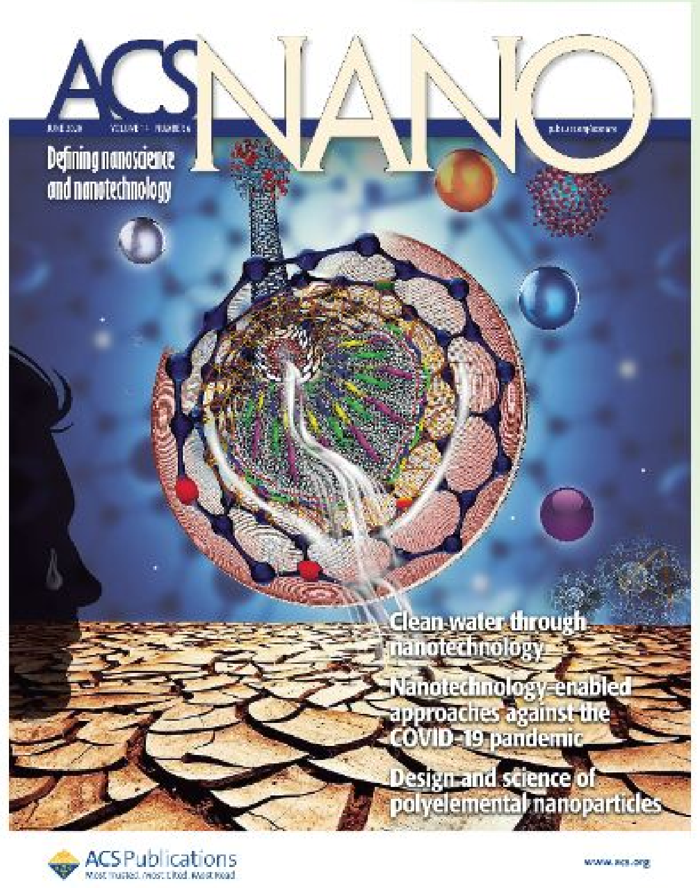


Products under implementat ion

Vijay Sampath and Tullio Servi

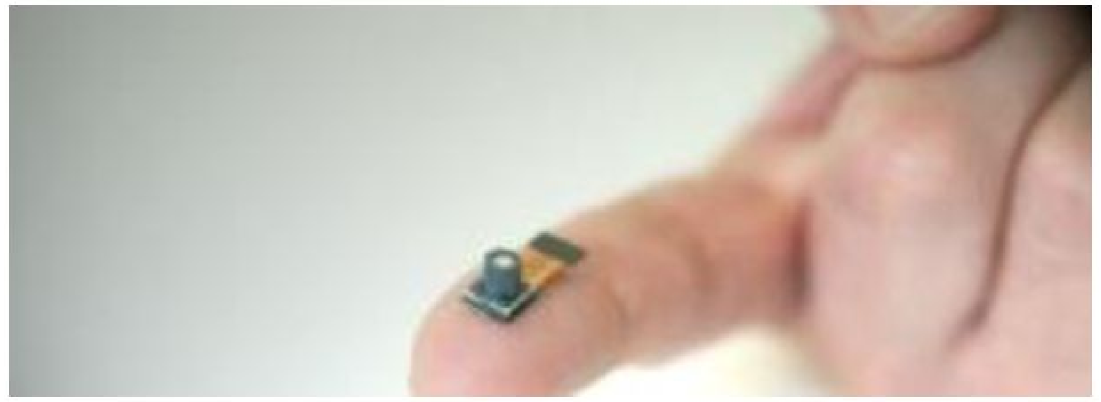
Evolution of materials to produc ts





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

Sensors and new opportuniti es

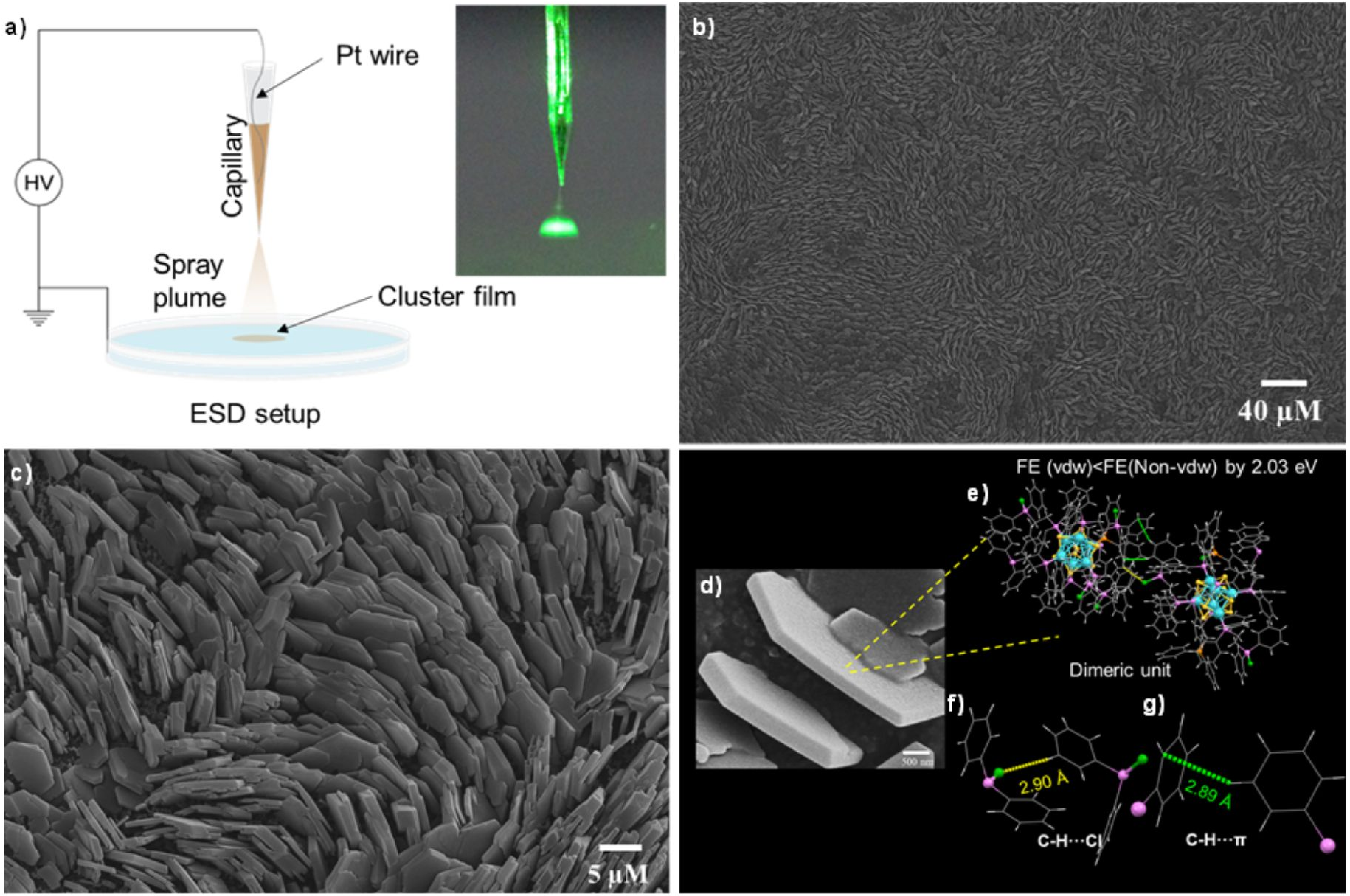


Water quality measurement – In the pipe line

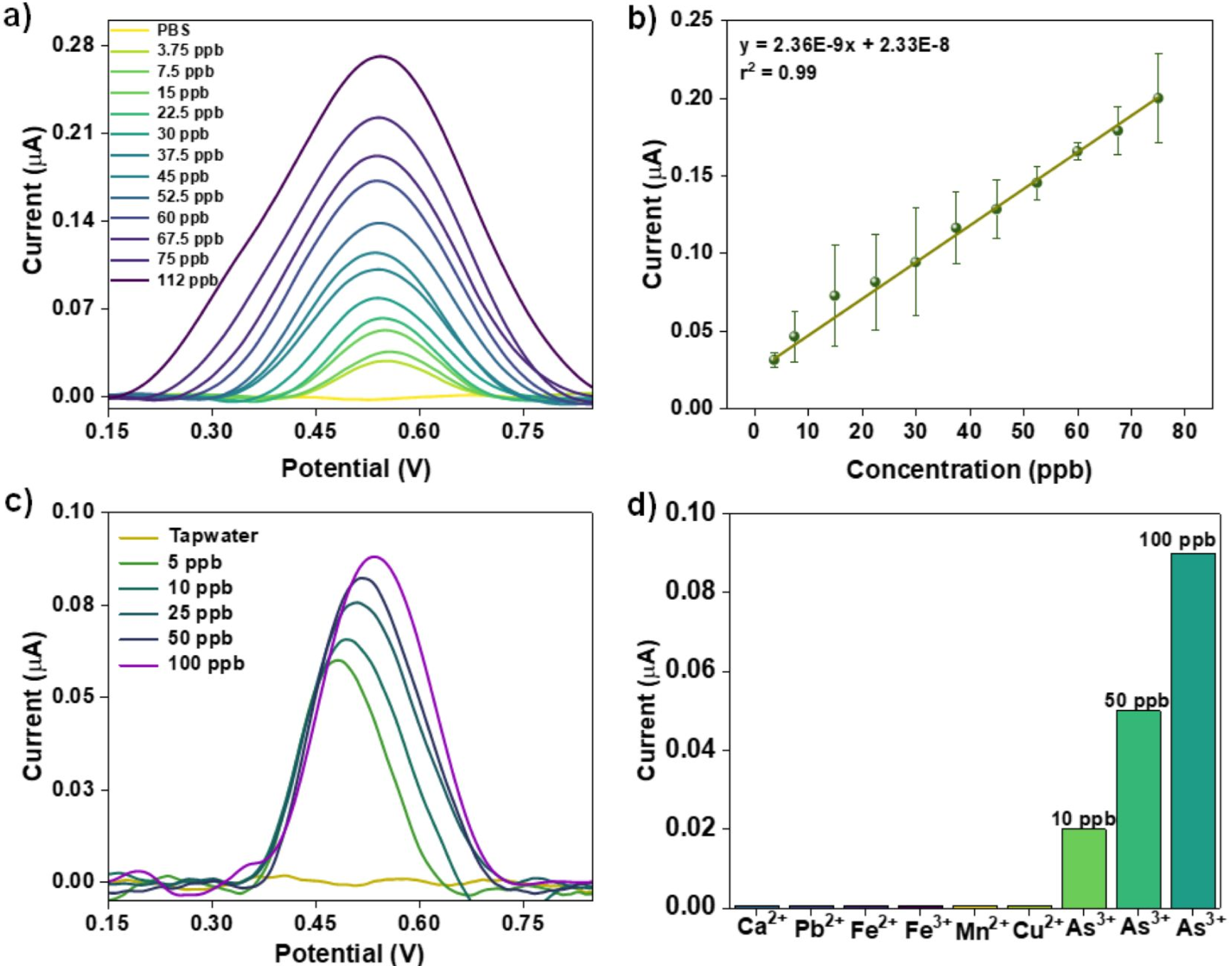
New electrodes - Aligned nanoplates of Co6S8

1,2-bis(diphenylphosphino)ethane (DPPE)

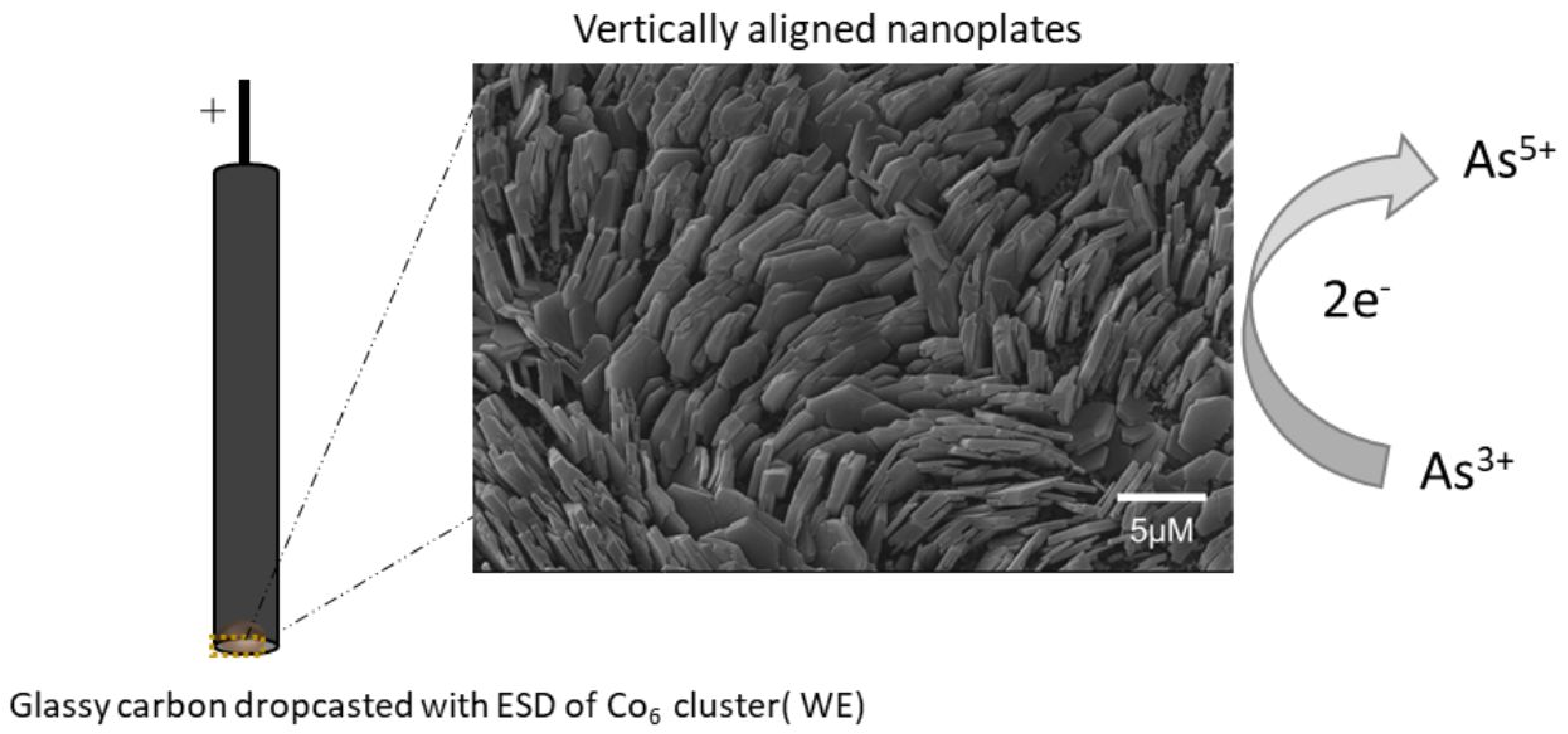
Electrospray deposition

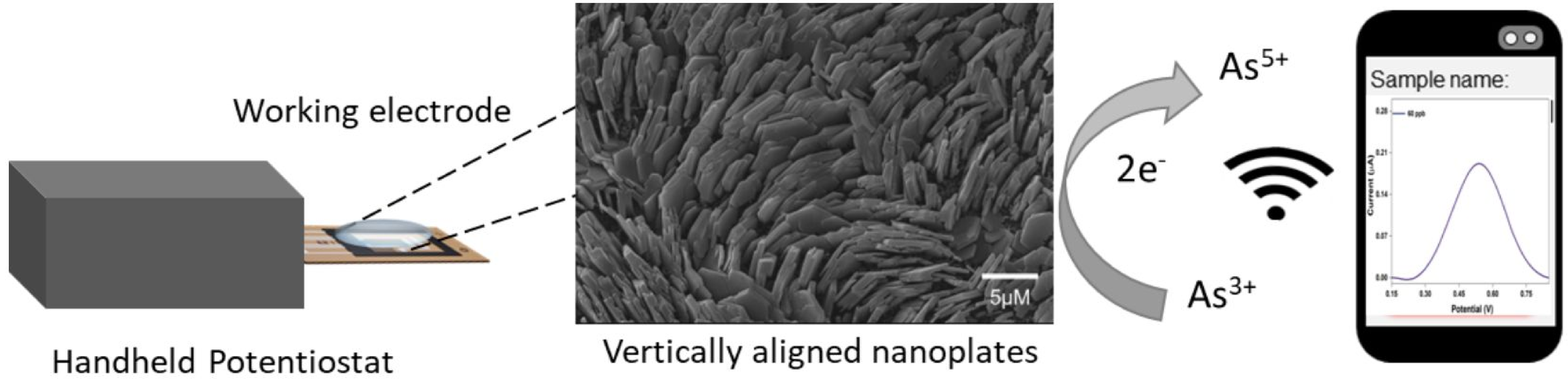


Sensing


a)
PBS
3.75 ppb
7.5 ppb
15 ppb
22.5 ppb
30 ppb
37.5 ppb
45 ppb
52.5 ppb
60 ppb
67.5 ppb
75 ppb
112 ppb
Current (μA)
Potential (V)
b)
y = 2.36E-9x + 2.33E-8
r2 = 0.99
Current (μA)
Concentration (ppb)
c)
Tapwater
5 ppb
10 ppb
25 ppb
50 ppb
100 ppb
Current (μA)
Potential (V)
d)
100 ppb
50 ppb
10 ppb
Current (μA)
Ca2+ Pb2+ Fe2+ Fe3+ Mn2+ Cu2+ As3+ As3+ As3+

Working electrode





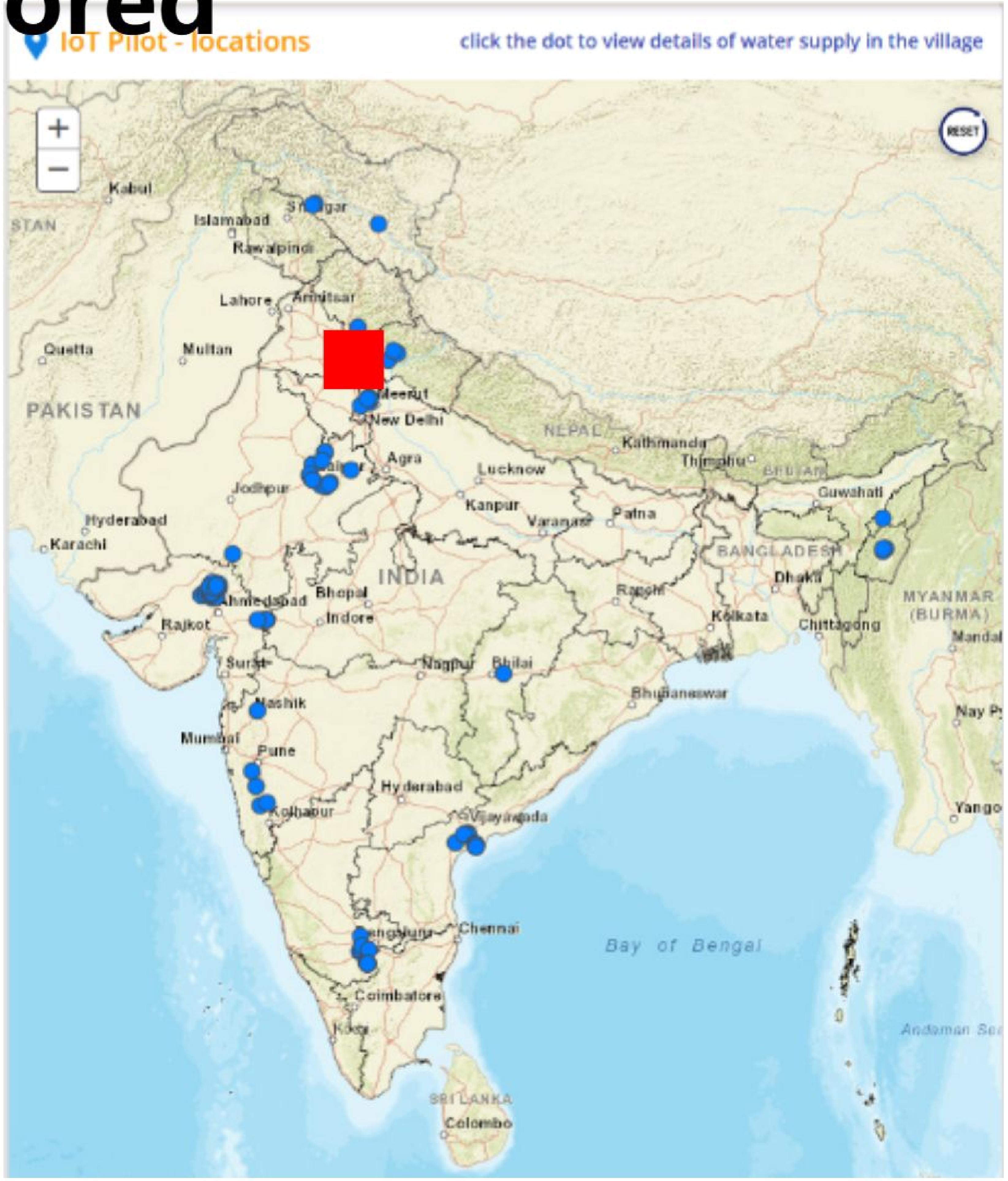
Anagha Jose et al. *ACS Materials Lett.,* 5 (2023) 893–899.

Arsenic poisoning across the worl d

E. Shaji, M. Santosh, K. V. Sarath, Pranav Prakash, V. Deepch and B. V. Divya, Geoscience Frontiers, 12 (2021) 10107 9.

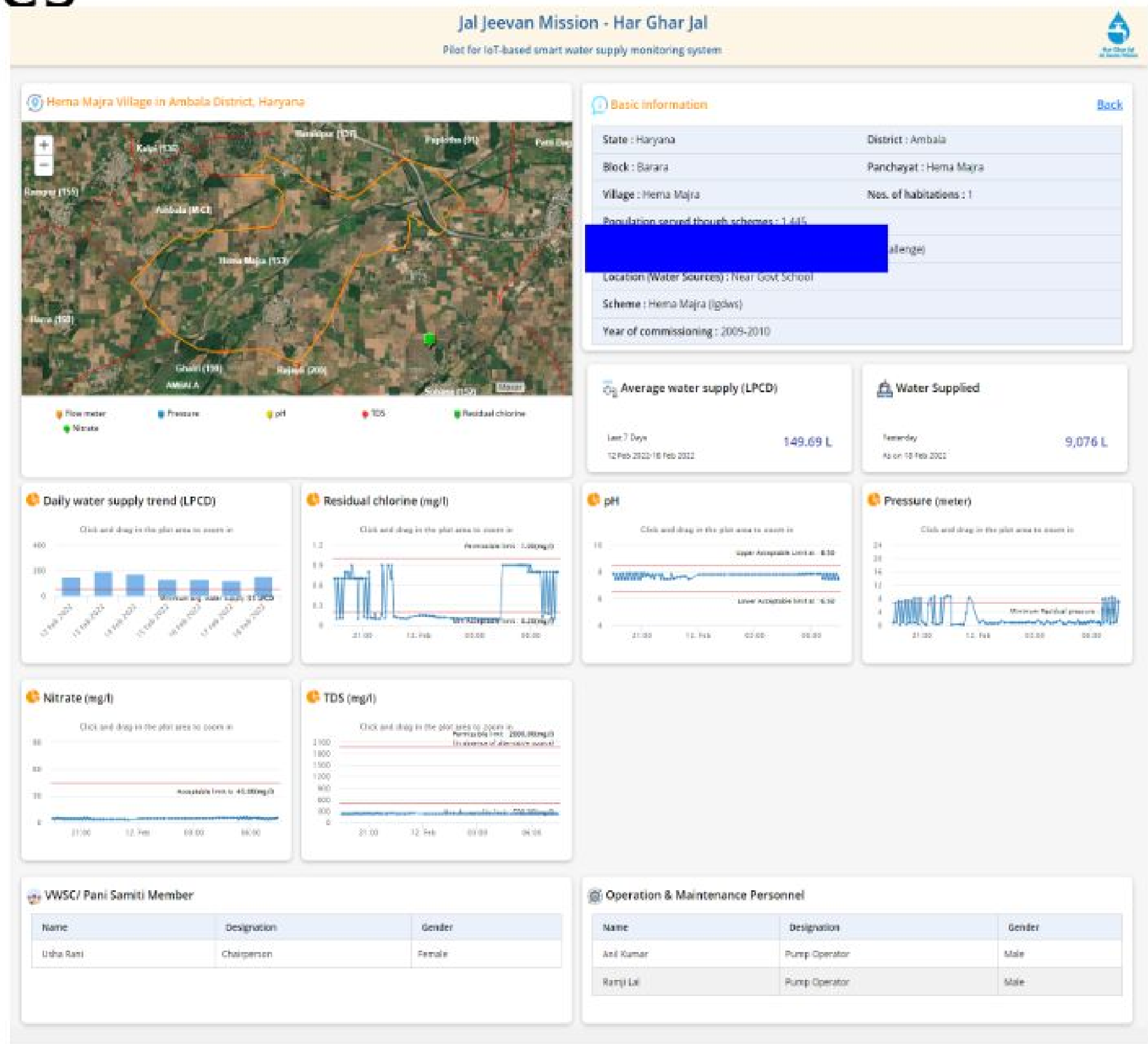

ब्रेक फास्ट

India's water is being monitored



IITM/IISc

Installations made by four companies



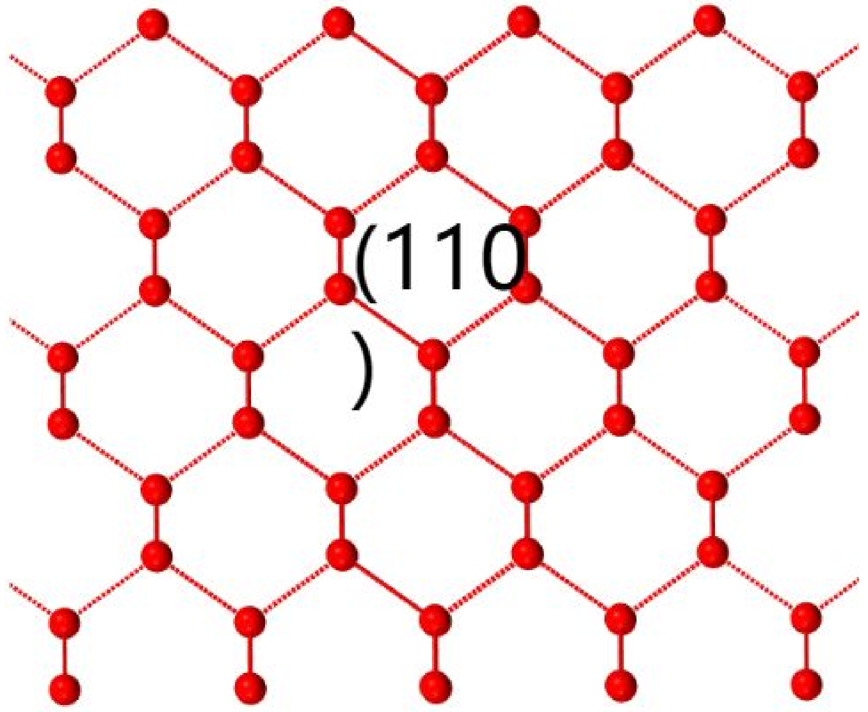

thermoscientific

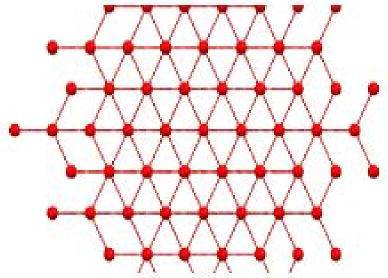
Imaging cubic ice at molecular resolution

(a)

(b)

3.65 Å





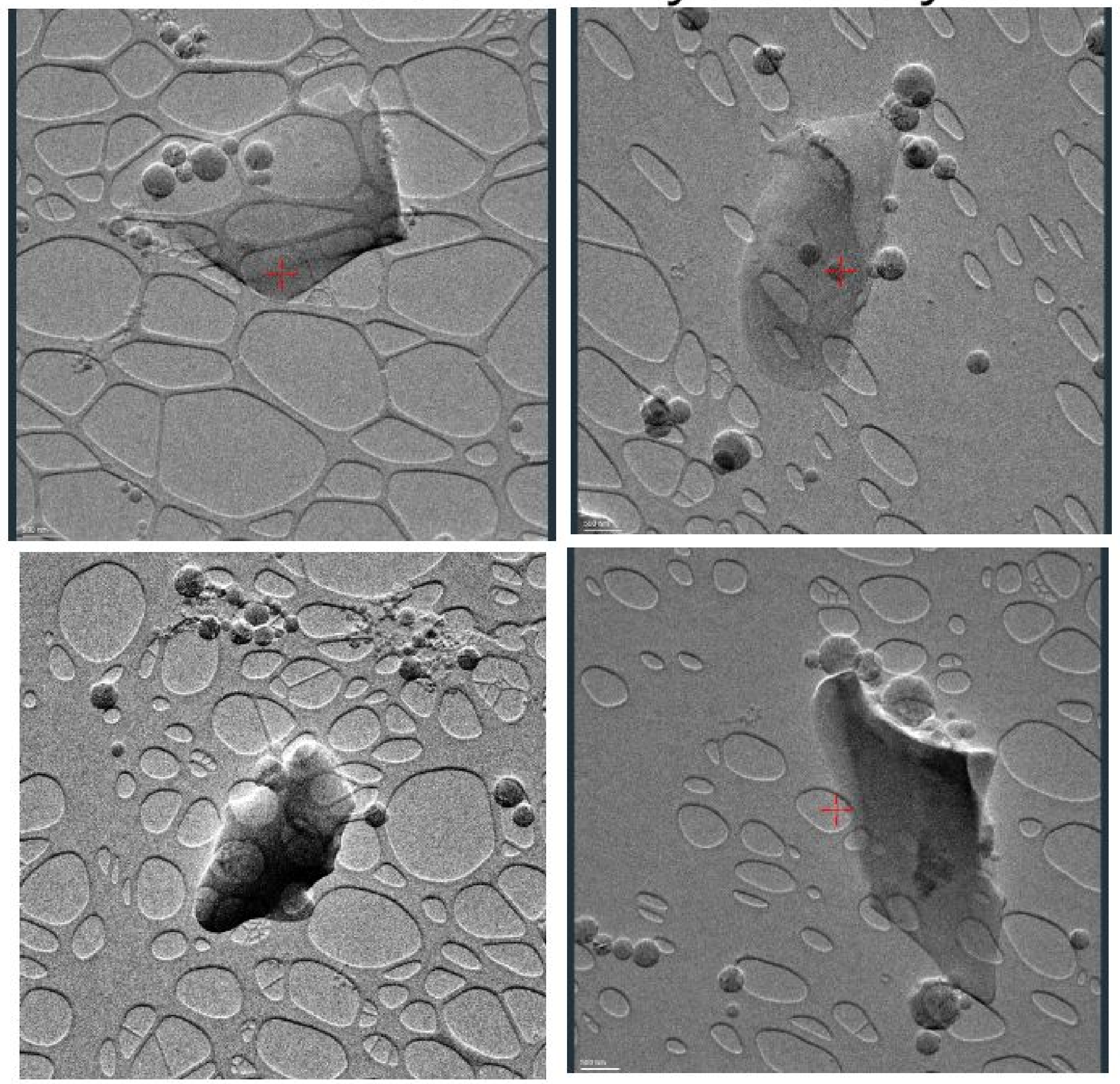
(C)

Stacking disorder)

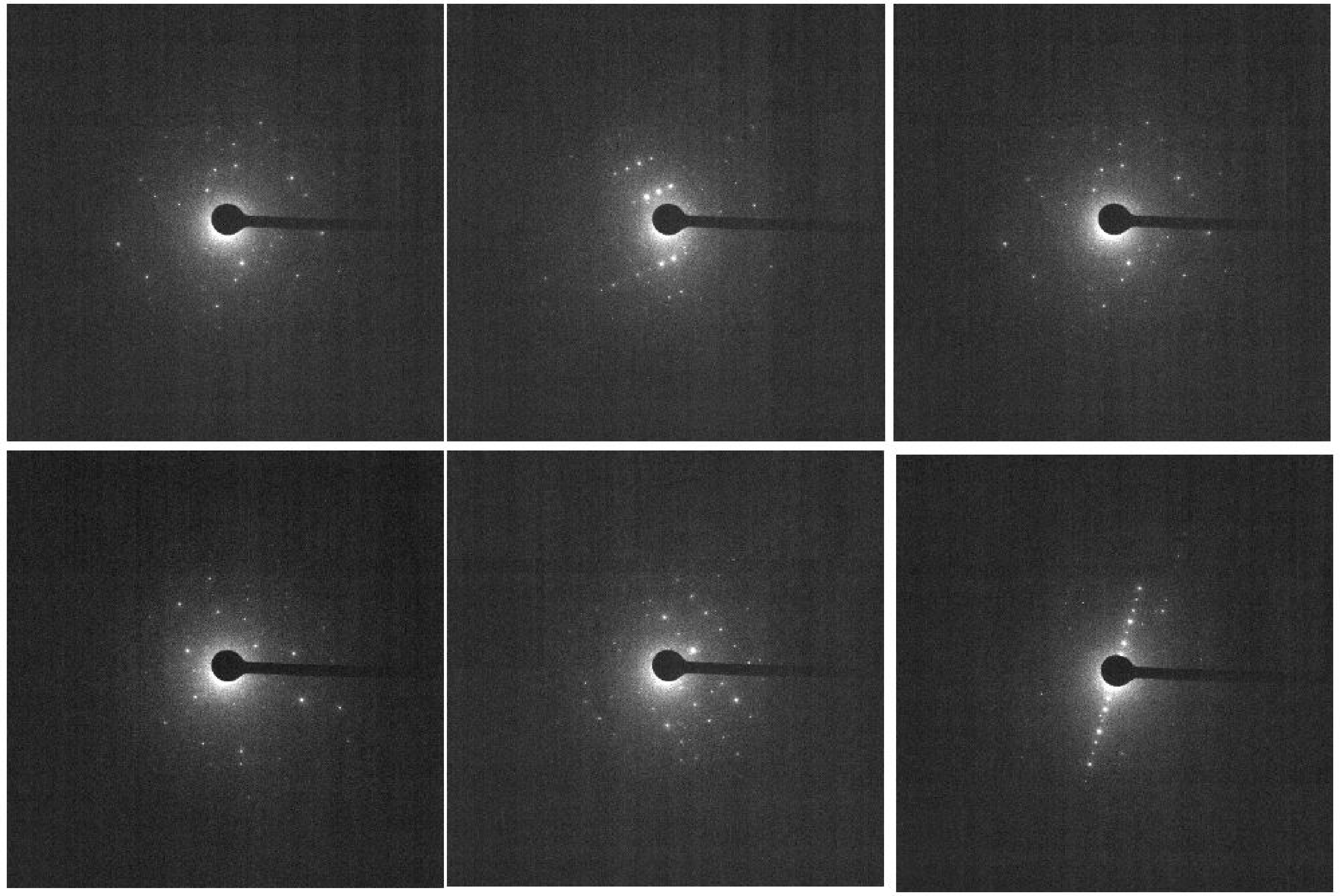
(111)

Electron diffraction of nanometer-scale crystals of clathrate hydrate

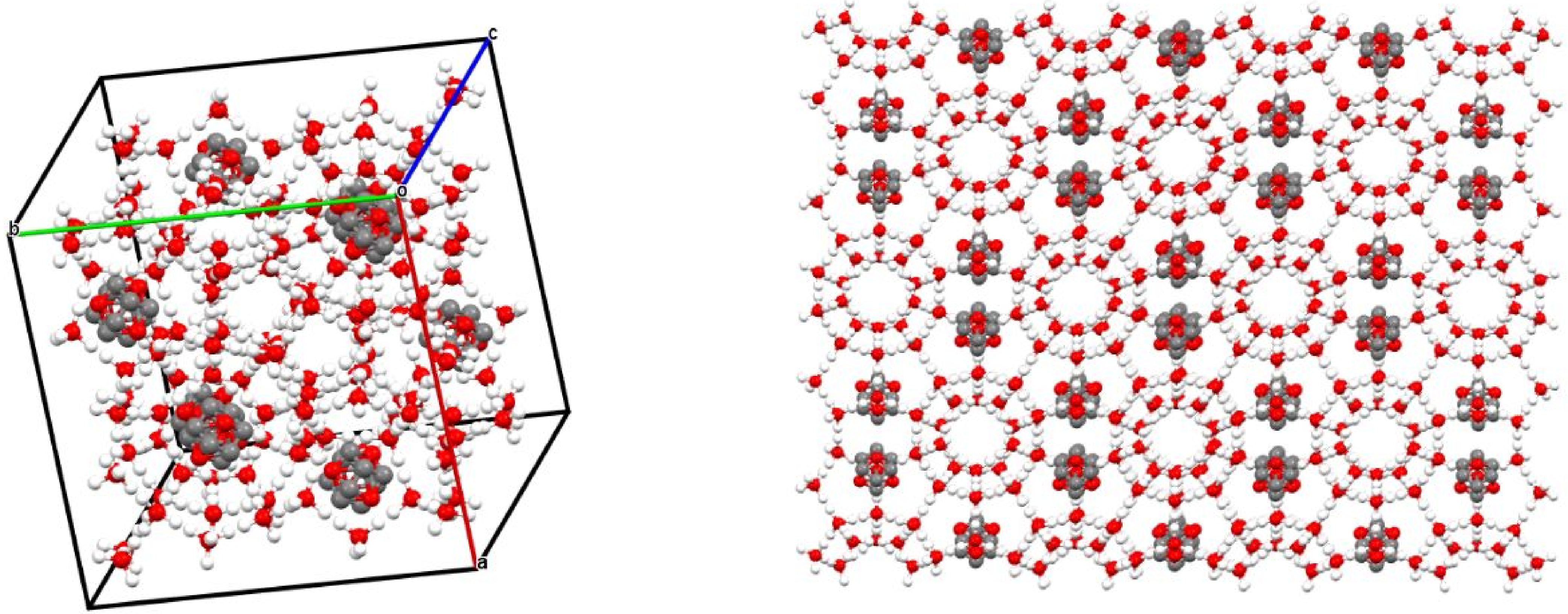
(a) THF-CH_4 Clathrate hydrate crystal



(b) 3 D electron diffraction



(c)



Crystal structure

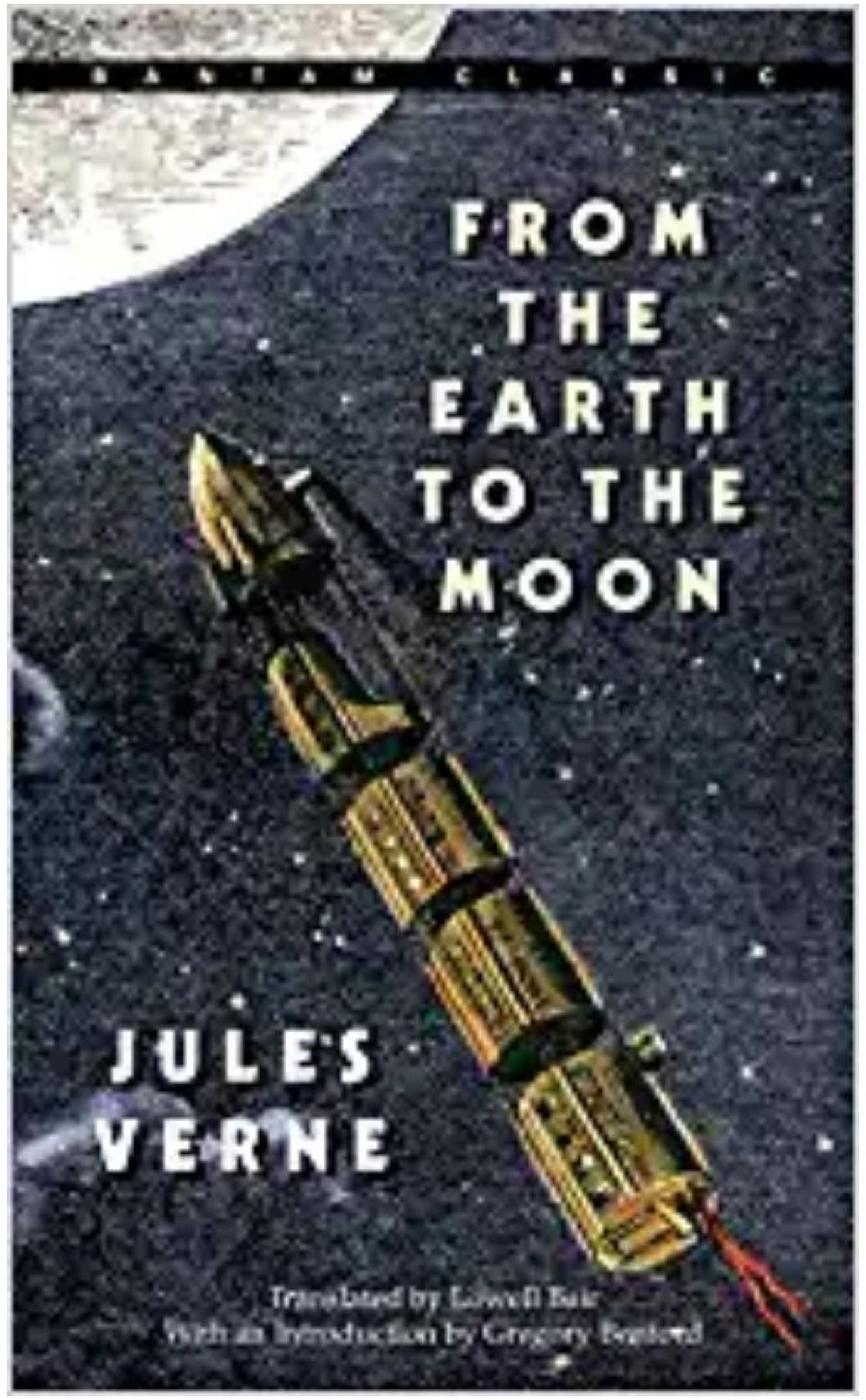
International Centre for Clean W
ater

Our dreams become reality with materials

Energy

H2O

Clean water



https://www.youtube.com/watch?v=fiJyptbXBtM

Clean water for all

https://www.peopleswaterdata.org

An ocean of opportun ities

Water presents a unique opportu nity to find a purpose in life.

Conclusions

Affordable clean water with advanced materials is demonstrated at scale.

Clean water for all is possible.

[redacted]

Water team at IIT: 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, Sonali Seth, 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, Sourav Kanti Jana, Tanmayaa Nayak, Sonali Seth…

Avula Anil Kumar, Chennu Sudhakar, Sritama Mukherjee, Anshup, and Mohan Udhaya Sankar

Funding: Department of Science and Technology, Government of India

Start-ups and partners:

PhD Theses: Bindhu Varughese, M. R. Resmi, M. Venkataramanan, N. Sandhyarani, R. Selvan, A. Sreekumaran Nair, M. J. Rosemary, Renjis T. Tom, C. Subramaniam, Jobin Cyriac, V. R. Rajeev Kumar, D. M. David Jeba Singh, Akshaya Kumar Samal, E. S. Shibu, M. A. Habeeb Muhammed, P. R. Sajanlal, T. S. Sreeprasad, J. Purushothaman, T. Udayabhaskararao, M. S. Bootharaju, Soumabha Bag, Robin John, Kamalesh Chaudhari, Ammu Mathew, Indranath Chakraborty, Radha Gobinda Bhuin, Ananya Baksi, Amitava Srimony, Anirban Som, Rabin Rajan Methikkalam, K. R. Krishnadas, Soujit Sengupta, Depanjan Sarkar, Atanu Ghosh, Rahul Narayanan, Avijit Baidya, Shridevi Bhat, Papri Chakraborty, Swathy Jakka Ravindran, C. K. Manju, Abhijit Nag, S. Vidhya, Jyoti Sarita Mohanty, Debasmita Ghosh, Jyotirmoy Ghosh, Md. Bodiuzzaman, Biswajit Mondal, Tripti Ahuja, Esma Khatun, Krishnan Swaminathan, K. S. Sugi, Amrita Chakraborty, Sudhakar Chennu, Sritama Mukherjee, Madhuri Jash, Sandeep Bose, Md. Rabiul Islam, Pallab Basuri, Mohd Azhardin Ganayee, Tanvi Gupte, Ankit Nagar, Srikrishnarka Pillalamarri, Arijit Jana, Paulami Bose, Gaurav Viswakarma, Vishal Kumar, Jayoti Roy, A. Anil Kumar, Jenifer Shantha Kumar

MS Theses: Ananthu Mahedranath, Ramesh Kumar Soni

>25 Post-doctoral fellows, >130 masters students and visitors

Indian Institute of Technology Madras

ıamurthi/V. Kamakoti

Associate Editor ACS Sustainable Resource Management

RESEARCH GROUP

THEMATIC UNIT OF EXCELLENCE

Manswita Mandal for help with the sli