Since 1959

Treatment Methods for Arsenic, Heavy Metals and Fluoride

Thalappil Pradeep
Institute Professor, IIT Madras
pradeep@iitm.ac.in
https://pradeepresearch.org

Co-founder

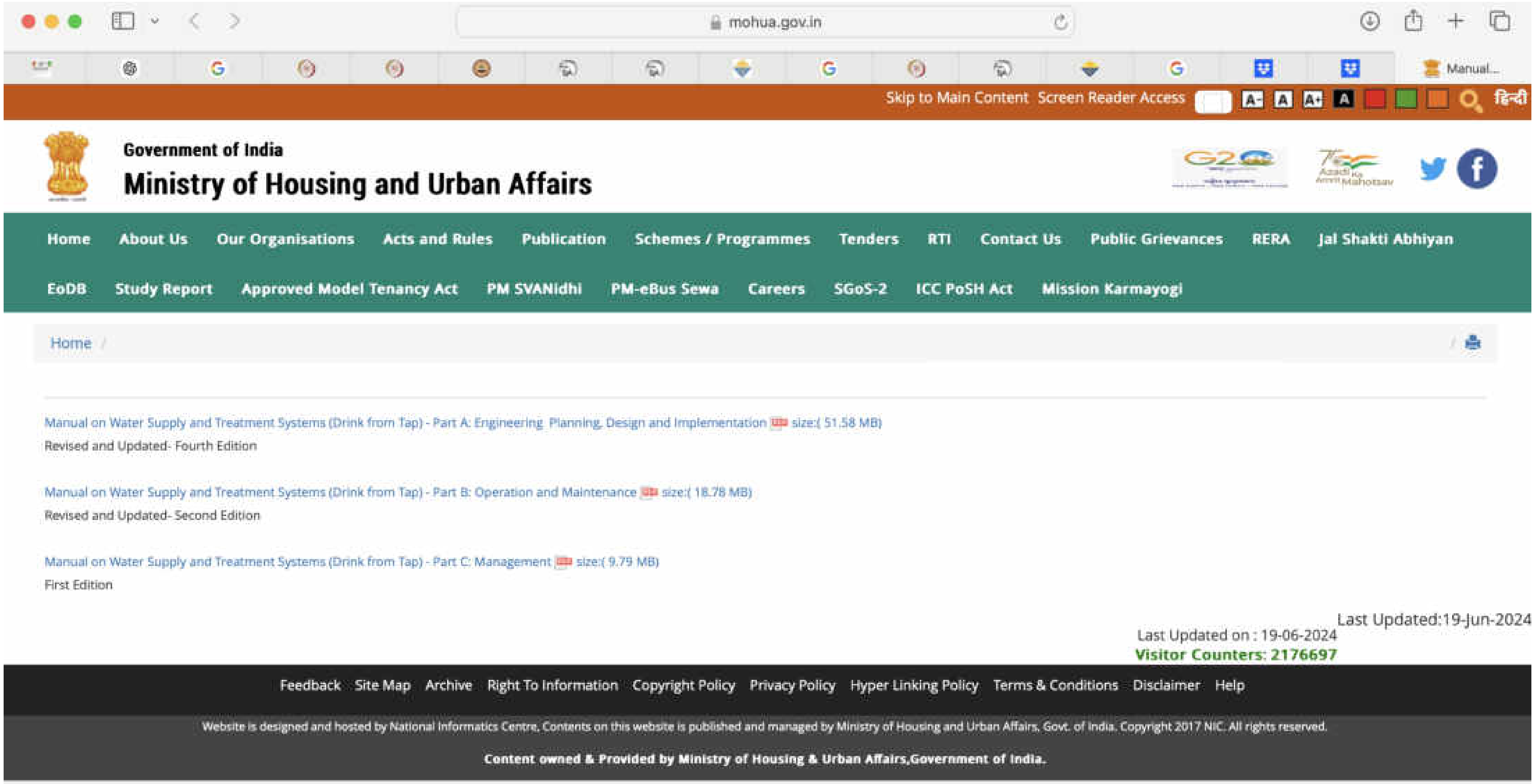
InnoNano Research Pvt. Ltd.
InnoDI Water Technologies Pvt. Ltd.
VayuJAL Technologies Pvt. Ltd.
Aqueasy Innovations Pvt. Ltd.
Hydromaterials Pvt. Ltd.
EyeNetAqua Solutions Pvt. Ltd.
DeepSpectrum Innovations Pvt. Ltd.

Associate Editor
ACS Sustainable Resource Management

Professor-in-charge
ICCW
International Centre for Clean Water

pradeep RESEARCH GROUP

Water Supply 24x7 Training Program, India-Israel CoWT, August 5-8, 2024, IITMRP



https://mohua.gov.in/publication/manual-on-water-supply-and-treatment-systems---drink-from-tap---march-2024.php

GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS

MANUAL ON WATER SUPPLY AND TREATMENT SYSTEMS (DRINK FROM TAP)

PART A: ENGINEERING - PLANNING, DESIGN AND IMPLEMENTATION

FOURTH EDITION - REVISED AND UPDATED

CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL ENGINEERING ORGANISATION

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MARCH 2024

RESEARCH ARTICLE

WATER RESOURCES

Global threat of arsenic in groundwater

Joel Podgorski[1,2]* and Michael Berg[1,3]*

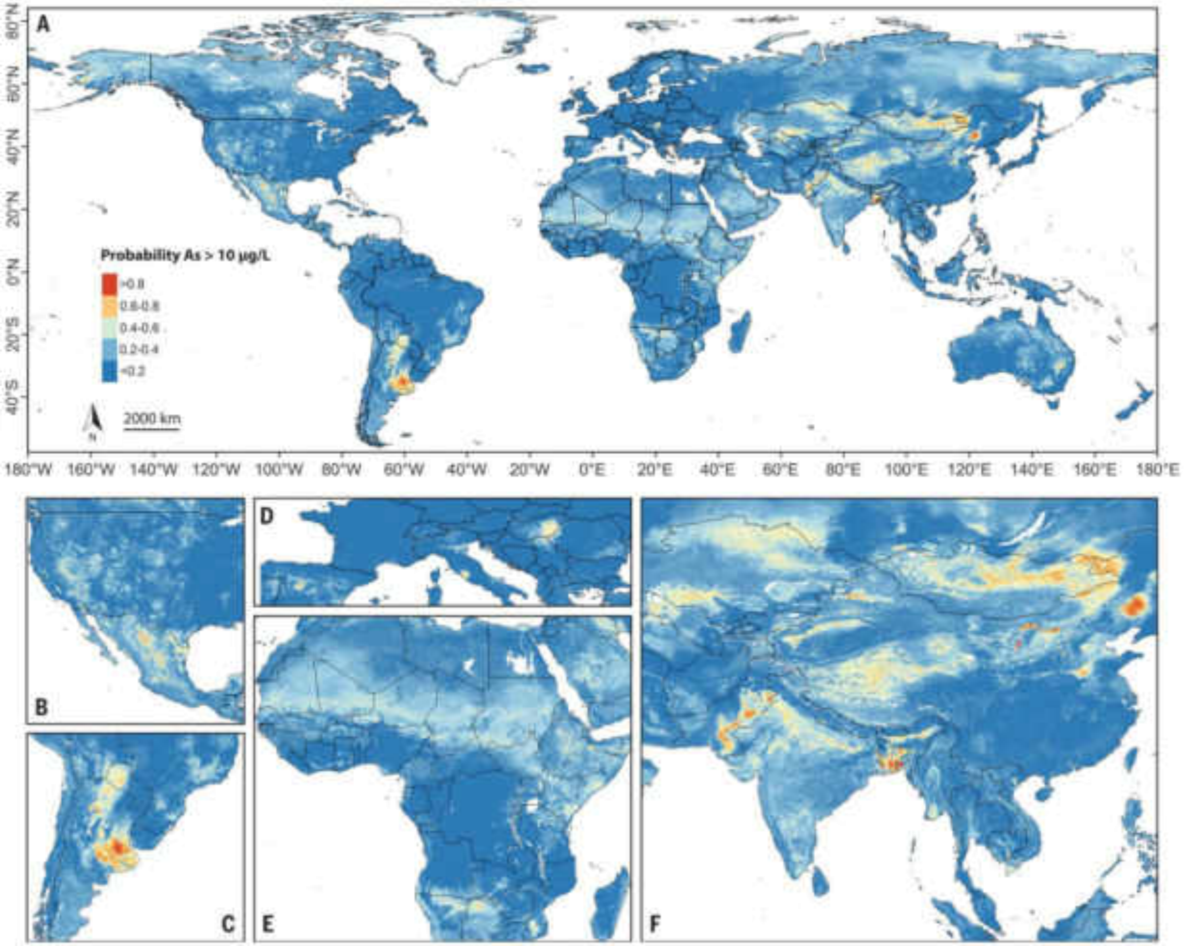


Fig. 2. Global prediction of groundwater arsenic. (A to F) Modeled probability of arsenic concentration in groundwater exceeding 10 μg/liter for the entire globe (A) along with zoomed-in sections of the main more densely populated affected areas (B) to (F). The model is based on the arsenic data points in Fig. 1 and the predictor variables in table S2. Figs. S2 to S8 provide more detailed views of the prediction map.

Using 200,000 data points

Podgorski et al., Science 368, 845–850 (2020) 22 May 2020

Analysis based on machine learning models

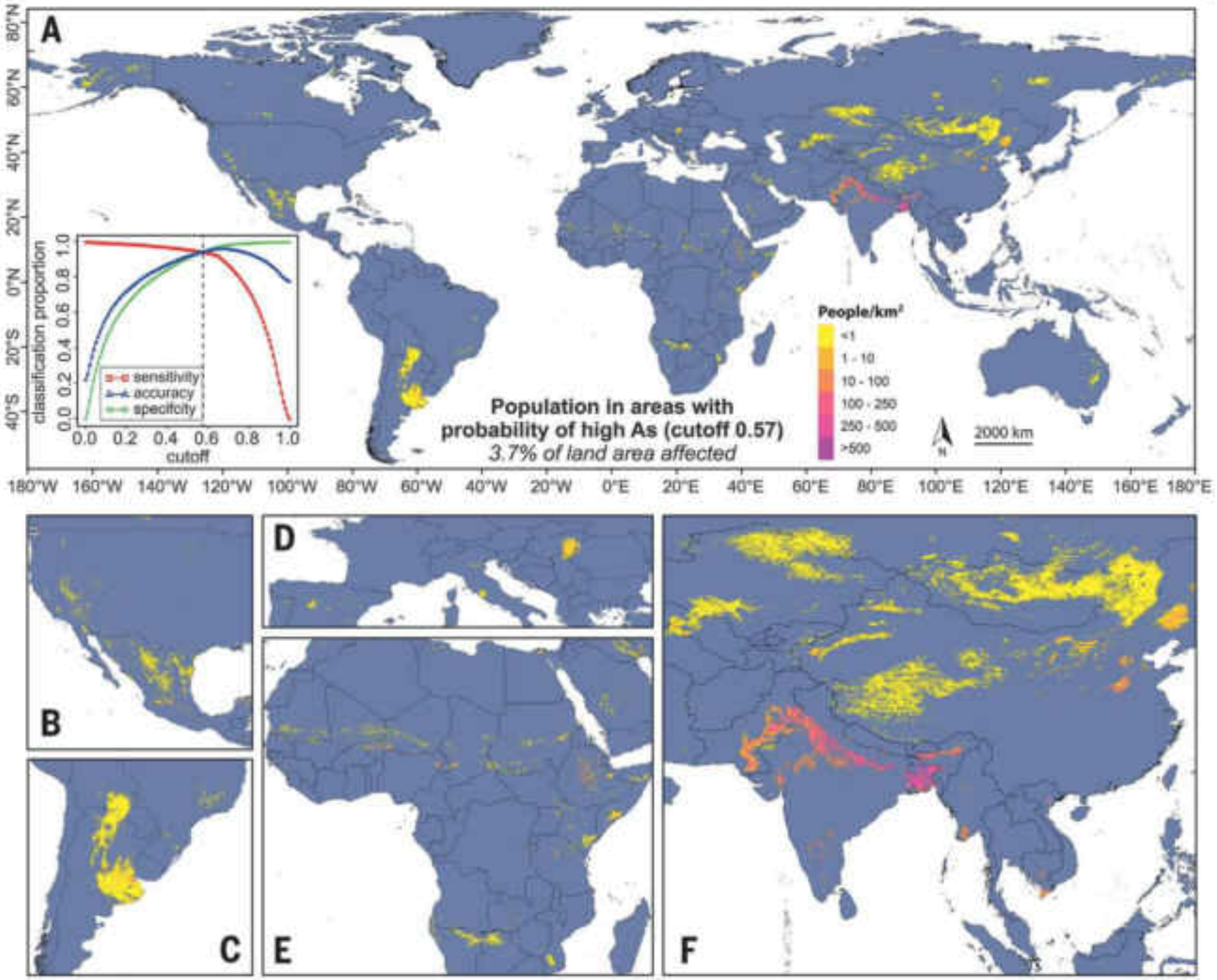


Fig. 4. Estimated population at risk. (A to L) Population in risk areas potentially containing aquifers with arsenic concentrations >10 mg/ liter using probability cutoffs of 0.57 (A), at which sensitivity and specificity are equal [inset in (A)] as applied to the full (training and test) dataset, and 0.72 (G), at which PPV and NPV are equal [inset in (G)] using the full dataset. The detailed areas of Fig. 2 are also repeated here for both models (B) to (F) and (H) to (L).

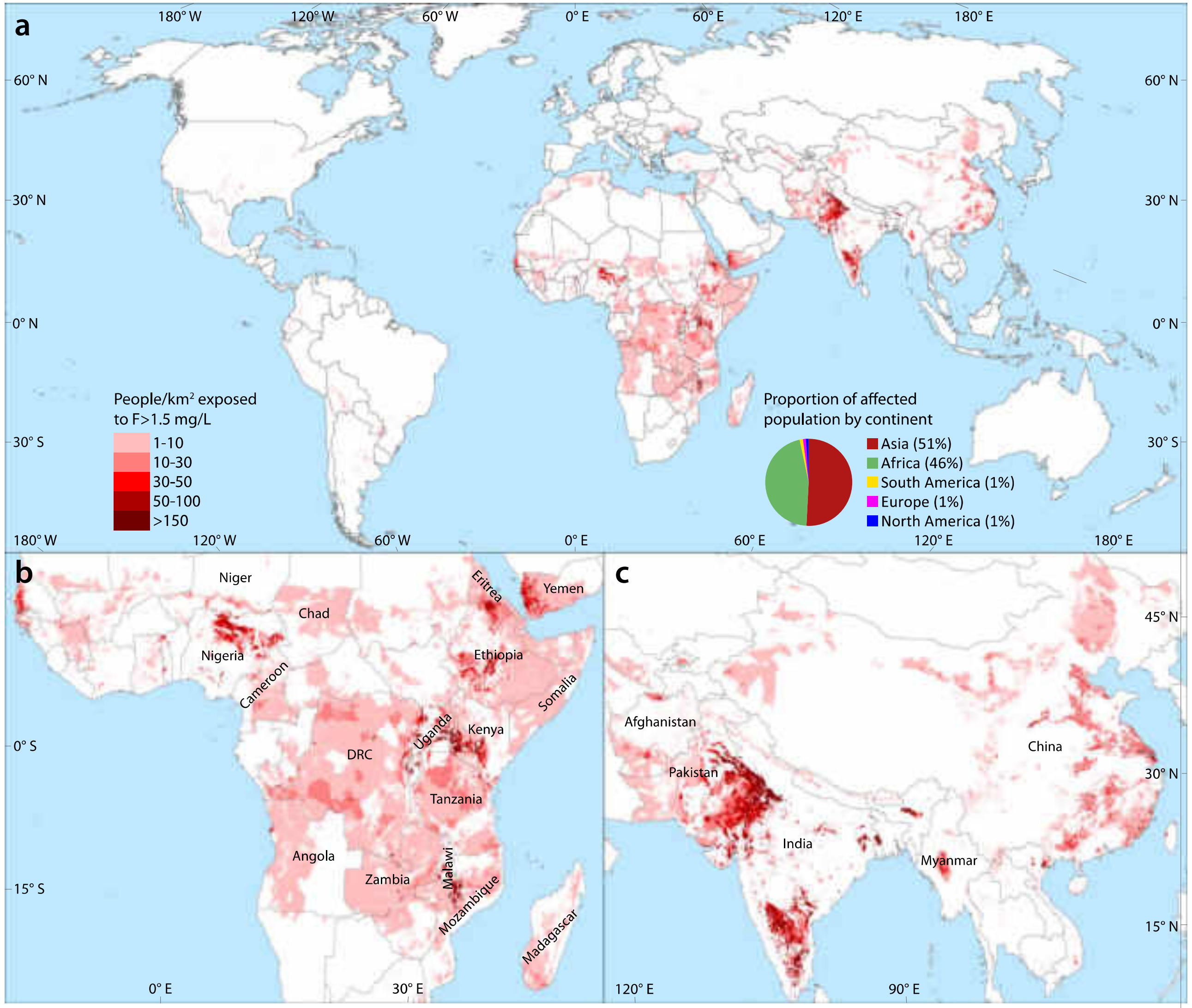


Fig. 4 Estimated population potentially exposed to fluoride concentrations in drinking water greater than 1.5 mg/L. a Global map and break-down by continent. Detailed views of **b** sub-Saharan Africa and southern Arabian peninsula and **c** south and east Asia with the most strongly affected countries indicated. The population was calculated with the hybrid approach (see text) for areas with a greater than 25% probability of incurring high fluoride in groundwater (Fig. 1) by multiplying the total population by the hazard percentage and the proportion of domestic water usage coming from untreated groundwater[51].

ARTICLE

https://doi.org/10.1038/s41467-022-31940-x OPEN

Global analysis and prediction of fluoride in groundwater

Joel Podgorski[1✉] & Michael Berg[1✉]

400,000 measurements, 10% > 1.4 mg/L

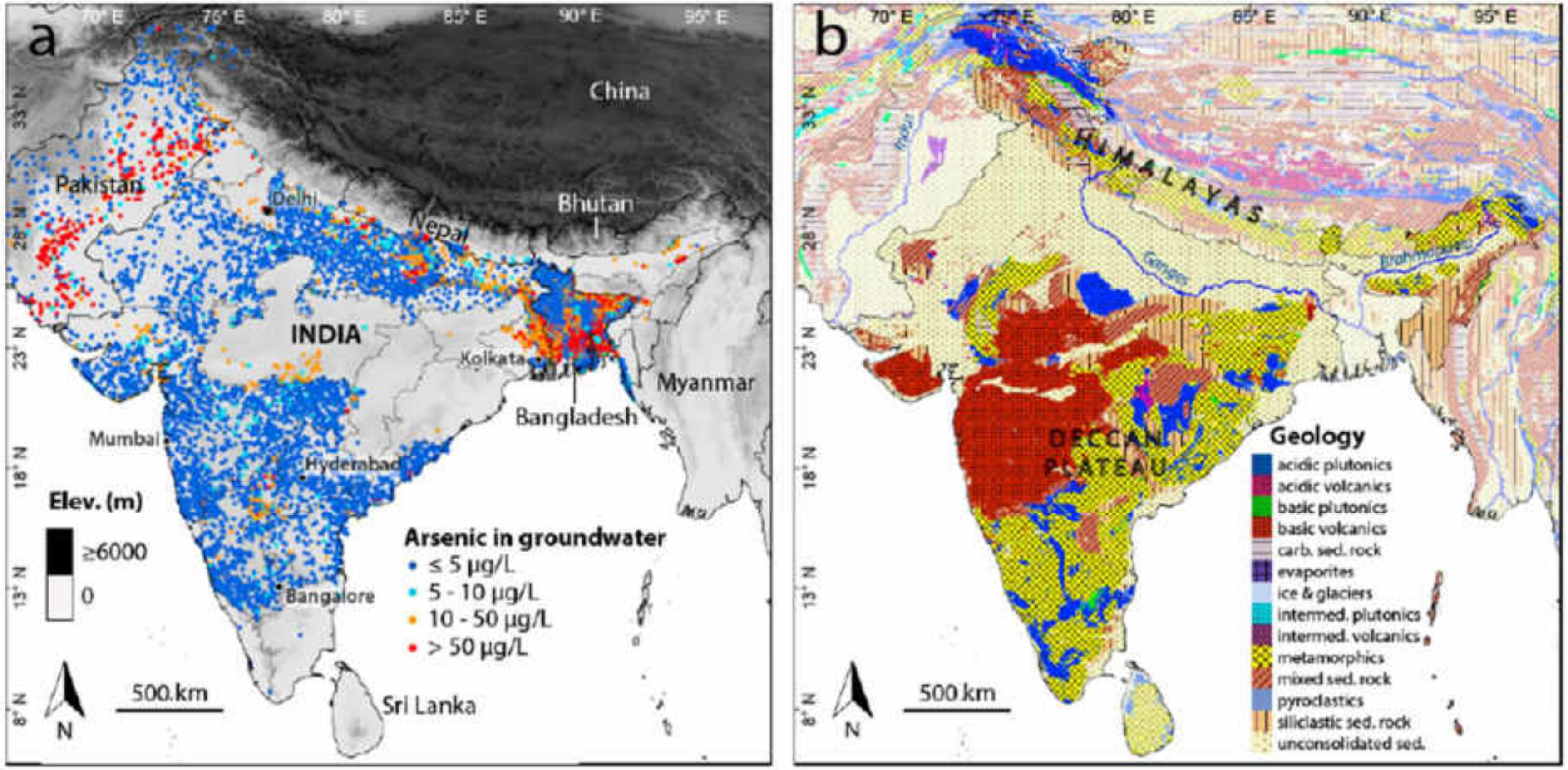


Figure 1. Arsenic concentration in Indian groundwater (**a**) topographical representation of averaged arsenic data points in Indian groundwater (**b**) Indian lithology [25].

Review

Arsenic Contamination in Indian Groundwater: From Origin to Mitigation Approaches for a Sustainable Future

Water **2023**, *15*, 4125. https://doi.org/10.3390/w15234125

Deepali Marghade [1,*], Girish Mehta [2], Sagar Shelare [2], Ganesh Jadhav [3] and Keval Chandrakant Nikam [3]

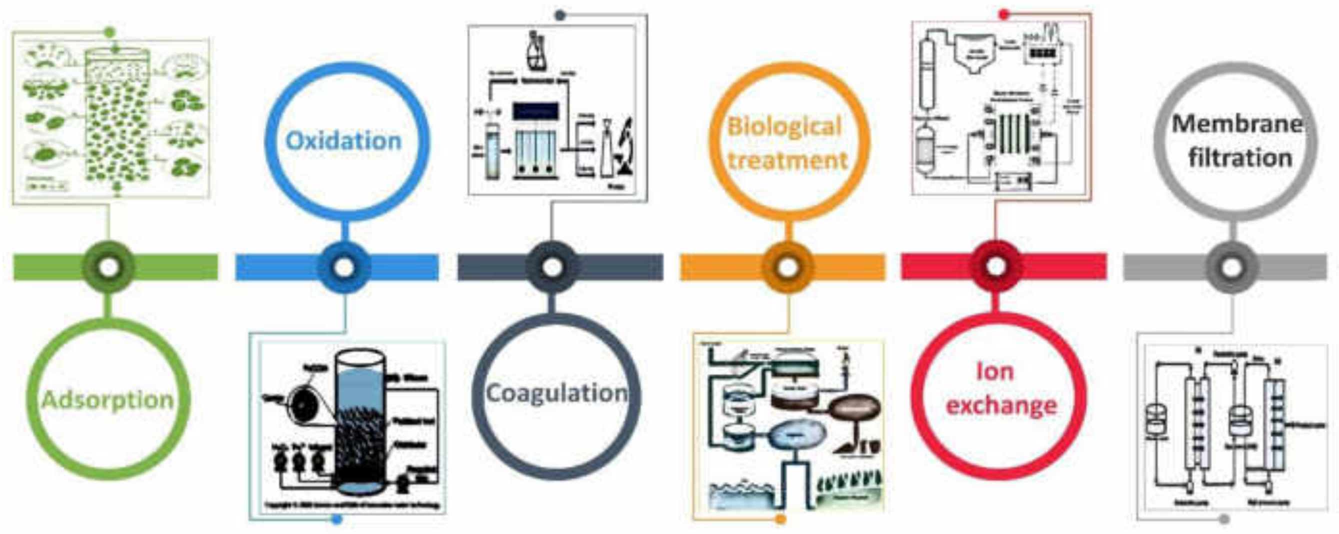
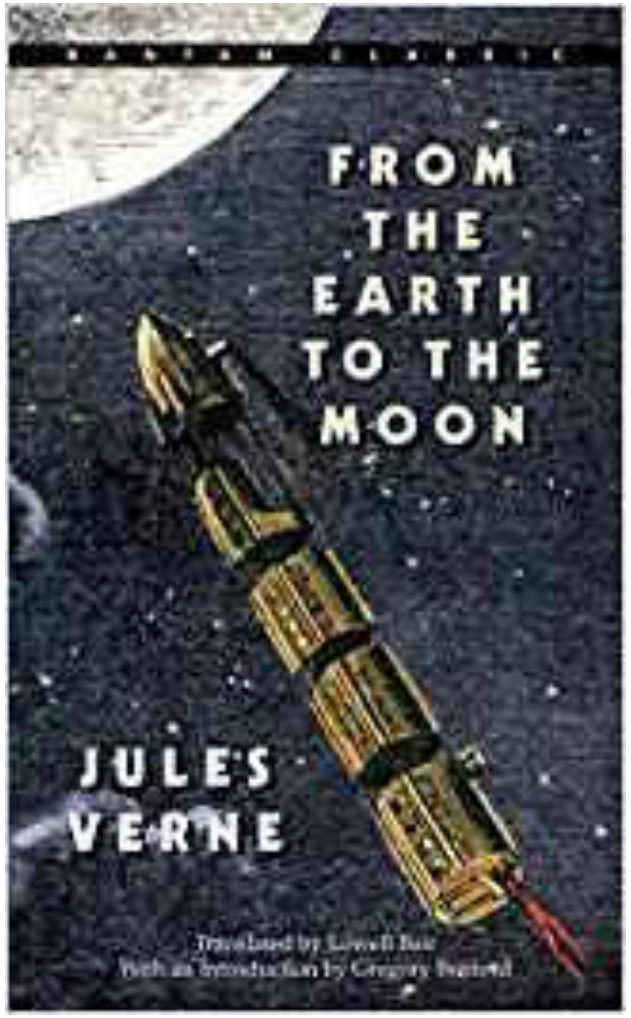


Figure 5. Various Mitigation Methods for Arsenic Contamination.

Our dreams become reality with materials



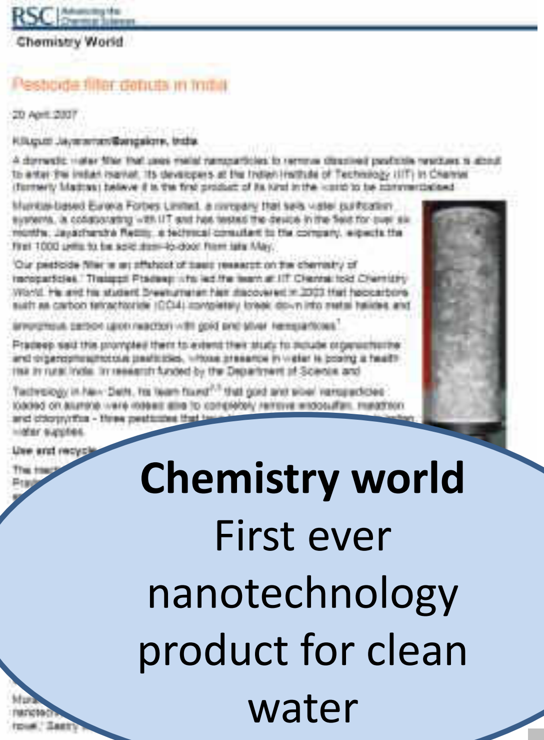
Water purification, history

Important milestones in the history of water purification (1800–2007) from the perspective of noble metal nanoparticles in water treatment (compiled from multiple sources on the World Wide Web).

Year	Milestone
1804	Setup of world's first city-wide municipal water treatment plant (Scotland, sand-filter technology)
1810	Discovery of chlorine as a disinfectant (H. Davy)
1852	Formulation of Metropolis Water Act (England)
1879	Formulation of Germ Theory (L. Pasteur)
1902	Use of chlorine as a disinfectant in drinking water supply (calcium hypochlorite, Belgium)
1906	Use of ozone as a disinfectant (France)
1908	Use of chlorine as a disinfectant in municipal supply, New Jersey
1914	Federal regulation of drinking water quality (USPHS)
1916	Use of UV treatment in municipal supplies
1935	Discovery of synthetic ion exchange resin (B. A. Adams, E. L. Holmes)
1948	Nobel Prize to Paul Hermann Muller (insecticidal properties of DDT)
1959	Discovery of synthetic reverse osmosis membrane (S. Yuster, S. Loeb, S. Sourirajan)
1962	*Silent Spring* published, first report on harmful effects of DDT (R. Carson)
1965	World's first commercial RO plant launched
1974	Reports on carcinogenic by-products of disinfection with chlorine Formulation of Safe Drinking Water Act (USEPA)
1975	Development of carbon block for drinking water purification
1994	Report on use of zerovalent iron for degradation of halogenated organics (R. W. Gillham, S. F. O'Hannesin)
1997	Report on use of zerovalent iron nanoparticles for degradation of halogenated organics (C-B. Wang, W.-X. Zhang)
1998	Drinking Water Directive applied in EU
2000	Adoption of Millennium Declaration during the UN Millennium Summit (UN Millennium Development Goals)
2003	Report on use of noble metal nanoparticles for the degradation of pesticides (A.S. Nair, R. T. Tom, T. Pradeep)
2004	Stockholm Convention, banning the use of persistent organic pollutants
2007	Launch of noble metal nanoparticle-based domestic water purifier (T. Pradeep, A. S. Nair, Eureka Forbes Limited)

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

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 ... water supplies.

Use and recycle

Chemistry world

First ever nanotechnology product for clean water

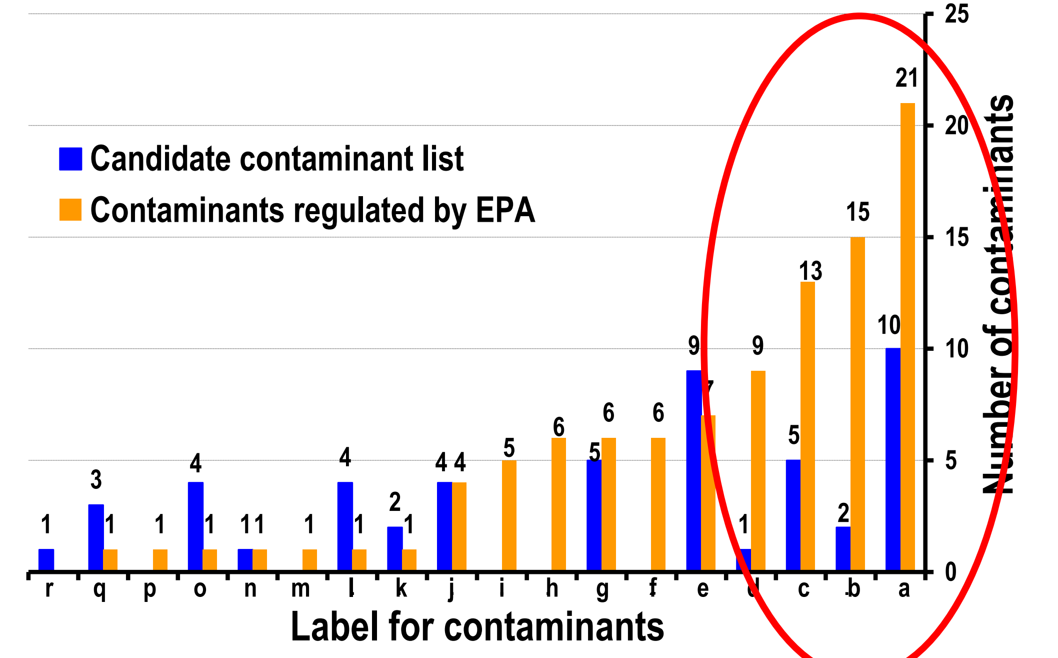
A plant to make supported nanomaterials for water purification; with capacity of 4.5 tons per month, 2007

1. Patents: A method of preparing purified water from water containing pesticides, **Indian patent 200767**
2. Extraction of malatheon and chlorpiryhphos from drinking water by nanoparticles , **US 7,968,493** A method for decontaminating water containing pesticides, **EP 17,15,947**

Product is marketed now by a Eureka Forbes Ltd.

Several new technologies are now available

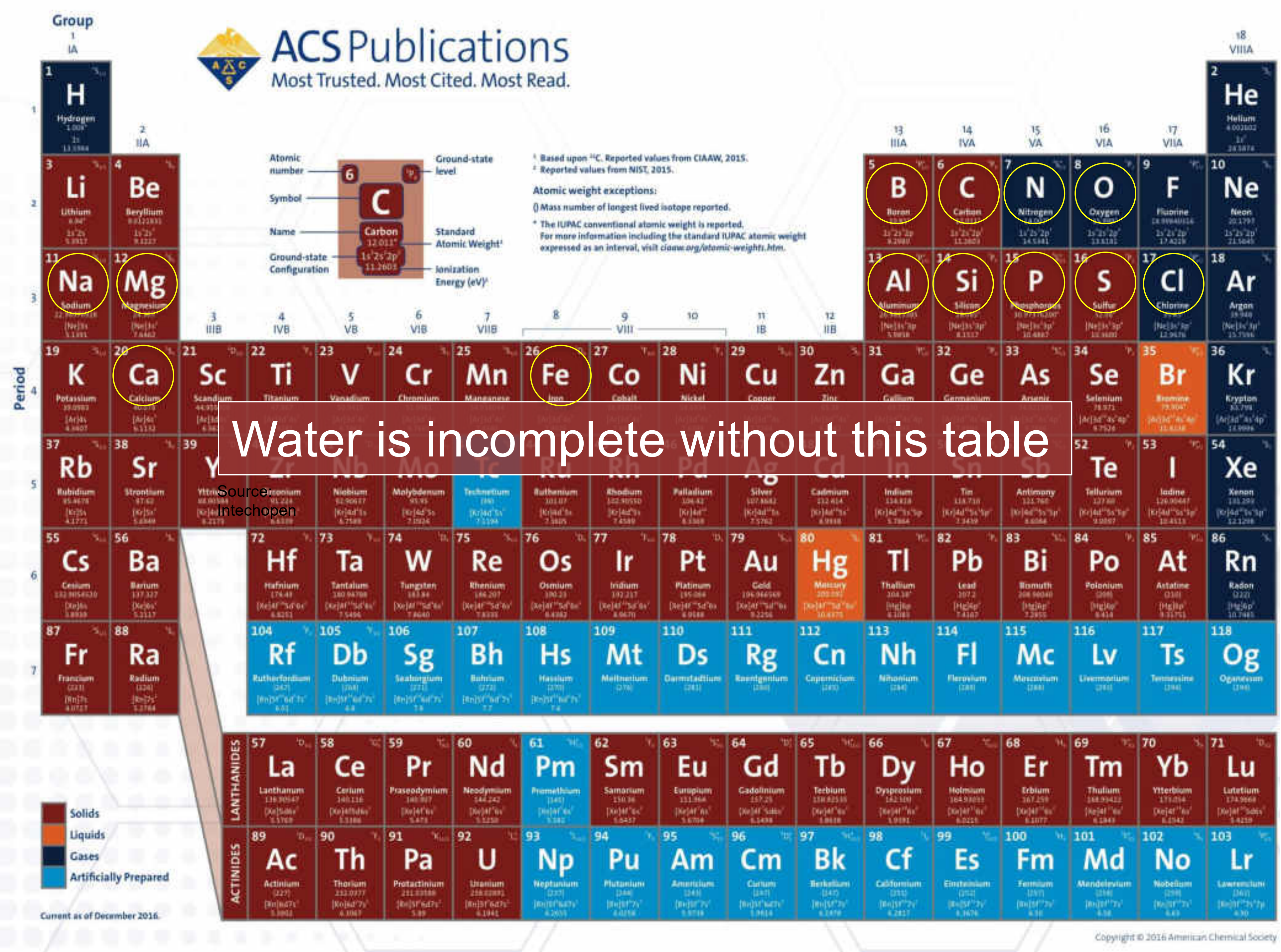
Future of water purification: An enigma with some pointers



(a): Halogenated organic (b): Metal (c): Organochlorine pesticide (d): Inorganic salt (e): Biological contaminant (f): Nuclear (g): Benzo derivative (h): Carbamate pesticide (i): Pesticides (others) (j): Unclassified (k): Triazine derivative pesticide (l): Organophosphorus pesticide (m): Organobromine pesticide (n): Non-metal (o): Nitrophenol derivative, (p): Dioxin, (q): Benzo and halogenated organic (r): Organometallics

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).



Water is incomplete without this table

Source Intechopen

$AB(s) = A^+(aq) + B^-(aq)$

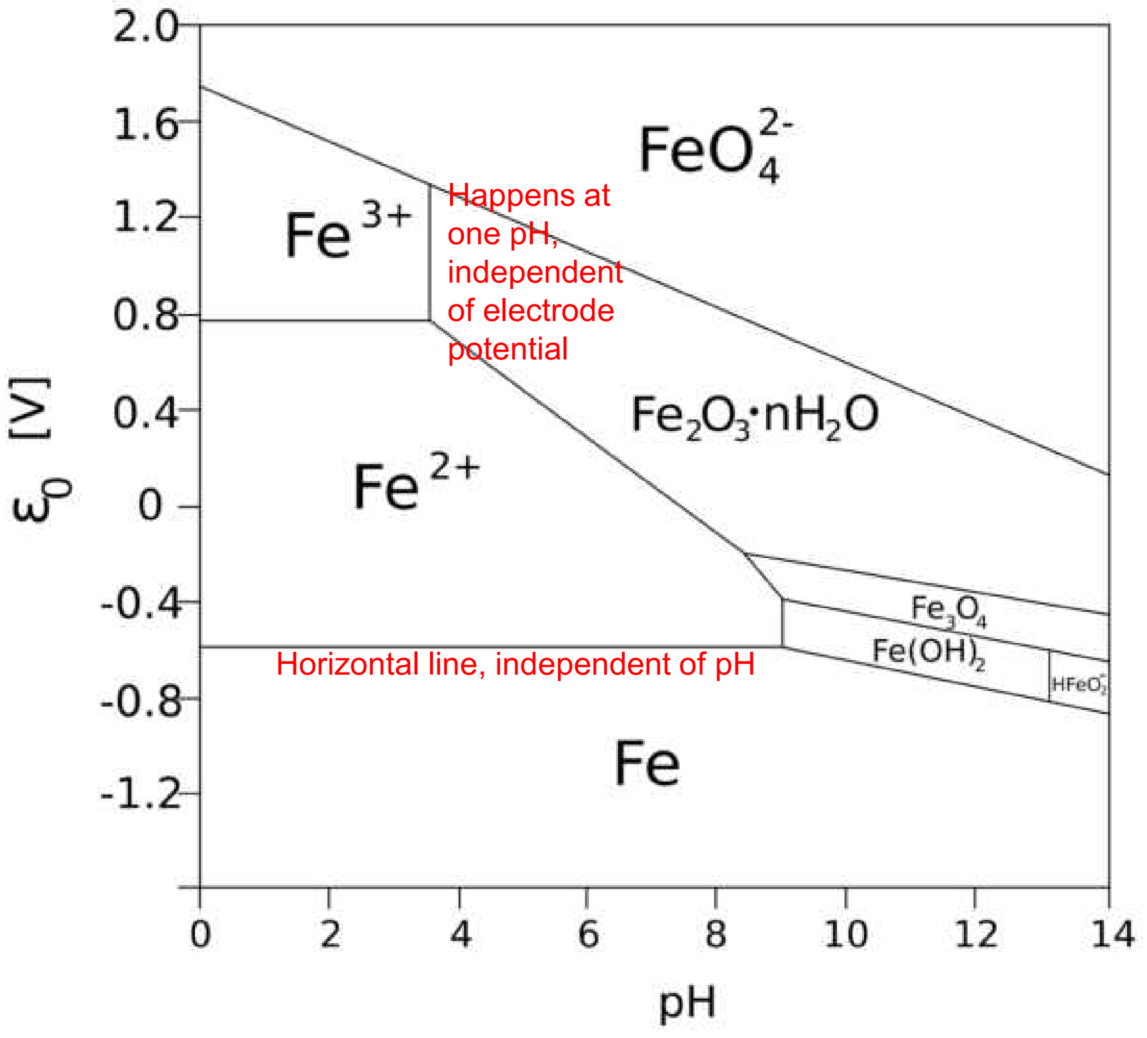
$K_{sp} = [A^+][B^-]$

Table 5-7

Solubility-Product Constants, K_{sp}, at 25 °C

Fluorides		Chromates (*cont.*)		Hydroxides (*cont.*)	
BaF_2	2.4×10^{-5}	Ag_2CrO_4	1.9×10^{-12}	$Ni(OH)_2$	1.6×10^{-16}
MgF_2	8×10^{-8}	$PbCrO_4$	2×10^{-16}	$Zn(OH)_2$	4.5×10^{-17}
PbF_2	4×10^{-8}	Carbonates		$Cu(OH)_2$	1.6×10^{-19}
SrF_2	7.9×10^{-10}	$NiCO_3$	1.4×10^{-7}	$Hg(OH)_2$	3×10^{-26}
CaF_2	3.9×10^{-11}	$CaCO_3$	4.7×10^{-9}	$Sn(OH)_2$	3×10^{-27}
Chlorides		$BaCO_3$	1.6×10^{-9}	$Cr(OH)_3$	6.7×10^{-31}
$PbCl_2$	1.6×10^{-5}	$SrCO_3$	7×10^{-10}	$Al(OH)_3$	5×10^{-33}
$AgCl$	1.7×10^{-10}	$CuCO_3$	2.5×10^{-10}	$Fe(OH)_3$	6×10^{-38}
Hg_2Cl_2[a]	1.1×10^{-18}	$ZnCO_3$	2×10^{-10}	$Co(OH)_3$	2.5×10^{-43}
Bromides		$MnCO_3$	8.8×10^{-11}	Sulfides	
$PbBr_2$	4.6×10^{-6}	$FeCO_3$	2.1×10^{-11}	MnS	7×10^{-16}
$AgBr$	5.0×10^{-13}	Ag_2CO_3	8.2×10^{-12}	FeS	4×10^{-19}
Hg_2Br_2[a]	1.3×10^{-22}	$CdCO_3$	5.2×10^{-12}	NiS	3×10^{-21}
Iodides		$PbCO_3$	1.5×10^{-15}	CoS	5×10^{-22}
PbI_2	8.3×10^{-9}	$MgCO_3$	1×10^{-15}	ZnS	2.5×10^{-22}
AgI	8.5×10^{-17}	Hg_2CO_3[a]	9.0×10^{-15}	SnS	1×10^{-26}
Hg_2I_2[a]	4.5×10^{-29}	Hydroxides		CdS	1.0×10^{-28}
Sulfates		$Ba(OH)_2$	5.0×10^{-3}	PbS	7×10^{-29}
$CaSO_4$	2.4×10^{-5}	$Sr(OH)_2$	3.2×10^{-4}	CuS	8×10^{-37}
Ag_2SO_4	1.2×10^{-5}	$Ca(OH)_2$	1.3×10^{-6}	Ag_2S	5.5×10^{-51}
$SrSO_4$	7.6×10^{-7}	$AgOH$	2.0×10^{-8}	HgS	1.6×10^{-54}
$PbSO_4$	1.3×10^{-8}	$Mg(OH)_2$	8.9×10^{-12}	Bi_2S_3	1.6×10^{-72}
$BaSO_4$	1.5×10^{-9}	$Mn(OH)_2$	2×10^{-13}	Phosphates	
Chromates		$Cd(OH)_2$	2.0×10^{-14}	Ag_3PO_4	1.8×10^{-18}
$SrCrO_4$	3.6×10^{-5}	$Pb(OH)_2$	4.2×10^{-15}	$Sr_3(PO_4)_2$	1×10^{-31}
Hg_2CrO_4[a]	2×10^{-9}	$Fe(OH)_2$	1.8×10^{-15}	$Ca_3(PO_4)_2$	1.3×10^{-32}
$BaCrO_4$	8.5×10^{-11}	$Co(OH)_2$	2.5×10^{-16}	$Ba_3(PO_4)_2$	6×10^{-39}
				$Pb_3(PO_4)_2$	1×10^{-54}

[a] As Hg_2^{2+} ion. $K_{sp} = [Hg_2^{2+}][X^-]^2$



Pourbaix diagram of iron.

Toxic elements

Most popular heavy metals: lead (Pb), zinc (Zn), mercury (Hg), nickel (Ni), cadmium (Cd), copper (Cu), chromium (Cr), and arsenic (As).

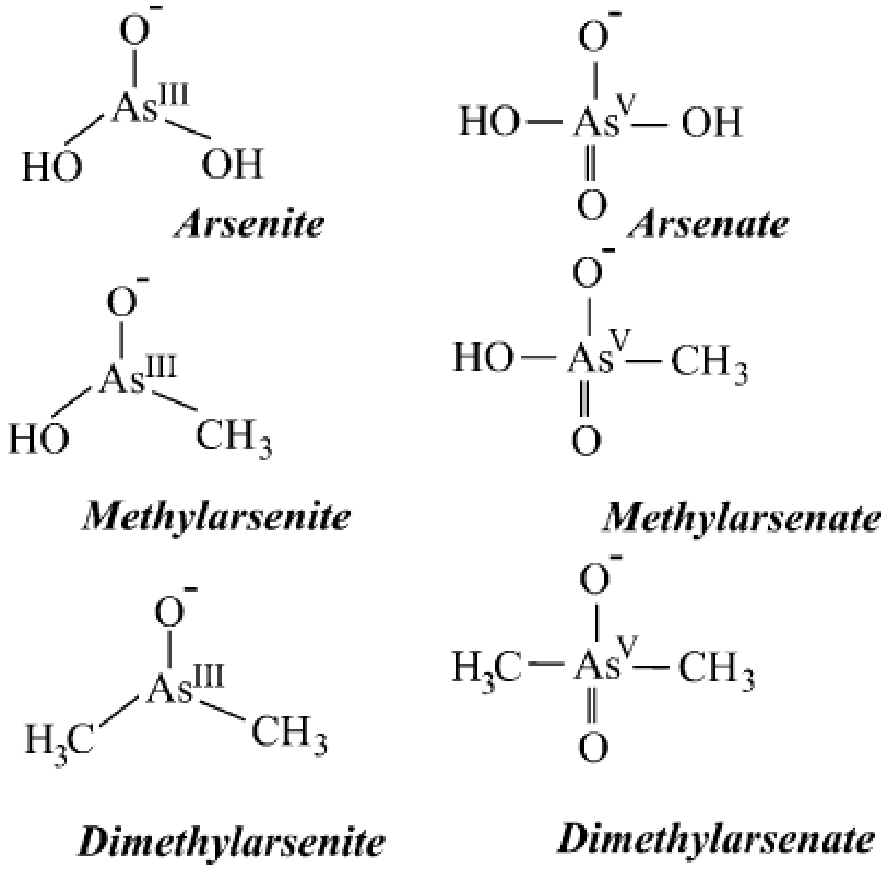
Commonly: arsenic, cadmium, chromium, lead, and mercury

Why are they toxic?

Arsenopyrite
FeAsS

$Fe^{3+}(AsS)^{3-}$ or FeAsS

Arsenic species of relevance



Scheme 1. Arsenic species found in water.

53rd element in abundance, 1/5 ppm in Earth's crust

Average concentration in soil 1-40 mg/kg

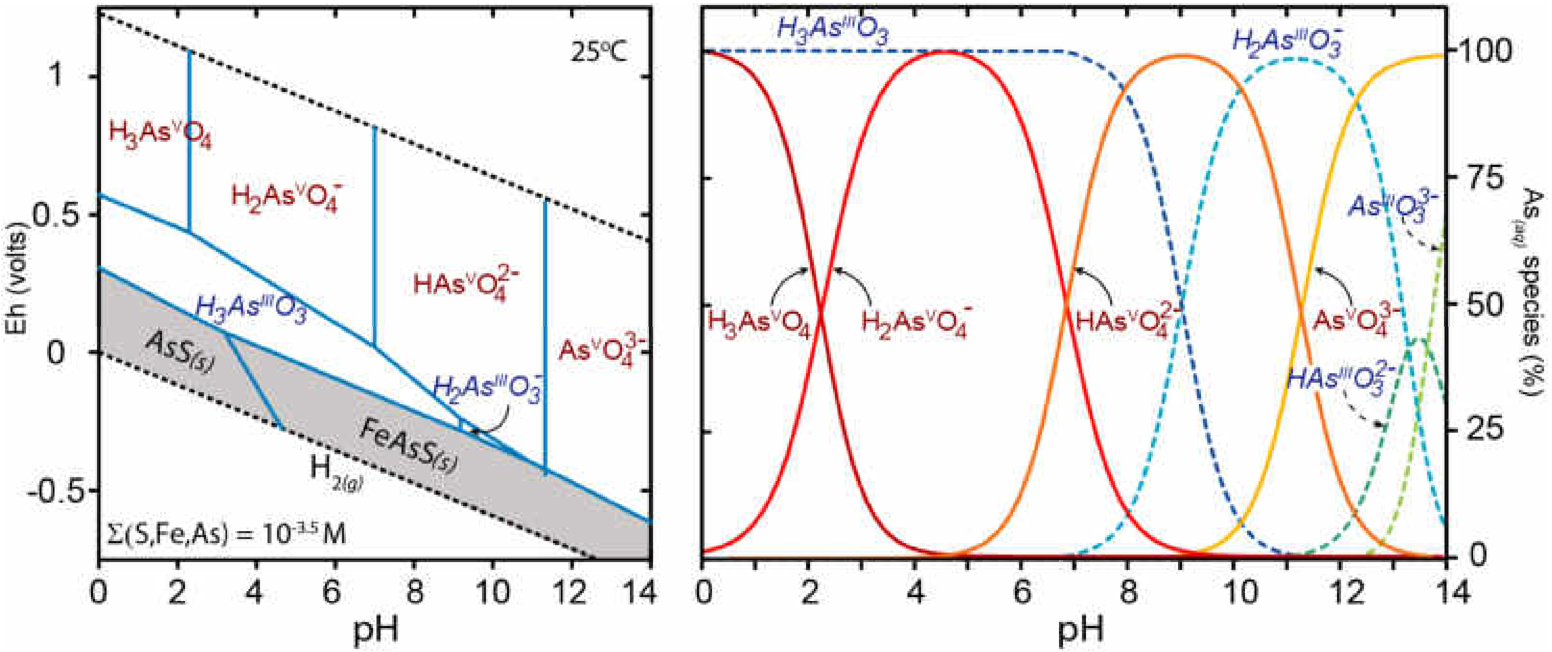


Figure 1. Eh-pH activity diagram of arsenic species at 25 °C, 1 bar, (S, Fe, As) = 10^{-3} M (**left**). Dashed lines bound the stability field of water, arsenate (As^V) species are shown in red, arsenite (As^{III}) species are shown in blue italics, solid phases are shown with a darkened background. The distribution of pH-dependent dissolved arsenic species are shown (**right**) with arsenate as red solid lines and red text and arsenite in dashed blue lines with blue italic text. Dissolved arsenic species become protonated at low pH and the charge on the oxyanion decreases. Under environmental conditions (pH ≈ 5–9), arsenate generally exists as $H_2AsO_4^-$ and $HAsO_4^{2-}$, while arsenite is the uncharged molecule $H_3AsO_3^0$. Under highly reducing conditions and in the presence of high sulfur activity, solid-phase arsenic sulfides (e.g., AsS) are stable.

water

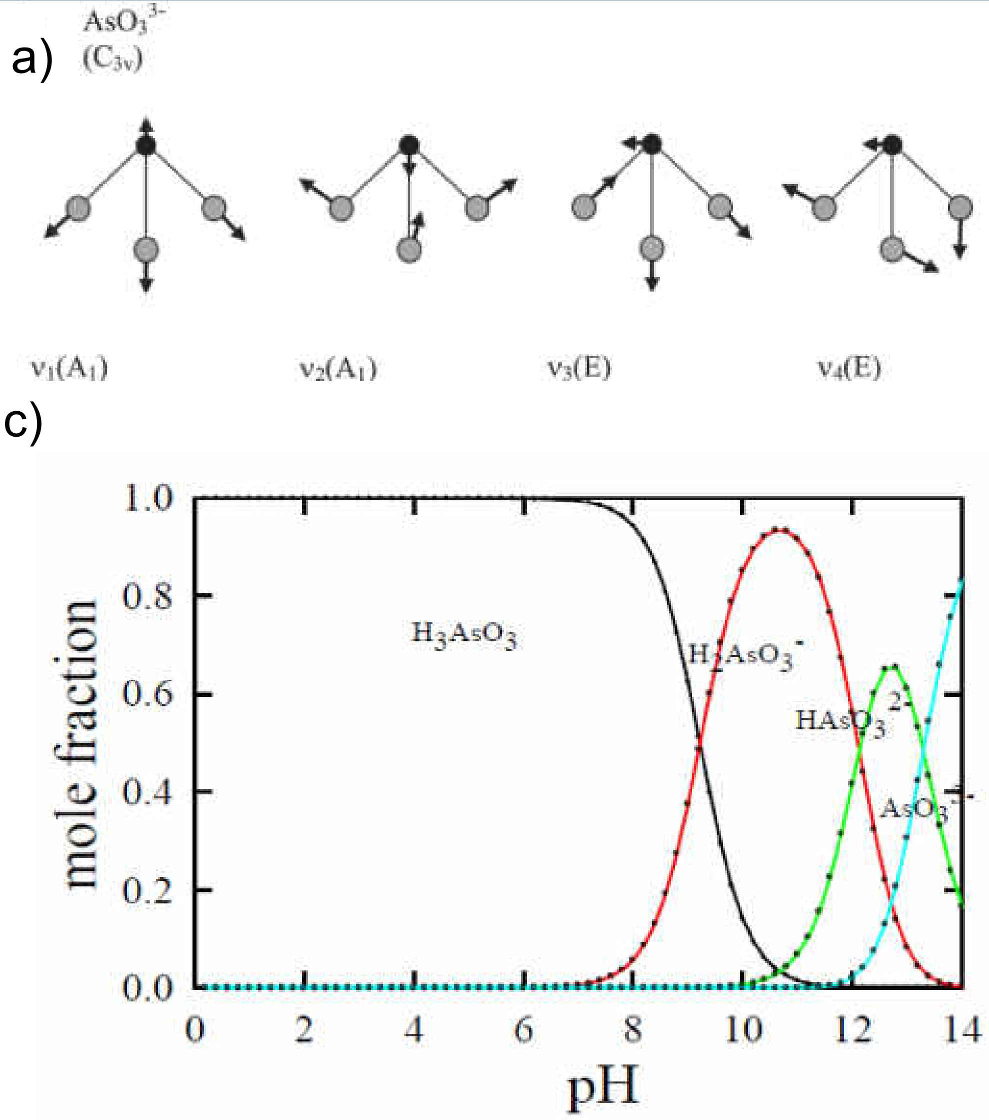
Review

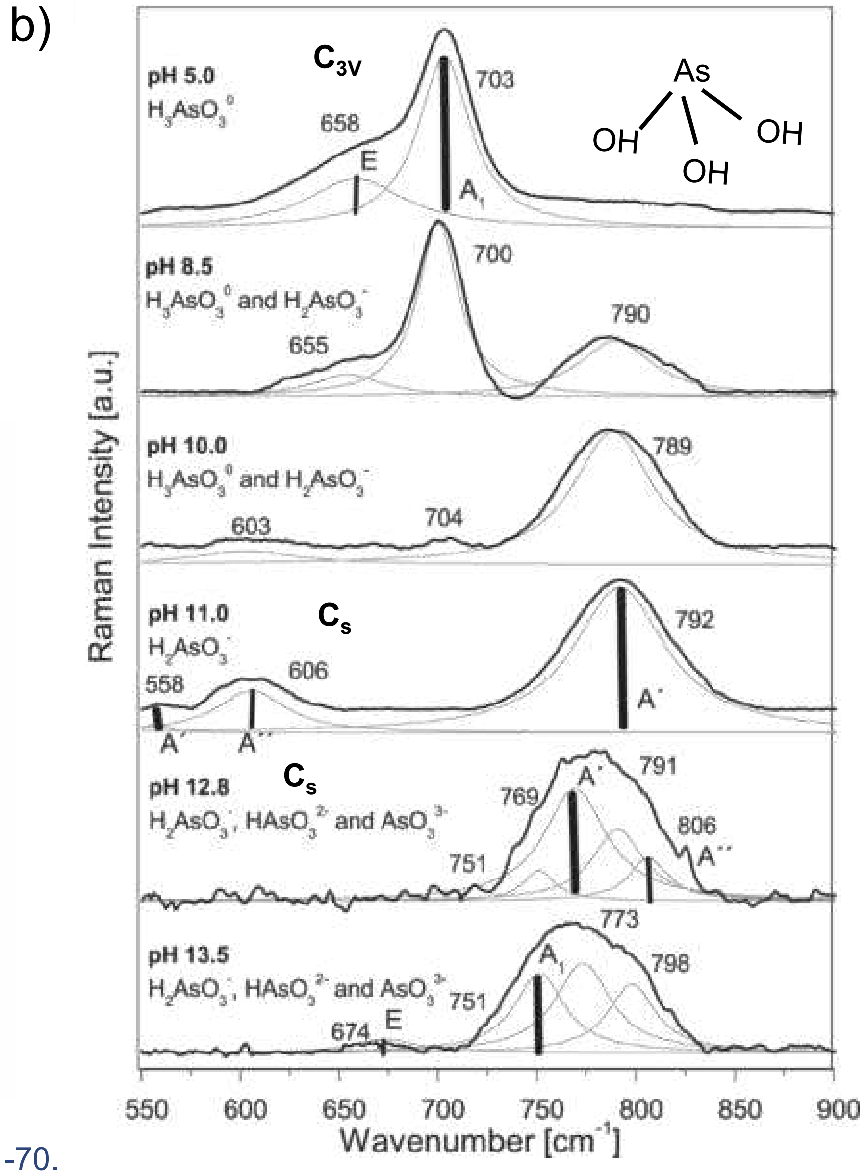
Arsenic in Drinking Water and Diabetes

Aryatara Shakya [1], Matthew Dodson [1], Janick F. Artiola [2], Monica Ramirez-Andreotta [2], Robert A. Root [2], Xinxin Ding [1], Jon Chorover [2] and Raina M. Maier [2,*]

1 Department Pharmacology & Toxicology, University of Arizona, Tucson, AZ 85721, USA; aryatarashakya@arizona.edu (A.S.); dodson@pharmacy.arizona.edu (M.D.); xding@pharmacy.arizona.edu (X.D.)
2 Department Environmental Science, University of Arizona, Tucson, AZ 85721, USA; artiola@gmail.com (J.F.A.); mdramire@arizona.edu (M.R.-A.); robroot.az@gmail.com (R.A.R.); chorover@arizona.edu (J.C.)
* Correspondence: rmaier@ag.arizona.edu

Distribution of arsenite species



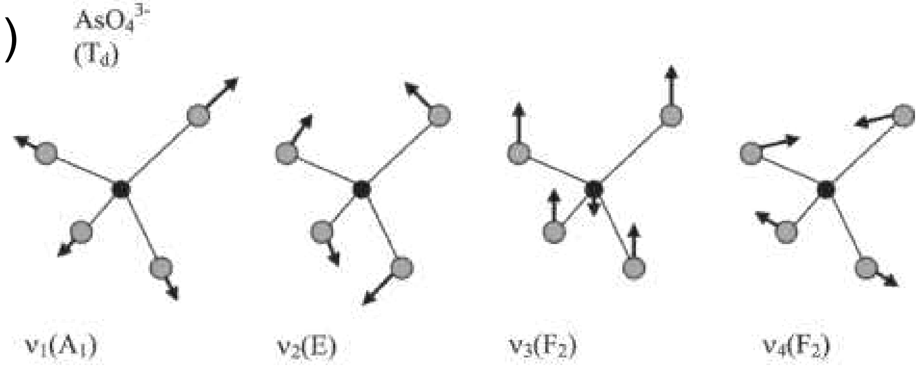


Inoue, K. *Advances in Materials Physics and Chemistry*, 2018, 8, 51-70.

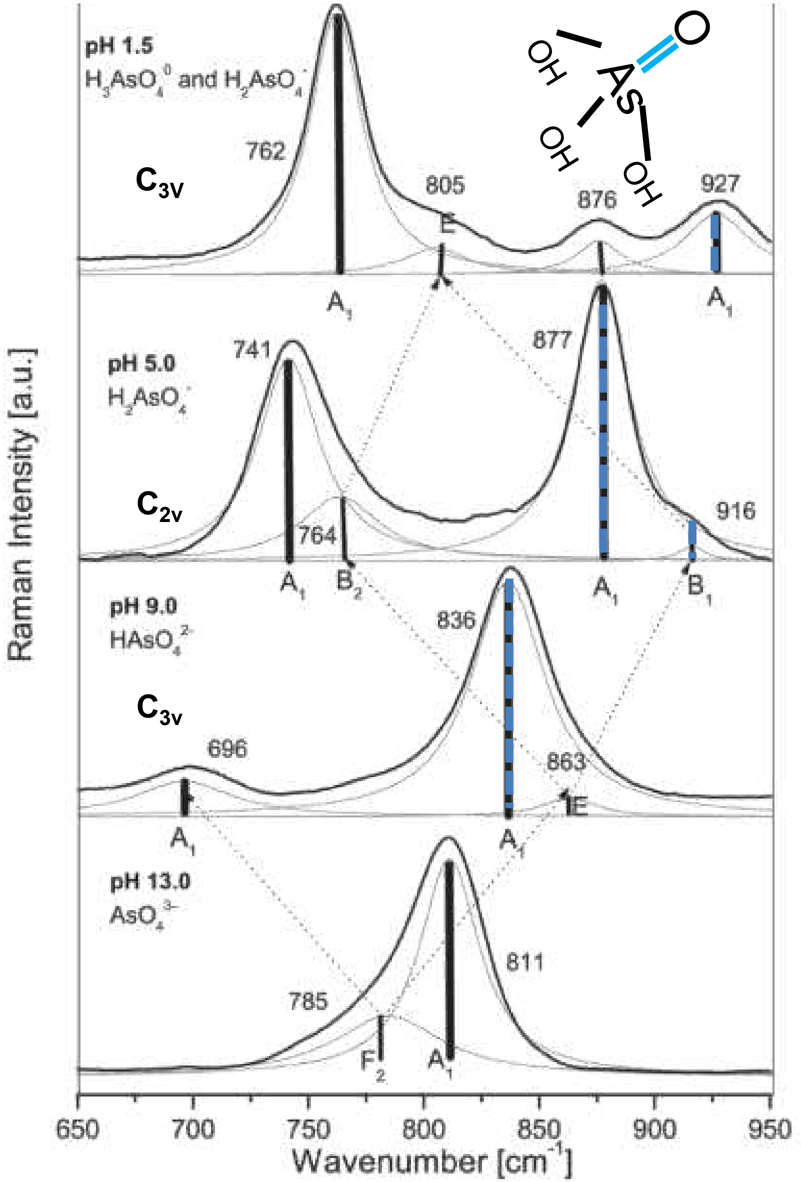
Müller, K. et al. *Water research*, 2010, *44,* 5660 - 5667.

Distribution of arsenate species

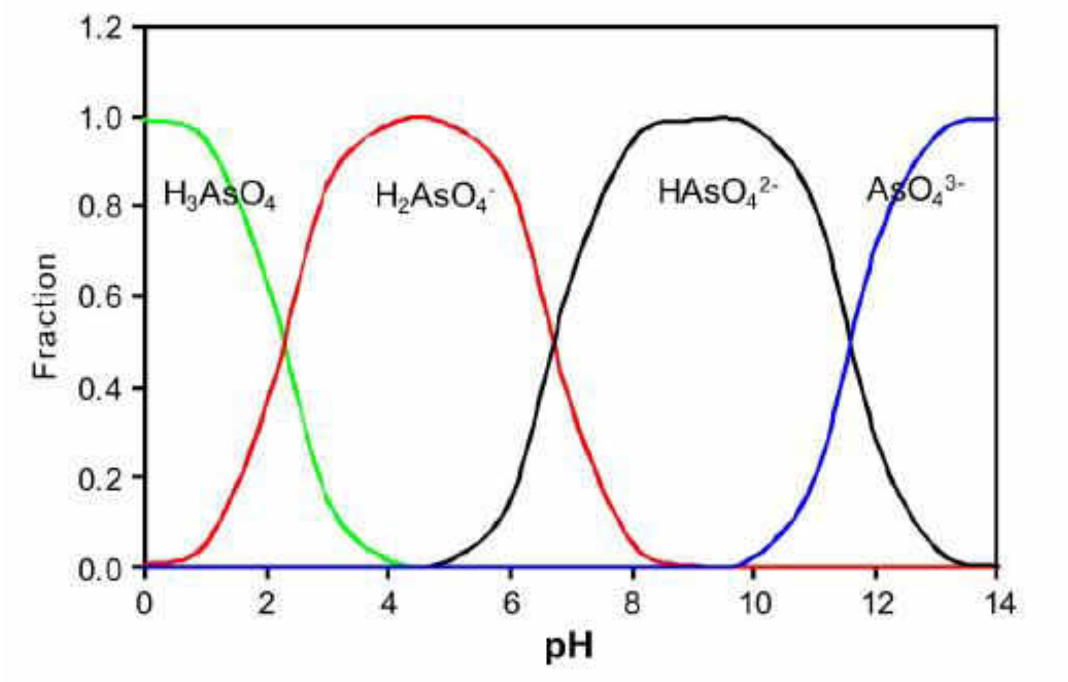
a)



b)



c)



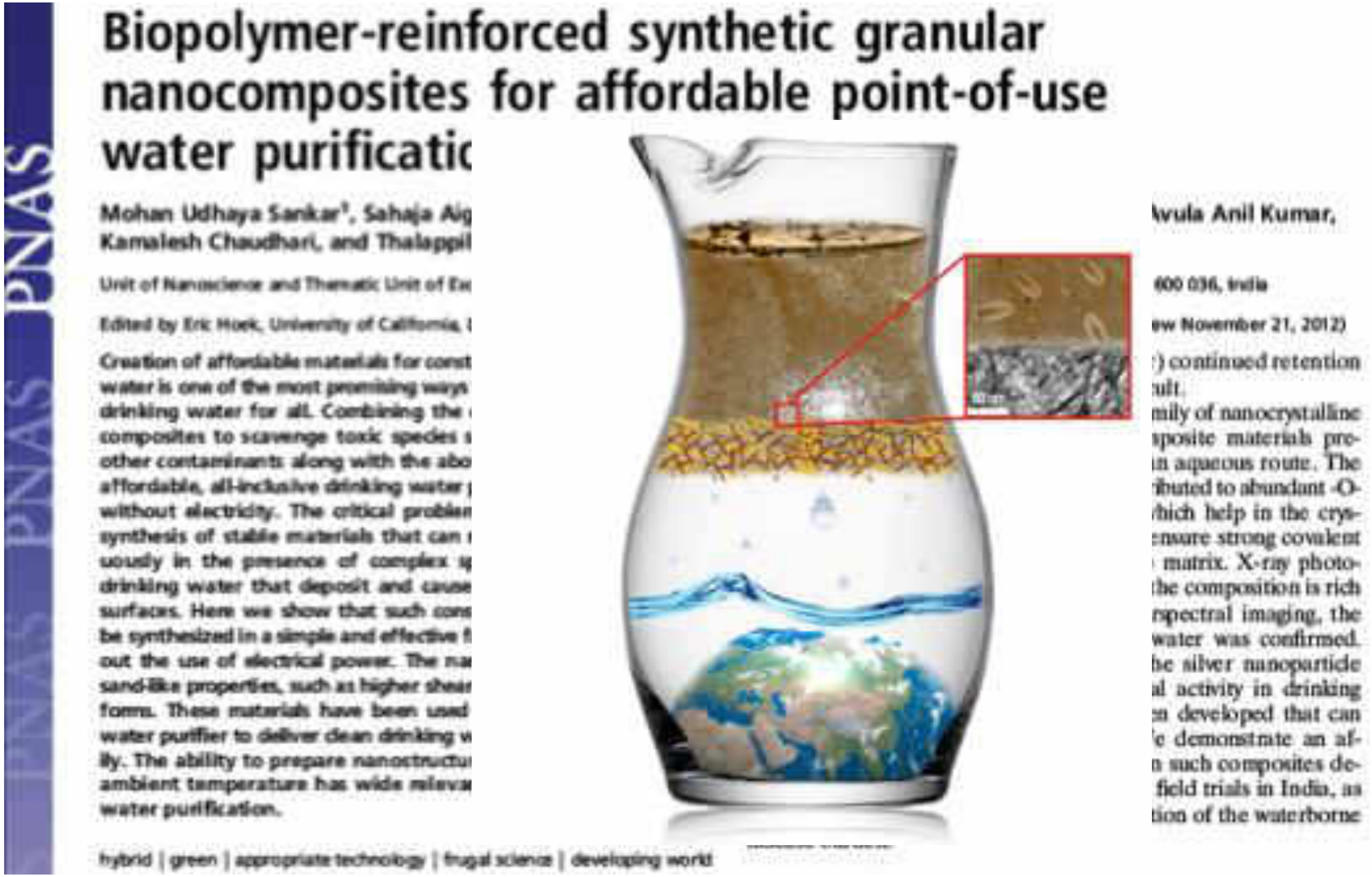
Sisi Q. et al. J. Environ. Eng., 2013, 139, 368-374

Müller, K. et al. *Water research*, 2010, *44*, 5660 -5667

Clean water for everyone

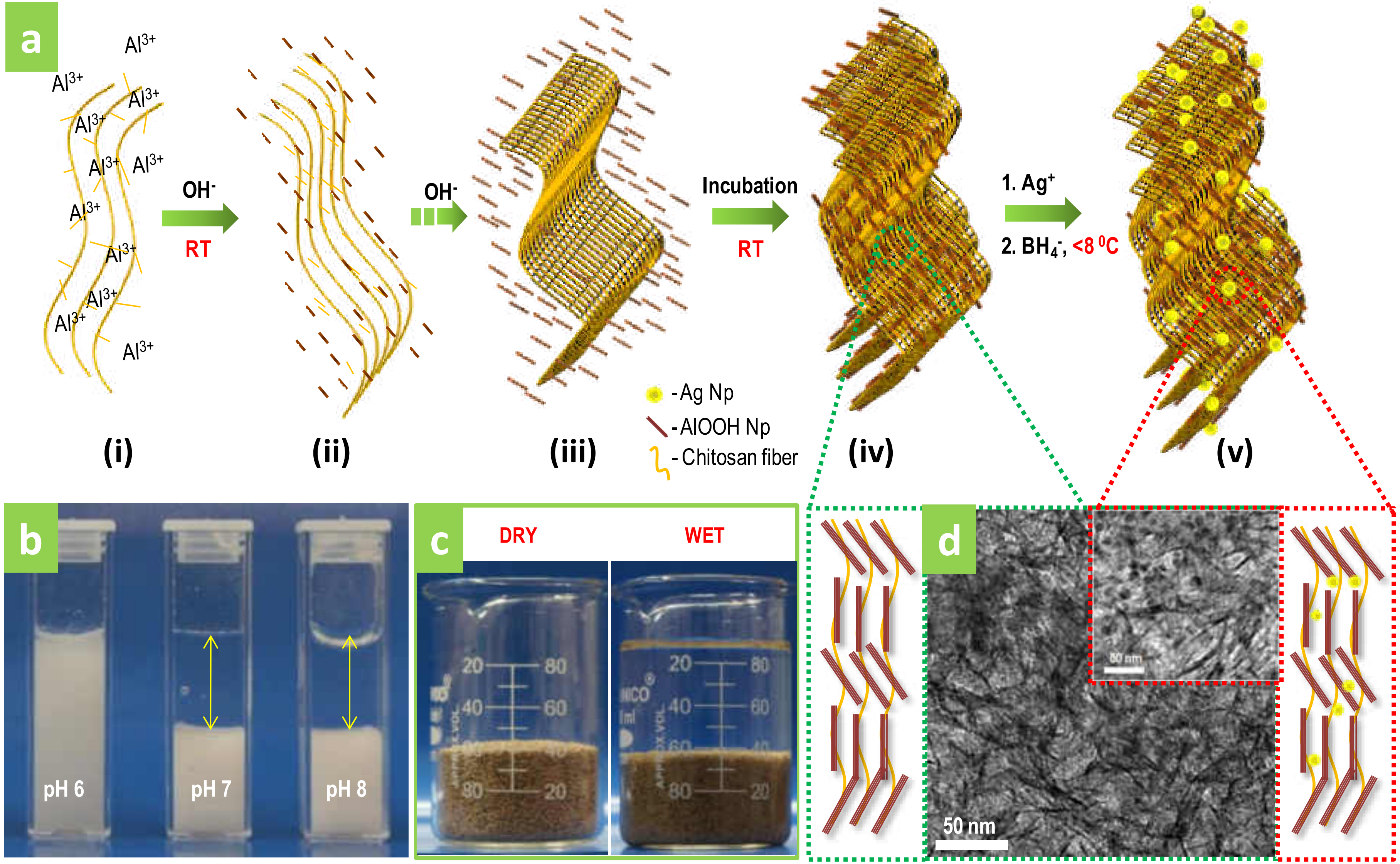
ACS Sustainable Chemistry & Engineering Editorial, December 2016

Water positive materials

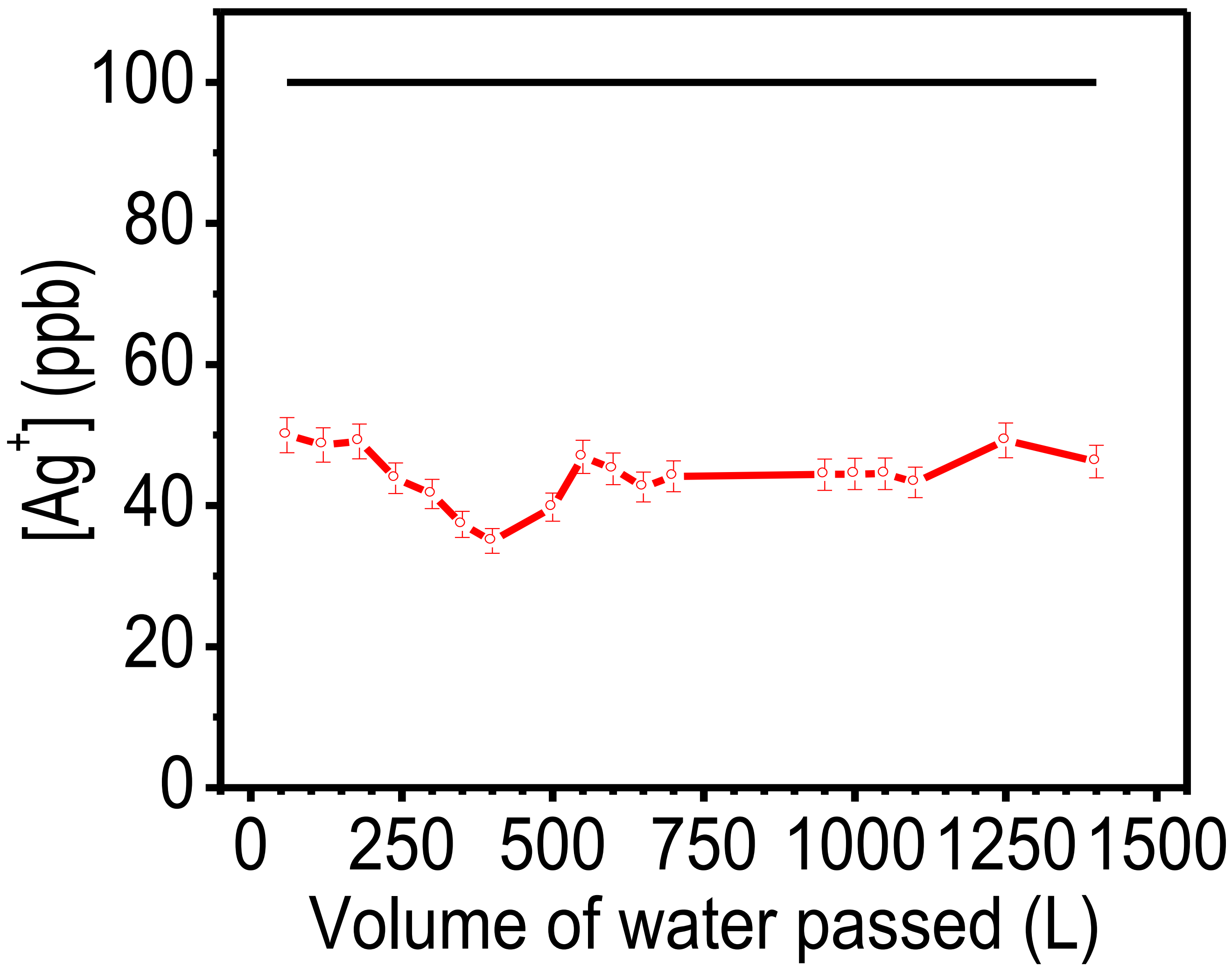


M. Udhaya Sankar, et. al. *Proc. Natl. Acad. Sci.,* 110 (2013) 8459-8464.

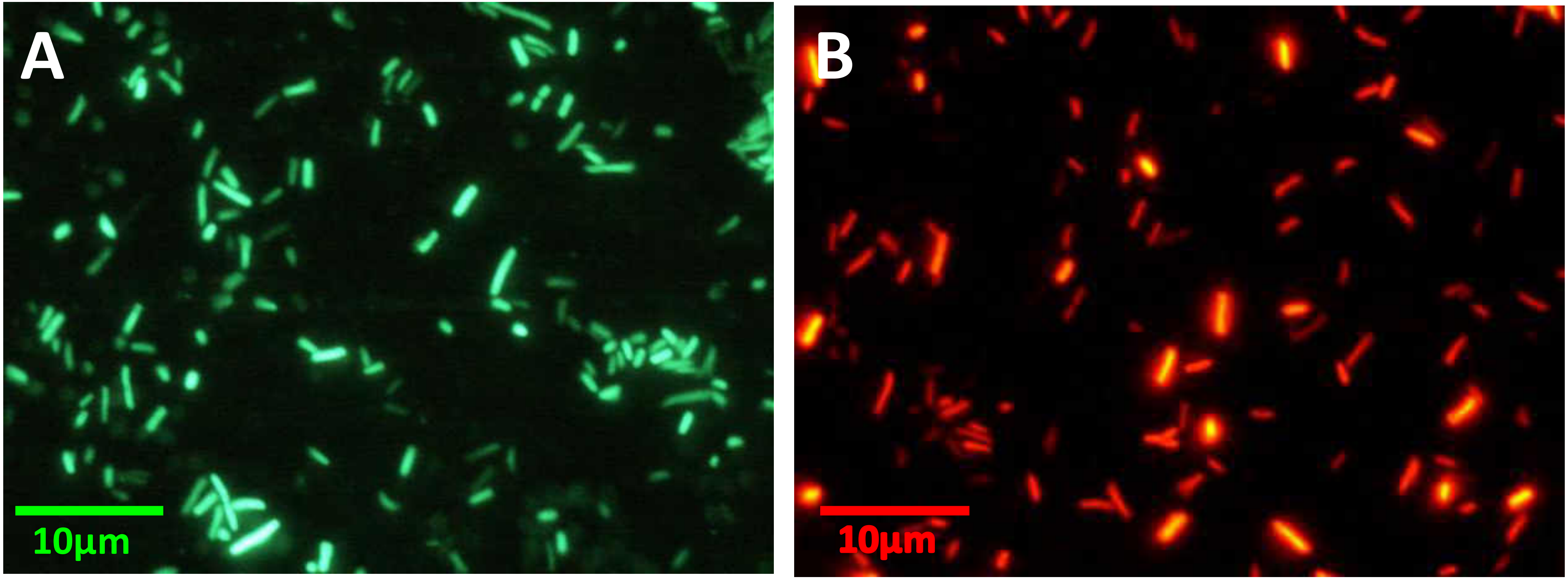
How to make?


a
Al3+
OH-
RT
OH-
Incubation
RT
1. Ag+
2. BH4-, <8 0C
-Ag Np
-AlOOH Np
-Chitosan fiber
(i)
(ii)
(iii)
(iv)
(v)
b
pH 6
pH 7
pH 8
c
DRY
WET
d
50 nm

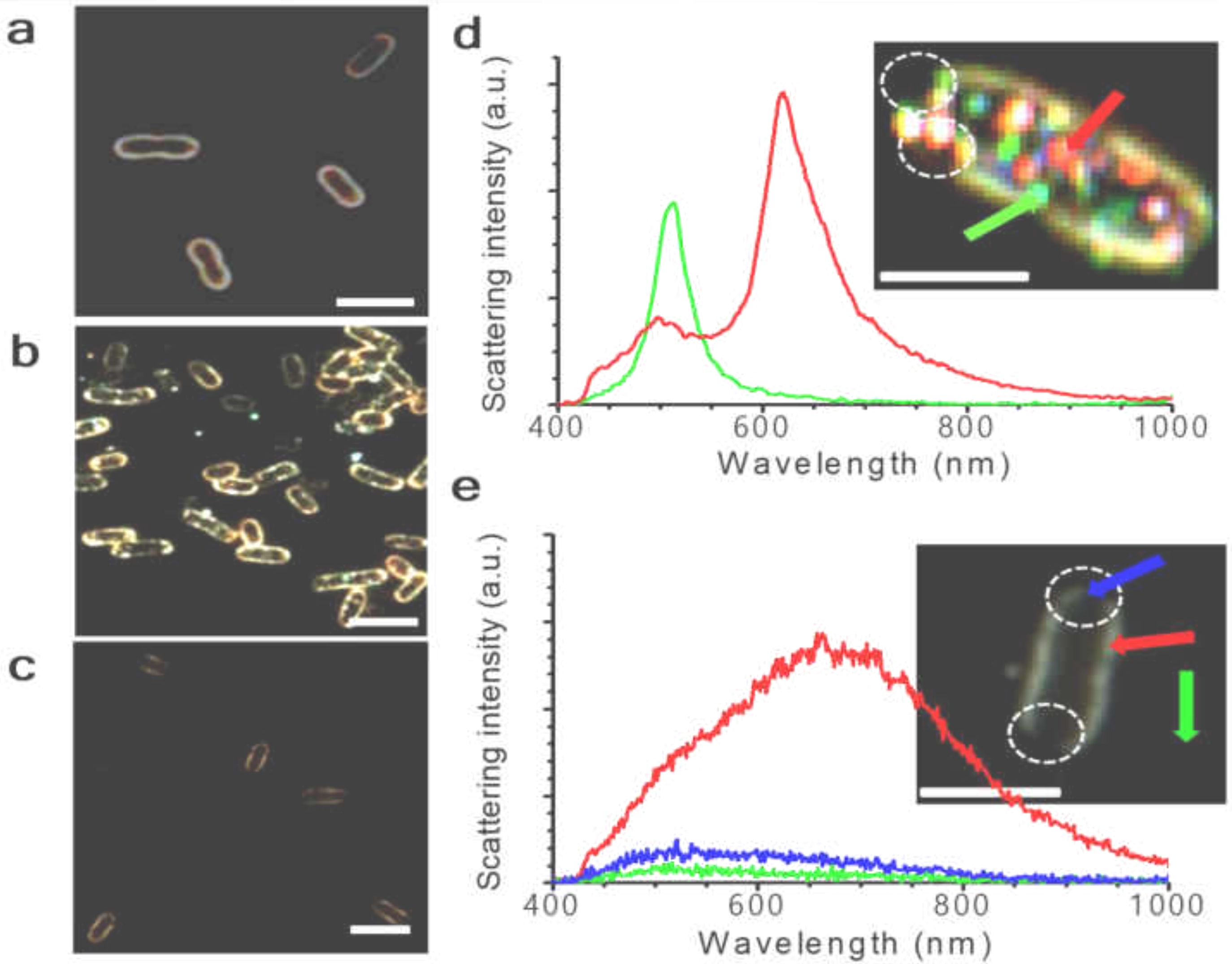
What is special?



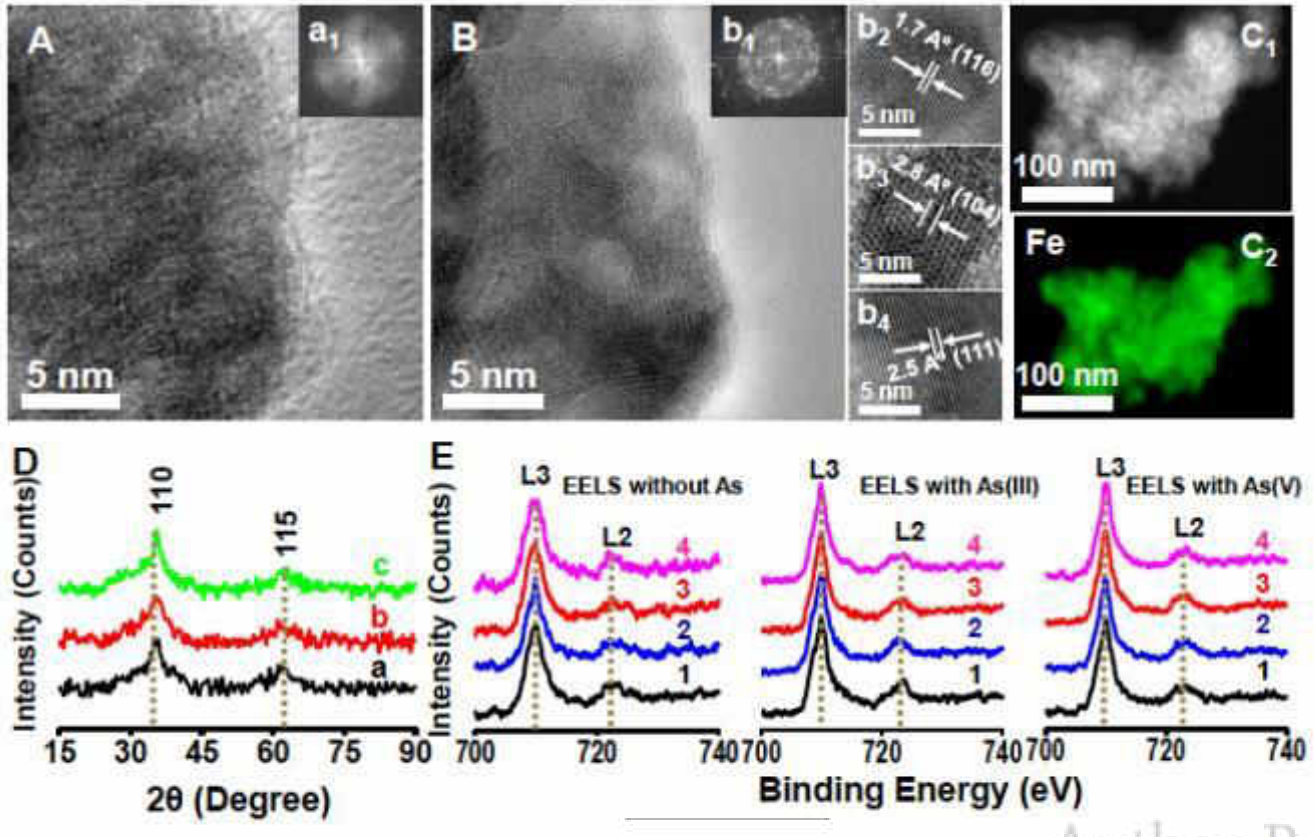
Live/dead staining experiments



No nanotoxicity



Variety of materials



www.advmat.de

Author Proof

ADVANCED MATERIALS

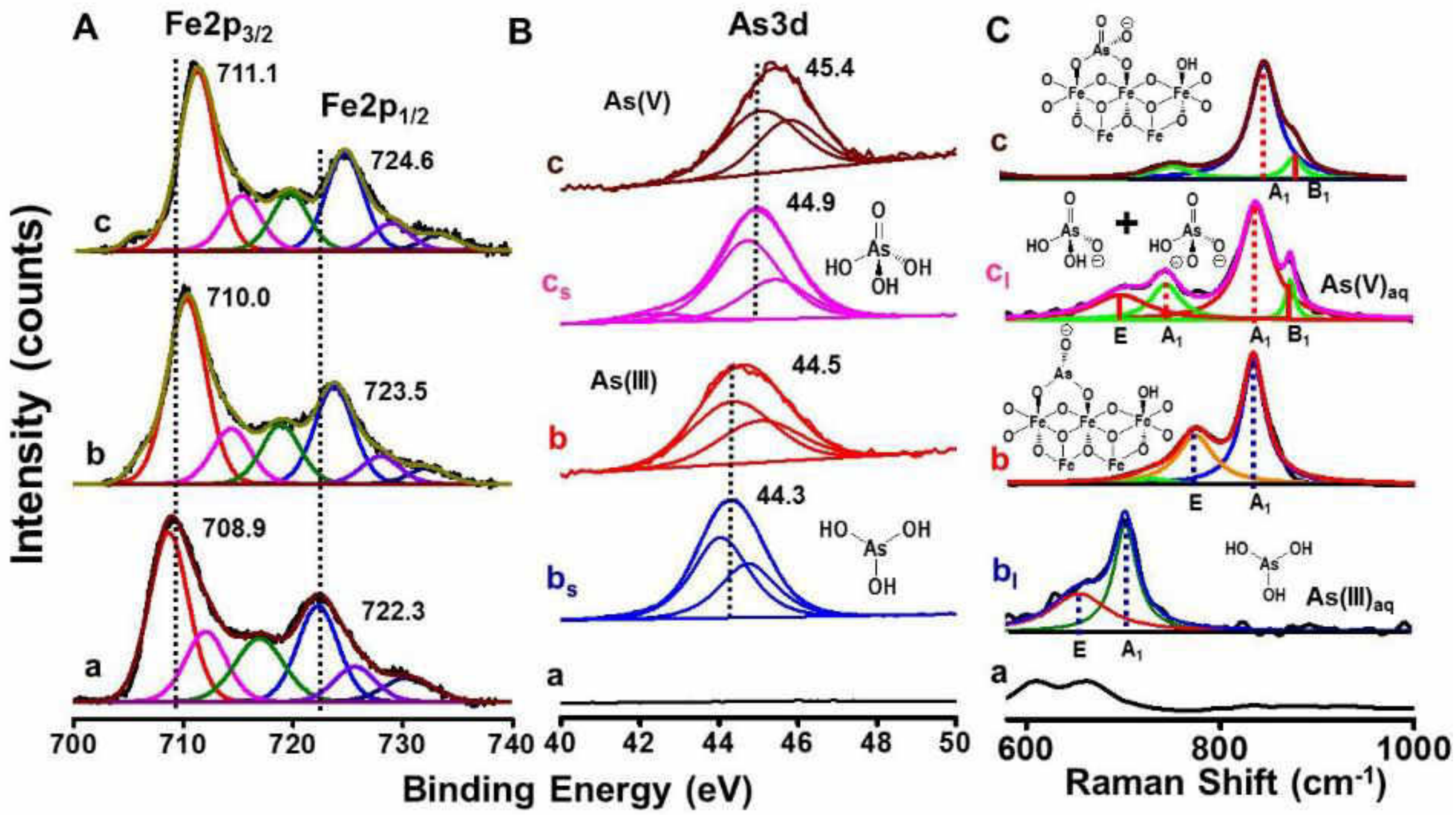
Communication

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*

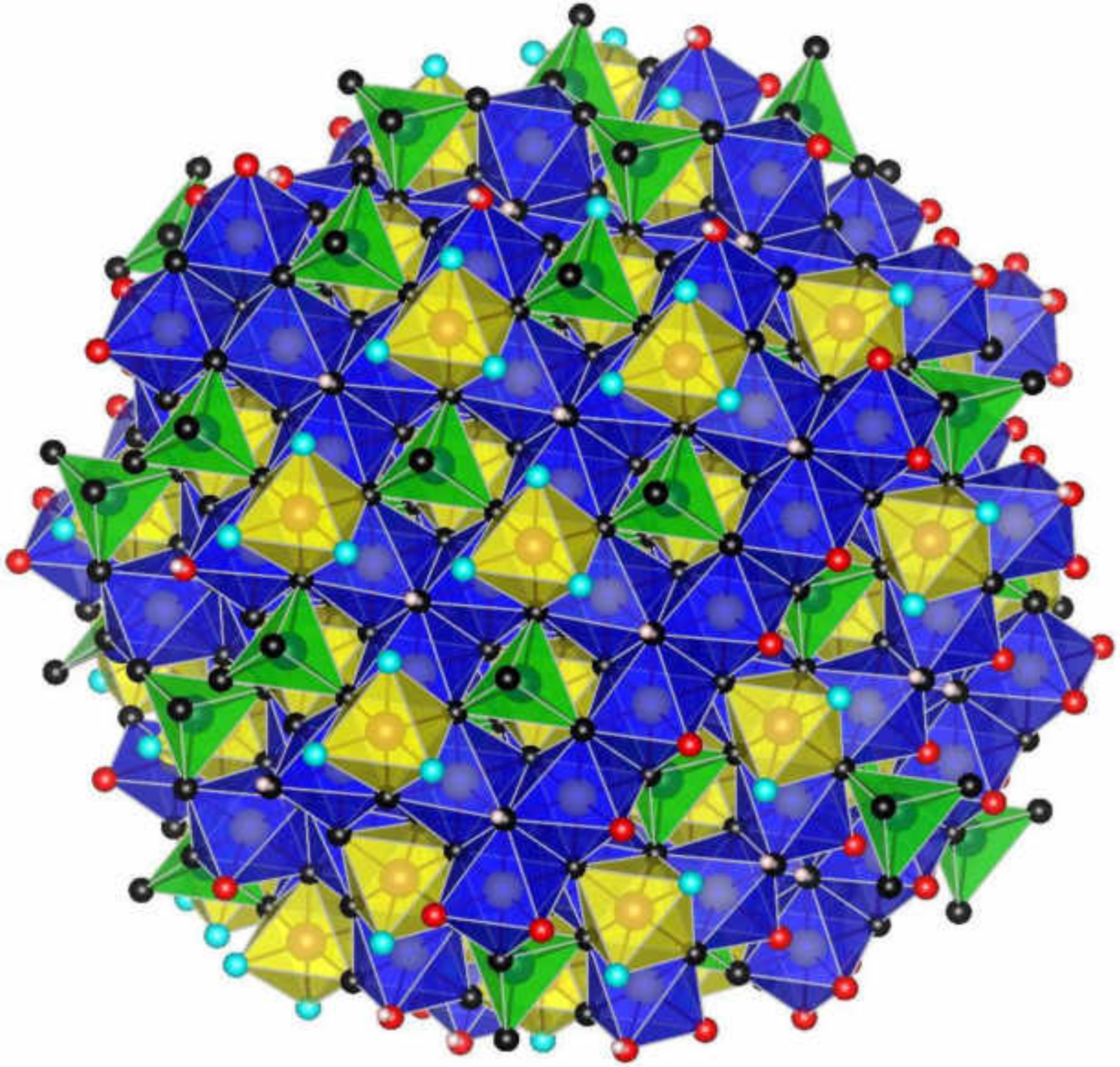
A. Anil Kumar, et. al. *Adv. Mater.*, 29 (2016) 1604260.

Mechanism



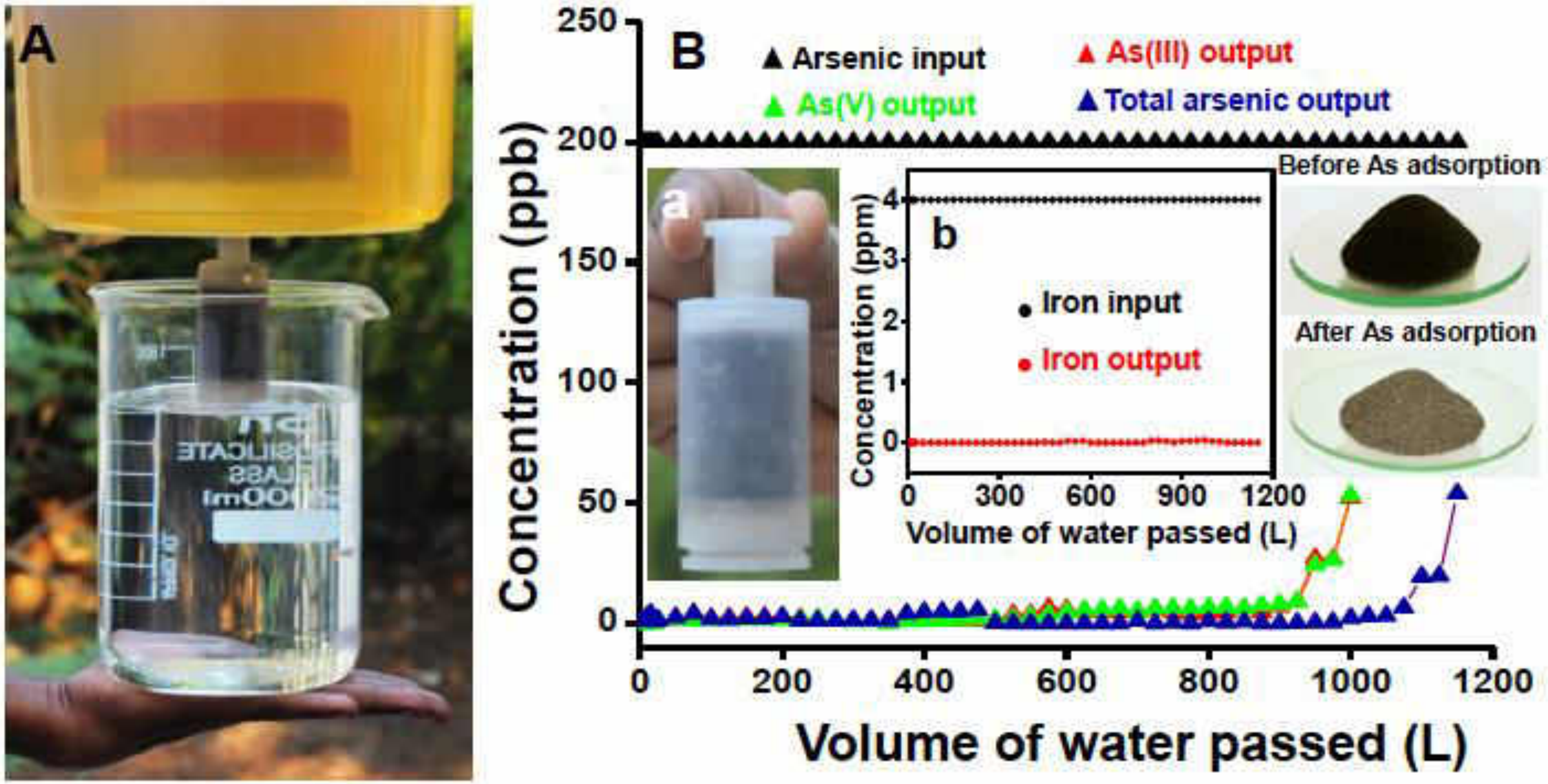
A
Fe2p3/2
711.1
Fe2p1/2
724.6
710.0
723.5
708.9
722.3
c
b
a
Intensity (counts)
B
As3d
As(V)
45.4
c
44.9
cs
As(III)
44.5
b
44.3
bs
a
C
c
A1
B1
cl
As(V)aq
E
A1
A1
B1
b
E
A1
bl
As(III)aq
E
A1
a
700
710
720
730
740
40
42
44
46
48
50
600
800
1000
Binding Energy (eV)
Raman Shift (cm-1)

Modeling surfaces



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

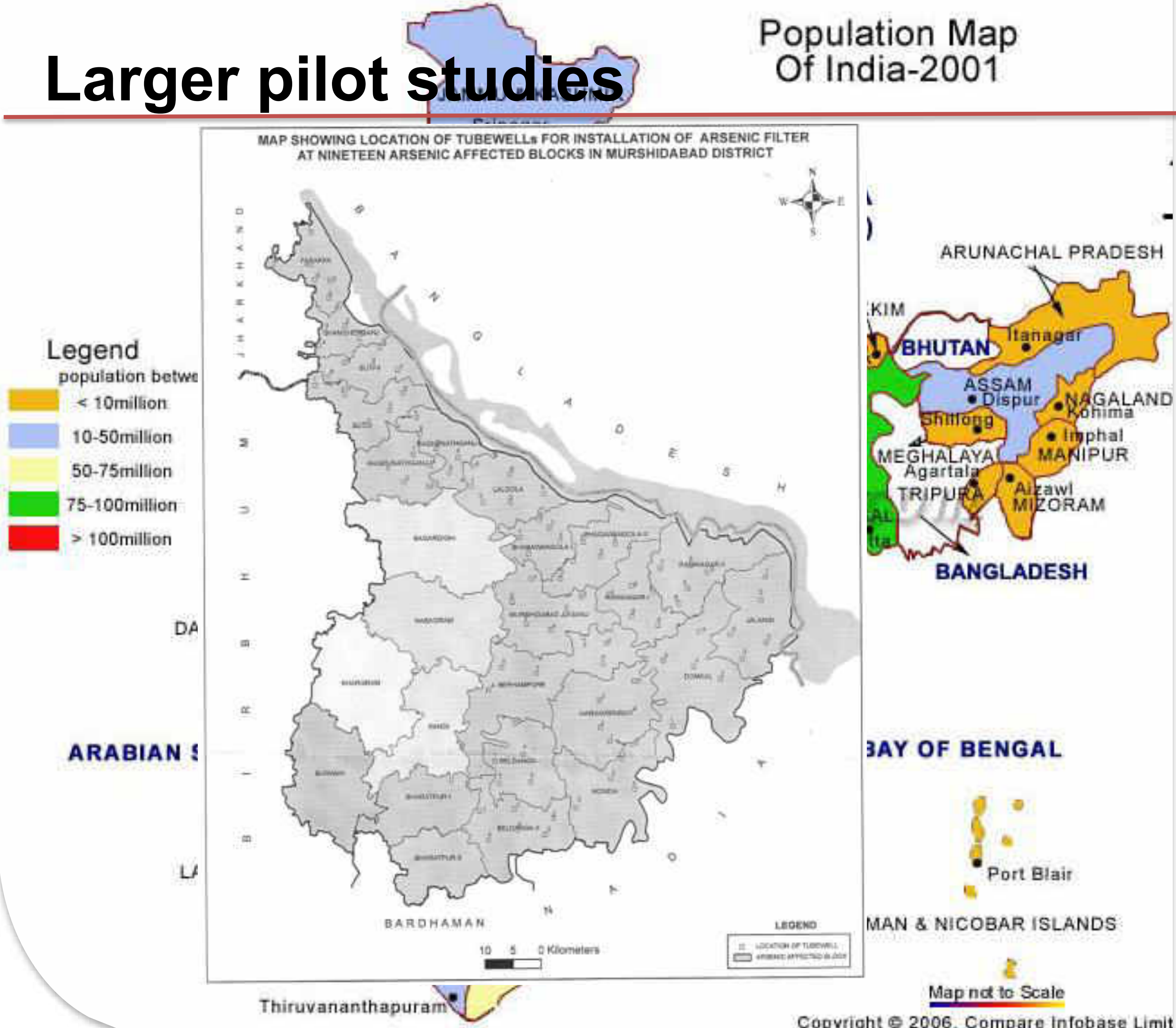
Lab studies



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

Initial pilot studies

Larger pilot studies



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

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)

Implementation - From 25 KLD to 1 MLD

Large water supply schemes

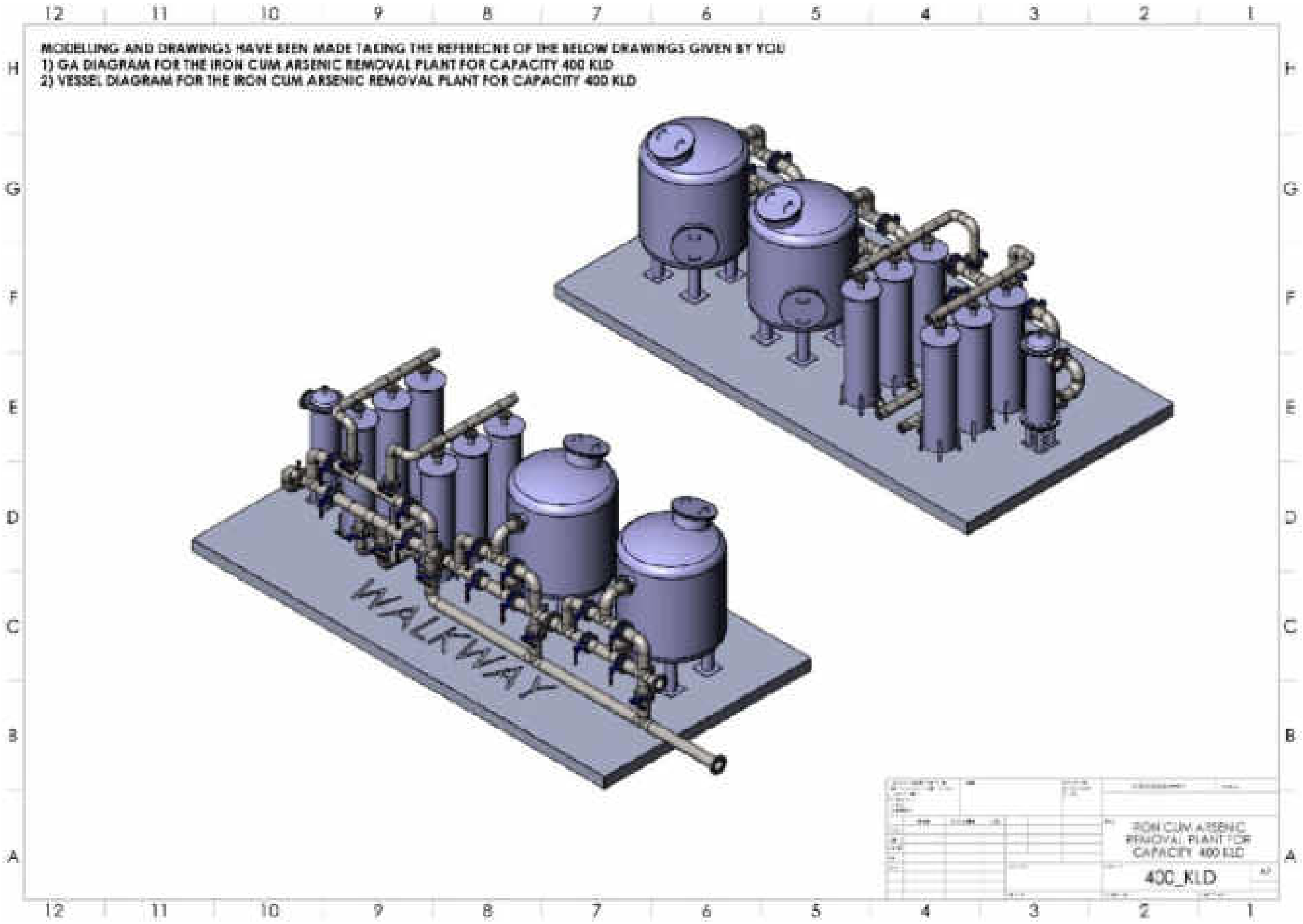
Capacity: above 1 MLD

5 schemes in use across India

Retrofitted Water Purification Plant

Capacity: 0.1-1 MLD

Over 180 units in use across India


MODELLING AND DRAWINGS HAVE BEEN MADE TAKING THE REFERECNE OF THE BELOW DRAWINGS GIVEN BY YOU
1) GA DIAGRAM FOR THE IRON CUM ARSENIC REMOVAL PLANT FOR CAPACITY 400 KLD
2) VESSEL DIAGRAM FOR THE IRON CUM ARSENIC REMOVAL PLANT FOR CAPACITY 400 KLD
WALKWAY
IRON CUM ARSENIC REMOVAL PLANT FOR CAPACITY 400 KLD
400_KLD

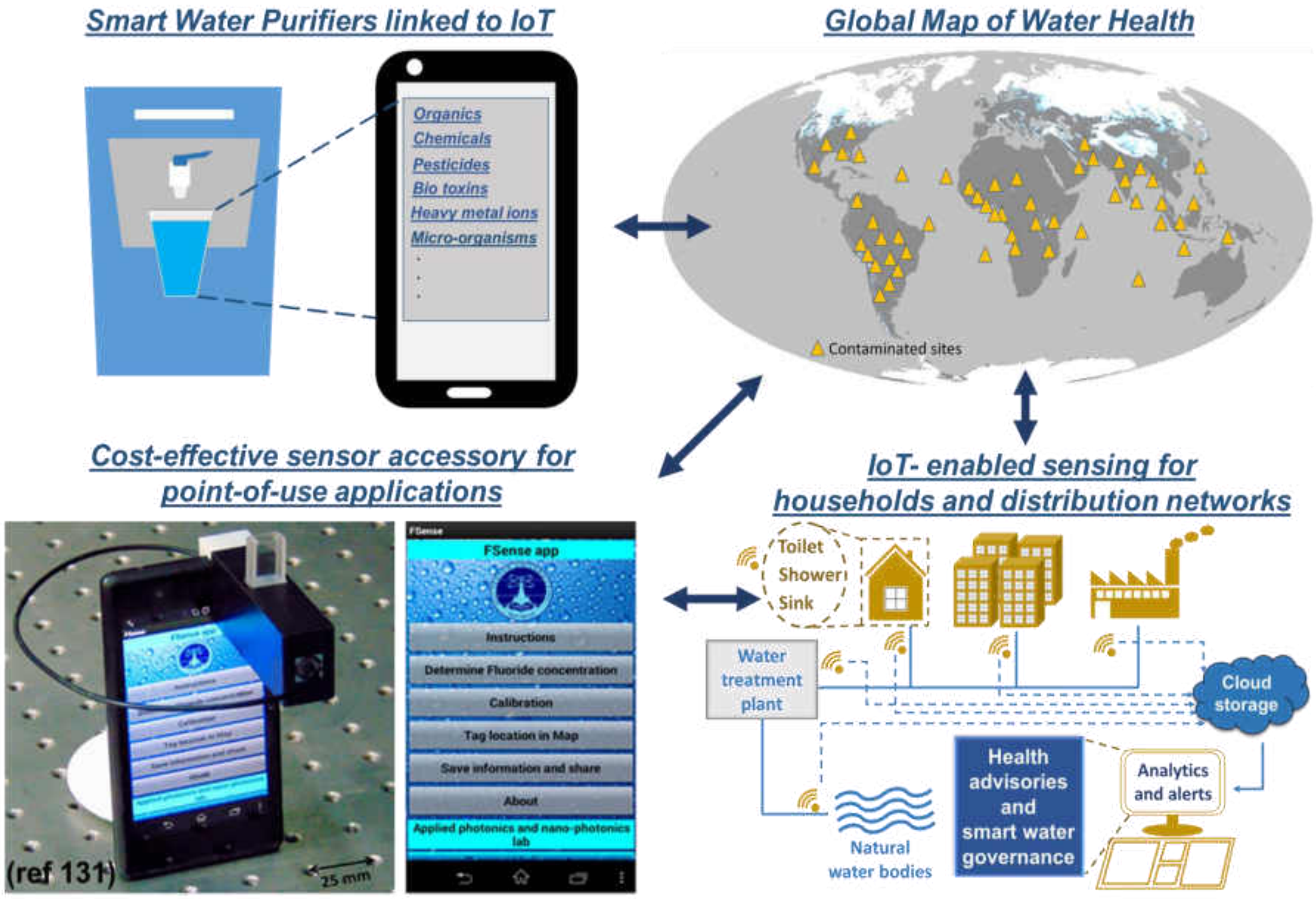
Cleanwater at 2.1 paise per litre!

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	0.025 cents
9	Cost of replacement of media	**1.36**	Rs. per head per day =Media replacement cost per year/365/Design population
		40.80	per head per month for 70 LPCD water

Across the country

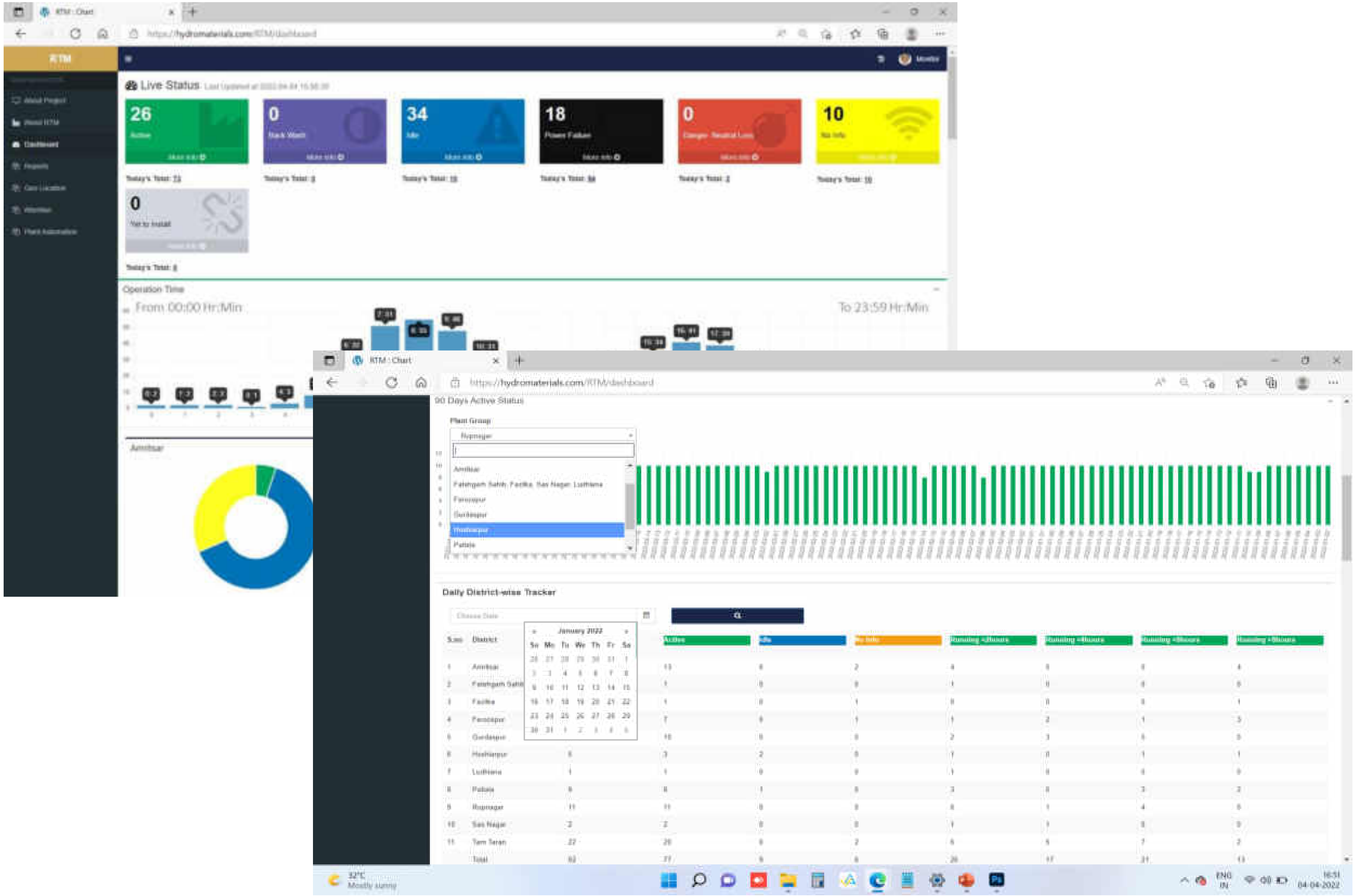
Smart water purifiers and big data

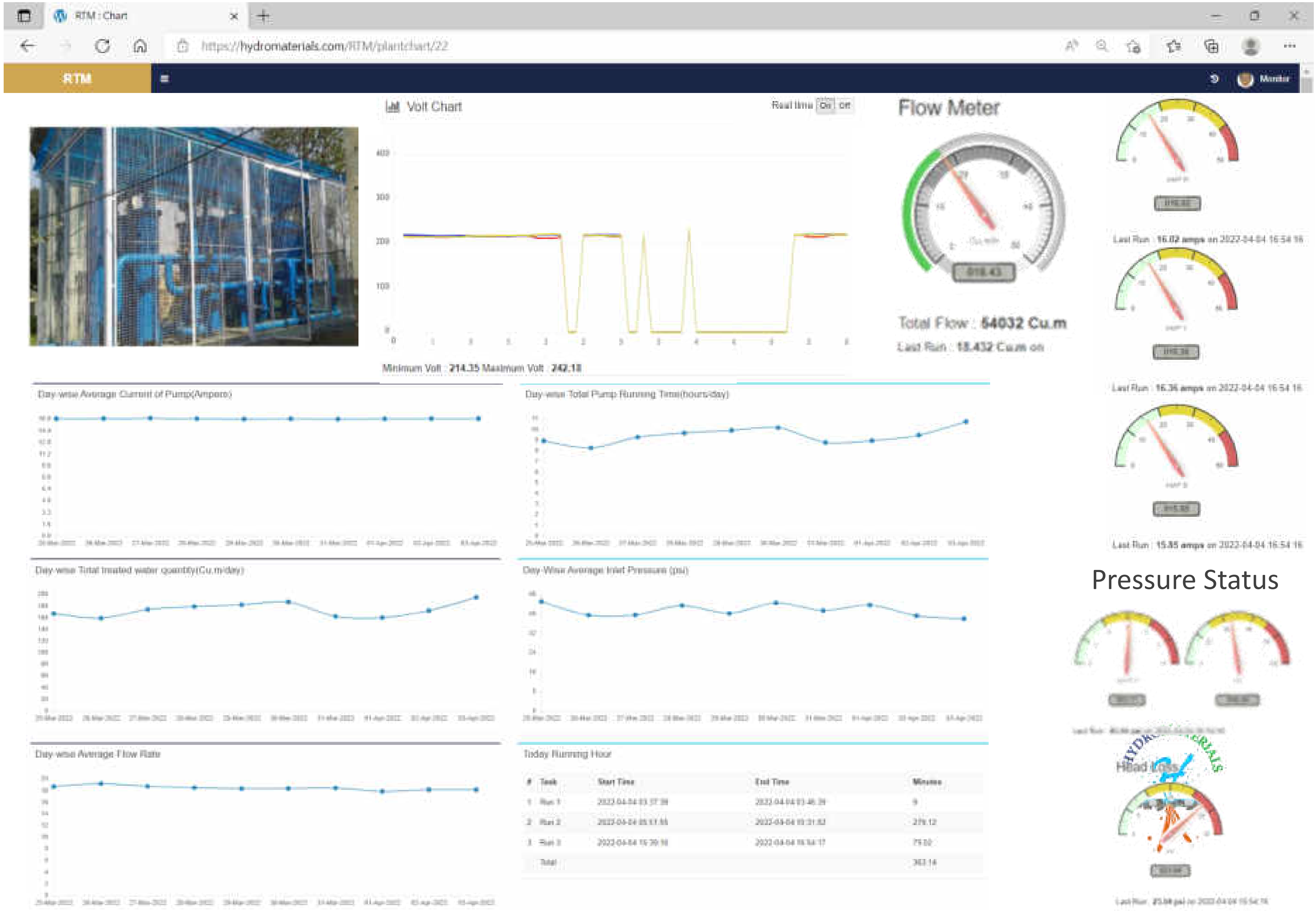


Ankit Nagar and T. Pradeep 14(2020). *ACS Nano*, 6420-6435

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


RTM : Chart
https://hydromaterials.com/RTM/dashboard
RTM
Live Status
26
Active
0
Back Wash
34
Idle
18
Power Failure
0
10
No Info
0
Yet to Install
Operation Time
From 00:00 Hr:Min
To 23:59 Hr:Min
Amritsar
90 Days Active Status
Plant Group
Daily District-wise Tracker
January 2022
District
Active
Idle
No Info
Amritsar
Fazilka
Ferozepur
Gurdaspur
Hoshiarpur
Ludhiana
Patiala
Rupnagar
Tarn Taran
Total



RTM : Chart
https://hydromaterials.com/RTM/plantchart/22
RTM
Volt Chart
Real time On Off
Minimum Volt : 214.35 Maximum Volt : 242.18
Flow Meter
Total Flow : 54032 Cu.m
Last Run : 18.432 Cu.m on
Last Run : 16.02 amps on 2022-04-04 16:54:16
Last Run : 16.36 amps on 2022-04-04 16:54:16
Last Run : 15.85 amps on 2022-04-04 16:54:16
Pressure Status
Head Loss
Day-wise Average Current of Pump(Ampere)
Day-wise Total Pump Running Time(hours/day)
Day-wise Total treated water quantity(Cu.m/day)
Day-Wise Average Inlet Pressure (psi)
Day-wise Average Flow Rate
Today Running Hour
Task Start Time End Time Minutes
1 Run 1 9
2 Run 2 276.12
3 Run 3 79.02
Total 363.14

Clean water 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**
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		40.80	per head per month for 70 LPCD water

Sensors and new opportunities



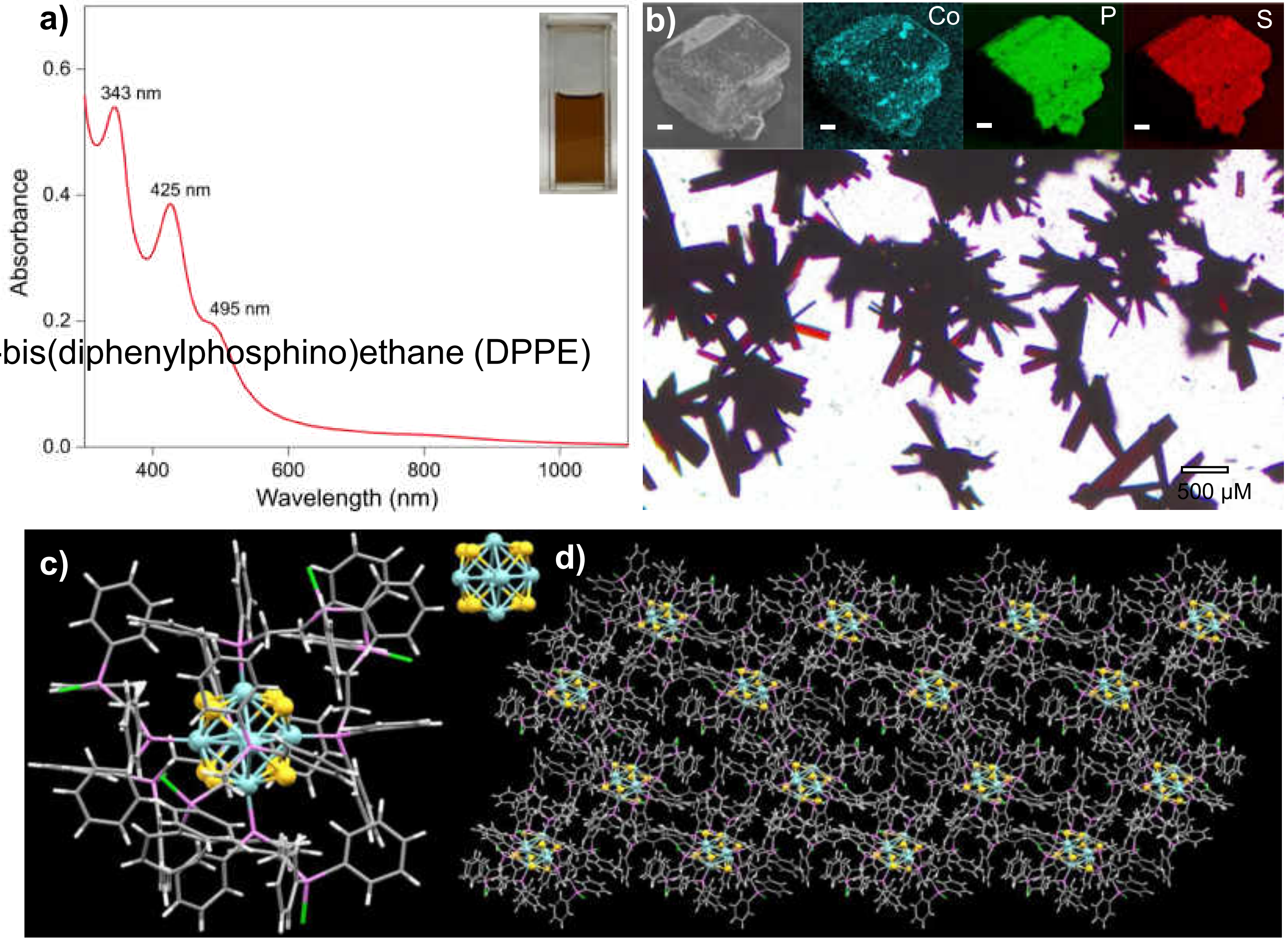
Analog/Grating Equipment
$ 5~6 Billion (2017)
a few **100k units (2017)**

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

Water quality measurement – In the pipeline

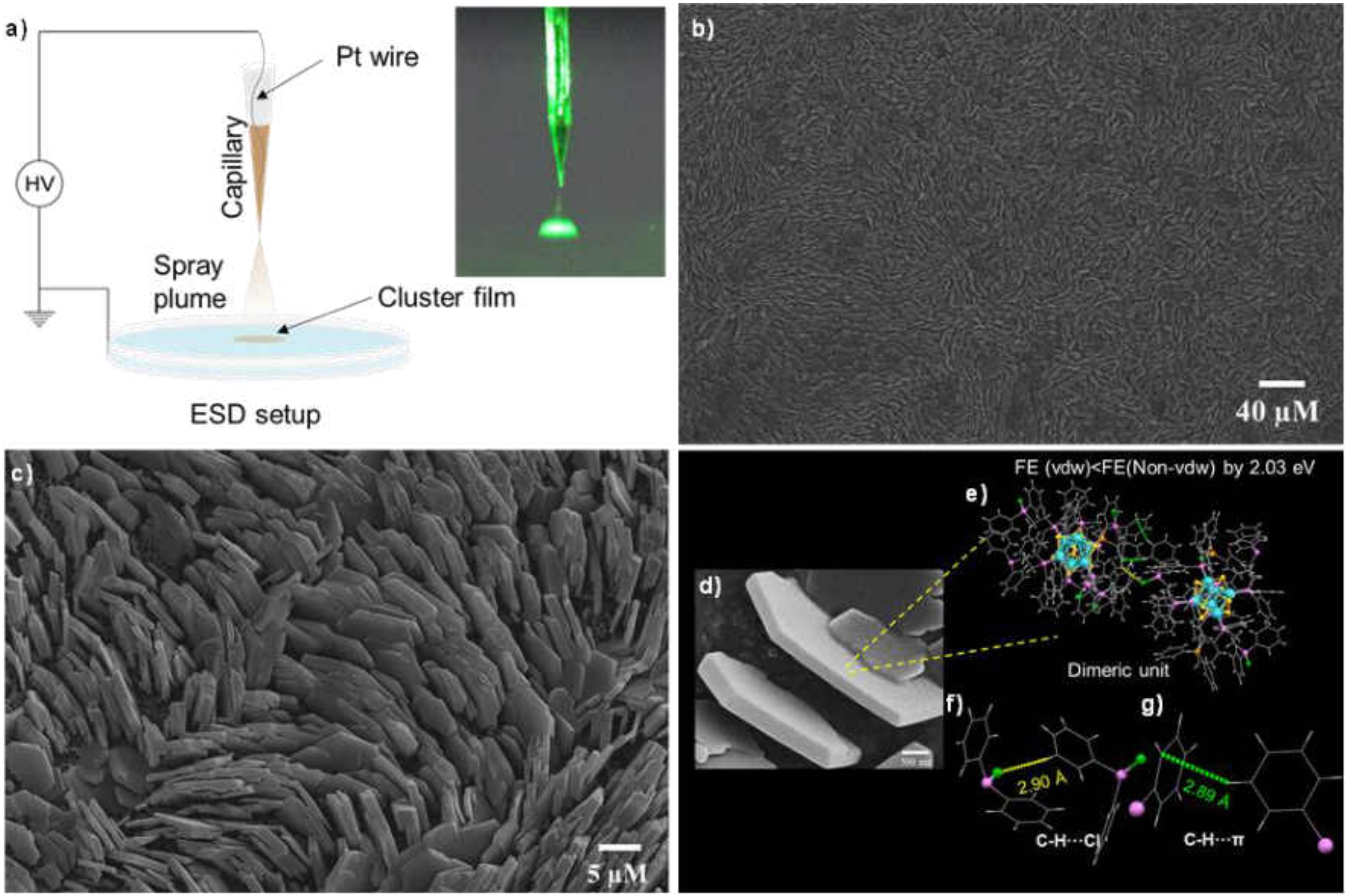
nanoλ

New electrodes - Aligned nanoplates of Co_6S_8

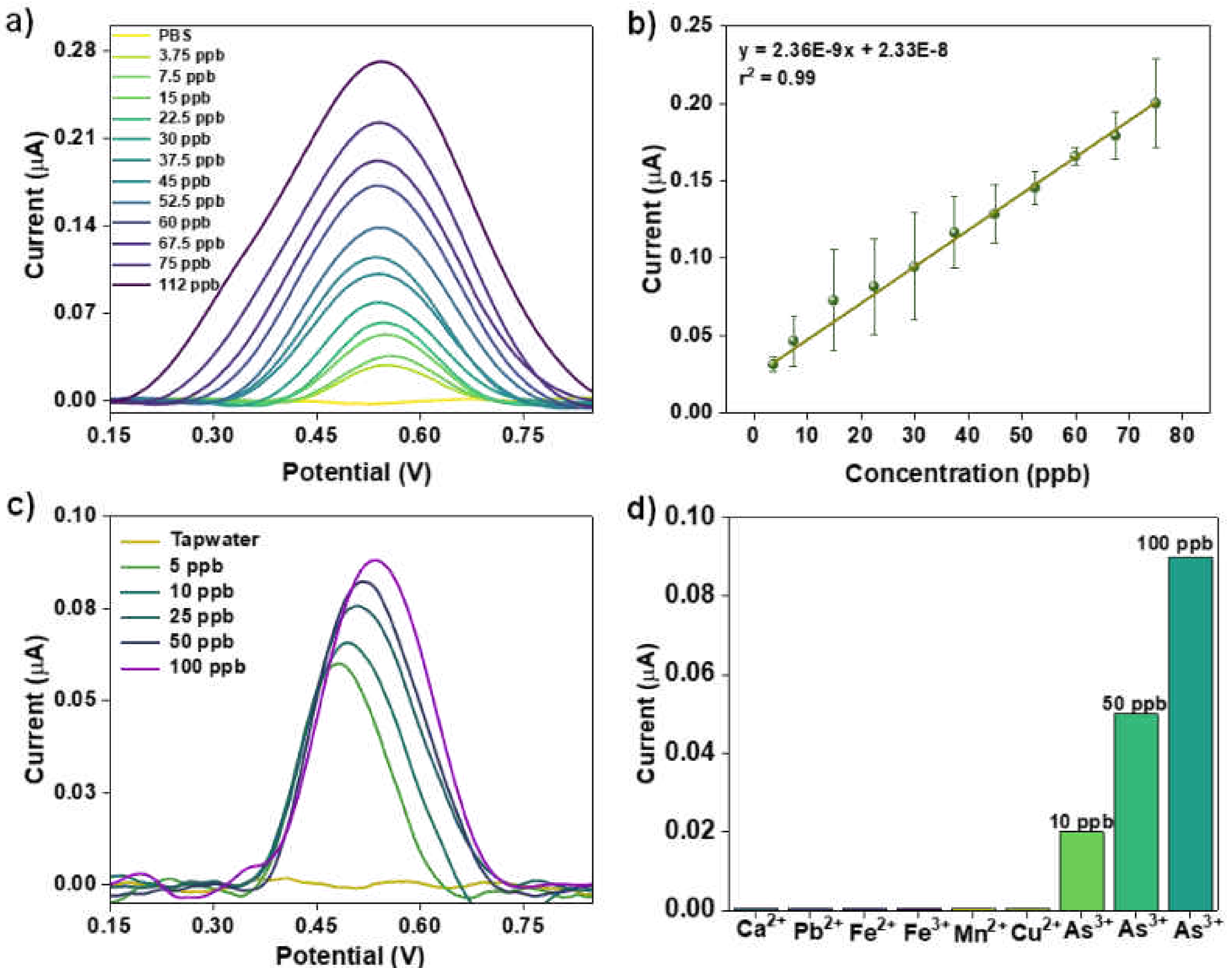


1,2-bis(diphenylphosphino)ethane (DPPE)

Electrospray deposition



Sensing

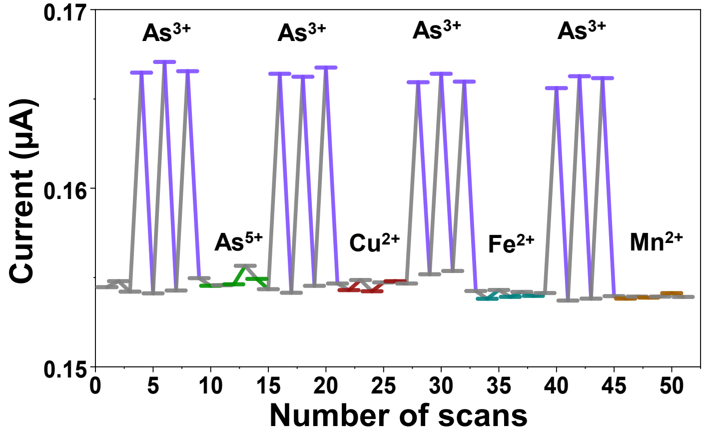


a)
PBS
3.75 ppb
7.5 ppb
15 ppb
22.5 ppb
30 ppb
37.5 ppb
45 ppb
52.5 ppb
60 ppb
67.5 ppb
75 ppb
112 ppb
Current (μA)
Potential (V)
b)
y = 2.36E-9x + 2.33E-8
r² = 0.99
Current (μA)
Concentration (ppb)
c)
Tapwater
5 ppb
10 ppb
25 ppb
50 ppb
100 ppb
Current (μA)
Potential (V)
d)
100 ppb
50 ppb
10 ppb
Current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

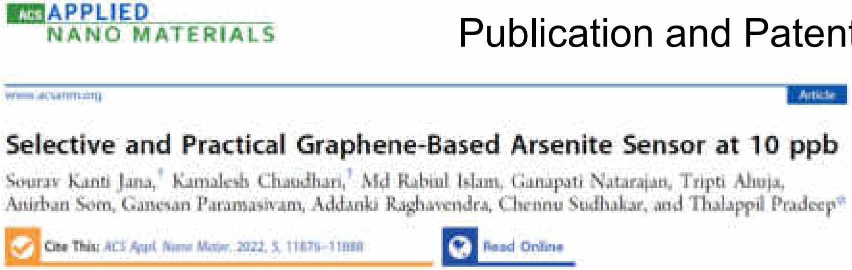
A drop-and-sense reagent free arsenic sensing test strips

IIT Madras patented
Arsenic sensing technology

Reagent free, Reusable test strip with selective arsenic sensing
Drop-and-sense technology with no pretreatment of samples



Publication and Patents



ACS APPLIED NANO MATERIALS

www.acsanm.org Article

Selective and Practical Graphene-Based Arsenite Sensor at 10 ppb

Sourav Kanti Jana, Kamalesh Chaudhari, Md Rabiul Islam, Ganapati Natarajan, Tripti Ahuja, Anirban Som, Ganesan Paramasivam, Addanki Raghavendra, Chennu Sudhakar, and Thalappil Pradeep

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WIPO | PCT

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(19) United States
(12) Patent Application Publication
PRADEEP et al.

(10) Pub. No.: US 2023/0273151 A1
(43) Pub. Date: Aug. 31, 2023

(54) A POINT-OF-CARE (POC) AMPEROMETRIC DEVICE FOR SELECTIVE ARSENIC SENSING

(71) Applicant: INDIAN INSTITUTE OF TECHNOLOGY MADRAS (IIT MADRAS), Chennai (IN)

(72) Inventors: Thalappil PRADEEP, Chennai (IN); Sourav KANTI JANA, Chennai (IN); Kamalesh CHAUDHARI, Chennai (IN); Md Rabiul ISLAM, Chennai (IN)

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G01N 33/18 (2006.01)

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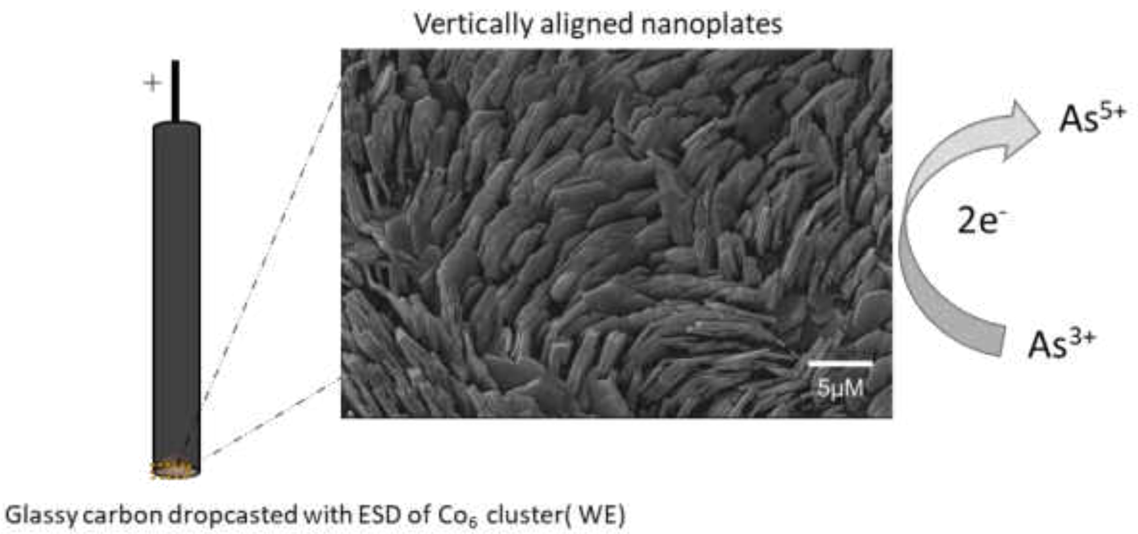
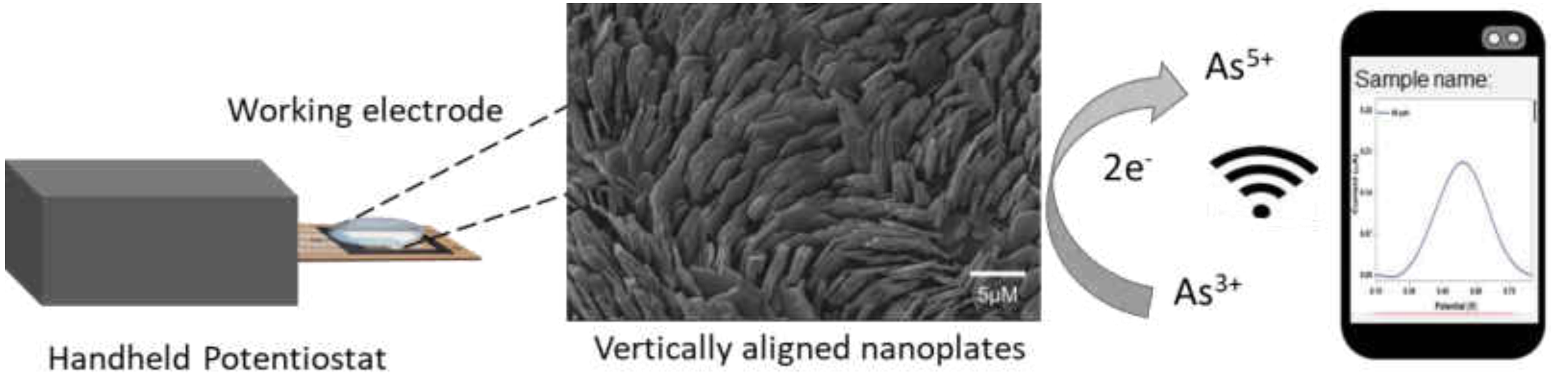
(57) ABSTRACT

EyeNetAqua

Working electrode





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

Monitoring in the field

EyeNetAqua Solutions Pvt. Ltd.

An ICCW incubated company

Eye of internet on quality, quantity and compliance for all

EyeNetAqua Solutions Private Limited

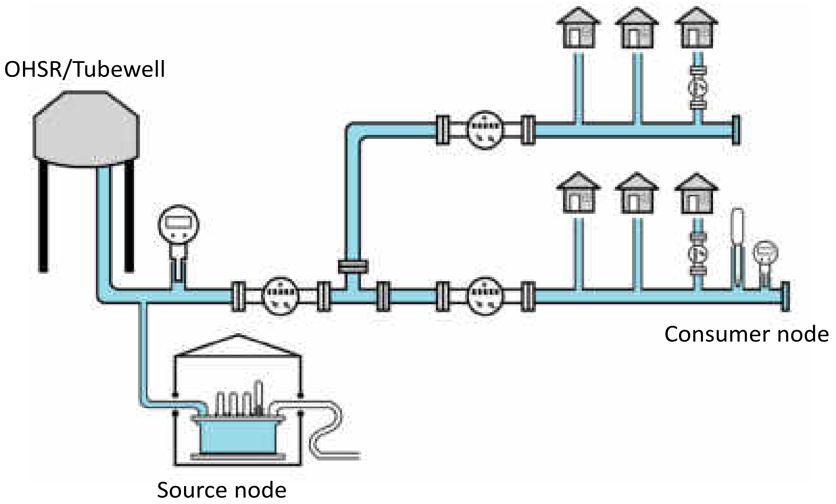
Installation model as per NJJM specifications

Tubewell/OHSR (Source node):

- 1. Flow meter (80-150mm) x 1
- 2. Pressure sensor x 1
- 3. pH sensor x 1
- 4. TDS sensor x 1
- 5. Residual Chlorine sensor x 1
- 6. In-house MVP of Free Residual Chlorine sensor x 1

Consumer tap (End tail node):

- 1. Flow meter (15-20mm) x 1
- 2. Pressure sensor x 1
- 3. Residual Chlorine sensor x 1
- 4. In-house MVP of Free Residual Chlorine sensor x 1

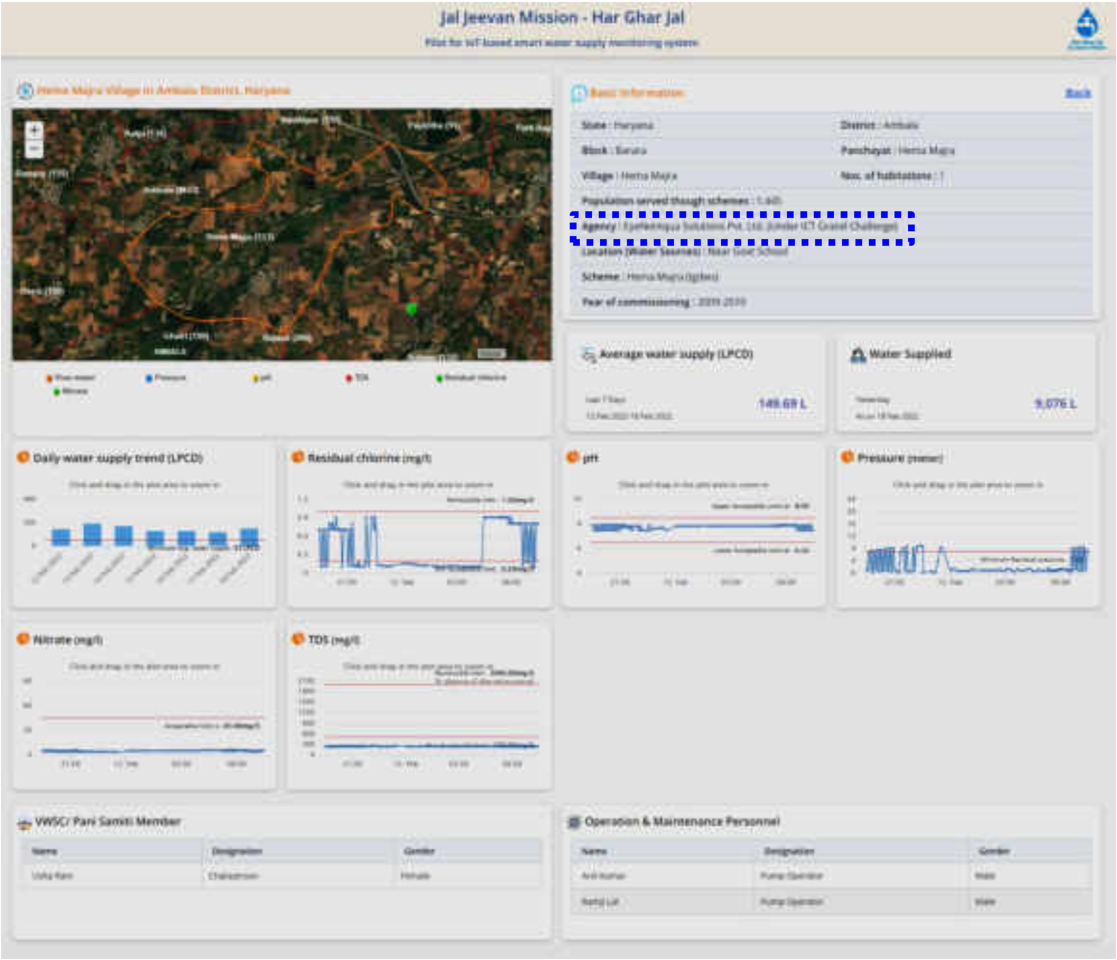


EyeNetAqua Solutions Pvt. Ltd.

An ICCW incubated company

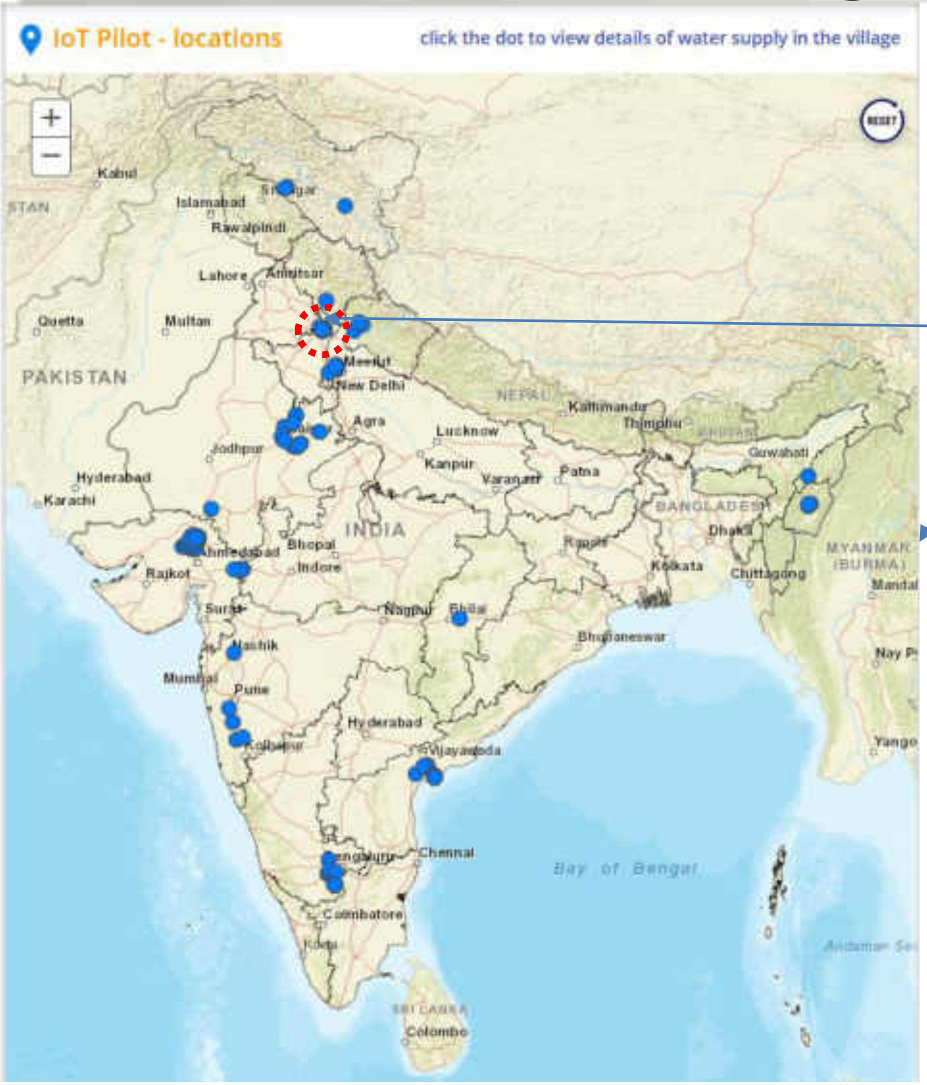
Eye of internet on quality, quantity and compliance for all

Real time water quality



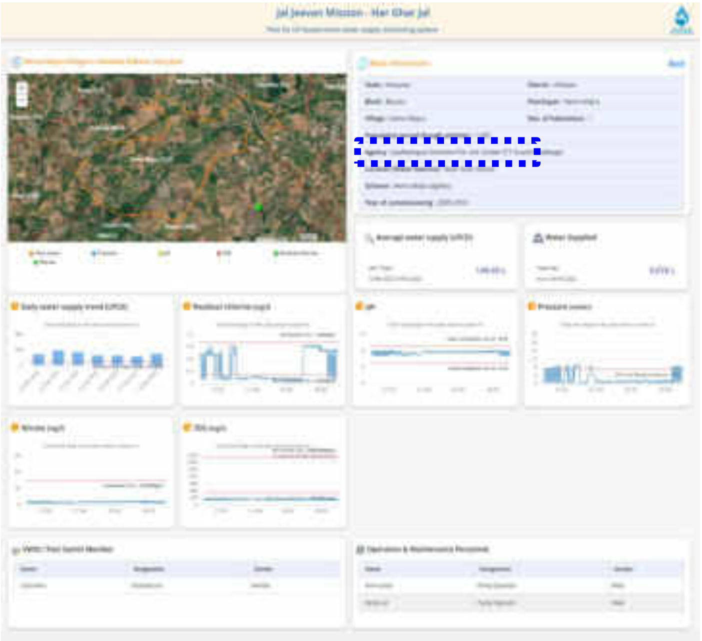
Snapshot of water quality analysers

India’s water is being monitored



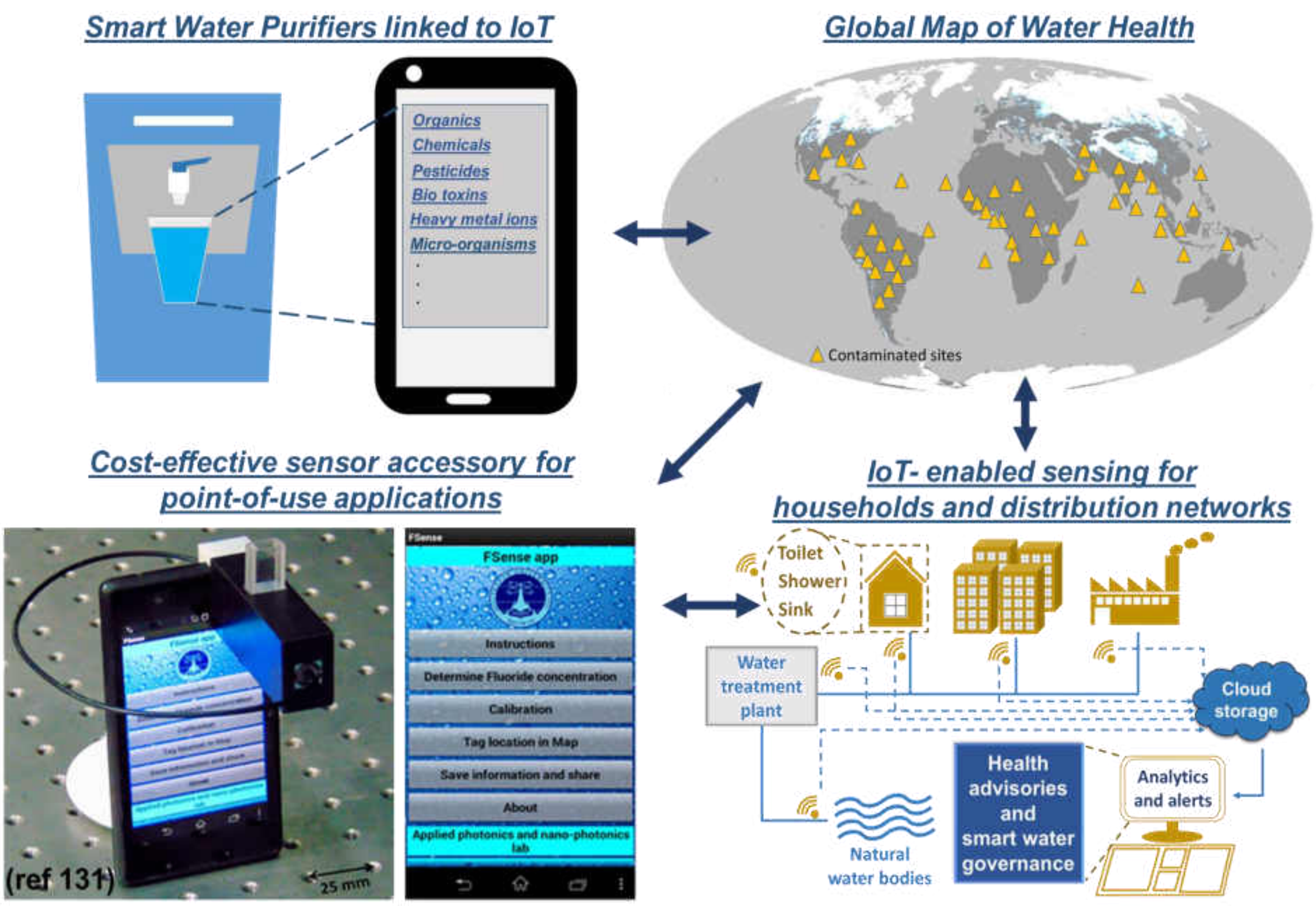
IITM/IISc

Installations made by four companies



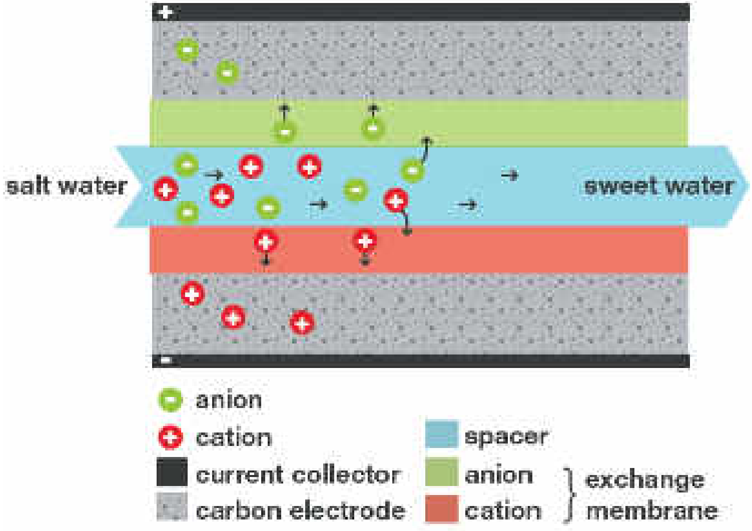
Mobile unit - A reagent free mobile water quality analyser

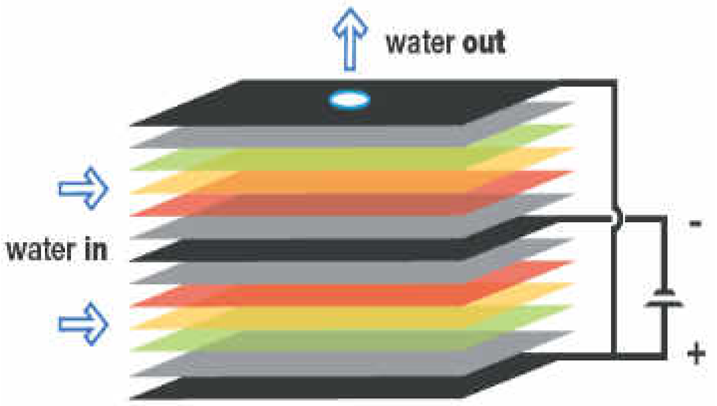
Smart water purifiers and big data

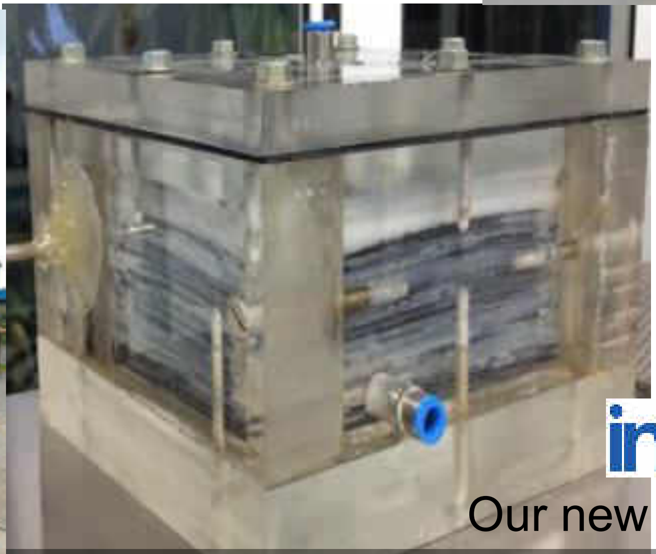


Ankit Nagar and T. Pradeep 14(2020). *ACS Nano*, 6420-6435

Capacitive Desalination (CDI)



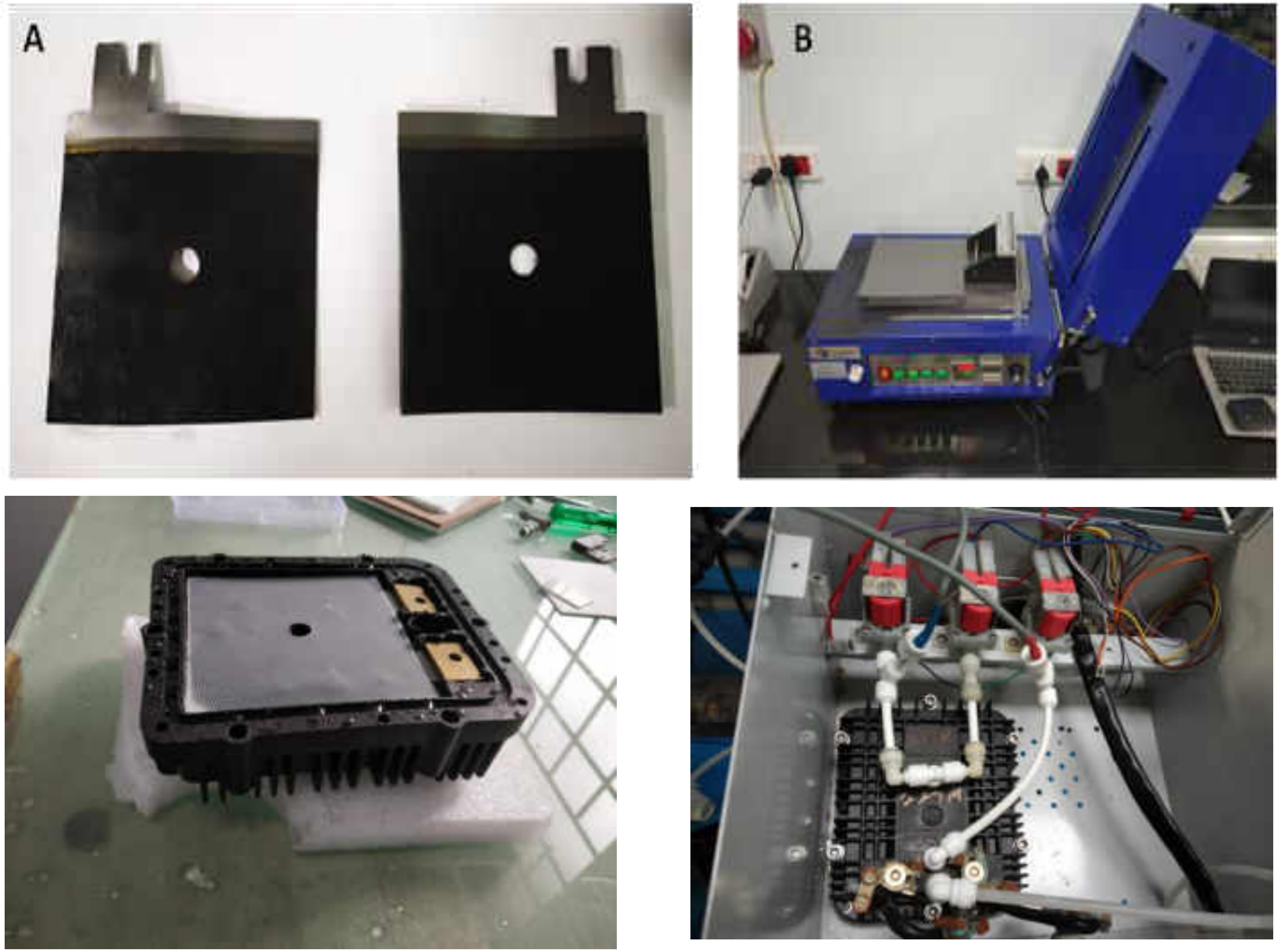




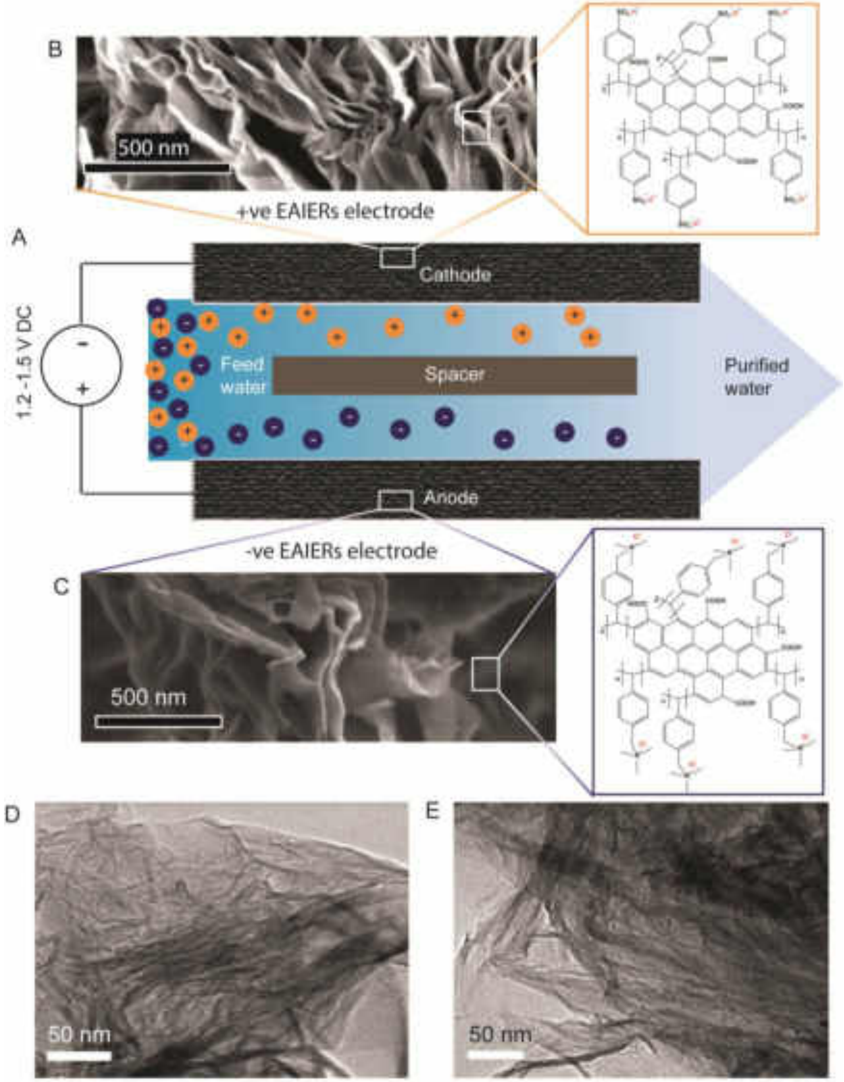
Our new company

Soujit Sengupta, Rabiul Islam and others

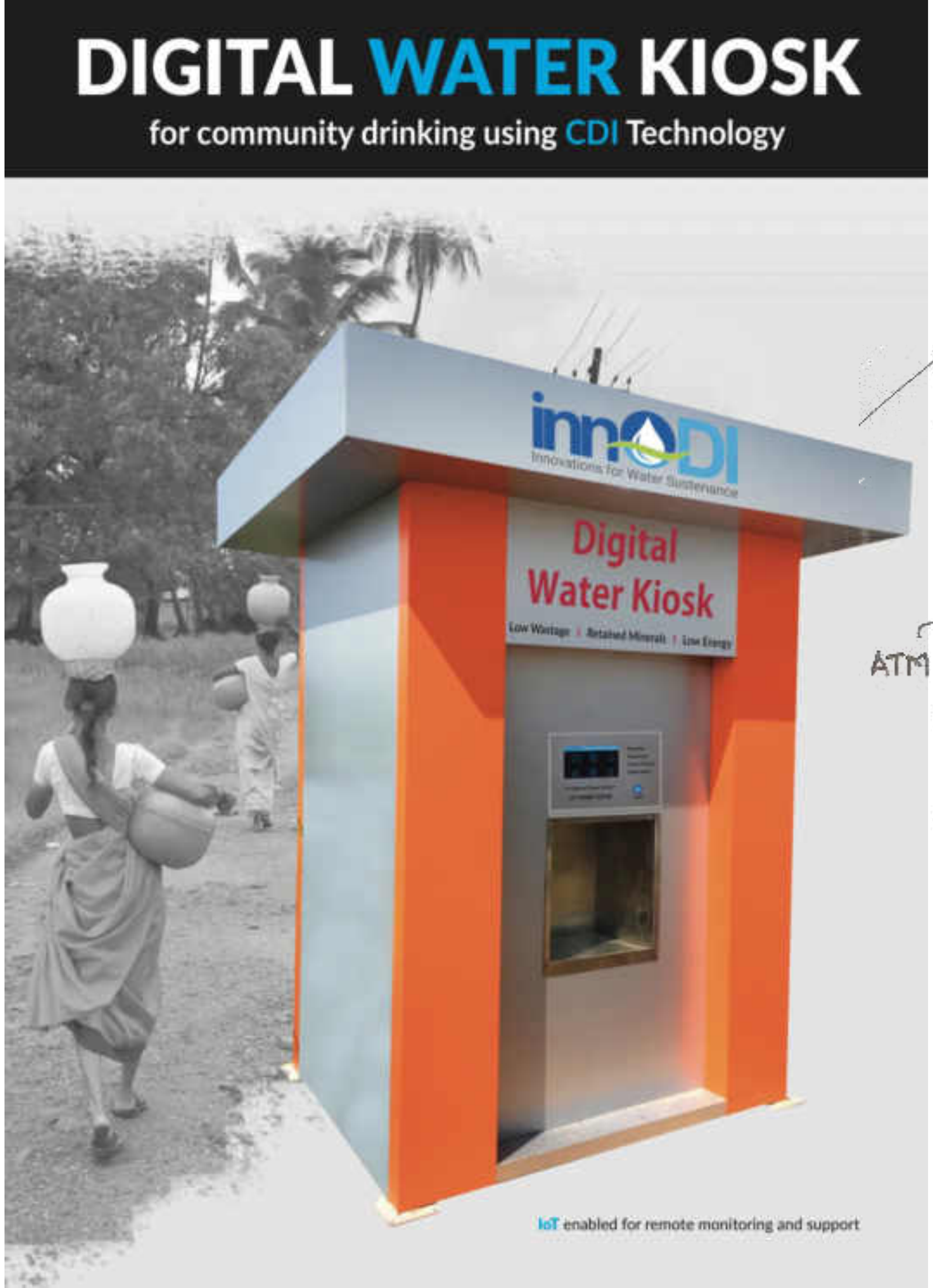
Various stages of electrode preparation

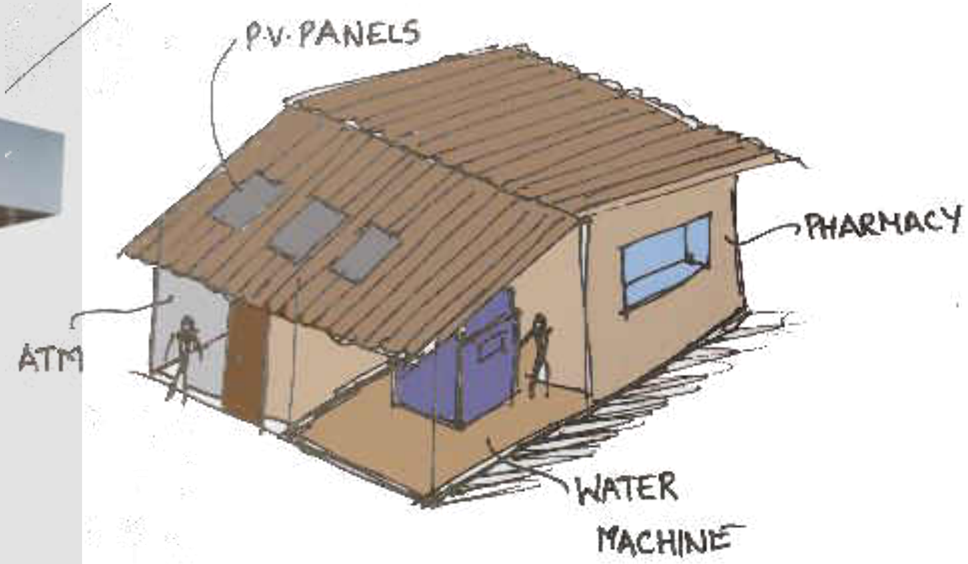


A Covalently Integrated Reduced Graphene Oxide -Ion Exchange Resin Electrode for Efficient CDI



Rabiul *et al., Adv. Mater. Interfaces* **2021**, *8,* 2001998

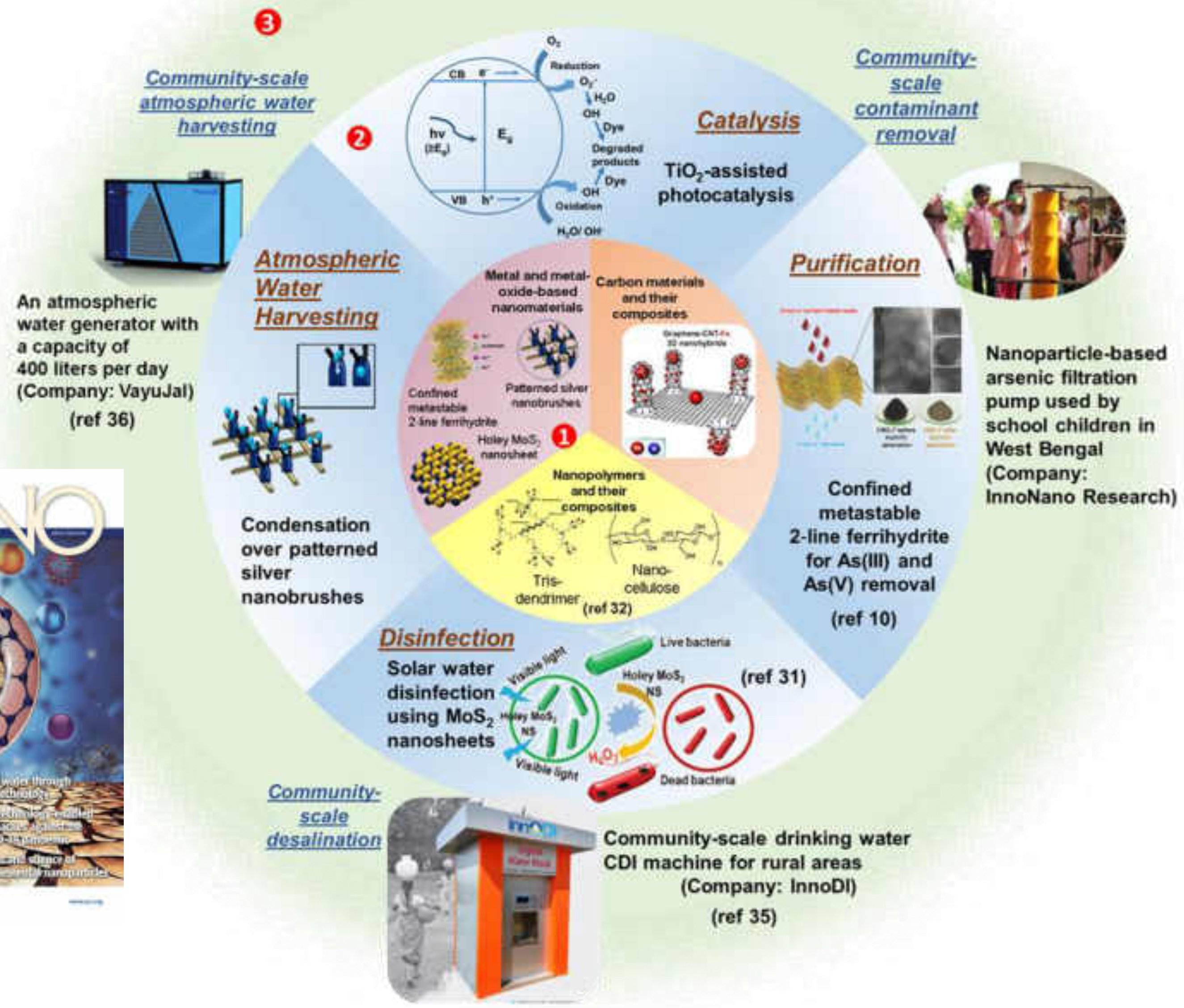


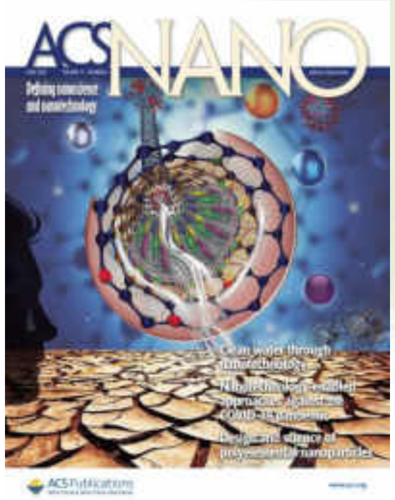


Products under implementation

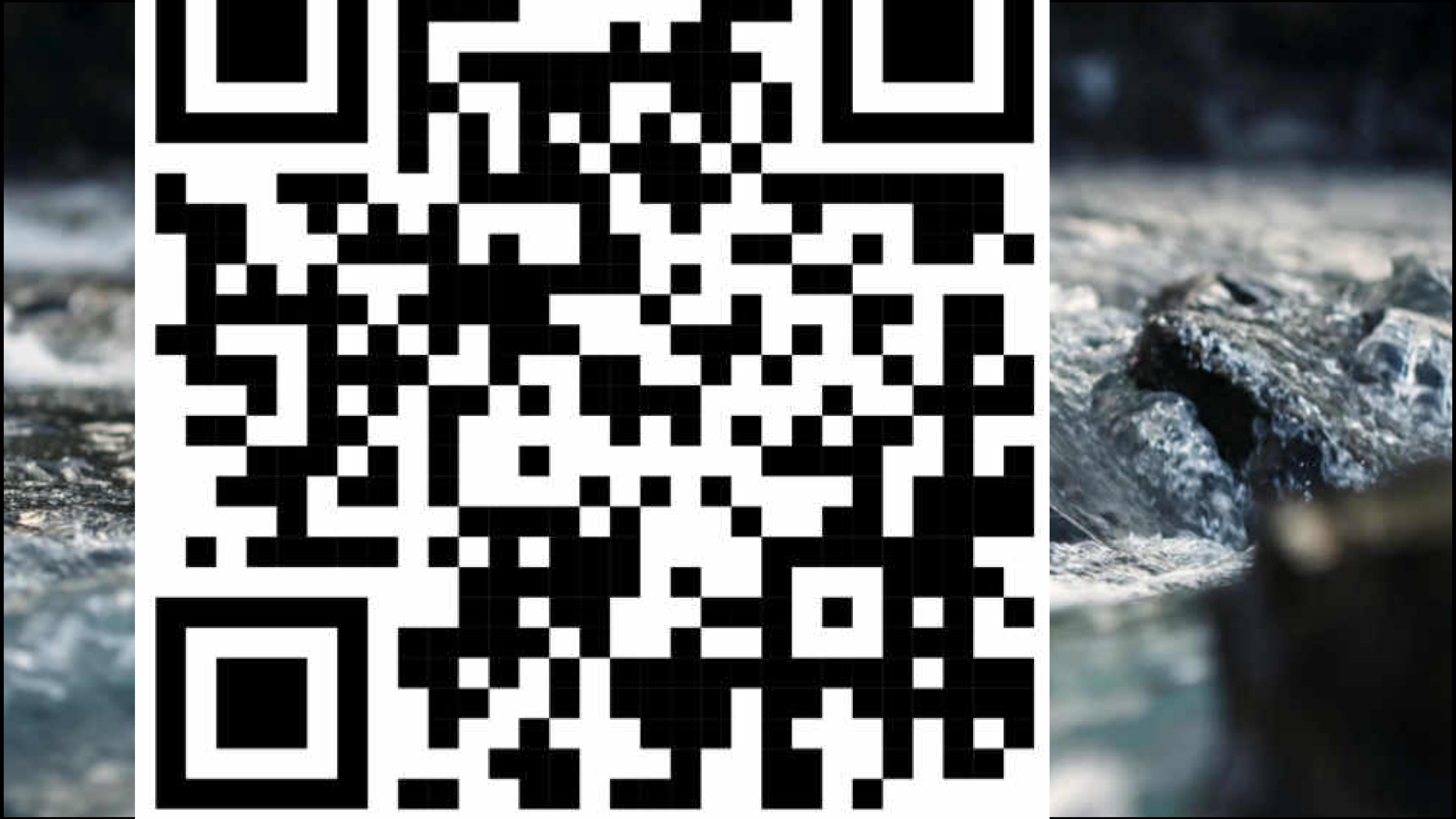
Vijay Sampath and Tullio Servida

Evolution of materials to products





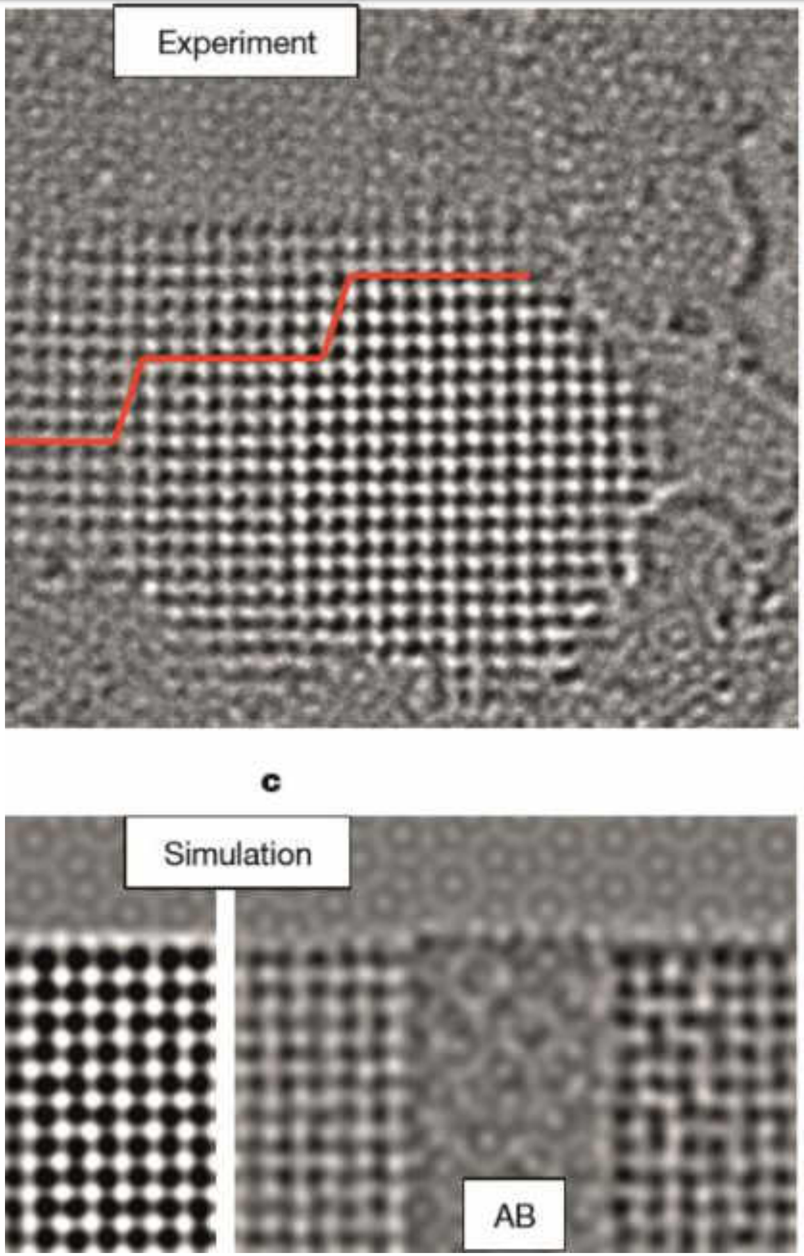
Ankit Nagar and T. Pradeep, *ACS Nano* 14 (2020) 6420-6435.

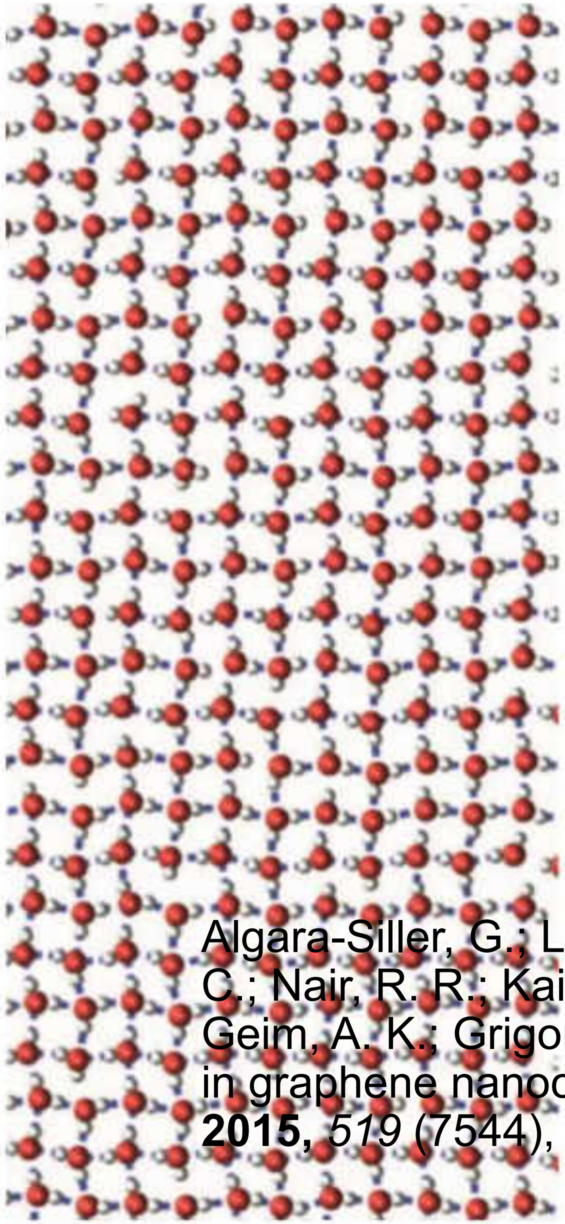


https://www.youtube.com/watch?v=fiJyptbXBtM


thermoscientific

Observing water





Algara-Siller, G.; Lehtinen, O.; Wang, F. C.; Nair, R. R.; Kaiser, U.; Wu, H. A.; Geim, A. K.; Grigorieva, I. V., Square ice in graphene nanocapillaries. *Nature* **2015,** *519* (7544), 443-445.

Indian Institute of Technology Madras

Associate Editor

ACS Sustainable Resource Management

Bhaskar Ramamurthi/V. Kamakoti

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Manswita Mandal for help with the slides