



Now in the 58th year

Clean water using advanced materials: Science, incubation and industry

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InnoNano Research Pvt. Ltd.
An IIT Madras Incubated Company

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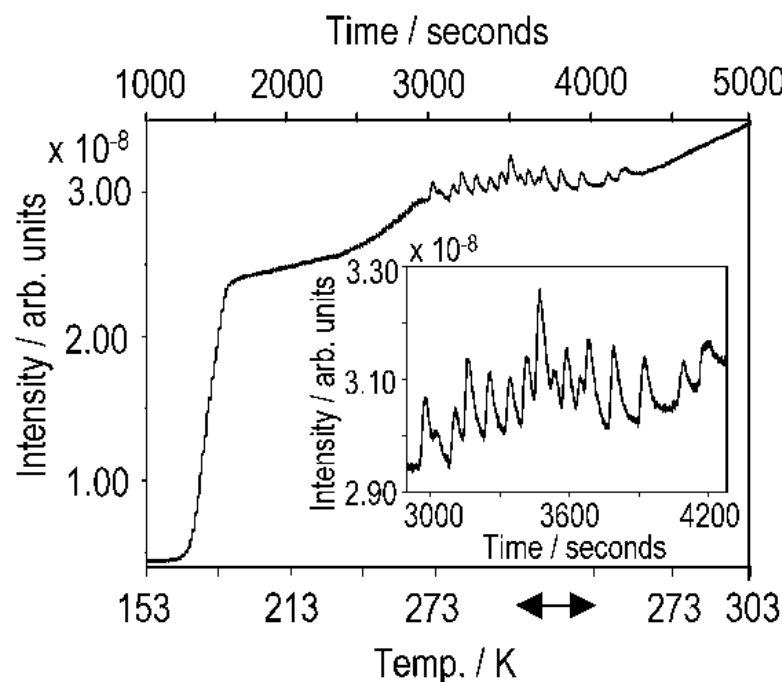
Prof. Amrutur V. Anilkumar
Prof. Uttama Lahiri



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ACS
Sustainable
Chemistry & Engineering



Concentration of CO₂ over Melting Ice Oscillates



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When melting ice oscillates as long as water and ice coexist. A model for CO₂ containing ice leading to its release, readsorption of CO₂ is proposed. Thermokinetics of these processes lead to non-Fickian behavior. Oscillations have been observed in several other solute or ice-

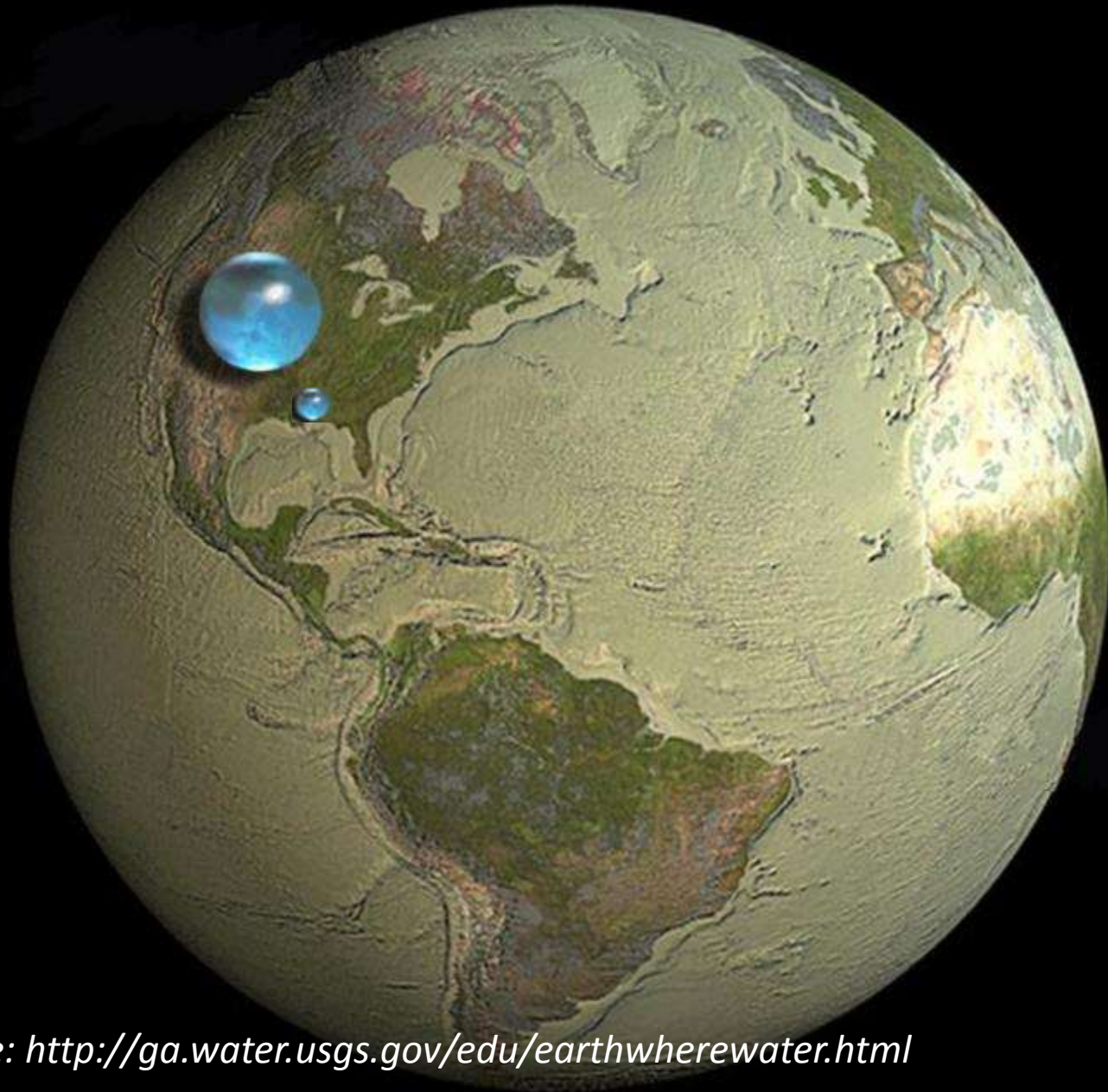
PACS numbers: 82.20.-w, 68.35.Ja, 82.40.Bj, 82.80.Ms

My greetings to Professor Roddam Narasimha



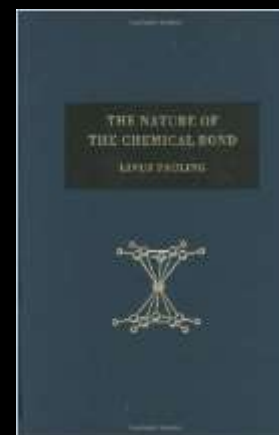
Our blue planet

12.6×10^{20} litres, 42×10^{45} molecules



Source: <http://ga.water.usgs.gov/edu/earthwherewater.html>

Water is probably the most researched subject, yet not fully understood.



Challenges and opportunities

- About 780 million people live without clean drinking water.
- More than two billion people worldwide rely on wells for their water.
- By 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity.
- Half of the global population lives in countries where water tables are rapidly falling - Ogallala Aquifer in the United States
- Over the past 40 years the world's population has doubled and use of water has quadrupled.
- Agriculture accounts for ~70% of global freshwater withdrawals and up to 90% in some fast-growing economies.

- By 2035, energy consumption will increase by 35 percent, increasing water use by 15 percent.
- In the US, thermoelectric power plants account for nearly 50% of all freshwater withdrawals.
- 46% of the globe's (terrestrial) surface is covered by transboundary river basins which can lead to future conflicts over water.
- The global middle class will surge from 1.8 to 4.9 billion by 2030, which will result in a significant increase in freshwater consumption.

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PERIODIC TABLE OF THE ELEMENTS

<http://www.ck12.org/periodic-table/>

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<http://www.kentchemistry.com/periodic-tables/periodic-table-1a.asp>

RELATIVE ATOMIC MASS (A_r)

LONGEST PERIOD: 18
WIDEST GROUP: 18

GROUPS: 1, 2, 10, 18, 16, 14, 12, 10, 8, 6, 4, 2

PERIODS: 1, 2, 3, 4, 5, 6, 7

LEGEND:

- Metals
- Non-metals
- Transition metals
- Lanthanides
- Actinides
- Alkali metals
- Alkaline earth metals
- Transition elements
- Non-transition elements
- Diatomic gases

STANDARD STATE (25 °C, 101 kPa)

He - gas
Ga - liquid
Ts - synthetic

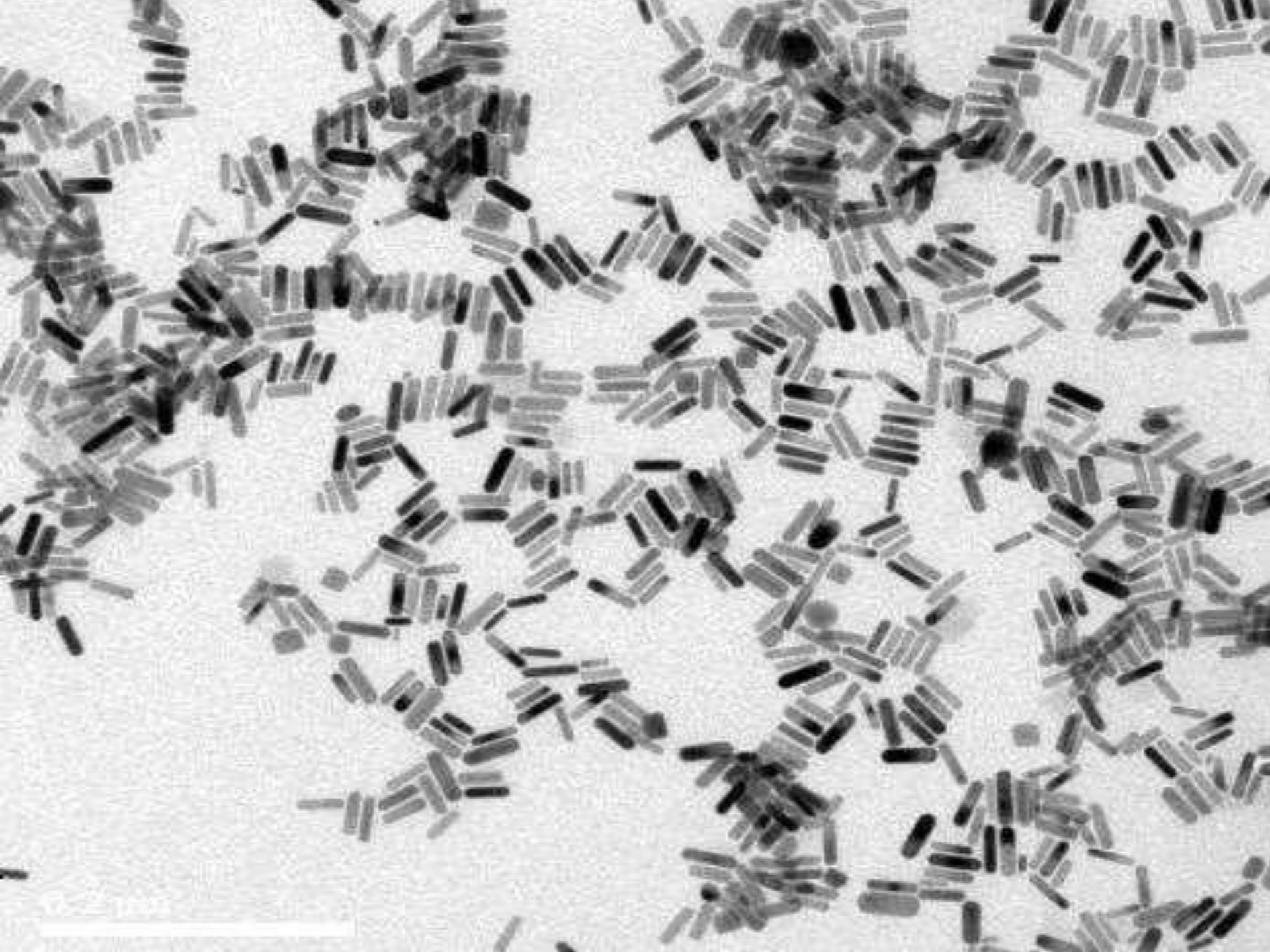
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3 Li 6.941
4 Be 9.012182
5 B 10.811
6 C 12.0107
7 N 14.0064
8 O 15.9994
9 F 18.998403
10 Ne 20.1797
11 Na 22.989769
12 Mg 24.304
13 Al 26.981538
14 Si 28.08558
15 P 30.973762
16 S 32.06
17 Cl 35.453
18 Ar 39.948
19 K 39.0983
20 Ca 40.078
21 Sc 44.955912
22 Ti 47.88
23 V 50.9415
24 Cr 51.9961
25 Mn 54.938044
26 Fe 55.845
27 Co 58.933195
28 Ni 58.6934
29 Cu 63.546
30 Zn 65.38
31 Ga 69.723
32 Ge 72.64
33 As 74.9216
34 Se 78.96
35 Br 79.904
36 Kr 83.80
37 Rb 85.4678
38 Sr 87.62
39 Y 88.90584
40 Zr 91.224
41 Nb 92.90638
42 Mo 95.94
43 Tc 98.90625
44 Ru 101.07
45 Rh 101.07
46 Pd 106.36
47 Ag 107.8682
48 Cd 112.411
49 In 114.818
50 Sn 118.710
51 Sb 121.757
52 Te 127.60
53 I 126.905
54 Xe 131.29
55 Cs 132.90545
56 Ba 137.327
57 La-Lu
58 Ce 140.12
59 Pr 140.90765
60 Nd 144.24
61 Pm
62 Sm 150.36
63 Eu 151.964
64 Gd 157.25
65 Tb 158.92532
66 Dy 162.50
67 Ho 164.93032
68 Er 167.259
69 Tm 168.93032
70 Yb 173.054
71 Lu 174.967
72 Hf 178.49
73 Ta 180.94788
74 W 183.84
75 Re 186.207
76 Os 190.23
77 Ir 192.222
78 Pt 195.084
79 Au 196.966569
80 Hg 200.59
81 Tl 204.38
82 Pb 207.2
83 Bi 208.980399
84 Po
85 At
86 Rn
87 Fr
88 Ra
89 Ac-Lr
90 Th 232.0377
91 Pa 231.03688
92 U 238.02891
93 Np 237.04817
94 Pu 244.06422
95 Am 243.06138
96 Cm 247.07035
97 Bk 247.07035
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99 Es 252.083
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823 Uuq

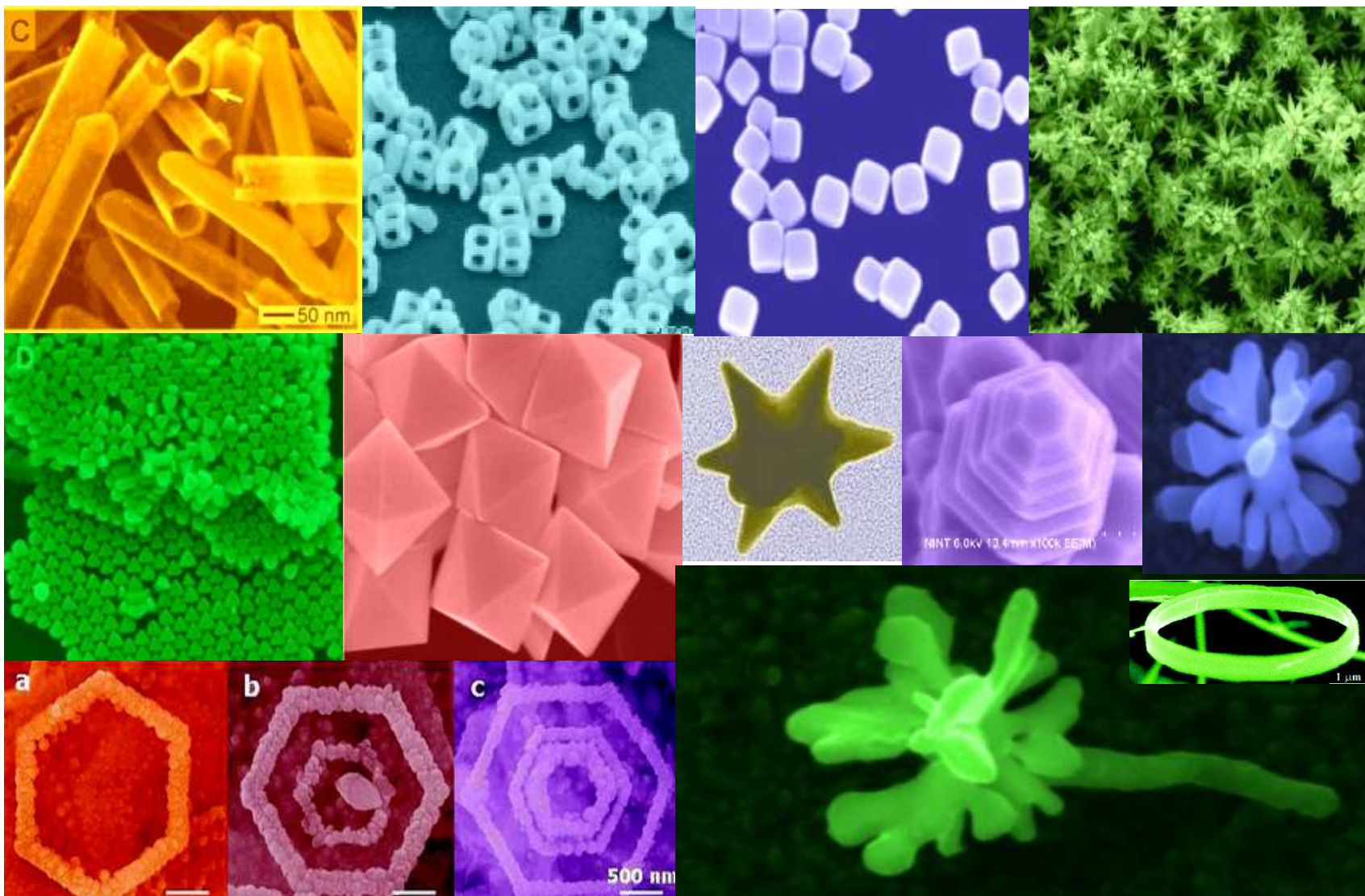
We have clean water on the surface of Earth only because chemistry permits it!

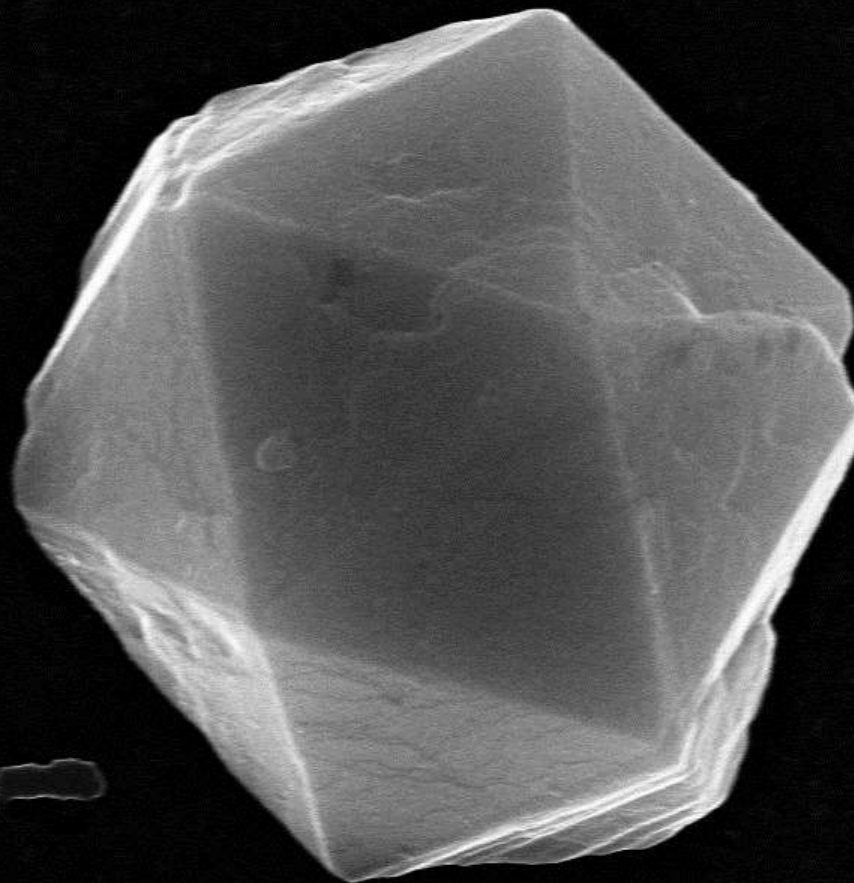
Why nanotechnology?

Nano 10^{-9}

Quantum



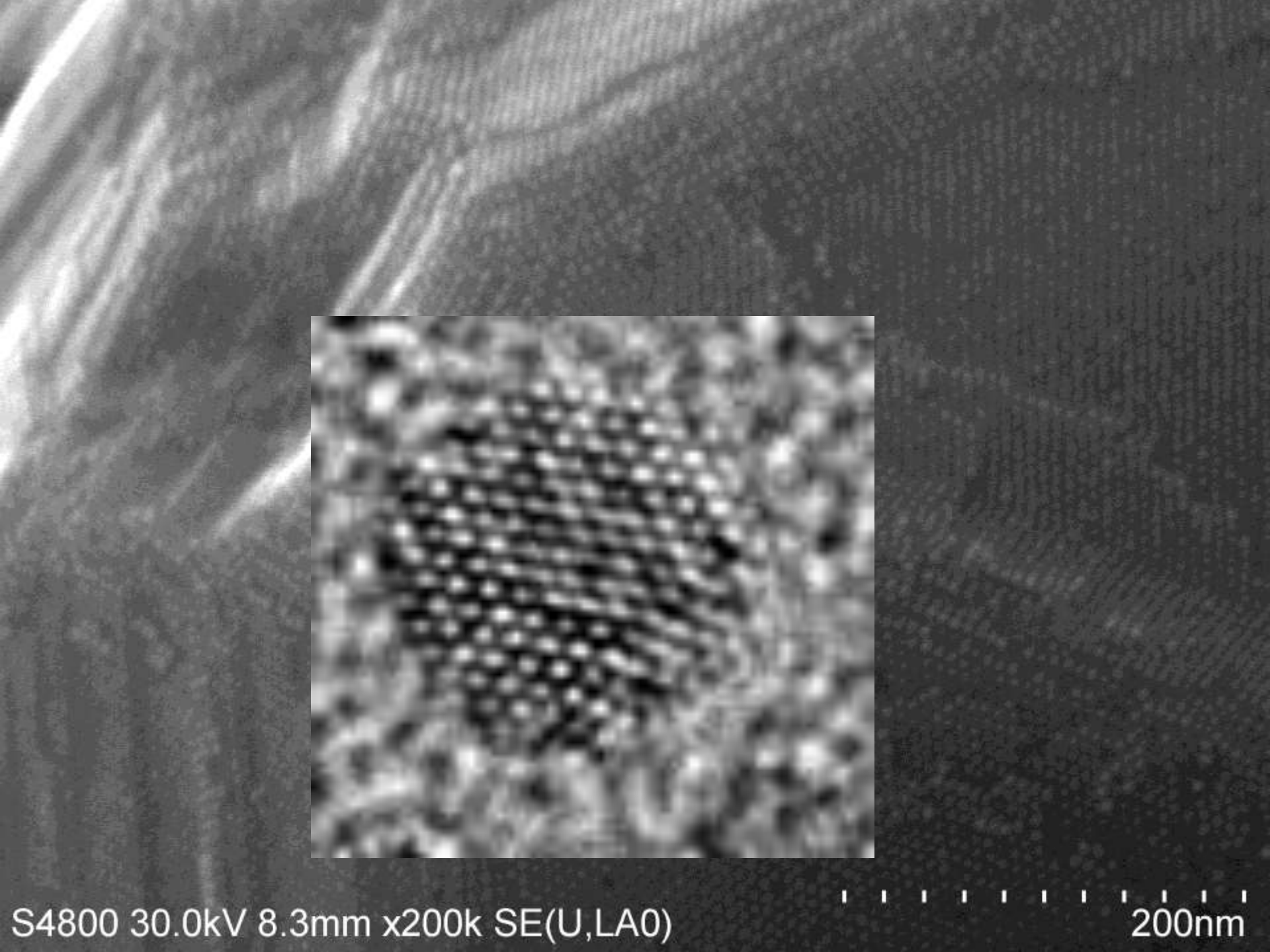




An object for the nanotechnology - nanomaterials.

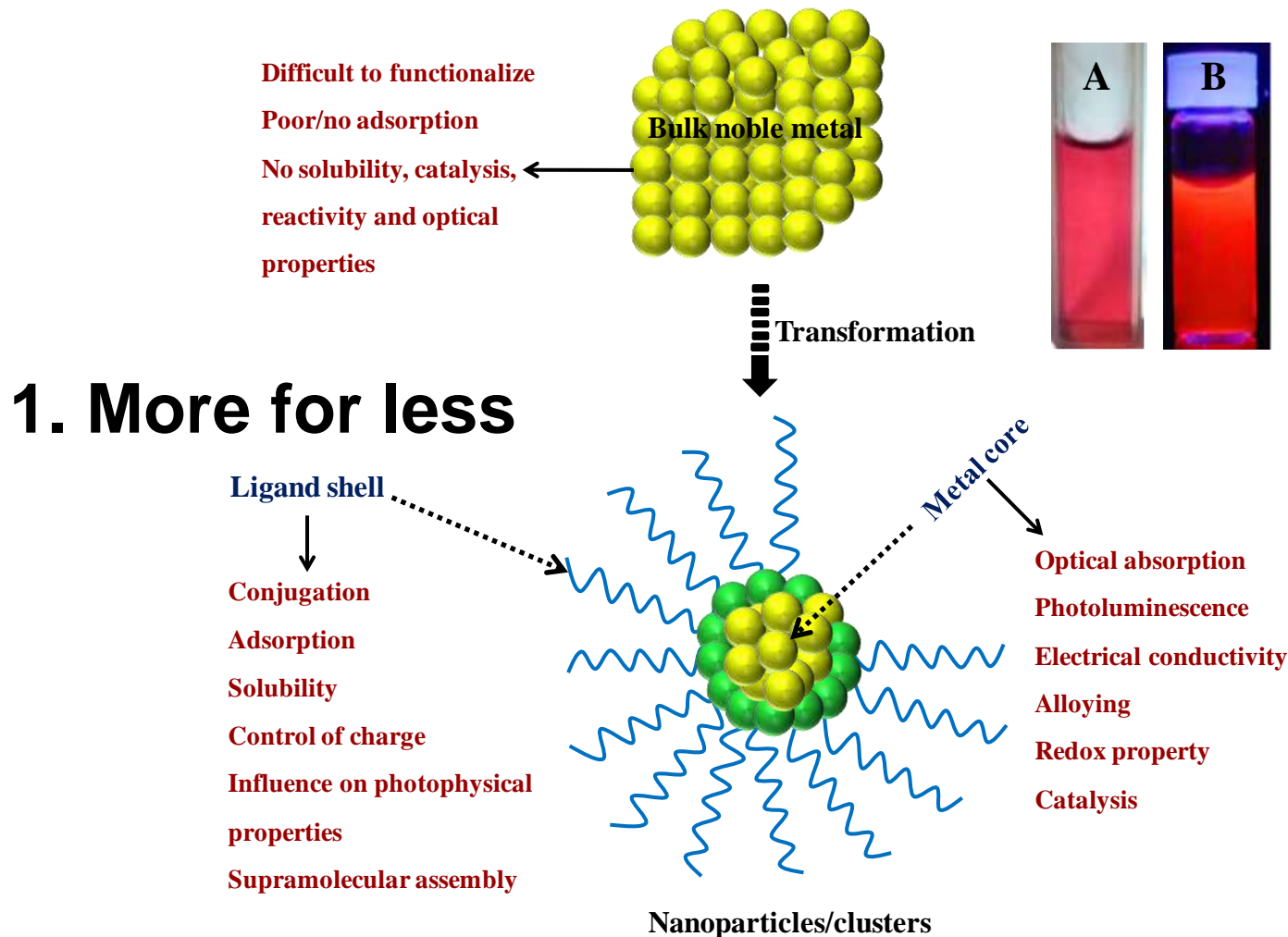
S4800 30.0kV 8.3mm x13.0k SE(U,LA0)

4.00um



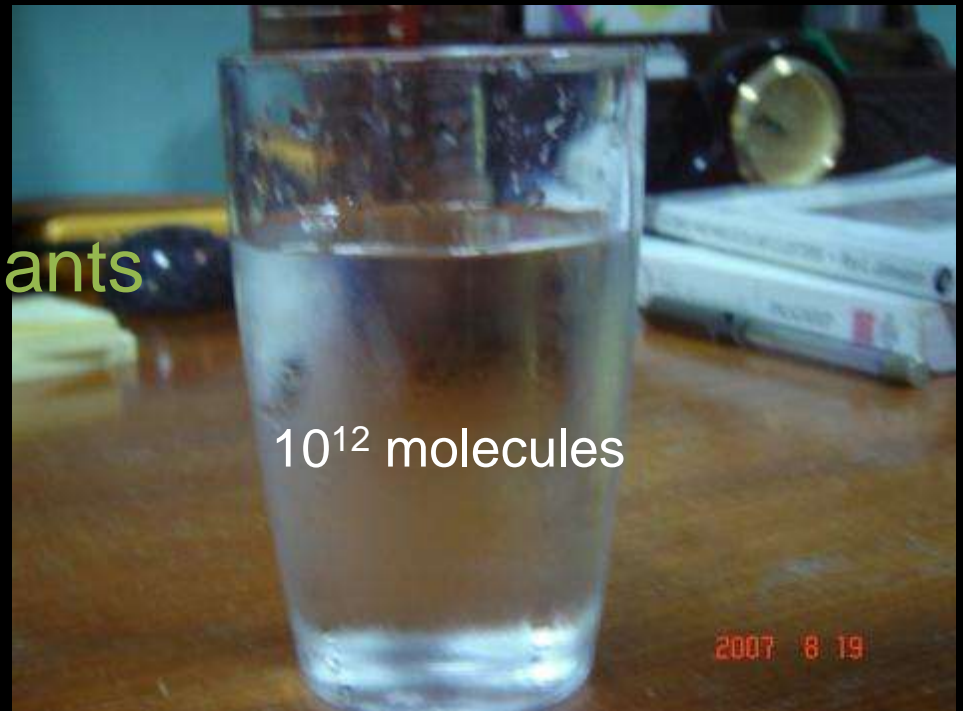
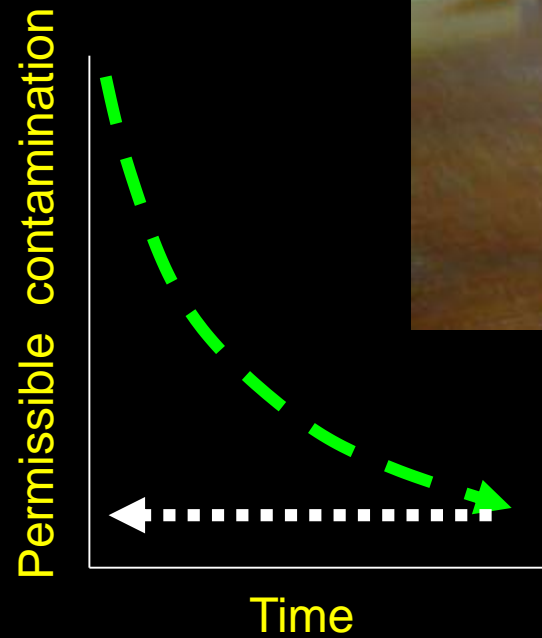
S4800 30.0kV 8.3mm x200k SE(U,LA0)

200nm

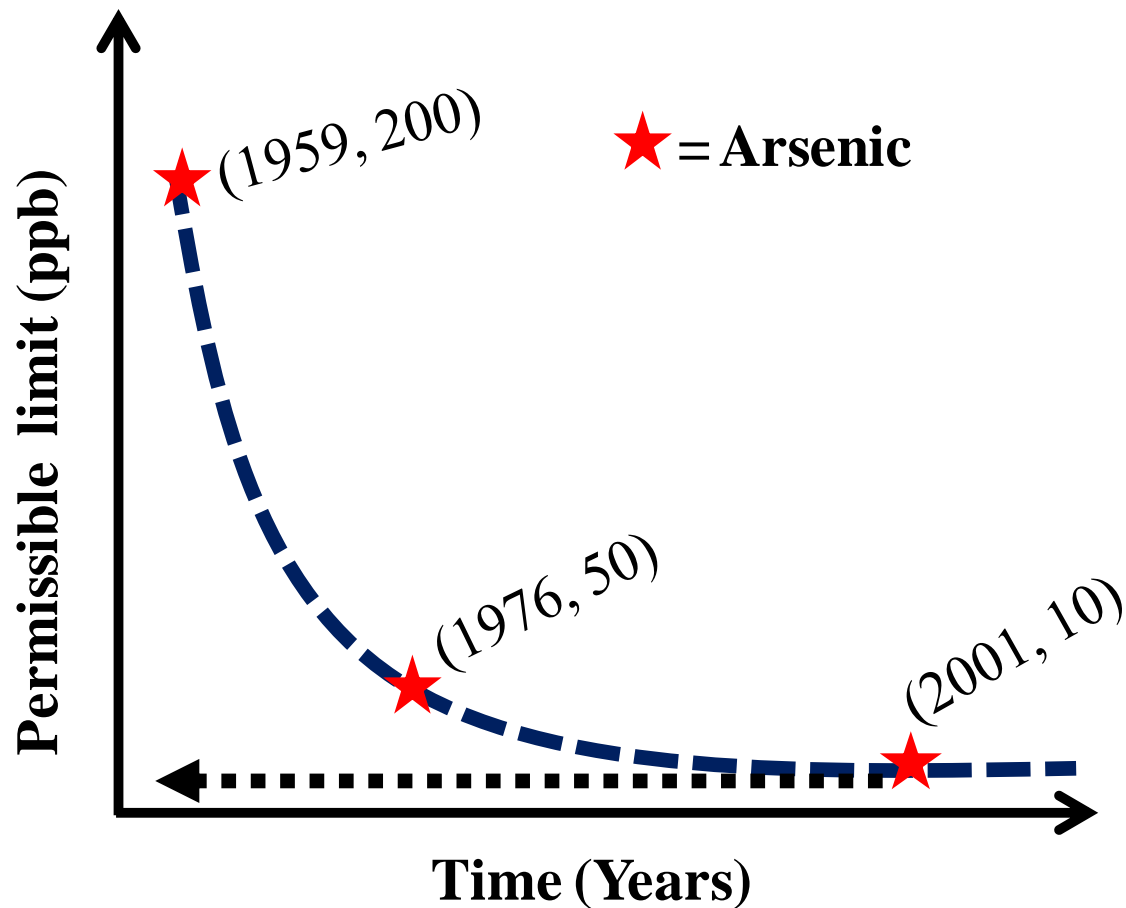


Variation in properties originating from ligand shell and metal core as bulk noble metals transform to nanoparticles/clusters. Sizes are not to scale. New properties such as color and photoluminescence arise in such size regime. Photographs of Au@citrate nanoparticles (inset A) showing intense absorption of visible light and Au@SG (SG corresponds to glutathione thiolate) clusters (inset B) showing intense photoluminescence upon ultraviolet irradiation (from the author's work).

2. Limits of contaminants

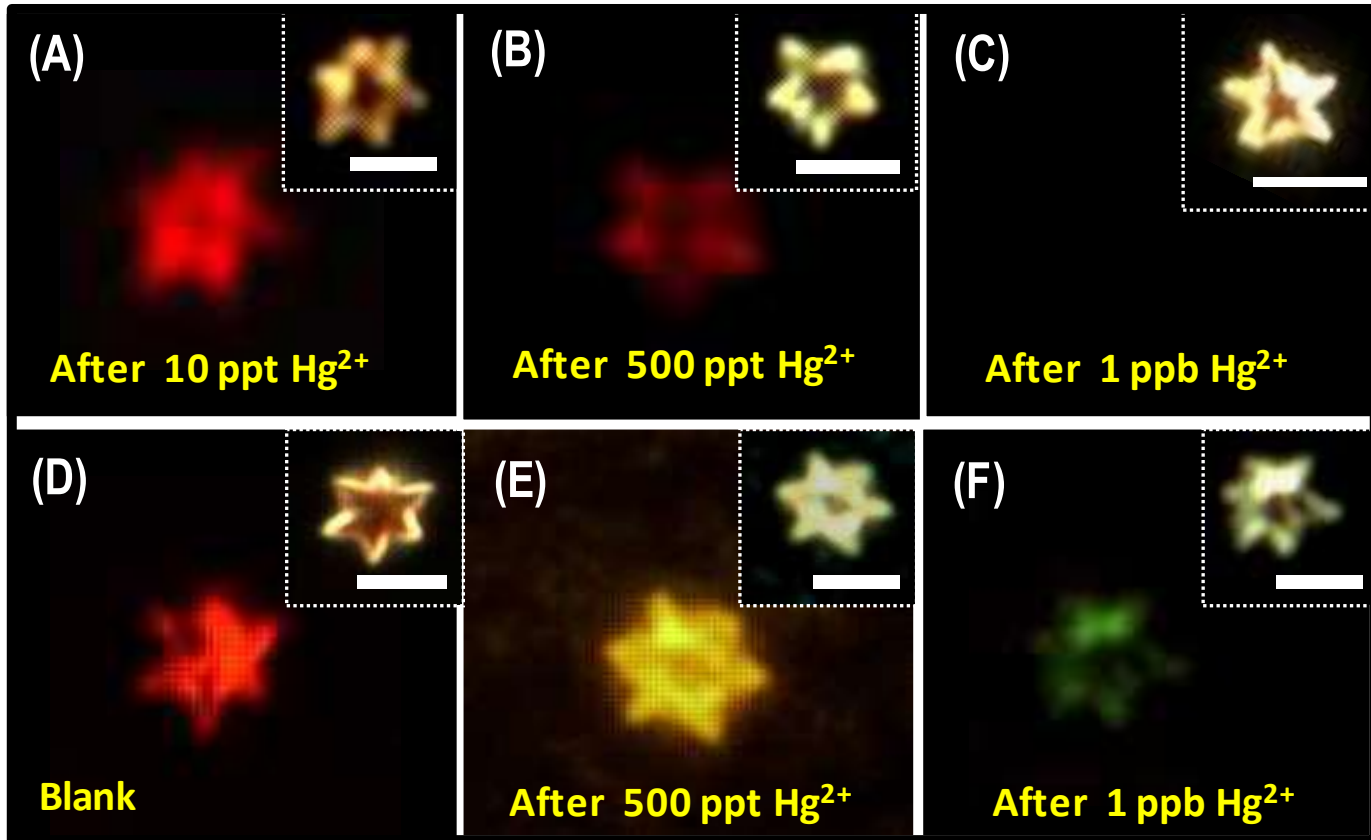


Permissible contamination reaches limits of detection



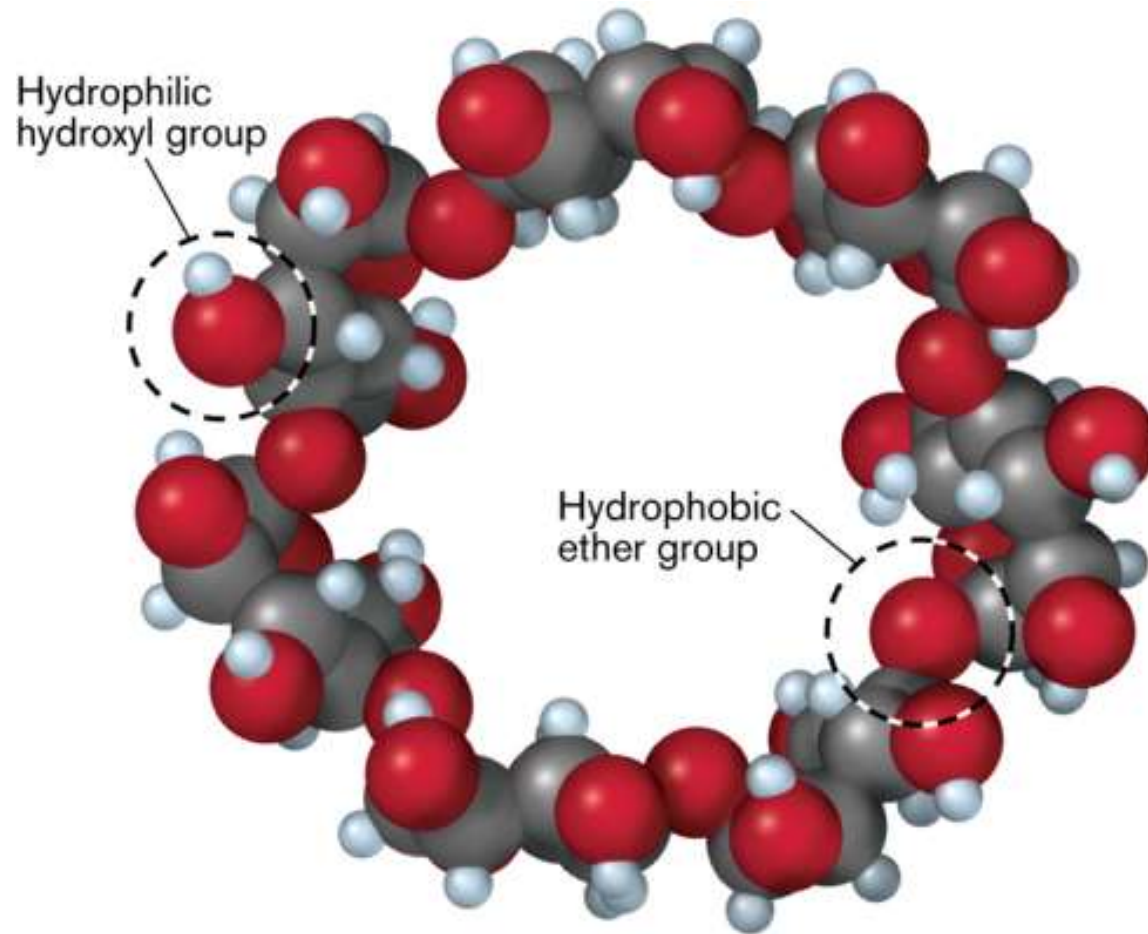
Decrease in the permissible limit of arsenic in drinking water, according to US EPA, with time. The graph indicates a general trend.

3. Can we reach limits?

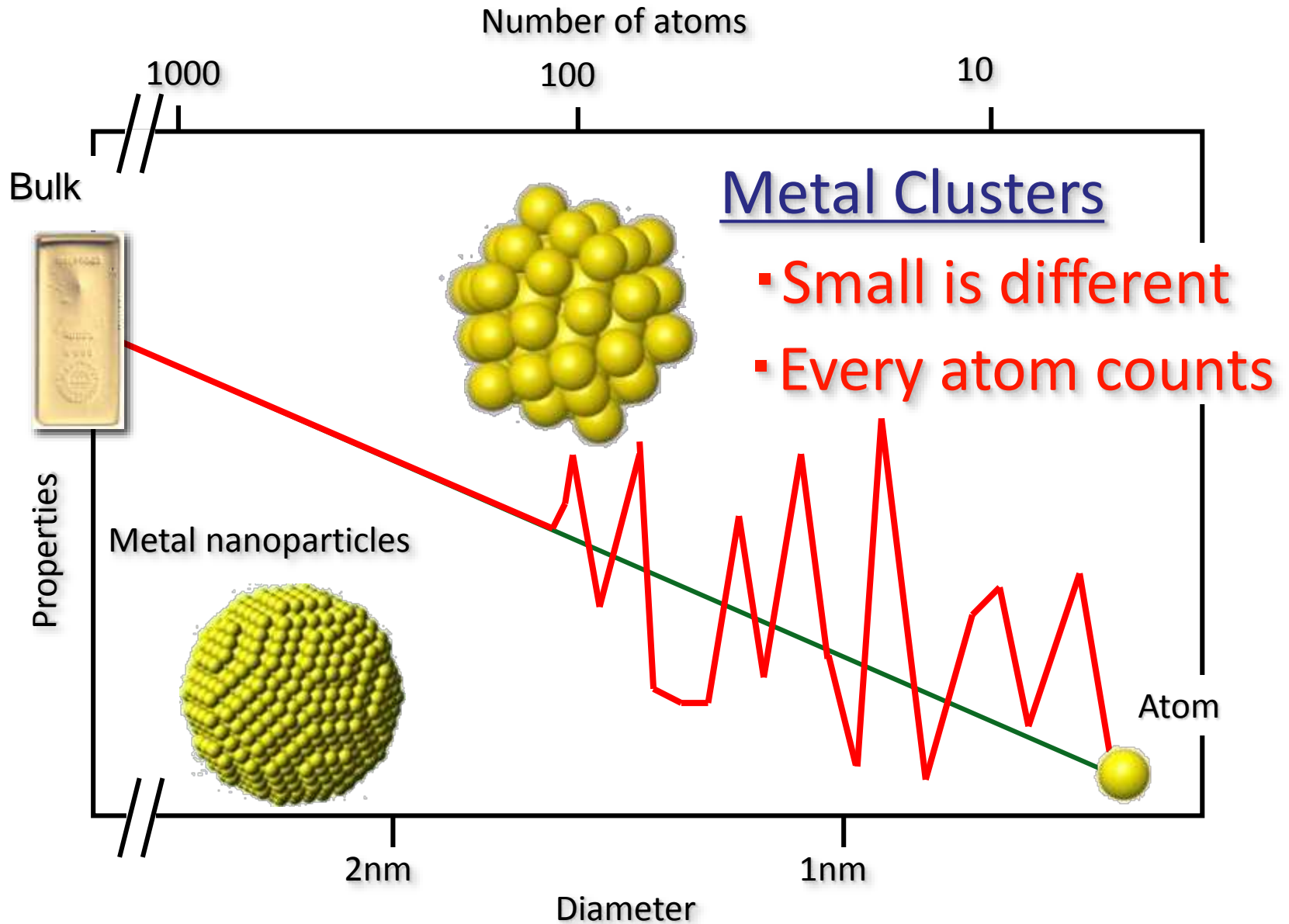


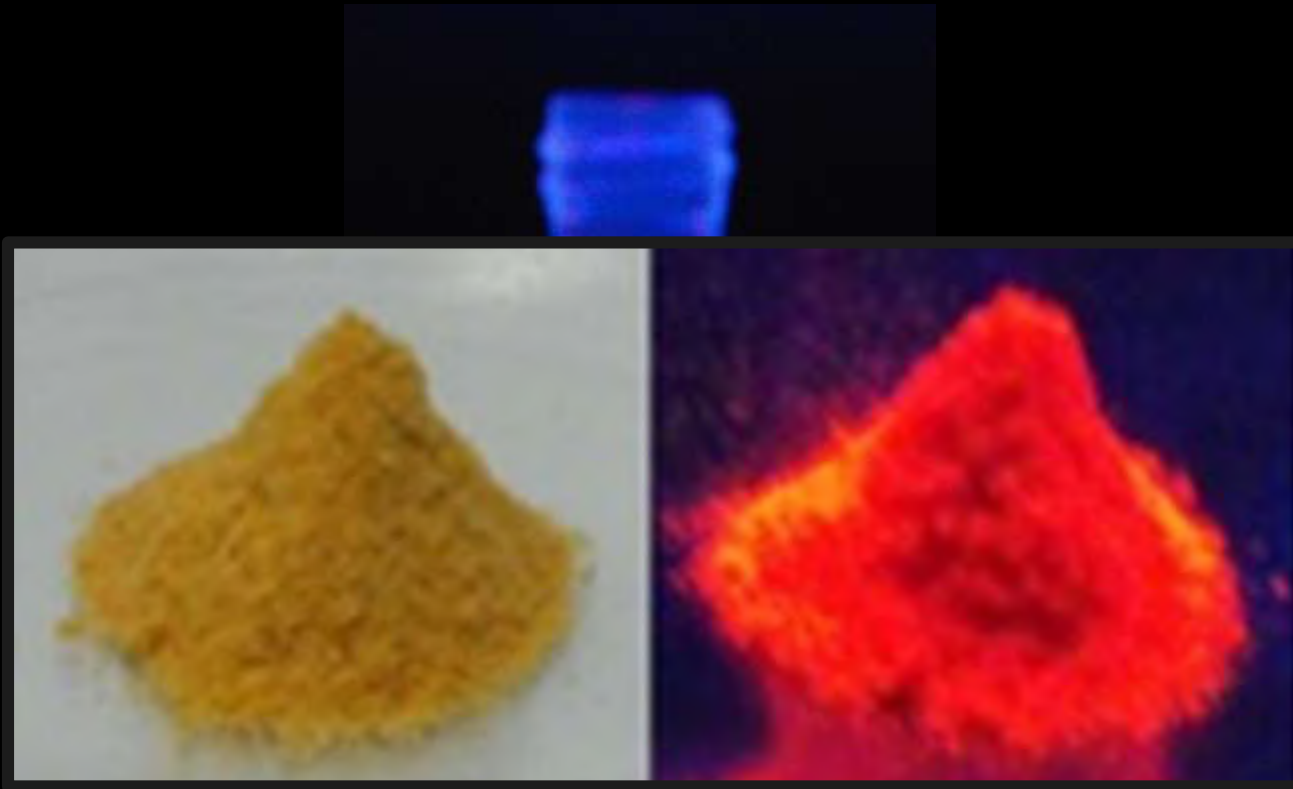
(A)–(C) Dark field fluorescence images of Au@SiO₂@Ag₁₅ MFs showing the gradual disappearance of luminescence with increasing Hg²⁺. (D)–(F) Fluorescence images showing variation in color during the addition of Hg²⁺ of different concentrations to Au@SiO₂-FITC@Ag₁₅ MFs. Insets in all images show the corresponding optical images of the MFs; scale bars are 3 μm.

Cavities, channels, imprints, assemblies, fibres, ...



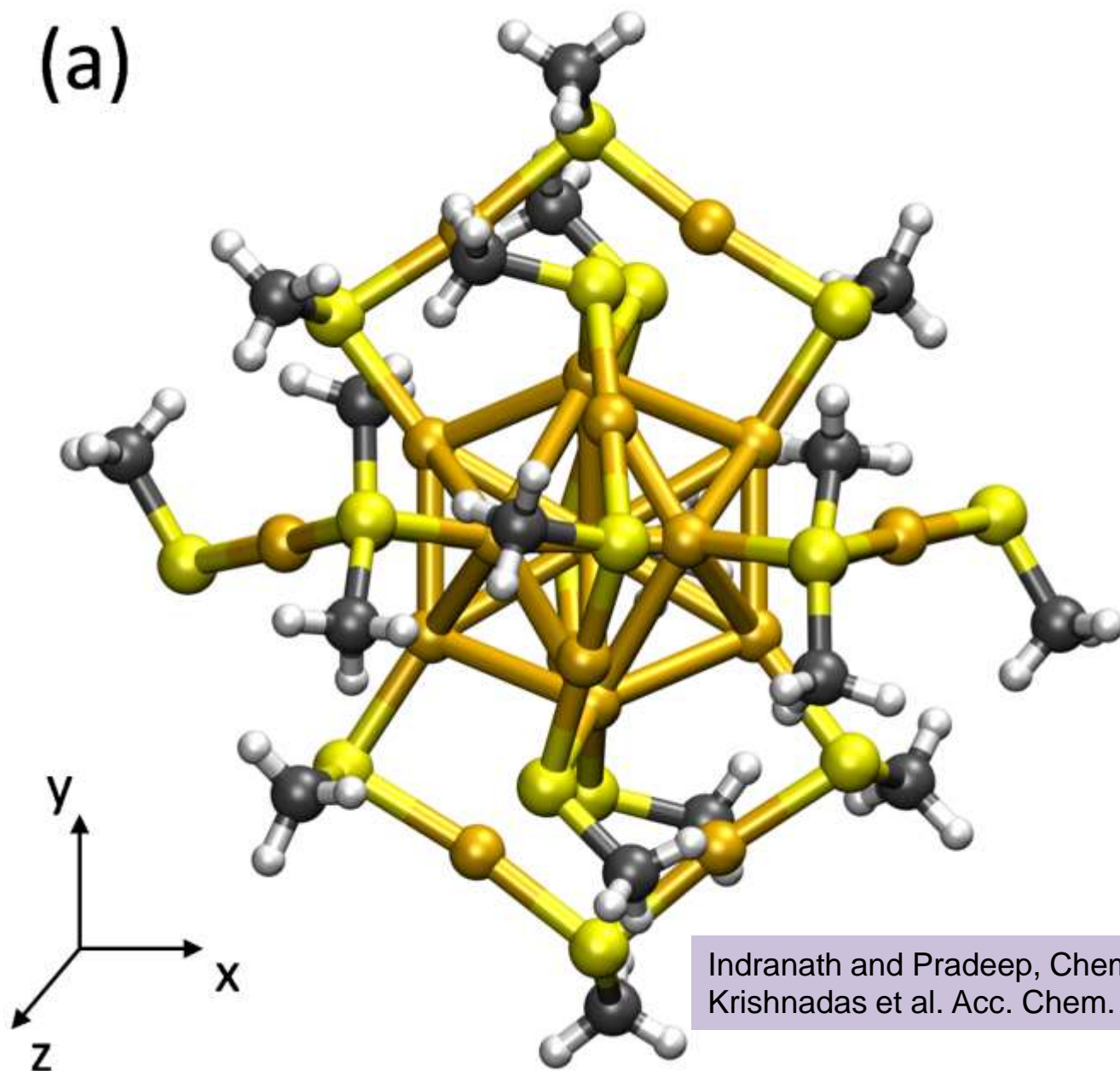
Metal Clusters





Shibhu, Habeeb, Uday, Kamalesh, Lourdu, Ammu, Ananya, Indranath, Atanu, Krishnadas, Shridevi, Papri,

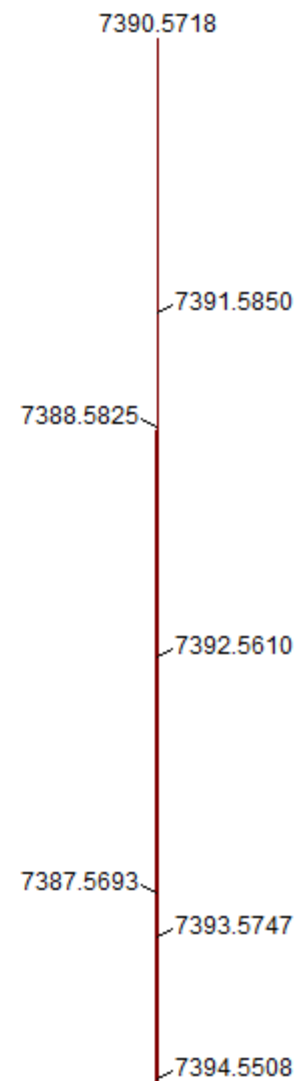
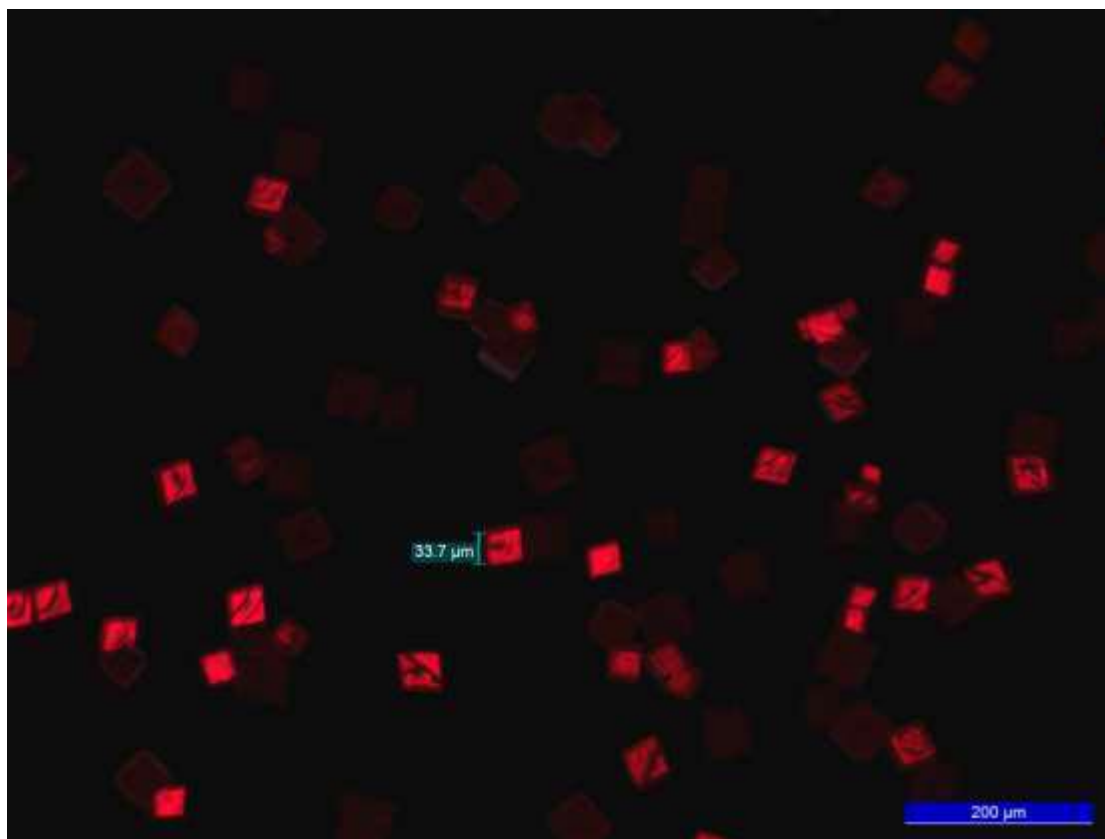
(a)



Indranath and Pradeep, Chem. Rev. 2017
Krishnadas et al. Acc. Chem. Res. 2017 (to appear)

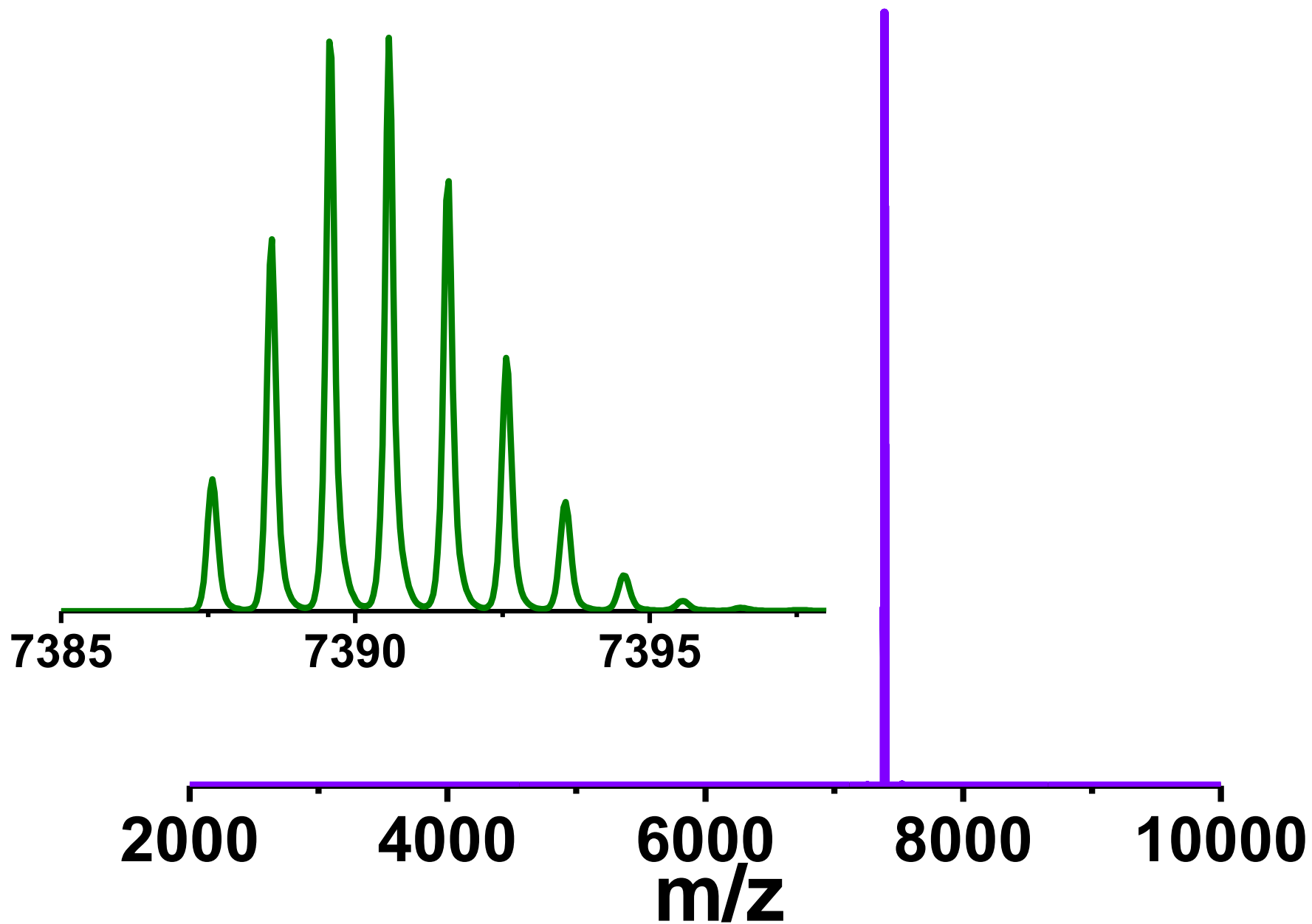
MS_3 32 (0.558) Cm (5:80)

$\text{Au}_{25}\text{PET}_{18}$



00 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000

$\text{Au}_{25}(\text{PET})_{18}^-$



Biopolymer-re nanocomposit water purifica

Mohan Udhaya Sankar¹, Saha
Kamalesh Chaudhari, and Tha

Unit of Nanoscience and Thematic Uni

Edited by Eric Hoek, University of Calif

Creation of affordable materials fo
water is one of the most promising
drinking water for all. Combinin
composites to scavenge toxic sp
other contaminants along with th
affordable, all-inclusive drinking
without electricity. The critical p
synthesis of stable materials tha
uously in the presence of com
drinking water that deposit and
surfaces. Here we show that suc
be synthesized in a simple and effe
out the use of electrical power. 1
sand-like properties, such as high
forms. These materials have beer
water purifier to deliver clean drin
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ambient temperature has wide
water purification.

hybrid | green | appropriate technolog



Featured in:

The Guardian, UK

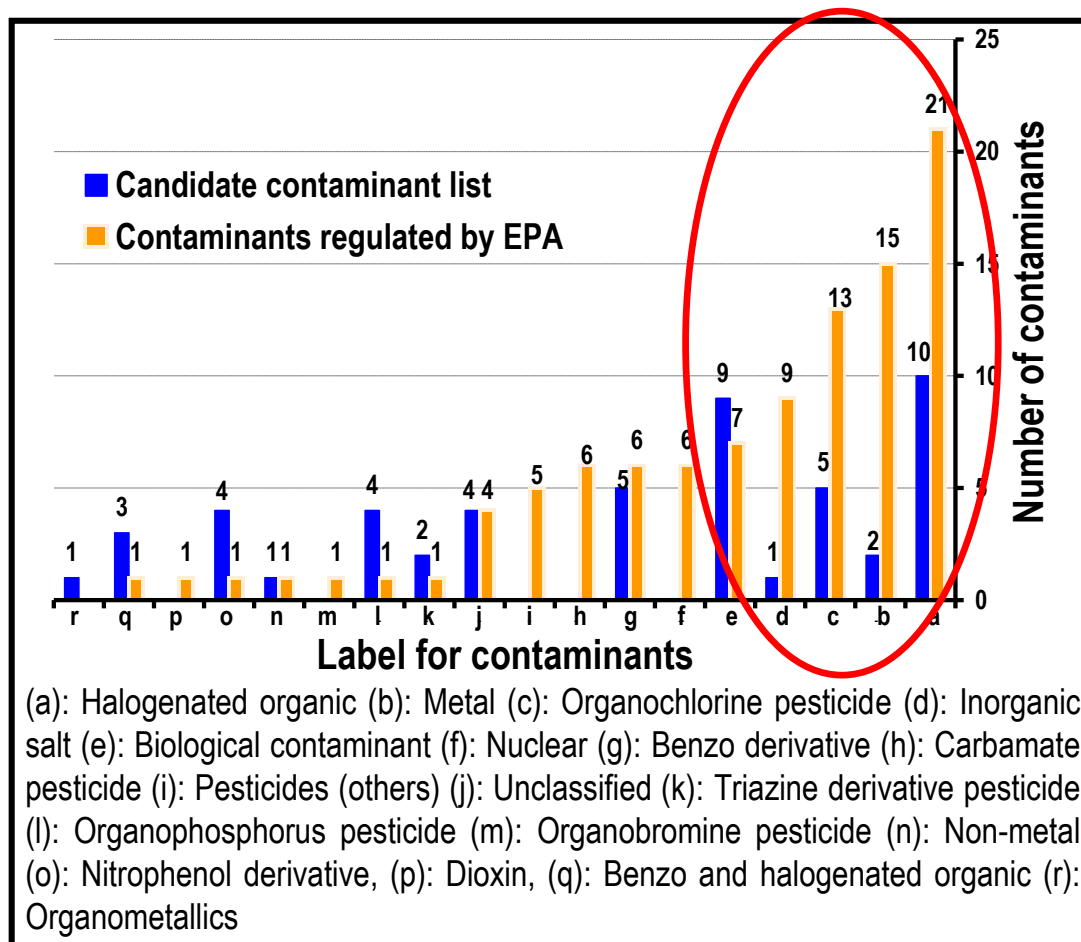
The Hindu, Telegraph, Times of India, etc.

Scientific American

New Scientist

and many others

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 Profession
Chemistry World

Pesticide filter debuts in India

20 April 2007

Kilugudi 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 Radoty, 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,' Thirupathi Pradeep, who led the team at IIT Chennai, told Chemistry World. He and his student Sreenivasan Raju discovered in 2003 that nanocarbons such as carbon nanotubes (CNTs) completely break down into metal halides and amorphous carbon upon reaction with gold and silver nanoparticles.

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 that gold and silver nanoparticles loaded on alumina were indeed able to completely remove endosulfan, malathion and chlorpyrifos – three pesticides that are common in drinking water supplies.

Use and recycle

The method

Pradeep

Pradeep

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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 malathion and chlorpyrifos 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



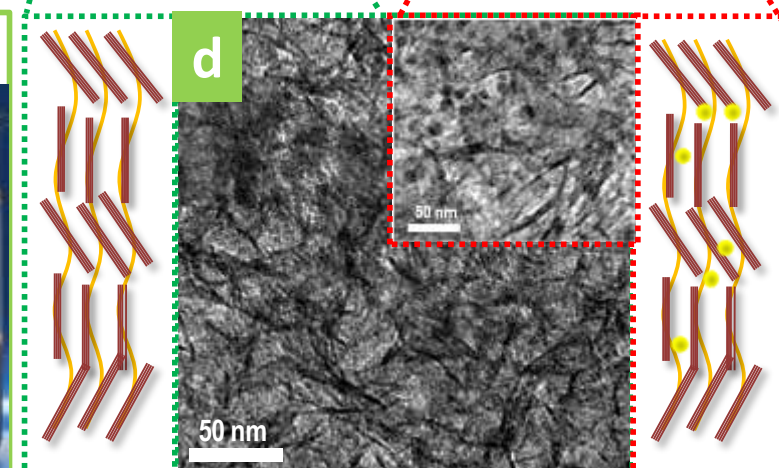
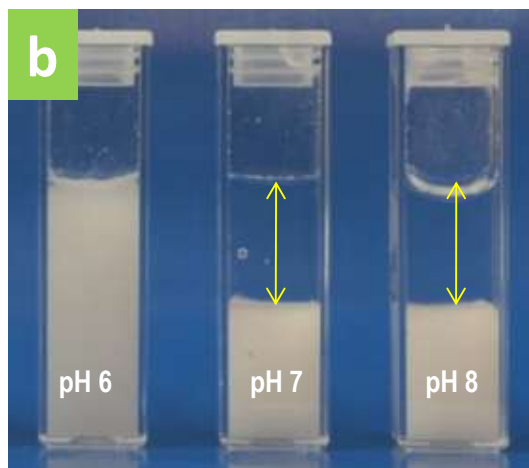
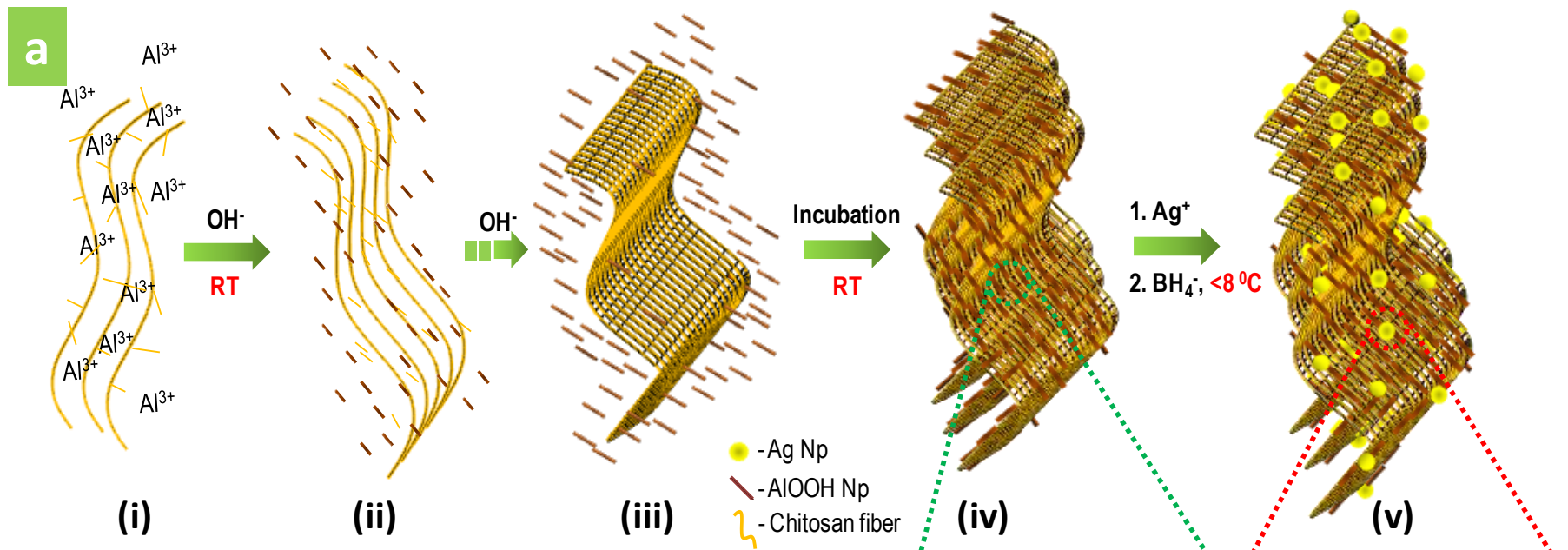
Affordable materials for water purification - Bioinspired

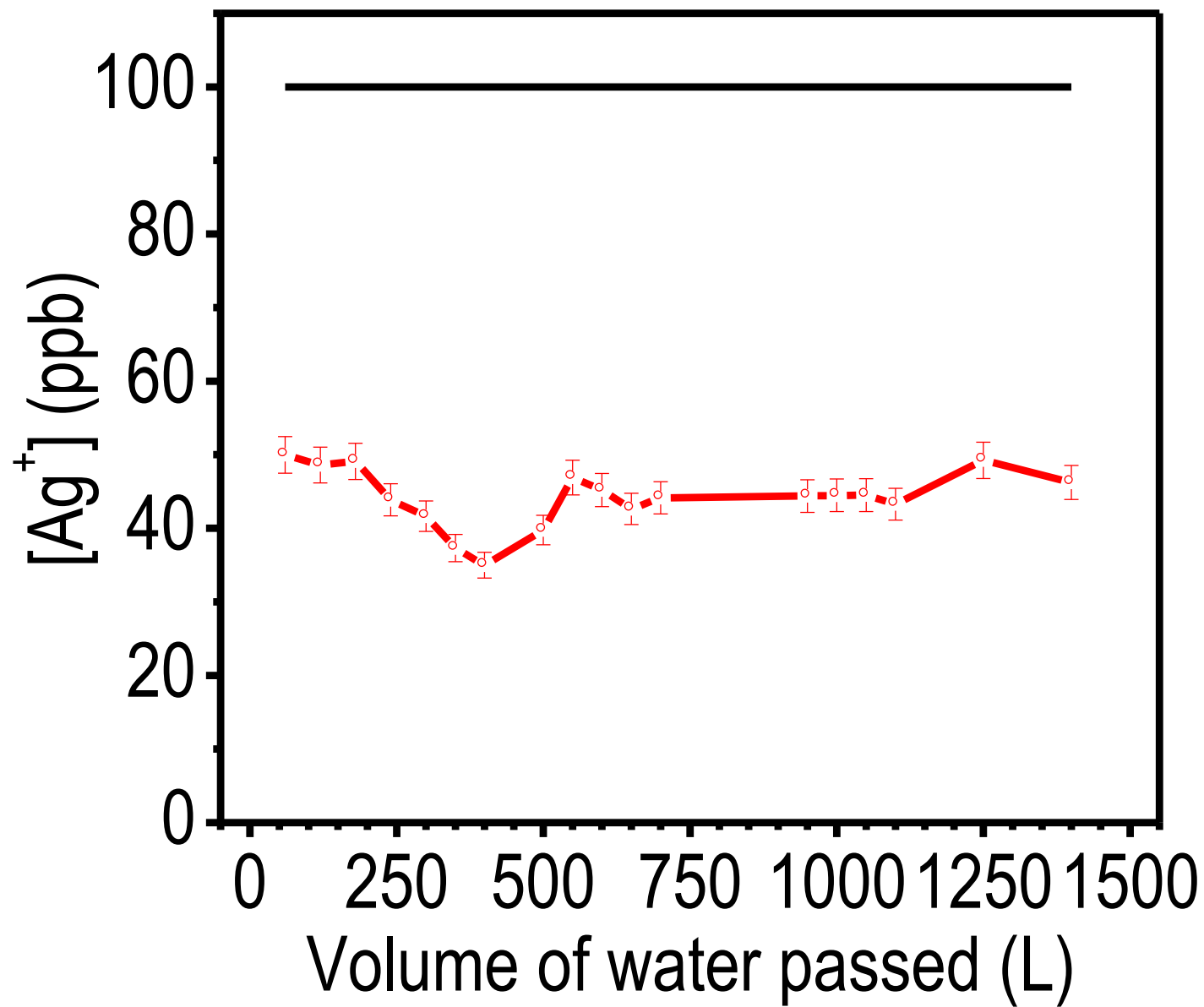
Water positive

Water-based, room temperature, water stable

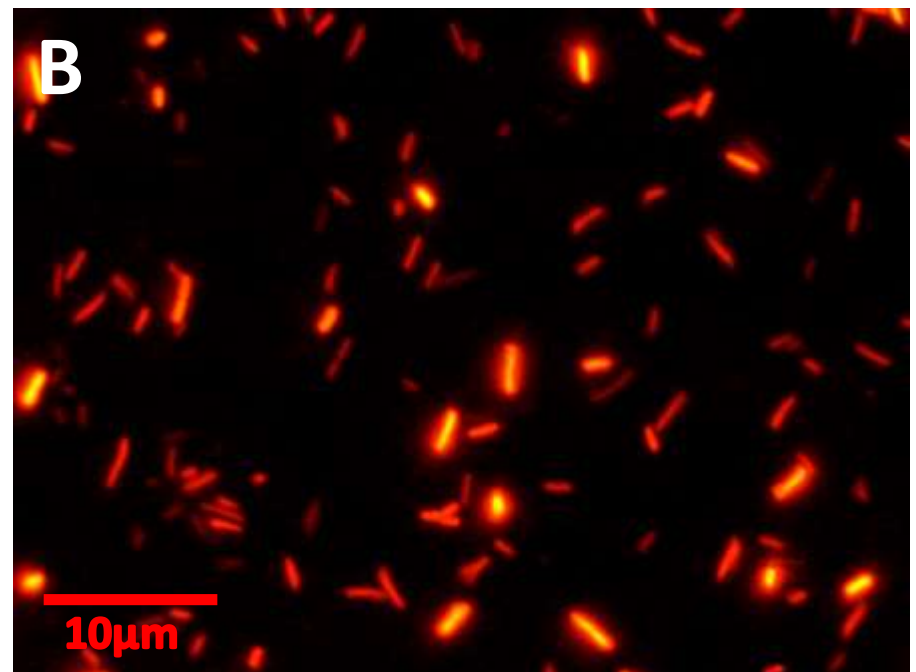
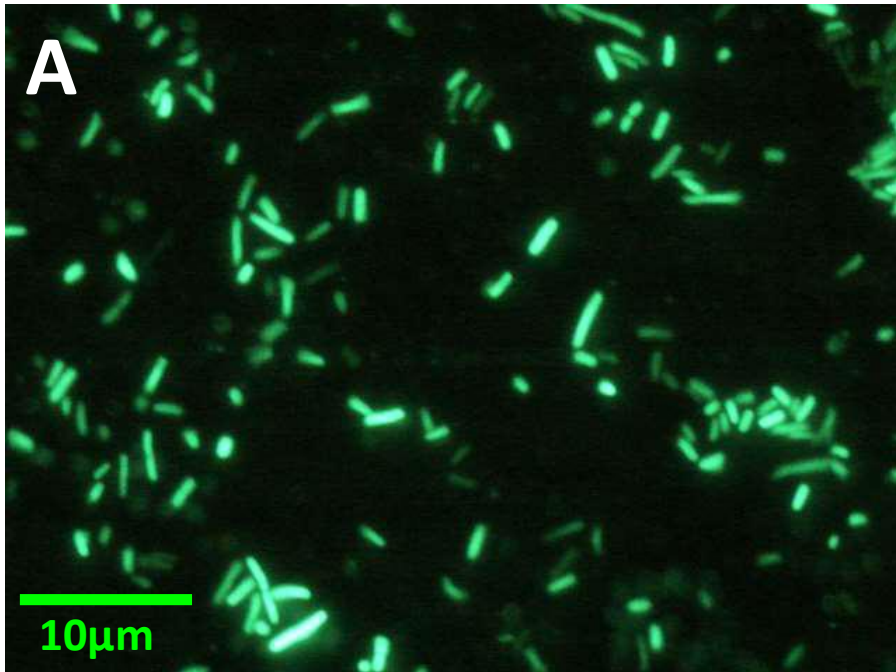
Green

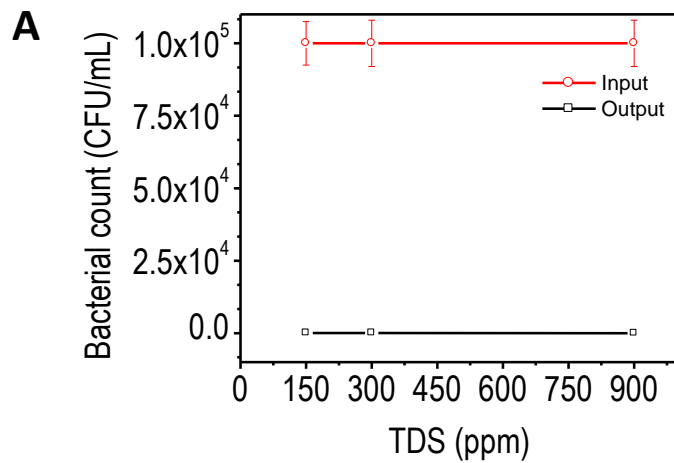
M. U. Sankar et al, PNAS 2013



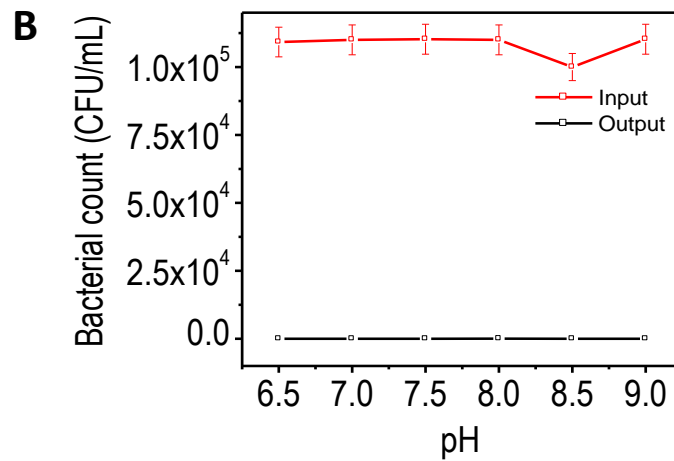


Live/dead staining experiments



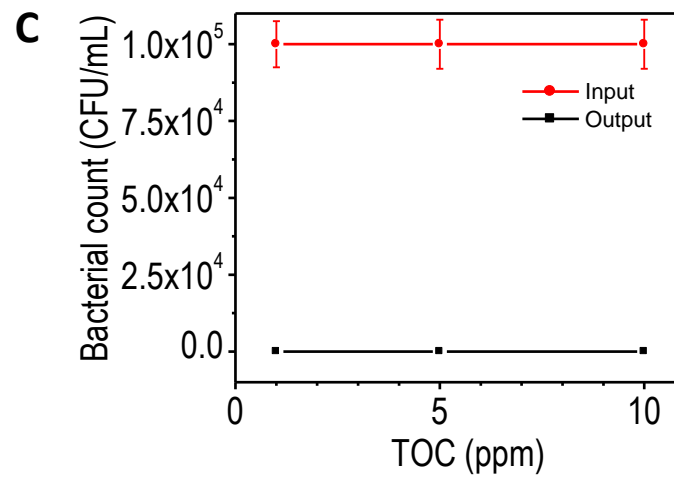


TDS

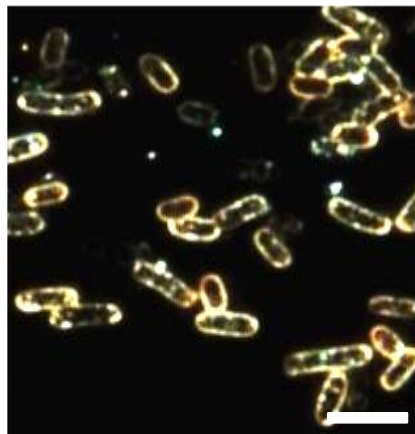
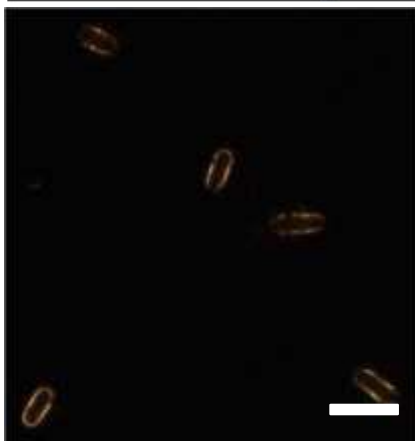
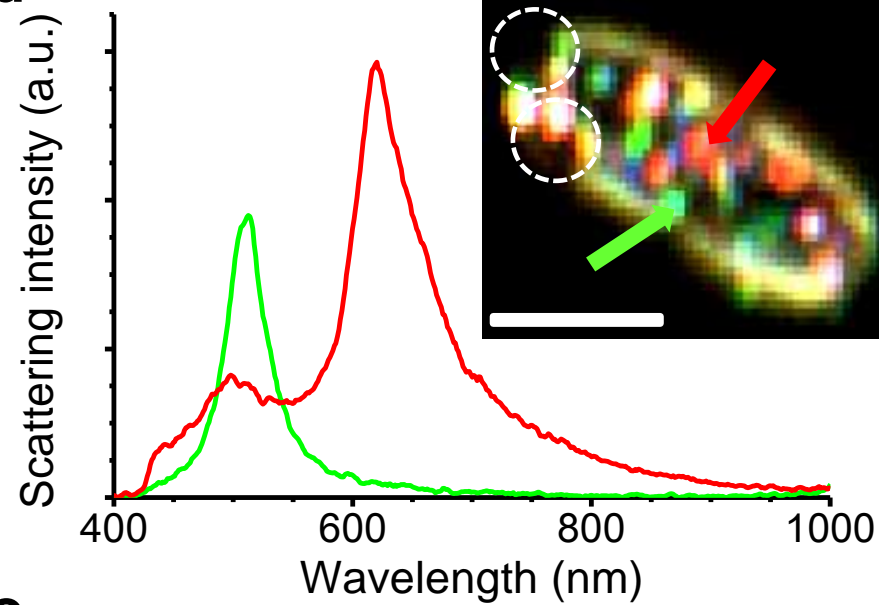
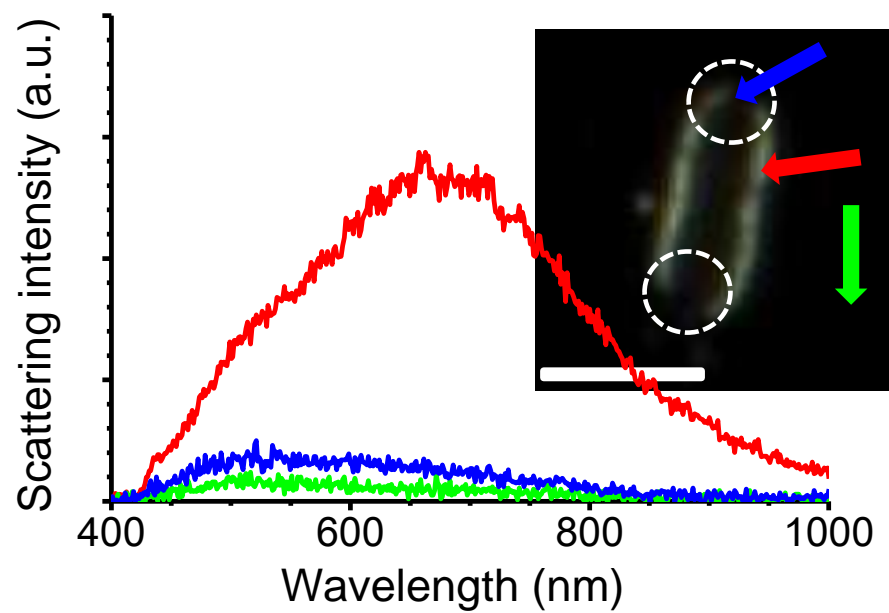


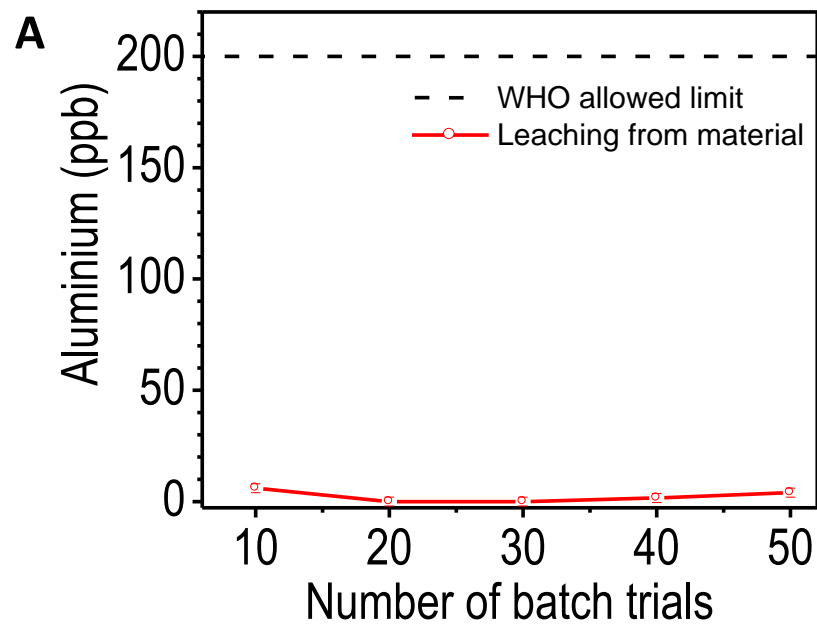
pH

Real water experiments

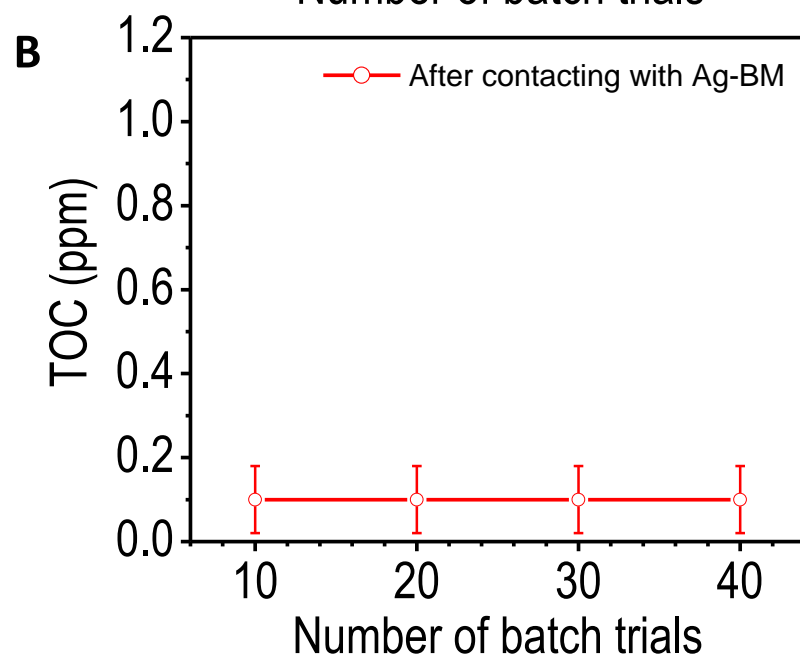


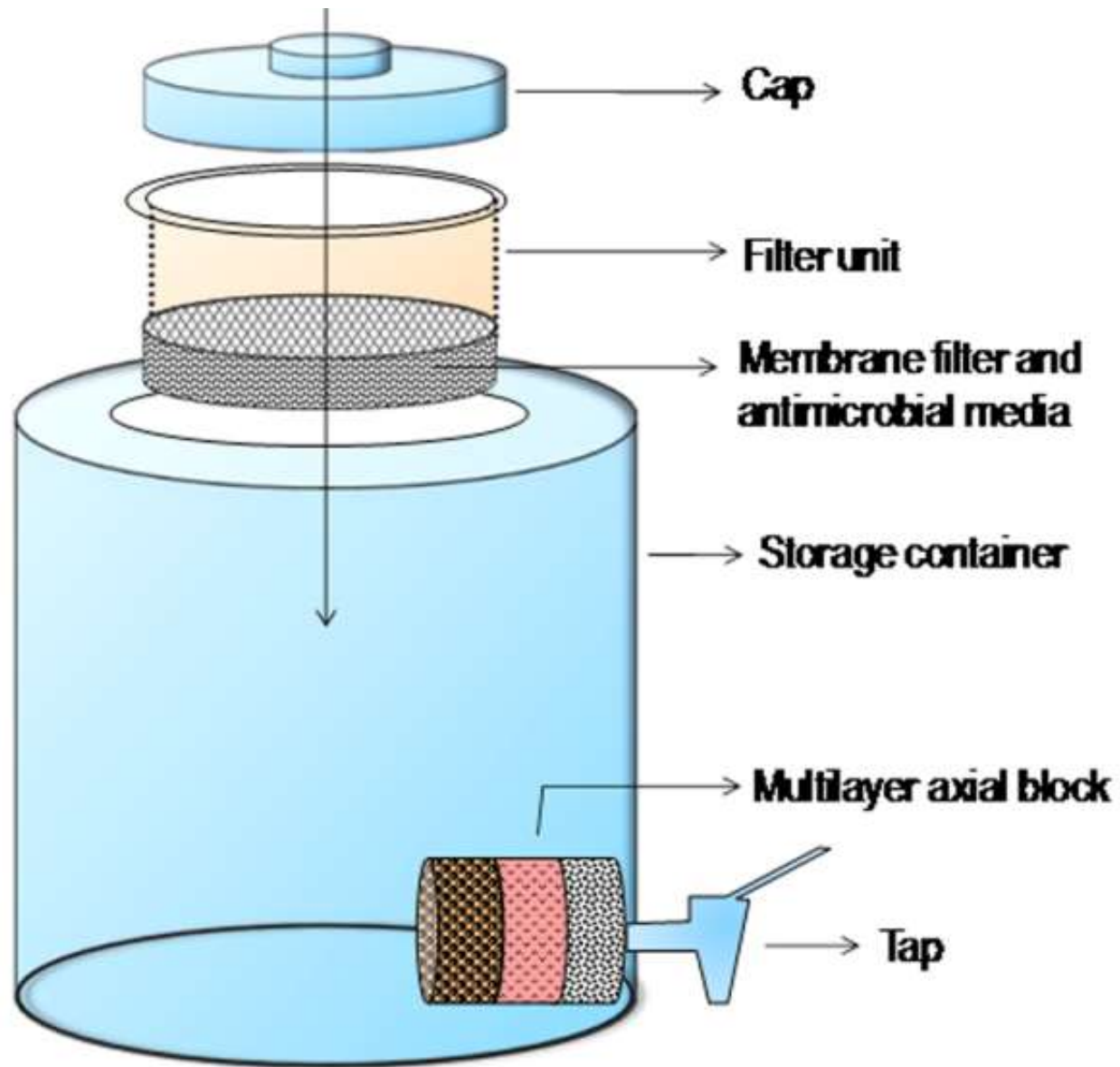
TOC – Humic acid

a**b****c****d****e**



Leaching experiments





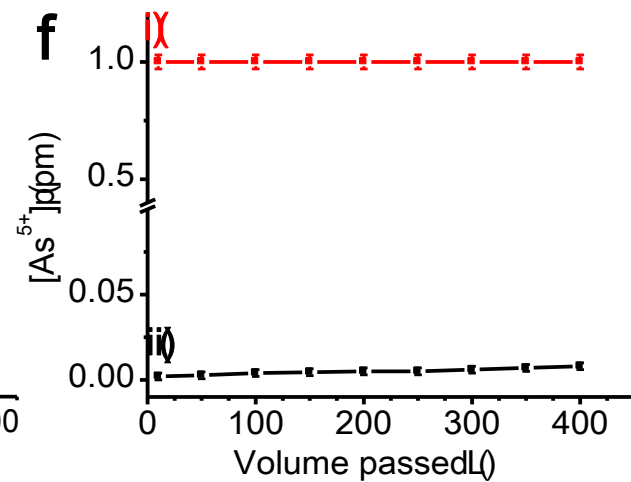
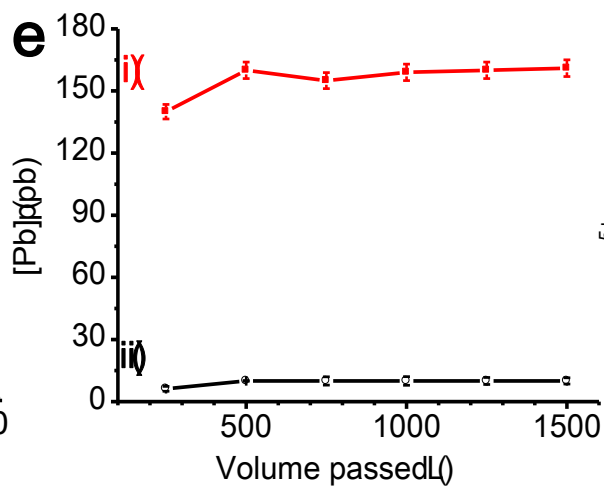
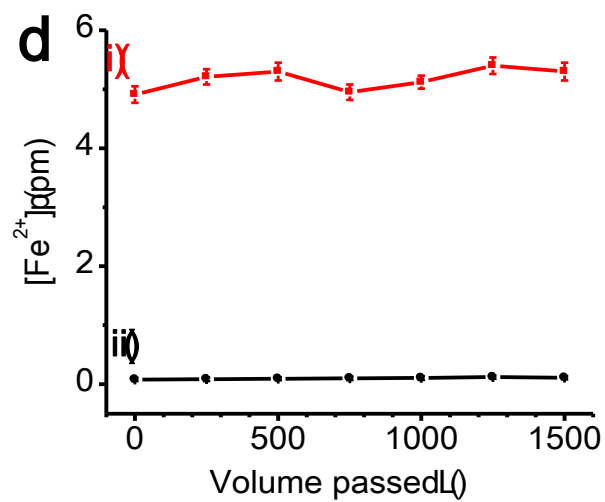
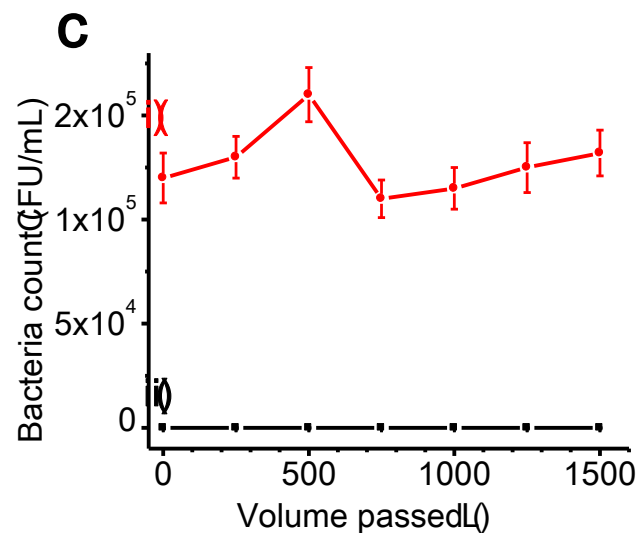
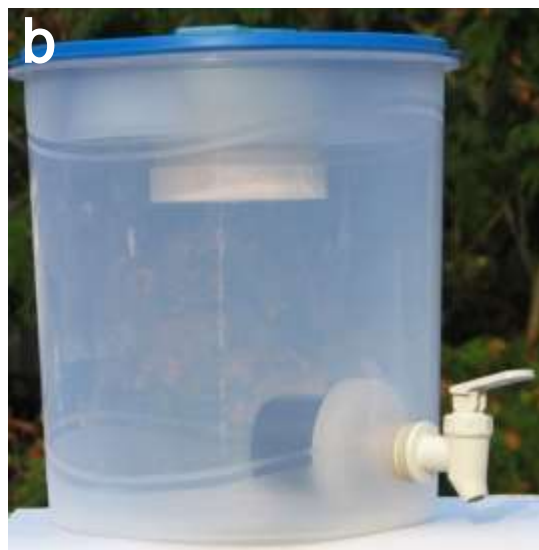
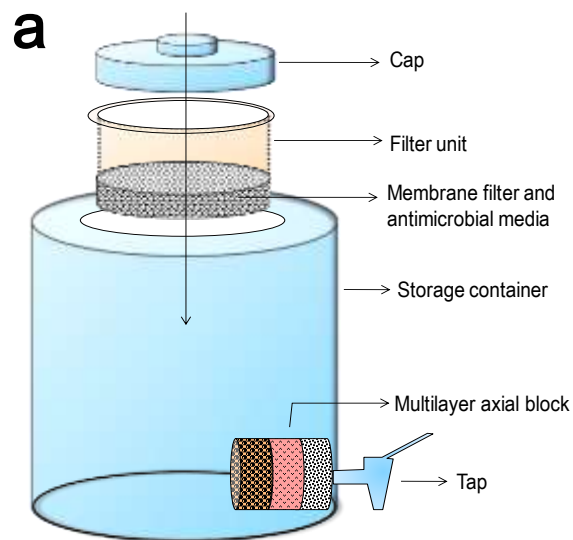
Physicochemical characteristics of influent natural drinking water

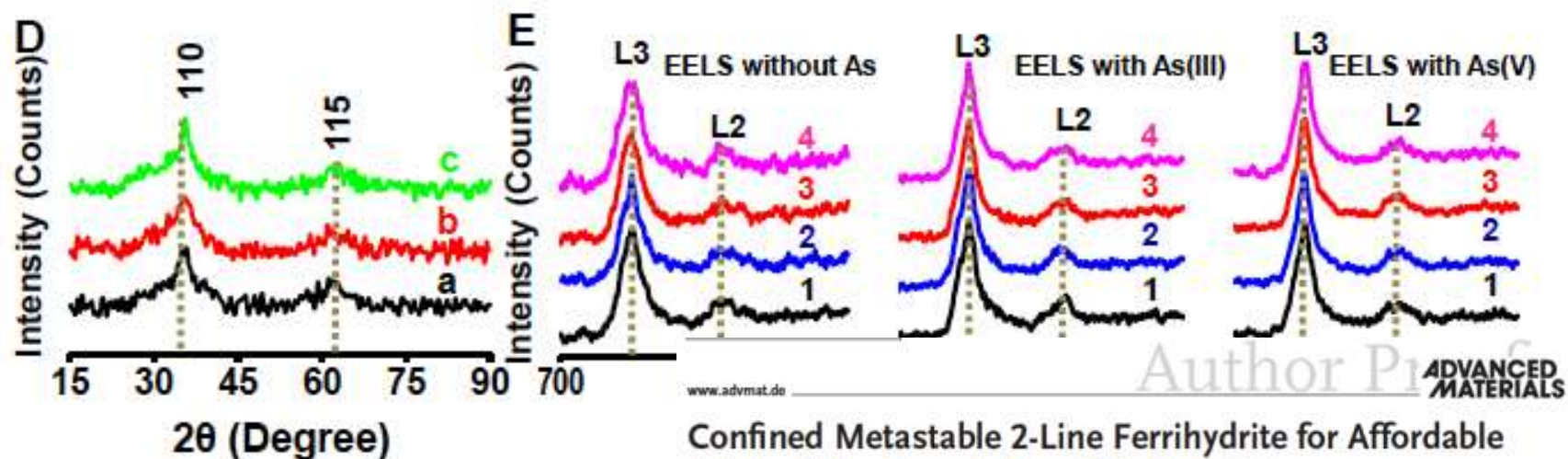
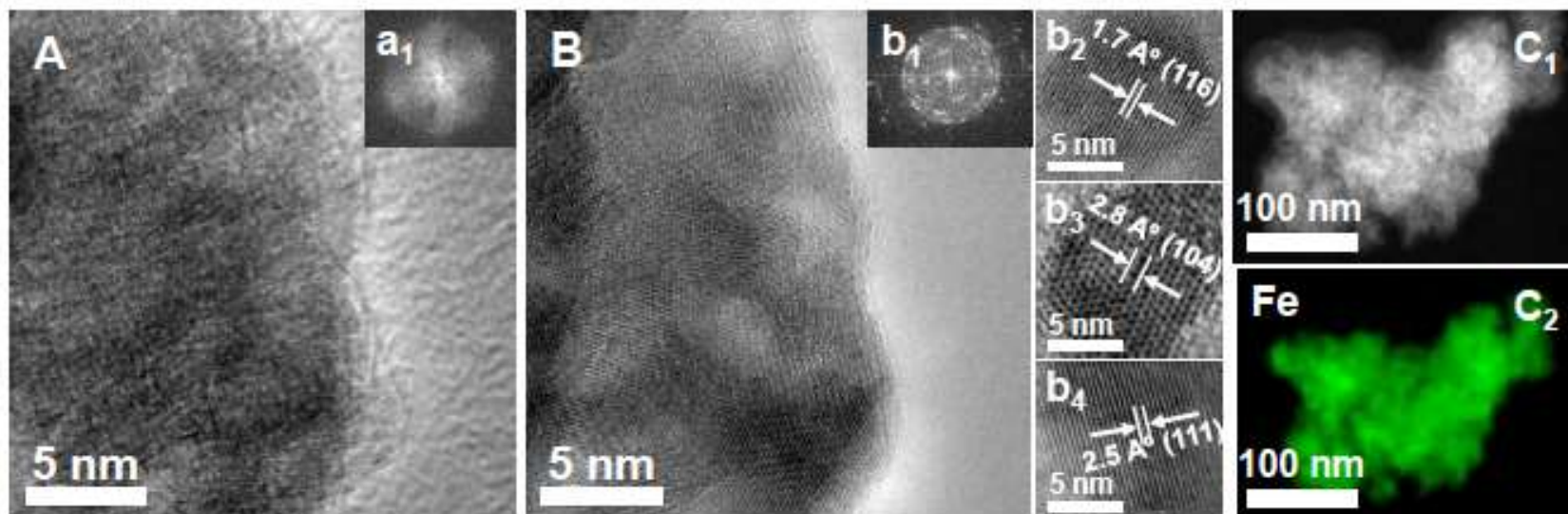
(Note: All parameters are expressed in mg L⁻¹, except for pH and conductivity)

ND-not detected

Natural drinking water (without treatment so that there is a residual bacterial count in it) was used for testing to ensure that the material functions in the field.

| Parameters | Value |
|--------------------------|-----------------------|
| Total coliforms (CFU/mL) | 1-2 x 10 ³ |
| p H @25° C | 7.8 |
| Conductivity (μS/cm) | 640.000 |
| Fluoride | 0.573 |
| Chloride | 86.340 |
| Nitrate | 1.837 |
| Sulphate | 32.410 |
| Silicate | 15.870 |
| Lithium | ND |
| Sodium | 53.740 |
| Ammonium | ND |
| Potassium | 2.330 |
| Magnesium | 14.340 |
| Calcium | 28.720 |



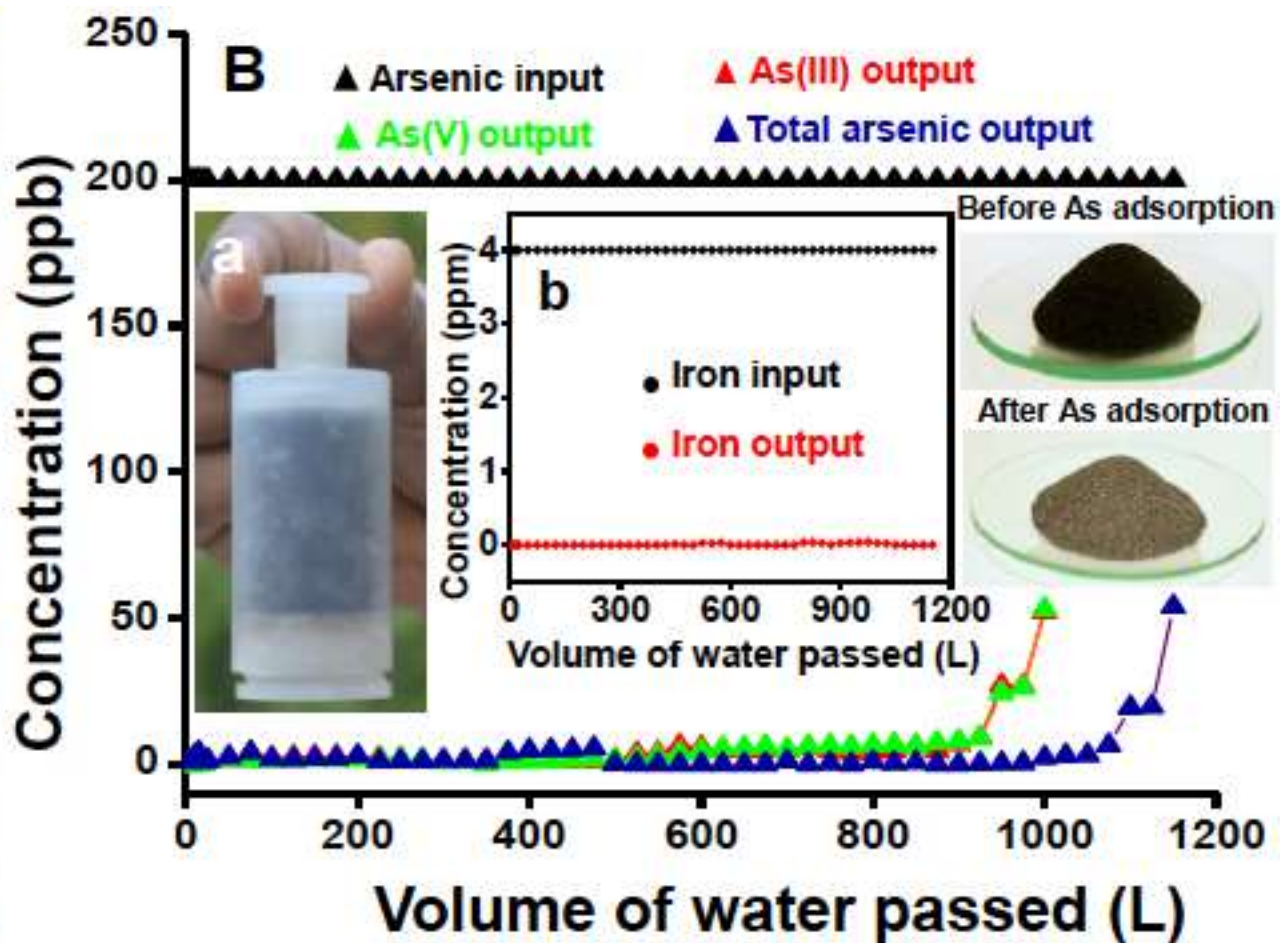


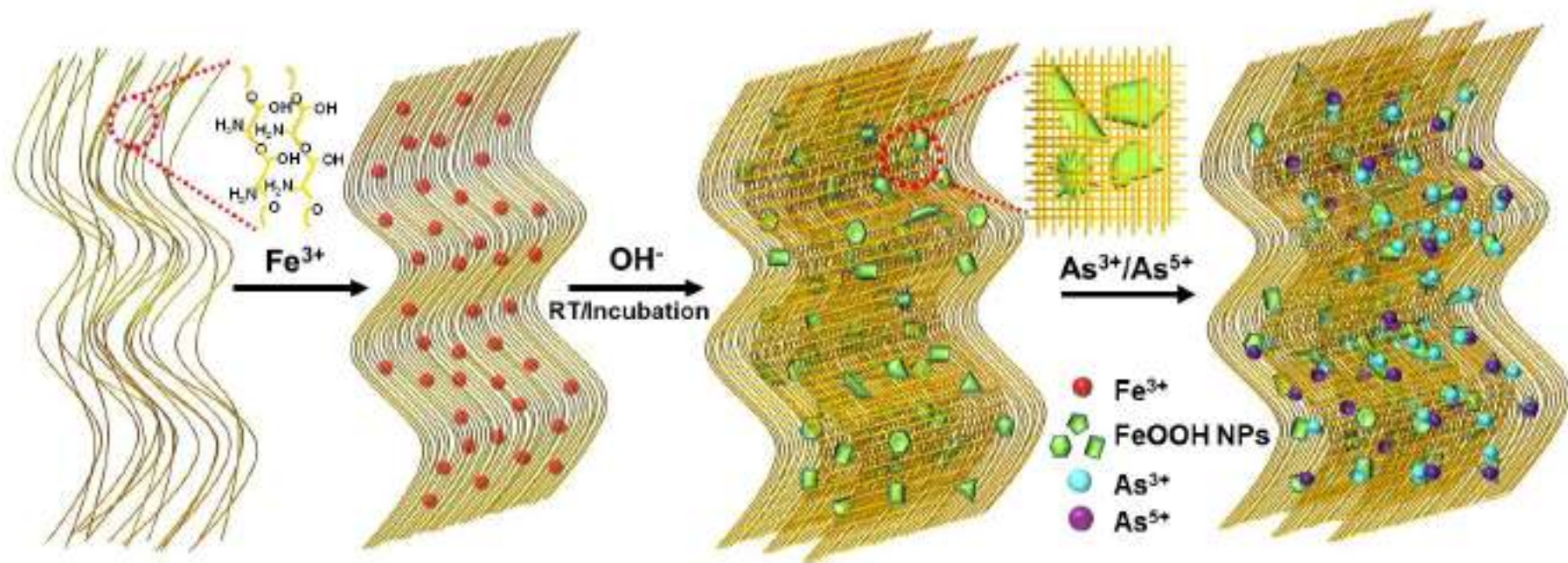
www.advmat.de

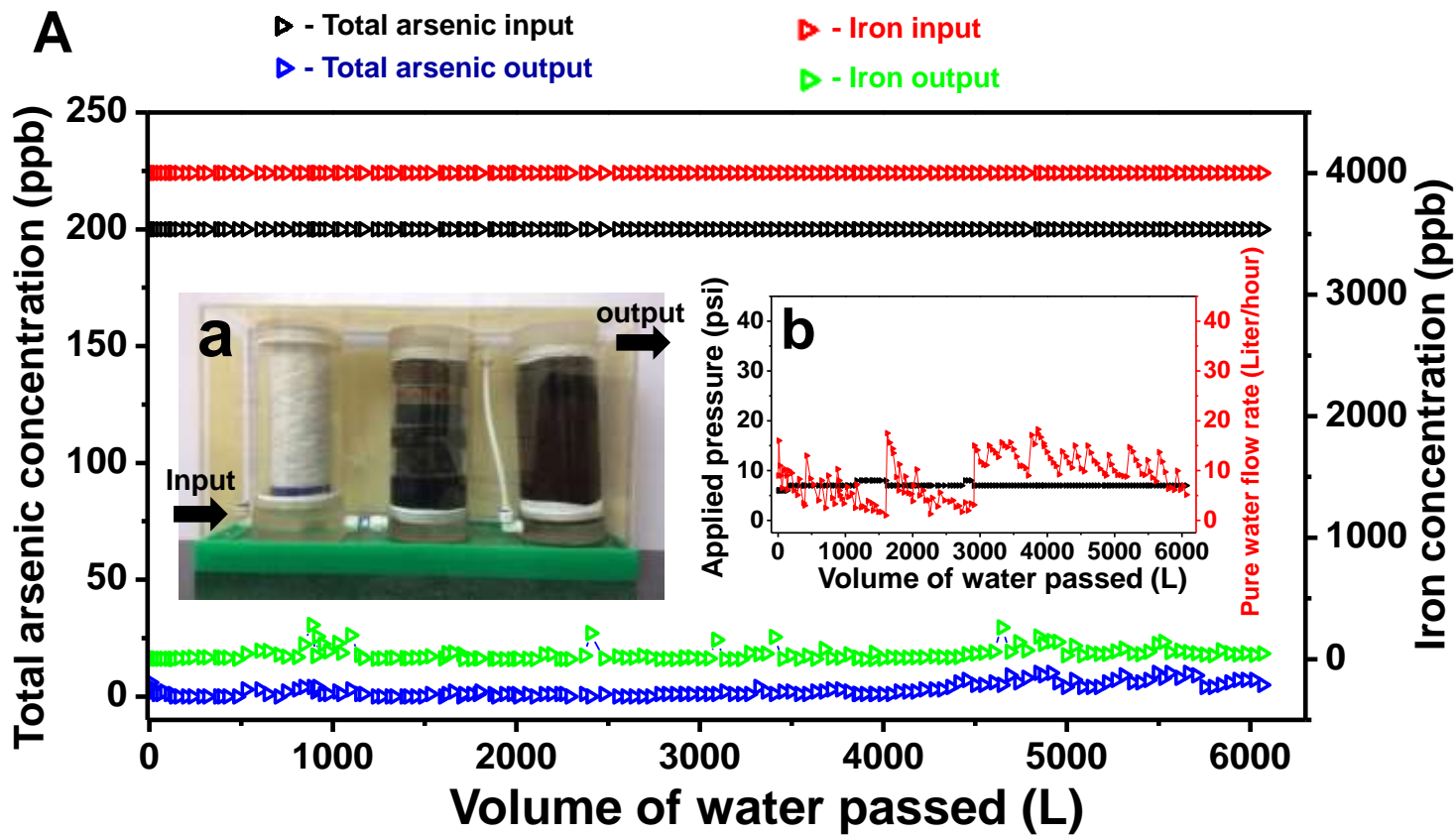
Author P1 ADVANCED MATERIALS

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

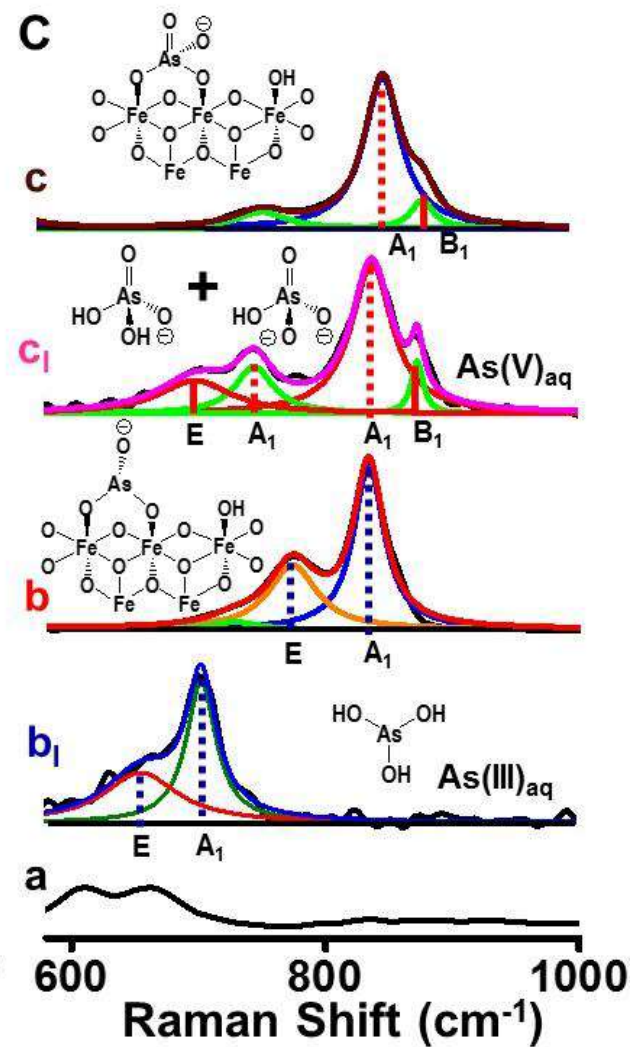
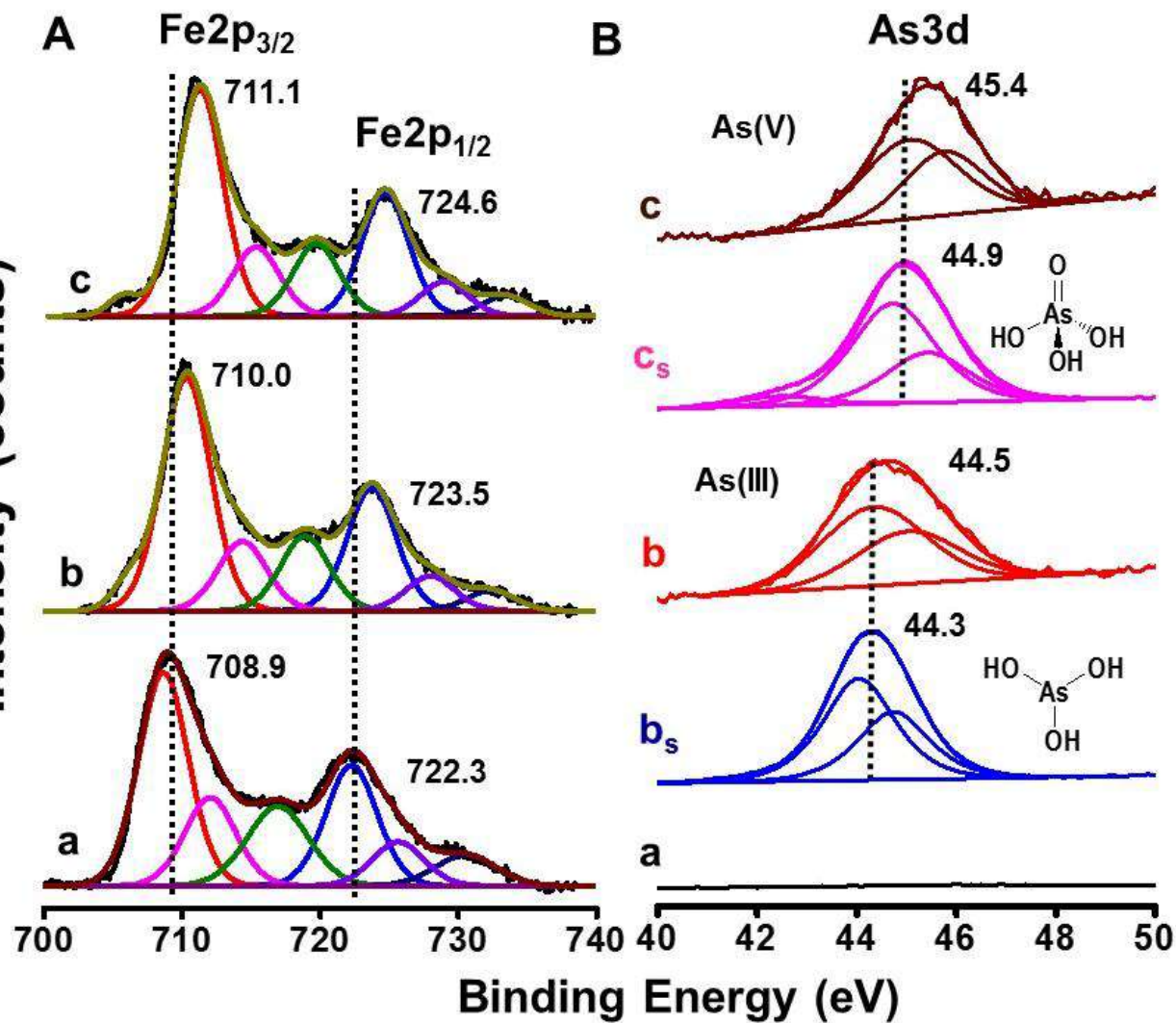
By Avula Anil Kumar, Anirban Som, Paolo Longo, Chennu Sudhakar, Radha Gobinda Bhui, Soujit Sen Gupta, Anshup, Mohan Udhaya Sankar, Amrita Chaudhary, Ramesh Kumar, and T. Pradeep*



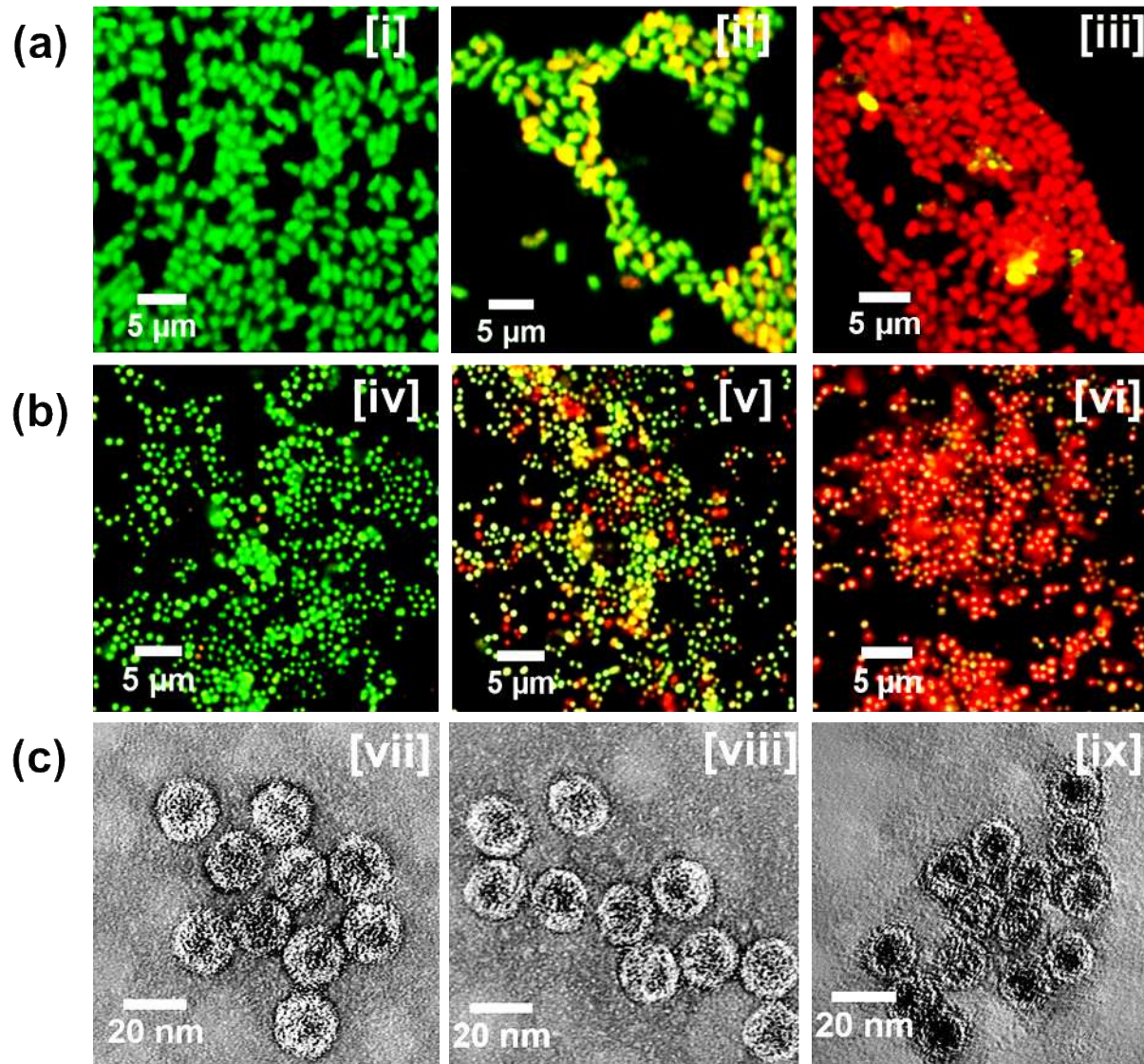




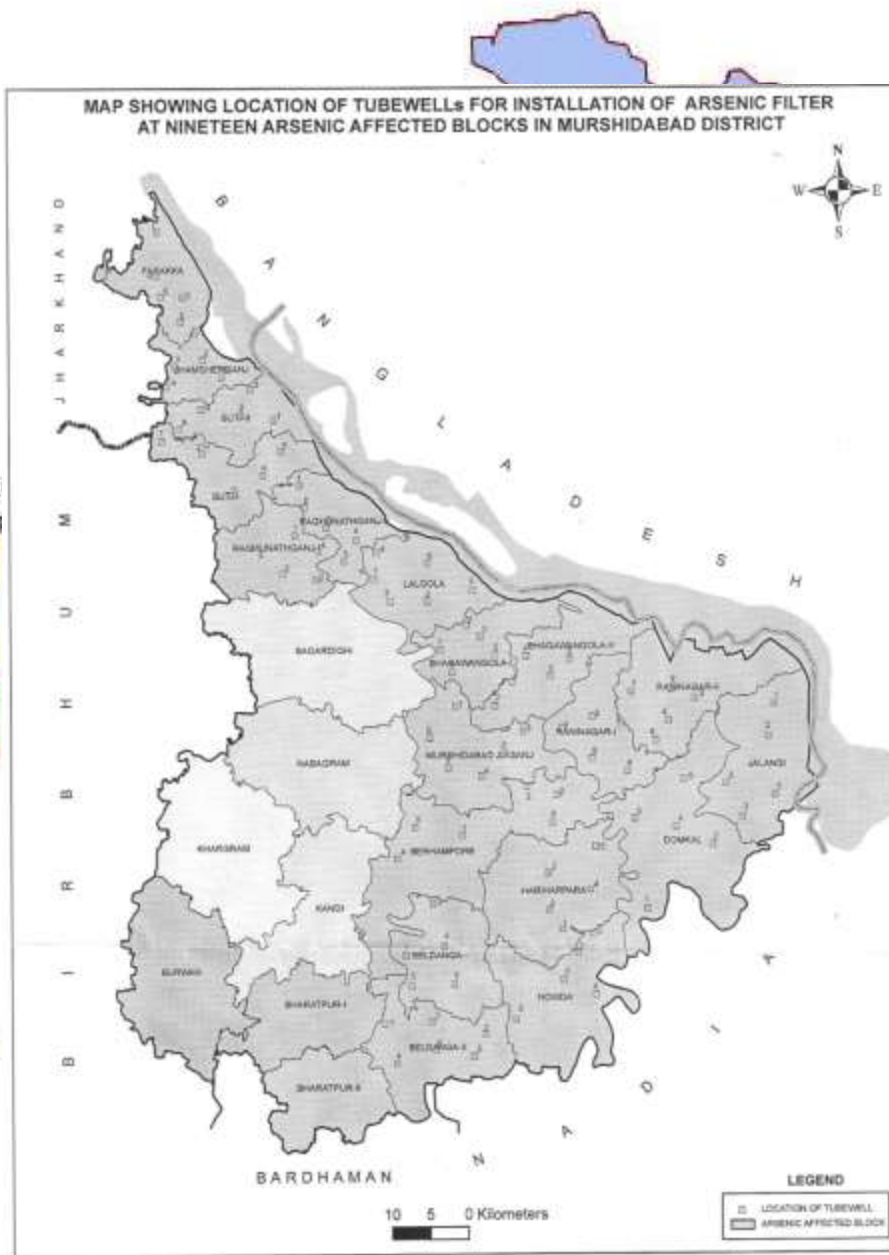
Intensity (counts)



Anion effect







Population Map Of India-2001



Imagining how new adsorbents are changing the dynamics at ground level



- Existing unit for iron and arsenic removal – 20 m³/h
- Uses activated alumina and iron oxide (old generation of adsorbents)



- Existing unit for iron and arsenic removal – 18 m³/h
- Uses iron oxyhydroxide (new generation of adsorbents)
- Input arsenic concentration: 168 ppb
- Output arsenic concentration: 2 ppb

A glimpse of performance data for installations in Murshidabad

| S.No | Sample Name | Input arsenic (ppb) | Output arsenic (ppb) | Number of days running |
|------|---|---------------------|----------------------|------------------------|
| 1. | Topidanga Jumma Masjid, Bhagwangola-II | 31 | 0 | 30 days |
| 2. | Bhandahara Jumma Masjid, Bhagwangola-II | 20.7 | 0.4 | 30 days |
| 3. | Horirampur Jumma Masjid, Bhagwangola-II | 37 | 0 | 45 days |
| 4. | Dhipara Jumma Masjid, Bhagwangola-II | 4.8 | 1.8 | 30 days |
| 5. | Bahadurpur High School, Bhagwangola-I | 9.4 | 0.2 | 30 days |
| 6. | Charlabangola Higher Sec School, Bhagwangola-I | 28.2 | 0.1 | 245 days |
| 7. | Mahisasthali Girls' High School, Bhagwangola-I | 0 | 0 | 30 days |
| 8. | Orahar Girls' High School, Bhagwangola-I | 0.53 | 0 | 10 days |
| 9. | Rabindratola BN Pandey High School, Bhagwangola-I | 84.3 | 0 | 245 days |
| 10. | Karbalajamam Masjid, Berhampore | 6.8 | 0 | 150 days |
| 11. | PHED office, Berhampore | 32 | 0 | 10 days |
| 12. | Nabipur Bazar Jumma Masjid, Raninagar-II | 1.3 | 0 | 60 days |
| 13. | Rukunpur Jumma Masjid, Hariharpara | 25.6 | 2.2 | 60 days |
| 14. | Klyanpur Jumma Masjid, Domkal | 64.7 | 0 | 200 days |
| 15. | Benadaha Mondalpara Hanafi Jamat, Beldanga-I | 9.04 | 0 | 180 days |
| 16. | Maniknagar Jumma Masjid, Domkal | 1 | 0.04 | 60 days |
| 17. | South Hariharpara Jumma Masjid, Hariharpara | 5.47 | 0 | 60 days |
| 18. | Lochan Mati Danga Para Jumma Masjid, Hariharpara | 14.6 | 0 | 150 days |
| 19. | Paschim Malipara Jumma Masjid, Raninagar – II | 3.3 | 0.13 | 90 days |
| 20. | Khalilabad Jumma Masjid, Hariharpara | 179.0 | 0 | 270 days |
| 21. | Bhatu Komnagar Masjid, Raninagar –II | 67.89 | 0.22 | 360 days |

Performance data from Murshidabad (continued)

| S. No. | Sample Name | Input arsenic (ppb) | Output arsenic (ppb) | Number of days running |
|--------|--|---------------------|----------------------|------------------------|
| 23. | Babaltali Jumma Masjid, Raninagar – II | 10.7 | 0 | 180 days |
| 24. | Sargachhi Paschimpara Jumma Masjid, Beldanga – I | 1.26 | 0.04 | 180 days |
| 25. | Pratappur Jumma Masjid, Hariharpara | 27.19 | 0.13 | 180 days |
| 26. | Fakirabad Jumma Masjid, Domkal | 24.67 | 0 | 180 days |
| 27. | Shialmari Jumma Masjid, Raninagar – II | 287.5 | 0.09 | 240 days |
| 28. | Bhabta Ahelahadis Jumma Masjid, Beldanga | 8.6 | 5.7 | 240 days |

A glimpse of performance data for installations in Nadia

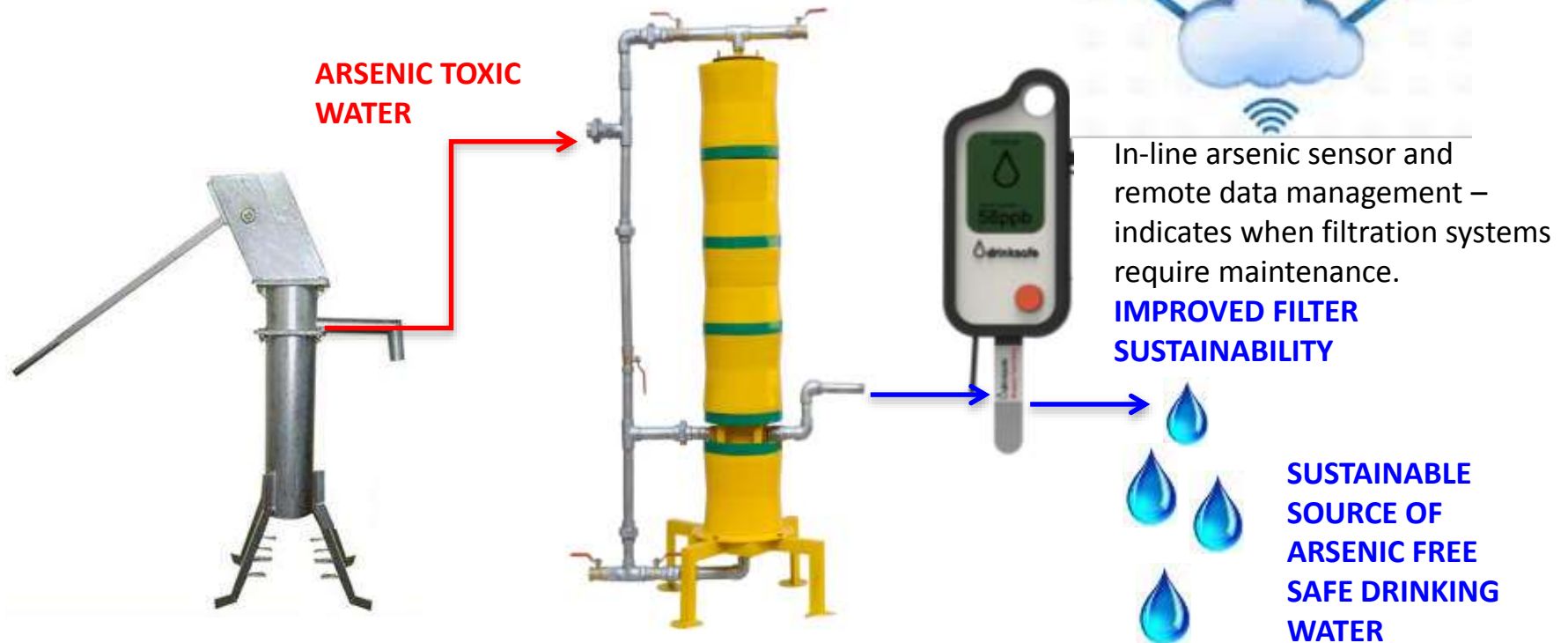
| S. No. | Sample Name | Input arsenic (ppb) | Output arsenic (ppb) | Number of days running |
|--------|---------------------------------|---------------------|----------------------|------------------------|
| 1. | Dhapadia Junior Madrasah | 46.5 | 2.15 | 30 days |
| 2. | Khidirpur Shishu Shiksha Kendra | 14.99 | 0 | 260 days |
| 3. | Junior Madrasah | 12.7 | 0 | 60 days |
| 4. | Dhapana Board High School | 14.96 | 0.6 | 45 days |
| 5. | Birpur Primary School | 19.56 | 0 | 90 days |
| 6. | Bethuaduari JCM High School | 4.56 | 0 | 45 days |
| 7. | Jugnuthala Primary School | 23.36 | 0 | 60 days |
| 8. | Dahakula Primary High School | 36.6 | 0 | 60 days |
| 9. | Bargachi Primary School Nagadi | 9.56 | 0 | 90 days |
| 10. | Dahakula Primary School | 22.7 | 0 | 60 days |
| 11. | BJ Kumari Primary School | 5.9 | 0 | 100 days |
| 12. | Arijnagar Primary School | 0.13 | - | 60 days |
| 13 | Patikpari Girls Primary School | 9.6 | 0 | 60 days |
| 14 | Bawanipur Primary School Nagadi | 0.49 | 0 | 60 days |

Work was featured in several journals



Nature Nanotechnology, July 2014 issue

Plan for immediate future

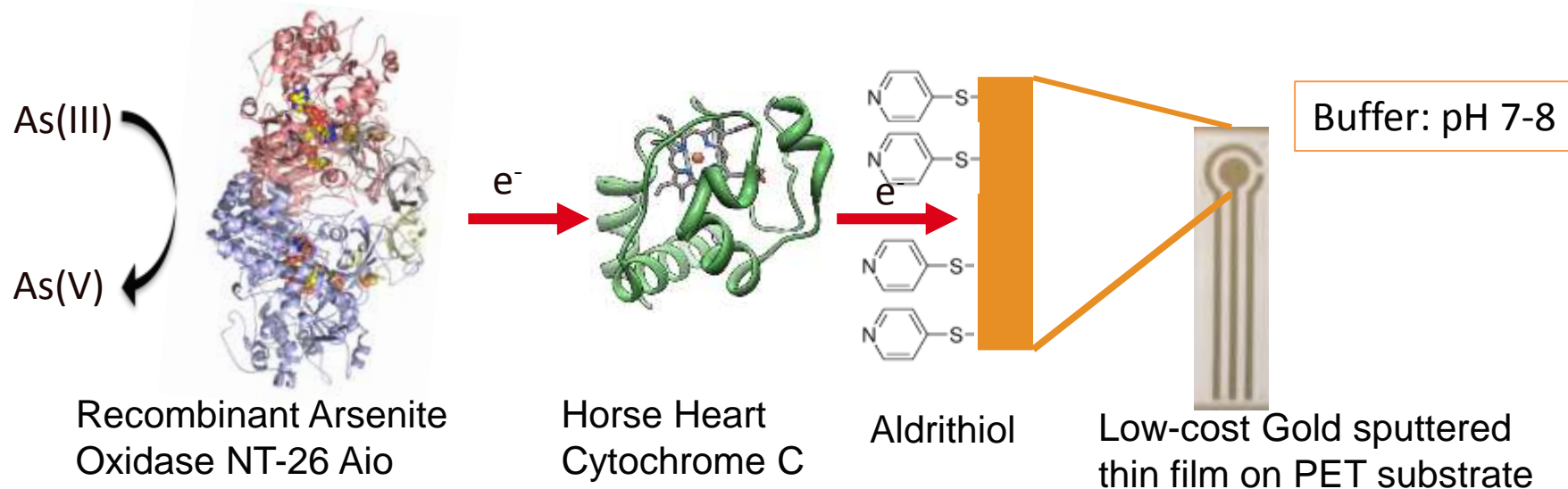


India Mark II hand water pump – most common water pump used globally

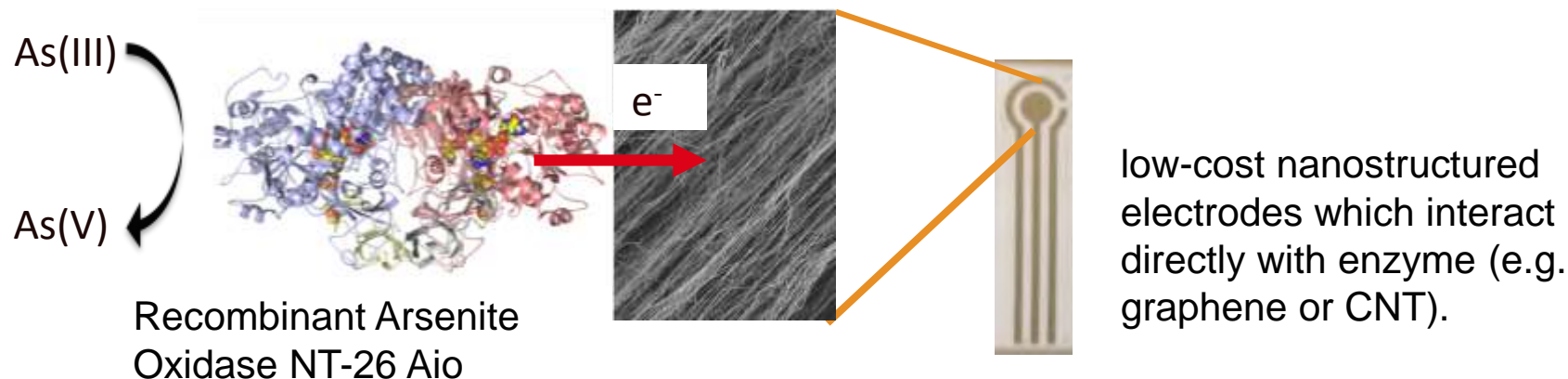
InnoNano Research's in-line arsenic removal filtration system

Biosensor Design

1st Generation Design (Mediated Electrochemistry)



2nd Generation Design (Direct Electron Transfer)



Integrate Arsenic *monitor* and Arsenic *filter* into in-line filtration/monitoring unit to improve management of Arsenic problem

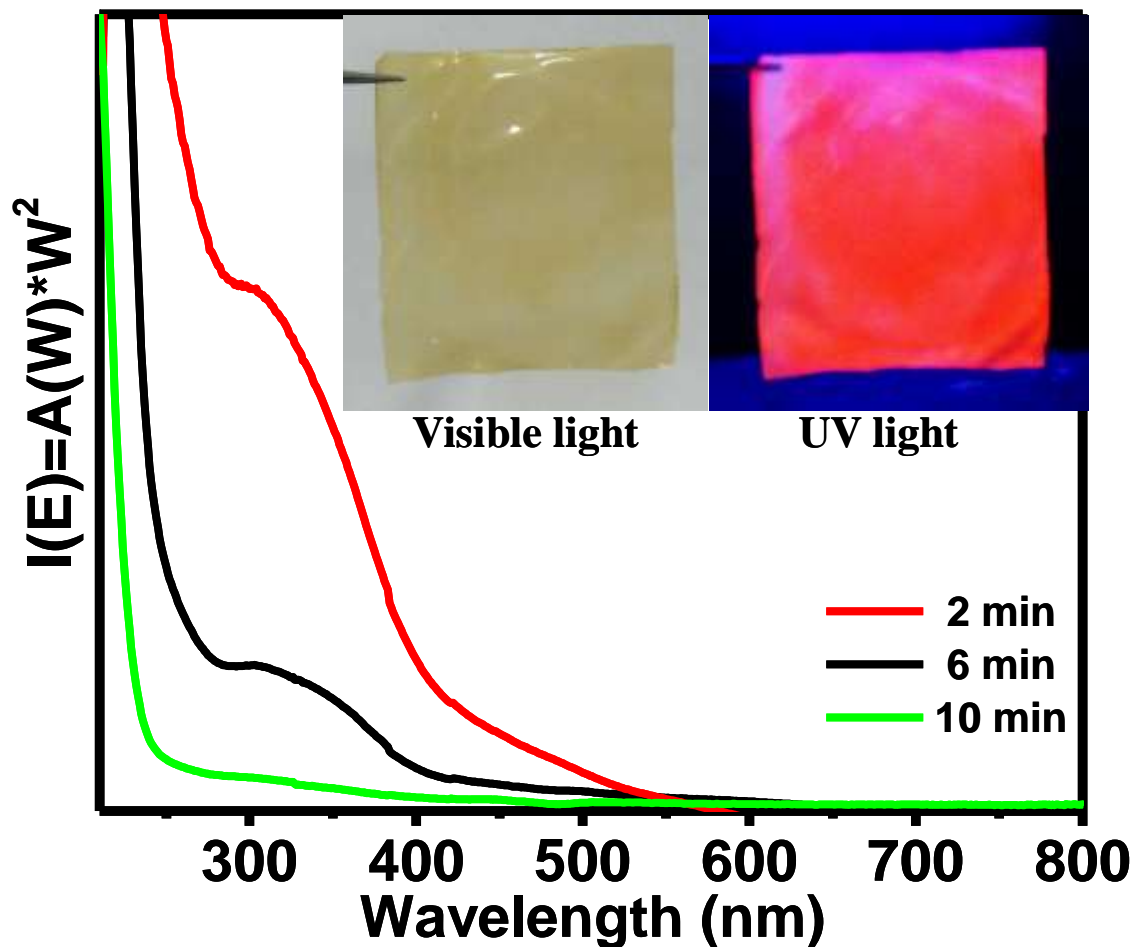


- ✓ Easy-to-use
- ✓ Quantitative
- ✓ Fast < 3 minutes
- ✓ Low cost
- ✓ Non-toxic
- ✓ Automatic recording of test results with well GPS position

- ✓ Proprietary nano materials
- ✓ Manufactured in India
- ✓ Filters arsenic & iron
- ✓ Integrated to Mark II hand pumps

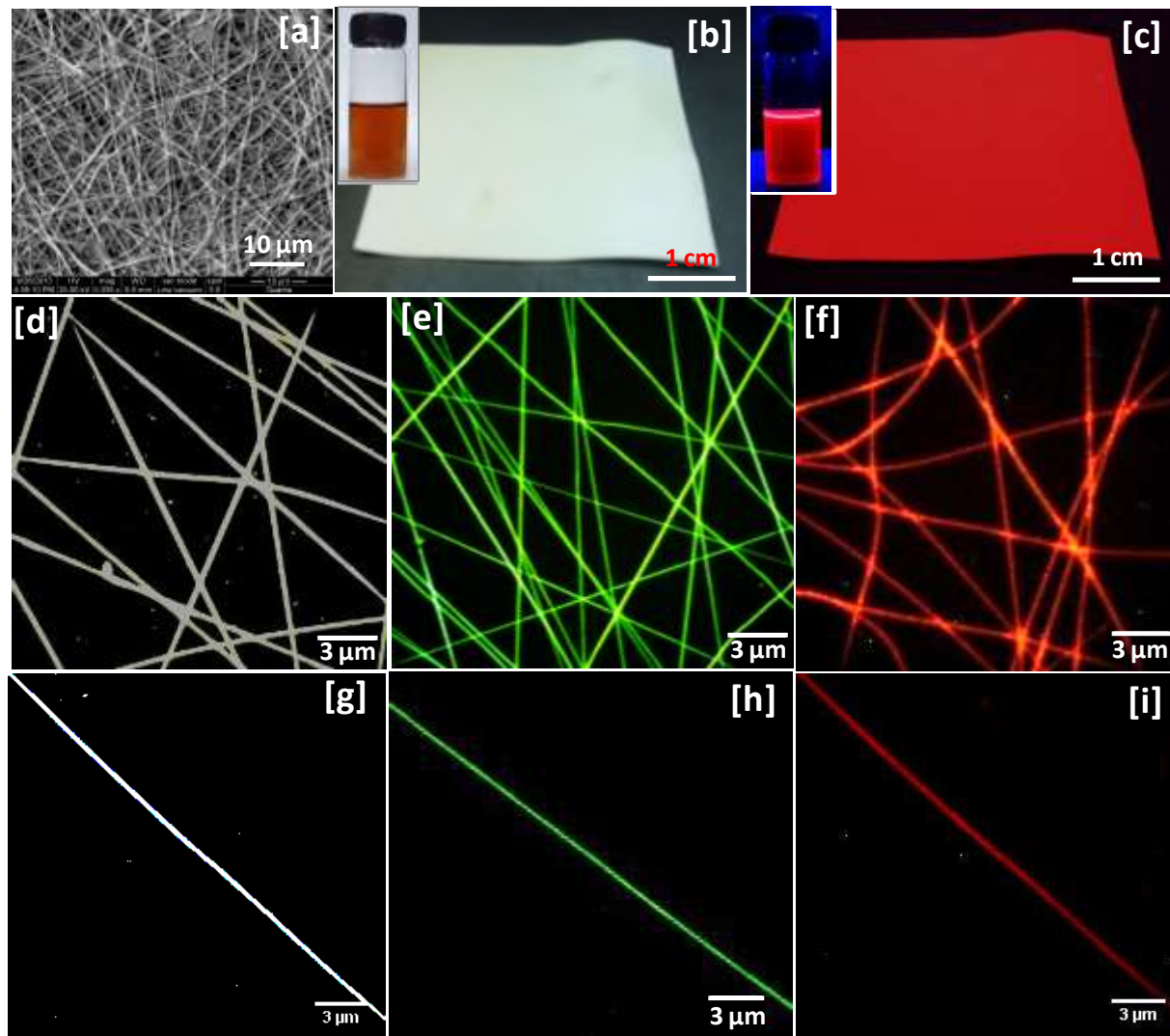
Quantum cluster based metal ion sensing paper

Large area uniform illumination using quantum cluster

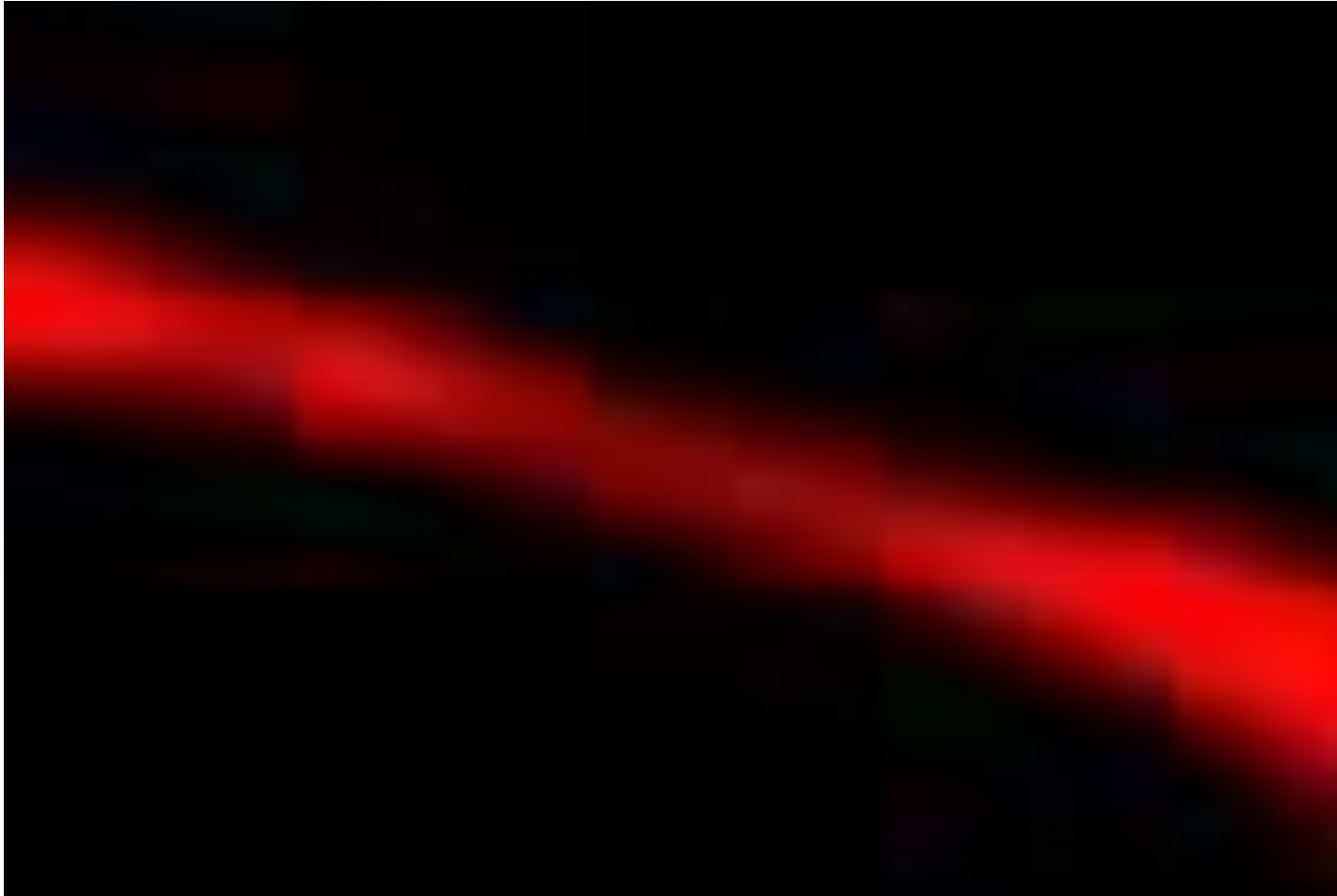


Decrease in the absorption of Au_{15} as a biofilm is dipped into the cluster solution. Inset: Free standing quantum cluster loaded film in visible light and UV light.

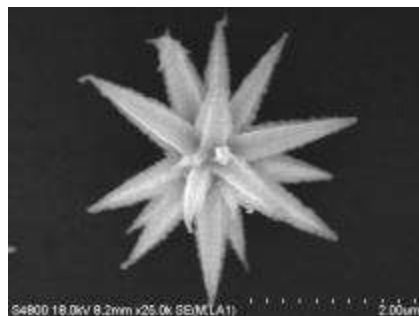
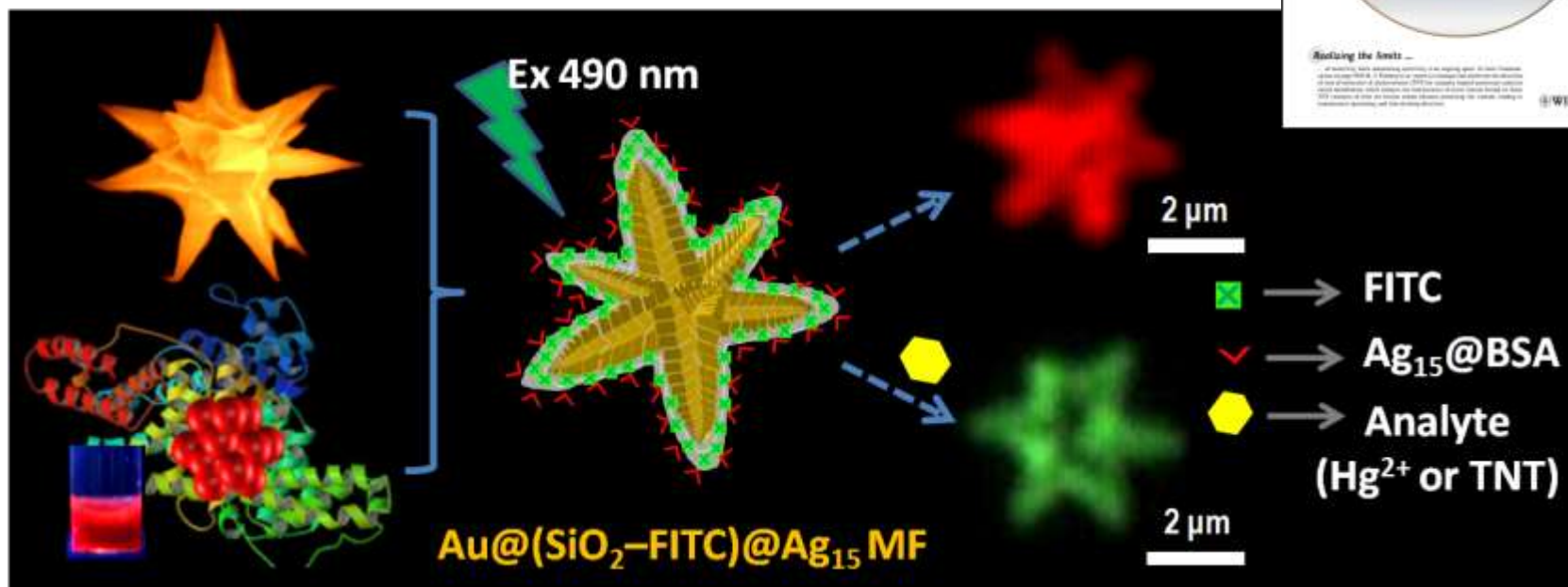
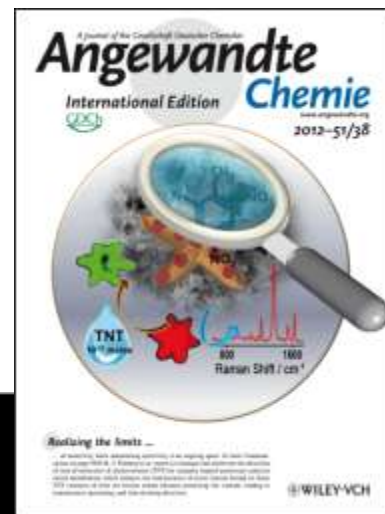
Approaching detection limits of tens of Hg^{2+}



Video of mercury quenching experiment using the nanofiber



Sub-zeptomolar detection



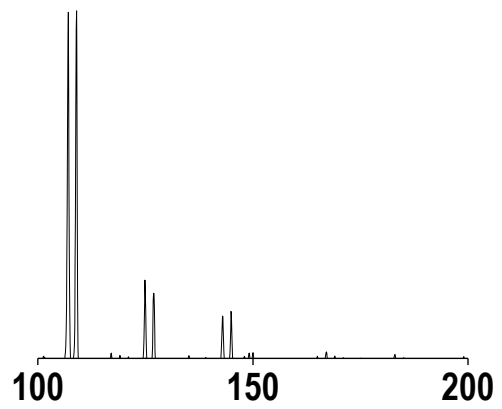
Featured in:

The Hindu, Telegraph, Times of India, etc.
C&E News
and many others

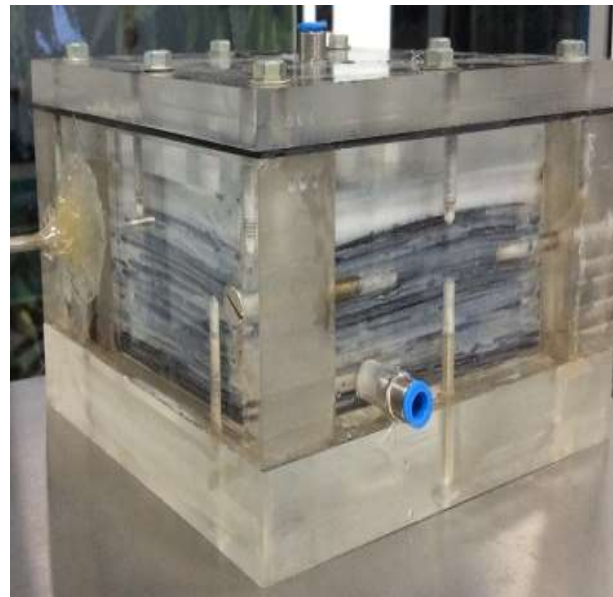
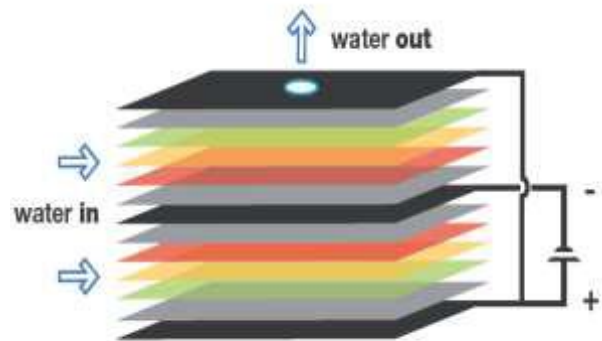
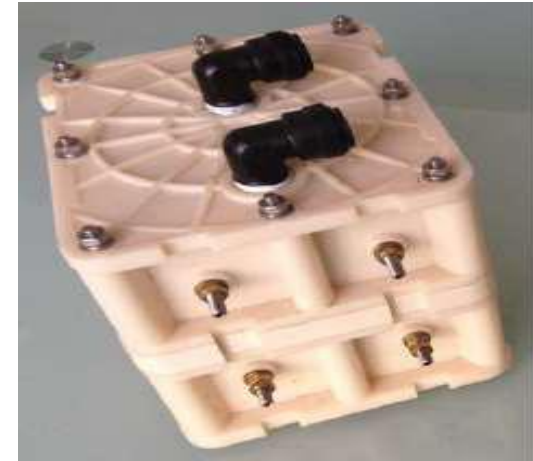
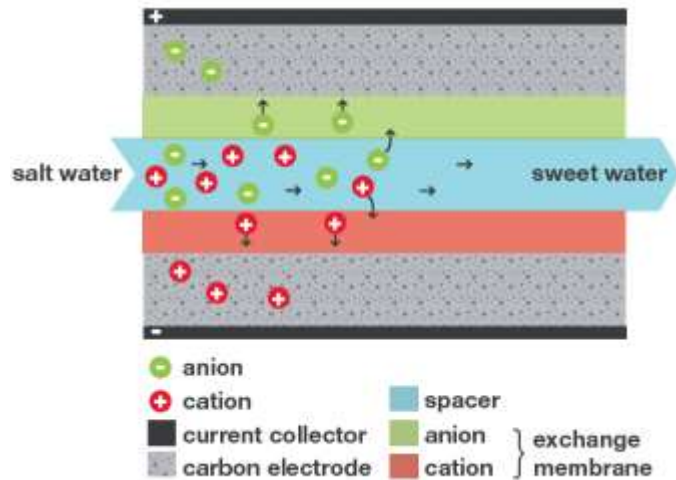
Ammu Mathew, et al. Angew. Chem. Int. Ed. 2012



D. Sarkar, et. al. Adv. Mater. 2016



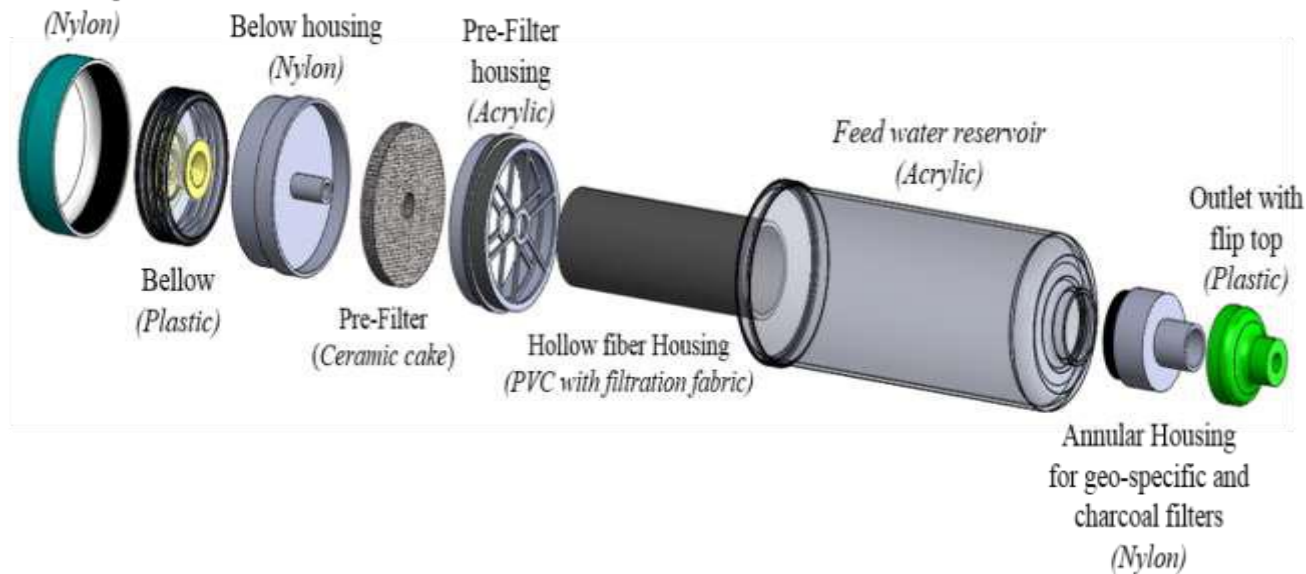
Capacitive Desalination (CDI)



Our new company

Geo-specific water purifier bottle

Design



Prototype







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Technology :: News :: May 7, 2013 :: 9 Comments :: Email :: Print

Cheap Nanotech Filter Clears Hazardous Microbes and Chemicals from Drinking Water

A \$16 device could provide a family of five with clean water for an entire year

By Luciana Gravotta

About 780 million people—a tenth of the world's population—do not have access to clean drinking water. [Water](#) laced with contaminants such as bacteria, viruses, lead and arsenic claims millions of lives each year. But an inexpensive device that effectively clears such contaminants from



More from Scientific American



NANOTECH ON TAP

Indian technology offers **CLEAN WATER** at low cost

GROUNDWATER in the Indian state of West Bengal naturally contains arsenic, causing ailments including skin diseases and cancer. Thanks to nanotechnology, thousands of people there have gained access to arsenic-free water since 2013, with the installation of treatment tanks using porous granules developed by a team at the Indian Institute of Technology (IIT), Madras, led by chemistry professor Thalappil Pradeep. The technology has received government support for field-testing as an option for low-cost, point-of-use water treatment.

The granules are nanocomposites made from ferric oxyhydroxide and a biopolymer, chitosan. Iron oxides remove arsenic ions from water by adsorption. The team boosted their metal oxyhydroxide's activity by reducing the particle size to nanoscale, thereby increasing the surface-to-volume ratio, and anchoring the material within a network of chitosan. With this structure, which resembles sand and is made at room temperature, embedded particles don't leach into water, and the captured arsenic stays put. What goes on "in the atomic scale is not completely understood," Pradeep says, but that has not stopped the material's real-world use.

At the Ambattur industrial estate, in a suburb of the Indian city of Chennai, a facility makes about 36 kg of the ferric oxyhydroxide-chitosan nanocomposite per day. Production at the plant—run by InnoNano Research, a start-up founded by the IIT Madras team—is enabling field trials in West Bengal.

With funding from the state government, about 100 community water purifiers using the nanocomposites, typically in 600-L tanks, have been installed in the district of Murshidabad, says an InnoNano cofounder known only as Anshup.

Each one, he estimates, serves 50–100 families and lasts one to two years. In the lab, the composite reduces a 1-ppm arsenic load to less than 10 ppb, the limit set by the World Health Organization (WHO). In field trials, natural arsenic loads of up to 330 ppb, the highest found in the field according to the team, drop to less than 10 ppb.



COURTESY OF THALAPPIL PRADEEP

Globally, 137 million people are exposed to arsenic levels greater than the WHO limit. And some 780 million people do not have clean drinking water, according to the Centers for Disease Control & Prevention (CDC). "Every 20 seconds, a child dies from a water-related disease, especially in the developing world," says Emmanuel I. Unuabonah, a researcher from Redeemer's University in Nigeria who also develops water treatment materials.

TO REMOVE MICROBES, the Ambattur plant produces smaller quantities of another material developed by the team, an aluminum oxyhydroxide-chitosan composite (*Proc. Natl. Acad. Sci. USA* 2013, DOI: 10.1073/pnas.1220222110). When impregnated with silver nanoparticles, the material kills microbes by gradually releasing Ag⁺, a microbicide. Team member Udhaya Sankar estimates that 120 g of the composite could continuously provide 10 L of microbe-free drinking water daily for a year.

In the lab, microbial loads of 10⁵ colony-forming units (100 times the amount in natural drinking water) drop to zero. Lab studies also show that together, the Fe and Al composites remove both arsenic and microbes; limited field trials corroborate the lab results, says team member Amrita Chaudhary.

The composites can be made to remove other contaminants, such as lead or mercury, and assembled for specific needs. The antimicrobial material is housed at the roof of a vessel fed with untreated water from the top. The vessel volume can vary from a few liters for a household to hundreds of liters for a small community. A multilayer block of composites for specific contaminants sits behind the water tap.

InnoNano's materials join many water purification techniques, including ultraviolet radiation, chlorine treatment, and various filtration methods. "You need a basket of technologies," Pradeep says, to address the diverse needs around the world.

A powder called the P&G Purifier of Water, developed by CDC and Procter & Gamble, is perhaps the best-known water purification technology for use in impoverished or disaster-stricken areas. The product, which contains ferric sulfate and calcium hypochlorite, costs 3.5 cents per sachet. One sachet treats 10 L of water in about 30 minutes, removing metals, including arsenic, and killing microbes. For a family using 10 L of drinking water per day, treatment would cost \$12.80 per year, a month's earnings for many West Bengalis. InnoNano's

filters would deliver the same amount of drinking water for \$2.00–\$3.00 per year, Chaudhary says.

The nanocomposites stand a good chance of being used on a large scale, Redeemer's Unuabonah says. However, more evidence of their robustness is needed, and the arsenic-scavenging material needs to be tested on higher levels of contamination.

The technology is already popular in Murshidabad. The system works well, says Rajeev Kumar, a former Murshidabad district magistrate, and because community units—such as schools or offices—are responsible for operating the tanks, people have a sense of ownership. In a documentary prepared for IIT Madras, residents ask for installations in their villages. The district has ordered at least 100 more purifiers.

For its part, InnoNano wants not only to provide a purification solution, but also to maintain the installations. "Originally, we were thinking of keeping our role to materials manufacturing," Pradeep says, "but that alone is not enough."—VIRAT MARKANDEYA, special to C&EN









World population density 1994

Parting message

Every problem is dwarfed in front of the giant water crisis looming large on the planet. Water stress – in quantity and quality- is felt most severely by the populous countries.

Indian subcontinent is at the centre of action.

Many of the problems of water quality can be handled affordably by new technologies. Arsenic, fluoride, mercury, pesticides,...affordable, accessible and reliable solutions are here in the country.

Persons/sq km



Miller Projection
SCALE 1:100,000,000
0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000
KILOMETERS

https://commons.wikimedia.org/wiki/File:World_population_1994.jpg



When we are unable to give clean water to children, the nation loses future.



Department of Science and Technology

Thank you

