Nano Technology for Safe Water Benefitting Bottom of the Pyramid

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Structure of Presentation

- Water Challenges facing India
- Priorities for finding out Technical Solution
- Nano sciences & Nanotechnology: Indian Scenario
- Research on Clean Water
  - Application Research
  - Developmental Research
- Thrust Areas for R&D

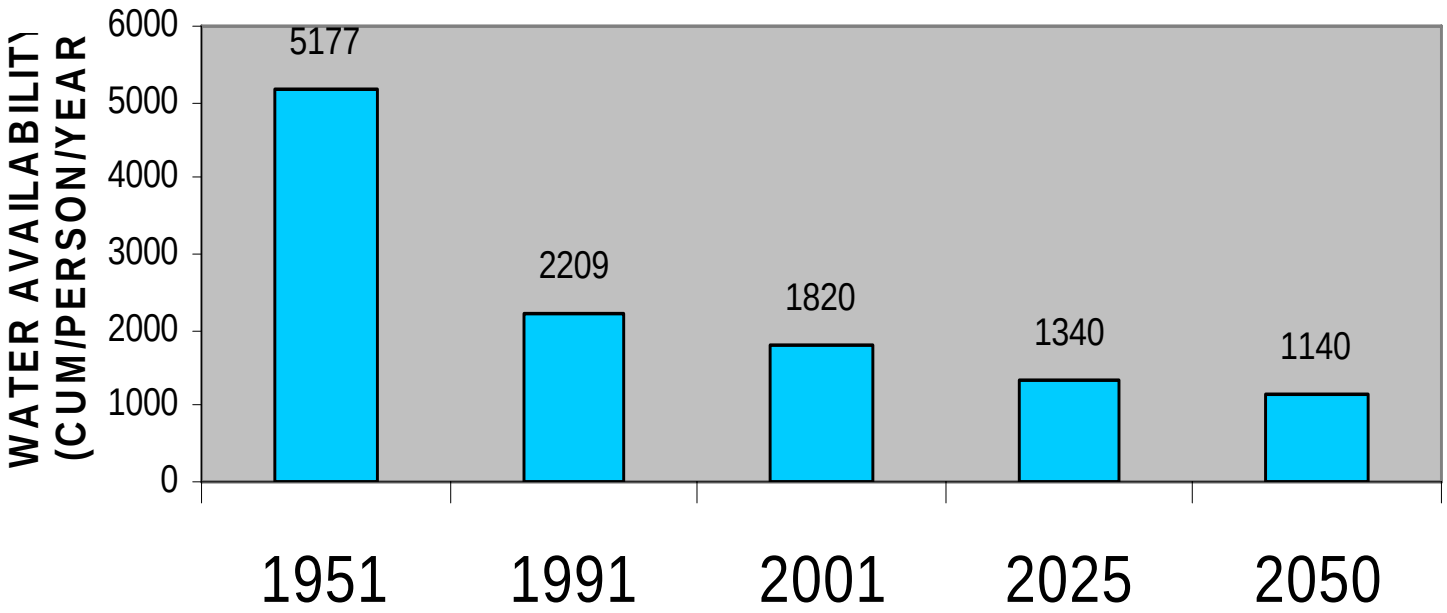
Water Challenges facing the Country

Water Shortage	Water Quality including Reject Management	Site Specific Water Use Management
Low per capita availability	Quality deficit of available water for specified uses	Storage capacity for seasonally available water
Evaporation loss from water bodies	Geological contamination through arsenic	Surface run-off on account of nature of geological terrain
Water winning and mining in water starved areas	Contamination through fluoride	Water body disuse
	Contamination through iron	Mismatched rates withdrawal and recharging capacity
	Contamination through multiple species	Non-optimal use of water in agriculture
	Biological contamination	Non-optimal use of water in industrial sector
	Alkali metal ion salinity	Unplanned water use and demand
	Alkaline earth metal salt salinity and hardness	River flood management
	Contamination of water on account of pesticides and other water derived residues	Wetland management
	Deficit of assurance for drinking water quality	
	Sea water intrusion in coastal areas	

Key Water issues

- Quantum deficit of water for irrigation
  - Irrigation area tripled to 330 million Ha from 1970-1999
  - GW loss of 109 km^3 from 2002-2008 in North India inhabited by 114 million
  - 31% districts covering 33% land area and 35% population unsafe
- Quality deficit of water for specified use
  - 347 districts (59%) affected by biological and chemical contamination reducing water availability for drinking, irrigation, municipal use

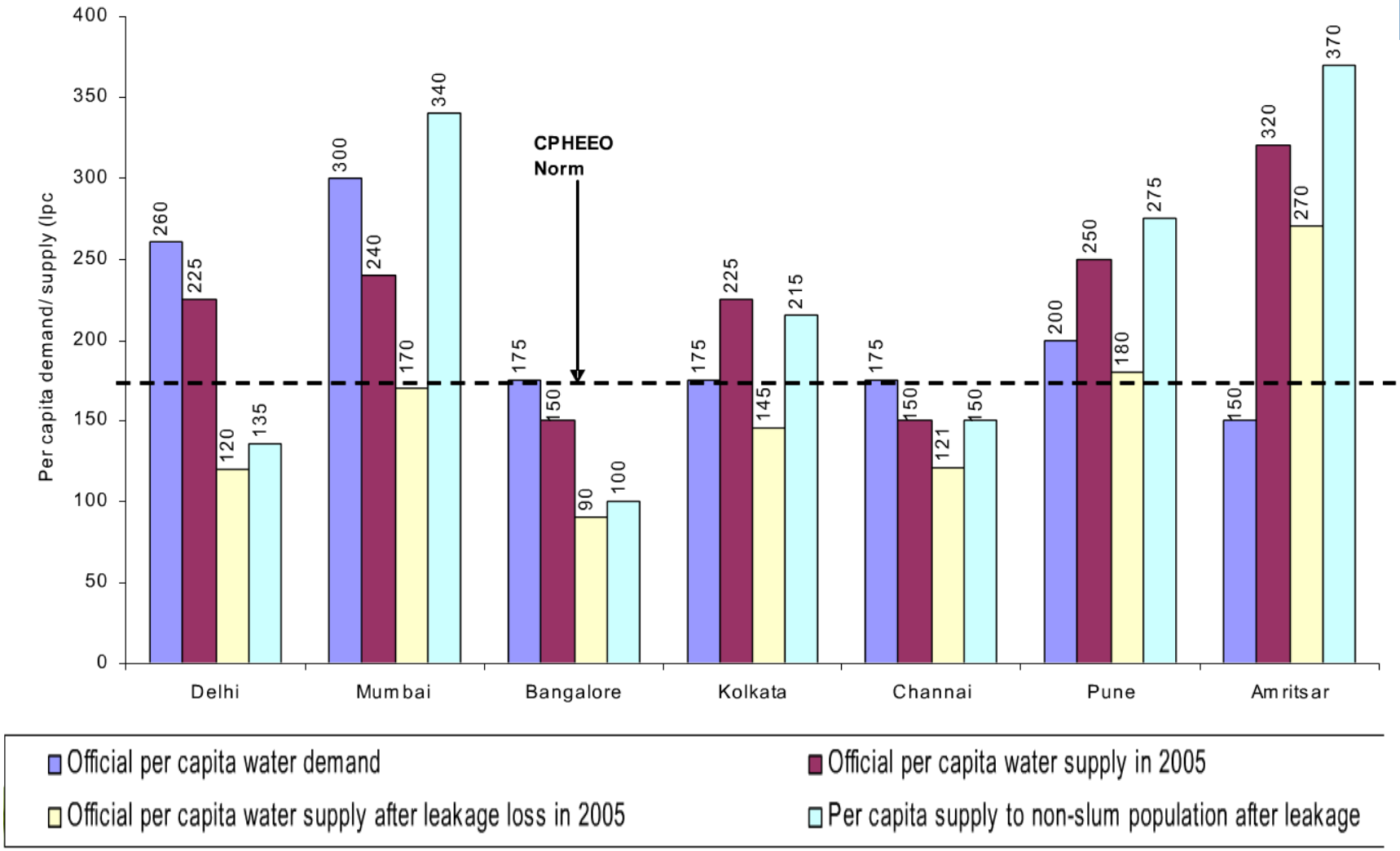
PER CAPITA WATER AVAILABILITY



Water Stressed< 1700 m^3/yr

Water Scarce< 1000 m^3/yr

Water Demand and Supply in Indian Cities



Water Quality Scenario in India

1. Physical

- High Turbidity in surface water ,Total hardness ,pH value . High Total Dissolved Solids

2. Chemical

- Iron ……23 provinces affected
- Arsenic …….. 5 provinces affected
- Fluoride ……..19 provinces affected
- Nitrate ……. Almost all hydrogeological formations have nitrate concentrations
- Salinity
  - Inland salinity: arid and semi-arid regions of 10 provinces affected
  - Coastal salinity: 7,500 km. long coast line affected

3. Bacteriological

E coli or Thermo tolerant bacteria (present in large number in open water bodies) , Total Coliform Bacteria

4. Virological

- Presence of Viruses

Water Priorities

- Water Purification

  Decentralized cost effective water treatment for communities and household levels

  Water quality monitoring: development of sensors and analytical techniques

- Water Reclamation & Reuse

  Integrated wastewater management for reclamation and reuse; technologies, tools and frameworks

- Water Efficiency in Irrigation

  Technology-rich water management for the sustainable intensification of agricultural systems

  Participatory water management in smallholder irrigation projects

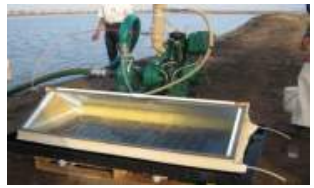
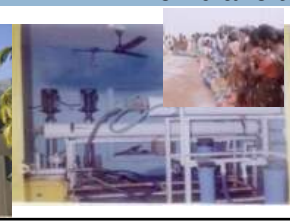
- Integrated Sustainable water resource Assessment & Management

  Development & testing of frameworks for integrated water resources assessment and management at different scales (present and future) experiences .

- Integrated Urban Water Management

  Efficient and effective planning and management of urban water systems

Technologies for meeting water quality related challenges

Type of water Contamination	Suitable Technologies
Saline (1000-40,0000 ppm)	Thermal desalination   Membrane techniques   
Turbidity + Pathogens	Alum + bleaching powder/ SODIS/ Ozonolysis; Microfiltration/ Ultrafiltration, UV irradiation    
Hardness/Fluoride/ Arsenic/Iron/ Nitrate	RO or specialty membranes/ Specialty Adsorbents and resins/ Electrolytic treatment    
Natural Disasters	Disinfection/Broad-spectrum solution at mass scale  
Water Reuse	Secondary/Tertiary treatment followed by RO (large scale) 

Research for Clean Water Solutions

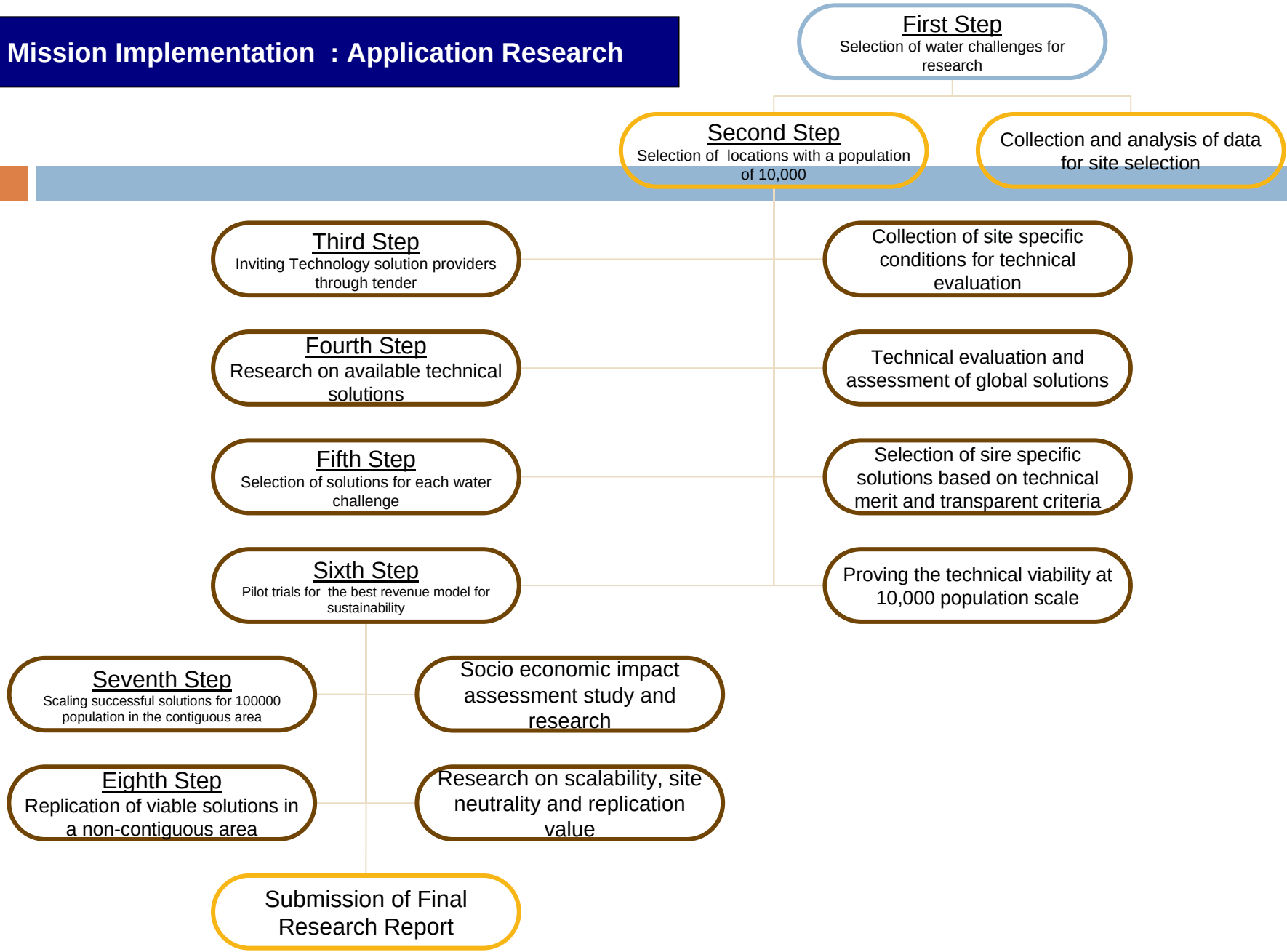
- Application Research on convergent Technological Solution : Technology Mission on ‘WAR’ for Water

  - Spotting & Scouting feasible Solutions from Industries Globally

  - Adaptation & Absorption of technologies in different social context

- Development Research in laboratories on emerging and nano-technologies

Mission Implementation : Application Research



Government Initiative in Nanoscience & Nanotechnology

- Department of Science & Technology (US $ 225 m)

  State-of-the art facilities ,Human Resources Development , Regulatory Framework, Centres for Nano Science and Nanotechnology,Centre for Knowledge Mgt,International Collaborations,Institute-Industry linked projects in Public-Private –Partnership mode

- Department of Information Technology (US $70m)

  Nanoelectronics, Nanometrology, Technology Development, Infrastructure Creation And Capacity Building, Human Resources, Industry Promotion

- Department of Bio-Technology

  Medical applications - delivery of drugs , bioseparation ,diagnostics,Toxicological studies Agriculture application for Pathogen detection, Smart delivery vehicle for pesticide,Waste management, aquaculture-nanofibres from aquatic weeds,Nanofilters for water purification,removal of VOCs from air,Effluent treatment

- Council of Scientific & Industrial Research, Indian Council of Medical Research, Central Manufacturing Technology Institute

Indian Nano Scenario in Nutshell

Strengths

- An investment of about US $ 200 million made since 2002.
- A community of about 1000 active researchers has been built.
- Good number of characterization facilities including some of the best.
- Scientific studies on nanoscale systems being performed at internationally competitive level.

Challenges

- More application-, product- and technology-oriented projects required.
- Industry and start-ups need to be attracted and involved.
- Greater networking among institutions working around specific themes required.
- Standards work needs greater push.
- Regulatory framework needs to be in place.

Application of Nanotechnology for Water and Wastewater Treatment

- *Innovative sensors for detecting water contaminants at low and ultra low concentration (microbial, organic and inorganic contaminants)*
- *Integrating advanced materials (noble metal nano-particles/CNT/Dendrimeric/multi-functional membranes) with existing and emerging solutions to improve their efficiency*
- *Disposability/reusability of advanced materials and their filtered/trapped rejects.*

R&D efforts :JNCASR, Bangalore

- Polymer/nano-particles system as nano-composite material for waste water treatment.

  - Combination of adsorbent and catalyst

  - Reusable and recoverable

  - Efficient material for removal of toxins

  - organic solvent and odorous compounds.

R&D efforts: IIT Kanpur

- *Development of carbon nano-fibers and nano-particles as adsorbent for environment remediation of waste water*
- *Application for waste water treatment*
- *Removal of arsenic and fluoride from waste water*
- *Water-solid (adsorbent /resins) multi stage continuous contactor for removing undesirable dissolved solutes*

R&D efforts: IISc, Bangalore

- *Dendrimer-Functionalised Membranes for removal of Organic Pollutants in Water*
- *Enhancing retention potential of membranes to lipophils organic compounds*
- *Encapsulation of contaminants inside the dendrimers*

R&D efforts: IIT Delhi

- *Hollow shells of silica as nano-membranes for entrapment of contaminants*
- *Designing of nano-membrane for use as nano-filter for removal toxins present in trace amounts and development of photo catalytic process to efficiently degrade toxins.*
- *Nanostructured sensors for water related safety and security.*

R&D efforts: IIT Bombay

- *Surface engineered nano-particles for detection and separation of toxic metal ions and organic dyes*
- *Nano-composite and charged nano filtration membranes for water purification with anti-microbial and photo- reactive functionality.*

R&D efforts :IIT Madras

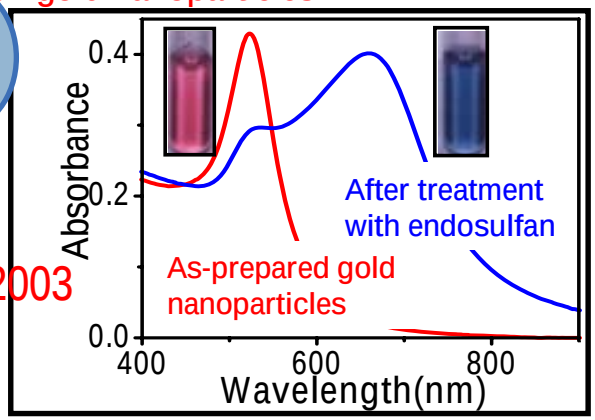
- Noble metal nano-particles for removal of halogenated organics including pesticides, heavy metals and micro-organisms
- Studies on ultra low concentration detection of the above contaminants
- Utilisation of quantum clusters for drinking water purification.

Technology from idea to commercialization:

A technology commercialized for the removal of pesticides from drinking water

1

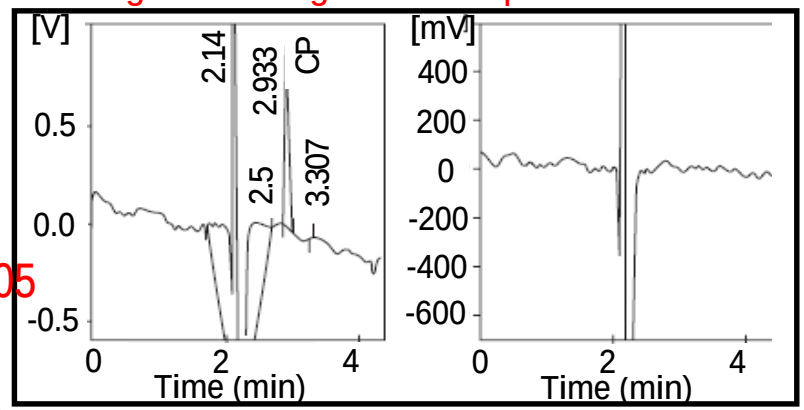
Initial research: Adsorption of endosulfan on gold nanoparticles



2003

2

Technology development: Complete removal of chlorpyrifos from drinking water using silver nanoparticles



2005

(L) Water spiked with chlorpyrifos (labeled CP) at 50 ppb. (R) After passing through the nanoparticle-based filter (no CP)

3

Plant setup: Manufacturing plant for silver nanoparticles supported on alumina

2006

4

Product commercialization: (L) Pesticide removal cartridge and (R) Aquaguard Gold Nova incorporating the cartridge

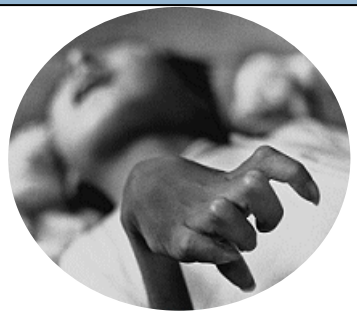
2007

Nanoparticle-based chemistry discovered in the laboratory has been translated to a product for water purification

Global issues on water purification –

Currently being commercialized by IIT-M

Unsolved technology problems: our solutions are covered in 14 patents, 15 research articles



Mercury contamination

Target: 6 cents per 100 liters

Microbial contamination

Target: 6 cents per 100 liters

Pesticide contamination

Target: 3 cents per 100 liters

For details of efforts in the area, please see: Noble metal nanoparticles for water purification: A critical review, T. Pradeep and Anshup, Special Feature, Thin Solid Films, 517 (2009) 6441-6478.

Fluoride contamination

Target: 22 cents per 100 liters

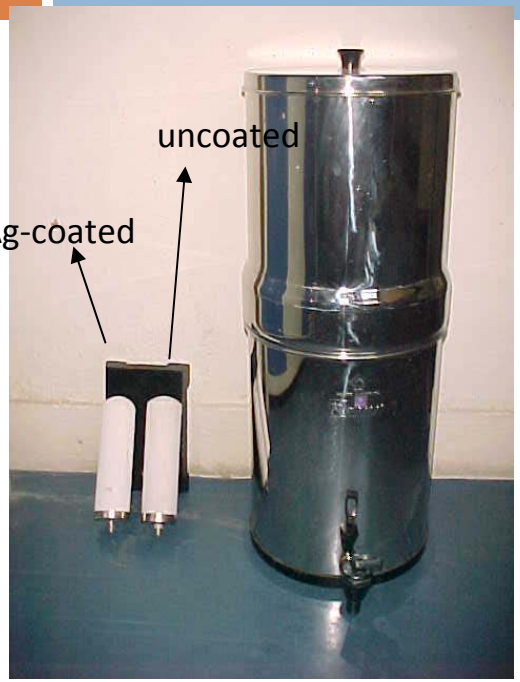
Affordable solutions based on new materials is now possible

R& D Efforts: ARCI, Hyderabad

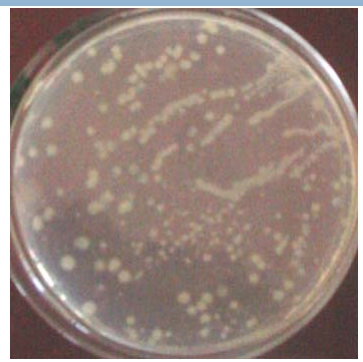
Commercial Nanosilver coated ceramic candle filters for drinking water

(Technology developed and transferred by ARCI)

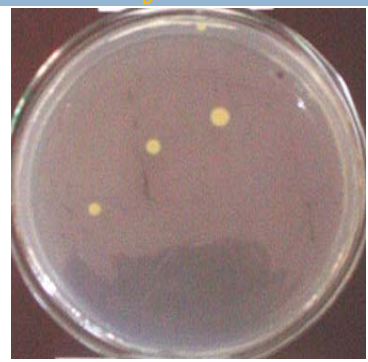
ARCI-filters for drinking water



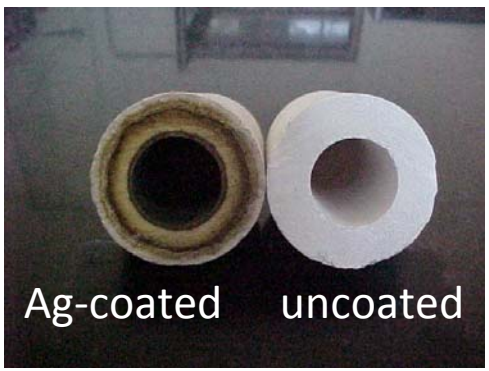
Antibacterial activity



Before filtration



After filtration



Cross section view

What Next?

- Technologies to meet technical, social, economic and environmental considerations
- Technologies developed globally to meet price-utility envelope of developing countries


Thank You

Nanotechnologies for Safe Water

Strategies and Partnerships to Benefit the Base of the Pyramid

K. Vijaya Lakshmi

IHC, Amaltas

New Delhi – April 21st 2011

Development Alternatives

The Need for Safe Water is Universal

People's health, quality of life, and life itself are at stake

The Problem and Solutions are Complex

The Context

- One in eight persons in the world lack access to safe water supply
- 3.5 million people die each year from water-related disease; 84 % are children. 98 % occur in the developing world
- 66 million people are affected by fluorosis and 10 million people are affected by Arsenicosis
- More than 60 % pf the population living in rural areas have no access to safe drinking (tap) water
- Poor people living in the slums often pay five to ten times more per liter of water than wealthy people living in the same city
- Waterborne diseases are costing the Indian economy 73 million working days a year

Common Water Pollutants

- Microbial
- Heavy metal,
- Arsenic,
- Fluoride,
- Nitrate
- Salinity
- Pesiticdes and endocrine disrupters etc.

- ***Still need effective treatment options***

Nanotechnlogies for Water purification

Offers Revolutionary, Promising solutions :

- *For both purification and sensors for pollutant detection*

Background to the Study

Premise of DFID NET-RC Initiative

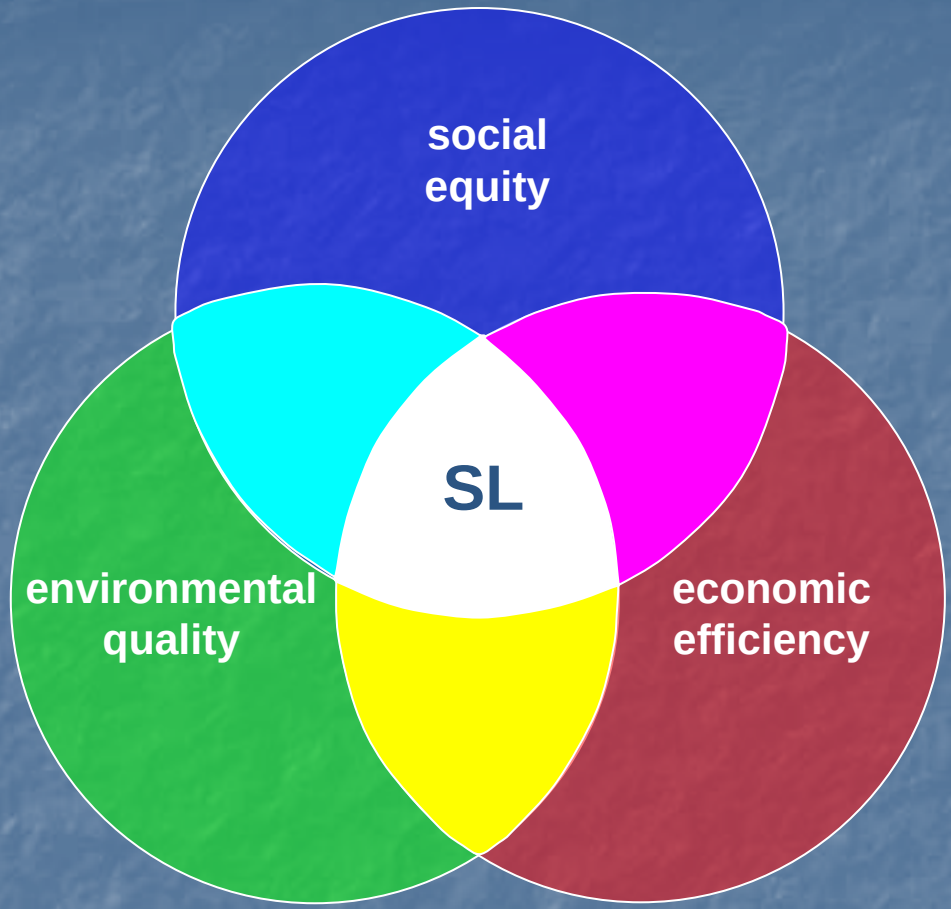
- **Research has a key role in anticipating and responding to future trends**
- **New and emerging, cutting edge Nanotechnologies for water purification, their relevance to the needs of poor people.**
- **Need for Translational research to support the longer term development agenda to ensure the benefits are derived by the poorest**
- **Quest for the most effective, safe and affordable approaches to reach the research benefits to poor people**

Significance of Nanotechnology

- Dimensions and tolerances are in the range of 0.1-100 nm
- Application of these nano structures and principles behind them to make nano scale devices and to produce new materials
- Offers more affordable, effective, efficient and durable ways of purification

Development Alternatives in Water Sector

Development Alternatives Group - Mission



We believe that the Key to sustainable development is the creation of sustainable livelihoods in large numbers

Water Testing - products

Jal-TARA Portable Drinking Water Quality Monitoring Kits

Standard Kit

Aqua check Vials

Fluoride Kit

Iron kit

Arsenic kit

Nitrate kit

Ensuring Safe Drinking Water

Jal TARA Filter - *a Bio*-Sand *Filtration System*

Unique Features

- Standardized system in 1000 litre tank with output of 2500 -3000 litres per day
- Ideally suited for rural/peri-urban community application
- Removes Bacteria (99.9%) and Turbidity
- Provides continuous flow with gravity filtration – No electricity required
- Provides cost effective chemical free treatment
- Low maintenance
- Allows customised fabrication and installation as per site conditions

Water Purification Systems

An Entrepreneur run

water supply enterprise

Kachipura

Village Panchayat Name	:Binwara
Distt.	:Tikamgarh
Total Population	:298
Total House Hold	: 61
Bank Facility	:Madhya Bharat Gramin Bank, Taricharkala
Co-Operative Service Center	
Aganwari Kendra	:No
Gram Swaraj Bhawan	:No.
Samodayik Bhawan	:No
School	:Primary Level 1
Water Source	:Ground water (Well)
Checkdam	:1
The main occupation of the villager	: Agriculture

The Concept

- Research has a key role in anticipating and responding to future trends
- New and emerging cutting edge Nano technologies for safe water are being developed that may have relevance to poor people.
- Need for translational research to support the longer term development agenda to ensure the benefits are derived by the poorest
- What are the most effective, safe and affordable approaches to new technology that might benefit poor people.

Findings of Risk Mapping

- There is no clear understanding on the health and environmental impacts of the technologies.
- Maximum risk was perceived during production and disposal.
- Both the severity and the probability of the risks is a direct factor of the management practices adopted by the industry.
- Operation related risks were perceived to be minimal.
- There is policy gap in terms of monitoring, production and application of nanotechnology based devices.

Purpose of the Consultation workshops

- To arrive at a consensus on market and policy barriers - ***affecting large scale roll out of nanotechnologies for water treatment***
- To prioritise Action and Initiatives to promote nanotechnologies in the water sector while attaining poverty alleviation and MDGs in India

Purpose of the Stakeholder Consultation

- The current study seeks to identify key challenges and barriers that may reduce the impact of nanotechnologies for providing clean drinking water reaching the under privileged in developing countries
  - Possible environmental implications and remedial measures
  - Successful service delivery models
  - Absorptive capacities of the population

Current Status of Nano tech Research

- Nanotechnology research in India has grown at a very fast rate, with an emphasis on water and energy sectors.
- The government has invested in creating infrastructure and training scientists to encourage this trend.
- Noble metal based nanotechnology for water purification has been productized and reached markets.

Technology	Description	Current Status
Hydrotalcite	Low-cost synthetic clay, hydrotalcite that attracts arsenic removing it from water packaged as a 'teabag' that can be dipped into household water supplies for about 15 minutes before drinking by CSIRO	Prototype developed
Silver Nanofiltration	High-speed, low-cost filter using plain cotton cloth dipped in a broth of silver nanowires and carbon nanotubes by Stanford researchers	Prototype being developed
Nanorust	Nano Iron binds with arsenic and is removed from water using a magnetic field. Technology developed by Rice University	Prototype being tested in Mexico
Nanofiber	Tea bags with ultra-thin nanoscale fibres, which filter out contaminants, and active carbon granules, which kill bacteria by Stellenbosch University	Under approval by SA Bureau of Standards
Nano Photocatalysts	Solar disinfection of water using photocatalytic nanoparticles (titanium dioxide) to remove chemical pollutants and pathogens from water being developed by NIBEC	Research
Carbon nano tubes	Simple method to produce carbon nanotube filters that efficiently remove micro- to nano-scale contaminants from water being developed by BHU	Research

Technology	Description	Current Status
Nano antimicrobials	Silver-based antimicrobial filter water bottle developed by IonArmour	**Market by InnovaMaterials**
Nano silver catalyst	UV disinfection with adsorption on nano silver based activated carbon blocks developed by IIT-C	**Marketed by Eureka Forbes**
Nano silver catalyst	Rice Husk Ash impregnated with Nano Silver particles, activated silica and carbon developed by TATA group	**Marketed by TATA Chemicals**
Nano silver catalyst	Coating technology for incorporation of nano silver in traditional candle filters for disinfection developed by ARCI	**Field testing by SBP Aquatech Pvt. Ltd.**

Barriers to BoP Reach

- Low Awareness among BoP on clean water
- Logistics reach to the BoP populations needs to be improved (including delivery, servicing and disposal)
- Lack of Innovative and affordable service delivery models to penetrate BoP (proven and tested at scale)

Barriers - Nanotechnology

- Lack of understanding/ agreement on health & environmental impacts of nanotechnology
- Disconnect between researchers and industry
- Cadre of incubators/technologists are missing
- Multi stakeholder cooperation (to enable service delivery models)
- Policy gap in terms of monitoring, production and application of nanotechnology based devices.

Research Questions

- **What should be our strategic responses for technology uptake by BOP and Governments., development agencies and other institutions.**
- **What are the country priorities in fulfilling the drinking water needs?**
- **The role and the nature of technologies that is anticipated in terms of the**
  - **production systems,**
  - **Technology efficacy,**
  - **Resource use patterns,**
  - **Models of delivery,**
  - **required financial and institutional systems etc**

Research Questions

- Are there any potential, environmental and health risks due to the nano chemistry to the producers, consumers and waste handlers? If there is a risk associated is it short term or long term.
- Are the general public made aware of these implications?
- What value do communities attach and how significant is the water quality in their lives in-terms of health benefits,
- Awareness levels of communities, what kind of information and demand creation aspects can be pursued.
- What are the resource implications, both in production and use of technology? (ex: wastage of water, leaching of unwanted chemicals into purified water.
- Is the waste generated adequately taken care? Whose responsibility it should fall?

Research Questions

- Is **simplicity of technologies** a problem? How important is change of mindsets?

- What are the avenues to overcome these barriers in terms of technological, financial, social, cultural and economic and environmental barriers?

Proposed criteria for selection of Technology for action research

- **Consumer Acceptance**: what is the level of acceptance by the wider/limited population? What are the trigger points of acceptance/ rejection?
- **Ability to reach the BoP**: Are the short listed technologies financially and logistically accessible for BoP customer.
- **Viability:** Is there willingness to pay for the services? At what scale is the model viable ex: Household, community, village/ town etc.
- What are the **institutional models** that are needed to ensure quality of service delivery and address issues of governance and gender issues, What kind of support systems are needed to safeguard the sustainability issues

Proposed criteria for selection of Technology for action research

- **Scalability:** Is there potential for scaling up? What are the systems, processes and strategies needed for scaling up? What partnerships (Govt., Corporate, Community level partnerships) and delivery models needed to scale up?)
- **Environmental**: Waste disposal practices? How safe is the residue to dispose off? Health hazardous due to improper way of disposal like in the case of Arsenic, Fluoride and Reverse Osmosis plants. Level of reject water, its nature, public health impacts in processing and handling, disposal practices, implications on the receiving water bodies or eco systems
- what **role the stakeholders have** in taking forward these measures. Any need for policy changes (ex: waste residues from fluoride treatment to be stabilised through road construction processes and policy changes needed to make it compulsory) etc.

- What are the **key elements of technology incubation that need to be tested** and what do these depend on

- some successful models and some areas of shortfall

- Why are some of the models not in large scale-are there any challenges/barriers something to do with local government policies, etc

- At what stage in the Development one needs to start interacting with key players

- Who are the drivers in the market

- Key players who will mainstream the policy

Research Questions

- What is the best way to build on nanotechnology research for development outcomes?
- What Processes/Systems/ Policies needed to manage the associated risks
- What is the scale of the commitment to longer term funding to be made in areas that are likely to have a high probability of high impact? Are they affordable?
- How can we support research that improves the uptake of this research?


thank you

The BoP Market

& water purifier

An overview

GRASP ANALYTIQUE PRIVATE LIMITED

Genesis of BoP in India ..

- Coined by C.K. Prahalad & Allen L. Hammond
- Refers to around 4 billion people in India at the bottom of economic pyramid
- With a purchasing power of $1500 a year or less
- Over $1.2 trillion market of a $5 trillion global BoP market ..(minus China)

The 4 conditions ..

- The innovation must achieve substantial price reduction-at least 90% of a cost of a comparable product or service in the west
- The innovation must be scalable: must be able to be produced, marketed and used in many locales and circumstances
- The innovation must be affordable at the bottom of the economic pyramid, reaching people with the lowest level of income in any given society
- The innovation must result in a product or service of world class quality

Pilot ..BoP market ..

- Conducted in BoP markets in UP, Punjab & Haryana
- 14 towns ..560 households ..140 retailers
- Find out ..need, triggers and barriers for water purifier ..

Take out from the study ..

- Most use hand pump in UP, while most in Punjab & in Haryana use tap water
- Majority are not satisfied with their drinking water
- Awareness about traditional methods of purification is high..but awareness about purifier is not very high
- Practice is very low ..need behavior change

Take out from the study ..

- About 6% were using purifiers ..
- Among users ..1% use filter with candles, 2% UV/RO & 3% non-electric purifiers
- Among non-users about one-third felt the need for purifier
- Major barrier ..price is perceived to be unaffordable ..lack of knowledge about purifiers

Take out from the study ..

- Most retailers stock non-electric purifiers ..
- Non-electric purifier also found to have highest shelf movement
- Need ..penetrative communication ..attractive price points and schemes ..

OPPORTUNITIES AND CHALLENGES OF NANOTECHNOLOGY FOR PROVIDING ACCESS TO SAFE DRINKING WATER TO BOTTOM OF THE PYRAMID POPULATIONS

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21 April 2011

NANOTECHNOLOGY- COMMON QUERIES

Everyone is talking about nanoscience and nanotechnology

Google search for ‘nano’ gets 100,000,000 hits

Bill Clinton, APJ Abdul Kalam, Baba Ramdev……

Governments and industries across the globe are pumping millions of dollars in nanotechnology research

Is it the next ‘IT’ which can get me a huge salary?

Can it stop ageing and cure cancer?

Can it get me safe water?

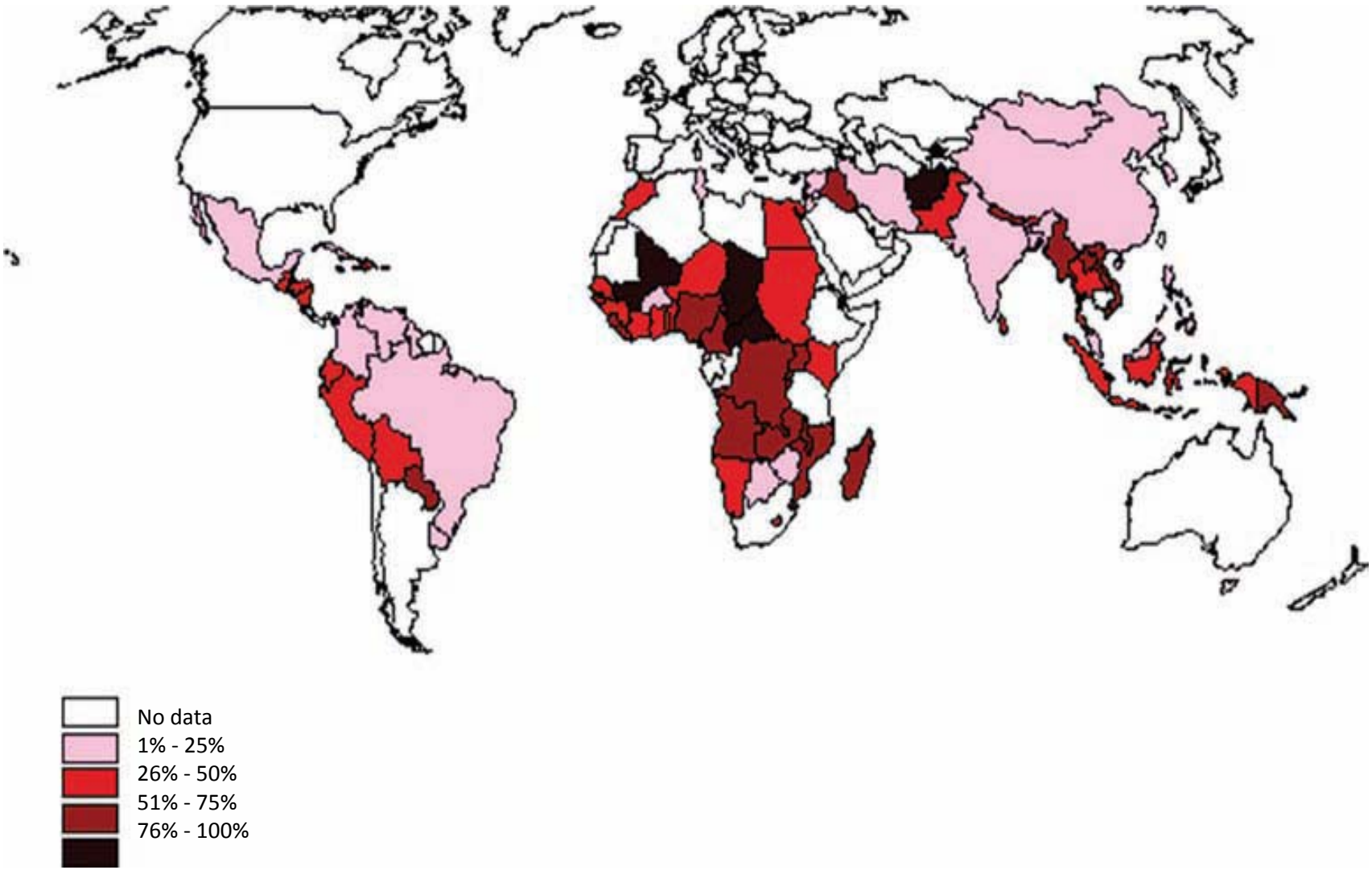
Is Nanotechnology factual or a figment of imagination?

Is nanotechnology risky? (‘Prey’ Michael Crichton)

NEED TO SEPARATE FACT - FICTION

HYPE - HOPE

SAFE DRINKING WATER :GLOBAL SCENARIO



Populations without access to safe drinking water.

(From *The World's Water* 1998–1999 by Peter H. Gleick. Copyright © 1998 Island Press.

Raw water : a cause for concern

Pathogenic microorganisms

Waterborne diseases such as

diarrheal disorders, salmonellosis, shigellosis, cholera, amebiasis, giardiasis, and
non-diarrheal disorders, such as infectious hepatitis, viral Hepatitis, typhoid fever, leptospirosis, etc.

Toxins produced by aquatic algae and bacteria can also cause severe health problems.

Chemical constituents - chloride, magnesium - create a risk of dehydration caused by acute laxative action and/or by decreasing the palatability of the water

Fluoride, arsenic, heavy metals have toxic effects

Pesticides – lindane, endosulfan

Potential of nanotechnology-based methods for water purification

Three major categories of nanomaterials based on applications

Nanomaterials as sorbents : **Removal of heavy metals and inorganic contaminants**

Nanomaterials as filtering agents: **Removal of contaminants by filtration**

Nanomaterials as catalysts : **Removal of pesticides and other organic matter including toxins**

Nanoparticles as antimicrobial agents for water disinfection : **killing of disease causing bacteria, viruses and protozoa**

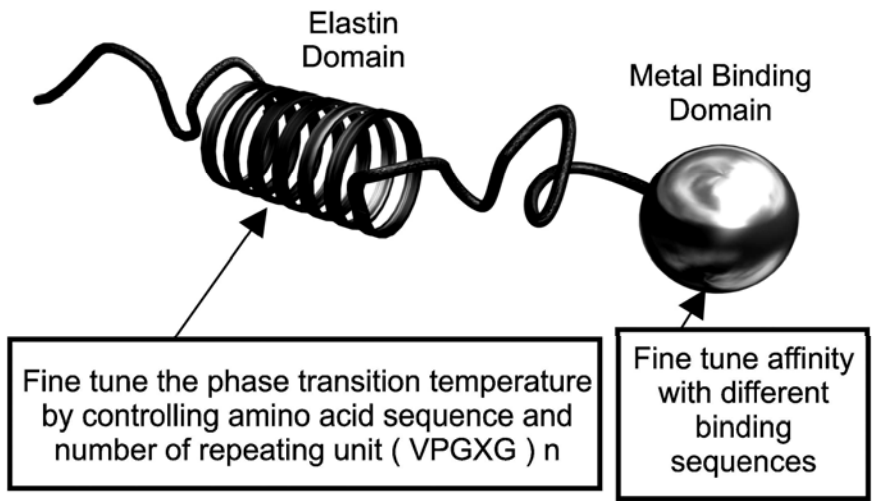
Nanomaterials as sorbents

Unique features:

Large surface area to volume ratio

Diameter	1 mm	1 um	1 nm
Surface area : volume	**6**	**6×10^2**	**6×10^5**

Possibility of functionalization

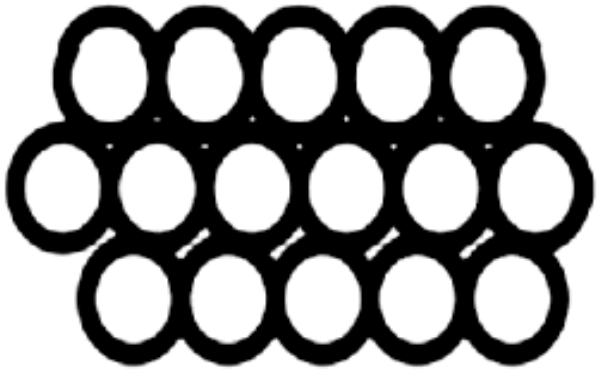


Capable of removing

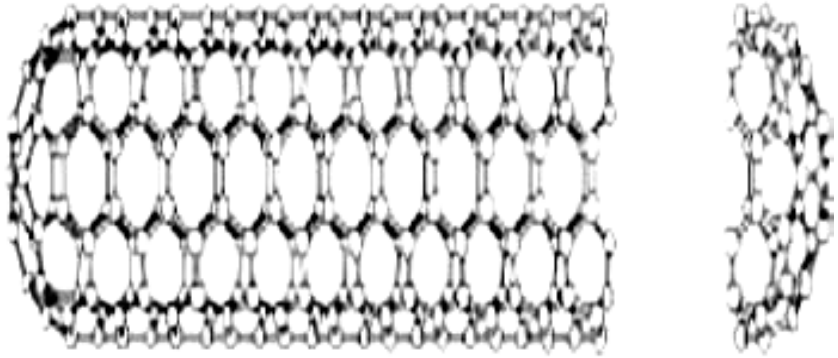
- **Metal ions**
- **Inorganic anions**
- **Volatile organic compounds**

Nanomaterials as sorbents

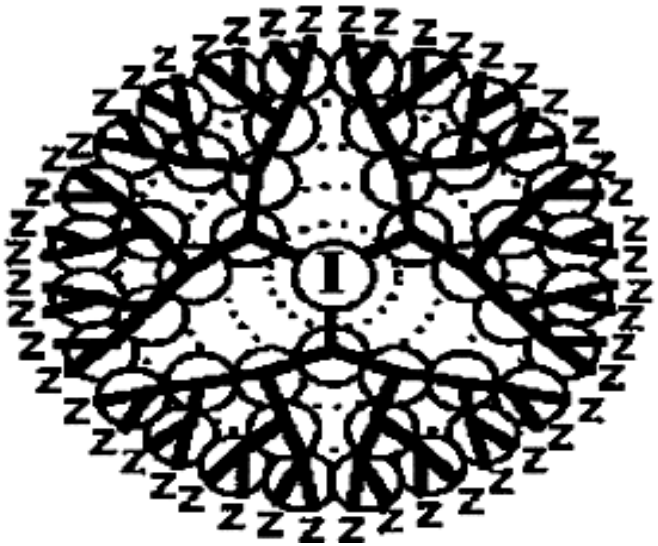
Metal-Oxide Nanoparticles



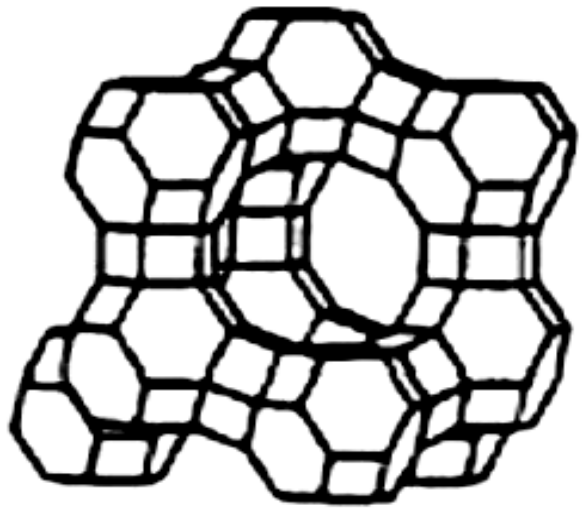
Carbon Nanotubes



Dendrimers



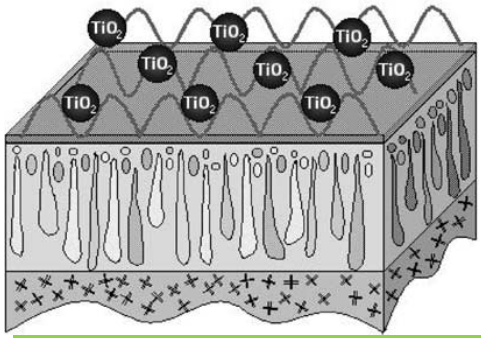
Zeolites



NANOTECHNOLOGY BASED MEMBRANE MATERIALS

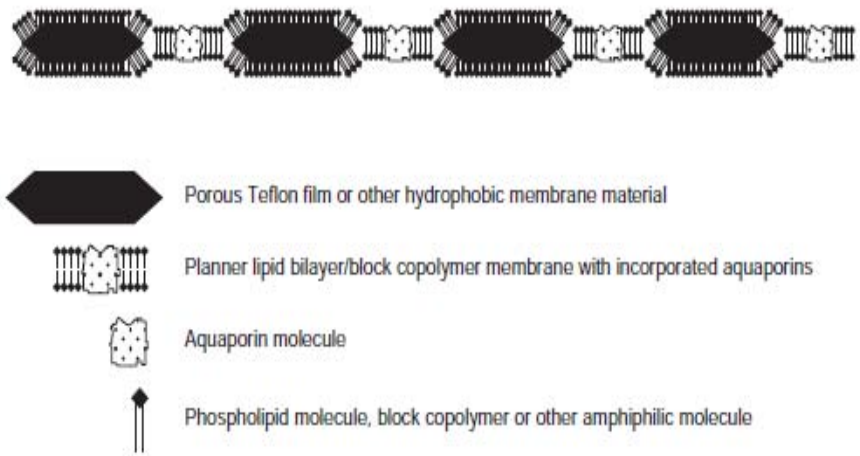
Types of membranes that are possible low energy replacement for conventional RO membranes applied to desalination

(1)inorganic– organic nanocomposite membranes,
(2) hybrid protein–polymer biomimetic membranes,
(3) aligned-carbon nanotube membranes



Schematic of hybrid membrane

e.g. thin film nanocomposite membranes containing silver and titania nanoparticles with the goal of producing potentially antimicrobial and ultraviolet (UV)-active nanofiltration membranes

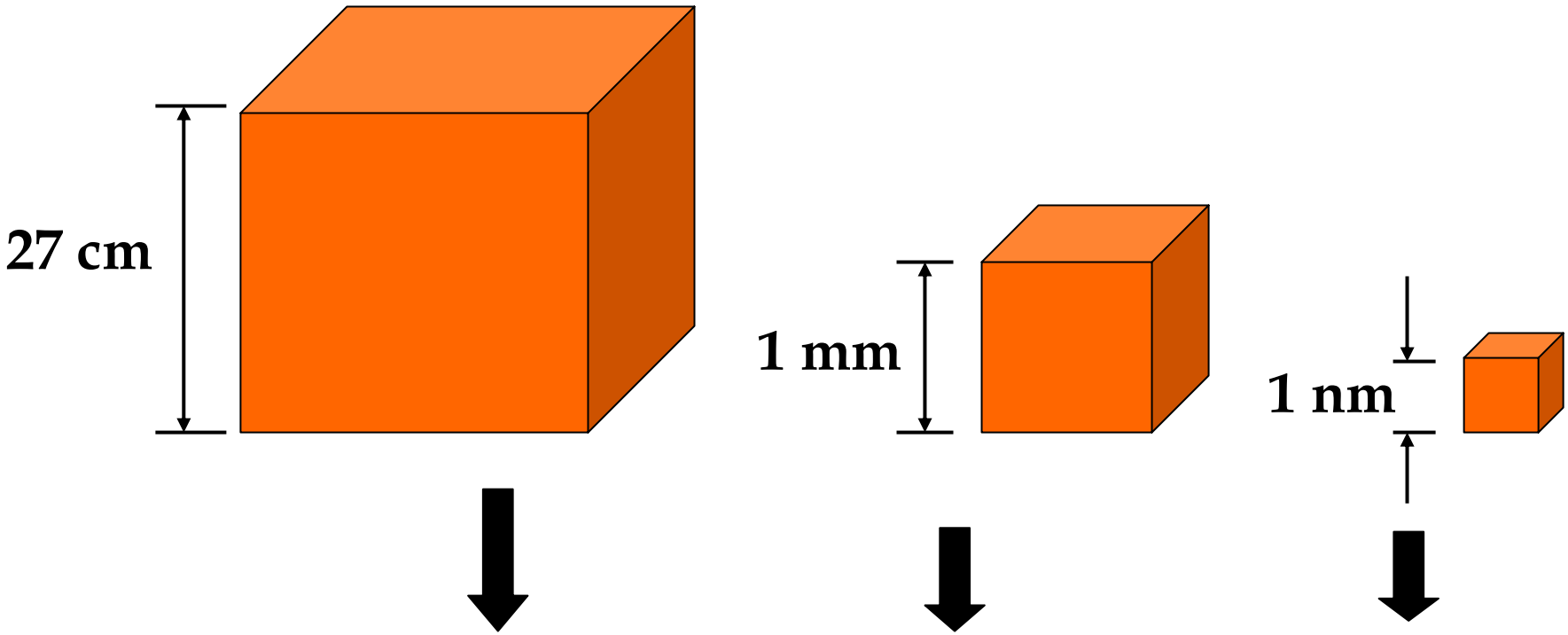


Lipid bilayer/triblock copolymer membrane formed around teflon film with incorporated aquaporins

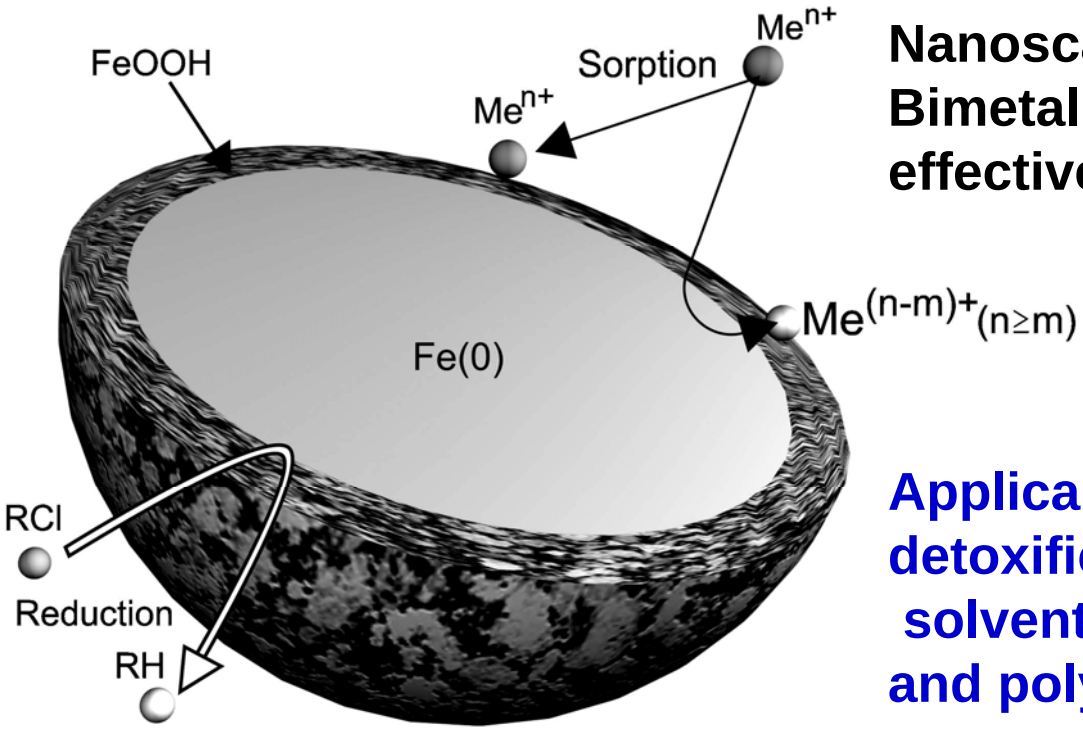
NANOCATALYSIS IN DEGRADTION OF POLLUTANTS

Problems of dyes, heavy metals, hydrocarbons can be tackled using nanoparticles catalyzing rapid degradation

Materials with size 1-100 nm (1 nm = 1 × 10^{-9} m) and properties dominated by surface



Nanomaterials as catalysts

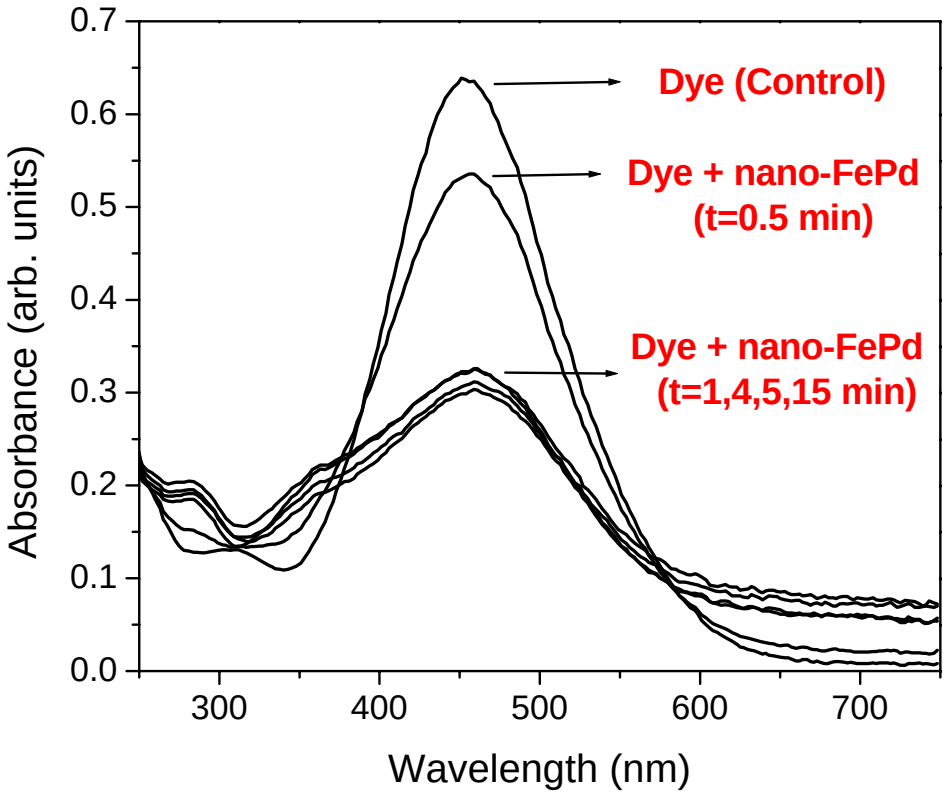


Nanoscale zero valent iron (nZVI, Fe0)
Bimetallic iron particles
effective redox catalysts

Applicability in transformation and detoxification of chlorinated organic solvents, organochlorine pesticides, and polychlorinated biphenyls

Schematic representation of nZVI and the reactions that occur on its surface

DEGRADATION OF DYES

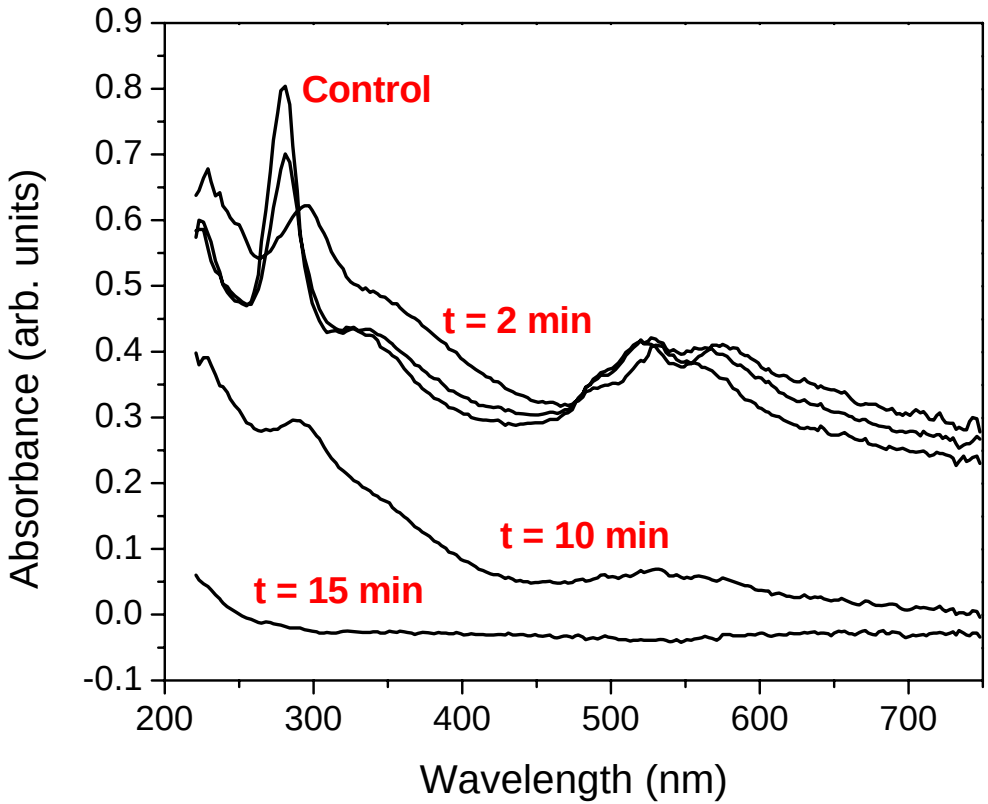


Bismarck Brown Azo Dye

Control **Bulk Iron (15 mins)** **Nano-FePd (5 mins)**

- 50 % degradation in 2 mins using nano-sized Fe-Pd

- ✓ Fast and efficient degradation
- ✓ Cheap material due to small quantity requirement
- ✓ Easily removable using magnetic separation



Natural Red 4 (Non-Azo Dye)

DEGRADATION OF CHLORINATED PESTICIDES

Serial No.	Amount of Fe/Ni	Time of Sampling	% Lindane degradation
1	10 mg	1 min	Nil
		3 min	Nil
		5 min	12.0
		7 min	55.0
2	50 mg	1 min	10.0
		3 min	84.0
		5 min	99.0
		7 min	99.0
3	100 mg	1 min	92.1
		3 min	94.0
		5 min	100.0
		7 min	-

TECHNOLOGY READY FOR SCALE-UP AND COMMERCIALIZATION

RAPID DEGRDATION OF PESTICIDE RESIDUES

Catalytic degradation of a recalcitrant chlorinated pesticide- lindane using biopolymer-stabilized iron-sulfide nanoparticles

Sci. Technol. Adv. Mat. 6:370, 2005
Indian Pat. No. 1242/MUM/2006

Reductive dechlorination of lindane with Fe-Pd bimetallic nanoparticles and azo dyes with Fe-Ni nanoparticles

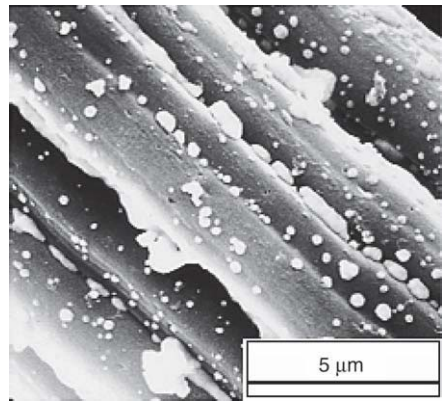
J. Haz. Mater, 175, 680, 2010

Env. Sci. Technol. 41:7437, 2007

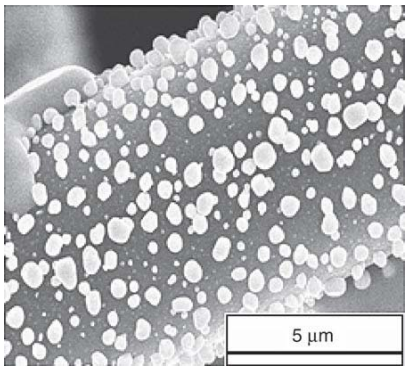
Appl. Catal. B 79:270, 2008

NANOMETALLIC PARTICLES FOR WATER DISINFECTION

- Silver (Ag),
- Copper (Cu),
- Zinc (Zn),
- Titanium (Ti)
- Cobalt (Co)
- New combinatorial oligodynamic materials
  Ag deposited on titanium oxide
  Ag-coated iron oxide



SEM: Silver deposited on activated carbon



SEM : Silver impregnated Glass fibres

MODE OF ACTION OF SILVER

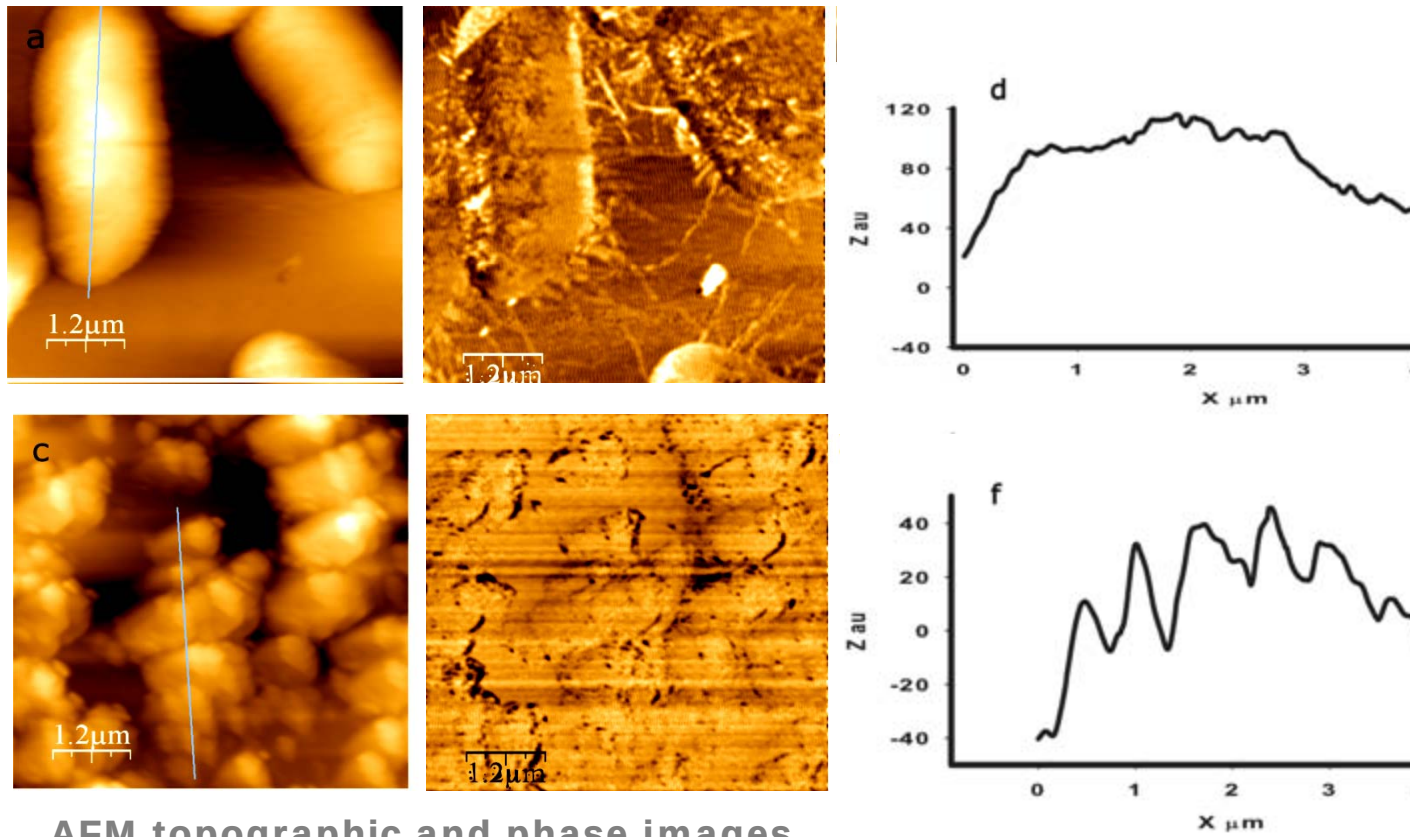
1. Reaction with thiol groups.
2. Reaction with amino acids and proteins.
3. Binding to critical enzyme functional groups.
4. Inhibition of the cellular respiratory chain.
5. Inhibition of cellular phosphate uptake.
6. Binding/densification of DNA.

Oligodynamic nanometallic particles may prove cost effective disinfection agents

ANTIMICROBIAL ACTION OF SILVER NANOPARTICLES

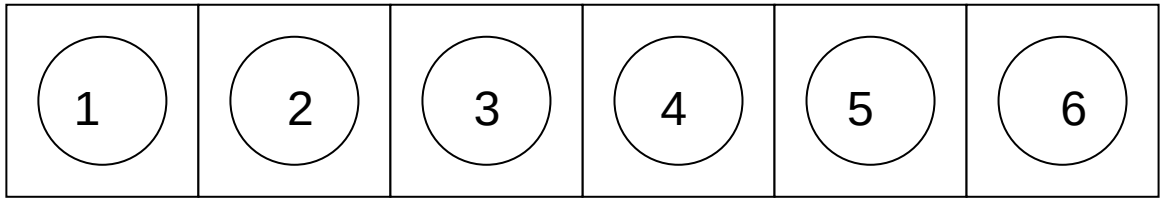
control

Ag_{nano} treated



AFM topographic and phase images and corresponding surface profile

Rapid detection of bacteria and their toxins

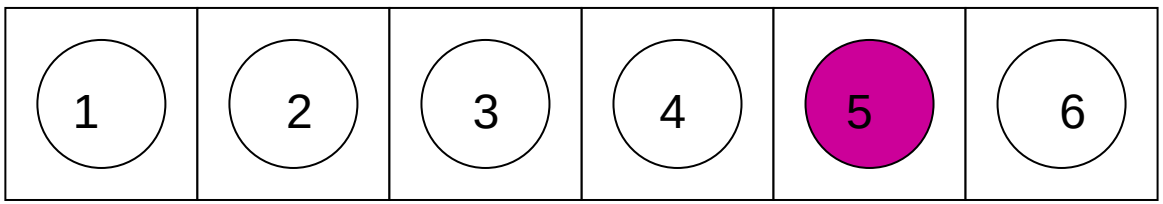


Nitrocellulose paper spotted with antibody 1-anti *S. typhi*, 2- anti *V. cholerae*, 3- anti *Shiga* toxin, 4- anti *Clostridium* toxin, 5- anti-*E.coli*, 6- control

Immerse in water sample

Treat with nanogold tagged antibody mixture for 20 min

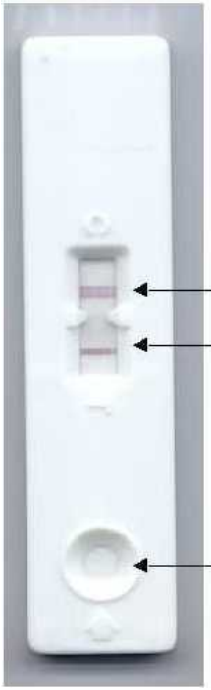
Wash off excess reagent



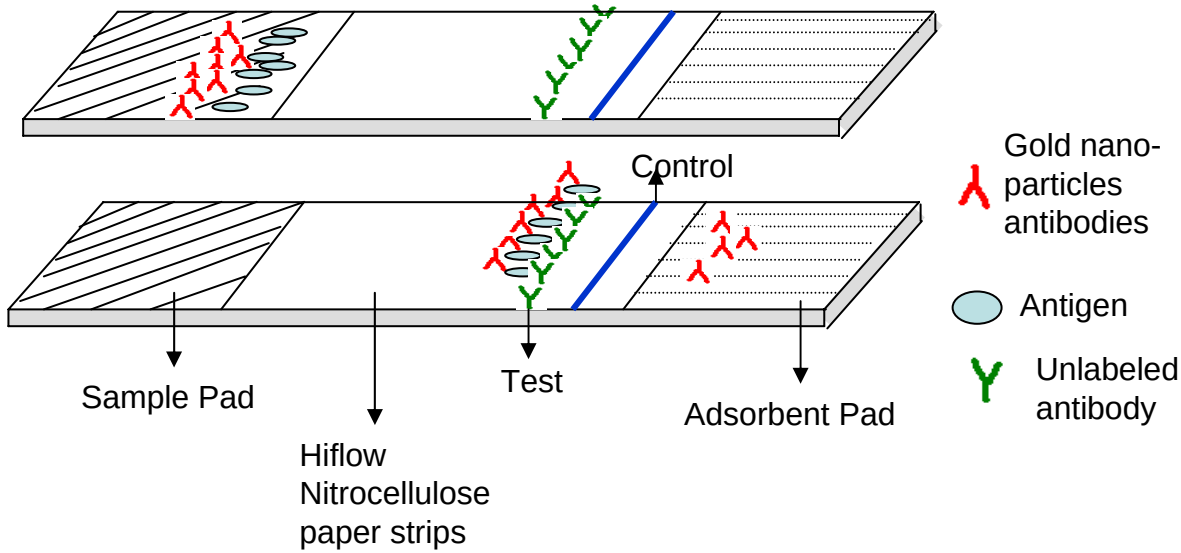
Detection of biothreat agent

Color development indicates presence of *E. coli* in water

DEVICES FOR THE DETECTION OF PATHOGENS



Lateral flow immunochromatographic device for **point-of-care testing**
Visual detection with **gold nanoparticles** as label



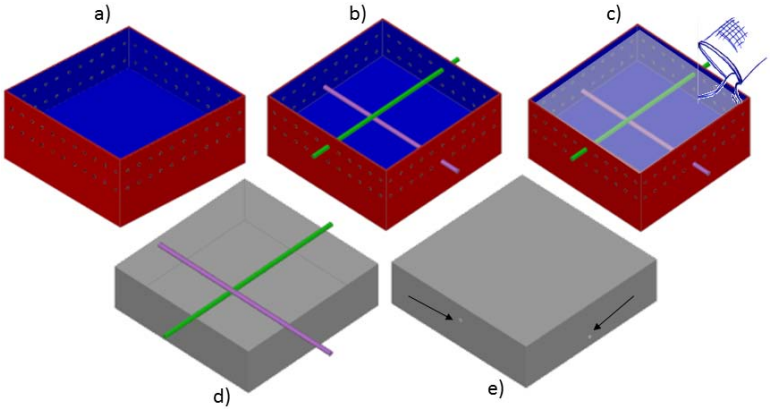
Advantages

- **Does not usually require extensive and destructive sample preparation**
- **Simple**
- **Robust**
- **Fast (detection time ~20 min)**
- **Visible reaction**

PROTOTYPE DEVELOPED

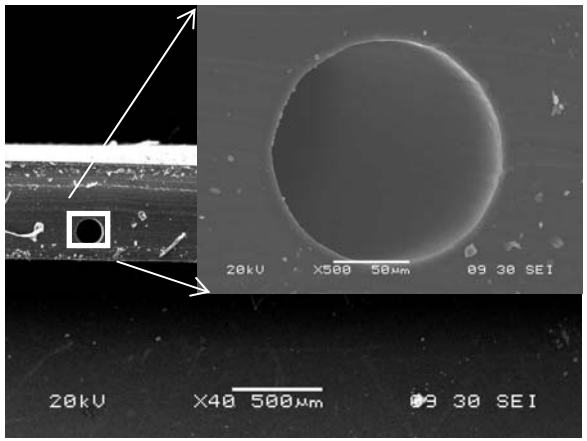
Our collaborators at NIV, Pune have successfully used nanogold conjugates (synthesized at ARI) in detection of Chandipura and Chicken guinea virus (1000 PFU/ml serum) from samples in disease affected areas.

MICROFLUIDIC IMMUNOSENSOR

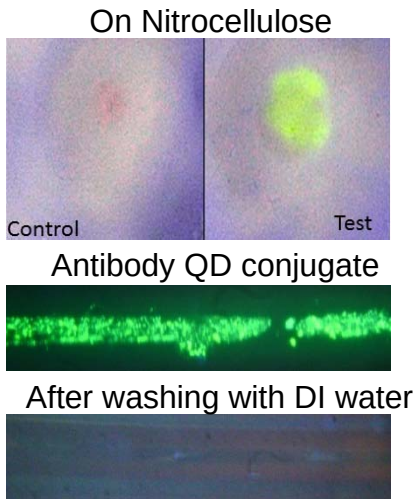


Fabrication steps: a) Device used for clamping micro-dimensional wires and molding PDMS; b) Copper wires clamped in the device; c) For microchannel fabrication liquid PDMS is poured; d) Cured PDMS with wires is demolded form the device and e) 3D microchannels fabricated after drawing the wires out from PDMS

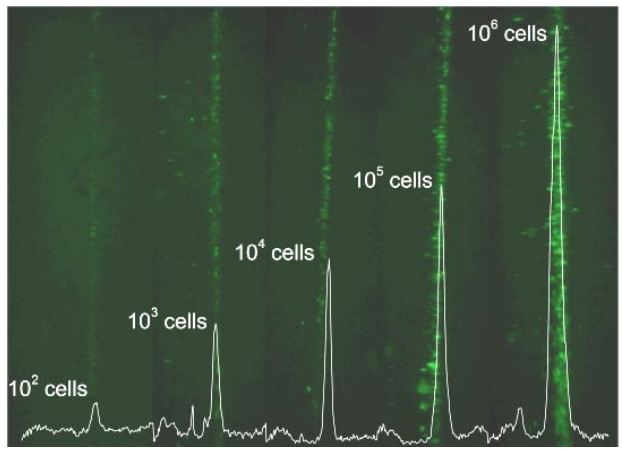
a) CAD image of the 3D microchannel; b) Optical image of fabricated 3D microfluidic device in PDMS; and c) Optical image of the 3D microchannel moulded in PDMS–higher resolution



SEM of 3D microchannel (inset higher magnification)



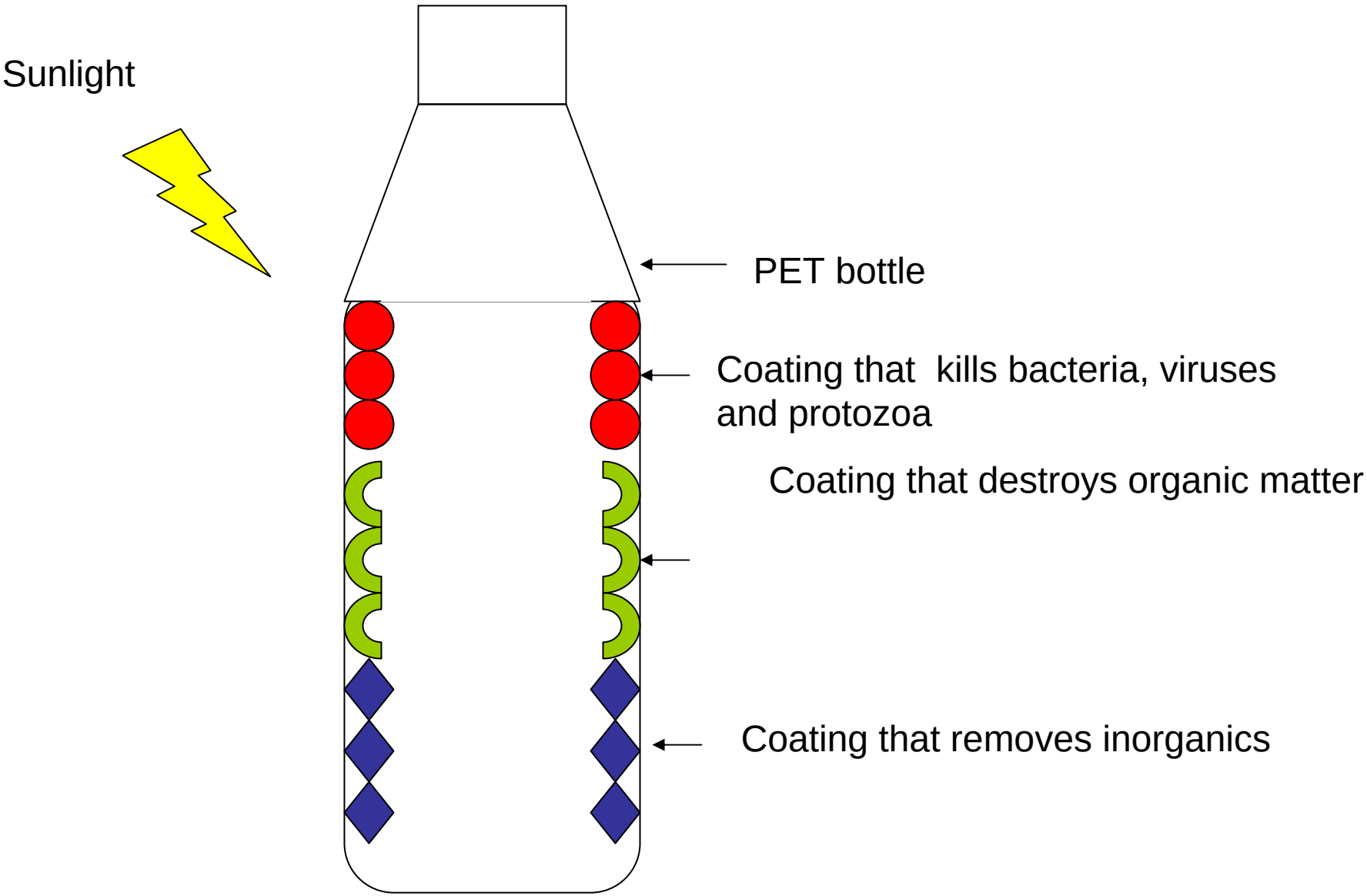
Control Experiment



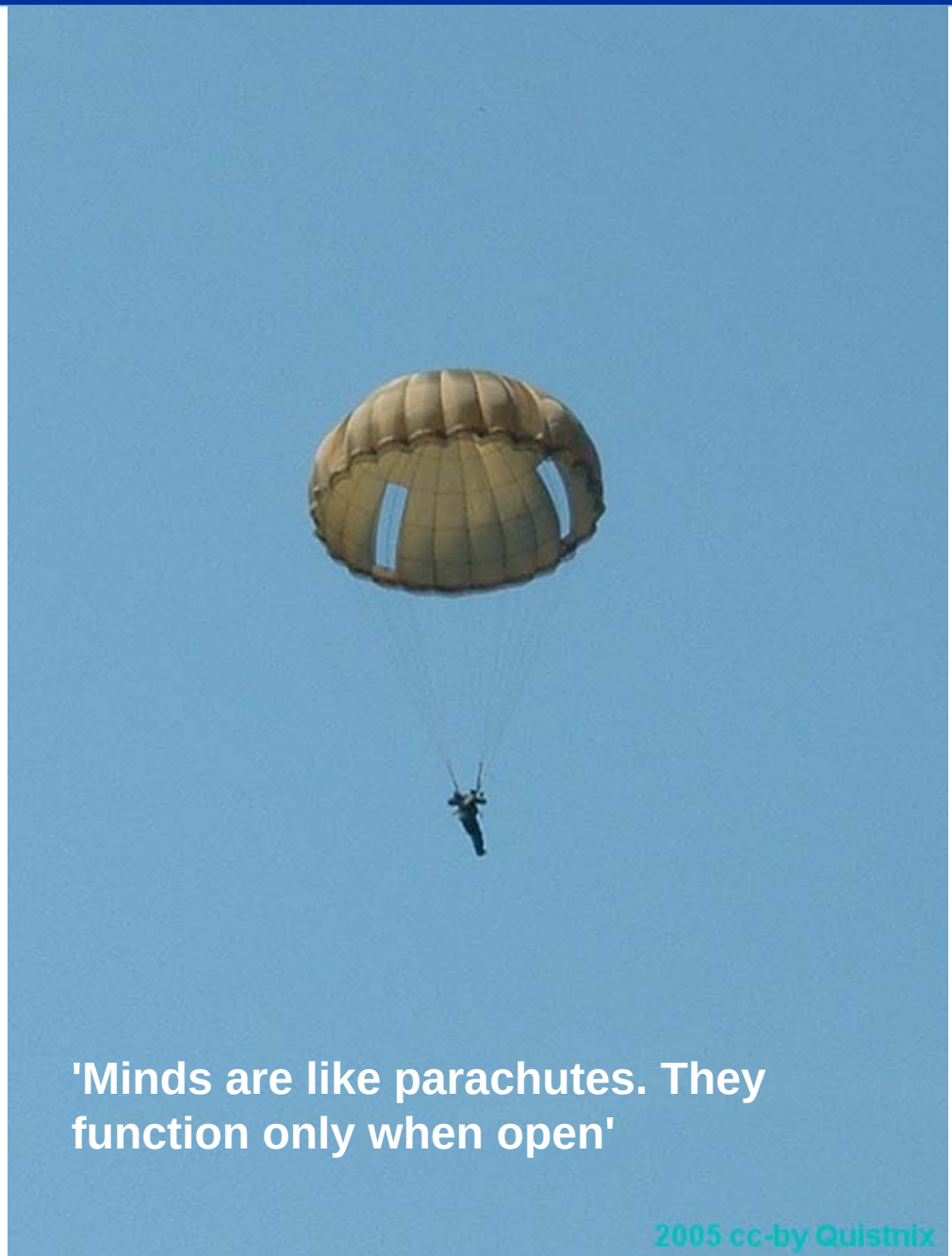
Fluorescence image of different concentration of E. coli captured PDMS-IgG labeled with QD-antibody conjugates in different microchannels. The overlap graph shows increase in fluorescence intensity with increase in cell count.

Biosensors & Bioelectronics 26: 3050 (2011)

Personal water treatment system



AN OPEN MIND NURTURES SCIENTIFIC THINKING



THANK YOU !

My Email: kpaknikar@gmail.com

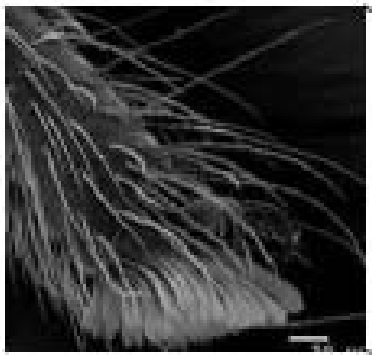
Nanosilver-coated Ceramic Candle Filters for Drinking Water Disinfection

Tata Narasinga Rao
Head,
Center for Nanomaterials
E-mail: tatanrao@gmail.com

International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Balapur Post, Hyderabad-500005, India

Responsible Nanotechnology

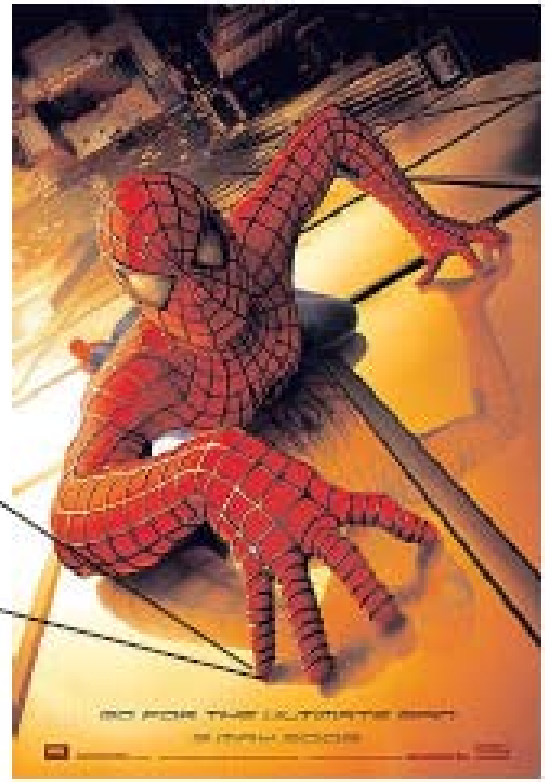
"With Great Power, Comes Great Responsibility"
Uncle Ben to Peter Parker in Spider Man



Nanoscale fibers on spider feet

(Dr. Nigel Walker, NIEHS NTP)

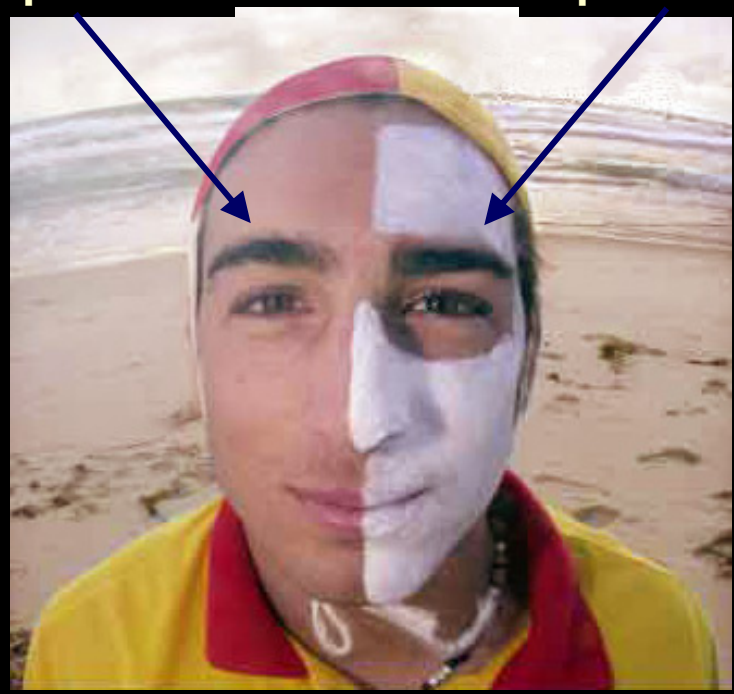
Paul Hermann Muller
Thomas Midgley



Which Sunscreen Should You Use???

Nanosized ZnO particles

Large ZnO particles

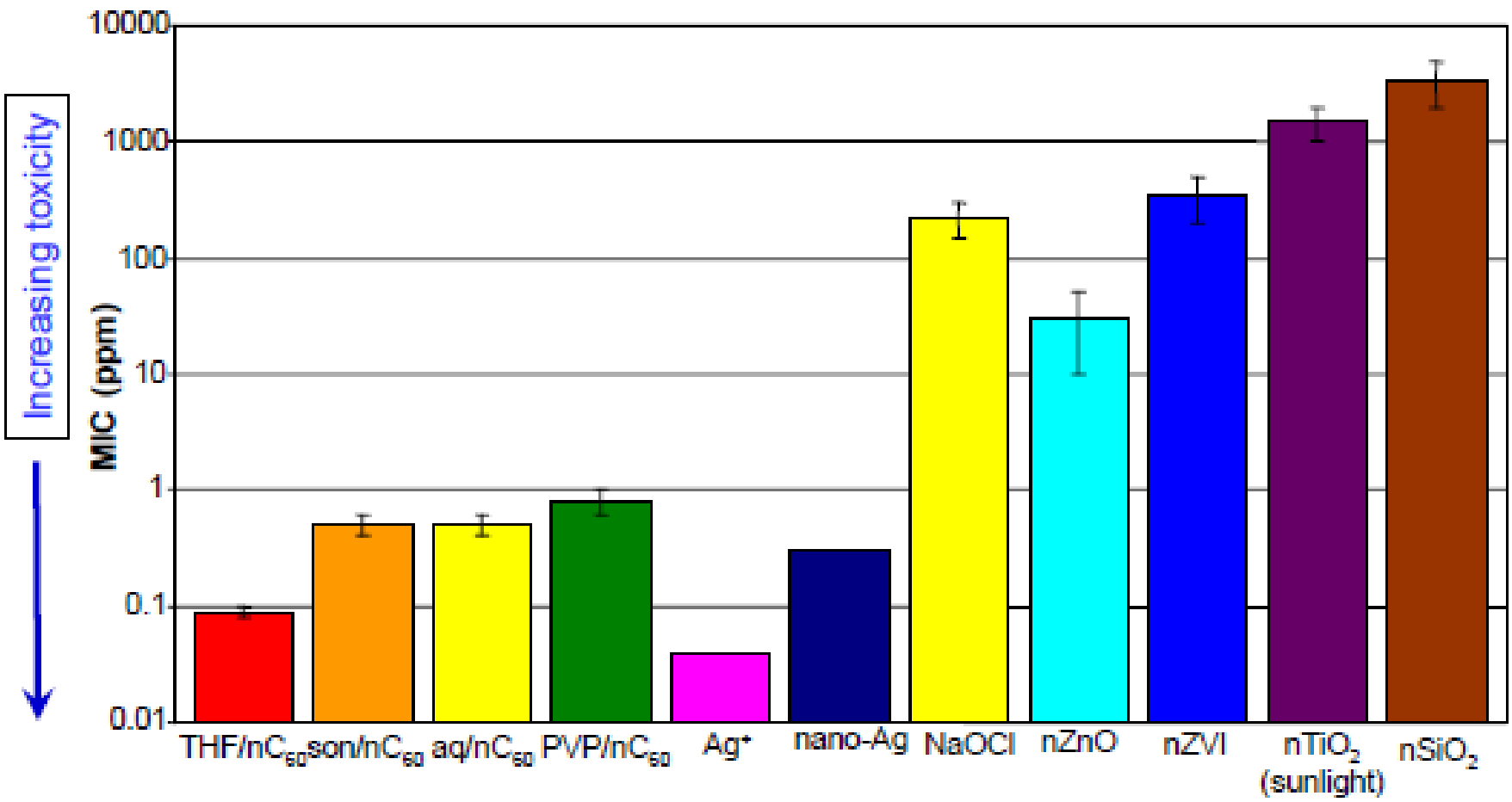


Nano-Z

hildre

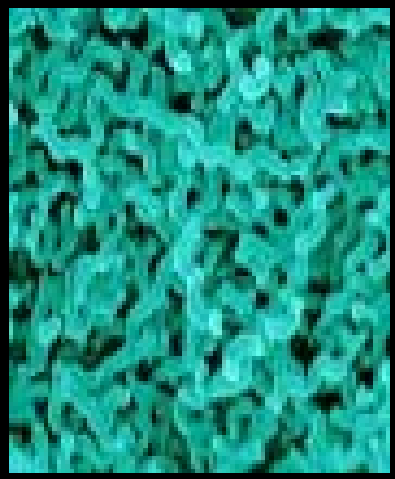
Clear

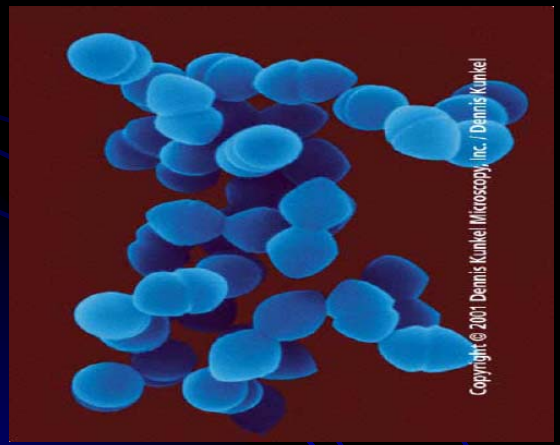
Toxicity of common nanomaterials to bacteria



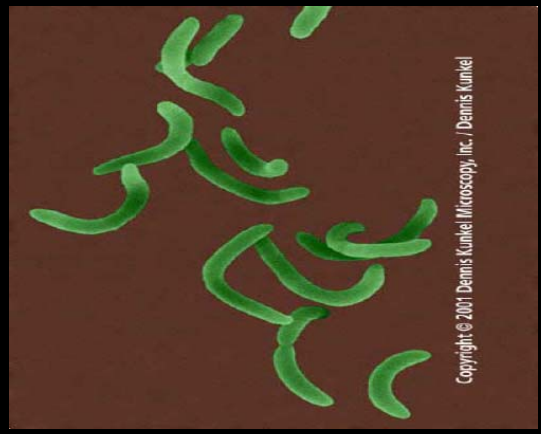
Bacteria are very diverse

E.g. Salmonella typhi –
Gram-negative, enteric,
causes typhoid fever



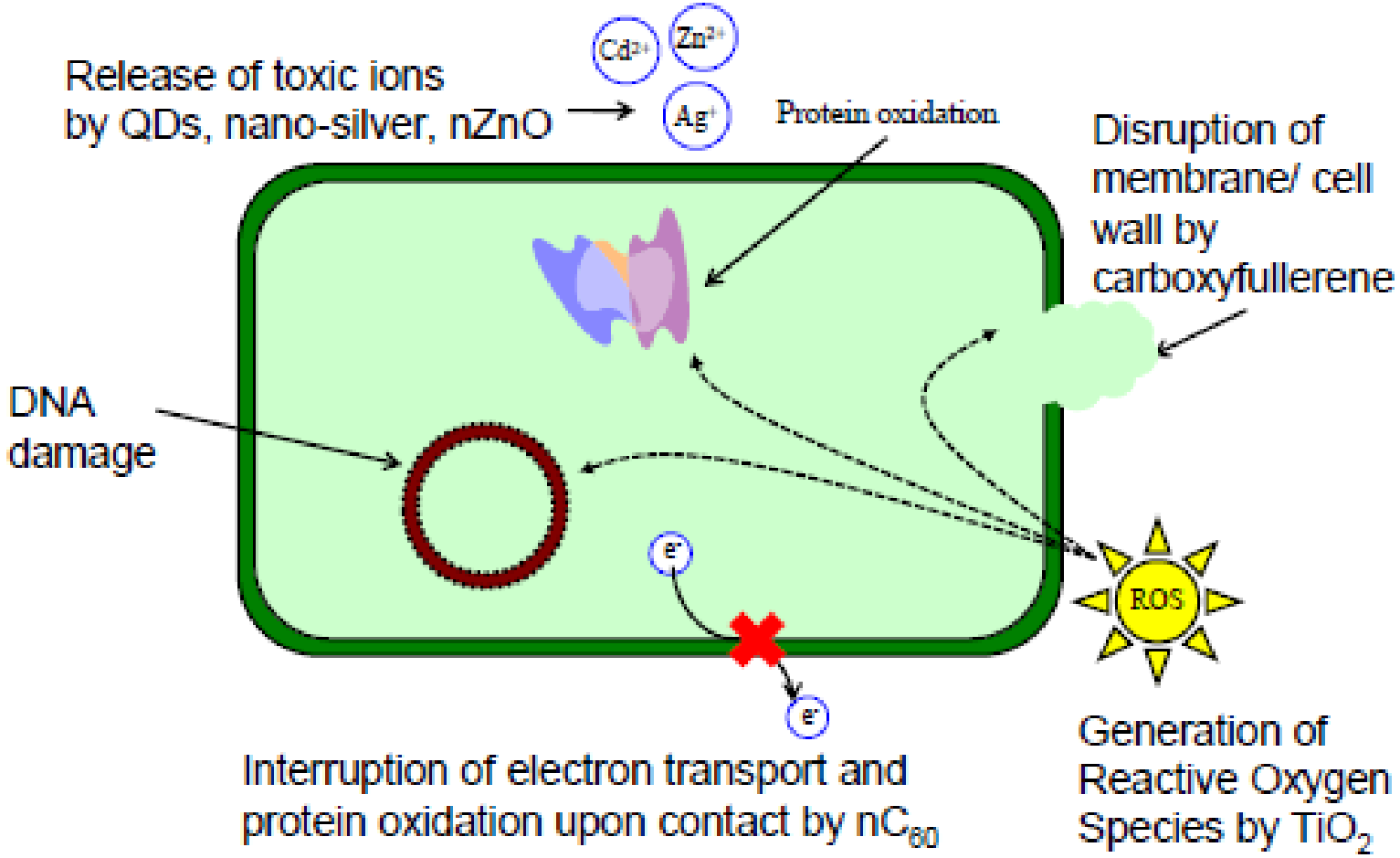


E.g. Enterococcus faecium –
Gram-positive,
causes skin and wound infections



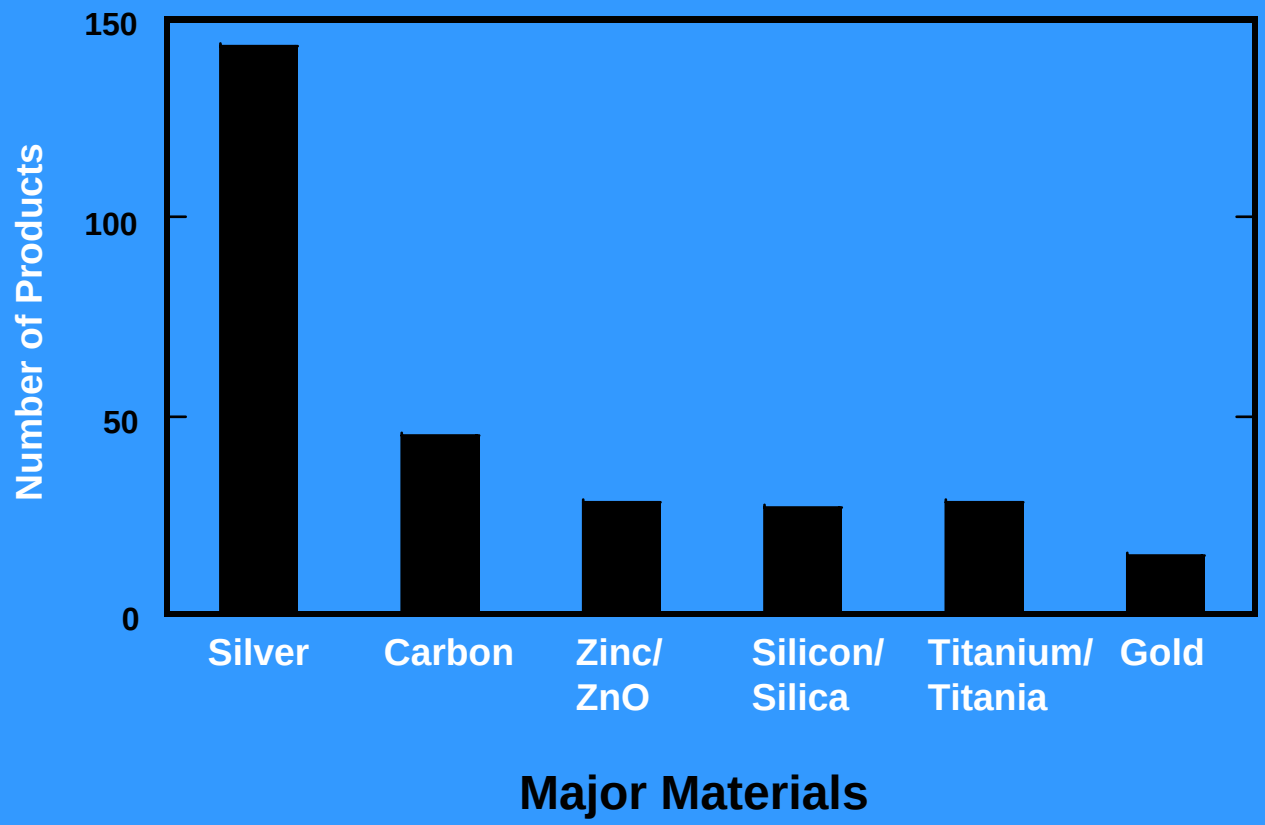
E.g. Vibrio cholerae –
Gram-negative,
causes Asiatic cholera

Bacterial Toxicity Mechanisms




Potential Leapfrogging Opportunities
for Microbial Control and Disinfection

Consumption of Nanomaterials in products



Nanosilver in home appliances

SAMSUNG, KOREA

Other applications

Tooth Paste

Nanogist Co., Ltd., Korea

*Nanosilver incorporated tooth paste

*prevents gums inflammation, periodontitis, periodontal disease

Pogene Co., Korea

•It prevents pollutants including nicotine stick to the teeth.

• It also eases toothache penetration when we eat something cold.

Nanosilver in cosmetics

Dongyang Nano Tech Co., Ltd., Korea
- Including nano silver particle
- Super sterilizing effect
- Face wash appropriable beauty soap
- Impact upon dimple and skin trouble
- Natural sterilizing by silver corpuscle, harmless to human

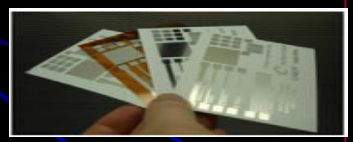
Nanogist Co., Ltd., Korea
- Maintains hair and scalp healthy and clean.
- Vanishes scalp infection caused by epiphyte.
- Diminish bacteria and inflammation.
- Eliminates dandruffs and relieve itching.

Nanosilver related projects
(Based on ARCI synthesis process)

Antibacterial textiles
(RESIL Chemical Pvt. Ltd.)

Ceramic candle filters
For drinking water disinfection
SBP Aquatech. Pvt. Ltd.

Medical devices (catheters)
(RELISYS Medical Devices Ltd.)



Printable Electronic Inks

Latex products

Community water filters
(Bigger tanks, Syntex type)

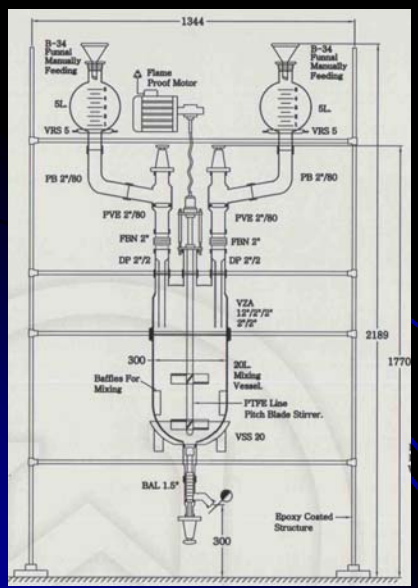
High through put filters
(For hotels, Apartments etc.,)

p-scaling of nanosilver synthesis for antibacterial textile applications (ARCI-RESIL project)

Resil's Requirement

- 0.01 - 0.05 wt % nanosilver suspension stable for 9 months
- Stability of the suspension at 6000 rpm centrifuge
- Suspension stability with tap water dilution
- Stability in contact (reaction) with the plastic containers
- Stability upon tansport (shaking and foaming) conditions
- Upscaling of the production **tons/month** level

UV- Visible spectra for nano silver suspension before and after **6000 centrifuge** (no change in spectrum)

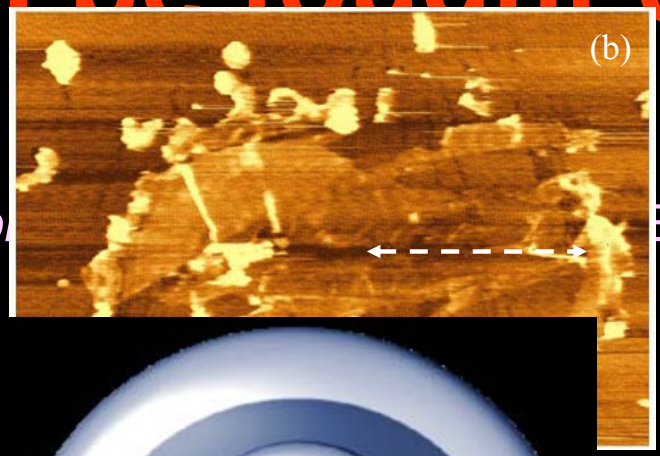


Reactor design (ARCI-Sigma Scientific)

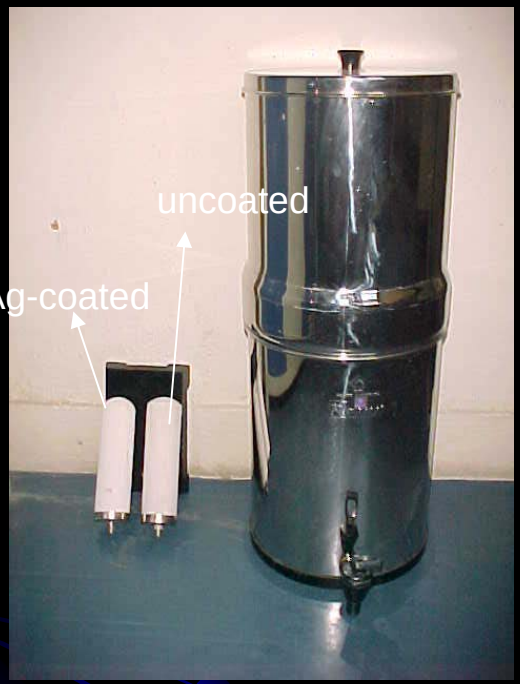
Batch type reactor with 15 L/h production capacity at ARCI (Produced **1000 L** suspension and supplied to Resil at cost)

The wars ... nty-first century will be fought over water

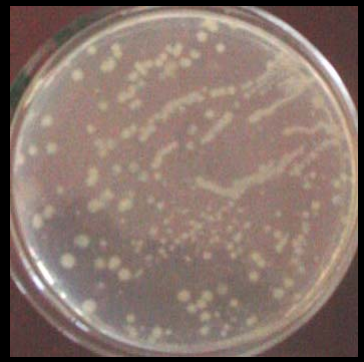
Ismail Serageldin, Wo... Environmental Affairs



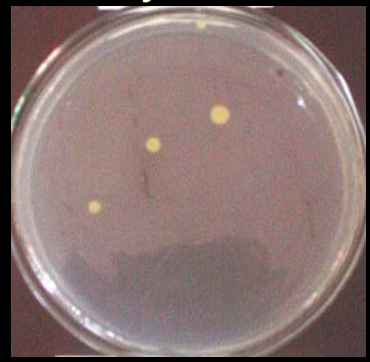
ARCI-filters for drinking water



Antibacterial activity



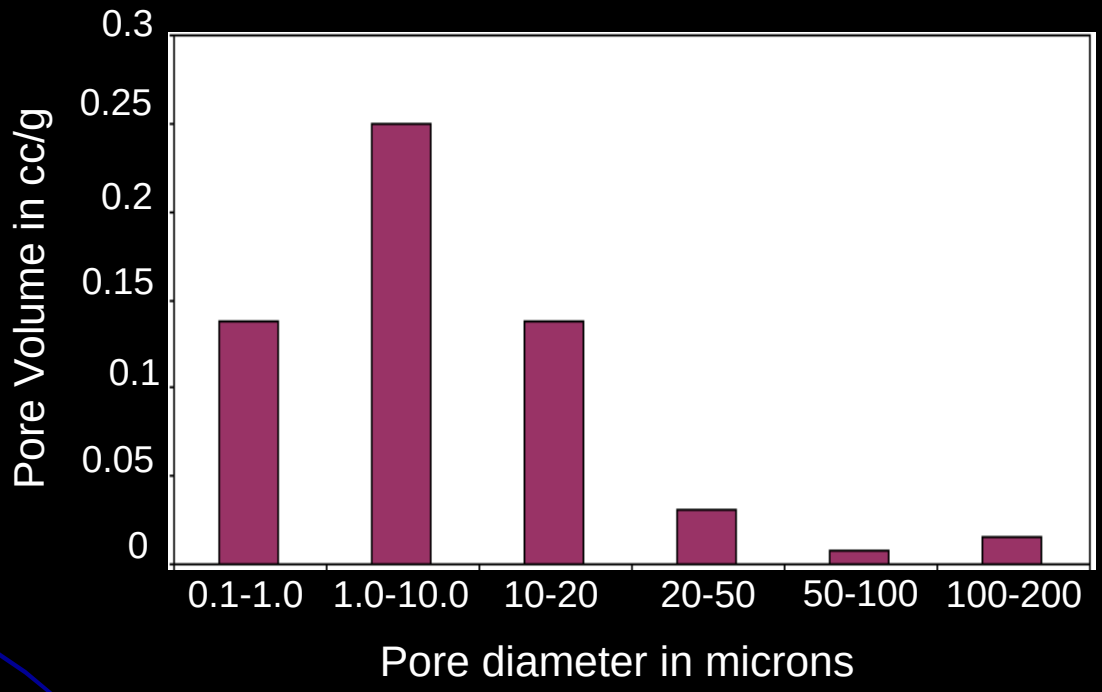
Before filtration



After filtration

Cross section view

Porosity of the ceramic candle filter



- Water throughput is 1-2 L / h
- No significant change in porosity due to silver
- Very good adherence of silver to candle
- Long time antibacterial activity

ARCI-Byrraju cooperation for field-testing of filters

Byrraju Foundation:

- A non-profit organization dedicated to rural transformation
- Working in 152 villages in Andhra Pradesh
- Provides access to safe drinking water
- Tests carried out by the foundation in 150 villages showed 94% of them failed in quality standards
- Ozonization, UV treatment and membrane filtration have been used for water treatment


Water pond in village


Sujala Water Plant

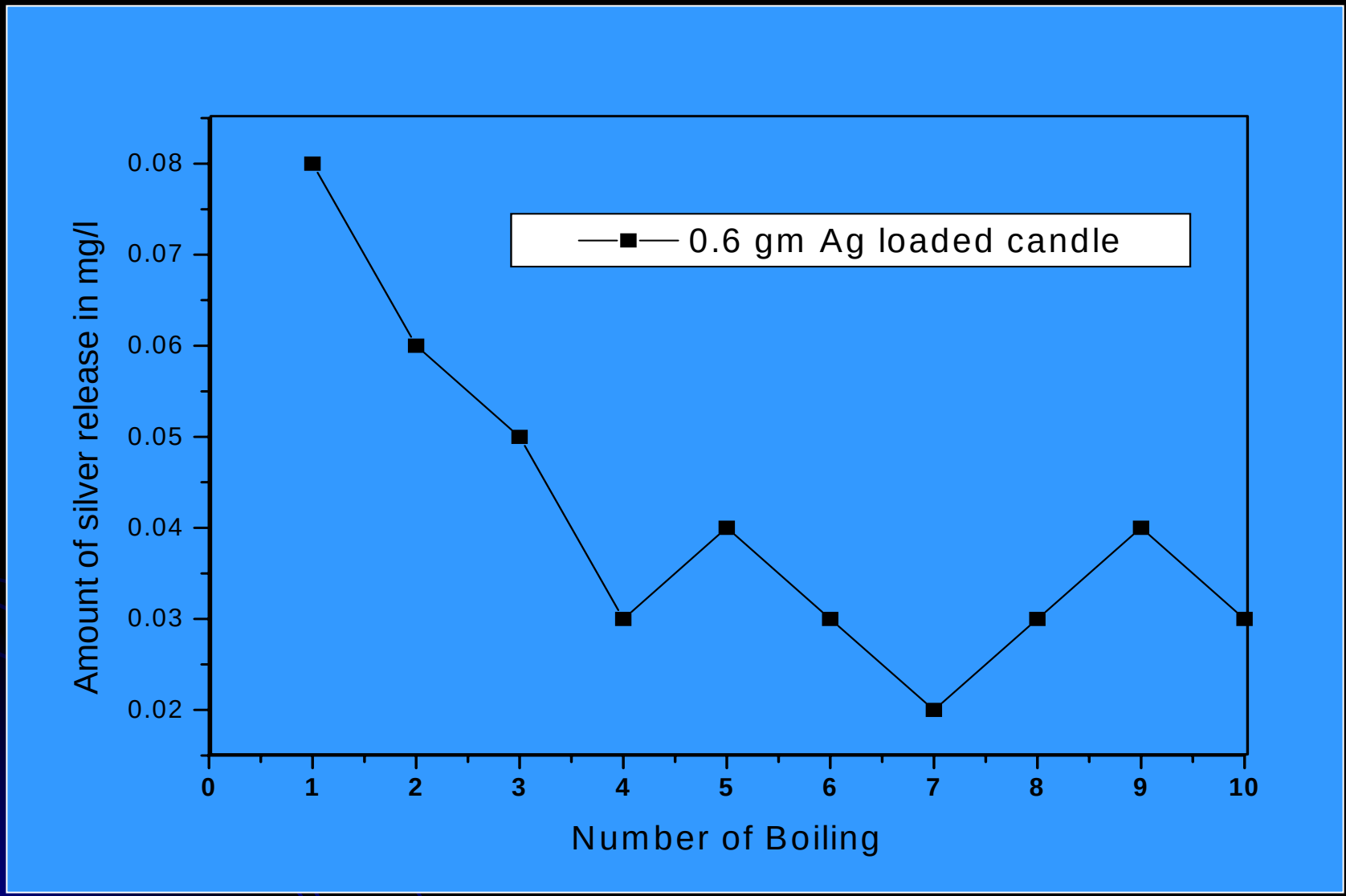

Water Testing Laboratory


Water Distribution

DATA from field trials

Name of the village	Date	Filter	Source	28h	48h	72h
Vempadu	2-01-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	2-02-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	2-03-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	2-04-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	2-05-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	2-06-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK
	28-07-07	Filter1 Filter2	Tap Tank	OK OK	Present OK	Present OK
	30-07-07	Filter1 Filter2	Tap Tank	OK OK	OK OK	OK OK

Accelerated test for silver leaching



- WHO allowed limits: 0.1 mg/Lit

1	Byraju foundation after one year	Ppm	0.01476
2		Ppm	0.01432
3		Ppm	0.01413
4		ppm	0.01443

Freshly prepared candles

Sample code 5 - D

1	First filtered water	ppm	0.067
2	Second filtered water	ppm	0.020
3	Third filtered water	ppm	0.036
4	Fourth filtered water	Ppm	0.056
5	Fifth filtered water	Ppm	0.045

WHO allowed limits: 0.1 mg/Lit (high doses cause argyria)

The EPA's critical dose for (Colloidal silver) a 160 lb. adult is 1.09 milligrams daily.

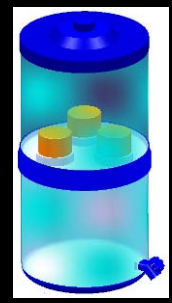
MASS SCALE PRODUCTION


Puritech
NANO SILVER CERAMIC CANDLE
Puritech
SBP
Puritech
STAINLESS STEEL WATER FILTER
WITH NANO SILVER CEREMIC CANDLE
Ensures Every Drop is Purified
Puritech
Puritech
BACTERIA FREE
DRINKING WATER
Visit us at:
www.sbptechnology.com

‘TERAFIL’- Red clay filtration media (disc)

Institute of Mineral and Material Technology (**IMMT**), Bhubaneswar

- **TERAFIL – Burnt porous red clay media (disc), used for filtration and treatment of both surface & ground raw water into clean drinking water.**
- **Materials of TERAFIL: Red clay (pottery clay), sand, wood saw dust**



For treatment of ground water:-

Quality of product water:-

- **Turbidity : Within BIS limits**
- **Bacteria : Within BIS limits**
- **Iron : Within BIS limits**
- **pH : Within BIS limits**

- **Cost of product water: Rs.2/- per ton**
- **Life of Terafil filtration disc: 5 years**
- **Life of Terafil stand-alone plant: 10 yr.**

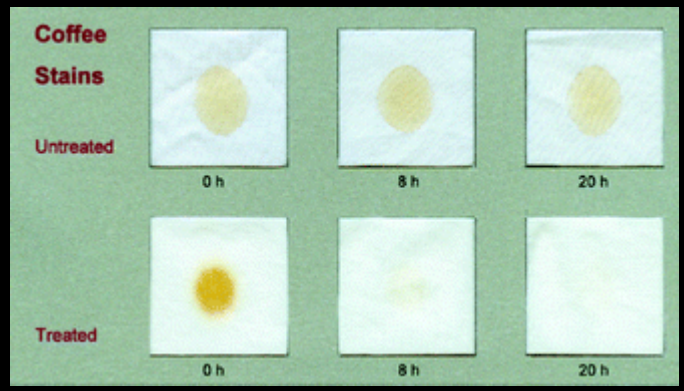
Nano-titania for self-cleaning textiles

ARCI TiO_2 suspension

Self-cleaning cotton

Kaihong Qi, Walid A. Daoud, John H. Xin, C. L. Mak, Waisze Tang and W. P. Cheung

Mater. Chem., 2006, **16**, 4567 - 4574, **DOI:** 10.1039/b610861j

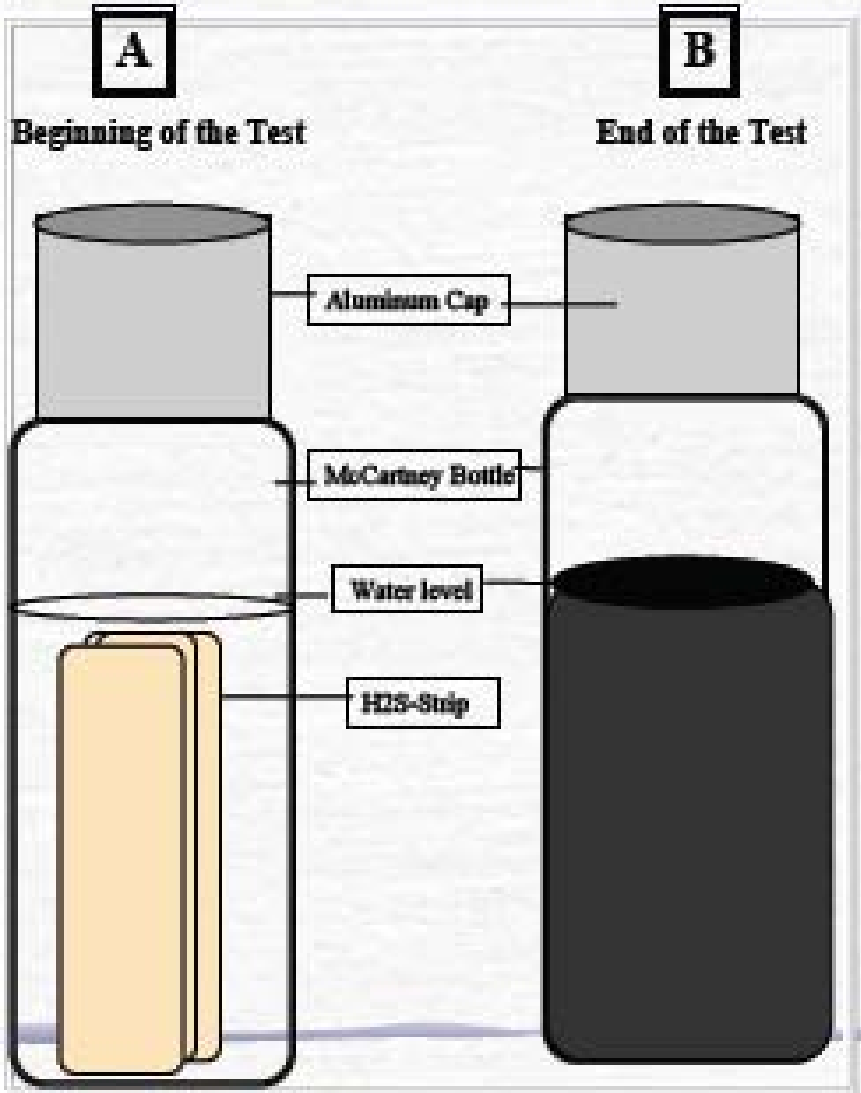


It's a fact of life: your clothes get dirty and *smelly* and they need to be washed.

"What a boon it would be to college life if your clothes would keep themselves clean"

Perhaps one day soon, college students will be able to do their laundry just by going for a walk in the sun.

H2S- STRIP TEST: PROCEDURE



1. Fill the vial with water to be tested, up to the arrow mark, and replace the cap.
2. Keep in a warm place, preferably 30-37^0 C, for 24-36 hr.
3. Observe for blackening of the contents.
4. If turns black, it is likely that water is not fit for drinking.

COMPOSITION OF H_2S-STRIP MEDIUM*

- Peptone ... 20 g
- Dipotassium Hydrogen PO_4... 1.5 g
- Ferric Ammonium Citrate ... 0.75 g
- Sodium thiosulphate ... 1 g
- Teepol ... 1 ml
- L- Cystiene HCl ... 0.25 g
- Water ... 50 ml

* Concentrated 20x

H_2S- STRIP TEST

- EASY TO PERFORM
- USER-FRIENDLY
- SCREENING TEST
- SUITABLE FOR HANDLING BY UNTRAINED PERSONNEL
- FOR COMMUNITY PARTICIPATION
- AS A SCREENING TEST IN MONITORING OF RURAL DRINKING WATER SOURCES
- LOW-COST RAPID TEST