

**DIRECTORATE OF ADVANCED STUDIES
EVENT CATALOGUE
2021**

16TH SEMINAR OF DAS EVENTS CALENDAR – 2021

**EMERGING NANOMATERIALS FOR WATER
PURIFICATION: A PERCEPTION OF LAB TO PRODUCTS
CHAIN**



16th Seminar (Online through ZOOM) of DAS Events Calendar

**Emerging Nanomaterials for Water Purification:
A Perception of Lab to Products Chain**

Presenter: Dr. Muzammil Anjum

Assistant Professor, Department of Environmental Sciences

Dated: Thursday, July 15, 2021 Time: 02:00 p.m. - PKT GMT+5

ZOOM Meeting ID: 955 408 3170 - Passcode: 67890

Organized By: Directorate of Advance Studies, PMAS-AAUR

ACTIVITIES

**Water, water
every where but
not a drop to drink**

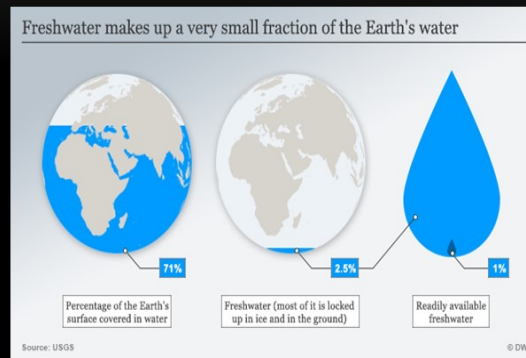
The Rime of the Ancient Mariner
Samuel Taylor Coleridge



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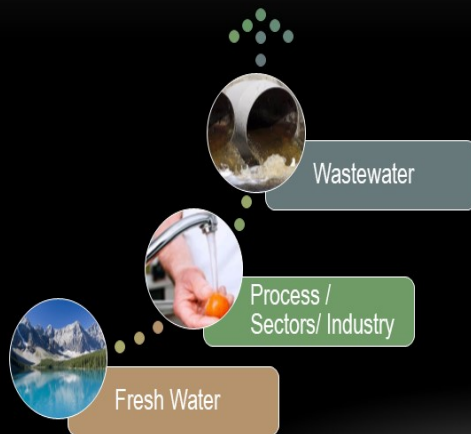
CAN WE USE ALL THE EARTH'S WATER ?

- ❑ **97.5%** of this water is salt water, leaving 2.5% as fresh water.
- ❑ Nearly **70%** of the fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture or as groundwater not accessible to human use.
- ❑ **Less than 1%** of the world's freshwater is accessible for direct human uses.

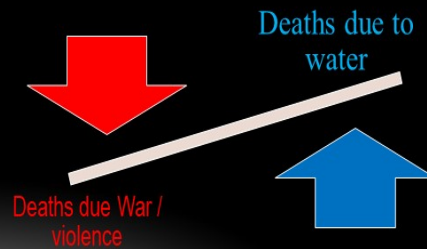


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PROBLEM OF THE CURRENT WORLD?



- This widespread problem of water pollution is **jeopardizing our health.**
- Unsafe water **kills more people each year** than war and all other forms of violence combined.



REASONS OF WATER SOURCE DEPLETION ?

- Increasing population high demand
- Climate change resulting in prolonged droughts and floods
- Pollution due to industrial process
 - Water toxicity due to organic pollutants, heavy metals etc.
- Lack of dams and water storage capacity specially in Pakistan perspective

UNSOLVED TECHNOLOGY PROBLEMS.....



Mercury contamination,
Minamata, Japan, 1956



Microbial
contamination,
Zimbabwe, 2009



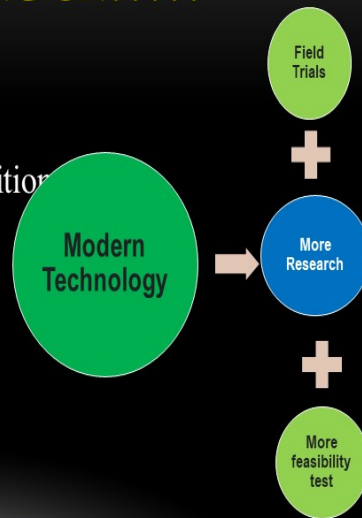
Pesticide
contamination,
Kerala, 2001



Fluoride contamination,
India, 2003

WHY RESEARCH IS STILL GOING ON?????

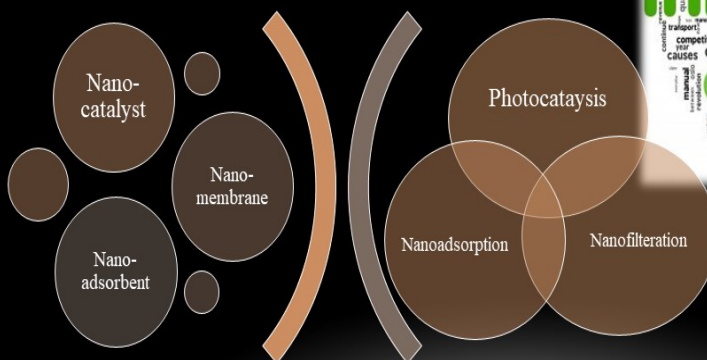
- ✓ Requirement of stable methods
- ✓ Day to day Change in wastewater composition
- ✓ Requirement of economical methods
- ✓ Requirement of effective methods
- ✓ Search for reliable methods



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INNOVATION

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers



Nanotechnology

**Nano-material based
wastewater Treatment**



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WHY TO USE NANOTECHNOLOGY IN WATER TREATMENT ?

Present scenario

- Current water treatment & distribution technologies concepts are mostly inefficient
- Draw backs include
 - Formation of DBPs during chlorination
 - Possibility of **contamination during water transport**
 - **High Cost** of operation during **RO** process
 - Low adsorption capacities.
 - Inability to **reuse Activated carbon** after one cycle
 - **Membrane fouling**

Problem associated with biological treatments

- Biological treatments are well known process, however, it has several disadvantage like:

Large sludge volume

Long Retention Time

Complex compounds

Lack of Specific
microorganism

Need for Process Improvement?

- ❑ Using of nano-materials to overcome the mentioned problems and improve the process efficiency
- ❑ The outcome could be;
 - Increasing the Biodegradation Digestion Efficiency
 - Lowering operational cost
 - Lowering the retention

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Our Contribution

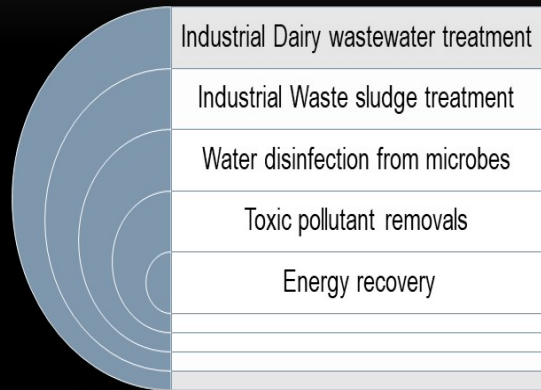
Research And Outcomes



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NANO-MATERIALS CATALYST SYNTHESIZED

- ZnO-ZnS@Polyaniline
- ZnO-ZnS/Ag₂O-Ag₂S
- Cr₂O₃/C₃N₄ (6M)
- C₃N₄/TiO₂ NT (2M)
- CuO-GO/TiO₂
- Ni(OH)₂/GO/TiO₂
- S-doped-rGO/ZnS

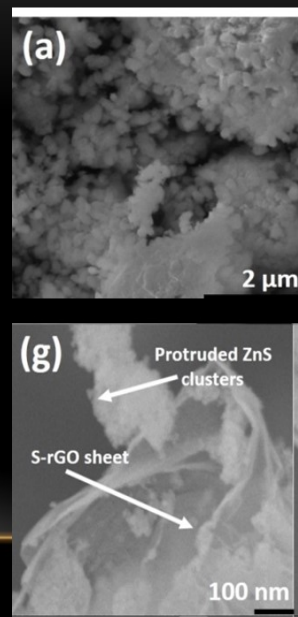
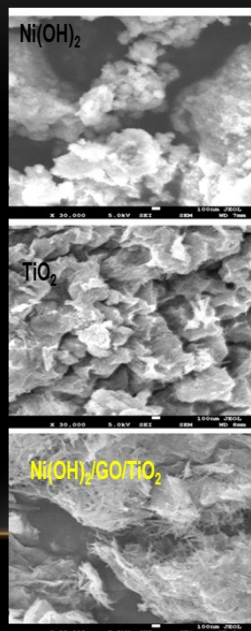
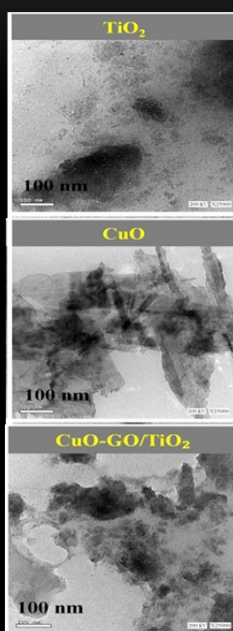


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NANO-CATALYTIC-AEROBIC TREATMENT INDUSTRIAL DAIRY WASTEWATER

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Scanning Electron microscopy (SEM)



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1-PHOTOCATALYSIS OF DW

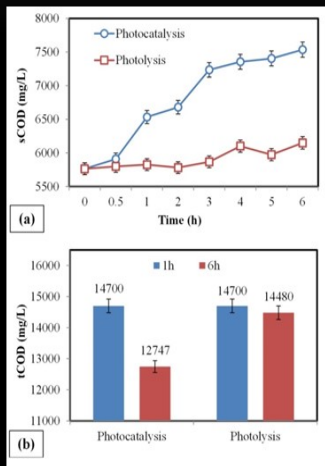
Photoreactor: Luzchem LZC-4 (Canada)



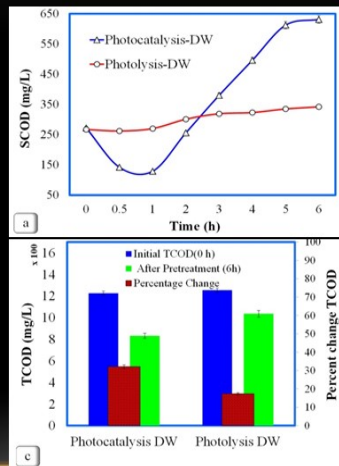
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SOLUBILIZATION OF DAIRY WASTEWATER

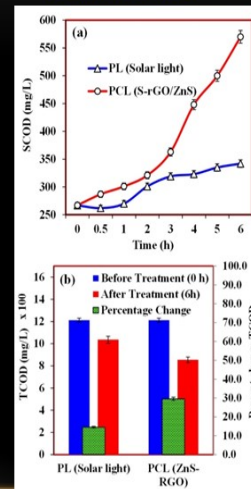
CuO-GO/TiO₂



Ni(OH)₂/GO/TiO₂



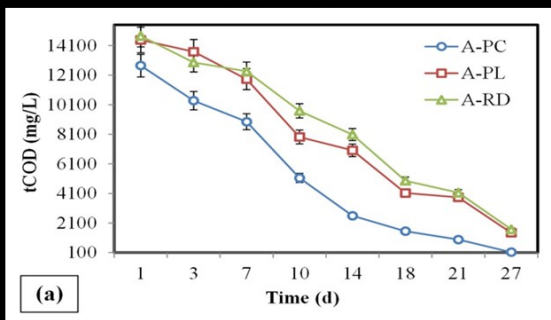
S-doped-rGO/Zn



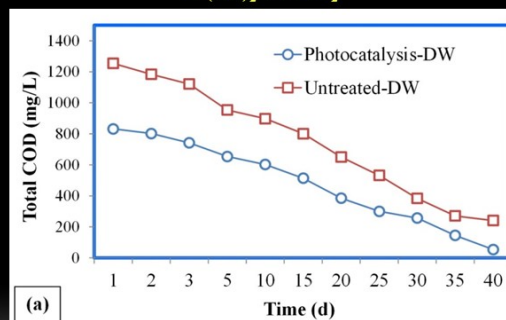
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Aerobic batch reactor COD Removal

CuO-GO/TiO₂



Ni(OH)₂/GO/TiO₂



Aerobic Digestion BioFlo*/Celligen 115 Bioreactor

Reactor Configuration

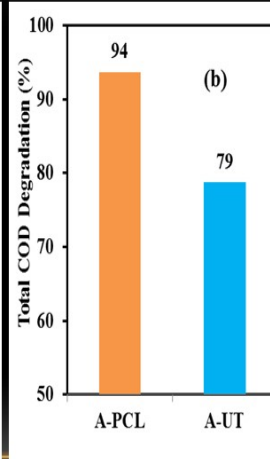
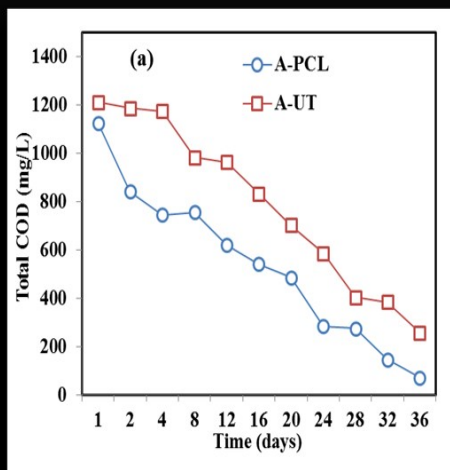
Solar photocatalytic reactor		Bioflo benchtop bioreactor	
Reactor type	Solar photochemical	Reactor type	BioFlo/CelliGen115 Benchtop Bioreactor
Reactor Mode	Batch	Reactor Mode	Batch
HRT	6 h	HRT	35 d
Working volume	4L	Working volume	4 L
Light	Visible Range (Solar)	Aeration	sparger
Catalyst type	ZnS/RGO	Inoculum	100 ml/L
Catalyst dose	0.5 g/L	Substrate: Inoculum	9.1
Temperature	Ambient outdoor	Temperature	35 °C
pH	5.7	pH	6.5
Agitation	150 rpm	Agitation	150 rpm



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COD Removal

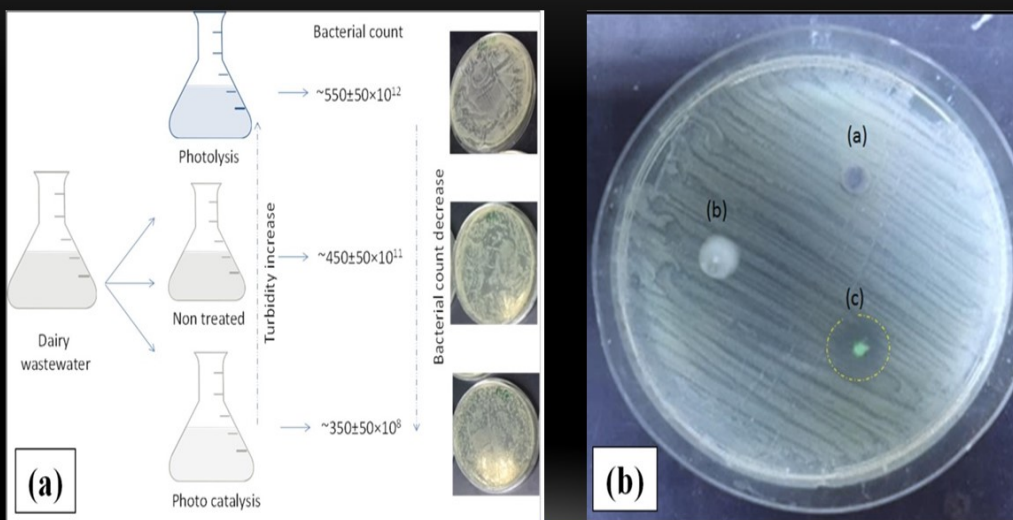
S-doped-rGO/Zn



20

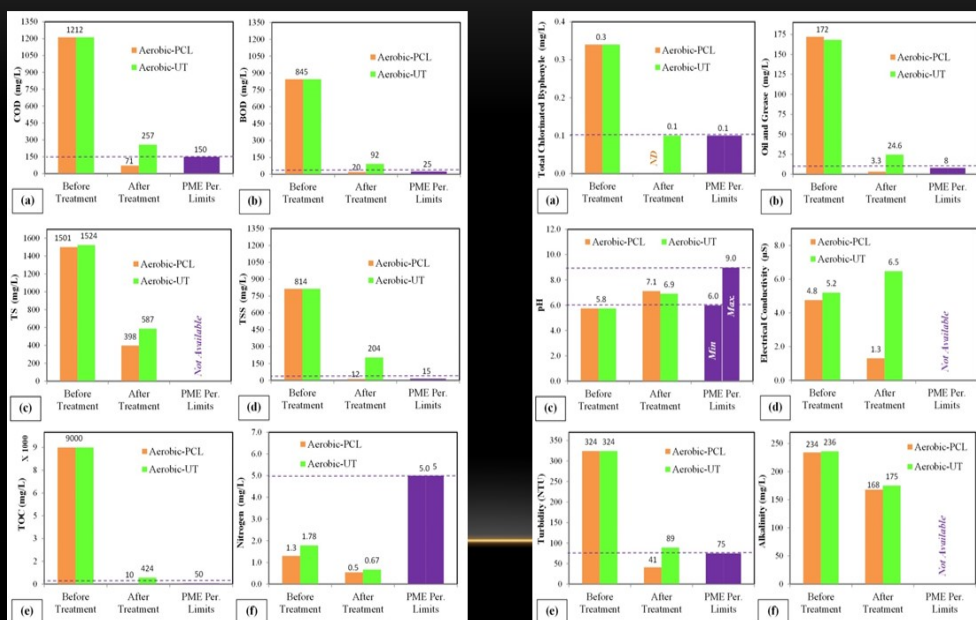
3- ANTIMICROBIAL PROPERTY

$\text{Ni}(\text{OH})_2/\text{TiO}_2/\text{GO}$



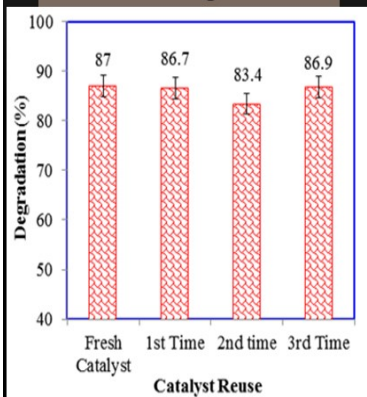
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WATER QUALITY ANALYSIS

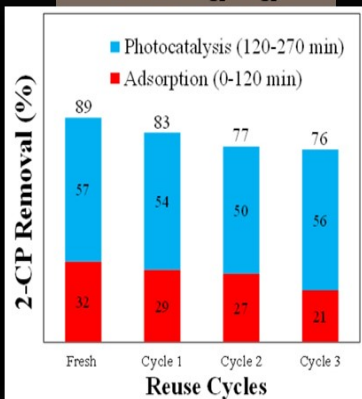


REUSABILITY

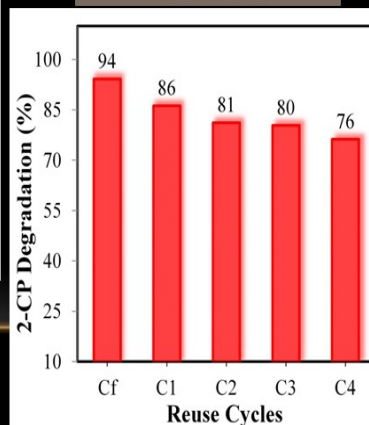
ZnO-ZnS@Pani



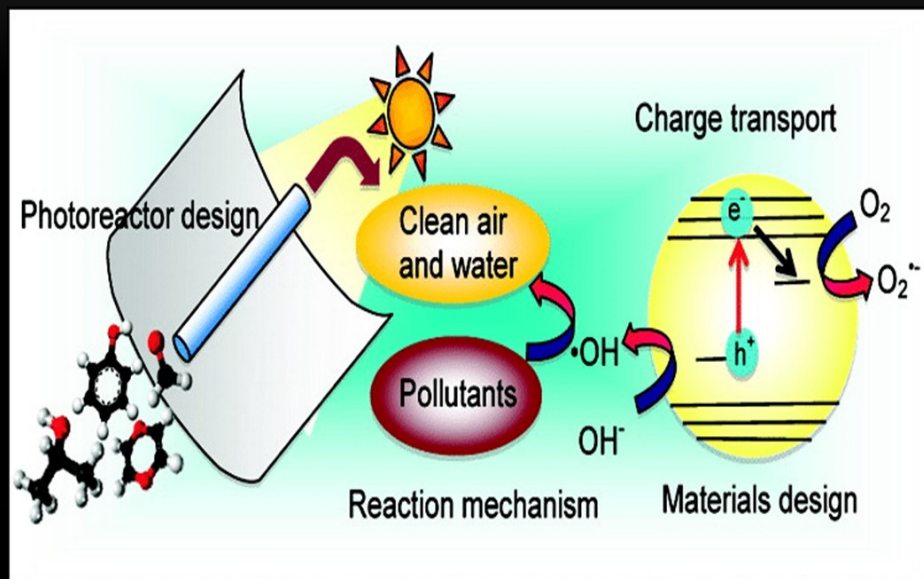
ZnO-ZnS/Ag₂S-Ag₂S



Cr₂O₃-C₃N₄



HOW IT WORKS ???

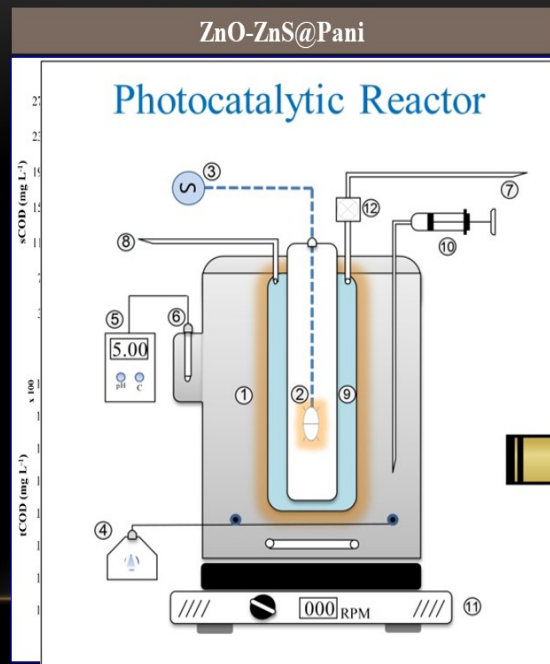


SOLUBILIZATION OF WASTEWATER SLUDGE

- Source of wastewater sludge
 - Sampling: Industrial City WW treatment plant, Jeddah
 - 550 industries
 - Connected with one central treatment plant
 - Sludge is highly complex
 - Photocatalysis: Luzchem photochem. reactor



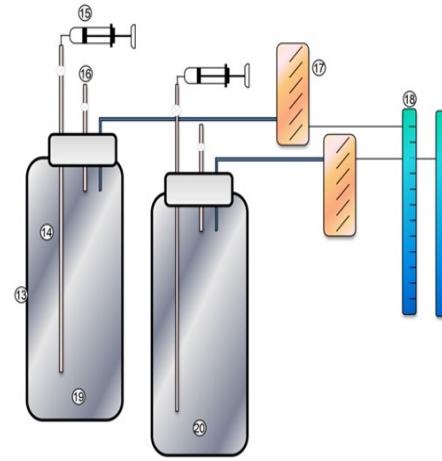
SLUDGE SOLUBILIZATION



ANAEROBIC DIGESTION OF SLUDGE

- Experiment:
Static Batch reactor
- Duration:
30-45 d
- Microorganisms:
Enriched Culture
- Source of Microbes:
Manure

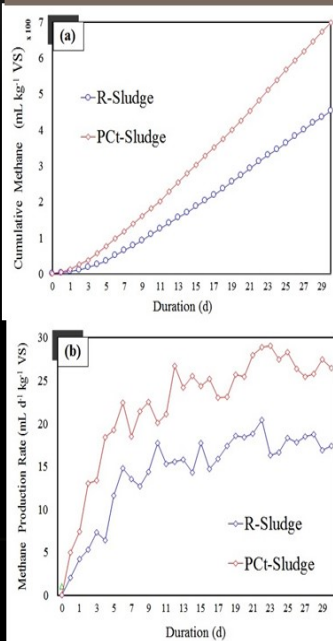
Anaerobic Reactors



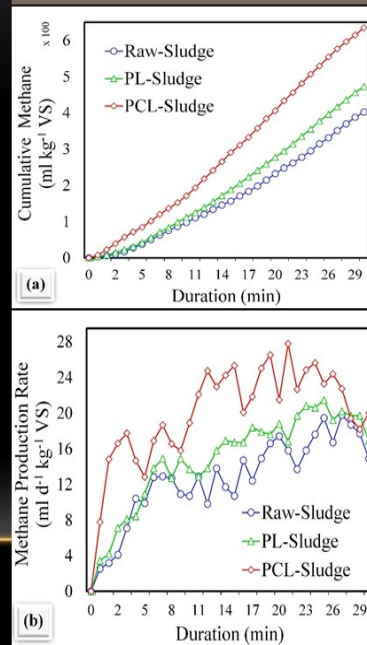
Experimental Setup

BIOGAS PRODUCTION

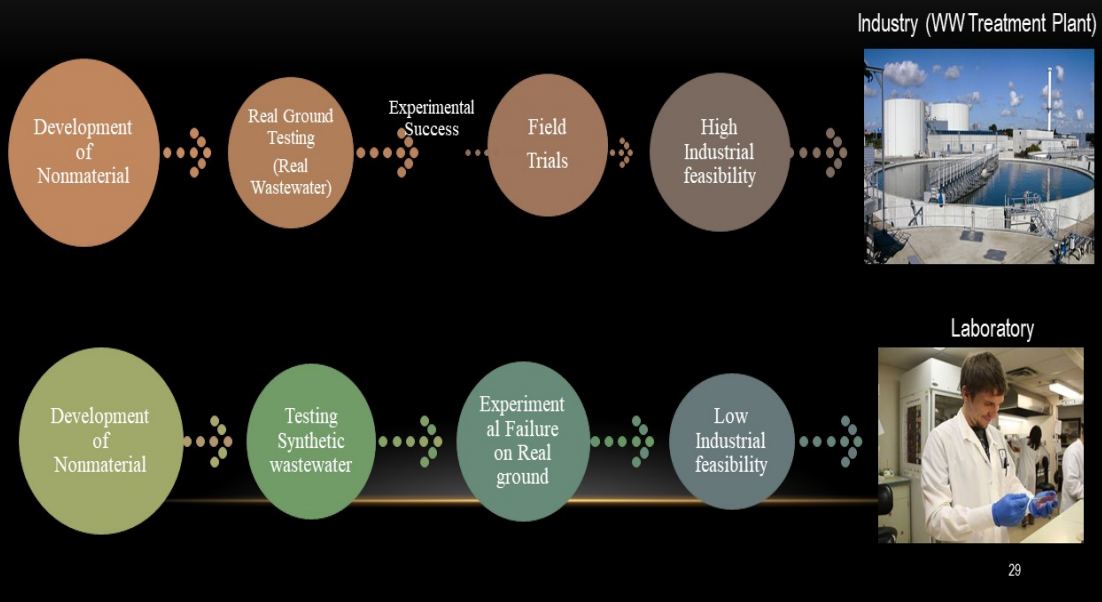
ZnO-ZnS/Ag₂S-Ag₂S



Cr₂O₃/C₃N₄



PERCEPTION LAB TO PRODUCT CHAIN



POTENTIAL APPLICATIONS OF NANOTECHNOLOGY IN WATER REMEDIATION

- Water Remediation



Water Remediation

Photo-catalysis

Nano-Filteration

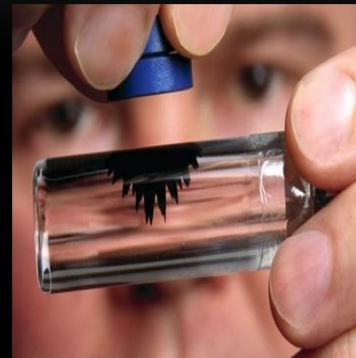
Dendrimers

Multibarrier systems

Groundwater remediation

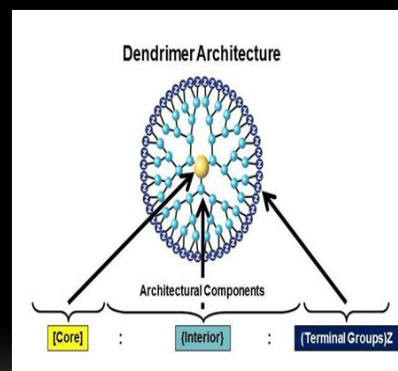
REMEDATION USING MAGNETIC NANOPARTICLES

- Researchers from Rice University have shown that nanoparticles of rust can be used to remove **arsenic** from water using a magnet.
- Arsenic sticks to Nano-sized rust (10 nm, Iron oxide) tends to be magnetic, it is removed from water using a magnet



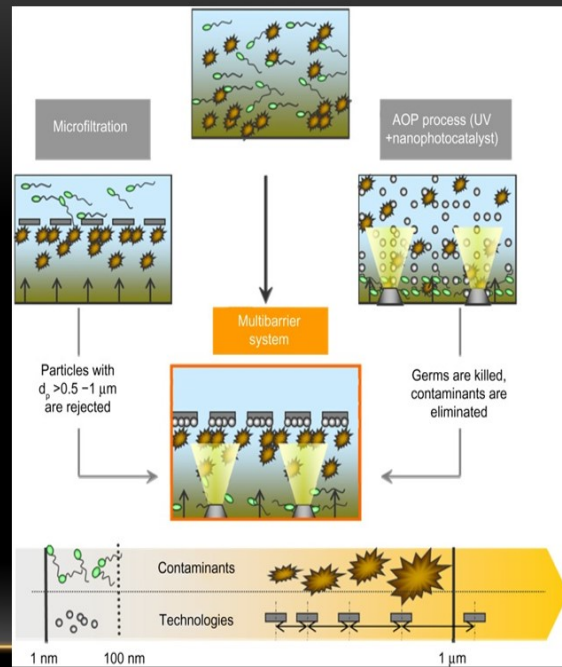
REMEDATION USING DENDRIMERS

- Dendrimers are highly branched polymers with controlled composition and nanoscale dimensions.
- Removal of metal contaminants.
- Act as “cages” and trap metal ions and metals, making them soluble in appropriate media or able to bind to certain surfaces.
- Industrial process
- Light harvesting material



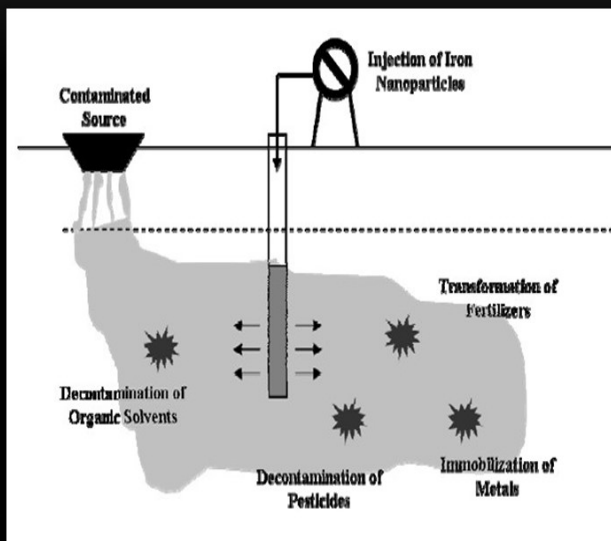
MULTI-BARRIER SYSTEM (INTEGRATED SYSTEM)

- ❑ Multibarrier system can be integrated in existed treatment plants
- ❑ UV -filtration membranes
- ❑ UV-filtration membranes – nanoparticles



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REMEDATION OF GROUNDWATER



- A nanoparticle–water slurry injected to the contaminated ground water.
- Contaminant levels around the injection level is reduced in a day or two.
- The nanoparticles do not change by soil acidity, temperature or nutrient levels.

COMMERCIAL NANO-MATERIAL BASED PRODUCTS

Super-hydrophilic filters

- Nano-filters allow filtering water from contaminants such as arsenic and other heavy metals.
- “LifeSaver Bottle” (a commercial product) has a super-hydrophilic filter inside that can block material up to 15nm in size, which includes viruses and bacteria.
- On site filtration



Nanotechnology socks contain nanoparticles of silver. These particles help kill the bacteria that makes our feet smell. Many people with smelly feet will benefit from this technology



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WHAT IS NEED FOR TECHNOLOGY TRANSFER?

- ❑ *Developing and Adapting Innovation*
- ❑ *Technologies*
- ❑ *Processes*
- ❑ *Licencing*
- ❑ *Joint Development*
- ❑ *Commercialisation*

Conclusion & Recommendation

- ❑ The nano-catalytic process is a practical approach which can be applied efficiently in different environmental remediation, **thus, it should be promoted for its testing in a small scale pilot or commercial scale system**
- ❑ The **unique properties of nanomaterials** and their convergence with current treatment technologies present great opportunities to revolutionize water and wastewater treatment

CONCLUSION & RECOMMENDATION

- Nanoscience, engineering, and technology holds great potential for the continued improvement of technologies for environmental protection.
- The recent breakthroughs give further evidence and support the predictions that nanoscale science and engineering “will most likely produce the breakthroughs of tomorrow.”



Nano in the Environment

Nano for the Environment