

Council for Mineral Technology



MINTEK

**NANOTECHNOLOGY
APPLICATION IN WATER
TREATMENT: AN OVERVIEW**

by

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FARM INN LODGE, PRETORIA, 23 NOVEMBER 2009**



Water : Source of life

- Water is a valuable resource
- Supports life for all living organisms
- Uses by humans: agricultural, industrial, household, recreational and environmental
- Covers 71% of Earth, 97.5 % salt water, 2.5% fresh water

Water Pollution: Sources

Sources	Pollutants	Effects
Industrial Activities: e.g. Chemicals, Textile, Food, Mining	Harmful Organics, Heavy Metals	Carcinogenic, Fatalities, Birth defects, Growth Inhibitors
Agricultural	Pesticides	Carcinogenic
Natural - leaching of rocks, soil erosion	NOM, Heavy metals.	Odour in drinking water, Potential fatalities
Household		Endocrine-disrupting

Water Treatment: Goals

- River, ground, water sea water for drinking
- Industrial waste waters for recycling or release
- Municipal waste water for recycling or release

Conventional Treatment Methods

Pollutant	Removal Method(s)	Challenges
Monovalent ions (e.g. Na ⁺ , Cl ⁻)	Reverse Osmosis	High costs, Low recovery rates
Hardness (Ca ²⁺ , Mg ²⁺)	Nanofiltration, ion-exchange	Nanofiltration, ion-exchange
Colloids (turbidity)	Coagulation, flocculation	Pretreatment procedure
Pathogens, bacteria, protozoa	Disinfection, Membrane process	High Energy process
Odour causing Organic Pollutants	Adsorption (Activated Carbon)	Not very effective
Harmful Organic Pollutants	Oxidation (UV-Irradiation, Chlorination, Ozone)	Not very effective, High cost. Chlorination-carcinogenic byproducts

Nanotechnology: Basic principles

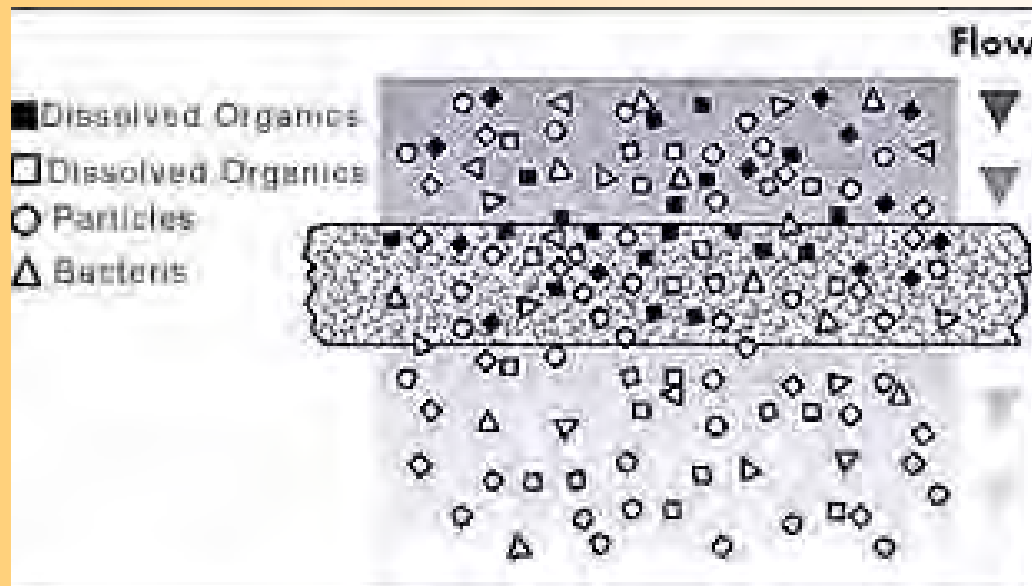
- Nanotechnology is a field of research and innovation concerned with building materials and devices on the scale of atoms and molecules
- By manipulating substances at the atomic level, a substance can be altered so that it acquires different properties compared to the substance in macro or bulk form
- Large surface area- high activity rates

Nanoparticles in Water Treatment

- Nanosorbents/Nanoadsorbents
- Nanocatalysts
- Nanobiocides
- Nanostructured and reactive membranes

Nanosorbents

- Mode of action: Adsorption
- Examples: f-CNTs, zeolites, aerogels
- Pollutants removed: Heavy metals (e.g. As, Hg, Cd, Pb), Dyes, fluorides, organic pollutants (e.g. BTEX, pesticides, halogenated Org), pathogens.



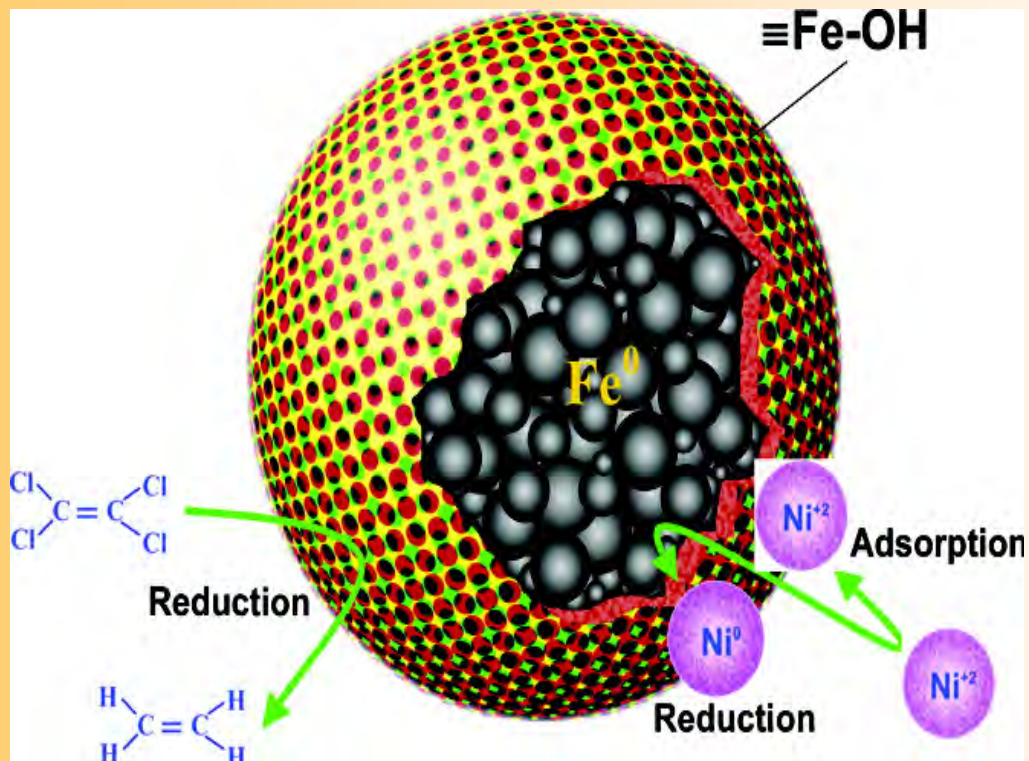
Nanocatalysts

- Have potential for treating contaminants that must be removed down to low levels
- Mode of action: Mineralize/particle reducers
- Work with or without activation (H_2 or light)

Nanocatalysts	Target Pollutants
Fe ⁰ NPs	Halogenated Organics, Phenols, Pesticides, Organic Dyes, Heavy Metal ions, Inorg anions
Fe/Ni, Fe/Pd, Fe/Pt NPs	Halogenated Organics, Phenols, Pesticides, Organic Dyes, Heavy Metal ions, Inorg anions
Au/Pd NPs	Halogenated Organics

Nanocatalysts: Illustration

- Fe(0) NPs- sorption and reducers



X.Li, W-X Zhang, *Langmuir*, 22 (2006) 4638-4642

Nanoscale photocatalysts

- Activated by visible light or UV radiation

Nanoparticles	Target Pollutant
Nanoscale TiO ₂	Poliovirus 1, hepatitis B, herpes simplex virus, bacteriophage. Ammonia, Organic Pollutants (pesticides, halogenated)
Ag-doped TiO ₂	E. Coli
Nanoscale ZnO	Organic Pollutants (aromatics, aliphatic, aromatic chloro compounds)

Nanobiocides

- Removal of pathogens
- Alternative to disinfectant methods such as chlorination

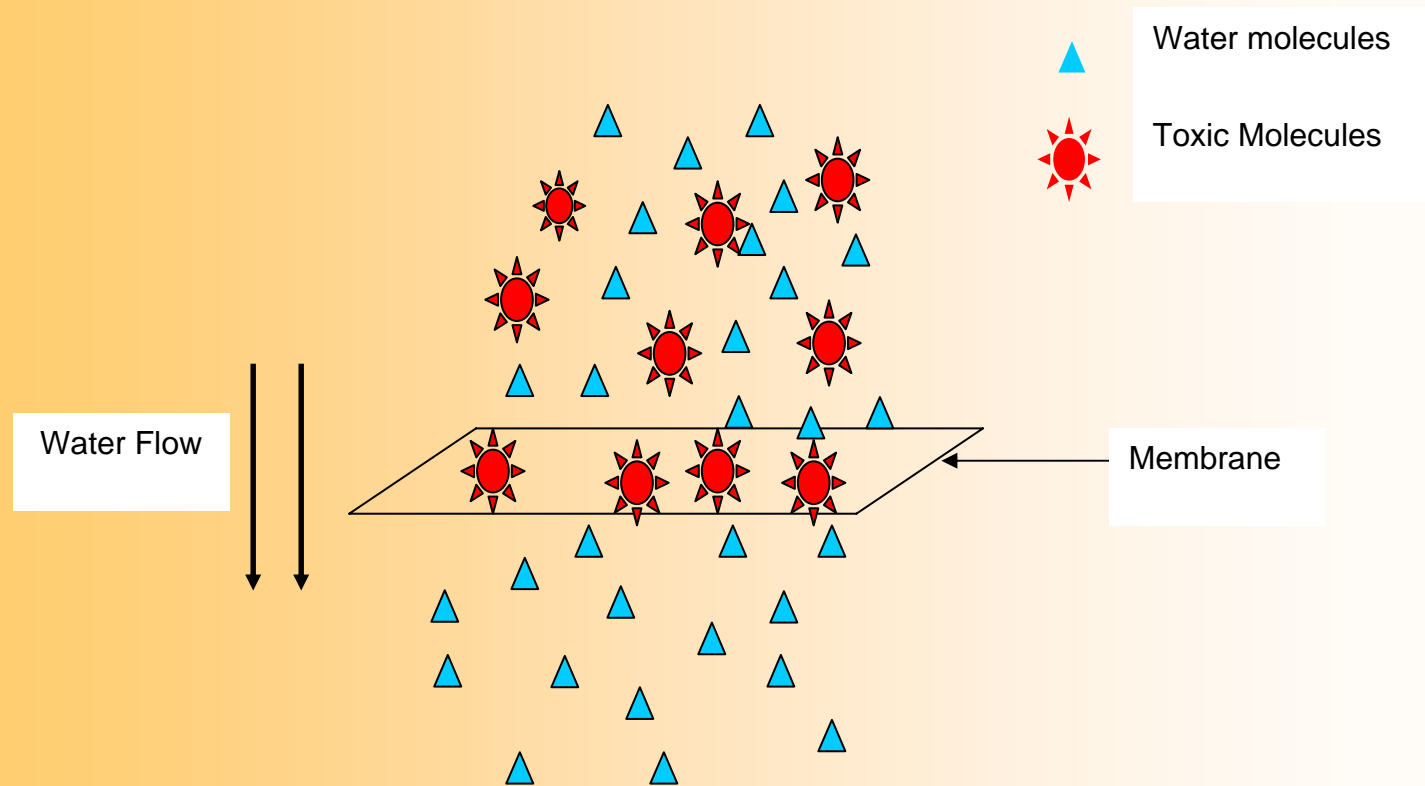
Nanoparticles/materials	Target Pollutants	Mode of action
Ag NPs (1-10 nm)	Bacteria, viruses	Deactivation
Au NPs	Bacteria, viruses	Deactivation
Nanoscale MgO·Cl ₂ , CaO·Cl ₂	Microbes- E. Coli, Bacillus Cereus	Deactivation
Buckyballs	Gram positive and Gram negative bacteria ~10nm	Sorption/filtration
CNTs	E. Coli, S. Aureus	Sorption/filtration
Zeolites	Bacteria	Sorption/filtration

Nanostructured Membranes

- E.g. Desalination membranes
- Polymers + NPs (e.g. nanosorbents)
- Mode of action: Draws in H₂O ions and repels dissolved salt
- Uses less energy than conventional membranes (RO)

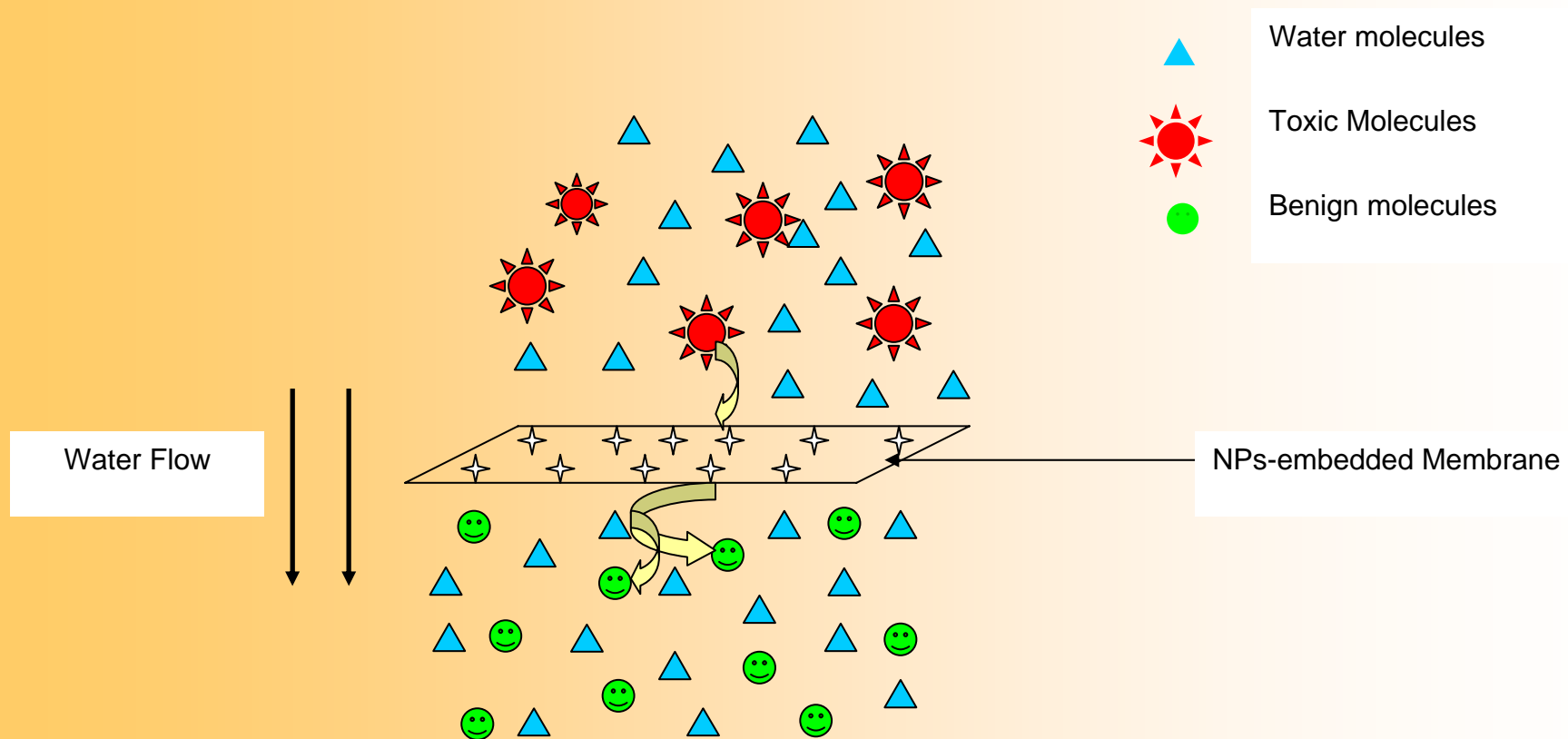
Nanostructured Passive Membranes

- Act as Barriers
- Block or retain particles
- Problem: Fouling



Reactive Membranes

- Embedded with NPs
- NPs-Catalysts/particle reducers



Challenges of Nanotechnology Application in Large Scale Water Treatment

- Dispersion (due to small size) with difficult recovery
- Tendency to aggregate
- Possible solution: immobilization of NPs on substrates, e.g. membranes
- Large scale production facilities
- NPs have potential to accumulate and remain in the environment
- Nanotoxicology/safety evaluation
- Safe disposal of wastes and energy efficiency.

THE END !!!

