

Mohamed Ateia

New Materials for Removal of Emerging Pollutants from Water

Mohamed Ateia, PhD

Department of Environmental Engineering and Earth Sciences
Clemson University



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يُفرق!



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Makes a
Difference!

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Education



**Agricultural
Engineering**

**BSc.
2009**

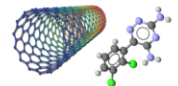


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**Civil & Env.
Engineering**

**MSc.
2014**



**Civil & Env.
Engineering**

**Ph.D.
2017**



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Work Experiences



Mechanical Engineer

06/2009 – 04/2010

Moon Trucks Co.
Egypt



Researcher

05/2010 – 03/2012

King Saud University
Saudi Arabia



Postdoc Fellow

10/2017 – Current

Clemson University
USA



Internship

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- 08/2015 (2 months): Visiting Researcher. Department of Chemistry, University of Copenhagen, Denmark.
- 07/2015 (3 months): Visiting Researcher. Department of Chemistry, University of Copenhagen, Denmark.
- 08/2013 (2 weeks): Science Communication for Global Scientists – Overseas Internship. London, UK.

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Water Treatment History



4000 B.C.

1500 B.C.

1700s

1800s

1900s

NOW



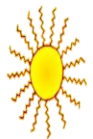
Sand Filters



Boiling



Cloth water filter



Sunlight



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Water Treatment History



4000 B.C.

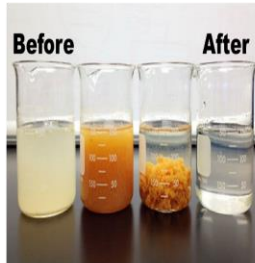
1500 B.C.

1700s

1800s

1900s

NOW



Makes a Difference!

Alum

الأمونيا

Ancient Egypt



معامل

عامصاء
Egypt Scholars

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Water Treatment History



4000 B.C.

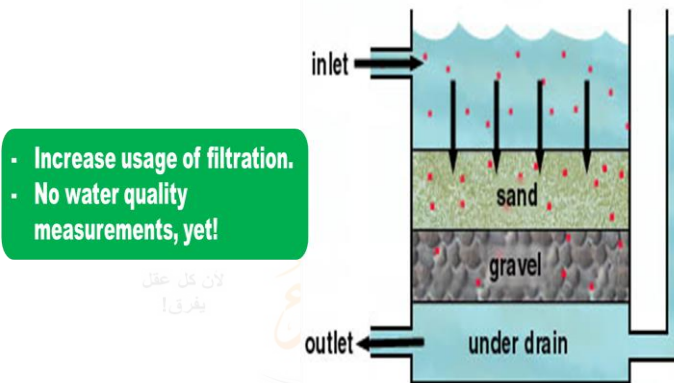
1500 B.C.

1700s

1800s

1900s

NOW



- Increase usage of filtration.
- No water quality measurements, yet!

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Water Treatment History



4000 B.C.

1500 B.C.

1700s

1800s

1900s

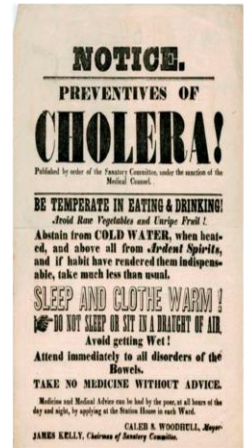
NOW



John Snow



John Snow



- Identification of waterborne disease (cholera!)
- > 150,000 people died in Europe.



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Water Treatment History



4000 B.C.

1500 B.C.

1700s

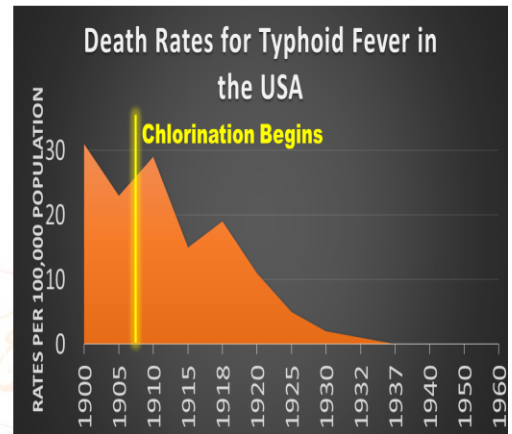
1800s

1900s

NOW

- Identification of pathogens in drinking water in US
- Application of disinfection.

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4000 B.C.

1500 B.C.

1700s

1800s

1900s

NOW

Surface Water Pollution

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4000 B.C.

1500 B.C.

1700s

1800s

1900s

NOW

Groundwater Pollution

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- 4000 B.C.
- 1500 B.C.
- 1700s
- 1800s
- 1900s
- NOW**

Oil Pollution

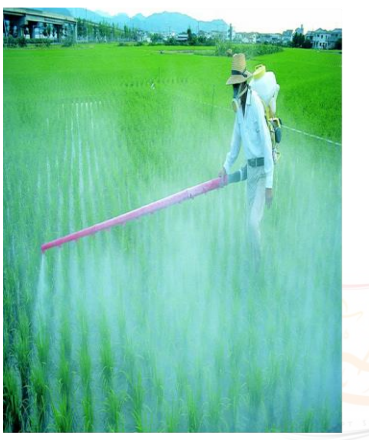


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- 4000 B.C.
- 1500 B.C.
- 1700s
- 1800s
- 1900s
- NOW**

Chemical Water Pollution



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4000 B.C. **1500 B.C.** **1700s** **1800s** **1900s** **NOW**

WATER TREATMENT PROCESS

An overview of how water is cleaned and treated before distributing to the population.
(Methods vary between countries depending on water standards)

- 1** Coagulants are added to the water (A) and then mixed together. Heavy particles in the water then begin to stick together and form large clumps.
- 2** Water is allowed to settle in a tank and the heavy particles drop to the bottom. These particles are then scraped away to be used as fertiliser.
- 3** Water is then filtered through layers of fine granulated materials. As particles are removed, turbidity diminishes and clear water emerges.
- 4** To protect against any bacteria, viruses and other microbes that might remain, disinfectant (B) is added before the water flows into underground reservoirs.
- 5** pH is maintained by adding alkaline substances (C) to reduce corrosion in the distribution system and the plumbing in your home.

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4000 B.C. **1500 B.C.** **1700s** **1800s** **1900s** **NOW**

WASTE WATER TREATMENT PROCESS

An overview of how waste water is cleaned and treated before returning to the water supply.
(Methods vary between countries depending on water standards)

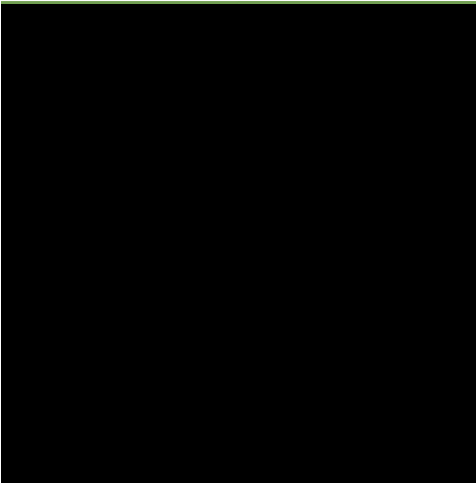
90% of the World's population does not have adequate sanitation
Source - World Health Organisation

- 1** Waste water and sewage is pumped underground to the lifting station where it's chemically treated and sent for separation.
- 2** The separation process filters out solids larger than 15mm. This waste is then transported to a refuse facility and banded.
- 3** Primary settling basins allow heavier material to sink and be scraped away. The waste is then fermented for 30 days and used as fertiliser.
- 4** Effluent is then pumped to the bio-reactors for 9 hours. Through a series of stages bacteria break down harmful matter and clean the water.
- 5** Secondary Clarifiers gravity feed the water through and bacteria continues to clean the water to a drinkable level.
- 6** The water is finally chemically treated with chlorine to ensure it is free from bacteria. Then it passes over a weir and into the water supply.

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4000 B.C.

1500 B.C.

1700s

1800s

1900s

NOW

REVERSE OSMOSIS DESALINATION

A separation process used to reduce the dissolved salt content of saline water to a usable level.

"The use of desalination overcomes the paradox faced by many coastal communities, that of having access to a practically inexhaustible supply of saline water but having no way to use it."

- USAID Desalination Manual

1

The saline feedwater is drawn from oceanic or underground sources.

2

Water is pre-treated to remove solids and adjust PH level to protect equipment

3

Water is forced through membranes which inhibit the passage of salt

4

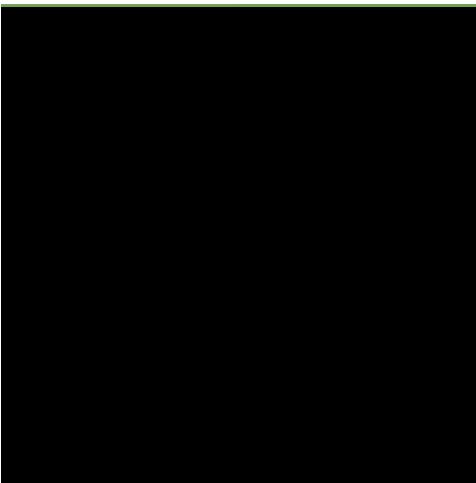
Water is post-treated by stabilising the PH level (adjusting the acid/alkalinity)

5

Water is stored and then distributed to communities when it is needed

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Techniques
for
Pollutants
Chemical
Removal
from
Physical
water

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Techniques
for
Biological

Pollutants
Chemical
Removal

from

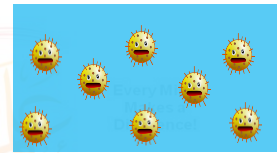
Physical
Water

- Examples: Biodegradation & Activated Sludge.

- Mechanism: Organic compounds can be absorbed and/or metabolized by plants and/or microorganisms.

- Pros: Low cost & Easy to operate.

- Cons: Long treatment time, not stable "efficiency", & Requires big treatment facilities.



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Techniques
for
Biological

Pollutants
Chemical
Removal

from

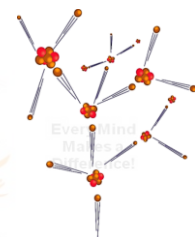
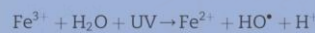
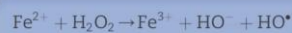
Physical
Water

- Examples: Advanced Oxidation & Photolysis (Fenton).

- Mechanism: Utilization of radicals (HO·) to mineralize organic compounds or degrade them into biodegradable compounds.

- Pros: Effective for organics and heavy metals removal.

- Cons: It involves the use of expensive reagents leading in high treatment cost & Requires pretreatment.



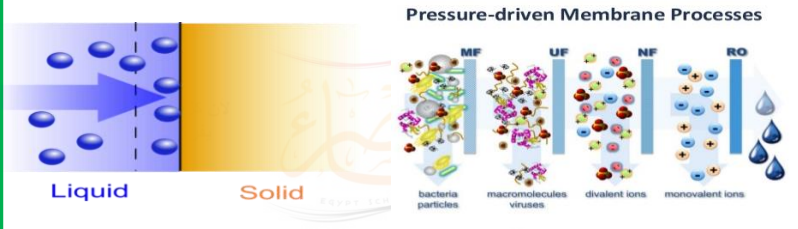
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**Techniques
for
Biological**

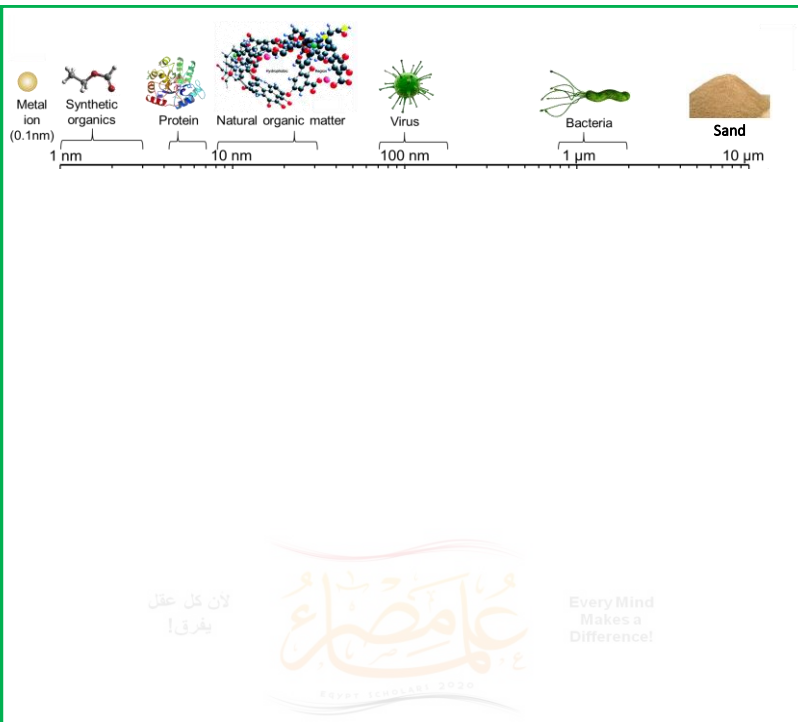
**Pollutants
Chemical
Removal**

**from
Physical**

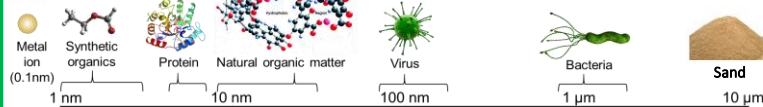
- Examples: Membranes & Adsorption (AC & CNT).
- Mechanism: When a solution containing absorbable solute comes into contact with a solid with a highly porous surface structure, liquid–solid intermolecular forces of attraction cause some of the solute molecules from the solution to be concentrated or deposited at the solid surface.
- Pros: Simple design, investment in term of both initial cost and land required, High efficiency & Easy to operate.
- Cons: High recovery cost, the efficiency decreases with the recycling & Spent adsorbent may be considered a hazardous waste.



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Advancement in Analytical Techniques



Unregulated Industrial/Agricultural Chemicals

Emerging Pollutants

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analytical
chemistry

Review
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Water Analysis: Emerging Contaminants and Current Issues

Susan D. Richardson^{*,†} and Thomas A. Ternes[‡]

[†]Department of Chemistry and Biochemistry, University of South Carolina, Columbia, South Carolina 29205, United States

[‡]Federal Institute of Hydrology, Koblenz, D-56068, Germany

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INTRODUCTION

This biennial Review covers developments in water analysis for emerging environmental contaminants over the period of October 2015–October 2017. *Analytical Chemistry's* policy is to limit reviews to a maximum of ~250 significant references and to mainly focus on new trends. Therefore, only a small fraction of the quality research publications is discussed. The previous Water Analysis review (with Susana Kimura) was published in 2016.¹ This year, Thomas Ternes has joined back again to cover the section on Pharmaceuticals and Hormones.



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Examples

- NANOMATERIALS

- DRINKING WATER AND SWIMMING POOL DISINFECTION BYPRODUCTS

- PER- AND POLYFLUOROALKYL SUBSTANCES

- SUNSCREENS/UV FILTERS

- ALGAL TOXINS

- PHARMACEUTICALS AND HORMONES

- BROMINATED AND EMERGING FLAME RETARDANTS



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Science

An antibiotic-resistant strain of typhoid fever has sickened more than 2,000 people in Pakistan so far this year: Public health experts worry it could soon spread to other countries:

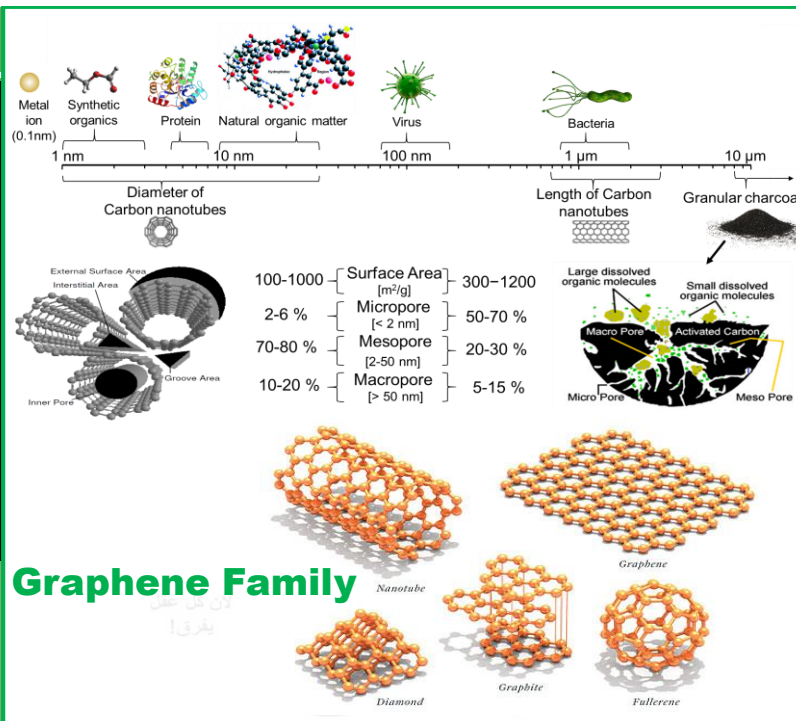


SCIENCEMAG.ORG

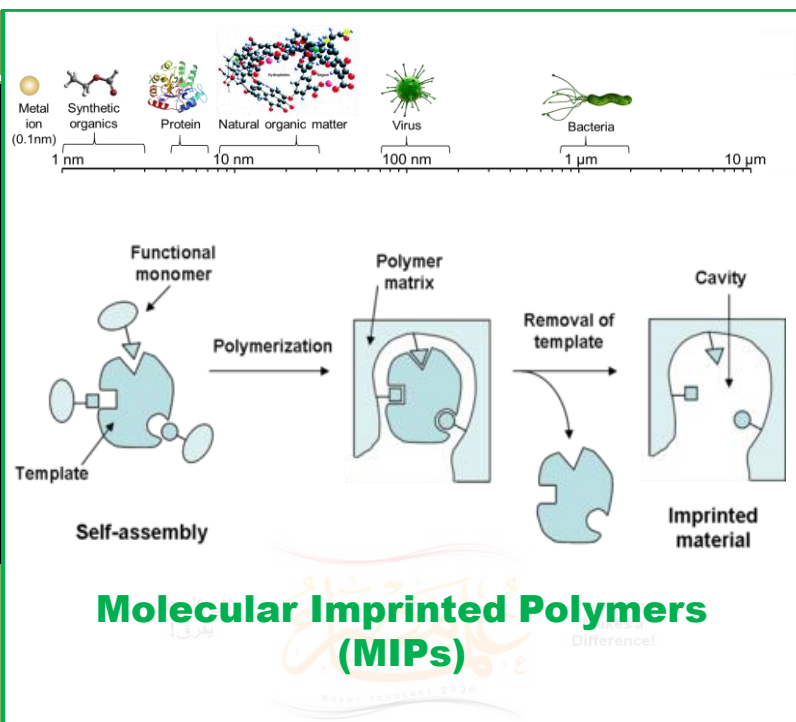
'Frightening' drug-resistant strain of typhoid spreads in Pakistan



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The top part of the image shows a scale from 1 nm to 10 μm with icons for Metal ion (0.1nm), Synthetic organics, Protein, Natural organic matter, Virus, and Bacteria.

The middle diagram illustrates the photocatalytic mechanism of TiO_2 . Light (energy) excites electrons (e^-) from the valence band to the conduction band, leaving holes (h^+). The excited electrons react with O_2 to form superoxide (O_2^-), and the holes react with H_2O to form hydroxyl radicals (OH^\cdot). These reactive species then degrade pollutants into $CO_2 + H_2O$.

The bottom part shows a chemical reaction scheme for photocatalysis. It starts with $e^- + h^+$ from direct photoexcitation. This leads to charge-carrier trapping, forming e^-_{tr} and h^+_{tr} . e^-_{tr} can reduce H_2O_2 to H_2O and O_2 to O_2^- . h^+_{tr} can oxidize H_2O to OH^\cdot and O_2 to O_2^+ . The hydroxyl radical (OH^\cdot) is produced via the oxidation of hydrogen peroxide. The superoxide (O_2^-) can be protonated or recombine to form H_2O_2 . The final step is the degradation of pollutants (PPCP) into degradation products.



Photocatalysts

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The slide features the Arabic phrase "لأن كل عقل يفرق!" (Because every mind makes a difference!) and the English phrase "Every Mind Makes a Difference!". It includes the logo for "معامل علماء" (Maamal Al-Uloom) and "EGYPT SCHOLARS 2020". The central text "Q & A" is written in large, bold letters.

