

# “The Use of Bio-waste Materials for Wastewater Treatment”

**Dr. Mohamed Hamouda**

**Assistant Professor, Water and Environmental Engineering**

## Workshop on Nature-Based Solutions(NBS) for Urban Water Security

**Organized by:**



**SCHOOL OF WATER  
AND WASTE**

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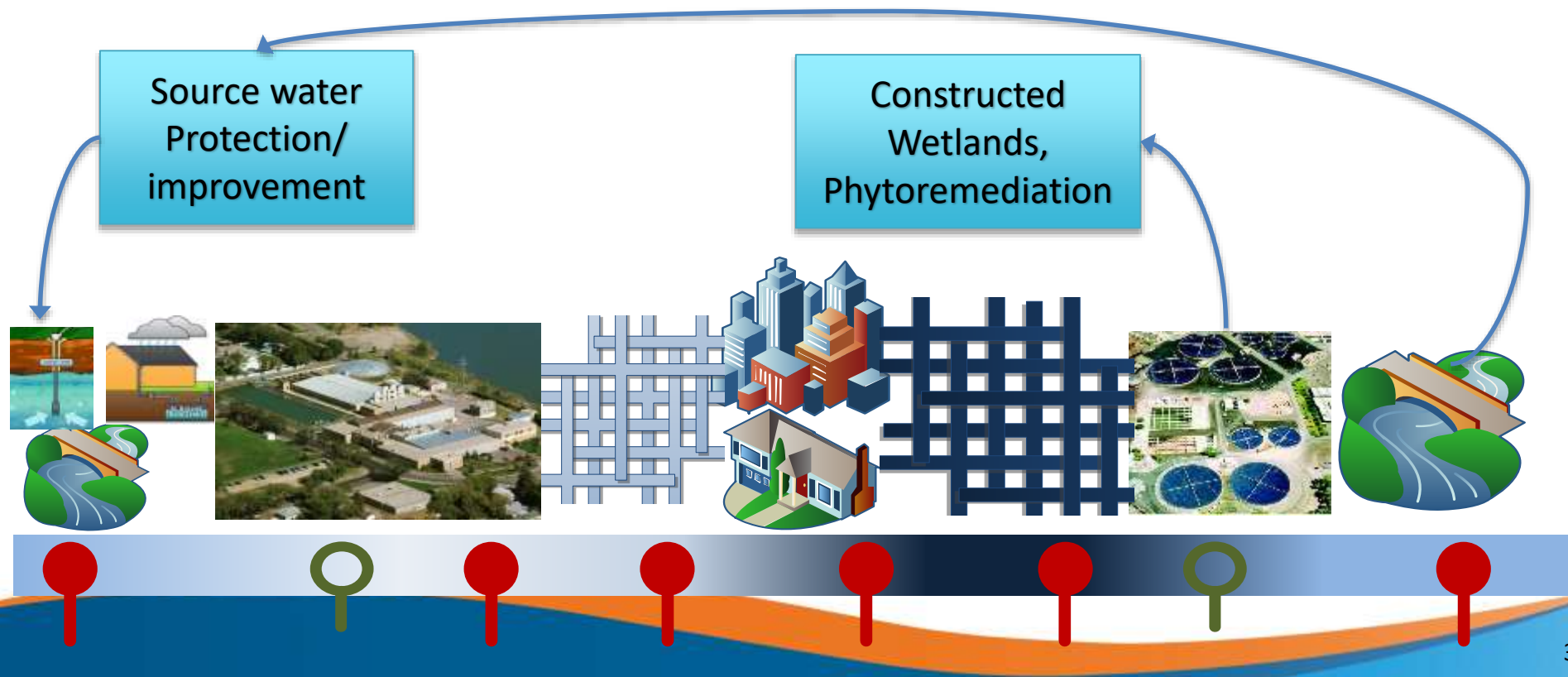
# Complexity of Water Supply & Sanitation

- Increase redundancy (multibarrier approach)
- Revision of standards + monitoring and compliance
- Quality management (e.g. QMRA, WSP → risk assessment)
- Decentralized solutions (POU POE)
- Social and institutional reform (Ethics in Water Use)
- Reliable/sustainable solutions (Nature-based solutions)



# NBS-Contribution

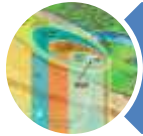
- “Solutions inspired and supported by nature that simultaneously provide environmental, social and economic benefits and help to build resilience” [EC, 2016]



# NBS-Framework

- The NBS police “narrow framework”: **NO bio-mimicry; NO bio-materials** (Fragakis, 2017) 🙄
- “Fulfilling the functions of urban infrastructures using or mimicking natural processes may simultaneously provide **co-benefits** for biodiversity and human well-being” (Cohen-Shacham et al., 2016) 🍌 **All you need is evidence!**
- **For wastewater treatment, most processes are predominantly biological.**
- Benefits, co-benefits, costs, trade-offs for human well-being and biodiversity can be monitored using maturely developed methods (MCDA, LCA, etc.)

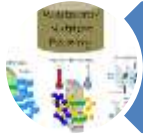
# NBS-Contribution...Wider Framework



Source Protection



Constructed Wetlands



Nutrient recovery and reuse



Wastewater recycling and reuse

Really any solution that uses  
**natural processes or materials** with  
proven benefits to human well-  
being and biodiversity



# Bio-waste Materials

- AKA biomass-based materials
- An abundant source of potentially sorbing biomass that comes from agricultural and food waste materials



Tea and coffee  
industry waste



Husks (rice, maize)



Shells (coconut,  
watermelon, eggs)



Stalk waste (wheat,  
grape, tobacco)



Peels (potato,  
banana)



# Main Application

- Removal of heavy metals and dyes from industrial wastewater

The Top 5 Toxic Threats:	Estimated Global Population At Risk(million people)
1.Lead (smelting, battery, mining)	18-22
2.Mercury (mining)	15-19
3.Chromium (tannery)	13-17
4.Arsenic (natural)	5-9
5.Pesticides (agricultural)	5-8

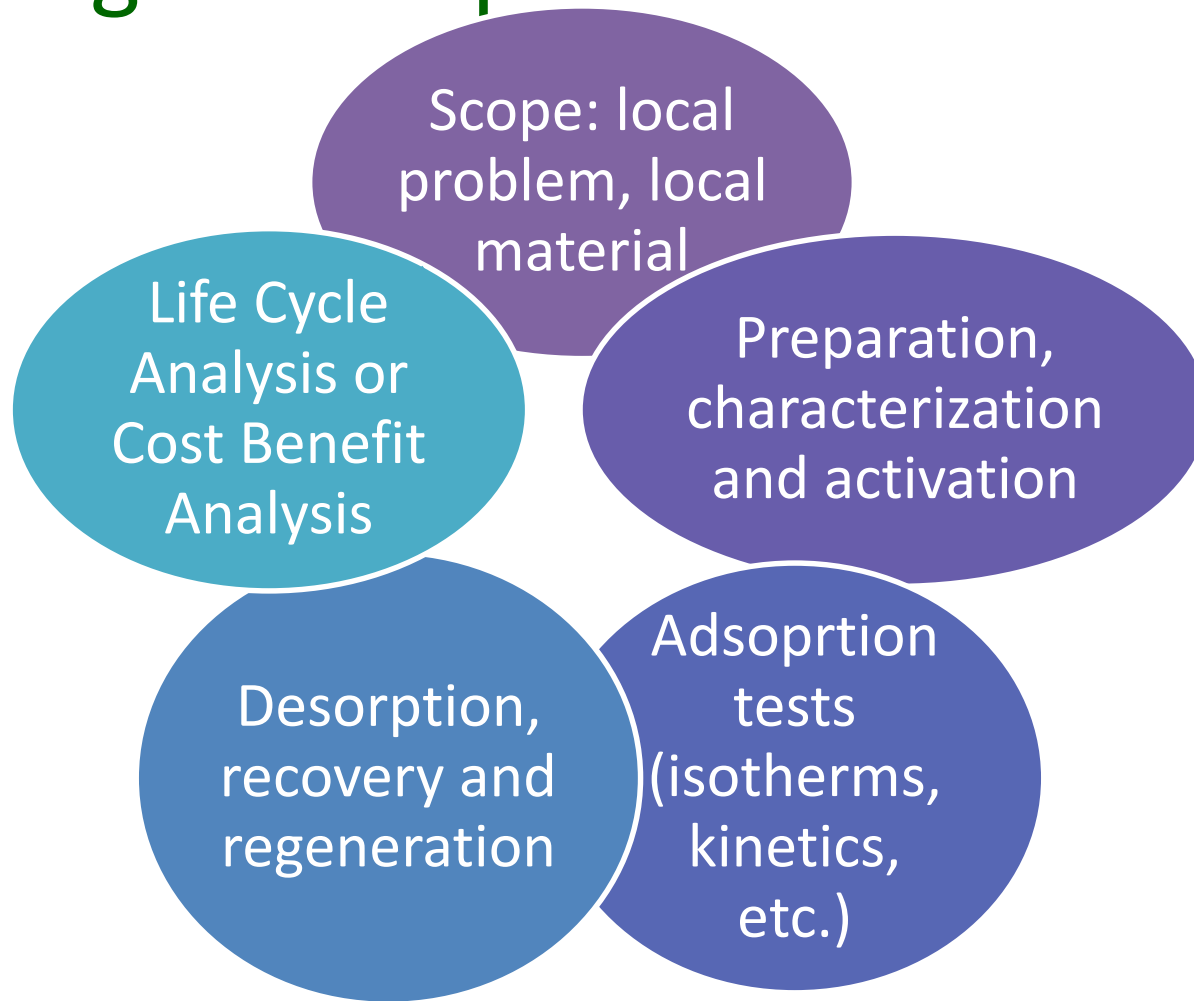
(Blacksmith Institute 2011)

# Other Potential Applications

Application	Reference
Potato peels for bio-reduction of perchlorate in groundwater	Okeke and Frankenberger Jr. (2005)
Natural polyelectrolytes for coagulation of drinking or wastewater	Kawamura (1991)
Silver impregnation for cheap and point-of-use disinfection	Dankovich and Gray (2011)



# Studying Bio-sorption



# Selection of Bio-waste Material

Minimal or no  
activation  
needed

- Natural form: wash, grind and sieve
- Activated form: physical (irradiation, pyrolysis), chemical (acid or alkali), biological (fungi enzymes)

Available at a  
point source

- Farms, Bakeries, Factories

Available in  
sufficient form

- Quantity, continuity (non-seasonal or long life) and consistency

Non-reactive  
with water

- Does not introduce another contaminant to the water

# Ongoing Study

- Evaluating the Use of Waste Eggshells for Lead Adsorption from Wastewater (RA Haliemeh Sweidan)
  - Utilize eggshells without activation and minimal processing
  - Investigate the mechanisms of lead removal; is adsorption supported by ion exchange or precipitation?
  - Scale up to a column study and investigate the Life Cycle Cost of the proposed treatment method

# Why Eggshells?

- Good adsorbent: organic dyes, phenol, and heavy metals

Minimal or no  
activation  
needed

- Even in natural form, eggshells can achieve good removal.

Available at a  
point source

- Bakeries and food industry

Available in  
sufficient form

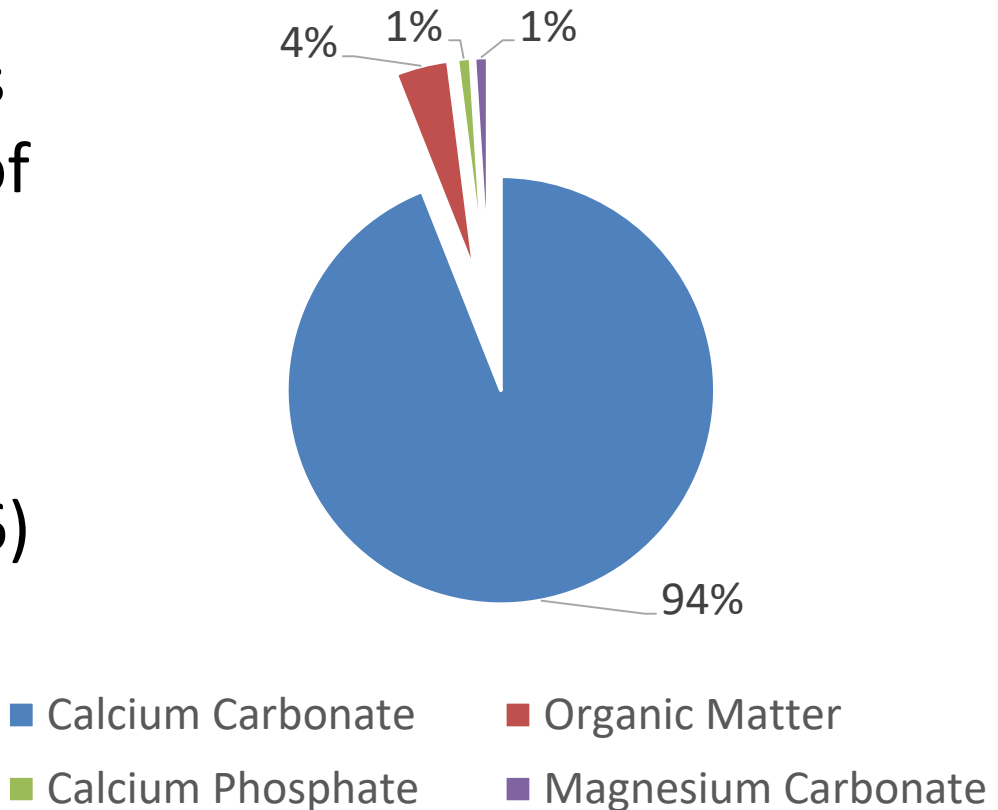
- 2 billion eggs are consumed in the UAE annually (Masudi 2015). Production is not seasonal, and its structure is consistent.

Non-reactive  
with water

- Eggshells are basically calcium carbonate. No toxic intermediate(s) or byproduct(s)

# Eggshells Composition

- ES are carbonates and phosphates of calcium and magnesium and organic matter.  
(Mittal et al. 2016)



# Why Lead?

- Tops the charts for toxic threats.
- Lead is extremely toxic to human health.
  - Physiological damage to the kidneys, liver, brain, nervous system, and reproductive system
  - Depression of brain development and cognitive skills in children

# Eggshell Preparation

Obtaining  
Chicken  
Eggshells  
from  
bakeries



Washing, crushing,  
membrane removal



Oven Drying



Sieving



Grinding



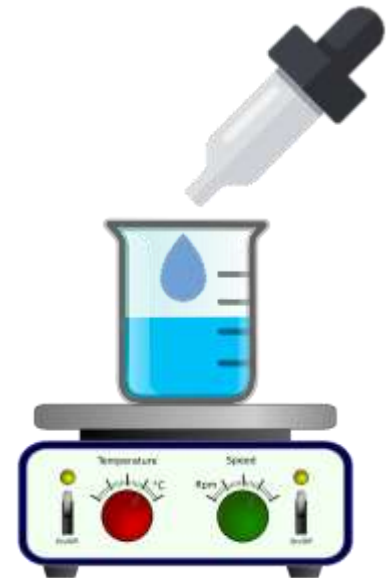


# Eggshells characterization



# Adsorption Experiments

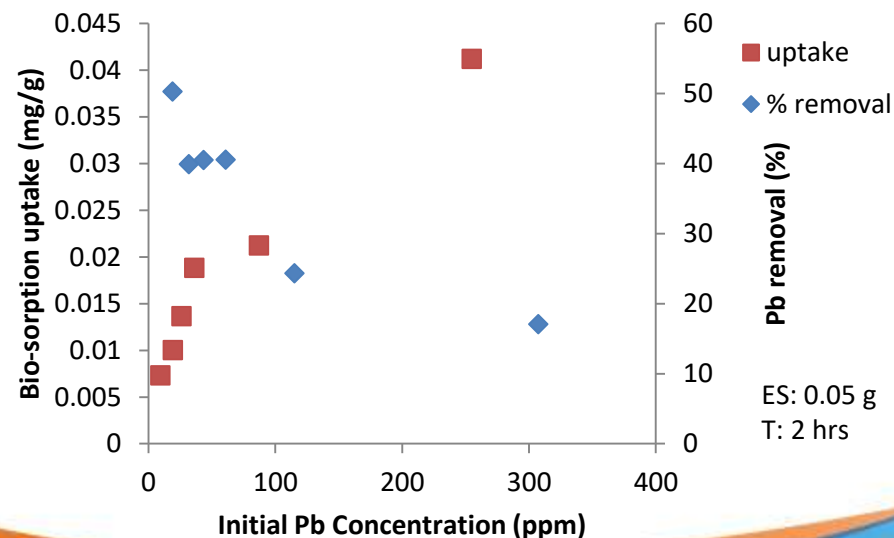
- Variables:
  - Eggshells particle size
  - Eggshell dose
  - pH
  - Lead concentration
  - Real wastewater effluent experiment
- Constants:
  - Time: equilibrium
  - Temperature
  - Shaking rate



Stir 2 hrs

# Preliminary Results

- Preliminary batch experiments show that eggshells can effectively remove lead from solution.
- Lead removal by eggshells could be the result of many mechanisms; including ion exchange, adsorption, or chemical precipitation.



# Future Directions

- Continue with analysis to investigate mechanisms of removal.
- LCA or MCA to identify benefits and costs to human well-being and biodiversity (suggestions are welcome)

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Thank You