WATER: AN ENVIRONMENTAL ENGINEERING PERSPECTIVE

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MY JOURNEY TO ENVIRONMENTAL ENGINEERING
MIDDLE SCHOOL AND HIGH SCHOOL
UNIVERSITY

- Undergraduate (4 years)
  - Baylor University
    - Major: B.S. Chemistry
    - Minor: Environmental Science

- Graduate
  - Rice University
    - Masters (MS) in Environmental Engineering - 2yrs
    - Doctorate (PhD) in Environmental Engineering – 2yrs
WHAT A ENGINEERING PROFESSOR DOES
What I Do

- Teach
  - Undergraduate and Graduate Courses
    - Introduction to Civil Engineering
    - Environmental Engineering
    - Water and Wastewater
    - Environmental Chemistry
  - Mentor Students
    - UG and Grad

- Research
  - Nanoscience
    - Nanomaterials for environmental applications and remediation
  - Water Quality/Treatment
    - Storm water runoff
    - Water conservation, recycling, and sustainability
    - Fate and transport of pollutants
    - Low Impact Development
    - Field studies for monitoring DO, PCBs, etc.
    - Water treatment & Wastewater treatment

- Service
  - University Committees
  - Outreach to the community
  - National organizations
  - Reviewer
Environmental Nanotechnology: Nano-adsorbents for The Removal of Metals for Potential Use as Remediation and Water Treatment Technologies
Metal Contamination

- Relatively high density
- Toxic at low concentrations due to bioaccumulation
- Sources
  - Vehicles – Cu, Pb, Zn
  - Commercial Fertilizer – Cd, Cu, Zn
  - Mine Drainage- Pb, Cu, Ni, Zn, etc
  - E-waste- Pb, Cr, Cd, Ni, Zn, others
ARSENIC CONCENTRATIONS IN DRINKING WATER

Arsenite - As(III)
Occurs as: H$_3$AsO$_3$ (pH below 9.2)
- Higher toxicity and more mobility than As(V)

Arsenate - As(V)
Usually occurs as ions: H$_2$AsO$_4^-$ and HAsO$_4^{2-}$
# Health Risks of Metals and As in Drinking Water

<table>
<thead>
<tr>
<th>Metal</th>
<th>2003 WHO Standards (mg/L)</th>
<th>EPA MCL or TT (mg/L)</th>
<th>Potential Health Effects from Ingestion of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.01</td>
<td>TT; Action Level = 0.015</td>
<td>Physical /mental developmental delays; attention span deficits, learning disabilities, kidney problems, high blood pressure</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.003</td>
<td>0.005</td>
<td>Kidney damage</td>
</tr>
<tr>
<td>Copper</td>
<td>2.0</td>
<td>TT; Action Level = 1.3</td>
<td>Gastrointestinal distress, liver/kidney damage</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.02</td>
<td>0.1*</td>
<td>Decreased body weight, heart &amp; liver damage, dermatitis</td>
</tr>
<tr>
<td>Zinc</td>
<td>5</td>
<td>5*</td>
<td>Growth retardation, skin changes, poor appetite</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.01</td>
<td>0.01</td>
<td>Skin changes, cancer (skin, kidney, lung, bladder)</td>
</tr>
</tbody>
</table>

MCL = Maximum Contaminant Level
TT = Treatment Technique
* Not currently regulated by EPA as a primary contaminant.
Scale of Nanoparticles

- Ant: ~5 mm
- Dust mite: 200 μm
- Human hair: ~10-50 μm wide
- Red blood cells with white cell: ~2-5 μm
- DNA: ~2-1/2 nm
- 5 Atoms of silicon: 1 nm
- Carbon nanotube: ~2 nm diameter

Head of a pin: 1-2 mm
Micro Electro Mechanical Devices: 10-100 μm wide
Red blood cells
Pollen grain

http://www.sustainpack.com/nanotechnology.html
WHERE CAN NANOMATERIALS MAKE A DIFFERENCE?

Membranes
E.g. water treatment

Adsorbents
E.g. contaminant removal

Oxidants
E.g. Disinfection

Catalysts
E.g. Industrial Application

Sensing
E.g. Water Quality

Analytical
E.g. Increasing Detection Limits
NANOPARTICLE CHARACTERIZATION

37 nm Fe$_2$O$_3$
SSA = 31.8 m$^2$/g
pzc = 6.8 pH

20 nm Fe$_3$O$_4$
SSA = 60 m$^2$/g
pzc = 6.8 pH

8.3 nm TiO$_2$
SSA = 185.5 m$^2$/g
pzc = 5.2 pH

(Engates, 2011)
**RESULTS: TiO$_2$**
REGENERATION STUDY: SA TAP WATER

![Bar Chart]

- **Y-axis**: Percent adsorbed/desorbed
- **X-axis**: Time (in minutes)
- **Legend**:
  - 1: Pb Adsorption
  - 2: Pb Desorption
  - 3: Cu Adsorption
  - 4: Cu Desorption
  - 5: Zn Adsorption
  - 6: Zn Desorption

The chart shows the adsorption and desorption of Pb, Cu, and Zn over time, with each element represented in a separate set of bars.
CONCLUSIONS

- pH 2, EDTA were the most effective.
- Single metal: regenerated and reused for 8 cycles.
- Multiple metals: regenerated and reused simultaneously.
- SA tap water: greater than 94% adsorbed and greater than 92% of desorbed after 4 cycles of regeneration.
- Multiple contaminants can be removed simultaneously.
ACKNOWLEDGEMENTS

- Students involved: Drs. Karen Engates and Jinxuan Hu, Jessica George, Allison Guenter and Valerie Grover
- This research was supported by NSF grants EEC-0823685 and HRD-0932339
- Valero Research Excellence Funds and Presidential Dissertation Fellowship
**What is Engineering?**

- Engineering uses the knowledge of math and science to problem solve, create and enhance technologies that benefit humanity and the environment.
WHY ENGINEERING?

- Problem solve
- Design things that matter
- Make a difference
- Work with people
- Salary
- Travel
- Options
WHAT DO ENGINEERS DO?

- Design recycling system to protect environment
- Design school to withstand earthquakes
- Create a new material to mend broken bones
- Create a system that uses renewable energy
GREAT ACHIEVEMENTS OF THE 20TH CENTURY

- Electrification
- Automobile
- Airplane
- Water Supply and Distribution
- Electronics
- Radio and Television
- Agricultural Mechanization
- Computers
- Telephone
- Air Conditioning and Refrigeration
- Highways
- Spacecraft
- Internet
- Imaging
- Health Technologies
- Petroleum and Petrochemical Technologies
- Laser and Fiber Optics
- Nuclear Technologies
- High-performance Materials
Rewards and Opportunities of an Engineering Career

1. Varied opportunities
2. Challenging work
3. Intellectual development
4. Social impact
5. Financial security
6. Prestige
7. Professional environment
8. Understanding how things work
9. Creative thinking
10. Self esteem
**Financial Reward**

Beginning Offers to 2012 Bachelor’s Degree Graduates

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Average Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>$60,639</td>
</tr>
<tr>
<td>Computer Sciences</td>
<td>60,038</td>
</tr>
<tr>
<td>Business</td>
<td>51,541</td>
</tr>
<tr>
<td>Health Sciences (including Nursing)</td>
<td>46,567</td>
</tr>
<tr>
<td>Mathematics and Sciences</td>
<td>42,355</td>
</tr>
<tr>
<td>Communications</td>
<td>42,286</td>
</tr>
<tr>
<td>Education</td>
<td>39,080</td>
</tr>
<tr>
<td>Humanities &amp; Social Sciences</td>
<td>36,319</td>
</tr>
<tr>
<td><strong>Average for All Disciplines</strong></td>
<td><strong>$44,259</strong></td>
</tr>
</tbody>
</table>
ENGINEERING JOB FUNCTIONS

- Analysis
- Design
- Test
- Development
- Sales
- Research
- Management
- Consulting
- Teaching
- Entrepreneurship
UTSA Engineering Programs

- Biomedical Engineering
  - To analyze and solve problems in biology and medicine, providing an overall enhancement of health care.
  - Currently graduate program only

- Civil and Environmental Engineering
  - Civil: deals with the design, construction and maintenance of the physical and naturally built environment
  - Environmental: application of science and engineering principles to improve the environment, to provide healthy water, air, and land for human habitation and for other organisms, and to remediate polluted sites.

- Electrical and Computer Engineering
  - deals with the study and application of electricity, electronics and electromagnetism and practical techniques for their implementation and application in computer systems

- Mechanical Engineering
  - applies the principles of physics and materials science for analysis, design, manufacturing, and maintenance of mechanical systems
Civil and Environmental Engineering

Civil Engineering:
- Structures: Tall buildings & towers, Bridges, Dams, Retaining walls, foundations
- Geotechnical: analyze the subterranean rock and soil to determine its suitability to support extreme loads.
- Transportation: design and analyze highways, railways, Airports, Urban and Suburban Road Networks, Parking Lots, and Traffic Control Signal Systems
- Water Resources: use of hydrologic and hydraulic principles to design: Drainage systems, Detention/retention ponds, Navigational waterways, and Flood control levees, dams, and lakes.

Environmental Engineering:
- translate physical, chemical, and biological processes into systems to remove pollutants from water,
- reduce non-hazardous solid waste volumes,
- eliminate contaminants from the air,
- Resolve problems of providing safe drinking water,
- Cleaning up sites contaminated with hazardous materials,
- Treating wastewater, and managing solid wastes
PROGRAMS OFFERED

- BS in Civil Engineering
- Masters of Science in Civil Engineering (courses+thesis)
- Professional Masters in Civil Engineering (courses only)
- PhD in Environmental Sciences and Engineering
UTSA COE STUDENT ORGANIZATIONS

American Institute of Aeronautics and Astronautics (AIAA)
American Society of Civil Engineers (ASCE)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
Biomedical Engineering Society (BMES)
COE Student Council
Engineers Without Borders
Institute of Electrical and Electronics Engineers (IEEE)
Institute of Transportation Engineers (ITE)
Society for Marketing Professional Services
National Society of Black Engineers (NSBE)
Society of Automotive Engineers (SAE)
Society of Hispanic Professional Engineers (SHPE)
Society of Manufacturing Engineers
Society of Mexican American Engineers and Scientists (MAES)
Society of Women Engineers (SWE)
Texas Society of Professional Engineers (TSPE)

http://engineering.utsa.edu/studentorganizations.html
iTEC

- A center that is a part of the College of Engineering at UTSA.
  - Aug. 2007 – Present

**Core Purpose:** To demonstrate the importance of science, technology, engineering, and mathematics (STEM) in our everyday world.

**MISSION:** Our mission is to motivate young people to pursue STEM related careers by demonstrating advanced technologies and engaging them in interactive activities that build technical skills and foster critical thinking, self-confidence, communication, and leadership.
iTEC ACTIVE LEARNING MODEL

- **HEAR**
  - Content

- **OBSERVE**
  - Demonstrations

- **SYNTHESIZE**
  - Competitions

- **DESIGN**
  - Concept

- **ANALYZE**
  - Challenges

- **INTERACT**
  - Interactive Applications

**Active Learning**
WHAT WE DO

- Provide *iTEC on Wheels* which expands our outreach into the community through programs on site

- Organize the GEAR Robotics Competition

- We conduct train-the–trainer workshops for teachers

- Conduct Summer and Spring Camps each year with over 1000 future scientist and engineers
ITEC ON WHEELS

- Subject designed instruction
- Demonstration with interactive application
- Grade appropriate concepts explained
- Maintains pedagogical congruency
- Supports team building and friendly competition
- Lesson include T.E.K.S. and S.T.A.A. R. Objectives
- Real world connections are emphasized
GEAR COMPETITION
TRAIN-THE-TRAINER WORKSHOPS

- Teacher Workshops
- Outcomes-Activities-Objectives
- Pedagogical Issues
- “How to teach” – how to facilitate learning

Teachers from Carrizo Springs Consolidated Independent School District (CSCISD) at Engineering Design using Lego NXT “train the trainer” Workshop (May 2010)
CAMPS

- Offer sessions
  - Thanksgiving
  - Spring Break
  - Summer
- K-2 are half day camps in the morning and afternoon.
- Grades 3 and above are full day camps that run from about 9am to 4pm
- All camps are Monday through Friday
- Students will perform experiments that are fun and age appropriate. By having a good time, we hope to create an environment where they never want to stop learning.
THOUGHTS FOR STUDENTS AND TEACHERS
HOW CAN WE BETTER PREPARE THE STUDENTS FOR CAREERS IN ENGINEERING?

- Help them be math ready
  - Math problems with applications
- Encourage them to take all the STEM courses they can in middle school and high school
- Do science fair or robotics clubs
- Invite speakers into the classroom who are engineers
- Teach them professional skills
- Technical writing preparation
OPPORTUNITIES FOR MY STUDENTS TO EXPERIENCE STEM FIELDS

- Science fair and Robotics club
- Summer programs for high school students at Universities and Community Colleges
  - [http://engineering2.utsa.edu/research/centers-institutes/ce3/](http://engineering2.utsa.edu/research/centers-institutes/ce3/)
- iTEC camps
  - [http://itec.utsa.edu/](http://itec.utsa.edu/)
- P-20 and PREP Programs
  - [http://www.prep-usa.org/portal/saprep/](http://www.prep-usa.org/portal/saprep/)
This is a 3-day camp for teachers who are interested in teaching beginning robotics in the classroom.

The curriculum is designed for grades 5-9 but can be modified to accommodate other grade levels. Participants will learn how to program using the Lego Mindstorm EV3 software and how to build basic robots. They will receive step-by-step instructions as well as opportunities to build challenges during the training. This is a fun session that offers a relaxed learning environment where teachers become students and learn activities to implement in the classroom. Connections to various subject areas will be covered and opportunities to program for specific audiences will be included.

**iTEC Camp (UTSA main campus):**
July 20, 21 and 22, 2015
iLearning #TI150720-F02

**ESC-20 Camp:**
July 27, 28 and 29, 2015
iLearning #TI150727-F01

**Registration fee: $275**
(includes a full 365-page beginner’s guide to Lego Mindstorm EV3, robotics competition resources, and a dedicated web guide for

**CONTACTS:**
Adrian Gutierrez - adrian.gutierrez@esc20.net (ESC-20)
Earl Bullock - earl.bullock@utsa.edu (UTSA)

For REGISTRATION and DETAILS:
Go to iLearning
www.esc20.net > Workshop
“Those who solve the world’s water problems deserve two Nobel Prizes: One for Science and one for Peace.”

John F. Kennedy
THANK YOU!