"Cutting Edge Solid/Hazardous Waste Management Research at FAU"

Combining Science and Technology
To Protect and Conserve Our Environment

Laboratories for Engineered Environmental Solutions

mission green

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http://labees.civil.fau.edu

Research Focus Areas

- Air/Water Quality
- Leachate
- Energy from Waste
- Watershed Management

Air/Water Quality

Urban Landfills *Do you think we might have a nuisance odor issue here?*

State of the Art

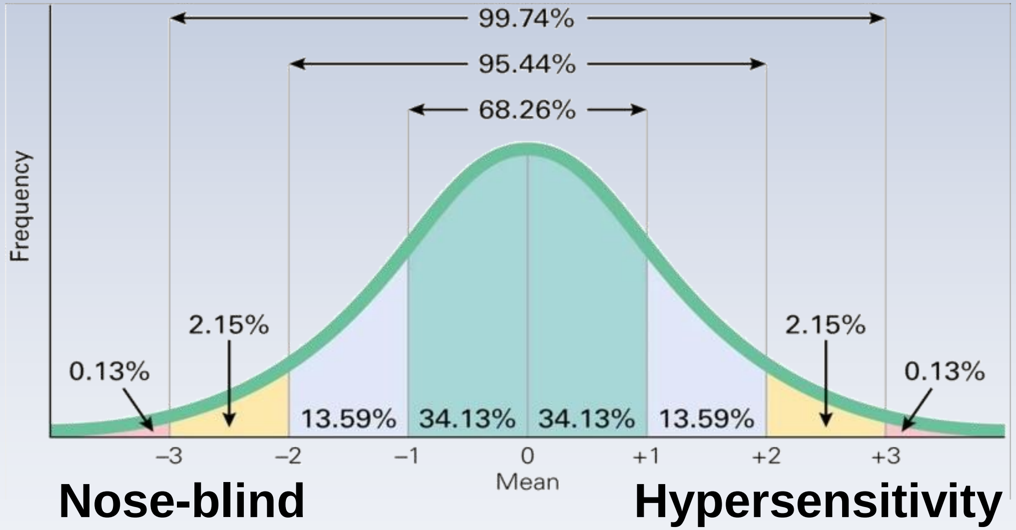
Nasal Ranger

Olfactometry

The Key Problem

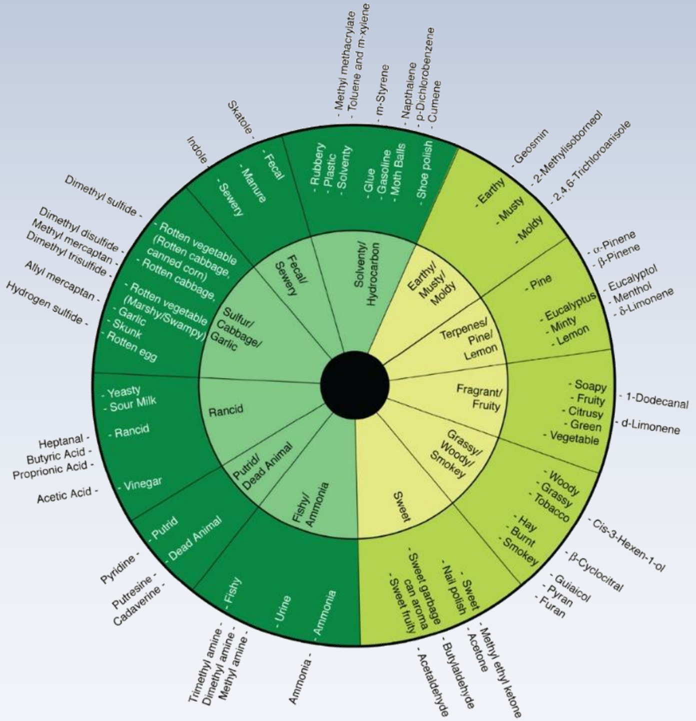
- **Subjectivity**

  Different individual perceptions of odors



Challenges

- Ability to deal with adverse environmental or meteorological conditions (temperature, humidity, etc.)
- Source identification/competing odors
- Sensitivity at very low (<ppb) levels
- Selectivity of odorants in real mixtures
- Synergistic and masking effects
- Subjectivity and individual perception



Developed Recommendations

ODOR COMPLAINT LOG FORM FOR LANDFILL ODORS

General Information

Date of odor complaint:

Name of the person:

Address of odor complaint:

Time of odor complaint:

Time AM/PM:

Day in a week:

Landfill in proximity to odor observation:

Description of Odor

What time was odor first detected?

What time was odor last detected?

Duration of odor (minutes or hours):

Location: indoors/outdoors:

Strength (1-5, with 1 being very light and 5 being very strong):

Character (type):

Meteorological Conditions at Time of Odor Observation

Temperature (°F):

Wind speed (mph):

Wind direction:

Sky conditions:

Precipitation accumulation (inch):

Pressure (inch):

Humidity (%):

- Wind speed/direction
- Temperature/humidity
- Precipitation
- Atmospheric stability class (A – F)
- Pressure drop over the previous 24 hours

Critical
Odor complaints are expected imminently

Severe
Odor complaints are highly likely

Substantial
Odor complaints are a strong possibility

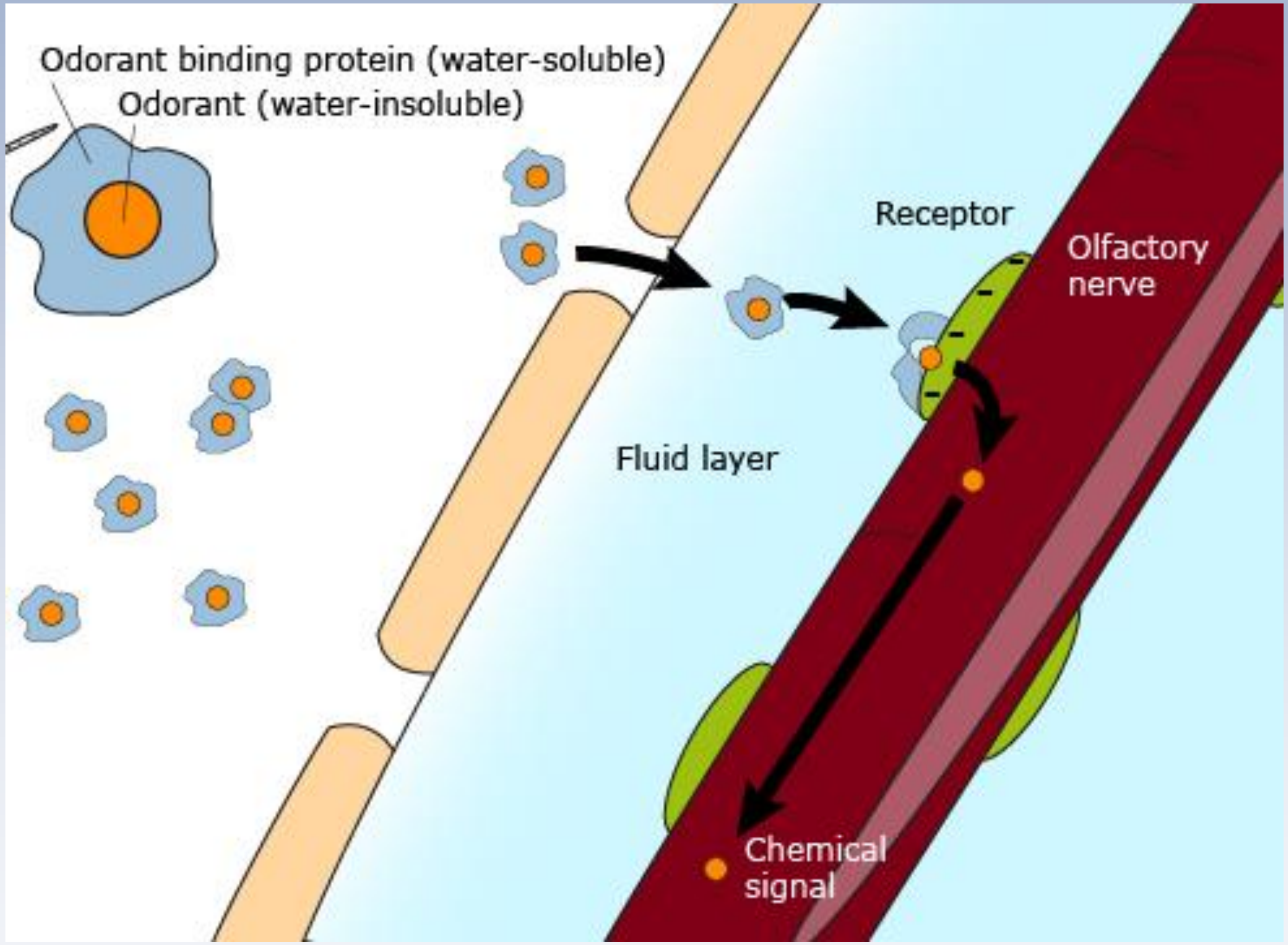
Moderate
Odor complaints are possible, but not likely

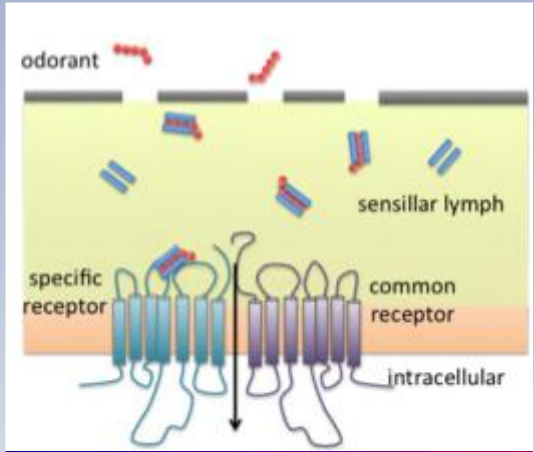
Low
Odor complaints are unlikely

Potential Solution for Quantifying Odors

- What if instead, we looked at this problem from the other direction?
  - For example, in wastewater there are simply too many organic constituents to distinguish
  - So we use an indirect, composite test for aggregate organics (i.e. BOD)
  - So why not do the same thing with odorants?
    - Since people only complain when odors are bad, is there a way to quantify an aggregate odor intensity (objectively)?

Used Biology as an Inspiration





There may be 10,000 different receptors

Specific receptors in certain sequences (receptor maps) register an individual odor

The Science of Smell

BIOSENSOR DEVELOPMENT

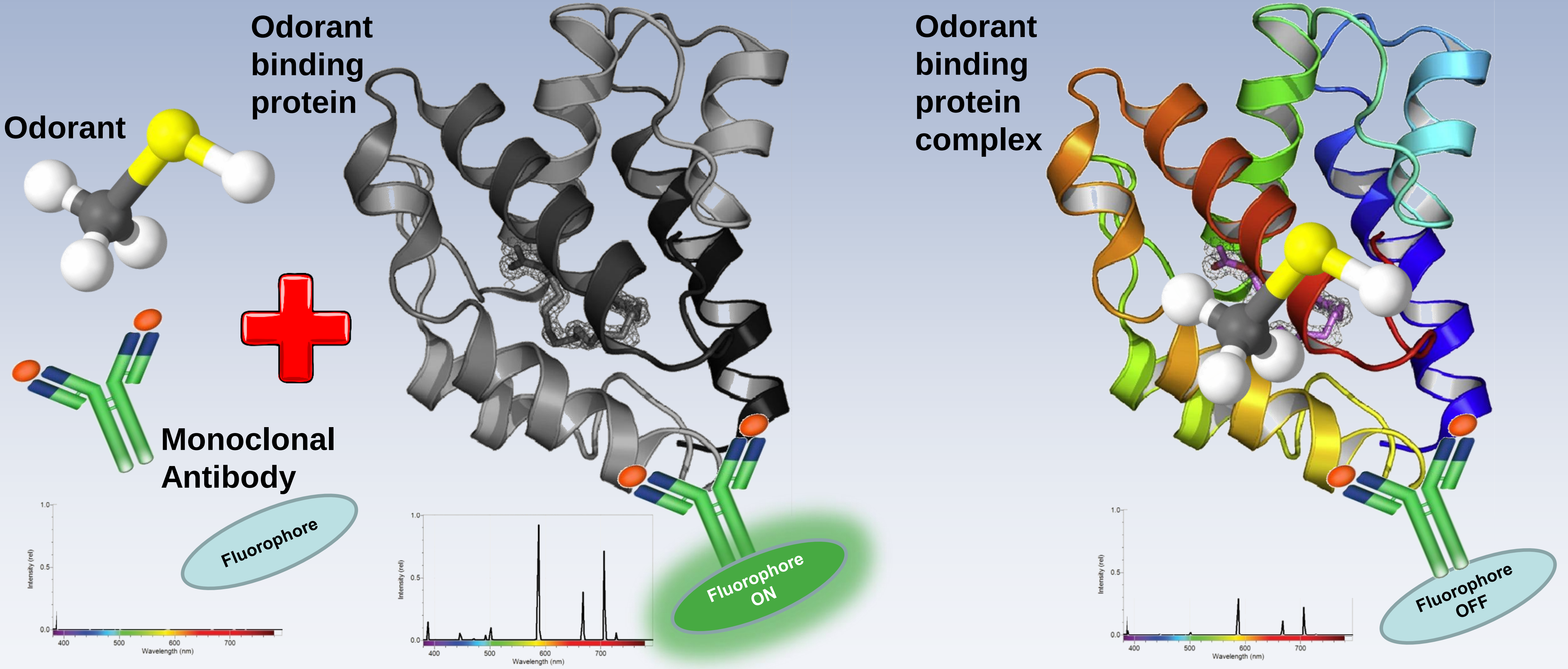
  

Proposed Approach

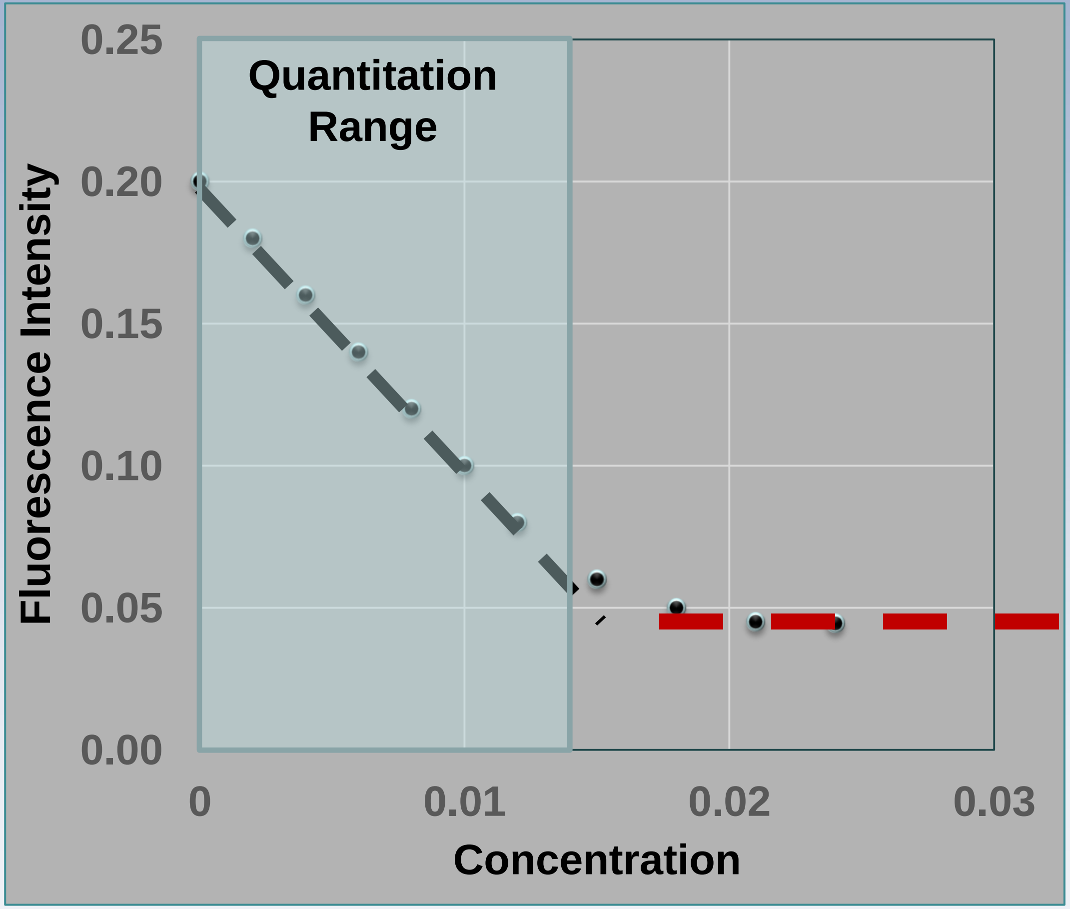
- Known protein isolates (hOBP2A) can bind with odorants in the µM-range
- Odor intensity is based on the number of bound receptors (non-specific?)
- If so, we can spectroscopically tag hOBP2A and its binding response will be concentration-dependent and follow Beer's Law (quantitative)
- May be reversible too

Mechanism


Odorant
Odorant binding protein
Odorant binding protein complex
Monoclonal Antibody
Fluorophore
Fluorophore ON
Fluorophore OFF
Intensity (rel)
Wavelength (nm)

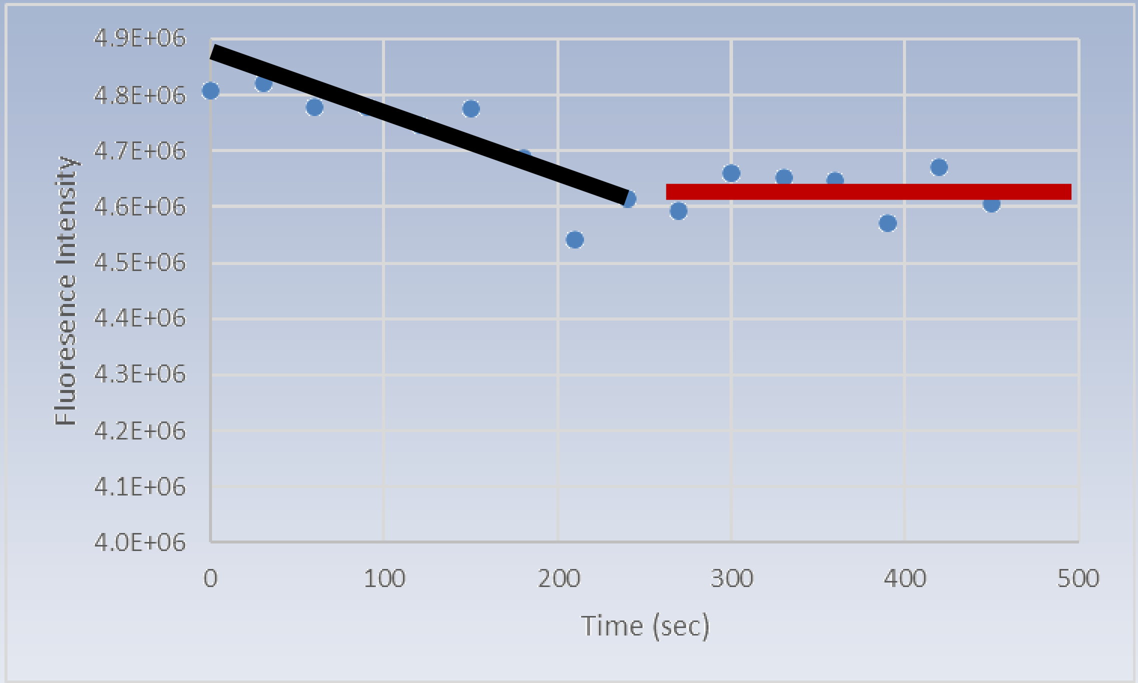
Objectives

- Create prototype biosensor
  - hOBP2A + 1-AMA tag complex
- Expose biosensor to odorants for various times
  - Single odorants and mixtures
- Measure spectroscopic signal to determine concentration dependence and quantitation range



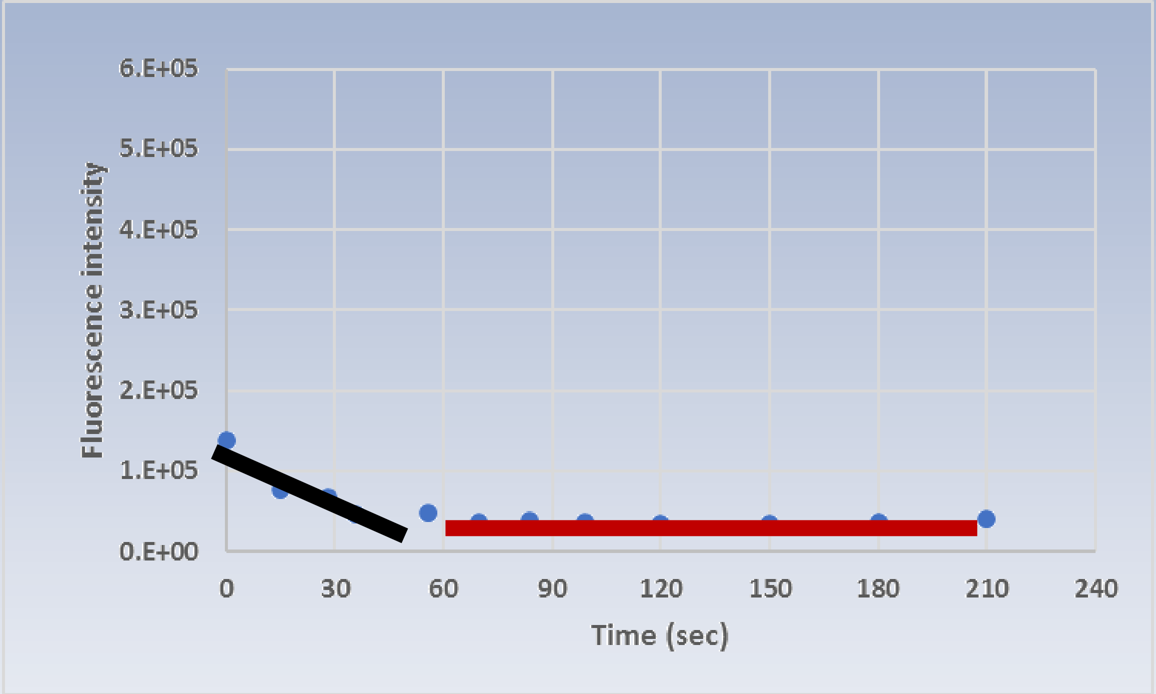
Quantitation Range for H_2S

- Initial experiments showed maximum detection limit occurs around 4 minutes
  - 100 mL of biosensor @ 0.5 lpm
- Under these conditions, the maximum quantitation limit appears to be ~4-5 µg H_2S



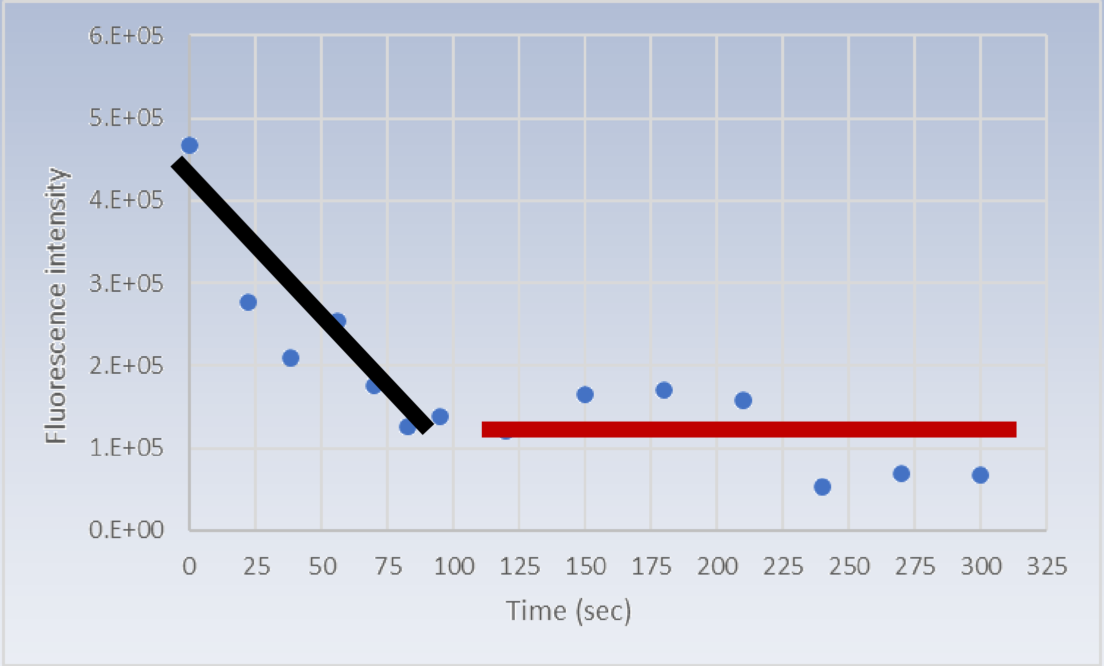
Quantitation Range for H_2S

- Initial experiments showed maximum detection limit occurs around 4 minutes
  - 100 mL of biosensor @ 0.5 lpm
- Under these conditions, the maximum quantitation limit appears to be ~4-5 µg H_2S
- Miniaturized to 10 mL, the limit is reached in 60 sec

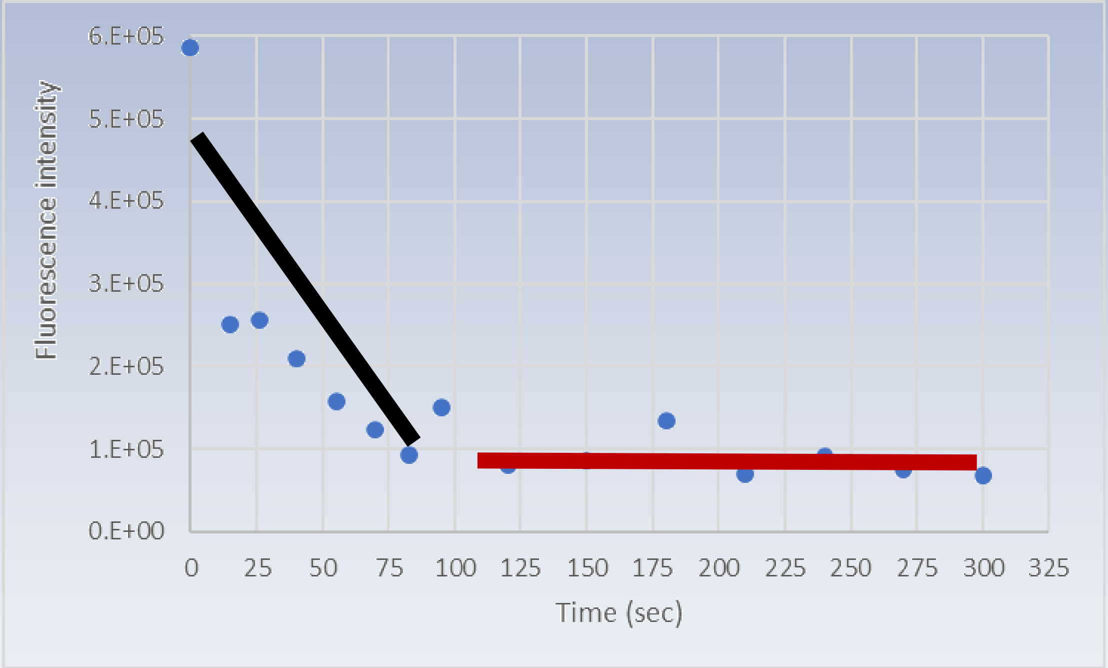


Other Gases Quantitation Ranges

Peak intensity for CH_4 0.5 slpm
Protein:fluorophore 1:1.4



Peak intensity for NH_3 0.5 slpm
Protein:fluorophore 1:1.2



Future Work

- Analyze difference in results for acidic, neutral, and basic odorants
  - Initial slopes were same order of magnitude with subtle differences, suggesting we might be able to tease out different odorants in mixtures using binding affinities
- Experiments with mixtures
  - "Standard landfill gas" (H_2S, CH_4, CO, N_2)
  - Concentration range for detection/quantitation
  - Flow rate and reversibility

Goal

Funding Partners

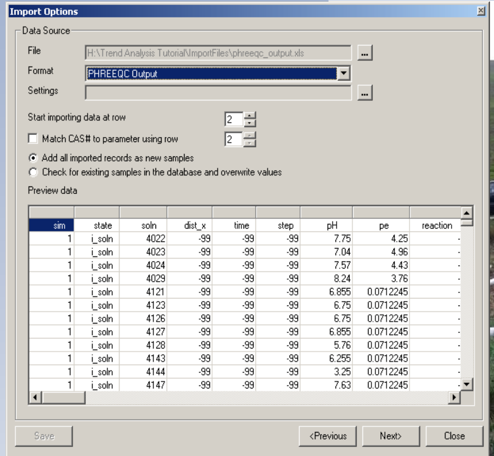
EREF

Hinkley Center
for Solid and Hazardous
Waste Management

Leachate

Biogeochemical Clogging

- Solids analyzed with x-ray diffraction
- Mixtures of leachate modeled with PHREEQC
- Clogging controls tested
  - Electronic pulsed scaling control
  - Dilution water
  - Acid injection
- Impacts to deep injection disposal well analyzed


Import Options
Data Source
File H:\Trend Analysis Tutorial\ImportFiles\phreeqc_output.xls
Format PHREEQC Output
Settings
Start importing data at row 2
Match CAS# to parameter using row 2
Add all imported records as new samples
Check for existing samples in the database and overwrite values
Preview data

sim	state	soln	dist_x	time	step	pH	pe	reaction
1	i_soln	4022	-99	-99	-99	7.75	4.25	-
1	i_soln	4023	-99	-99	-99	7.04	4.96	-
1	i_soln	4024	-99	-99	-99	7.57	4.43	-
1	i_soln	4029	-99	-99	-99	8.24	3.76	-
1	i_soln	4121	-99	-99	-99	6.855	0.0712245	-
1	i_soln	4123	-99	-99	-99	6.75	0.0712245	-
1	i_soln	4126	-99	-99	-99	6.75	0.0712245	-
1	i_soln	4127	-99	-99	-99	6.855	0.0712245	-
1	i_soln	4128	-99	-99	-99	5.76	0.0712245	-
1	i_soln	4143	-99	-99	-99	6.255	0.0712245	-
1	i_soln	4144	-99	-99	-99	3.25	0.0712245	-
1	i_soln	4147	-99	-99	-99	7.63	0.0712245	-

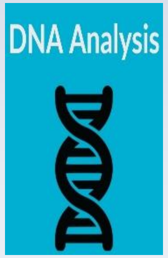
Save <Previous Next> Close

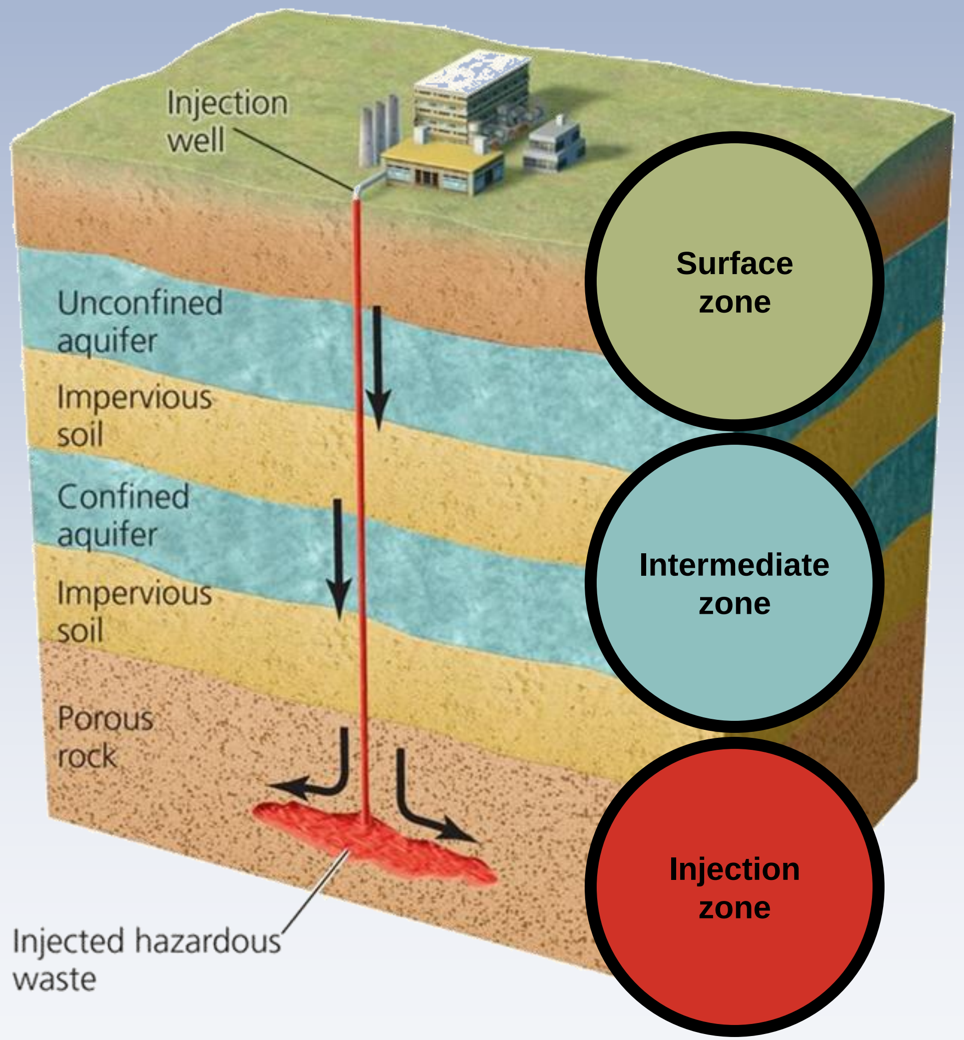
Main Findings

- Solids are mostly calcite ($CaCO_3$) with mineral salt impurities and biological residues
- Practical solutions were implemented in the field for managing clogging impacts
- A new mechanism for clog formation was tested and duplicated in the lab
- This is leading to new ideas for clogging control in leachate collection system piping networks

Deep Injection Well Biofilms

- Collect samples from 3 zones inside a deep injection well
  - Mineralogical analysis
    - Dominated by $CaCO_3$ (>90%)
    - Mineral salts (<10%)
    - High precipitation potential
  - Microbiological analysis
    - Methanogenic archaea & sulfate reducers
    - *Entamoeba*
    - Enterovirus and *Pseudomonas* phage





Electrochemical Oxidation of Leachate

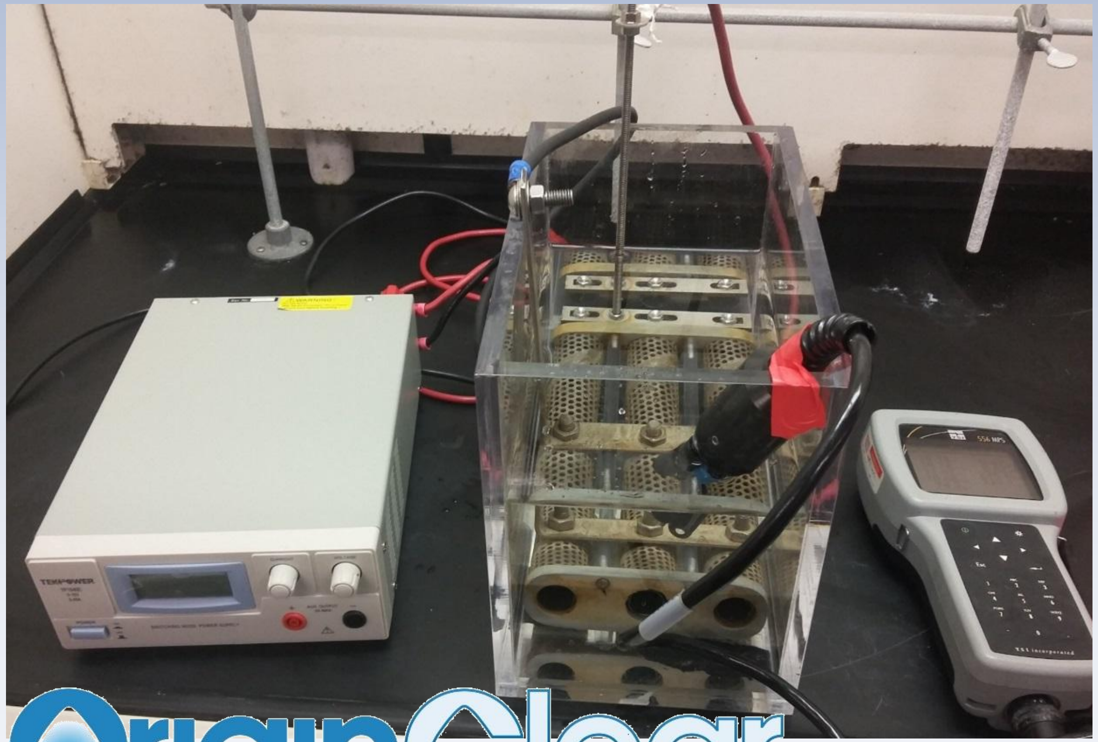
- To determine the treatment performance of EOx, coupled with different pre-treatment to remove COD and ammonia from landfill leachate
- Assess the generation of halogenated byproducts (THMs and HAA5)

Raw Leachate

Parameter	Range
pH	7.2 – 8.1
COD	5,500 – 10,000 mg/L as O_2
Ammonium-N	2200 – 3200 mg/L as NH_4^+-N
BOD	500 – 700 mg/L as O_2
Turbidity	230 – 1000+ NTU
Conductivity	30 – 80 mS/cm
Temperature	~25°C
TDS	23 – 54 g/L
Chloride	8 –14 g/L as Cl^-

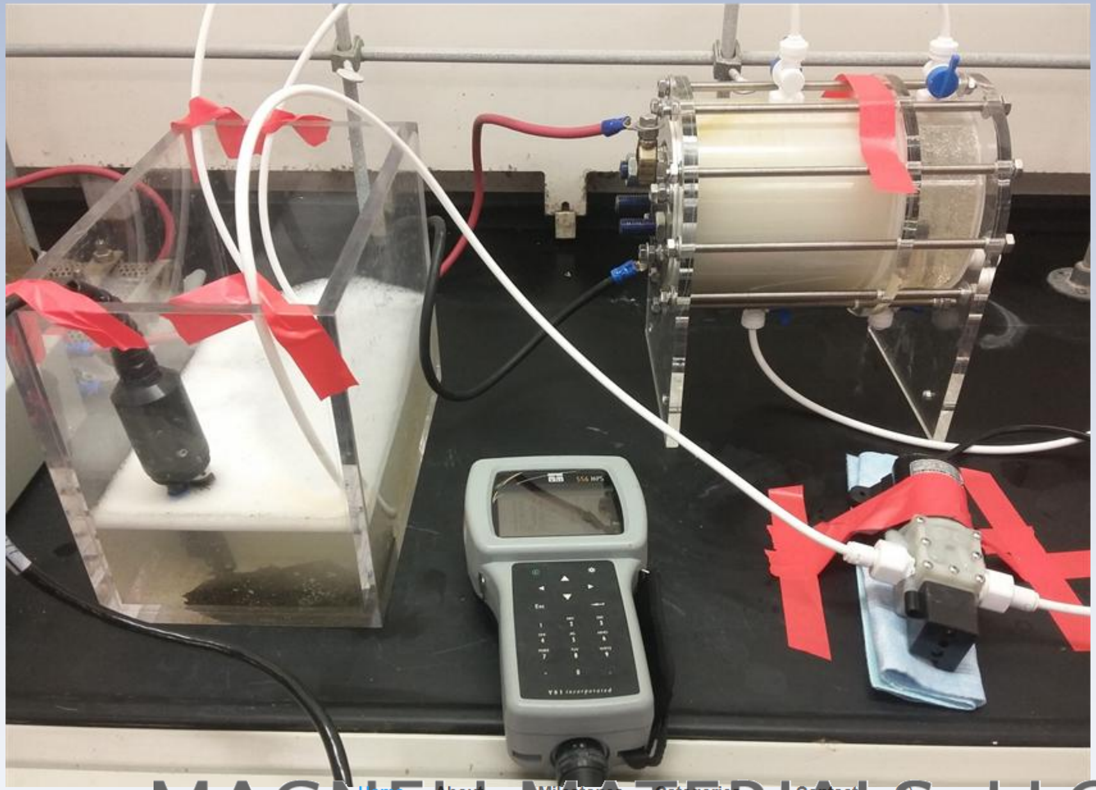
EOx Reactors

OriginClear Roughing EOx Reactor



OriginClear

Magneli EOx Polishing Reactor



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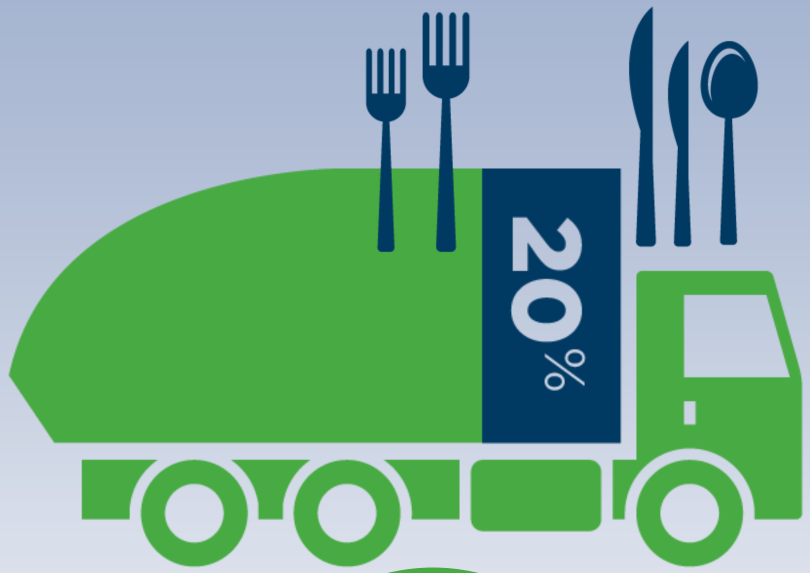
MAGNELI MATERIALS. LLC

Main Findings

- Pre-Treatment
  - Ozone
  - Fenton’s Reagent
  - Lime
  - Two-stage EOx
- Higher chlorides increase removal of COD
- Longer reaction times also increase performance
- Maximum performance achieved from pre-ozonation with Magneli EOx
  - COD removal = 52%
  - Ammonium-N removal = 52%
  - THMs = 5500 µg/L
  - HAA5 = 51,000 µg/L

Energy from Waste

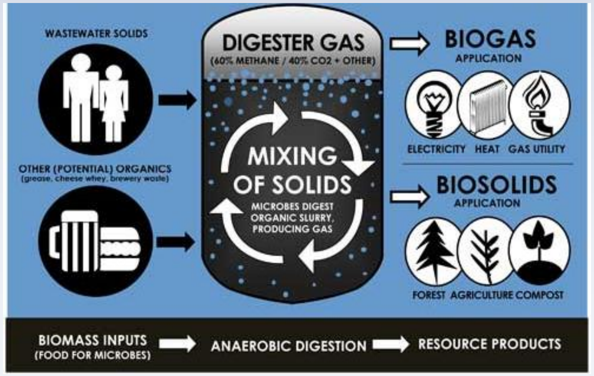


- In Florida, organic wastes make up 6-20% of the MSW
  - Only 2-5% is diverted from landfills
  - So ~2 million tons/yr landfilled
  - High moisture content (70%)
  - Low heating value (<2500 BTU/lb)*
- So, this stuff is undesirable for WTE, but ideal for anaerobic digestion

*Compared to MSW (~5000 BTU/lb)

Anaerobic Digestion

- There are 1497 anaerobic digesters in the US
- 83% are used strictly for wastewater applications
- Recent innovations in co-digestion have unlocked the potential for cleaner biogas (65-75% CH_4)
- If 10% of the digester feed is food waste, the biogas output can triple



Food Waste Anaerobic Digestion

- **Can we take advantage of unused digester capacity in the wastewater sector to generate more clean biogas from diverted food waste?**
  - Ultimate digestibility testing
    - Biogas production
    - Methane content
    - VS destruction
  - Meat trimmings from butchers and FOG from grease traps
  - Various feedstock ratios
    - (1:2 – 1:10) at SRT = 7 – 28 days

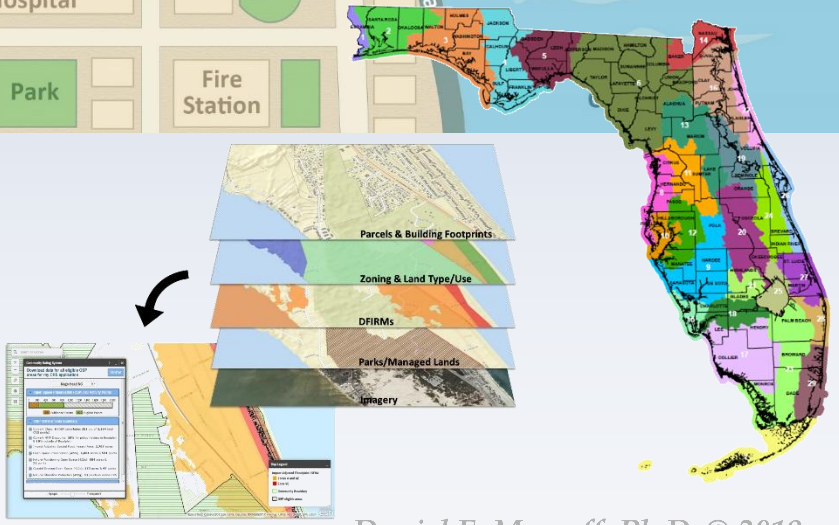
Major Findings

- Typical biogas production rate (0.2 – 0.5 m^3/kgVS) for anaerobic digesters was surpassed at SRT > 21 days
- Maximum biogas production
  - Meat 1:7 (0.23 m^3/kgVS)
  - FOG 1:4 (0.52 m^3/kgVS)
- Methane production was >60% for both feedstocks
- With these values, diverting 0.6% of Palm Beach County food waste to one digester would produce enough power for 130 – 360 homes

Watershed Management

- **Catalog and analyze Florida watershed data and maps**
- **Develop a screening tool for flood management and apply to coastal and inland watersheds**
- **Develop guidance for preparing watershed management plans to improve CRS score**

NATIONAL FLOOD INSURANCE PROGRAM



Funding Partners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