Surface and Drinking Water Quality at UIUC

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Background and Introduction

- Foreign Country
- Water taken from faucets, (electric) drinking fountains, and a pool
- Measured:
  - pH
  - Conductivity
  - TDS - Total Dissolved Solids
  - Turbditiy
- Requirements:
  - WHO - World Health Organization
 - EPA - Environmental Protection Agency (USA)

|	Drinking Water	Surface Water
pH	6.5 - 9.5	6.5 - 8.5
Conductivity	0.05 - 0.50 mS/cm	< 50 mS/cm
TDS	500 ppm	500 ppm
Turbidity	max < 5000 & median < 1000 ntu	-

Methods and Procedure

Setup and Data Acquisition

- 4 Analog Sensors (TDS, Conductivity, pH, Turbidity)
- 1 Digital Sensor (Temperature)
- Takes measurements simultaneously and individuall
- Labels and writes to multiple files on microSD
- Sets the frequency and number of measurements
- LCD displays menus and alerts
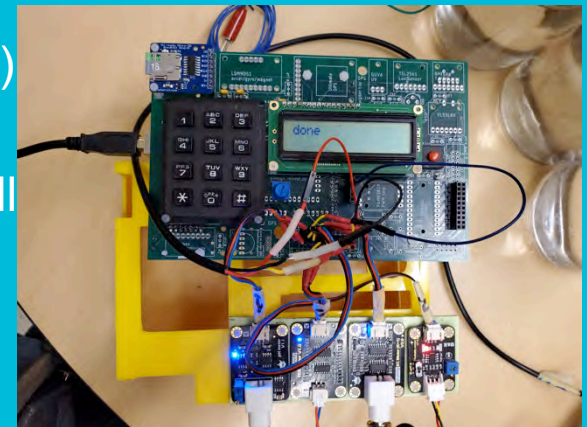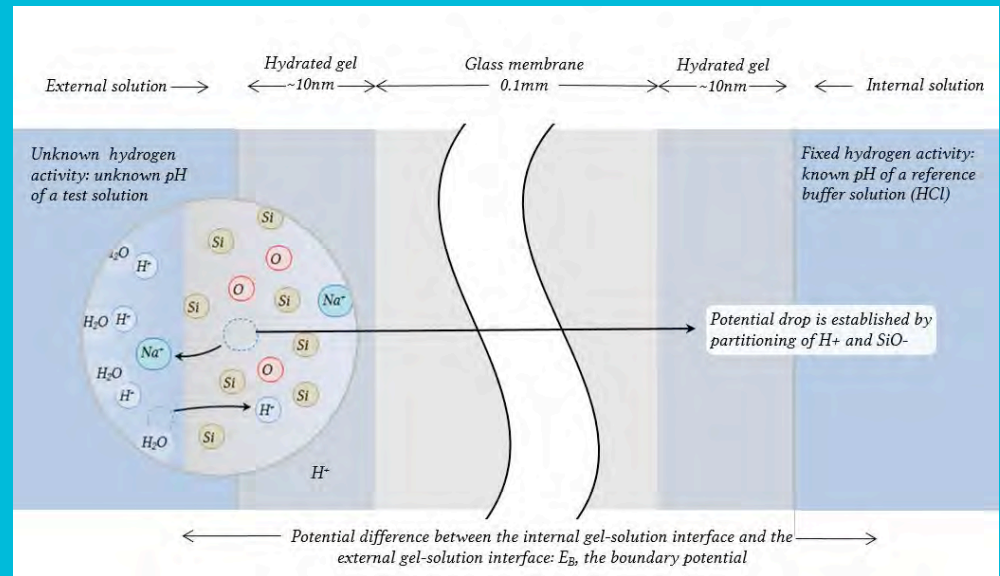
Measurement Locations

- Boneyard Creek
  - Scott Park
  - Drainage Pipe
  - Bardeen Pavilion
  - Mech. Eng. Building
  - Daniels Hall
- Loomis Laboratory
- ARC
- Ikenberry Dining Hall
- Illini Union
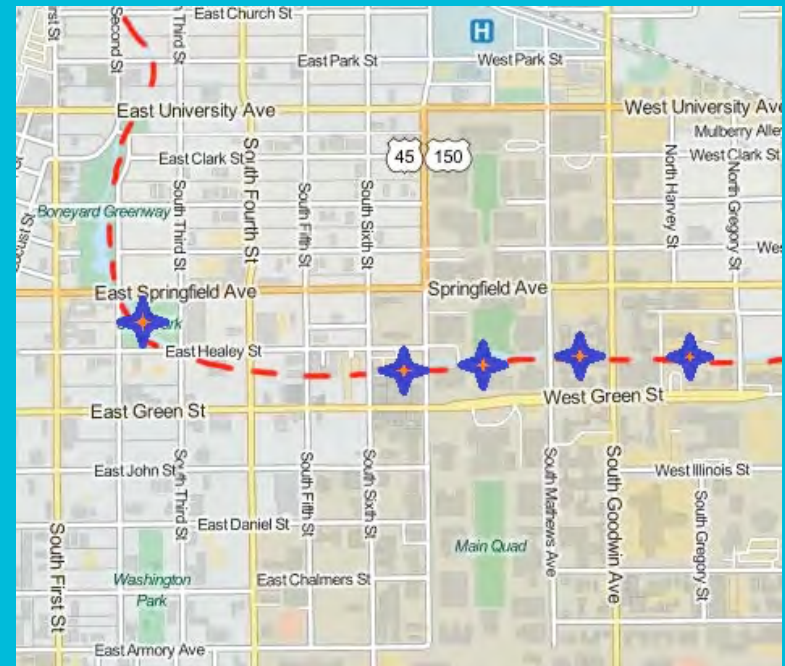
pH

- Electrode
  - Reference Electrode
  - pH glass Electrode
- What is a glass electrode?
  - Ion-specific
  - H^+
  - Hydrated gel
  - Potential difference in and out
- Specifications
- Calibration: linear relationship

External solution	Hydrated gel ~10nm	Glass membrane 0.1mm	Hydrated gel ~10nm	Internal solution

Unknown hydrogen activity: unknown pH of a test solution

Fixed hydrogen activity: known pH of a reference buffer solution (HCl)

Potential drop is established by partitioning of H+ and SiO-

Potential difference between the internal gel-solution interface and the external gel-solution interface: E_B, the boundary potential

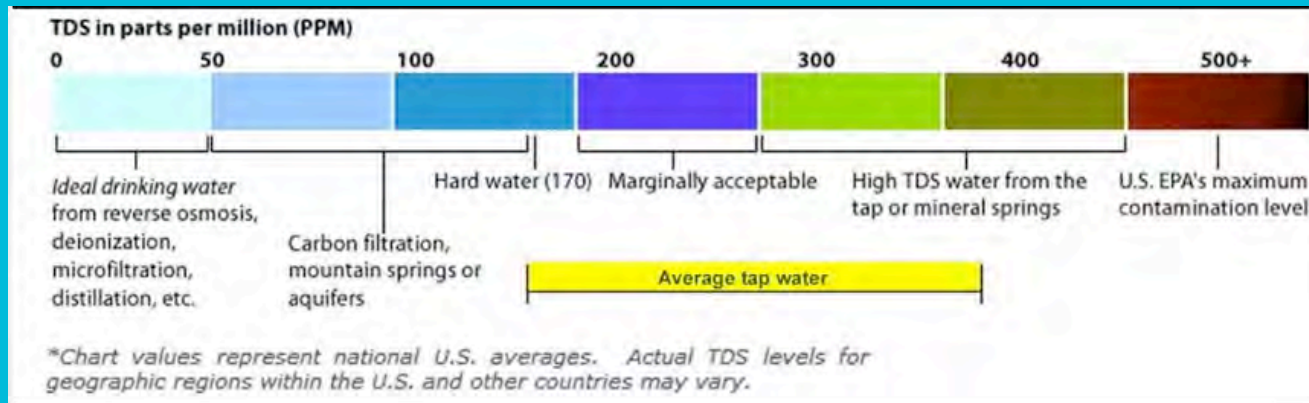| Power Supply	5.00 V
Measurement Range	0 - 14 pH
Temperature Range	0 - 60 ºC
Accuracy	± 0.1 pH (25 ºC)
Response Time	< 1 min

Conductivity

- Ratio of current density and electric field
- SI unit of S/m
- Dependent on ions present
- Pure water has a conductivity of $5.5*10^{-6}$ S/m
- Dependent on temperature
- Calibrated with known solutions

Power Supply	3.0-5.0 V
Measurement Range	0 - 20 mS/cm
Temperature Range	0 - 40 ºC
Accuracy	± 5%
Output Voltage	0 - 3.0 V

TDS

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- Uses conductivity of solution to determine TDS
- Similar to conductivity sensor
- Used in conjunction with temperature

Power Supply	3.0-5.0 V
Measurement Range	0 - 1000 ppm
Working Current	3 - 6 mA
Accuracy	± 10%
Output Voltage	0 - 2.3 V

TDS in parts per million (PPM)

0   50   100   200   300   400   500+

Ideal drinking water from reverse osmosis, deionization, microfiltration, distillation, etc.

Carbon filtration, mountain springs or aquifers

Hard water (170)   Marginally acceptable   High TDS water from the tap or mineral springs   U.S. EPA's maximum contamination level

Average tap water

*Chart values represent national U.S. averages. Actual TDS levels for geographic regions within the U.S. and other countries may vary.

Turbidity

- Uses property of Rayleigh scattering, light transmittance
- Only for undissolved solids
- Problems for device:
  - Testing
  - Values
  - Calibration
  - Manufacturer/Seller information
- Possible fixes

Power Supply	5.00 V
Measurement Range	> 2 μm
Operating Temperature	5 - 90 °C
Analog Output	0 - 4.5 V

Temperature

- Operates on a one-wire bus
- Requires a 4.7 kΩ resistor between the voltage and data line input
- Used in conjunction with Conductivity and TDS meter
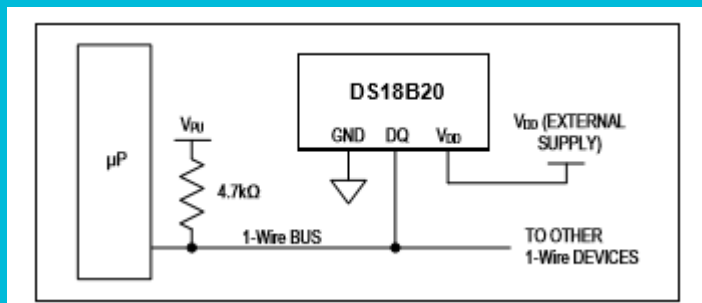
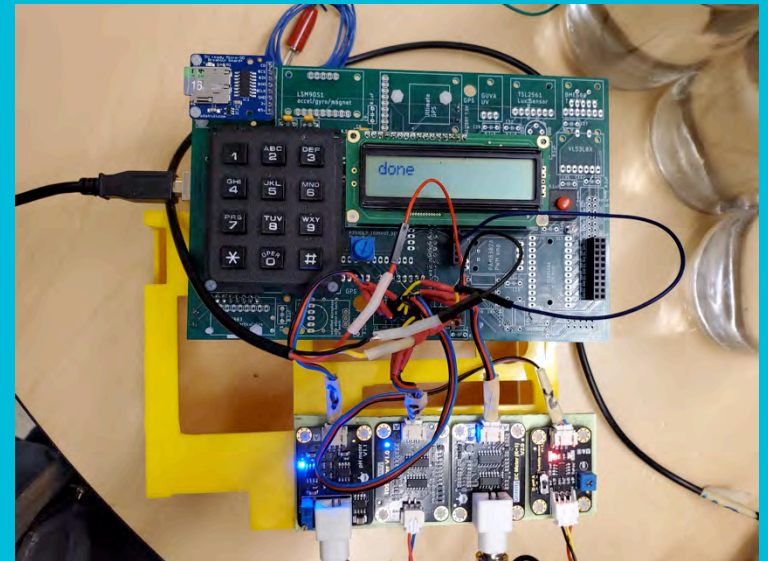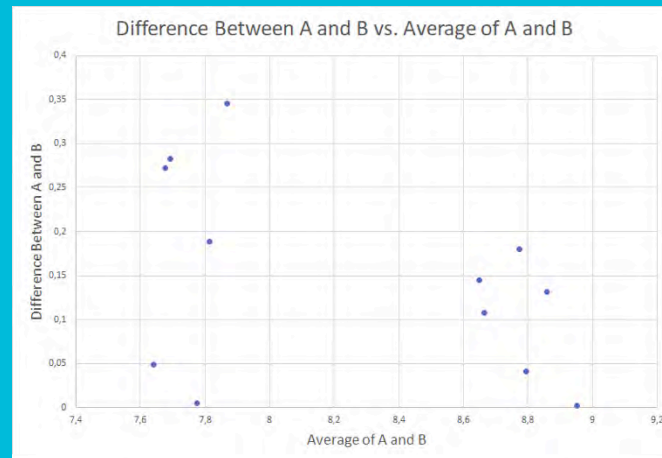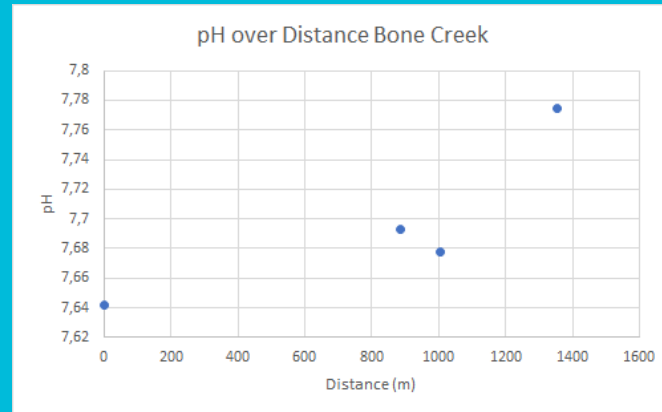| Power Supply	0-5.5 V
Measurement Range	-55ºC - 125 ºC
Accuracy	± .5 ºC

Cross-calibration

- Sensor sets calibrated on predetermined samples
- Collected samples tested with each set
- Higher Accuracy

Results

pH

- Requirements:
  - Drinking Water:

    6.5 - 9.5

  - Surface Water:

    6.5 - 8.5

- pH over B.C.
- Sensor A and B

pH over Distance Bone Creek

Difference Between A and B vs. Average of A and B

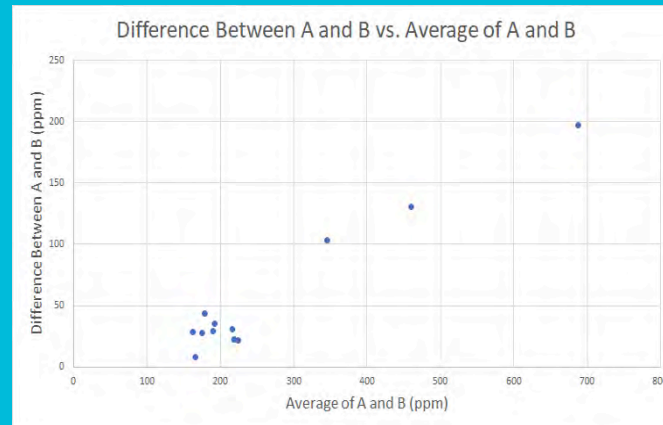|	Mean	
	A	B
Loomis Filter Orange	8.577	8.722
Loomis Filter Green	8.611	8.719
Loomis Drinking Fountain	8.793	8.924
ARC Drinking Fountain	8.773	8.814
Ike Drinking Fountain	8.950	8.952
Union Drinking Fountain	8.684	8.864
ARC Pool	7.720	7.909
B.C. Scott Park	7.617	7.666
B.C. Bardeen Pavilion	7.551	7.834
B.C. Mechanical Eng.	7.542	7.814
B.C. Daniels Hall	7.744	7.772
B.C. Drain Pipe	7.694	8.040

Conductivity

- Requirements:
  - Drinking Water: 0.05 - 0.5 mS/cm
  - Surface Water: < 50 mS/cm
- Sensor A and B very similar
- Notice:
  - High conductivity ARC Pool
  - High conductivity Scott Park

	Mean	
	A	B
Loomis Filter Orange	0.175	0.229
Loomis Filter Green	0.213	0.203
Loomis Drinking Fountain	0.213	0.178
ARC Drinking Fountain	0.238	0.235
Ike Drinking Fountain	0.240	0.240
Union Drinking Fountain	0.172	0.177
ARC Pool	1.452	1.523
B.C. Scott Park	0.606	0.589
B.C. Bardeen Pavilion	0.326	0.336
B.C. Mechanical Eng.	0.314	0.315
B.C. Daniels Hall	0.356	0.350
B.C. Drain Pipe	0.965	0.941

TDS

- Requirements:
  - Drinking Water:

    <500 ppm

  - Surface Water:

    <900 ppm

- Sensor A and B
- Over 200 ppm

Difference Between A and B vs. Average of A and B

	Mean	
	A	B
Loomis Filter Orange	156.258	199.920
Loomis Filter Green	160.927	188.776
Loomis Drinking Fountain	162.153	169.971
ARC Drinking Fountain	174.166	209.878
Ike Drinking Fountain	175.545	204.639
Union Drinking Fountain	148.797	177.204
ARC Pool	589.040	785.840
B.C. Scott Park	293.308	397.041
B.C. Bardeen Pavilion	207.896	230.122
B.C. Mechanical Eng.	200.787	231.231
B.C. Daniels Hall	214.060	235.754
B.C. Drain Pipe	395.389	525.806

Conclusions

- Drinking water samples
  - Elkay fountains
- Surface water samples
  - ARC Pool
  - Drainage Pipe
- Safety of water
  - Devices
  - Results

Discussion

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- What can the device do?
- Accuracy
- Future modifications and uses

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