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SmartFARM
Soil Library & Calibration Protocol

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Outline

Part I – Soil Library

- Soil Library
- Soil Sampling Location and types
- Soil Library Building Process
  - -Soil Homogenization (by Grinding)
  - - Soil Saturation
  - - Soil Drying

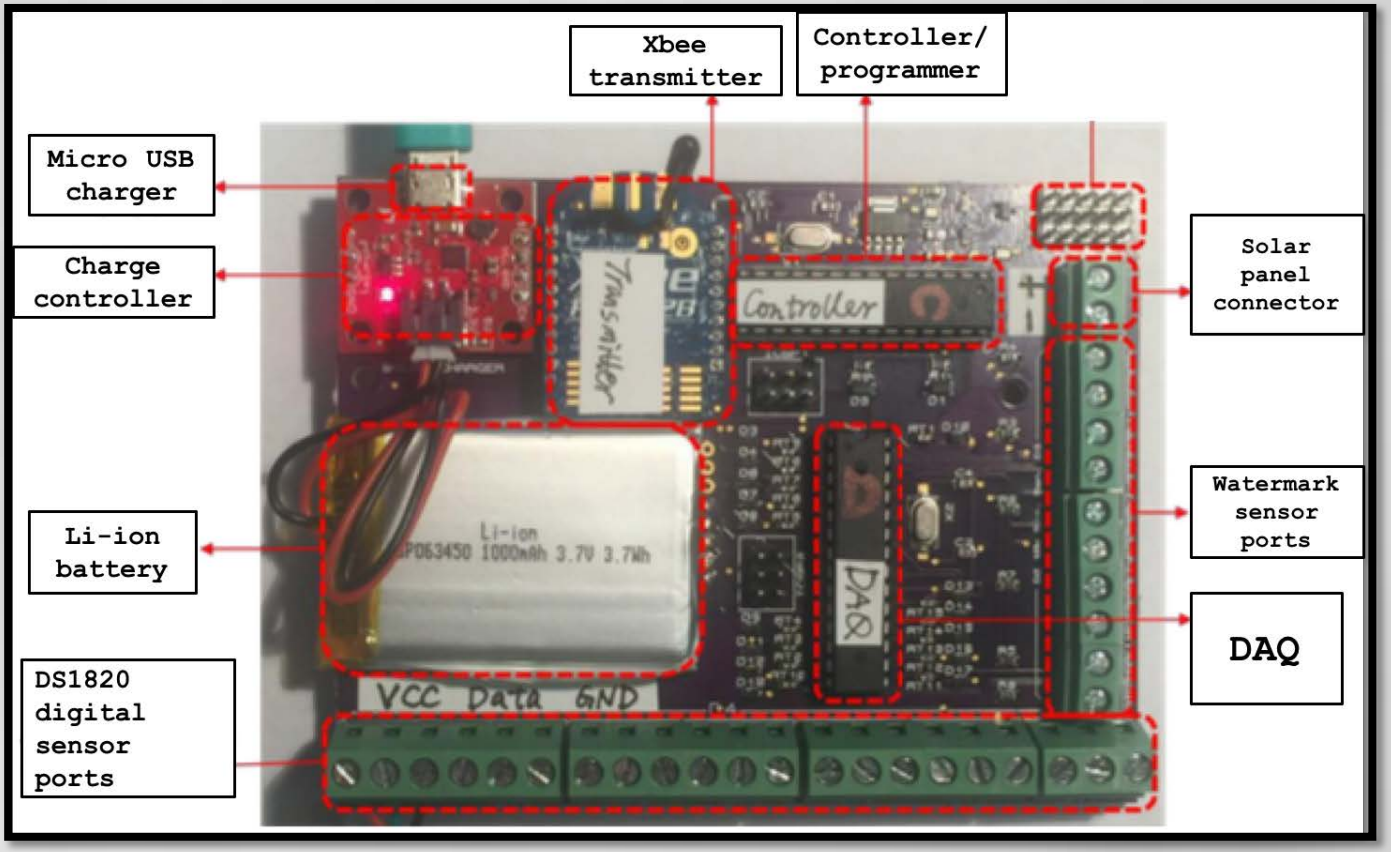
Outline

Part II – Calibration Protocol

- Calibration Protocol
  - Watermark Sensor
  - Raspberry Pi Circuit
  - Sensor Calibration using trough and Buckets
  - Calibration of pH probes
  - Determination of pH for soil samples
  - Results and Discussion

PART I
Soil Library

Smart Farm Data Acquisition –New Board



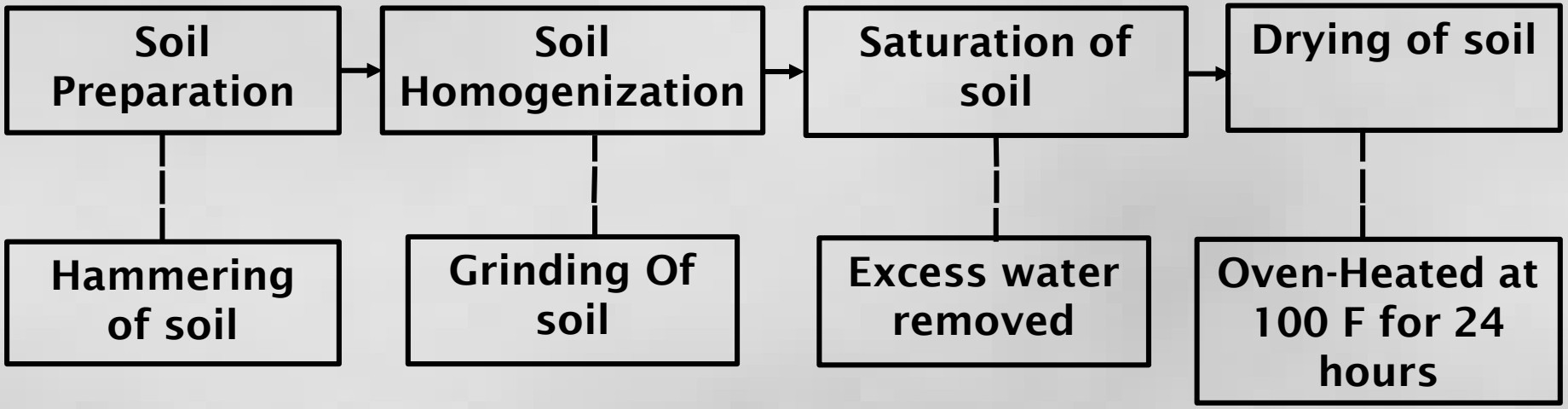
Labelled smart farm DAQ board

Soil Library

- **Need Justified to Build a Soil Library**
- **Sandy, Sandy Loam, Loam, Clay Loam and Clay (5 Soils) as a Start**
- **Resizable to 12 – 15 Soils based on nature of sensors and research needs**
- **Could be used for multiple soil parameter sensing like,**
  - Moisture
  - Organic Matter
  - Salinity
  - pH
  - N, P, K, Na
  - Compaction

Soil Library

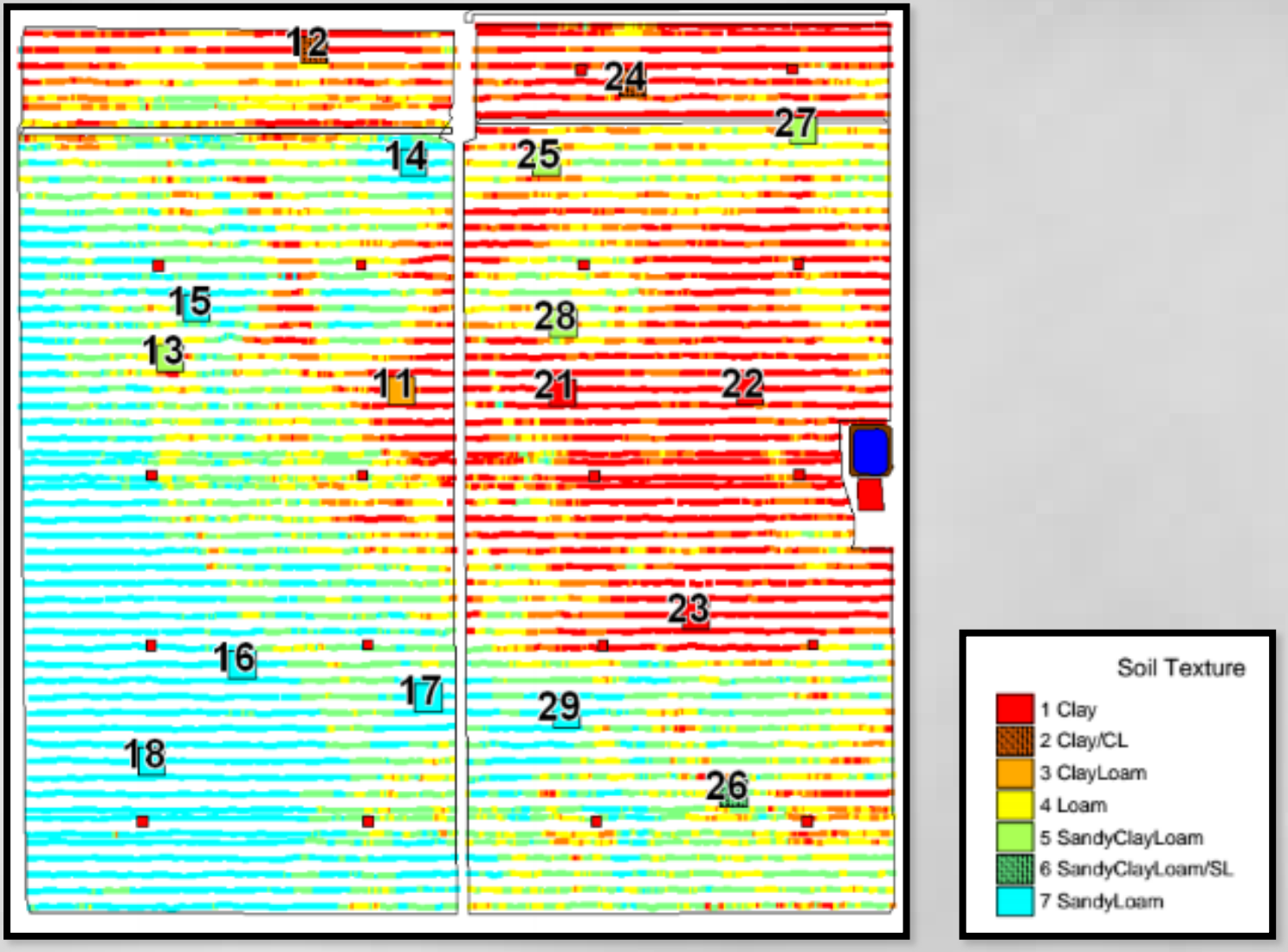
- **Soil Library Building**
  - **Based on Protocol**
  - **Application (Sensor Calibration)**



Soil Library - Location and Types

- The soil collected towards the soil library are from Ranch-71 (Delano, California)
- 4 types of soil collected were *Clay loam*, *Sandy clay loam*, *Sandy Loam and Clay*

Soil Texture Map – Ranch 71



Field Soil Collection – 71N

Dr. Yager and other graduate students got hands-on experience by using an auger to drill out soil samples

Field Soil Collection





- Soils collected in different texture zones from UAL (Univ. Ag. Lab, Fresno State) fields,
  - Almond
  - Citrus
  - Feed Crops

Types of Soil Collected and processed

S. No.	Sample	Type of soil	Location	ID	Status
1	a	Clay	71N	21	processed
	b	Clay	71N	23	-
2	A	Sandy loam	71N	14	processed
	B	Sandy loam	71N	15	processed
	C	Sandy loam	71N	17	processed
3	A	Sandy clay loam	71N	12	processed
	b	Sandy clay loam	71N	13	processed
4	a	Clay loam	71N	11	processed
5	a	Fresno field – 1	-		processed
	b	Fresno field - 1	-		processed
6	a	Fresno field – 2	-		-
	b	Fresno field – 2	-		-

Soil Validation Through Lab Tests

SAMPLE	OM	ENR	P1	HCO3_P	K	Mg	CA	Na	pH	BUF	H	CEC	K	Mg	Ca	H	Na	NO3_N	S	Free	Sol	SAND	SILT	CLAY	TEXTURE	Avail. H2O	ermeabilit	Location
ID		#/A	ppm	ppm	ppm	ppm	ppm	ppm		pH			%	%	%	%	%	ppm		Lime	Salts	%	%	%		In/Ft	In/Hr	
11	0.9L	47	1	16H	73L	197L	4568VH	358H	8.2		0	26	0.7	6.2	87	0	6	11L	19M	H	0.7M	43	22	34	ClayLoam	1.41	0.12	71N
12	1.2L	54	5	17H	167L	311L	4758VH	361H	8.2		0	28	1.5	9	84	0	5	3VL	17M	H	0.5L	33	26	40	Clay/CL	1.58	0.13	71N
13	0.9L	47	11	23VH	123L	244M	3144VH	356H	7.9		0	20	1.6	10	80	0	7.9	6L	10L	H	0.5L	47	20	32	andyClayLoa	1.36	0.14	71N
15	0.5L	40	8VL	17M	46L	138L	1480M	503VH	6.4	6.9	1.1	12	1	9.5	62	9	18.4	3VL	39VH	L	2.7H	61	22	16	SandyLoam	1.17	0.41	71N
17	0.5L	40	13	30VH	63L	56L	1406VH	140H	7.6		0	8.2	2	5.6	85	0	7.4	2VL	9L	L	0.3L	73	12	14	SandyLoam	1.06	0.53	71N
21	1.4L	57	6	28VH	167L	209VL	7408VH	534H	7.8		0	41	1	4.1	89	0	5.6	2VL	306V	H	2.0M	25	24	50	Clay	1.59	0.13	71N
23	1.5L	59	5	13M	157L	263L	5077VH	390H	8.1		0	30	1.4	7.3	86	0	5.7	10L	46VH	H	0.8M	31	24	44	Clay	1.56	0.15	71N

Sampled 2006: 2-36' Probe samples per location

Resampled 2012: 12 to 16 X 8" T hand probe per location

Resampled 4/18/2015: 8-1.75" x 15" auger cores from 2 adjacent rows between trees N & S of sprinklers

Resampled 6/2/2016: 12-1.75" x 16" auger cores from 3 adjacent row marks

Soil Prep

Soil Preparation process

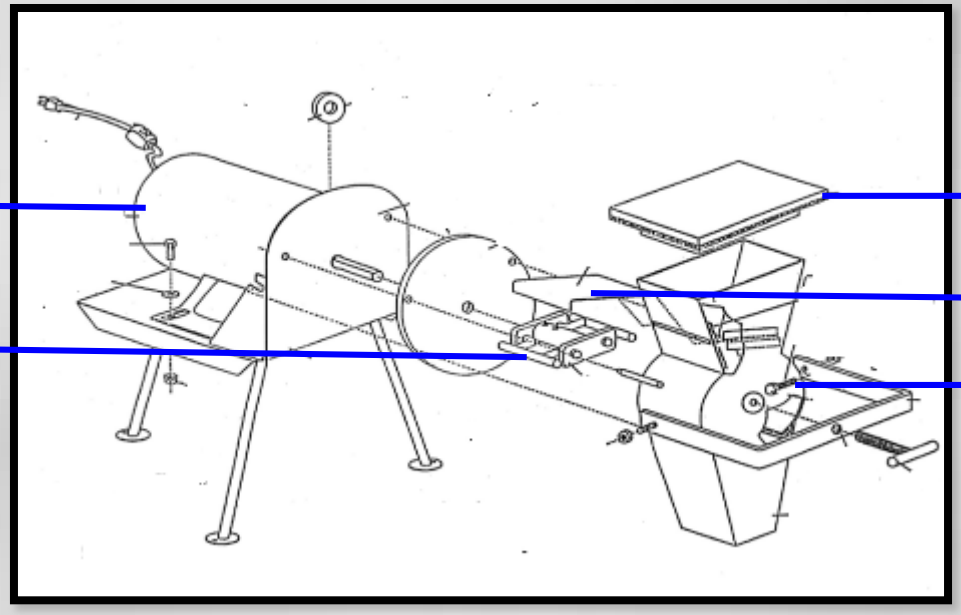
- Aggregates broken down with an hammer
- Safety check for Grinding: No huge chunks
- Filtering foreign material:
- E.g., Wood chips were removed manually

Soil Grinder

The Humboldt Soil Grinder

- Function is to grind the aggregate soil particles are broken up into smaller grains
- Continuous grinding is ensured by using the **gate** below the hopper to feed the soil at a rate that doesn't stall the motor

Humboldt Soil Grinder



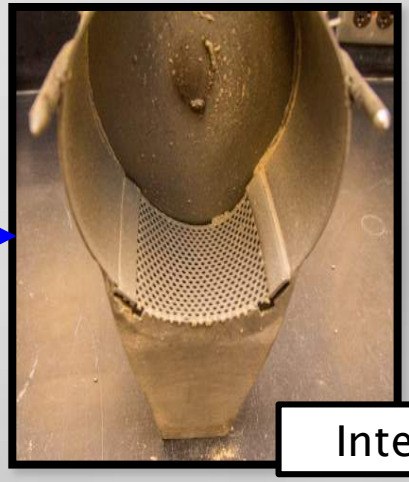
Motor

Lid

Gate

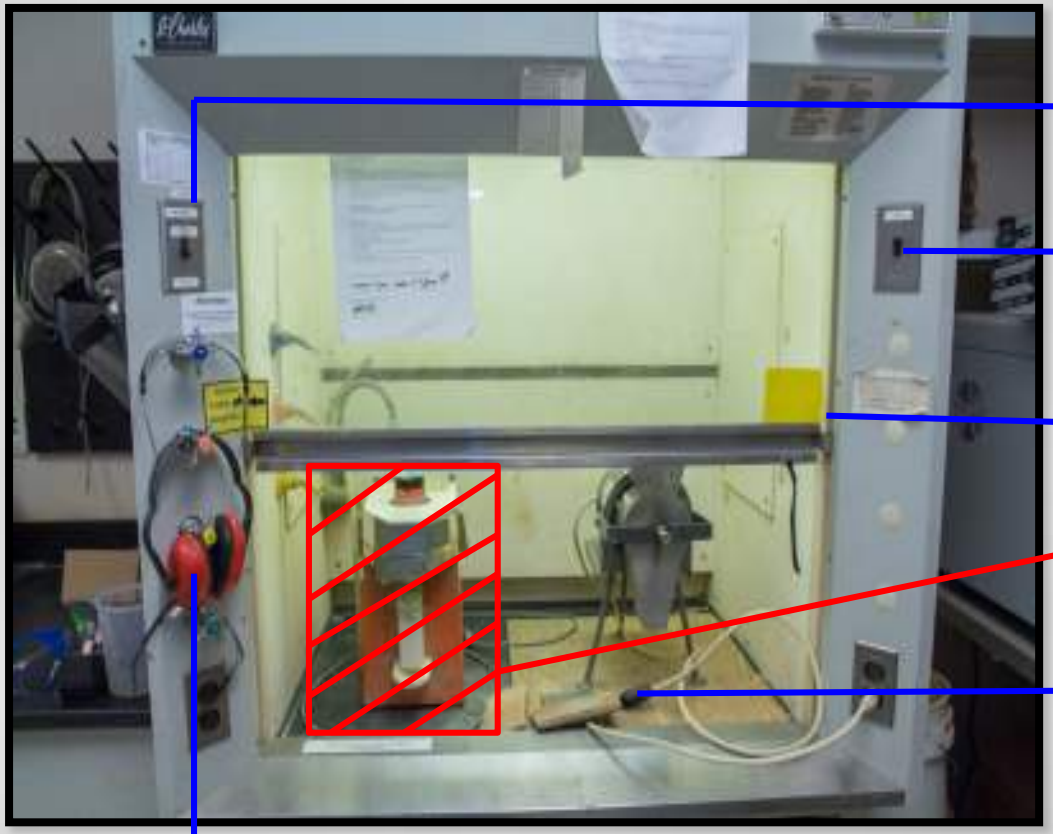
Flails

Interior Section of grinder



Interior of hopper

Soil Grinder Lab Setup



Blower Switch

Lights On/Off

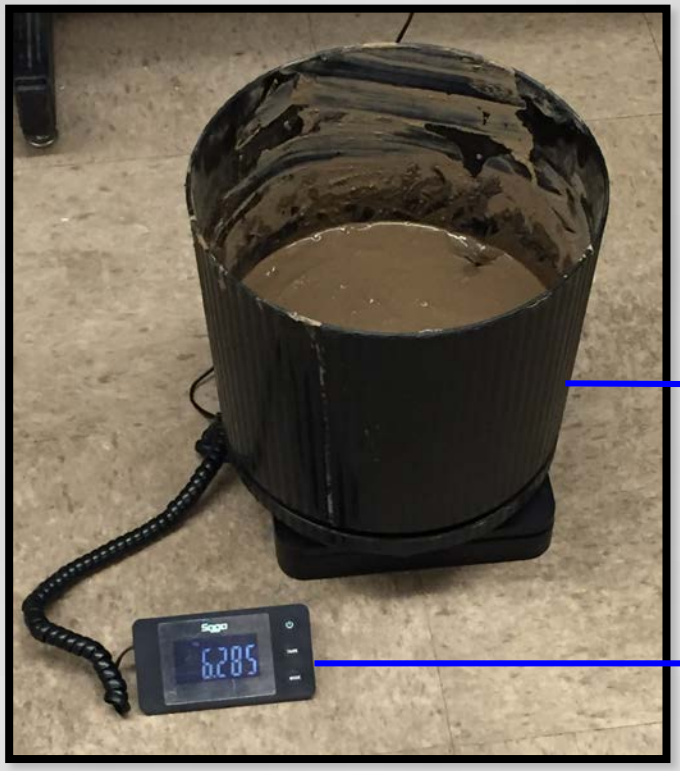
Protective Window

Not Used

Motor Switch for operating grinder

Safety equipment's

Soil Saturation

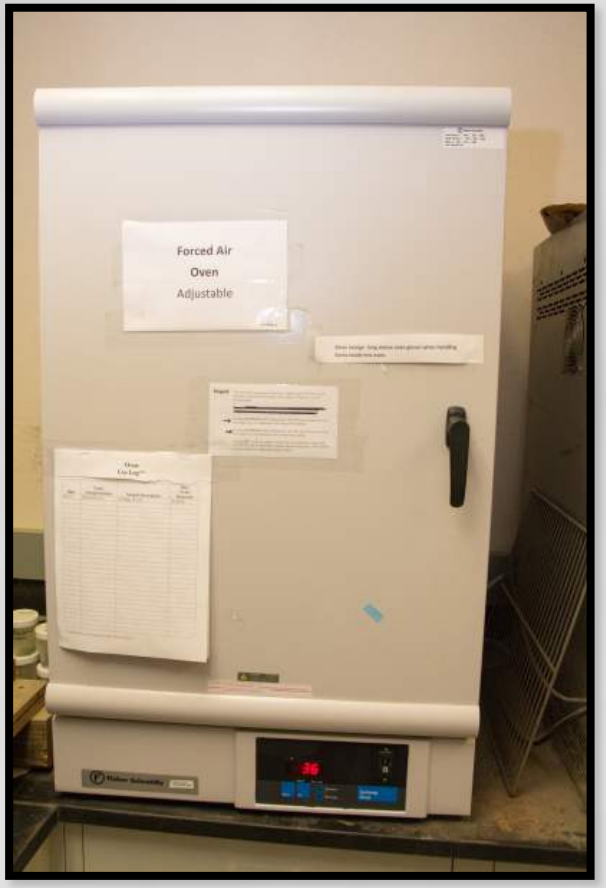


Weight of water = **0.835 kg or 0.22 gallons**

Saturated soil after 2 days of resting

Weighing Apparatus

Soil Drying

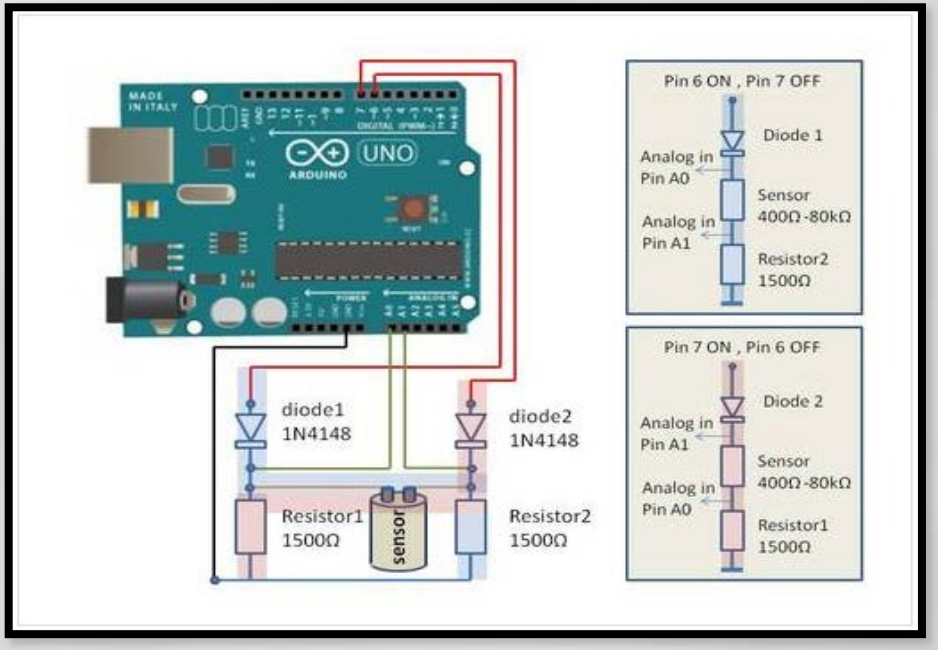


Forced Air Oven

- At saturation state, the bucket was placed inside this oven
- The temperature was set at 100 F
- The oven is equipped with tubular opening on its ceiling which was used as an entry point for sensor wires

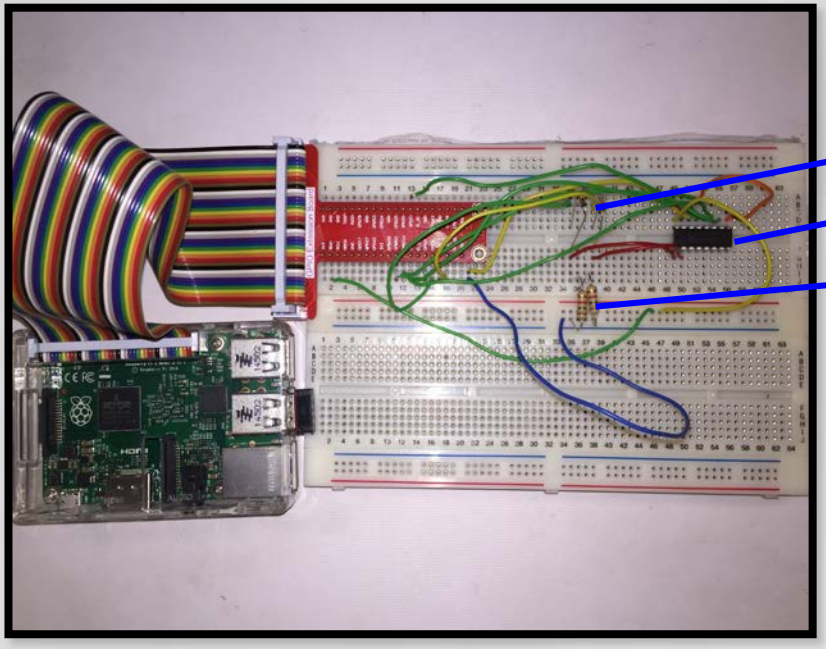
PART II
Calibration Protocol

Watermark Sensor – Arduino Uno circuit



UCSB Setup

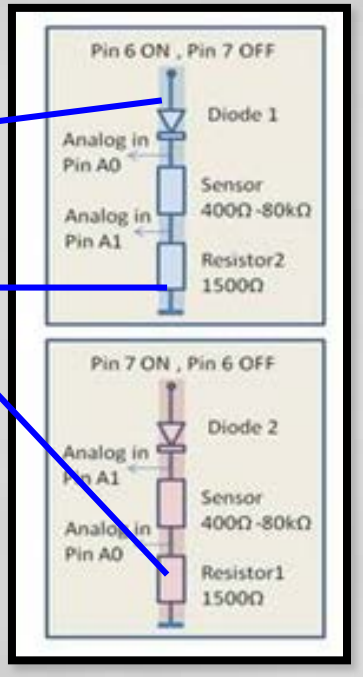
Watermark Sensor – Raspberry Pi circuit



Diodes

ADC 3008 (10 bit)

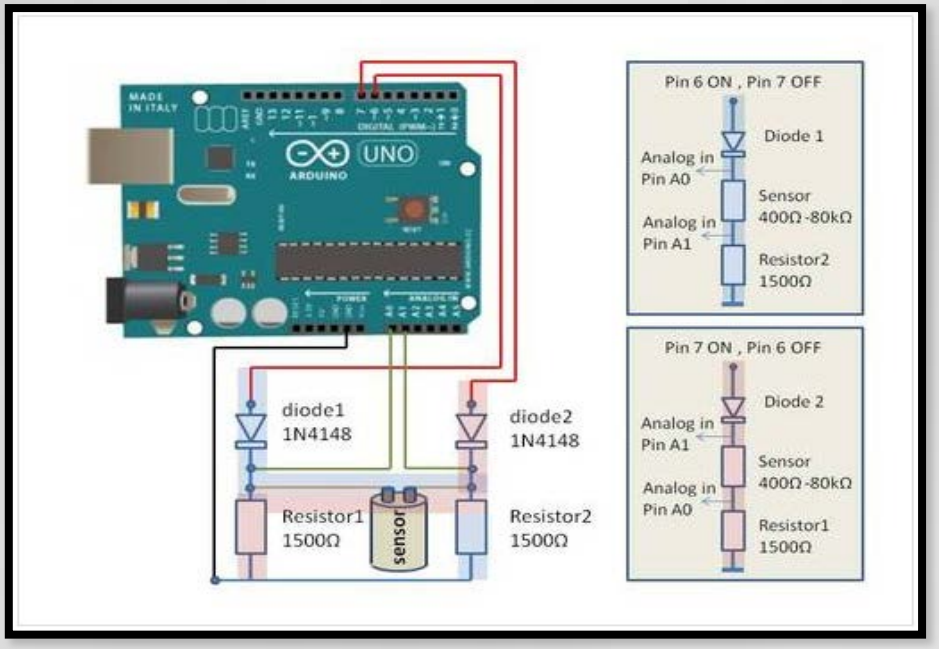
Resistors 1500Ω

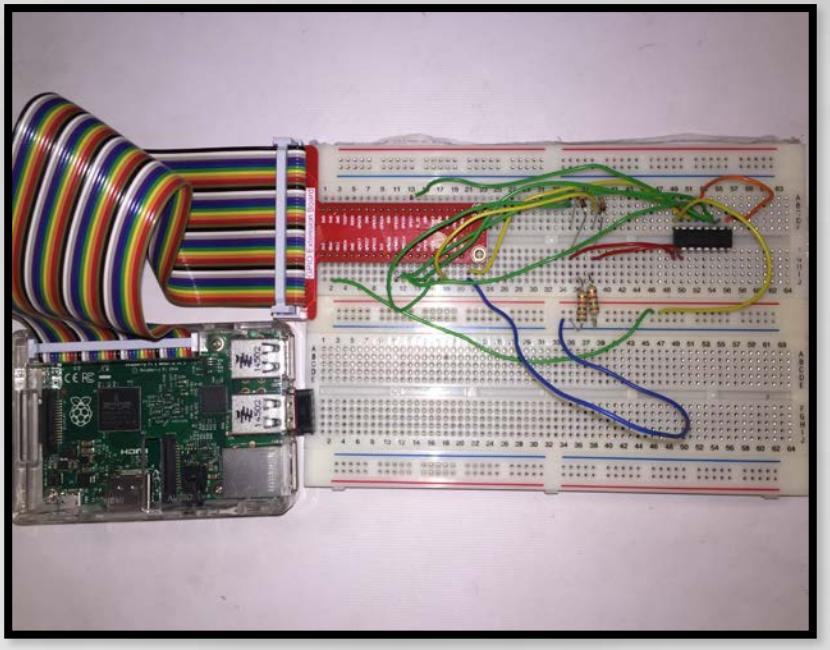


Raspberry Pi Setup

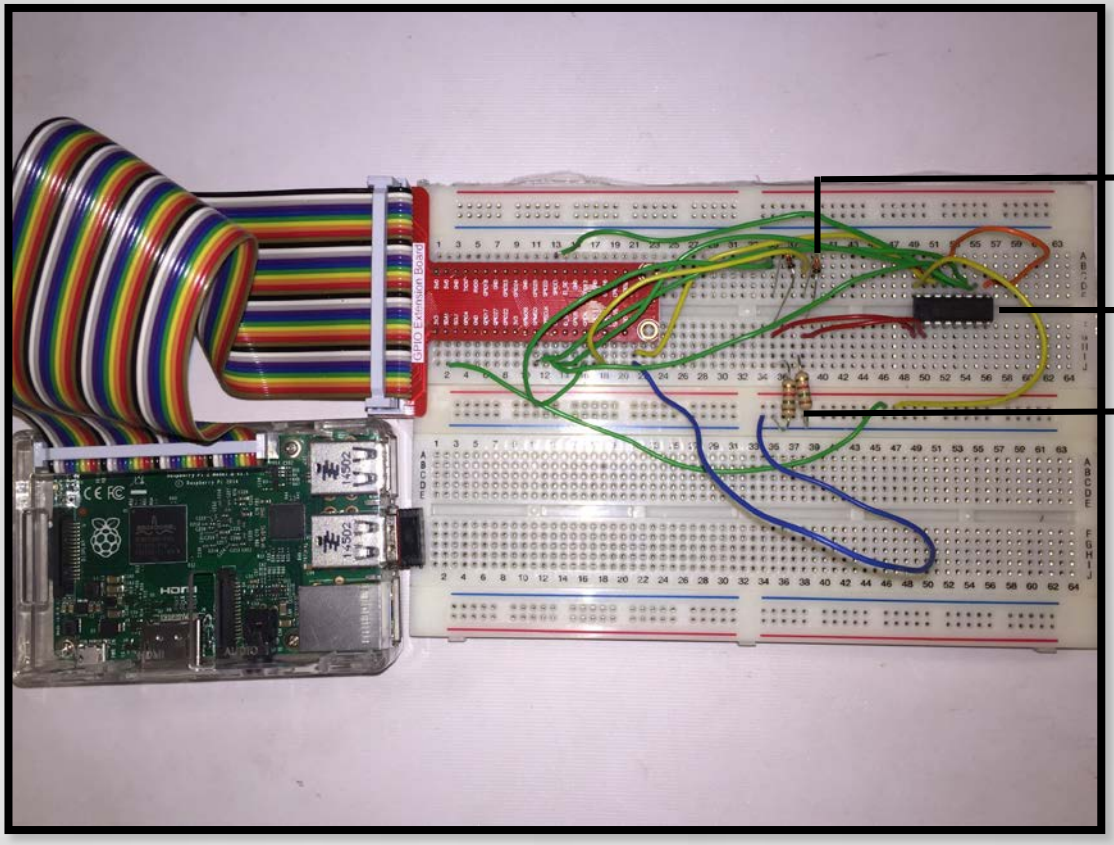
Circuit Diag.

Watermark Sensor – Raspberry Pi circuit





Watermark Sensor – Raspberry Pi Circuit Integration



Diodes

ADC3008

Resistors of 1500 ohms

Sensor Calibration

Tubular opening for Sensor wires

Bucket with saturated Sand

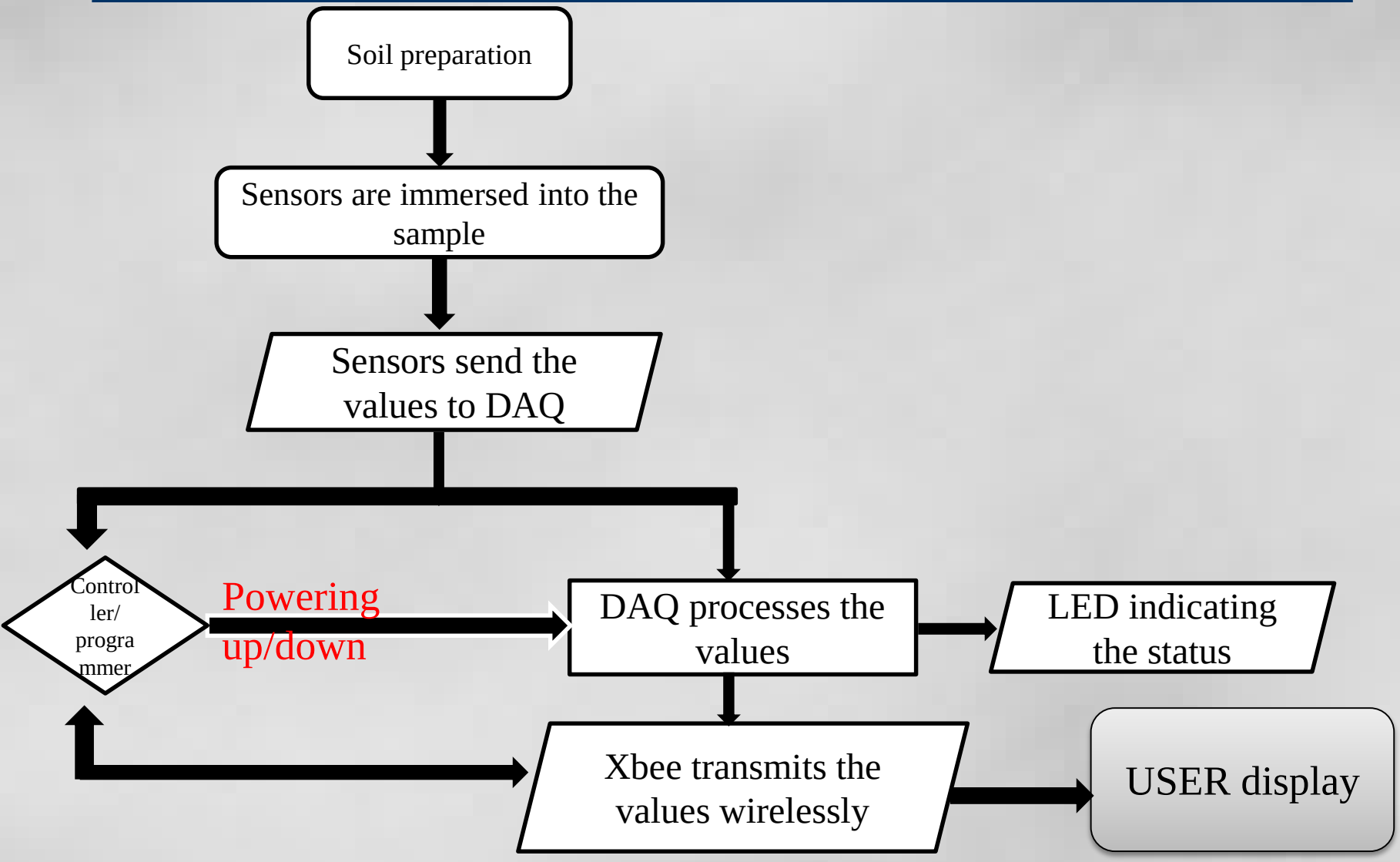
Forced Air Oven

Temperature setting module

Smart Farm Data Acquisition –New Board and its Experimental Setup

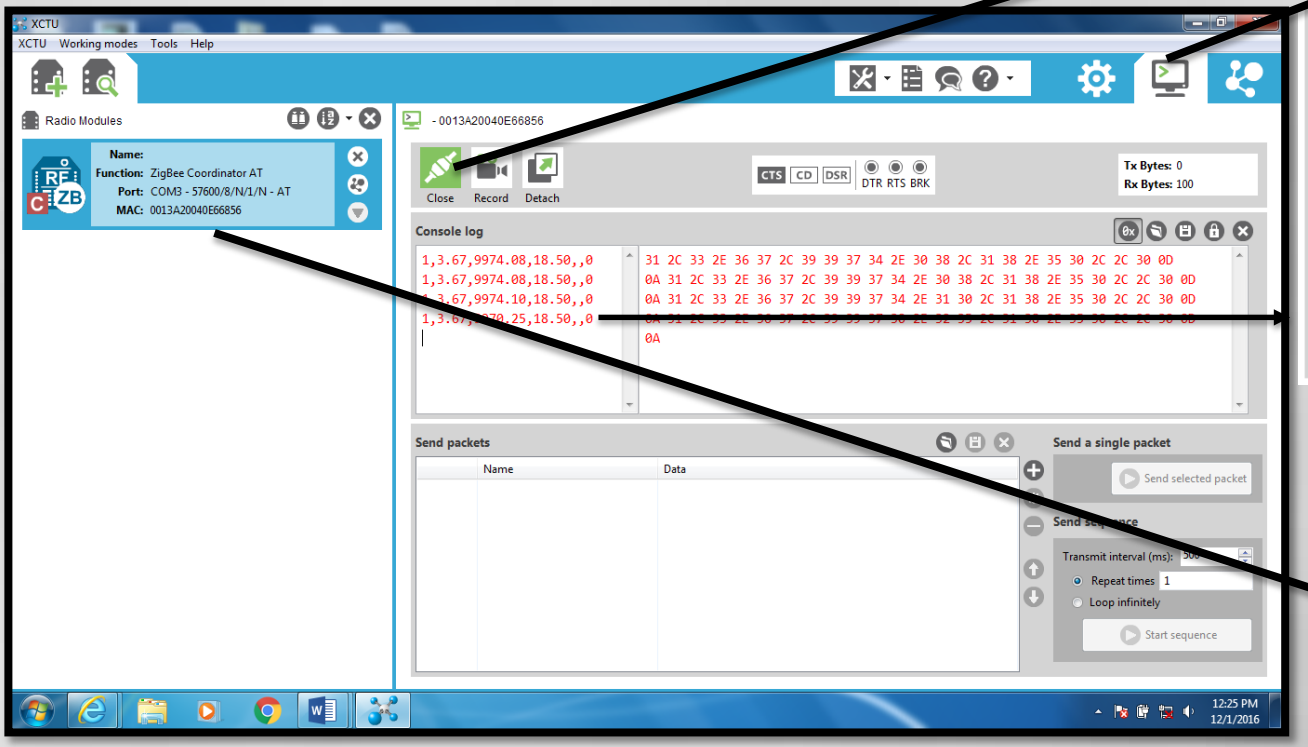
A Styrofoam cup is used in the setup which holds ample amount of processed soil to retrieve soil properties using various sensors

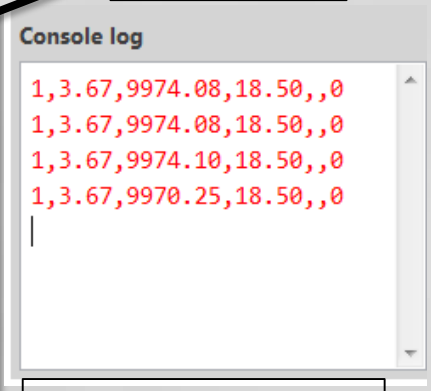
Methodology



Methodology

- The values obtained are displayed in the following format in the XCTU software





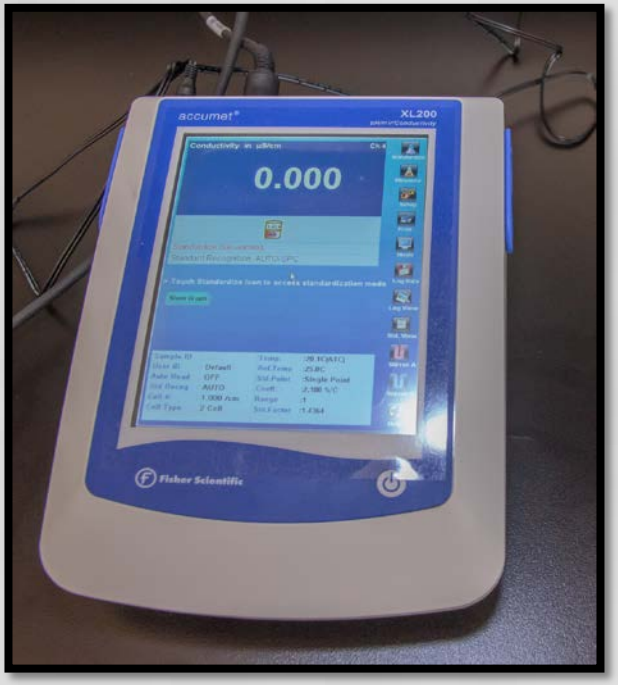
open/close circuit button

Xbee input

Output from the smart farm DAQ board

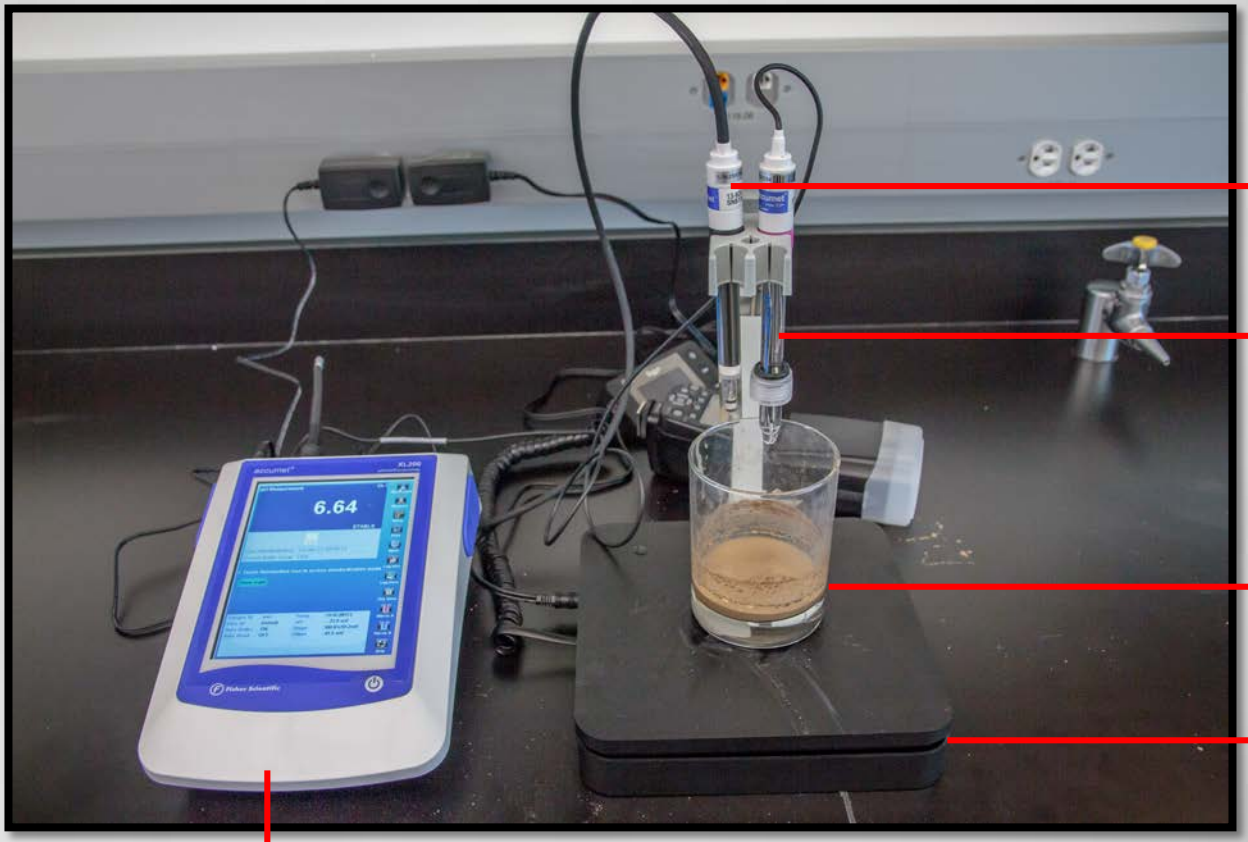
Specifications of the added Xbee

Calibration of pH Probes – Bench Meter



- Accumet XL200 pH/conductivity benchtop meters provide advance measurements with less work
- Provides pH calibration with 0.001 pH resolution
- pH range -2.000 to 20.000 pH
- Has the option to standardize temperature as needed for our experiment

Determination of pH using soil sample - Setup



Conductivity/ Temperature probe

pH electrode

Soil Slurry Solution

Weighing Scale

Accumet XL200 pH meter

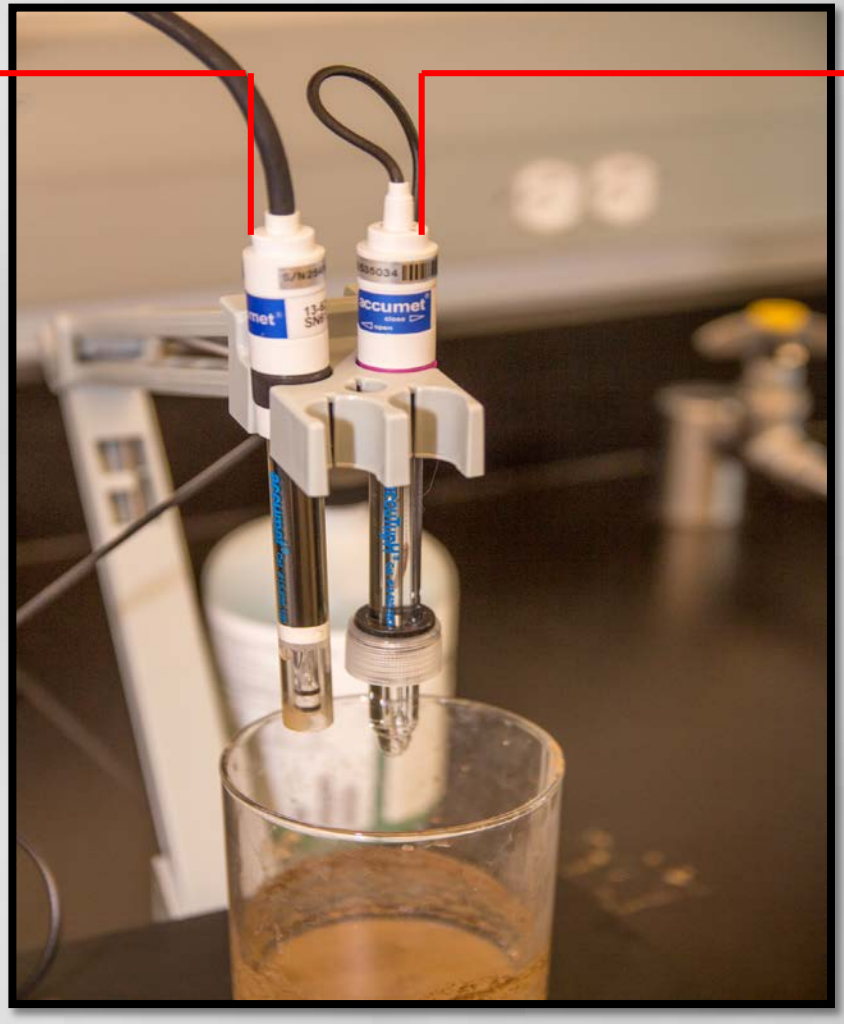
Temperature probe and pH electrode

Accumet Temperature Probe

Probe is two cell conductivity

Mercury free

Probe is made of epoxy and ranges from 10 to 2000 µs.



Accumet pH Electrode

Refillable with 3M KCl + AgCl

Response time < 10 sec

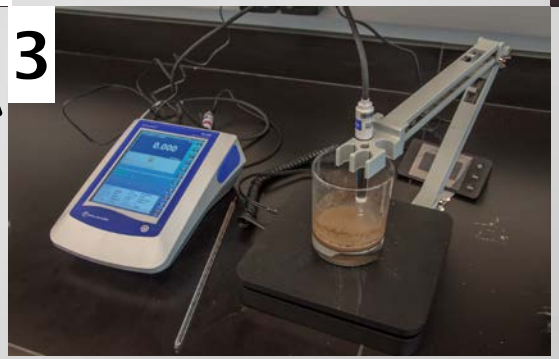
pH range is 0 to 14

Determination of pH using soil sample (Sandy Clay Loam)- procedure

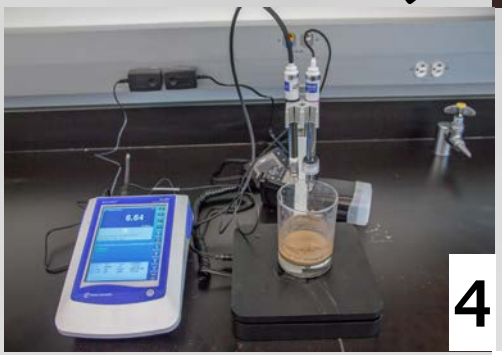
1. Measure 30g of soil sample in a glass beaker

2. Add 30g of distilled water to the soil sample and allow it to rest for 1 hour

3.After constant stirring every 15 mins, measure temperature of the mixture



4.Insert pH probe and measure standardized value for various samples



Questions?