Development of a Time/Cost Effective, In-Situ Sensor Probe for Accurate Characterization of Dissolved Solids Levels in Indian Septic Tanks

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Background / Rationale

- In India, over **12 billion liters** of human waste are treated by wastewater treatment plants every day
- A key issue identified with these plants is the lack of accommodation for the spectrum of dissolved solids levels that vary amongst thousands of urban and rural communities, attributed primarily to the high cost and arduousness of laboratory wastewater characterization
- Most Indian communities use independent septic tanks as opposed to communal sewage systems, further increasing variability in dissolved solids levels
- To address this variability, Indian municipalities require an accurate, inexpensive, and time-effective system to be placed in septic tanks that independently characterize the dissolved solids levels of their local wastewater

Figure 1. ***Septic Tank Pictured in Rural Indian Community*** [1]

Key Design Objectives

Objective	Target / Justification
Runtime	Runtime for the system should be **< 24 hours** as this is the estimated process time for the standardized Buchner Vacuum Filtration Process (APHA 2540) [2]
Cost	Cost should be **< $170 USD** as this is the baseline price for a common laboratory vacuum pump used in laboratory characterization [3]
Accuracy	Measured data should have an **R^2 > 0.8** as this is of higher accuracy than current cheap, commercially available sensors
Water Resistance	The system should be operable when fully submerged in wastewater, indicating an IP rating of **IPX7+** [4]

Design / Methodology

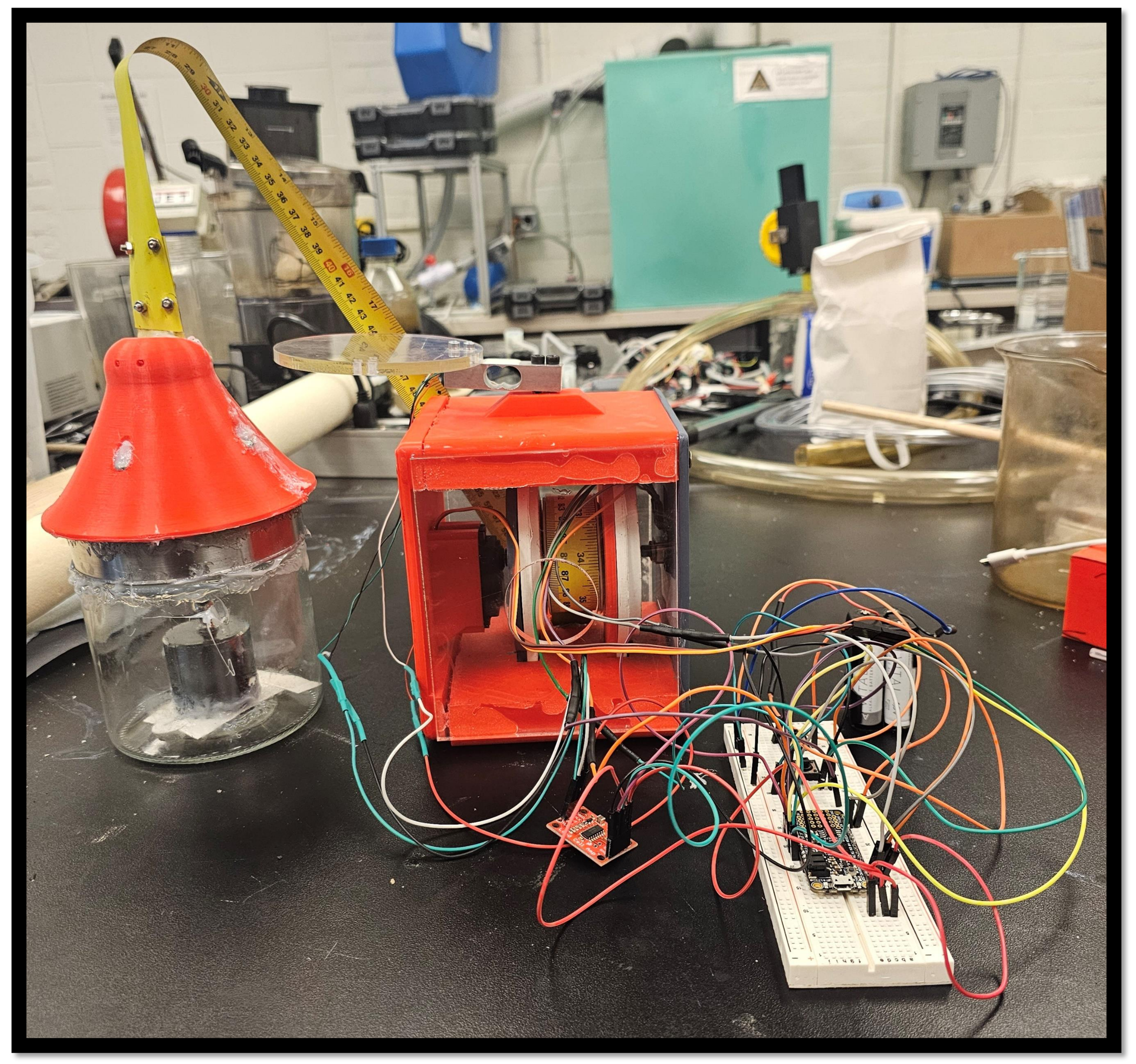
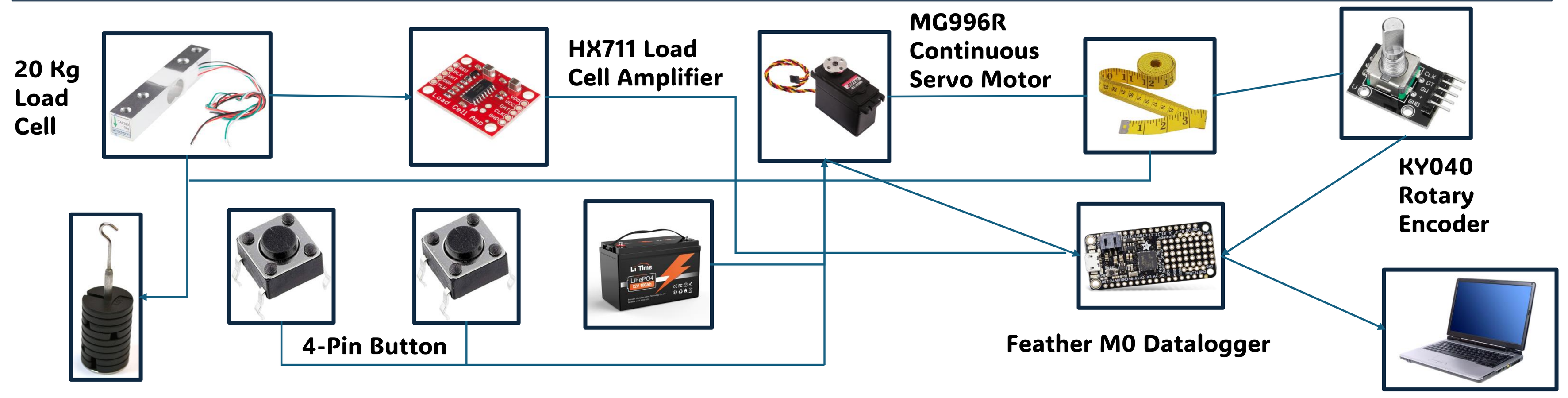


Figure 2. ***Prototype of Proposed System***

System Principle: To measure dissolved solids levels, the proportionality between density of wastewater and dissolved solids levels at varying depths in wastewater is utilized in the following process:



- **Step #1:** *Container is lowered incrementally into wastewater sample using servo motor*
- **Step #2:** *Rotary encoder outputs pulses to datalogger which is converted to travelled distance, load cell outputs force readings*
- **Step #3:** *Data is outputted to CoolTerm serial monitor which captures data as .txt file*
- **Step #4:** *Container is retracted from wastewater sample*
- **Step #5:** *Force readings are converted to density, depth-density graph is plotted*
- **Step #6:** *Proportionality is utilized to plot depth-dissolved solids graph*

Objective Targeted	System Features
Runtime	Each trial takes an average of **13 seconds** in a wastewater depth of ~ 25 cm
Cost	Total cost of system components and printed enclosure is **~ $65 CAD**
Water Resistance	System utilizes waterproof epoxy and liquid resin-printed enclosure, allowing for full submersion in wastewater testing and exceeding **IPX7**

Testing / Results

- For testing, buckets with a 25 cm depth containing 6% and 13% concentration samples of a kaolinite-soil simulated sludge were utilized
- The graphs on the right depict depth (cm) vs force (g) readings as the container was incrementally lowered into the sludge
- The 13% concentration graph has **a lower-sloped trendline,** indicating that the buoyant force experienced by the container is higher due to **higher density** resulting in overall lower force readings
- To obtain dissolved solids levels, the graphs on the right would be converted to density graphs and a proportionality constant would be utilized to convert the graph into dissolved solids values

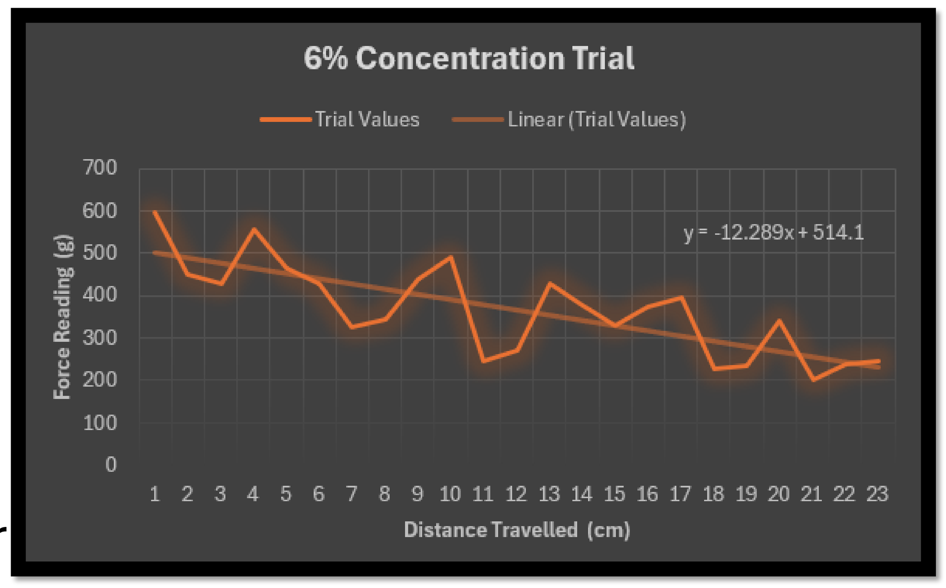


Figure 3: ***Graph of 6% Concentration Experiment Values***

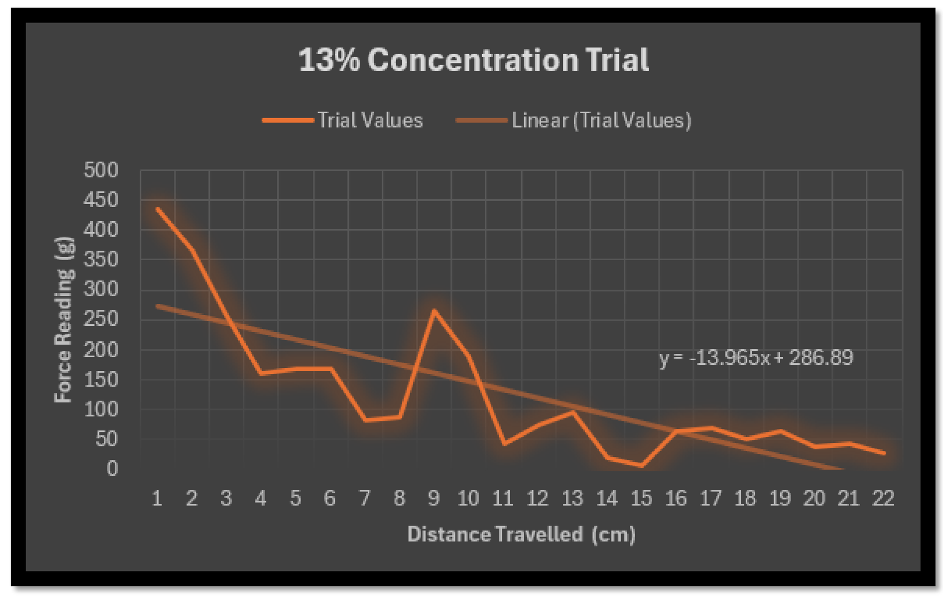


Figure 4: ***Graph of 13% Concentration Experiment Values***

Future Steps

Proposed future steps for the system are outlined in chronological order below:

1. The Buchner Filtration Process would be utilized on a sample with a known dissolved solids level to calibrate the system and find the proportionality constant to use with unknown dissolved solids levels
2. Design circuitry would be improved for long-term energy usage through the use of capacitors and improved voltage sources/regulators, then all connections would be soldered for robustness
3. System enclosure/circuitry would be improved for water resistance to protect it from water accumulated due to humidity of tank
4. System would undergo more rigorous tests to determine accuracy/R^2 value, then be placed on a trial basis in septic tanks in Uran Islampur, India

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References:
1. Mishra, S. (2016). *Manage septic slush or pay up* [Review of *Manage septic slush or pay up*]. The Telegraph. https://www.telegraphindia.com/odisha/manage-septic-slush-or-pay
2. Hawach Scientific. (2019). The Operating Steps of Vacuum Filtration - Hawach. Vacuum Filtrations. https://www.vacuumfiltrations.com/the-operating-steps-of-vacuum-filtration/
3. Maisi. (2022). How Much is a Laboratory Vacuum Pump. Maisigroup. https://www.maisigroup.com/laboratory-vacuum-pump-price/
4. International Electrotechnical Comission. (2024). IP ratings | IEC. Www.iec.ch. https://www.iec.ch/ip-ratings