Team 65: Electric Paintbrush Cleaner

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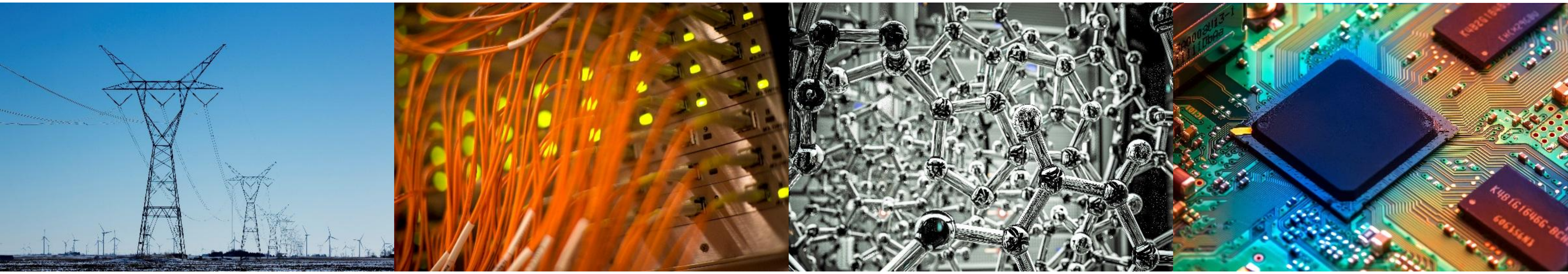

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Introduction/Problem Statement

- Original Problem: No efficient method for cleaning brushes while painting.

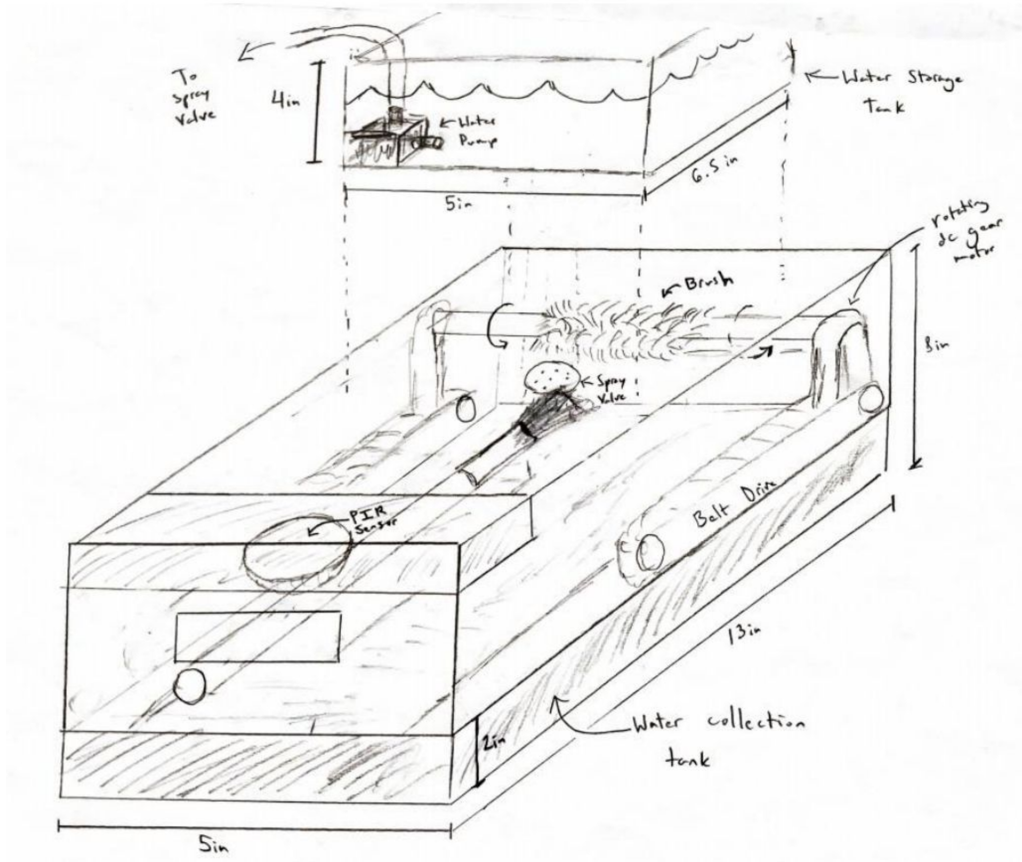
- Common method: Cups/Bowls of water.

- Problems with this method:
  - Easily tipped over (messy).
  - Become less effective over time.
  - Distracting.

Overview of Original Project Solution

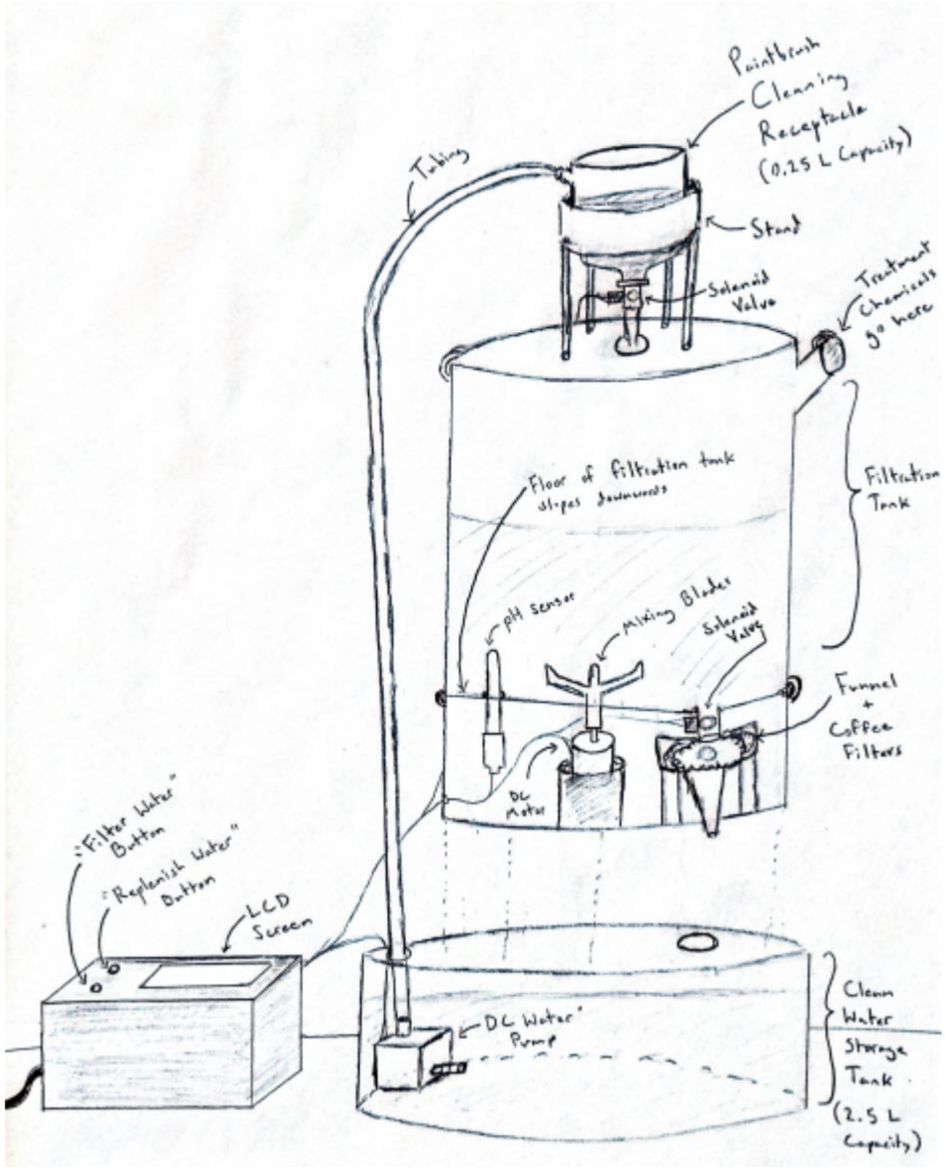
- “Electric Sharpener” Design

- Major Drawbacks:
    - Poor use of water.
    - Damaging brush system.
    - Watercolor only.



Overview of New Project Solution

- “Water Filter” Design
- Major Improvements:
  - Allows for Acrylic Paints.
  - Eco-friendly.
  - More efficient.



What if you don’t filter?

Photo Credit:
https://www.rosemarieoleary.com/art-blog/44-don-t-pour-acrylic-paint-down-the-drain

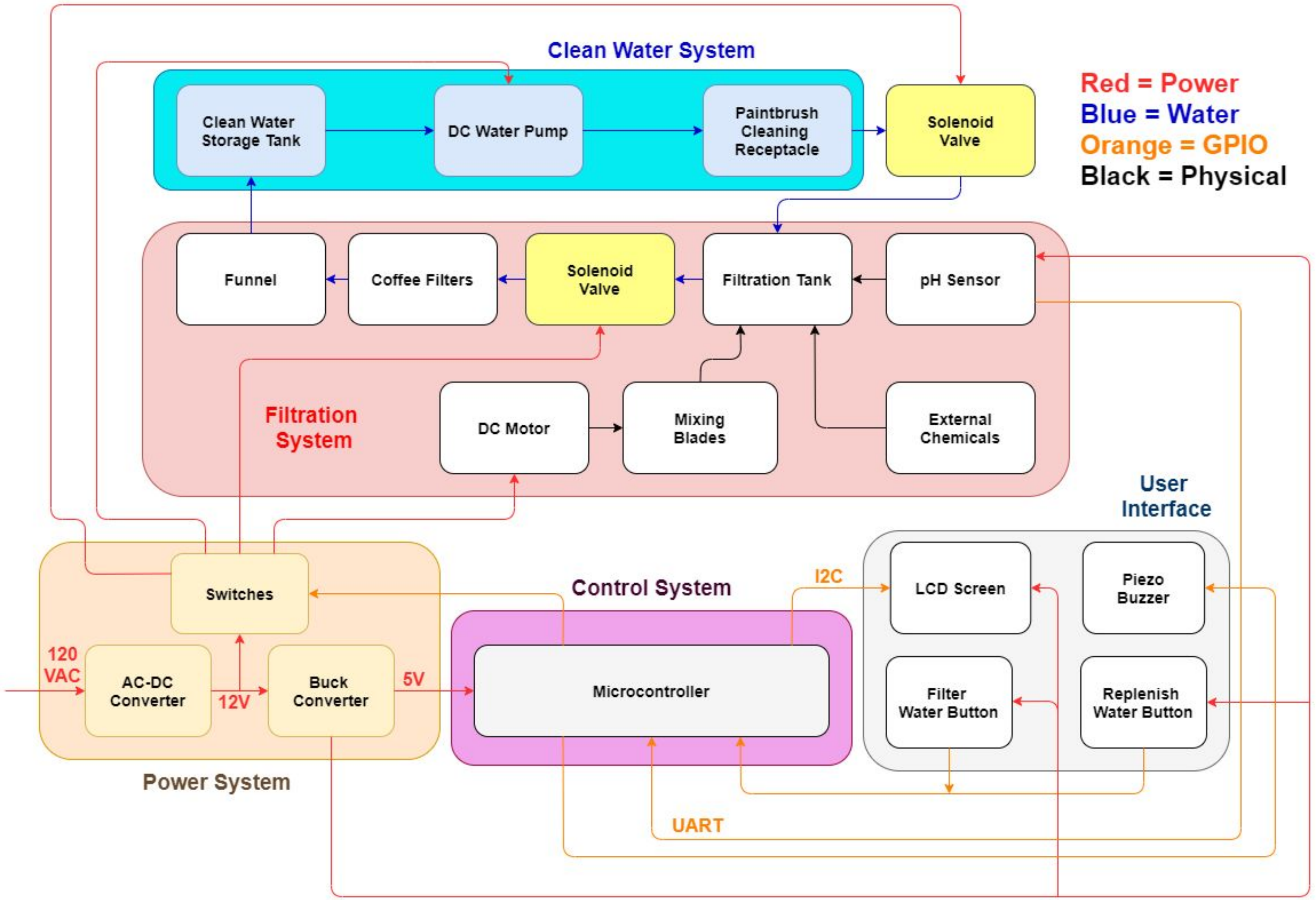
High-Level Requirements

- Replenish paint brush cleaning receptacle at least 8 times from 2.5 liter water storage tank

- Range of acceptable pH at end of filtration:
  - $6.5 < pH < 8.5$

- Filtration system must successfully remove acrylic paint particles
  - Wastewater should visibly go from opaque to transparent

Block Diagram



Critical Requirements and Verifications

- Two most critical components are microcontroller and pH sensor

- Microcontroller
  - Responsible for governing flow of water
  - Processes data from pH sensor to calculate how much aluminum sulfate and hydrated lime powder
  - Processes user input and displays information to user

- pH sensor
  - Must provide accurate measurement of wastewater pH

Solution Feasibility

- Water consumption in original solution is determined by flow rate of water pump:

$$\frac{1\ rinse}{4\ sec} \cdot \frac{60\ sec}{1\ min} \cdot \frac{1\ min}{9.16\ L} \cdot 2.5\ L = 4.07\ rinses \approx 4\ rinses$$

- Water consumption in new solution is determined by ratio of refill amount to water storage capacity, as well as painting circumstances:

$$\frac{1\ refill}{0.25\ L} \cdot 2.5\ L = 10\ refills$$

Solution Feasibility (Continued)

- Worst-case: 1 rinse per refill
- Average: 4 rinses per refill
- Optimistic: 7 rinses per refill

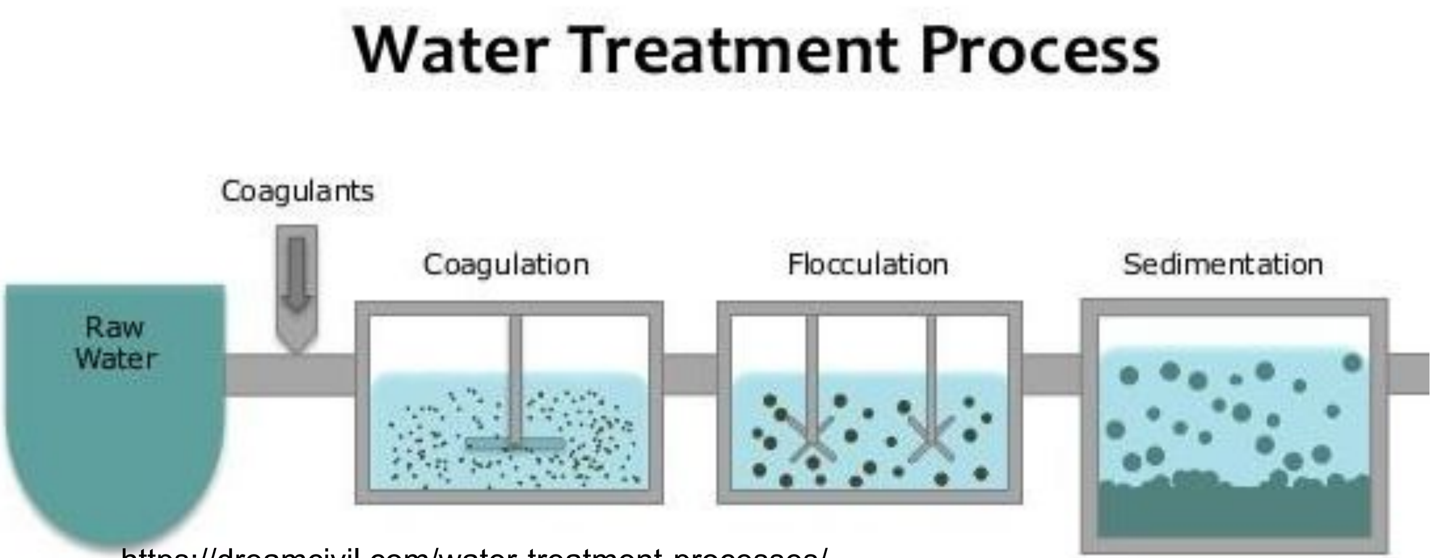
$$Estimated\ Minimum\ Efficiency\ Improvement: \left(\frac{10\ rinses}{4\ rinses}\right) = 2.5x\ More\ Rinses$$

$$Estimated\ Average\ Efficiency\ Improvement: \left(\frac{40\ rinses}{4\ rinses}\right) = 10x\ More\ Rinses$$

$$Estimated\ Maximum\ Efficiency\ Improvement: \left(\frac{70\ rinses}{4\ rinses}\right) = 17.5x\ More\ Rinses$$

Solution Feasibility (Continued)

- Water treatment process is based on municipal water treatment techniques, using Aluminum Sulfate as a coagulant.
  - From USALCO: “Iron free Aluminum Sulfate (Alum) is most widely used in municipal drinking water and wastewater treatment systems” (https://www.usalco.com/products/aluminum-sulfate-solution-alum/)



https://dreamcivil.com/water-treatment-processes/

Tolerance Analysis

- Filtration subsystem is most imperative
  - Aluminum Sulfate decreases pH
  - Hydrated Lime Powder increases pH
  - Successful Range: 6.5 < pH < 8.5

- 15mg/L of aluminum sulfate lowers pH by ≈ 0.4

$$\frac{15mg\ Al_2(SO_4)_3}{1L\ Water} \cdot 0.25L\ Water = 3.75mg\ Al_2(SO_4)_3\ to\ decrease\ pH\ by\ 0.4$$

$$\frac{25mg\ Al_2(SO_4)_3}{1L\ Water} \cdot 0.25L\ Water = 6.25mg\ Al_2(SO_4)_3\ to\ decrease\ pH\ by\ 1.5$$

- 2 tbsp of hydrated lime powder raises pH by ≈ 1.0

Tolerance Analysis (Continued)

- Adding 2 tbsp of hydrated lime powder to 6.25mg of aluminum sulfate vs 3.75mg:

$$7.0\ units - 1.5\ units + 1.0\ unit = 6.5\ units\ on\ the\ pH\ scale$$

$$7.0\ units - 0.4\ units + 1.0\ unit = 7.6\ units\ on\ the\ pH\ scale$$

- To be remain within upper margin of an 8.5 pH, wastewater pH can be as high as 7.9 initially:

$$8.5\ units + 0.4\ units - 1.0\ unit = 7.9\ units\ on\ the\ pH\ scale$$

Old vs New Solution Tradeoffs

	Advantages	Drawbacks
Original Solution	• Smaller physical profile • Only part that requires replacement is cleaning brush	• Takes too long for user to clean paintbrush • Poor efficiency of water use • No means of filtering acrylic paint wastewater
New Solution	• Allows for proper disposal of acrylic paint particles • Gives user control over when to receive a new supply of water • Estimated average of 10x more rinses compared to original solution • Can accommodate various paintbrush sizes	• Higher cost compared to original design ($276.57 vs $110.24) • Success of design is highly sensitive to reliability of pH sensor • User is responsible for maintenance and providing external components to get project to work (i.e. coffee filters, chemical treatment)

Cost

- Cost of Labor: $26,250
- Cost of Parts: $276.57
- Total Cost: $26,526.57

Description	Manufacturer	Part Number	Quantity	Unit Price
MOSFET	Nexperia	PSMN022-30PL	2	$0.90
Buck Converter	CUI Inc.	VXO7805-500	1	$2.36
AC-DC Converter	Signcomplex	ZF120A-1204000	1	$15.58
pH Sensor	Atlas Scientific	ENV-40-pH	1	$75.00
pH Sensor Board	Atlas Scientific	EZO-pH	1	$40.00
Solenoid Valve	Plum Garden	PL-220101	2	$9.55
DC Water Pump	DFRobot	FIT0563	1	$9.29
DC Motor	Greartisan	12V 200RPM	1	$15.99
LCD Screen	SunFounder	I2C LCD2004	1	$12.99
Microcontroller	Atmel	ATMEGA328P	1	$2.08
Pack of Pushbuttons	Sparkfun	COM-10302	1	$5.85
Aluminum Sulfate (2 lbs)	FDC	16828-12-9	1	$11.99
Hydrated Lime Powder (2 lbs)	Hi-Yield	33362	1	$14.99
Miscellaneous (PCB/Manufacturing)	Various	Various	N/A	$60.00
Total				**$276.57**

Schedule

- Split up by the subsystems:
  - Yael: Control System/User Interface
  - John: Filtration System
  - Luis: Clean Water Subsystem
- As a team:
  - Integrate subsystems together
  - Test and verify entire system

Ethics and Safety

- Separation of water from the electrical components
  - Design to prevent spillage, covers for electrical components
- Safety manual
  - Informs users of potential risks or hazards
  - Precautions for working with chemicals
- Seek and accept honest criticism from users

Conclusions and Future Development

- Overall, new solution is a major improvement over previous solution in terms of efficiency and eco-friendliness

- Future development: Make filtration process fully automatic