Efficient Water Usage and Recycling

Team ThREe
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Problem Definition

- Efficient water usage and recycling
- Find ways which water saving technologies can be incorporated into a modular accessory dwelling unit (ADU)
- How to integrate water recycling and bioremediation systems into the ADU
- Used in low-income neighborhoods
- Good HERS ratings
- Come up with bill of materials by the end of the quarter
Project Overview:

- Group members research about water efficiency, recycling, and bioremediation
- Existing regulations on water quality and consumption
- Design water recycling and bioremediation systems:
  - Where does water go after use
- Cost analysis
- Bill of materials
Current Water Use

California per capita use: **146 gallons** of water per day
An average person uses **80-100 gallons** of water per day indoors

Indoor water use can be more efficient with low consumption fixtures

<table>
<thead>
<tr>
<th>Appliance Name</th>
<th>Amount of Water Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet</td>
<td>1.664 gal/day/person</td>
</tr>
<tr>
<td>Shower head</td>
<td>2.73 gal/day/person</td>
</tr>
<tr>
<td>Faucet</td>
<td>3.468 gal/day/person</td>
</tr>
<tr>
<td>Dishwasher (standard)</td>
<td>0.47 gal/day/person</td>
</tr>
<tr>
<td>Dishwasher (compact)</td>
<td>0.583 gal/day/person</td>
</tr>
<tr>
<td>Countertop Dishwasher</td>
<td>0.783 gal/day/person</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>1.429 gal/day/person</td>
</tr>
</tbody>
</table>

Outdoor water use
- 30-60% household water use, near 60% in dry regions
- ~50% of irrigation water is wasted due to evaporation, wind, and runoff
- An average US family uses 96 gallons of water per day outdoors
● 75% of water used each day is deemed “Gray Water”
  ○ Gray Water is water that is considered recyclable in the state of California and can be filtered for further use
  ○ The remaining water is “Black Water” which must go to wastewater treatment plant
● Washing Machines, bathroom sinks, showers are all grey water producers
● Our team has focused on how to reuse this water to reduce waste water for toilet flushing and irrigation
● We have a team goal of reducing individual water waste by 20 gallons per day, means 140 gallons per person per week
  ○ Low flow filter saves individual roughly 10 gallons per day
  ○ Our system in theory saves an individual 24 gallons of water per day after low flow appliances have been applied
Water Flow Chart

- Laundry Machine
- Bathroom Sink
- Bathroom Shower

Bioremediation System → Filtration System

- Irrigation
- Toilet Tank
- Kitchen Sink
- Toilet
- Dishwasher

- Sewer

Wenhan
By the California code of regulations title 22, Division 4, Chapter 3, Article 3: Uses of recycled water.

Recycled water used for the surface irrigation or other purposes of the following shall be a disinfected tertiary recycled water. The definition of disinfected tertiary recycled water is a filtered and subsequently disinfected wastewater.

The recycled water can be used for:

- Flushing toilets and urinals
- Food crops, including all edible root crops, where the recycled water comes into contact with the edible portion of the crop
- Residential landscaping
- Any other irrigation use not specified in this section and not prohibited by other sections of the California Code of Regulations
By the California code of regulations title 22, Division 4, Chapter 3, Article 3: Uses of recycled water. Recycled water used for the surface irrigation or other purposes of the following shall be a disinfected tertiary recycled water. The definition of disinfected tertiary recycled water is a filtered and subsequently disinfected wastewater.

<table>
<thead>
<tr>
<th>Disinfected Tertiary Recycled Water</th>
<th>The median concentration of total coliform bacteria maximum in 7 days sample: MPN of 2.2 per 100 milliliters</th>
<th>The median concentration of total coliform bacteria maximum in 30 days sample: MPN of 23 per 100 milliliters</th>
<th>The median concentration of total coliform bacteria maximum at all time: MPN of 240 total coliform bacteria per 100 milliliters</th>
</tr>
</thead>
</table>

The definition of **MPN** is: The most probable number (MPN) analysis is a statistical method based on the random dispersion of microorganisms per volume in a given sample.

<table>
<thead>
<tr>
<th>Disinfected Wastewater</th>
<th>The maximum <strong>NTU</strong> requirement within 24- hour period 0.2 <strong>NTU</strong> more than 5 percent of the time</th>
<th>The maximum <strong>NTU</strong> requirement at all time 0.5 <strong>NTU</strong></th>
</tr>
</thead>
</table>

The definition of **NTU** is: **NTU** stands for Nephelometric Turbidity unit, i.e. unit used to measure the turbidity of a fluid or the presence of suspended particles in water.

Wenhan
Background:
- Bioremediation is process in which indigenous microbes decompose organic + inorganic contaminants (soil or water)
- Ex situ vs in situ processes
- Water from bathroom sinks, showers, and washing machines
- **Purpose:** primary treatment → coarse filtration, flotation decomposition
- **Preliminary System design + Reasoning**
- **BioGF:** multi-strain blend of microbes that degrades FOGs
System Overview

- Purpose is to ensure particles in the water do not damage pipes for toilet or clog drip irrigation system
- Sensors are safety check to make sure system is working
- Sensors when readings are within desired range will transmit green light, when outside of range light will be red
Filtration System Attachment

Sediment Filter

- Will remove larger particles (silt, sand, loose scale, organic material)
- Better sediment filtration will lengthen the lifespan of the carbon adsorption unit
- Spin down method
- Sediment trapper helps handle dirtier water

<table>
<thead>
<tr>
<th>Filtration Method</th>
<th>What sizes can filter</th>
<th>Initial Cost</th>
<th>Replacement Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Micron Filters</td>
<td>Physical barrier</td>
<td>5-50 microns</td>
<td>$40</td>
</tr>
<tr>
<td>Spin Down Filter</td>
<td>“Centrifugal” force</td>
<td>10-711 microns</td>
<td>$84</td>
</tr>
</tbody>
</table>
Carbon Adsorption Unit

- Carbon block acts as a second sediment filter
  - Removing smaller particles not previously removed
- Largest size PAC unit (20” x 4.5”)
  - Lifetime ~150,000 gal
  - More surface area, higher flow rate
- Adsorbs chlorine, organic chemicals, THMs, VOCs, solvents, industrial cleaners
- Very limited microbial filtering

<table>
<thead>
<tr>
<th></th>
<th>Particle Size</th>
<th>Flow rate</th>
<th>Surface area</th>
<th>Replacement Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAC</td>
<td>10-50 microns</td>
<td>Not limited</td>
<td>smaller</td>
<td>~$30</td>
</tr>
<tr>
<td>PAC</td>
<td>0.5-20 microns</td>
<td>1-3 gal/min</td>
<td>larger</td>
<td>~$30</td>
</tr>
</tbody>
</table>
pH Sensor

- Measures pH level of the water
- Most outdoor plants thrive in water ranging from 6-8 pH
- Water should be filtered near 7 pH so probe will confirm health of system
- I found the Atlas Scientific Industrial pH probe
  - It is indefinitely submersible
  - Accuracy is +/- 0.002

<table>
<thead>
<tr>
<th>Response Time</th>
<th>Life Span</th>
<th>Recalibration Life Span</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% in 1s</td>
<td>4 Years+</td>
<td>1 Year</td>
<td>234.99</td>
</tr>
</tbody>
</table>
Electric Conductivity Sensor

- Measures the Conductivity of the water
  - Conductivity is affected by inorganic dissolved solids
  - In our system the soaps are the main contributor to the water conductivity
- Tap water does not exceed 800 uS/cm
- The EC Sensor will essentially let us know that the filter is keeping the Conductivity rating down
- The probe I found is from Atlas Scientific
  - Is indefinitely submersible
  - Accuracy is +/- 2%

<table>
<thead>
<tr>
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<th>Life Span</th>
<th>Recalibration Life Span</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% in 1s</td>
<td>10 Years</td>
<td>10 Years</td>
<td>157.99</td>
</tr>
</tbody>
</table>
• Filtration Team
  • Create 3D Cad design for components
  • Connect components for System Diagram

• Find and Apply fixtures for low flow/lower water appliances
  • This includes shower heads, sinks, toilet, dishwasher & washing machine
  • Recycling water is good but the best way to conserve it is by limiting the water use in the first place

• Educate Residents
  • During the last two weeks the team will be working on means to educate resident of ADU
  • This includes attachments to appliances to remind user to be water cautious and avoid negligent usage
• Look into requirements for pipe regulations for recycled water
• Proper signage identifying water is recycled water (similar to what UCI has)
• Gray water can’t be stored for more than 24 hours, our water is filtered so it is potentially not gray water anymore
  • Potentially add bleach or chlorine to toilet water since it is no coming into contact with humans