UC Berkeley

BEARNOULLI

$$\frac{P_1}{\gamma}+z_1+\frac{v_1^2}{2g}+h_p=\frac{P_2}{\gamma}+z_2+\frac{v_2^2}{2g}+h_L$$

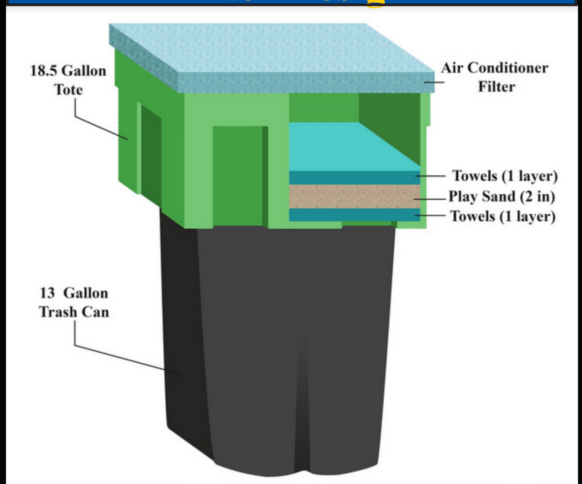
Purpose of Competition

The purpose of this competition is to bring Civil and Environmental Engineering students together to research, design, test, construct, and present a wastewater filtration treatment system using a limited amount of everyday materials. As we collaborate, students apply wastewater treatment principles and solve a real-world challenge.

Scenario

On our 200 acre farm, Bearnoulli grows high-quality produce. We are committed to bring the freshest lettuce to our customers with no traces of contaminants that may cause foodborne illnesses. Prior to shipping, we wash our lettuce with river water that has been treated in our washing facility. But recently, our treatment facility was shut down for maintenance. During this inconvenient time, a highly valued customer made a request for a small shipment of De Morges Braun lettuce. Eager to uphold our reputation, we accepted the task and built a treatment system to filter the river water to wash our produce before shipping it out. We identified the major influent constituents to be pine needles, soil, fine sand, bentonite clay, and pickling lime. Our team of experienced scientists and engineers put together a filtration system from materials found near the farm. In addition to treating the highest quality water, we also focused on optimizing the filter's sustainability, treatment efficiency, and cost-effectiveness.

Filter Design



Filter Overview

Chemical Treatment: Prior to physical filtration, alum and pickling lime are added to every 4.5 gallons of dirty river water. Alum causes coagulation of small particles which allow them to be physically filtered out. Pickling lime raises the pH, which drastically fell from the addition of alum. Post physical filtration, 65 mL of Clorox bleach was added to the collection tote to reduce the microbial load in the effluent.

Physical Treatment:

- **Air Conditioner (AC) Filter -** Untreated river water is poured through a standard AC filter placed on top of a plastic tote. At this stage, the pine needles and larger soil particles are filtered out.
- **First Rag Layer -** The water then passes through a layer of terrycloth rags. The top layer of rags acts as a diffuser for the layer of sand below and absorbs fine particles from the wastewater.
- **2" Play Sand Layer -** After passing through the first layer of rags, the wastewater goes through two inches of play sand. The two-inches of sand captures the fine particles that percolate through the AC filter and reduce overall turbidity.
- **Final Rag Layer -** The final layer of terry cloth rags prevents the sand from falling through the holes of the plastic tote. Like the first layer, it adds an additional barrier for particles that make it through previous barriers.
- **Totes -** The top 18.5 gallon tote is made from a flexible plastic durable enough to be punctured to make holes that fall within the dimensions of the receiving container below and maximize the volume of water collected.which allowed effluent to flow through. We decided to use a tall and structurally-sound 13-gallon trash can as a water collection vessel. Unlike a plastic tote, it does not buckle under the weight of the top tote.

Once the water is filtered through, it is collected in the trash can where a calculated amount of bleach is prepared such that the water is clean enough to wash lettuce. The upper tote can easily be removed, allowing the collection tote to be readily transported if needed.

Testing Results

Before beginning the design process, Bearnoulli analyzed samples of the river water for their water quality parameters at UC Berkeley's Environmental Engineering Lab . The pH values were too high, dissolved oxygen values were lower than values at room temperature, and turbidity values were high (Table 1).
We split ourselves into subteams to focus on each water quality parameter and determined what materials and methods to test. Aside from water quality, environmental friendliness, cost, and ease of implementation were also considered.

Batch Name	pH	DO (mg/L)	Electrical Conductivity (μS/cm)	Turbidity (NTU)	Chlorine (ppm)
Inlet Water	8.31	7.75	381	1939	3
Treated Effluent	6.89	8.17	1464	150	116

Table 1. Influent and effluent water quality

Teams tested their hypotheses by performing small-scale experiments. We incorporated the best designs into our first complete filter design, and with a few more iterations, we had a simple, yet effective design. We then ran the waste-water through our filter to obtain a much better water quality (Table 1).

Cost Analysis

Item	Cost per unit	Units	Price
18.5 gallon Tote	$8	1	$8
13 Gallon Trash Can	$8	1	$8
AC Filter	$2.67	1	$2.67
Alum (1oz.)	$1.60	1	$1.60
Pickling Lime (1 ounce)	$0.20	1	$0.20
Clorox Bleach, concentrated (5 cups)	$1.17	1	$1.17
Play Sand (1 lb.)	$0.10	30	$3
Terrycloth Rags (1 lb.)	$5	1	$5
Total Materials Cost			**$29.64**
Operator	$40/hr	1	$40
Scissors	$2	1	$2
Total Operational Cost			**$42**
Total Cost			**$71.64**

Sustainability

To carry out a life cycle assessment of the system, we used Carnegie Mellon University's Economic Input-Output Life Cycle Assessment (EIOLCA) tool. The EIO-LCA gives a reasonable estimate of total energy use, water use, and greenhouse gas emissions produced throughout a product's entire supply chain.

Global Warming Potential	Energy Use	Water Use
32.8 kg of CO_2 Equivalent	0.51 Gigajoules	1.33 Kilogallons

One of Bearnoulli's primary goals is environmental sustainability. With that in mind, we maximize the amount of reusable and recyclable materials in our filter design. While in use, the filtration system has a negligible environmental impact since only the chemicals are of concern. Bleach is highly reactive so it disappears quickly once it comes into contact with contaminants in the water. Additionally, in the design process we tried to reuse and recycle the filter testing material to reduce the amount of waste produced. By choosing to use eco-friendly and recyclable materials, Bearnoulli has minimized the design's environmental impact from process to completion.

2015 Leadership

Project Manager: Elly Lin
Assistant Project Manager: John Law
Construction Manager: Heidi Ayran
Materials Managers:
Alex Chang & Lydia Yiu
Treasurer: Hoang Tran
Creative Officer: Chloe Cheok