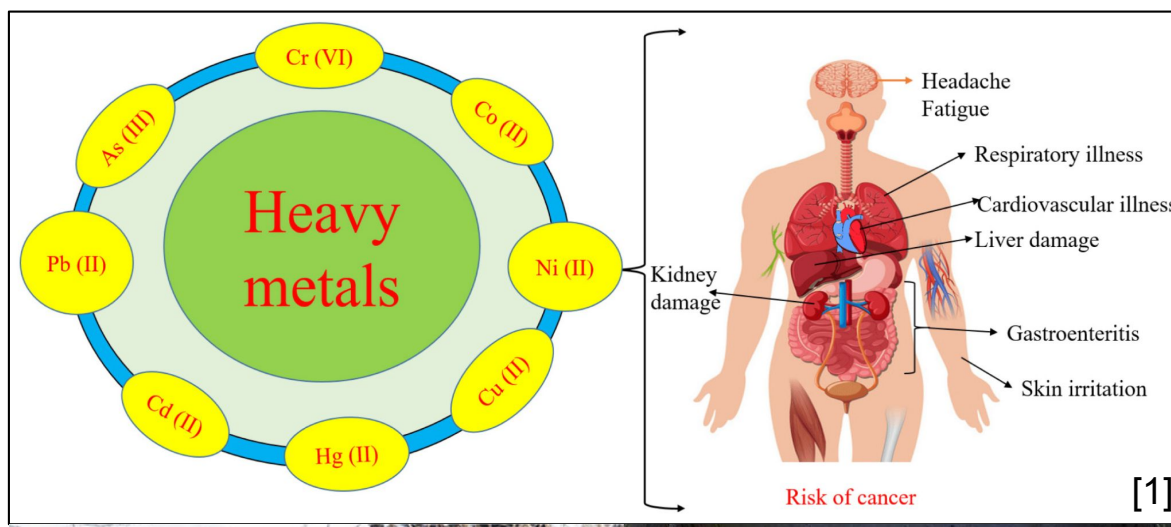


Issue Statement



Heavy Metal Contamination spread through water:

- Affects **1 in 3 children worldwide**
- Lead** contributes to **1.5 million deaths per year**
- Natural disasters worsen** heavy metal pollution

Fruit Waste:

- ~45% of all fruit production is wasted
- Fruit waste is the biggest contributor to food waste**

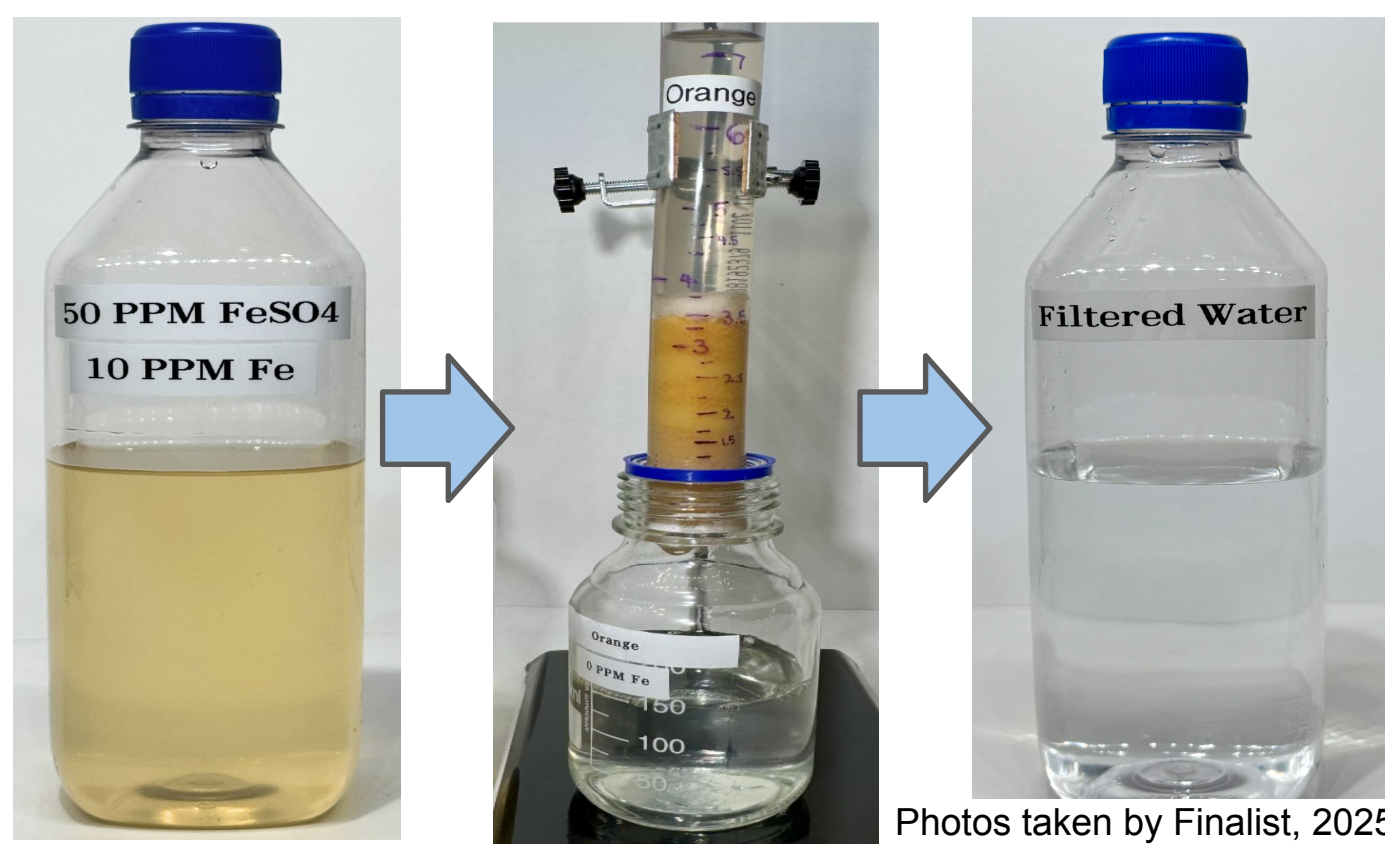
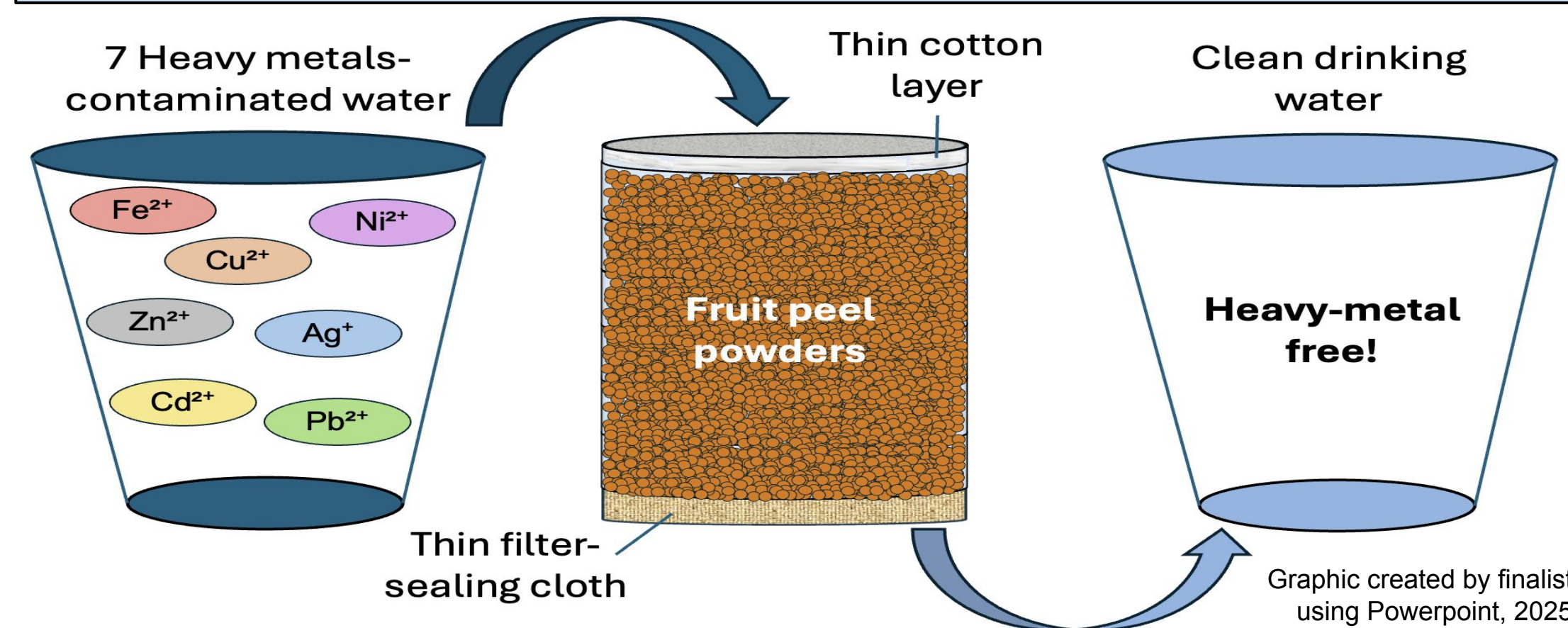
[1] Zhang et al. (2023). Water Quality Degradation Due to Heavy Metal Contamination: Health Impacts and Eco-Friendly Approaches for Heavy Metal Remediation. Toxics. 11(10), 828. <https://doi.org/10.3390/toxics11100828>
[2] EPFL. (2018). Removing heavy metals from water. EPFL. <https://actu.epfl.ch/news/removing-heavy-metals-from-water-4/>
[3] PickPik. (n.d.). Bunch of fruit peels (Photograph). PickPik. <https://pickpik.com/green-waste-compost-compost-bin-bunch-fruit-peels-132514>

Research Objectives

- Develop** a nearly zero cost method for heavy metal toxin removal using fruit peel waste without any chemicals
- Conduct** a comparative analysis of four types of fruit peel waste to determine the most effective option when implementing developed method; explore its mechanisms
- Design, build, and test** two prototype filters for real world application

My Innovative Solution

Create a novel method where **fruit peel waste** can be made into a **sustainable** filtration material using **household items** capable of removing **at least 7 types of heavy metals** and contaminants, providing a nearly zero **cost** solution for safe drinking water



- Filtration Design Criteria:**
- Filters contaminated water into safe, **drinkable quality**
 - Removes **7 heavy metals** (Pb, Cd, Cu, Fe, Zn, Ag, Ni)
 - Uses only **common household materials** (no lab equipment involved)
 - Only uses fruit peel waste** for sustainability (**no chemicals**)
 - Nearly **zero cost**, accessible for under-resourced areas
 - Achieve **reasonable flow rate**

Experimental Materials

4 Fruit Peel Wastes

Orange	Lemon	Pomelo	Banana
- Vitamin C: 136 mg - Pectin: 30% of solid (Iniguez et al., 2024) - Highest Vitamin C content	- Vitamin C: 129 mg - Pectin: 24% of solid (Suliman et al., 2013) - Natural Detoxifier, Antioxidant	- Vitamin C: 31.2 mg - Pectin: 28% of solid (Öztürk et al., 2024) - Highest Waste to Pulp Ratio	- Vitamin C: 8.7 mg - Pectin: 21% of solid (Sriroth et al., 2017) - Most Globally Produced Fruit

Images taken by finalist, 2025

7 Heavy Metal Solutions & 2 Mixed Solutions

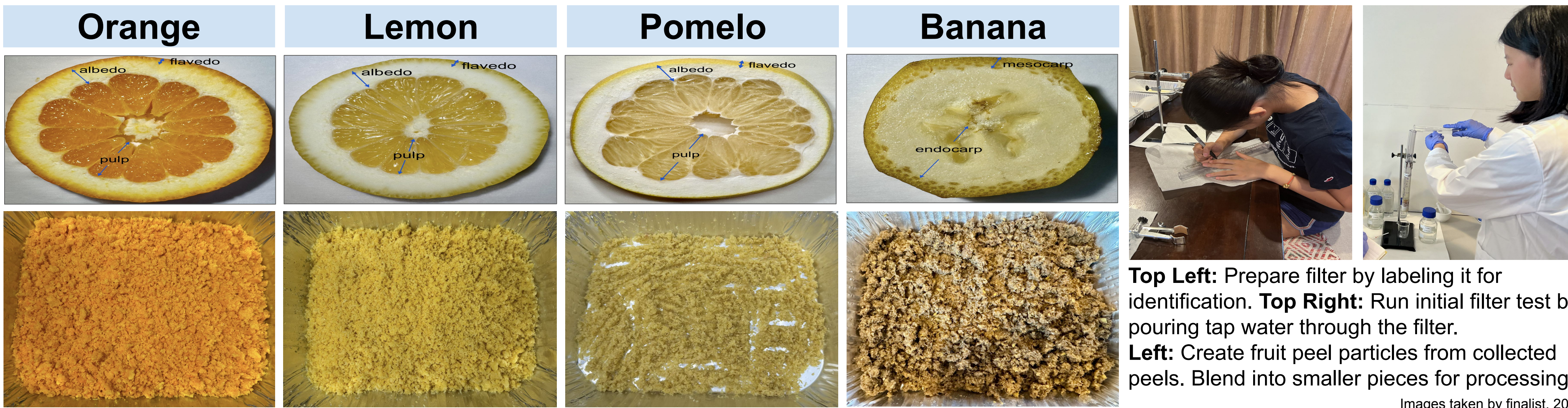
Metal Selection Criteria			2 Mixed Solutions:			
- most common metal contaminants in water - Cu + Fe + Zn (10 PPM) - harmful to the human body			- Pb + Cd + Cu + Fe + Zn + Ag + Ni (10 PPM)			

Lead(Pb) Pb(NO ₃) ₂	Cadmium(Cd) Cd(NO ₃) ₂ · 4H ₂ O	Copper(Cu) Cu(NO ₃) ₂ · 3H ₂ O	Iron(Fe) FeSO ₄ · 7H ₂ O	Zinc(Zn) Zn(NO ₃) ₂ · 6H ₂ O	Silver(Ag) AgNO ₃	Nickel(Ni) Ni(NO ₃) ₂ · 6H ₂ O
10 ppm	10 ppm	1, 10 ppm	0.3, 10 ppm	5, 10 ppm	10 ppm	10 ppm
-Gasoline, batteries -Behavioral harms -High fatality rates	-Mining, industrial activity -Damages liver, heart -Hazardous to wildlife	-Wiring, plumbing -Damages liver, kidney -Hazardous to wildlife	-Industrial activity, plumbing -Damages immunity, induces pathogen growth	-Waste runoff, production -Anemia, harms immunity -Harms wildlife	-Mining, chemical production -Hurts lungs, organs -Harms wildlife	-Plumbing systems -Gastro-intestinal issue -Harms wildlife

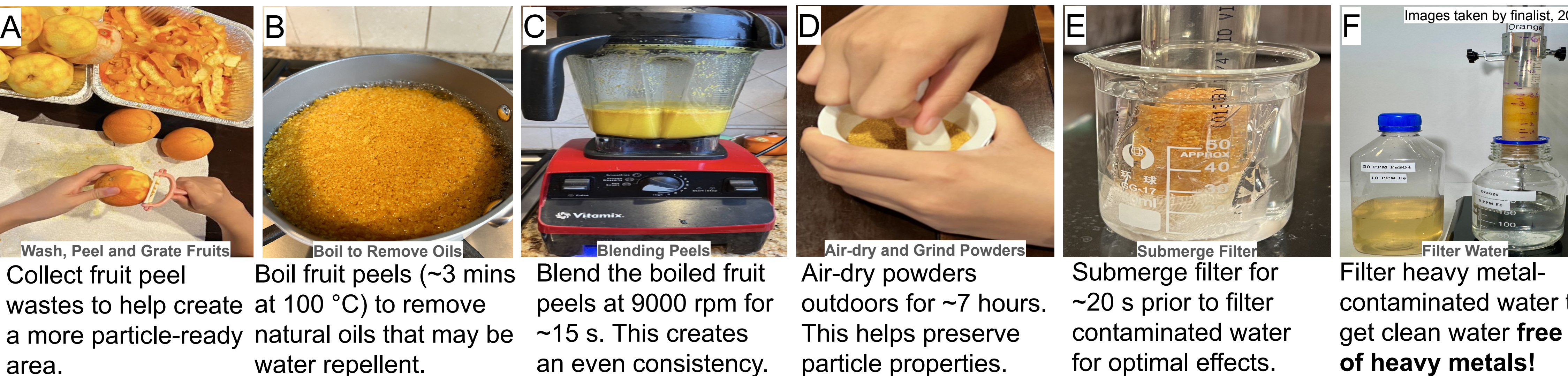
Table created by finalist, 2025

Peel To Purify: An Innovative Fruit Waste-Based Solution for Contaminated Water Treatment

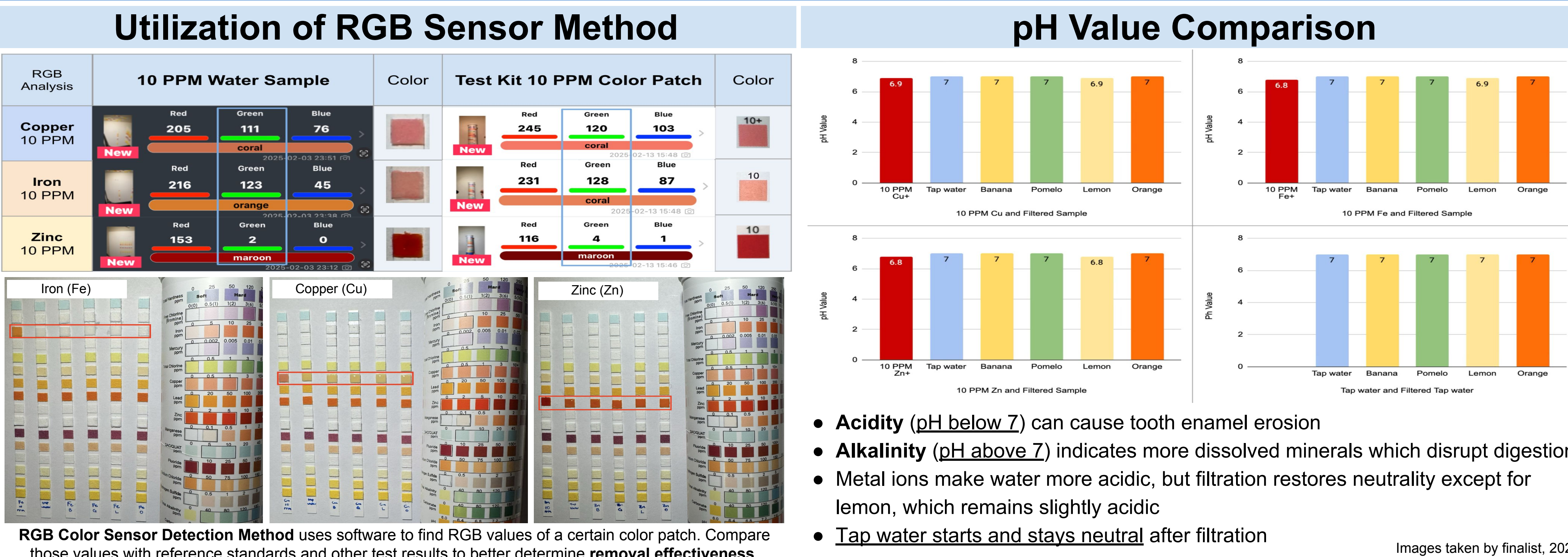
Experiment Preparation: Fruit Peel Particle Forming and Filtration Set-up



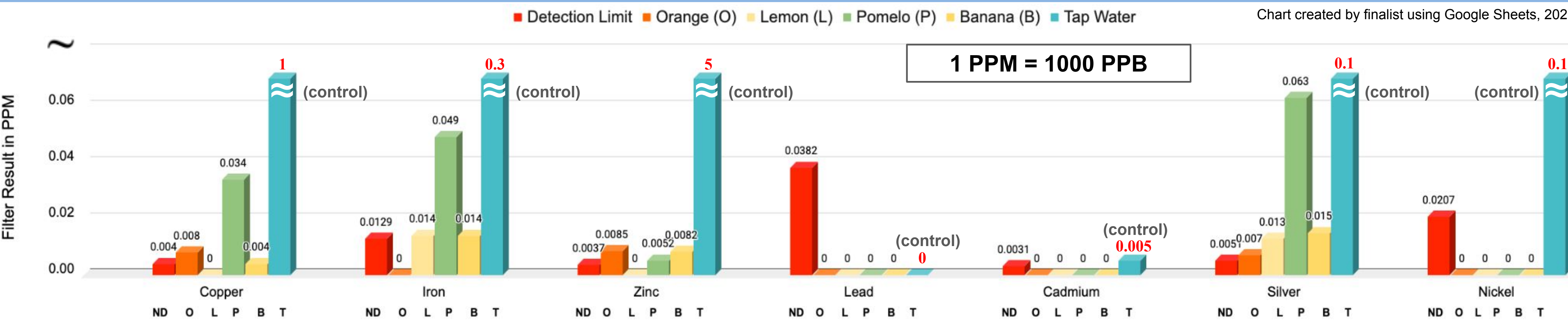
Development of Fruit Peel Waste-Based Water Filtration Method



Result 1: Test Strip Trial Analyses and RGB Sensor Method



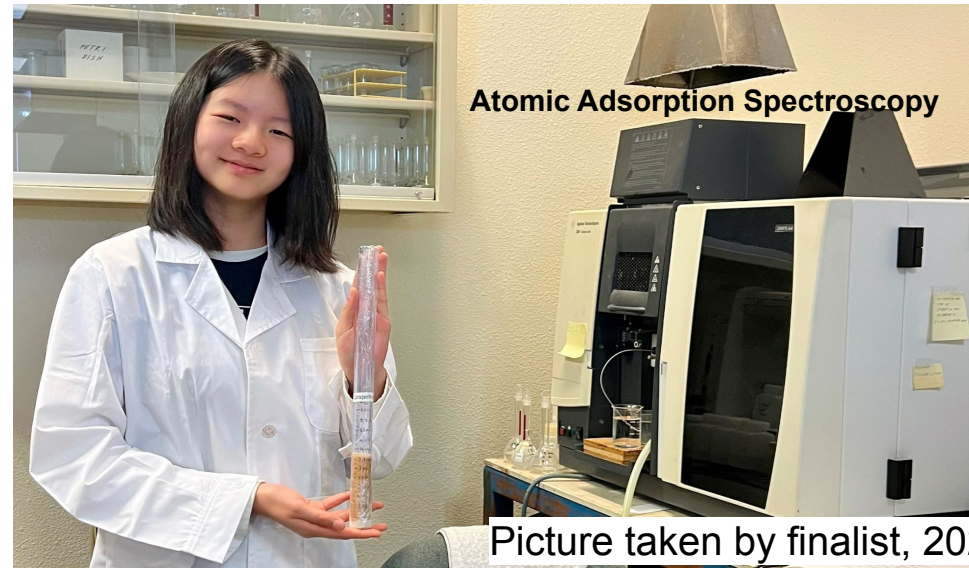
Result 2: Atomic Adsorption Testing at Professional Laboratory



- Atomic adsorption spectroscopy (AAS) was used for heavy metal solution lab testing; defined substrate technology (DST) was used for E. coli quantification.

- All filters reduced all 7 heavy metal concentrations by over **3000x**, from 10 PPM to PPB. These results outperformed the US EPA's drinking water standards by up to 1000x.

- **Lemon/Banana Filter** reduced 10 PPM of **copper/iron/zinc** solution by up to 1250x; **hybrid Orange/Lemon/Banana/Pomelo filter** reduced solution of **all 7 heavy metals** to non-detectable levels.



Study of Flow Rate and pH Level

Filter	Banana	Pomelo	Lemon	Orange
Filtration Time (50 mL)	1' 30"	1' 58"	3' 15"	7' 8"

Table created by finalist, 2025

Efficiency Calculations

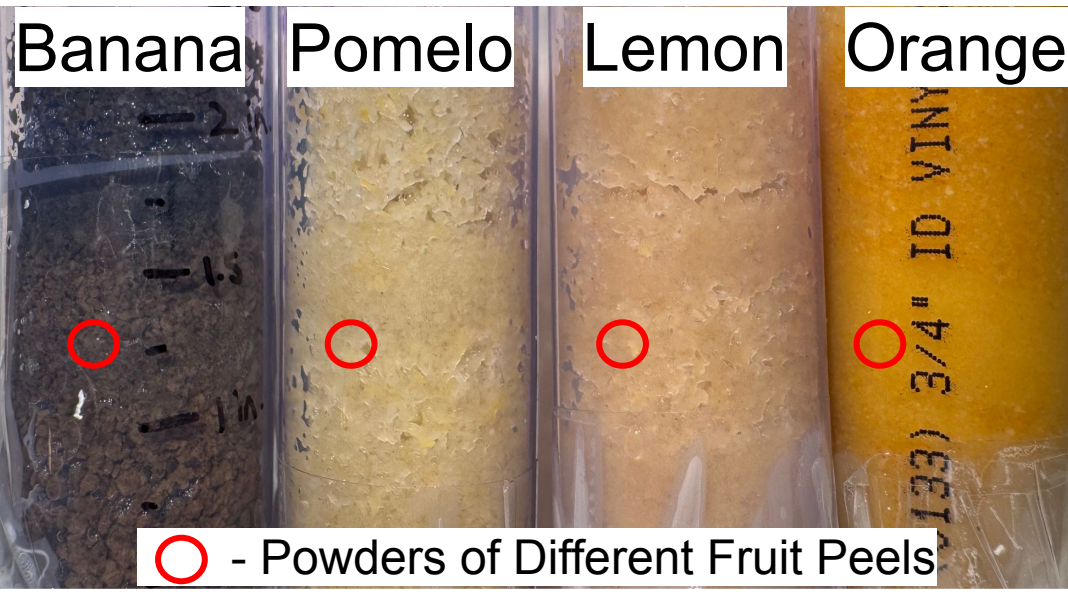
- ~4 gram of fruit peel powders filters >12L with fastest flow rate
- After > ~12 L, flow rate may reduce; filter still functions with reduced flow rate

Improving Flow Rate

- Pressurize filter** using pump: Add air pressure to filter (Prototype 1)
- Enlarge size of filter**, quantity of water: Natural water pressure is added

Cause for Different Flow Rates

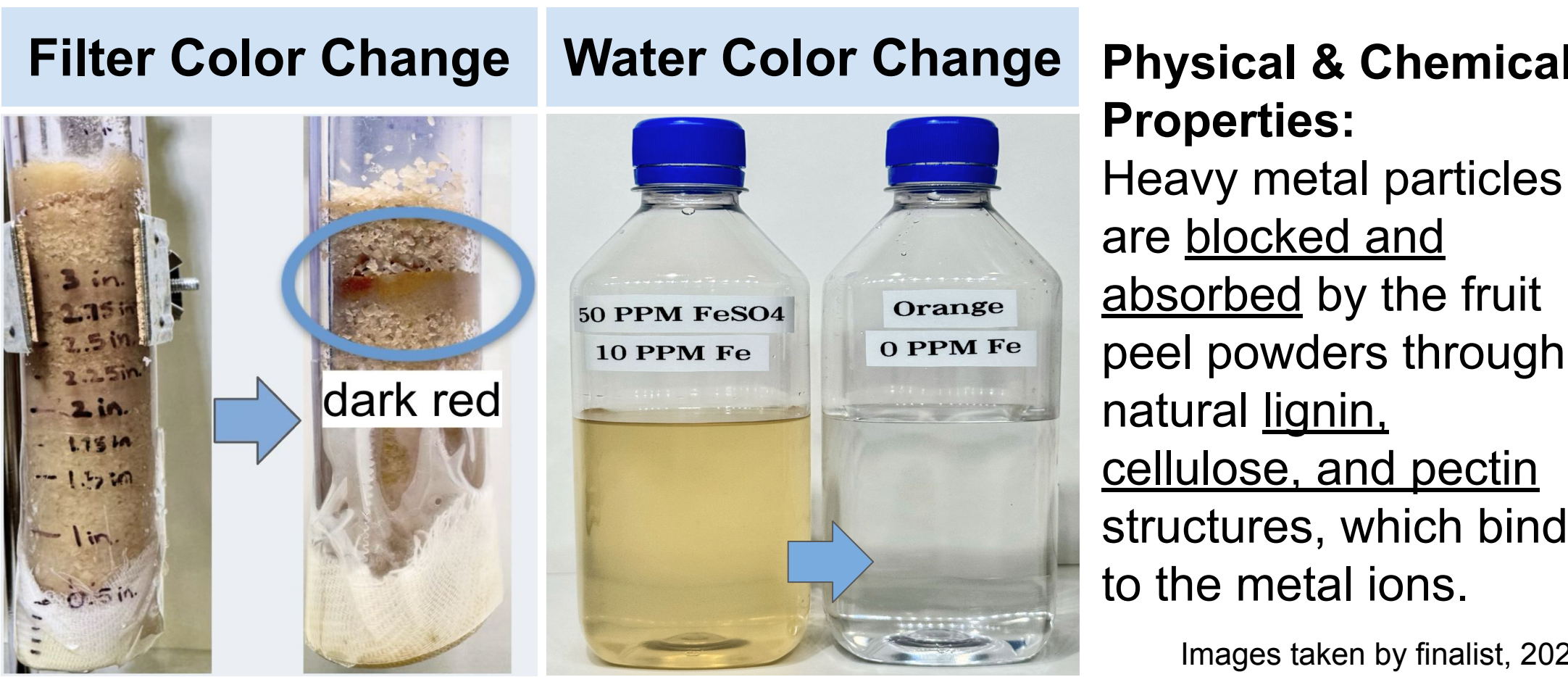
- Powders have same granularity while dry
- Powders have different lignin, pectin compounds
- This varies porosity (amount of space between particles)



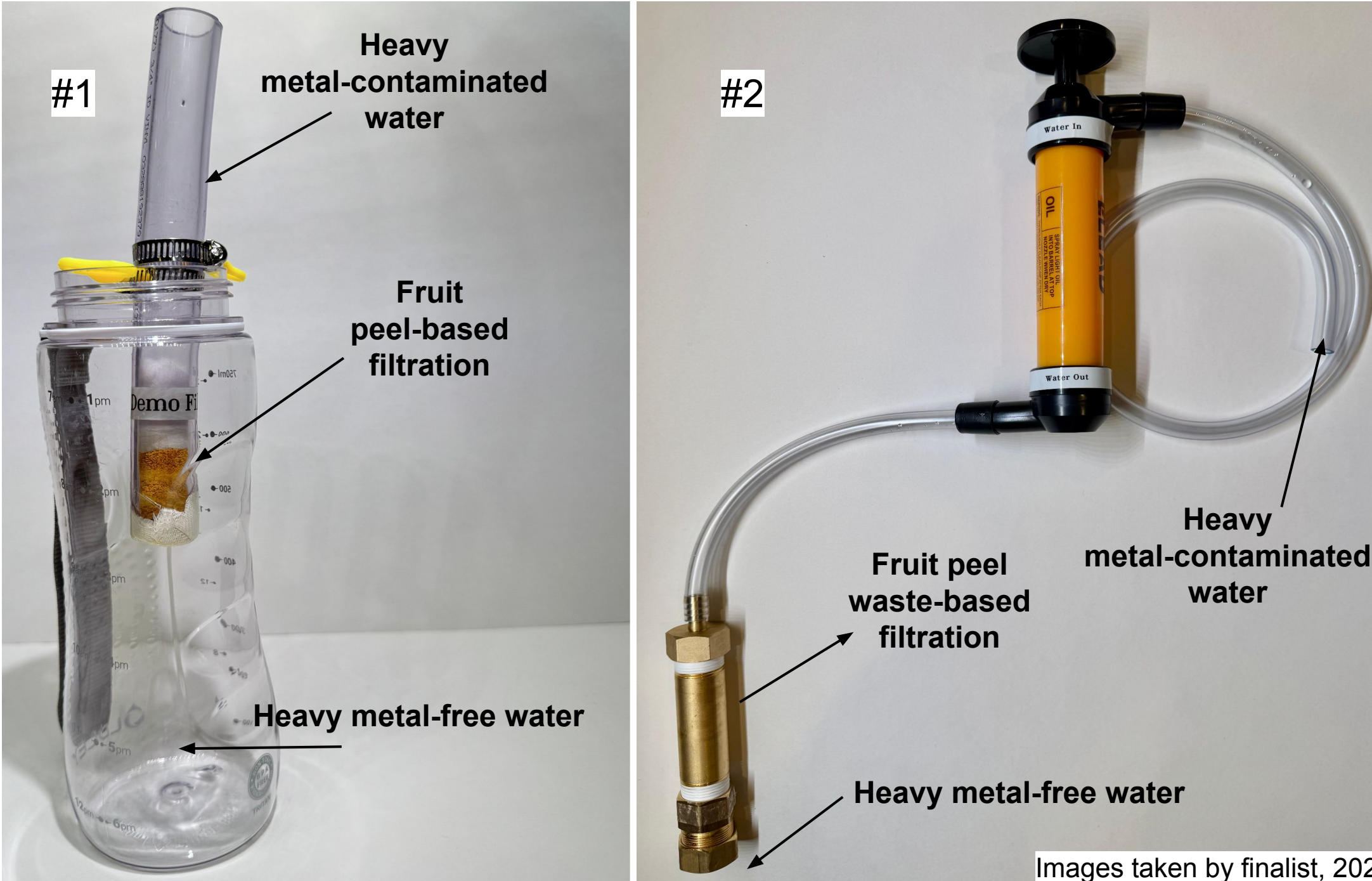
pH Testing Results

- pH remains unchanged around 7 before and after filtration

Why My Filters Work



Prototype Demonstrations



Designs	Pressure	Flow Rate	Real World Applications	Cost
Prototype #1	No (0 PSI)	~30 mL/min	- Portable and Easy Usage - Nearly Zero Cost	\$0.50
Prototype #2	Yes Pressurized by hand (~44 PSI)	~300 mL/min	- Filters Large Quantities - Portable and Faster Flow Rate	\$6

Table created by finalist, 2025

Conclusions

- Developed a novel fruit peel waste-based filtration system for successful heavy metal removal of 7 toxic metals (**Pb, Cd, Cu, Fe, Zn, Ag, Ni**)
- Banana peels were generally most operative among the 4 types of fruit peels (Orange/Lemon/Pomelo/Banana), balancing **efficiency with effectiveness** at filtration.
- The combined filter (Lemon+Banana) performed up to 1250x better than the US Environmental Protection Agency (EPA)'s drinking water standard.
- The proposed solution works as a primary filtration system; it can also be integrated as an add-on to extend filter lifespan and filtration effectiveness.
- ~4 gram of fruit peel powders filters >12L with fastest flow rate
- Future Work**
- Expand to more fruits, test removal effectiveness of more heavy metals, study long-term filtration efficiency, expand range of tested contaminants