Inactivation of Virus Using Salicylic Acid and Conventional Wastewater Treatment Technologies

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Introduction

- Current antiviral products contain active ingredients that harm the environment with overuse [1].
- Previous research lacks mechanisms that essential oils/natural acids use to inactivate viruses [1].
- Natural products have the potential to be used as antimicrobials in disinfectant products [1].

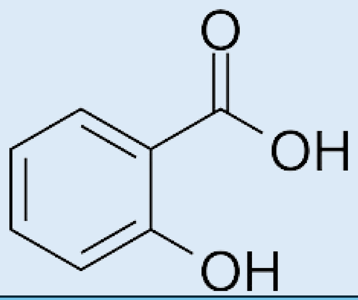

Figure 1: The following image shows the structure of salicylic acid, (the primary natural acid I will be investigating). The molecule is a carboxylic acid with a benzene ring and a hydroxyl (O-H) group. The molecule has an acidic (low) pH, which may contribute to some of its antimicrobial properties [2].

Research Question

Which naturally derived antimicrobial compound would be the most effective surface disinfectant or sanitizer against viruses, MS-2 and PhiX-174?

Results

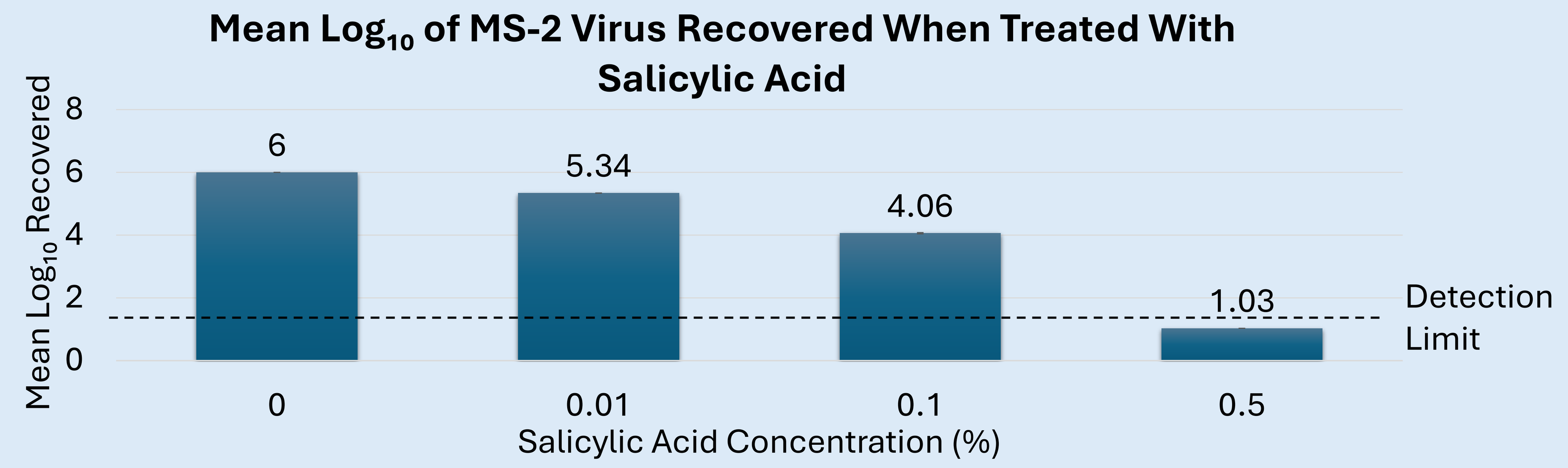

Figure 4: The above graph shows the MS-2 virus recovered after being treated with salicylic acid for 10 minutes. As salicylic acid concentration increases, less virus is recovered.

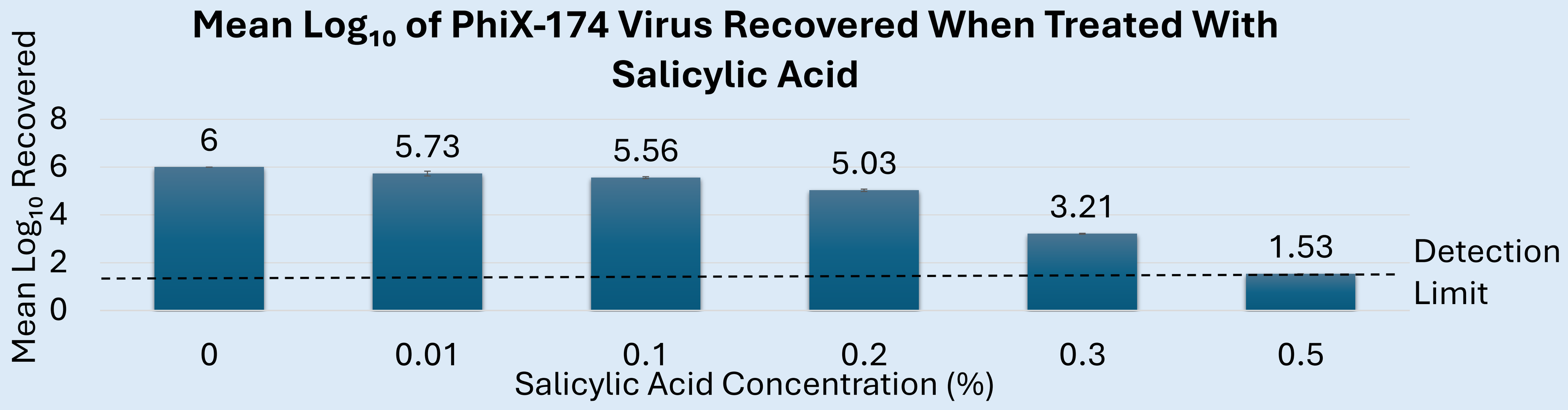

Figure 5: The above graph shows the PhiX-174 virus recovered after being treated with salicylic acid for 10 minutes. As acid concentration is increased, less virus is recovered.

Discussions/Conclusions

- 0.1% salicylic acid is the optimal concentration for future synergistic experiments for virus MS-2 due to its 1-2 Log_{10} reduction.
- 0.2% and 0.3% salicylic acid are optimal concentrations for future synergistic experiments for virus PhiX-174 due to its 1-2 Log_{10} reduction.

Future Areas of Research

- Test how natural acids/essential oils work in synergy to inactivate virus.
- Test the effectiveness of other natural antimicrobials in inactivating virus.
- Test essential oils/natural acids as sanitizers on various other viruses because research has shown that these antimicrobials have different success in inactivating different viruses [3].

Microbiology Methodology

Propagating Virus

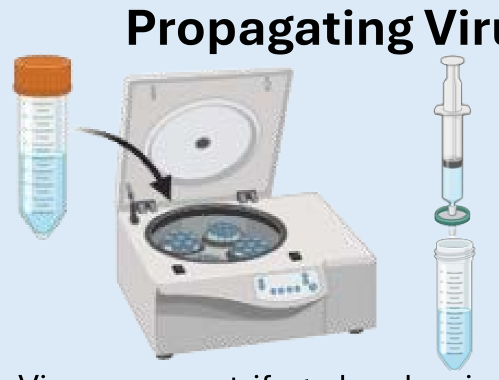

Figure 2: Virus was centrifuged and syringe filtered to remove contaminants (Created with BioRender.com).

Plaque Assay
(How much virus grew?)

1. Plate diluted virus.
2. Incubate plates overnight.
3. Count plaques that formed overnight.

Treating Bacteriophage with different concentrations of salicylic acid (.01%, .1%, 0.2%, 0.3%, and 0.5%) for 10 minutes.

Plaque Assay (How much virus was inactivated?)

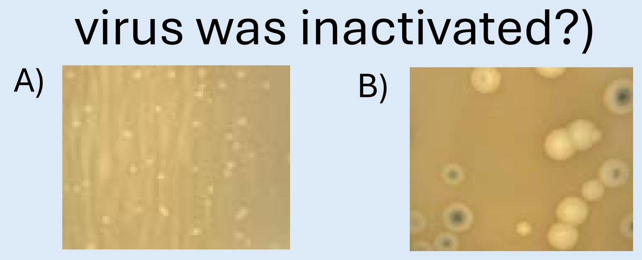

Figure 3: (A) Image of MS-2 virus plaques on a plate of *E. coli* host Bacteria. (B) Image of PhiX-174 virus plaques on a plate of E. coli Bacteria.

Water Treatment Methodology

Dosing Wastewater with Chlorine

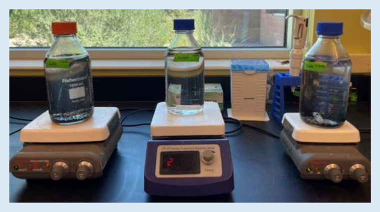

Figure 7: Experimental Set-Up

Adding Granulated Activated Carbon (GAC) and Catalyzed GAC to Wastewater

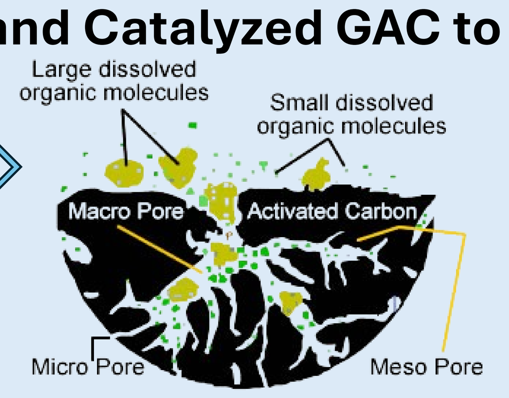

Figure 8: GAC is a form of carbon that has a net-like structure. The structure makes it very good at removing contaminants, including organics and chlorine [7].

Monitoring Amount of Chlorine in Wastewater every 10 minutes until chlorine levels decrease by 99%.

Calculate Chlorine Removal Rate by GAC and CGAC.

$$\ln \frac{C(t)}{C_0} = -kt$$

C(t) is chlorine concentration, C_0 is initial chlorine concentration, k is the rate of chlorine removal, and t is time.

Introduction

- Reverse osmosis systems use high pressure vessels to push water through a membrane, removing salts [4].
- An RO system can be pretreated to extend its lifespan [5].

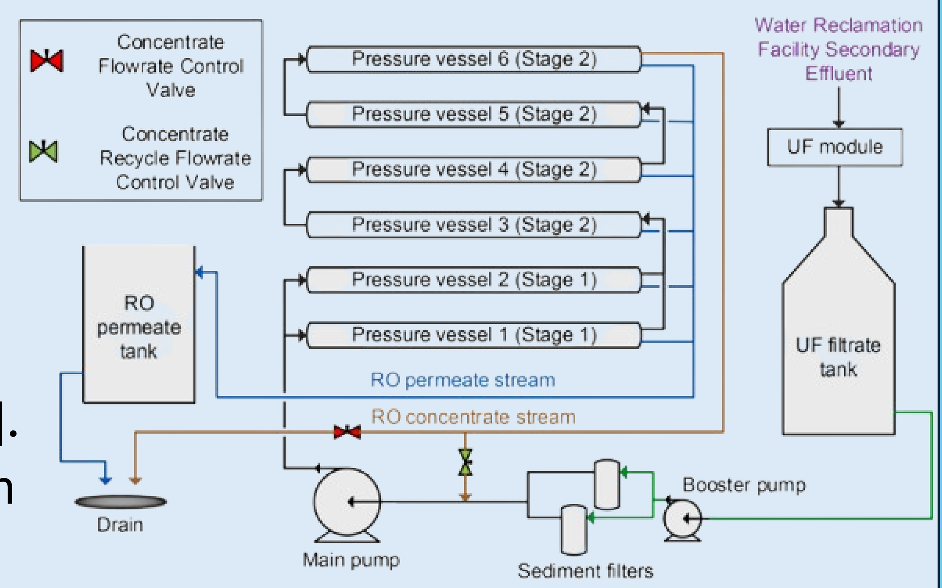

Figure 6: Schematic of Reverse Osmosis System [4]

- Chlorine can react with organic contaminants in wastewater to form disinfection byproducts, which are carcinogens and regulated by the EPA [6].

Research Objective

Investigating the efficiency of chlorine removal in secondary municipal wastewater by GAC and CGAC.

Results

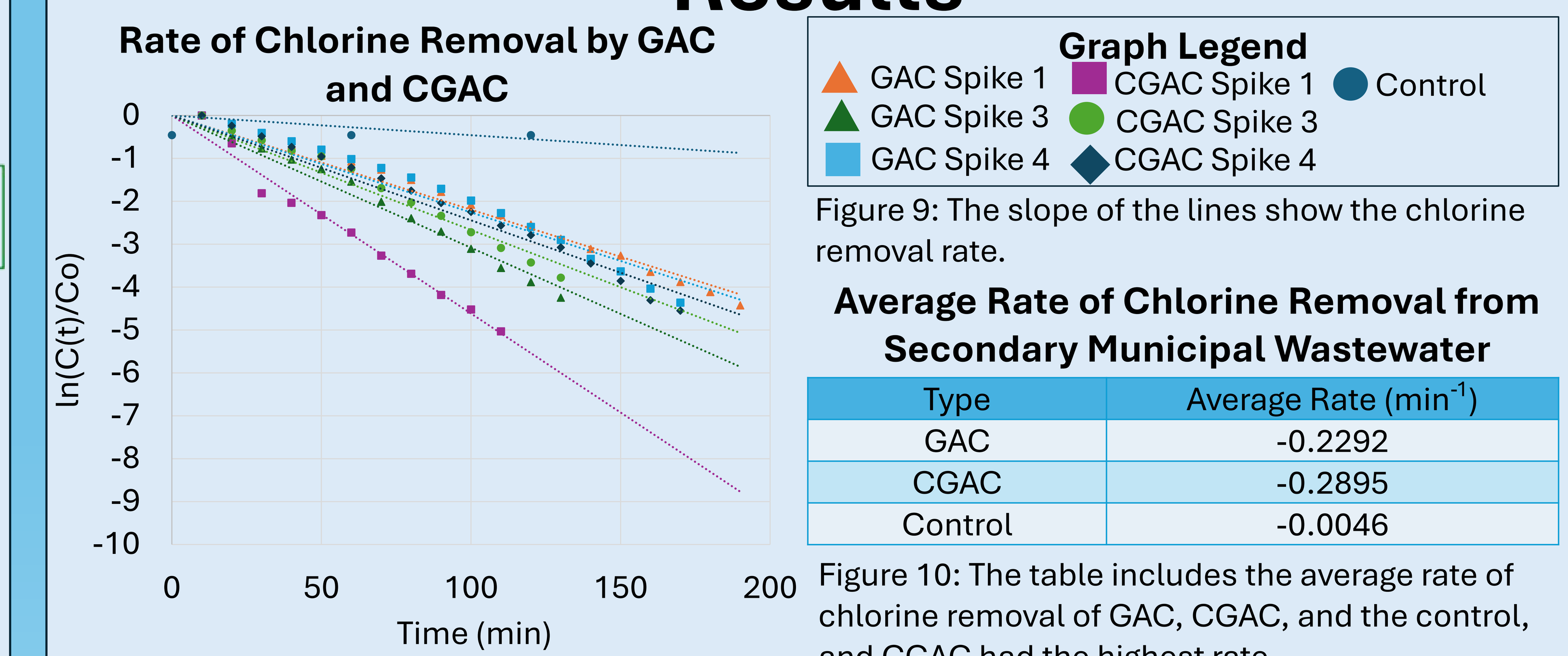

Figure 9: The slope of the lines show the chlorine removal rate.

Average Rate of Chlorine Removal from Secondary Municipal Wastewater

Type	Average Rate (min^{-1})
GAC	-0.2292
CGAC	-0.2895
Control	-0.0046

Figure 10: The table includes the average rate of chlorine removal of GAC, CGAC, and the control, and CGAC had the highest rate.

Discussions/Conclusions

- CGAC was 26% more efficient than GAC.
- After the first chlorine dose in secondary municipal wastewater, the performance of GAC and CGAC did not have a noticeable difference.
- Both GAC and CGAC are effective in removing chlorine in a short period of time.

Future Areas of Research

- Test chlorine removal in wastewater samples which contain different contaminants to see how that affects the effectiveness of GAC and CGAC
- Compare the effectiveness of GAC made from different sources (i.e. coconut shell, corn husk, etc.) in removing chlorine from wastewater.

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