

Abstract

Salmonella, *Escherichia coli* (*E. coli*), and Shigella are examples of bacterial pathogens that can enter the body through drinking water. We are designing a system to actively detect biofilm growth in water through non-invasive means. The response of the system is measured and recorded to determine the amount of biofilm growth within the sample. This system is tested while adjusting different environmental conditions such as pH and temperature which facilitate biofilm growth. The sensor's response is recorded under these conditions to better understand how it is affected by them. This information will help us better understand and finetune the limitations and accuracy of the sensor.

Introduction

Water supplied to households are treated at water treatment plants, stored in water tanks and supplied through pipelines [1]. However, if bacteria are somehow able to enter the pipes, they can clump together to form a film that sticks to the wall of the pipe and contaminate the water flowing through over time [2]. Waterborne diseases account for over 450,000 medical emergencies and about 7,000 deaths in 2017 [3]. Detection of bacterial growth and biofilm in water pipes are pertinent to avoiding bacterial infections. Current solutions to this problem include introducing chemicals which attract the bacteria to a single point to be detected and implementing optical transceivers. However, a non-invasive way to detect biofilm growth in both public and private water supplies can increase the efficiency of dealing with water contamination. Environmental conditions such as turbidity, pH, salinity, conductivity, and temperature can affect the growth of biofilm [2]. Our sensor's response to changes in these environmental factors were tested. The sensor's response was recorded while the sample was in a water bath and its temperature was increased from 20°F to 75°F. The sensor was also tested on samples of increasing salt concentration. Our objective is to develop a novel, non-invasive, real-time method of detecting biofilms.

Approach

- Our approach involved producing a DI water sample and recording the output of the black box as the concentration of salt in the water was increased. In doing this, the effect that the change in concentration had on the output of the black box could be observed.
- Taking the same DI water sample, the output of the black box was measured as the temperature of the sample was increased to observe the effect that temperature has on the black box output.



Figure 1 | Late stage biofilm growth in a pipe

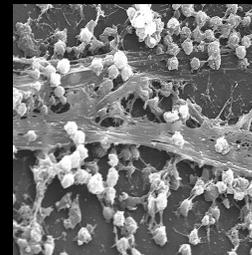


Figure 2 | Biofilm under a microscope

Results and Discussion

- The black box was tested at varying temperatures and salt concentrations.
- The graphs show the black box voltage response and phase shift due to the increase in salt concentration of the sample as well as the temperature increase of the sample.

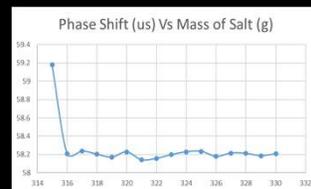


Figure 3 | The Phase Shift response of the black box to different thicknesses of PolyHEMA

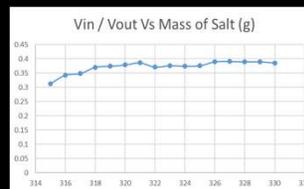


Figure 4 | The Voltage response of the black box to different thicknesses of PolyHEMA

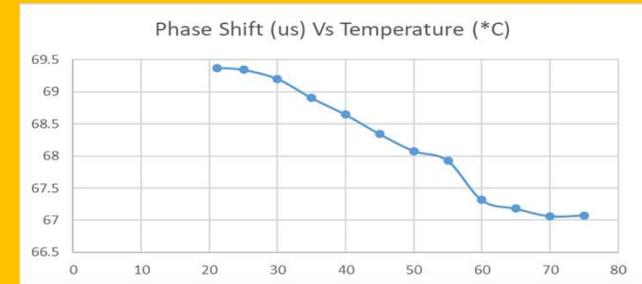


Figure 5 | The Phase Shift response from the black box to the increase in temperature of the sample

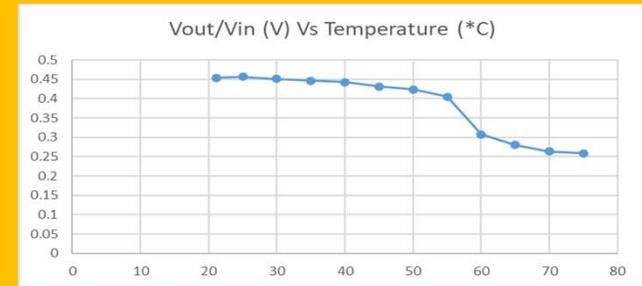


Figure 6 | The Voltage response from the black box to the increase in temperature of the sample

Conclusions

- The voltage response of the black box system increases as the concentration of salt in the sample increases. On repeat experiments the same trend can be found from the recorded data.
- The voltage response of the black box system decreases as the temperature of the sample increases.
- The phase shift response of the black box system is not affected by the change in salt concentration of the sample.
- The phase shift response of the black box system decreases as the temperature of the sample increases. Though the rate of decrease varies.

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