Development of a Smart Water Pre-Treatment System for Controlled Environment Agriculture Using Micro-Plasma and AI Machines

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Abstract

This project integrates two previously designed systems to decrease the level of total dissolved solids (TDS) in recovered ground water. One system consists of a nanofiltration system composed of graphene nanoplatelets, activated carbon, and filter paper. The other system is a micro-plasma based treatment process. Water is run through the plasma based system and then through the graphene and carbon system. A robotic arm will be used to monitor the system and to take samples. Once these systems are complete and working individually, the intent is to create a proof of concept where they will then be integrated with other processes downstream such as electrodialysis and electro-deionization.

Corona Discharge System

A high voltage source charges the plate and grounds the needle. A peristaltic pump, pumps the water from the reservoir and through a ground hypodermic needle (Figure 1). The difference in electric potential causes the corona discharge which results in the particles in the water clumping together to make for better filtration in the activated carbon and graphene filter (Figure 6). UV spectroscopy is performed on the treated water to find the absorbance (Figure 3). This absorbance can be used to find the concentration of Methylene Blue in the solution (Figure 4). As can be seen, the concentration of dye decreases after each pass. Samples are ran at different voltages and a sample is run through the system five times at the same voltage in order to determine the most effective voltage and to ensure repeatability. The initial sample is composed of 600 mL of DI water with 2 grams of powder Methylene Blue Dye. After each pass through the corona discharge, samples are stored in vials for the UV spectroscopy and water characteristics are measured, more specifically the TDS, pH, and conductivity.

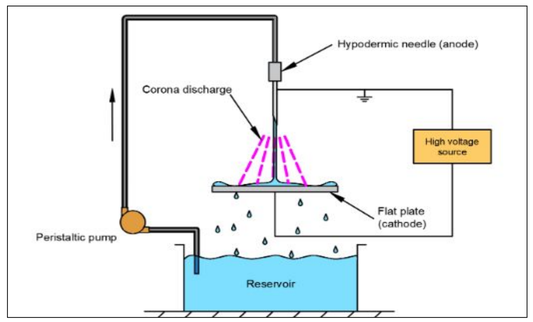

Fig 1. Corona Discharge System Diagram

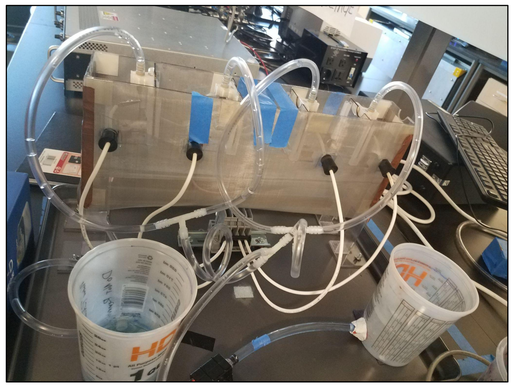

Fig 2. Corona Discharge System

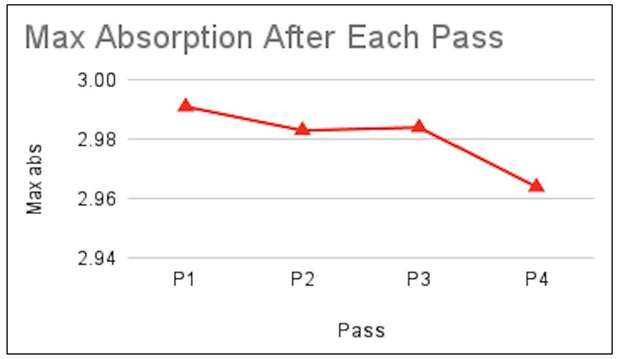

Fig 3. Maximum Light Absorption After Each Pass

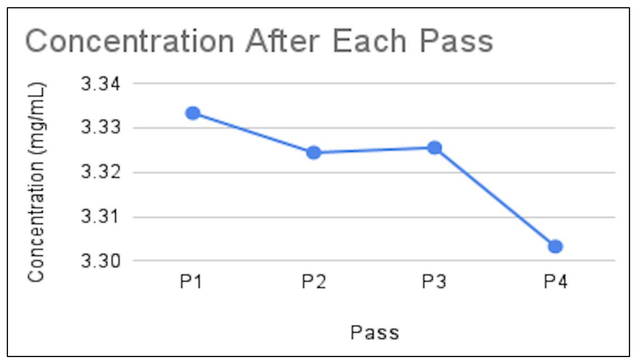

Fig 4. Concentration of Methylene Blue after each pass

Activated Carbon and Graphene Filter

The activated carbon and graphene filter is made of PVC Pipe. This system is gravity fed. The water treated by the corona discharge system is inserted at the top and runs through the graphene, activated carbon, and filter paper. The results of this system can be seen in Figure 6.

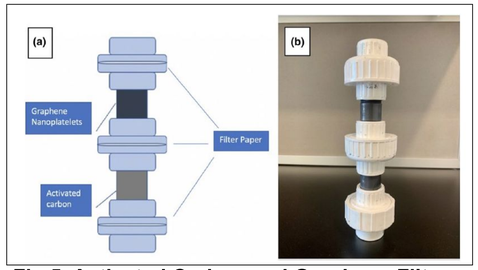

Fig 5. Activated Carbon and Graphene Filter Diagram (a) and Physical Model (b)

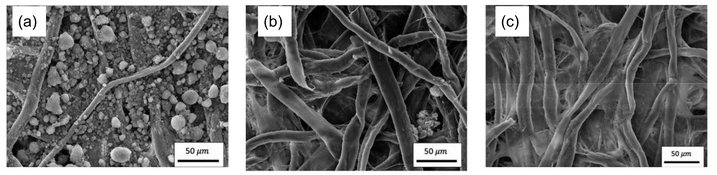

Fig 6. Scanning electron microscope images of the filter paper after the 1st pass (a), second pass (b), and third pass (c)

Robotic Arm

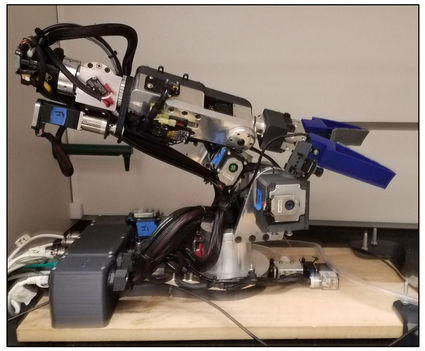

Fig 7. Robotic arm used for monitoring

The Annin Robotics Control Software (ARCS) is used to calibrate and control the robotic arm shown in Figure 7. The two cameras operate through an Arduino mega. The camera will be used to locate the test samples and give coordinates to the robotic arm to move the test samples. The arm is equipped with a pneumatically powered gripper that will take the samples. The thermal camera will also monitor the temperature of the filtration system as to correlate it with the amount or intensity of the corona discharge and record any issues.

Future Work

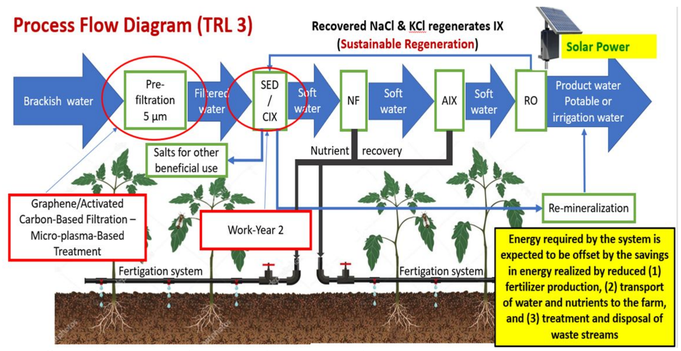

Fig 8. Future plan for additional systems

Testing will continue to determine the number of passes through each system that yield the best results. In addition, it will the order of the systems will be determined after testing. Once the systems are integrated, they will be automated to check the TDS, conductivity, pH, temperature, and flow rate of the system to ensure it is working properly. In the future, it is expected that further systems will be added downstream (Figure 9).

Acknowledgements

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FRESNO STATE Lyles College of Engineering