

## PROJECT: Green Coagulants

### Summary

Difficulty	Easy-Medium
Time required	1 Week
Prerequisites	Know terms such as coagulation, sedimentation, filtration
Material Availability	Plants (Prickly Pear <i>Cactus Opuntia</i> , Moringa seeds), ferric chloride
Cost	[\$50 ]
Safety	Protective gloves while working with Prickly Pear
Green Chemistry Principle	4

**ABSTRACT:** Compare the functionality, the impact on water quality, and the cost of using plant-based coagulants versus synthetic coagulants.

**OBJECTIVE:** The objective of this project is to find a more green alternative to existing synthetic chemicals that are used for coagulation processes in water treatment.

## Background

**INTRODUCTION:** Surface waters require a number of treatment steps prior to drinking. These steps often include aeration, coagulation/flocculation, sedimentation, filtration, and disinfection. This project focuses on the coagulation process associated with drinking water treatment. Typically the synthetic chemicals, Aluminum chloride also known as Alum ( $\text{AlCl}_3$ ), Ferric chloride ( $\text{FeCl}_3$ ), or polyaluminum chloride (PAC) are used for coagulation processes. There are however, numerous drawbacks to using these synthetic chemicals, including inefficiency at low temperatures, associated health problems, high costs, production of large volumes of sludge and the significant effect on pH that these chemicals cause. This has caused a push for “greener” alternatives, especially for use in low and middle income countries. While coagulants are typically thought of for use in drinking water treatment, they are also often used for waste water treatment in different industrial processes. However, that is above the scope of this project.

### TERMS & CONCEPTS:

- **Aeration:** is a process when air and water are mixed turbulently. Aeration is used to reduce carbon dioxide gas, and to help make other contaminants easier to remove.
- **Coagulation/flocculation:** Is the process of causing suspended matter consisting of large and small solids, in raw water to be chemically destabilized so that they come together to cause larger agglomerates known as flocs.
- **Sedimentation:** The physical removal of the suspended flocs. This is done by letting the flocs sit undisturbed so that they settle.
- **Filtration:** Water passes through a filter made up of adsorbents such as sand or activated carbon or through a membrane thereby removing additional contaminants.
- **Disinfection:** A process to kill water borne bacteria and pathogens through boiling the water, a physical method such as ultraviolet radiation or a chemical inactivation. For large scale water treatment plants that are commonly used in the US. Chlorine is added to disinfect the drinking water.
- **pH:** Is a measure of the acidity or basicity of a solution containing water. Solutions with a pH less than 7 are called acidic such as lemon juice that

has a pH around 3. Solutions with a pH greater than 7 are basic. Pure water has a pH close to 7.

### **BIBLIOGRAPHY:**

Ying, C.Y. *Emerging usage of plant-based coagulants for water and wastewater treatment*, *Process Biochemistry* 45 (2010) 1437-1444.

GE Power & Water: Water & Process Technologies.

<http://www.gewater.com/handbook/index.jsp>

### **Materials**

- 30mg Prickly Pear *Cactus Opuntia* => can purchase the plant for about \$10 (wear gloves when handling)
- Ferric Chloride
- Cactus or plant to test of your own (confirm that plant you are using is non-toxic)
- Moringa seeds => \$10 on amazon
- Oven
- 5 glasses
- 5 small plastic cups
- Scale
- 1L soda bottle
- Dirt
- Table spoon
- Food processor, coffee grinder, blender, or mortar and pestle

### **Procedure**

Prepare Dirty Water:

1. Use a 1TBS of top soil in 1L soda bottle
2. Shake the soda bottle to suspend and mix the dirt into the water

Alternatively:

1. Collect 2L of dirty water from a nearby body of surface water that has visible suspended dirt

### Preparing Plant-Based Coagulant

1. Cut the pads of the prickly pear plant into 1cm wide strips
2. Bake the strips, and any other plant you are using in the oven at 250°C until the pads seem dry (this may take a few hours)
3. Grind each of the dried plants and moringa seeds separately in a coffee grinder, a food processor, or with a mortar and pestle

### Testing Coagulation:

1. Add 3/4 Cup of dirty water each to five different containers, one container will not have any coagulant added, this is your control.
2. Add 1 teaspoon of Ferric Chloride solution (with gloves) to one of the containers
3. Add 1 teaspoon of prickly pear powder to one of the containers
4. Add 1 teaspoon of version of your own plant powder to one of the containers
5. Add 1 teaspoon of moringa seed powder
6. In the last container do not add any coagulant. This will be your control.
7. Stir each of the containers for 3 minutes
8. Let the containers sit for 20 minutes and watch what happens

### Observations

- Which coagulant worked the best?
- How do you quantify which one worked the best?
- Other than with volume how can you measure how much coagulant you add, does this result in a different “best” coagulant?
- What other changes have you seen?

### Variations

- If you are interested in exploring a more advanced version of this project ask your science teacher if you can use a pH probe if they have one or a turbidity meter. You can measure the final pH of your water or change the pH of your water using lemon juice to make it more acidic or soap to make it more basic.

- You may also want to try different types of dirty water to mimic different situations.
- Lastly, other natural coagulants that have been examined include maize (a type of corn) and tannins that can be found in tree bark, leaves and even tea.

