Practical investigation – Polymers in water and solids recycling

See why we need to understand organic chemistry to effectively manage water to protect public health and the environment. Why do we need to know organic chemistry in water and solids recycling?

Wastewater is the water we use in our homes, schools and businesses. It goes down drains from sinks, baths, showers, laundries and toilets.

We manage and treat our wastewater to protect public health and protect the environment. We treat wastewater to different levels, so it can be recycled again, and its quality is suitable for its purpose.

We can produce many things from wastewater. Some of the things we produce are:

- recycled water for reuse as irrigation, at businesses and our homes,
- recycled water to release into the environment to keep creeks and rivers healthy.
- a valuable fertiliser called biosolids made from the food scraps and other organic waste
- renewable energy generated while we make biosolids.

Did you know?

Penrith Water Recycling Plant is one of 30 wastewater treatment and water recycling plants.

You can learn about Penrith

Understanding the theory and application of organic chemistry and using working scientifically skills is important to be a sustainable business, as we can better recycle water and solids from wastewater.

What are some applications of organic chemistry?

Wastewater is 99% water. The remaining one per cent is made up of things you've added to water as you've used it. We need an understanding organic chemistry to:

- identify the properties of waste in wastewater so, we can make predictions about ways we can separate water and waste.
- recognise the value of polymers in water treatment.

How do we use polymers effectively and efficiently?

We carefully select polymers with specific properties, so that their application is also suitable for its purpose. Identifying the structure and chemical properties of polymers in water treatment is important to predict how they behave. We also need to consider the other variables though, such as how we are going to apply the chemical to use it effectively and efficiently. We'll look at a specific example of applying polymers in flocculation.

Every day we take water samples to our labs and model, on a small scale, the chemical mixing at the plant. This test is called a 'jar test'. We use jar tests to check that our chemical dosing will be effective for the source of water on the day. We also use mock water samples to test various scenarios at our treatment plants. This means we can adjust our water treatment to produce the best quality water for our customers and the environment.

How can I recreate a jar test in the classroom?

A ‘jar tester’, is a specialised piece of equipment that can best model chemical mixing at the treatment plant.

You can still perform your own ‘jar test’ at the school and test how chemical techniques variables can change the effectiveness of water treatment.

A jar tester is used to model chemical mixing on water treatment plants.

What you’ll need

Safety first! Adult supervision is required. Follow all safety instructions as directed on product packaging and safety data sheets.

Equipment list	Additional notes
personal protective equipment (PPE)	Safety glasses, gloves, enclosed shoes, lab coat or protective long sleeve clothing
4 x 2L ‘jars’ i.e. beakers or containers	You can substitute with other size containers and scale accordingly. Avoid metals that may react with contents inside.
4 x stirring rods or magnetic stirrer	Jar testers are very specialised equipment, so a stirrer is a close substitute.
1- 5mL syringe or measuring cylinder	To add known volume of polymer (flocculant).
tap water	You can also try and substitute with other sources of water.
bucket	To make a large composite water sample.
flocculant	You can purchase polymer flocculants at local hardware or pool supply stores. • Aluminium sulfate and other inorganic salts are also marketed as flocculants. See label to find polymer flocculants. To increase effectiveness, you may want to combine a coagulant like aluminium sulfate. • You may need to calculate and create a diluted stock solution to accurately dose your polymer. • *Your results may not look like the jar test demonstration as we used industrial grade cationic polyacrylamide designed for wastewater treatment.
clay in water suspension	This replicate and exaggerates suspended solids that can be found like soils, sediment, and other organic matter in water. You will then further dilute this solution. The aim is to get the suspended particles, with samples as close to equal turbidity (cloudiness) in each jar. • Measure 1 tablespoons of modelling clay. • Break up the clay as much as possible in 500mL of water. • Shake before use.
stopwatch	To time settling speed observations
hand lens, microscope or turbidity meter (optional)	To observe the changes in turbidity.

Activity

1. Prior to starting, ensure you are wearing appropriate PPE and understand risks and controls. Collect all equipment and prepare stock solutions as instructed above.
2. Read the concentration and dosing suggestions on your flocculant. Decide the range of volumes that you'd like to apply to your four 'jars' of water. Calculate the volume you would need to apply into a 2L jar (you may need to dilute several times - a serial dilution).
3. Fill a bucket with 8 L of tap water (or your choice of water).
4. Shake your stock clay solution, measure, and add 80 to 100 mL of clay solution into the bucket of water to create your water sample.
5. Stir the water to make the water uniform, quickly transfer and fill 2 L of into each of your 'jars'. You may want to mix the sample water between the jar to make the turbidity as uniform as possible.
6. Take observation notes or photos on the physical characteristics of the water such as the turbidity (record with turbidity meter if available) and the particle size in the water.
7. Add your desired volume of polymer flocculant to one of the jars.
8. Mix the water with stirrer for 5 minutes. Stop and let the solids settle. Start the timer.
9. Take observation notes or photos on the physical characteristics of the water such as the turbidity (record with turbidity meter if available) and the particle size in the water.
10. Repeat steps 7-8 for the other 3 jars.
11. Be patient and come back to the mixture every couple minutes. Observe whether there are differences between jars. Stop after 30 minutes of observations.

Results

This is a sample results table. Draw this up depending on the equipment and jar test you've designed.

If you do not have a turbidity meter are there ways you can still turn qualitative observations into numerical data? Working scientifically and problem solving are important. Try using ranks or categorising turbidity into classes. Can you measure the size of the flocs? Are there other methods?

Floc size, turbidity and settling observations taken at multiple time points during jar test experiment				
Time	Polymer dosing in the jar			
	mL	mL	mL	mL
Before polymer				
During polymer addition 0 min				

After polymer 1 min				
Settling 5 min				
Settling 10 min				
Settling 20 min				
Settling 30 min				

Discussion

- Do think any of samples meet the Environmental Protection Licence guidelines for wastewater treated at Penrith Water Recycling Plant? Yes or No? For which parameters?
- What can you do to make this test more reliable? accurate?
- How would you communicate your observations in a report?

Q. What can change in our source of water? How does this affect water treatment?
A. There are many variables which can change water quality which is why we monitor and manage our water from our wastewater treatment plants, reuse as recycled water or discharge into our environment. Things like temperature, pressure and concentration. Wastewater also can be impacted by our behaviour that changes the quality of our water such as what we put down sinks or drains. The focus of this jar test was looking at concentration (chemical dosing polymers and solids in water) where pressure and temperature remain stable at our plant.

Alternative jar test experiment designs

You may want to design your own jar test experiment! So, get creative, things like:

- Testing for the optimal dose of a single flocculant on a given source of water (fixed variable).
- Predicting what would happen if you added other flocculation aids like a coagulant (which neutralises charges on particles).
- Testing the effectiveness of different types of flocculants and comparing the results.
- Testing how variables like mixing speed affect flocculation.
- Testing the effect of a fixed dose of polymer on different water samples (vary solids in water, salts, acidity).

There are many more options what interests you?