Greater Western Water
Winnovators 2025

Report

Management of Sludge from Water Treatment Plants in Cambodia

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WaterAid Winnovators Program

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Solution overview:

A two-part solution has been developed to address sludge management limitations that relate to the drinking water treatment plants in Cambodia.

1. Jar testing educational guide; as a water treatment solution.
2. Geobag presentation; as a sludge management solution.

This report is to be read together with the PowerPoint presentation. The presentation includes details on the whole solution in context and is the key document for the geobag component of the solution.

The following information in this report, including the appendix, is the key document for the jar testing component of the solution, and references for the whole project.

1. Jar Testing Introduction

1.1 What is a Jar Test?

The presence of suspended solids, dissolved substances, algae, bacteria, and organic matter in raw water can present significant challenges for water treatment plant (WTP) operators[2]. A reliable process to separate these from raw water is to use coagulation-flocculation (C-F), followed by sedimentation and sometimes floatation[2].

Jar testing is a method that simulates this C-F process at a smaller scale. It can provide water treatment operators (WTOs) and engineers with data to help understand how the chemicals could behave with their source water and plant. They could thus optimise the chemical dosage used for efficient water treatment[1].

A jar testing setup will have multiple jars tested simultaneously. The aim is to have the water in the jars be identical except for one change in chemical, or physical process between jars. Controlling one change between jars allows for comparison between different scenarios.

1.2 Jar Testing for Sludge Management

Jar testing can be used to analyse many parts of the water treatment process, including sludge production. Dosing coagulant chemicals helps the particles in the water stick together in larger particles, called 'flocs'. The flocs can be separated from the water by allowing them to settle to the bottom or float to the top. This is the sludge in the Water treatment process.

Adjusting the amount and type of coagulant chemical used can change the size and density of the flocs and the volume of sludge produced. This optimisation may result in a smaller volume for moving and handling.

1.3 When to do Jar Testing

Jar testing should be performed before, and during the commissioning of a new WTP or when a new raw water source is being considered for a WTP. This can indicate how the water is expected to react to the current or planned chemical dosing.

The frequency of routine jar testing depends on the WTP context. Jar testing seasonally or monthly can help identify the impacts on the raw water from temperature change, and water quality differences. If the raw water quality is known to change a lot, or if the WTP has no or minimal water quality sensors collecting data, the frequency should be higher, such as weekly, or even daily. It should also be conducted whenever a chemical type is changed, or new pumps, mixers, motors, or chemical feeders are installed[1].

There is no set of requirements for when to do the jar testing; however, the more it's done the more efficiently the water treatment plants will operate[1].

1.4 Why do Jar Testing?

Jar testing allows WTOs to understand why a WTP is not treating water as expected. It can allow WTOs to understand the cause and if adjusting a chemical dosage can make the WTP treat the water more efficiently.

Jar testing allows the opportunity to try different treatment dosages and compare the performance of several different chemical treatments. This can look at the formation times of floc, their size, settleability, and filtration characteristics[1].

Jar testing can also help WTOs reduce running costs[1]. One of the common problems in WTPs is overdosing, especially with coagulants. Dosing too much coagulant means extra money is being spent on chemicals, and removing the extra sludge produced. Jar testing helps operators find the optimal dosage of chemicals, thus reducing waste and running costs.

2. Benefits of Jar Testing

There are several benefits of jar testing:

1. **Optimised chemical dosage and plant performance**: Jar tests help determine the optimised amount of chemicals needed for effective water treatment.
2. **Reduced operational costs**: By determining the optimal chemical dosage rate, money is saved from avoiding extra chemical spending, and overproduction of sludge which needs to be managed to continue the WTP running.
3. **Cost-effective experimentation**: Jar testing is a relatively inexpensive way of testing different treatment options, providing information about chemical dosages before testing them on a larger scale at the WTP[1].
4. **Reduced environmental impact**: Reducing both the volume of chemicals used and sludge produced could reduce the environmental impacts. This is due to less

chemicals being available in the sludge to be released into the environment via unintentional run-off.

3. Common Jar Tests

Key types of tests include coagulant testing, flocculation testing, filterability testing and pH testing[5,6,7]. Here is a detailed explanation of these test types.

Coagulant testing: Used to determine the best coagulant and its optimal dosage to effectively remove solids and turbidity.

Flocculant testing: Different jars of raw water are treated with different flocculants or combinations of flocculants to evaluate the effectiveness of different flocculants in aiding floc formation.

Filterability testing: Treated water is passed through a filter to determine the filtration rate. This is to assess how easily the treated water can be filtered and the clogging potential.

Flocculation dynamics testing: The purpose of this test is to observe the formation and settling behavior of flocs under different mixing conditions. This could help operators find the optimal mixing intensity and duration of flocculation.

4. Conclusion:

Jar testing is a core skill for developing water treatment operation capabilities. It is a useful tool to help improve a plant by mimicking a smaller scale situation. This can result in many benefits for PWOs beyond sludge development, including cost savings and optimisation of the water treatment processes. The following Appendix A supports this report with further common testing scenarios and setup options to allow PWOs to understand what could be achievable and where to start when considering jar testing at their facilities.

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Appendix A: Jar Testing Educational Guide

Introduction:

The purpose of this appendix document and jar testing introduction in the above report is to be a guide for WTOs. It will allow them to see what type of jar testing could be possible at their plant, and how the jar testing could be used as a tool to optimise their treatment processes. This can be targeted to many areas of the water treatment process, including effecting sludge production.

This document is intended to be read by operators who have varying levels of water treatment knowledge. It could be used to teach operators who do not know how to perform jar test experiments, and operators who know how to do common jar testing but do not have a routine jar testing program.

1. Common Jar Testing Elements

1.1 Common Chemicals Used

- **Coagulants:**

Aluminium sulphate, commonly called 'Alum', is the most common coagulant used in water treatment. It is widely available and relatively low cost. When deciding which coagulant is best for a specific raw water source, water quality parameters such as pH, colour, and turbidity need to be considered. There are different coagulants which work better at different pHs, when treating colour and turbidity[9].
Common coagulants, also referred to as flocculating agents, used for jar testing are summarised in the table below[3]:

Flocculating agent	Typical stock solution strength	Shelf life	Details
ACH (aluminium chlorohydrate)	23% Al_2O_3 SG 1.33	2 months	Not affected by raw water alkalinity and temperature, produce strong and rapid flocs
Alum	24% Al_2O_3 1% w/v =10 g/L of supplied liquid SG 1.3	1 month	Affected by raw water temperature, alkalinity and pH. Small and dense flocs are formed at pH 6-7
Ferric chloride	15% w/v =10 g/L of supplied liquid SG 1.45	1 month	Large and strong flocs and work in a wider pH than alum
Polyaluminium chloride (PACl)	20-23% w/w SG 1.18	1 month	Dense flocs, less affected by temperature
Cationic polyDADMAC	0.1%w/v=0.1 g/L of supplied polyacrylamide	2 weeks	Reduce of alum dosages, sludge production and alkalinity consumption improved metal ion coagulation turbidity and colour removal
Non-ionic/anionic polyacrylamide	0.01% w/v=0.1 g/L of supplied polyacrylamide	1 week	Flocculant aid, filter aid, filter conditioning. Filter aid doses are not generally determined by jar testing.

Table 1: Typical coagulation solutions used in water treatment

A diluted batch of the coagulant is mixed from the stock solution. Different coagulants have different shelf lives. This needs to be considered when deciding when to make a new batch.

- **pH adjustment:**

Often, a chemical is added before the coagulant to adjust the pH of the water, so the coagulant can work effectively. A pH adjustment is also commonly used after filtration to have the water fall within a safe drinking range[9]. Common chemicals include calcium oxide (lime), sodium carbonate, sodium hydroxide, and carbon dioxide.

- **Disinfection:**

Chlorine is commonly used for water disinfection, often in the form of sodium hypochlorite, and chlorine gas.

- **Taste and odour:**

Activated carbon has many benefits in water treatment and can be used to help with the taste and odour of water associated with organic matter[8].

1.2 Typical Parameters to Measure

The following is a list of common parameters to test before, during, and after conducting a jar test.

- pH
- Turbidity
- Chlorine (total, and residual)
- Common metals such as iron, and aluminium
- Colour
- Time
- Size of flocs

2. Jar Testing Setups

2.1 Common Facilities and Equipment

The following are commonly used equipment for jar testing[3,4]:

- **Jar test apparatus**: The mixing setup. It can be a stand holding up the stirrers or a box with multiple stirrers in a row, with a shelf for the jars. This allows for testing different water samples or chemical dosages at the same time.
- **Beakers**: The 'jars'. These transparent glass beakers are used to hold the water samples during the test.
- **Syringes**: For accurate addition of chemicals.
- **Graduated cylinder**: To measure liquid volumes.
- **Timer**: To manage the mixing and settling time during the jar test.
- **Turbidity meter**: Used to measure the cloudiness of the water samples, this is a key indicator of water treatment performance.

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- **pH meter or pH paper**: Used to measure the pH level of the water sample. This can be tested at many stages during the process to make sure the target is achieved.

Figure 1: A common jar tester with eight 2L jars[7]

2.2 Requirements to Build a Simple Jar Tester

If buying a new professional jar tester isn't an option, the following instructions show how to build a simple jar tester from common parts and items that could be obtained from local hardware and electronics stores[1].

Figure 2 is a diagram of the proposed simple jar tester from the parts listed. Figure 3 is a diagram for the 1.5-volt motors that operate at a low speed, operators could use a 25-ohm, 2-watt variable resistor to control each motor. It is also recommended to use a sheet metal screw to hold the fittings in place, instead of gluing any of the fittings together.

The follow descriptions are for constructing a 2-jar setup. Is it recommended to duplicate this to have more jars to test with at the same time. For detailed instructions on how to build this specific jar tester, please see the referenced document by National Environmental Services Centers (2005).

Parts needed:

- **Base**: One piece of 18mm plywood baseboard
- **PVC Pipe**: One 24-inch long, ¾ inch diameter piece of PVC pipe. Cut into the following four pieces:
  - One 5-inch long
  - One 12-inch long
  - Two 3.5-inch long
- **PVC tee**: Two ¾-inch PVC Tees
- **Fitting cross**: One ¾-inch fitting cross
- **Motors**: Two 1.5-volt motors to fit into the tees
- **Couplings**: Two couplings for the motors to fit over motor spindles

- **Copper wire**: Two pieces of 7-inch straight-solid copper wire with loop on one end for the stirrer
- **Copper disc**: Two copper discs with a diameter of 0.75-inch for soldering to the loops on the stirrers
- **Screws**: Eight ½-inch long, sheet metal screws
- **Red wire**: One 20-inch piece of 18-awg red wire cut into two even pieces
- **Black wire**: One 20-inch piece of 18-awg black wire cut into two even pieces
- **Battery**: One alkaline "D"-cell battery
- **Battery mount**: One D-cell battery mount
- **Variable resistors**: Two 25-ohm 2-watt variable resistors, one for each motor
- **Junction box**: One plastic electrical junction box to house the electrical components.
- **Toggle switch**: One DC toggle switch
- **PVC flange socket**: One ¾-inch PVC flange socket couple to attach pipe to base
- **Jars**: Two clear Mason jars

Tools list:

- Drill
- 1/8-inch drill bit
- Philips and straight screw drivers
- Wire cutters
- Solder
- Soldering iron
- Hack saw
- Wire strippers
- Tape measure

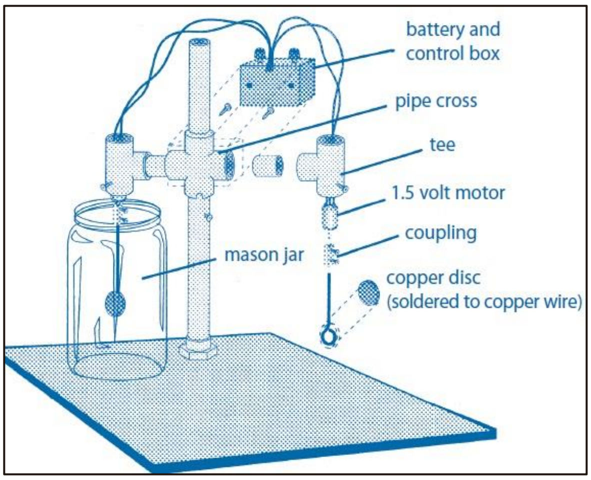

Figure 2: A simple jar tester[1]

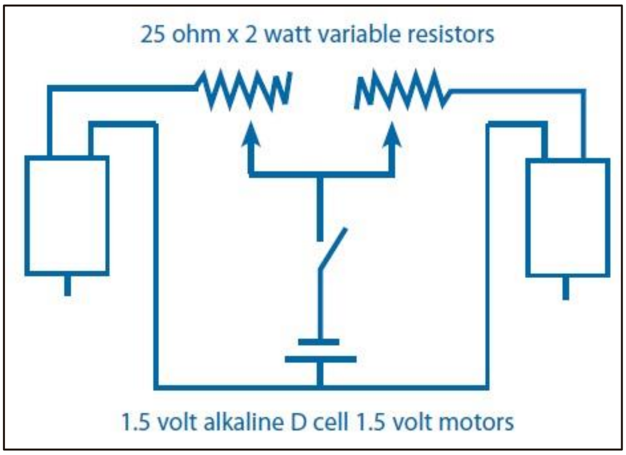

Figure 3: The electric circuit for the simple jar tester[1]

3. Next steps:

PWOs could use this document to develop an understanding of how jar testing works and review their situation with equipment for different types of setups and testing. Beyond this understanding, it is advised to seek out instruction manuals that suit their needs, skill, and equipment. This should include a template to write in the data once collected to assist in understanding the trends from the testing. Due to the variety of different ways to perform a jar test, this could vary greatly for different PWOs. The intention of this is to guide, direct and motivate PWOs to seek their own training and resources to support the jar testing that works best for them.