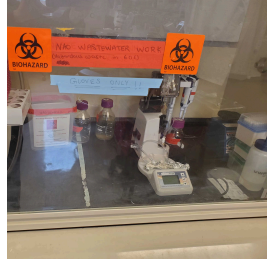


Mar 03, 2024

## Concentration and nucleic acid extraction of viruses from wastewater primary sludge

DOI

[dx.doi.org/10.17504/protocols.io.36wgq3k1xIk5/v1](https://dx.doi.org/10.17504/protocols.io.36wgq3k1xIk5/v1)



Ari N Machtinger<sup>1,2</sup>, Olivia S Hershey<sup>1,2</sup>, William J Bradshaw<sup>1,2</sup>, Emily H Soice<sup>1,2</sup>, Daniel P Rice<sup>1,2</sup>, Michael R McLaren<sup>1,2</sup>

<sup>1</sup>Media Laboratory, Massachusetts Institute of Technology; <sup>2</sup>SecureBio

NAO



Michael R McLaren

SecureBio

### Create & collaborate more with a free account

Edit and publish protocols, collaborate in communities, share insights through comments, and track progress with run records.

Create free account

OPEN  ACCESS



DOI: <https://dx.doi.org/10.17504/protocols.io.36wgq3k1xIk5/v1>

External link: <https://naobservatory.org>

**Protocol Citation:** Ari N Machtinger, Olivia S Hershey, William J Bradshaw, Emily H Soice, Daniel P Rice, Michael R McLaren 2024. Concentration and nucleic acid extraction of viruses from wastewater primary sludge. **protocols.io** <https://dx.doi.org/10.17504/protocols.io.36wgq3k1xlk5/v1>

**License:** This is an open access protocol distributed under the terms of the **[Creative Commons Attribution License](#)**, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited

**Protocol status:** Working

**We use this protocol and it's working**

**Created:** January 18, 2024

**Last Modified:** March 15, 2024

**Protocol Integer ID:** 93742

**Keywords:** wastewater-based epidemiology, WBE, viral concentration, metagenomics, viromics, wastewater, wastewater sludge, total nucleic acid extraction from wastewater, nucleic acid extraction of virus, total nucleic acid extraction, nucleic acid extraction, rna viral kit, wastewater primary sludge this protocol detail, wastewater processing protocol, dna sequencing of virus, modified wastewater processing protocol, wastewater sample, viral particles from solid, ml of wastewater sludge, wastewater sludge, viral particle, wastewater, primary sludge, present in wastewater, wastewater matrix, nucleic acid, extraction, pes 75 mm filtration unit, untargeted rna, acid extraction, dna sequencing, purposes of untargeted rna, rna, mm filtration unit, filtrate, concentrated product, innovaprep concentrating pipette select, performing concentration, virus, pellet, processing

**Funders Acknowledgements:**

**Open Philanthropy**

Grant ID: NA

**Musk Foundation**

Grant ID: NA

## Abstract

This protocol details our workflow for performing concentration and total nucleic acid extraction from wastewater primary sludge (settled solids) for the purposes of untargeted RNA and DNA sequencing of viruses present in wastewater.

*Protocol overview:* In this protocol, 20 mL of wastewater sludge is concentrated to a final volume of 400 uL using the InnovaPrep Concentrating Pipette Select. Prior to concentration, the wastewater sample is treated with Tween 20 and sonicated to dissociate viral particles from solids in the wastewater matrix. The sample is then centrifuged to remove larger solids. The pellet is discarded, and the supernatant is filtered with a 0.45 um PES 75 mm filtration unit to remove remaining suspended solids and bacteria. This filtrate is then concentrated with the Concentrating Pipette, using Ultra CPT tips and recommended device settings for the InnovaPrep modified wastewater processing protocol. Nucleic acids are then extracted from the concentrated product using the Zymo quick-DNA/RNA Viral kit using the manufacturer protocol with a few modifications that we have found to be helpful.



## Guidelines

RNA processing and handling: Please review **Protocol Note: Working with RNA Samples** before handling RNA samples.

## Materials

Materials:

(for one sample replicate and one negative control)

- 2 x **InnovaPrep Ultra CPT (Unirradiated)** tips for the InnovaPrep Concentrating Pipette Select
- 2 x **0.45 um PES 75 mm vacuum filtration tops** (VWR No. 10040-470)
- 2 x **0.22 um PES vacuum filtration top** (VWR No. 10040-444)
- 2 x 100 mL pyrex bottles
- 2 x **50 mL falcon tubes** (VWR No. 21008-178)
- 2 x 5 mL centrifuge tubes
- 2 x 25 mL serological pipettes (Thermo Fisher No. **170357N**)
- 1.5 mL microcentrifuge tubes (VWR No. 1420-2600)
- PREempt wipes (VWR No. 10822-456)
- Parafilm (Millipore Sigma No. HS234526C)
- RNaseZap
- Kimwipes (VWR No. 34120)
- Paper towels
- Filtered micropipette tips

Reagents:

- Tween 20
- 1x Phosphate Buffered Saline (w/o Ca & Mg)
- Ice
- **CP Select Elution buffer (Tris)**
- **CP Select Storage Fluid**
- All buffers in the **Zymo quick-DNA/RNA Viral Kit**

Equipment:

- **InnovaPrep Concentrating Pipette Select**
- **Branson M 1800 Sonicator** (filled  $\frac{3}{4}$  with tap water)
- **Attachment for vortexer** (Cole-Parmer No. UX-04724-89)
- Scientific Industries Vortex Genie 2
- Vacuum Line
- Micropipettes (1000 uL, 200 uL, 10 uL, 2 uL, 1 uL) and holder
- Timer
- Floor Centrifuge (Ex: Beckman Coulter Avanti J series)
- Rotor compatible with 50 mL tubes (Ex: Beckman Coulter JA-14.50)



## Troubleshooting

## Safety warnings

**! Biosafety precautions:** All raw wastewater samples will be received and stored with primary and secondary containment. The primary container (the bottle or falcon tube) should remain in the secondary container (a Ziploc bag containing paper towels to absorb spills) until processed. All raw samples must be handled within a dedicated fume hood or biosafety cabinet. All laboratory personnel handling these samples must use safety glasses, gloves, and lab coats. Samples will be transported between processing stations within a secondary container that has been cleaned with PreEmpt. All surfaces (outside of the fume hood/sash, centrifuge lid and rotor, etc.) will also be wiped down with PreEmpt. All autoclave-able bottles that are in contact with wastewater samples will be cleaned by filling with 10% bleach for at least 20 minutes before disposal.

## Before start

Read the 'Safety Warnings' section for biosafety precautions necessary for handling raw wastewater samples. Prepare the fume hood for wastewater handling, gather materials and reagents (centrifuge tubes, serological pipettes, pipette tips, micropipettes, a marker, strips of parafilm, PBS). Label centrifuge tubes (one for each influent sample, and two for a negative control sample). Ensure proper PPE.



## Reagent Preparation

7m

- 1 Prepare a [M] 1 % volume Tween 20 stock solution. For a 500 mL stock, combine 5 mL of Tween 20 with 495 mL of 1X PBS. Filter sterilize with a 0.22 um vacuum filtration unit.

7m

### Expected result

This recipe produces enough 1% Tween 20/PBS solution for approximately 24 dissociation treatments.

## Part 1: Sludge Handling, Dissociation, Centrifugation, Filtration

52m

2

5m

### Safety information

Refer to the 'Safety Warnings' section for biosafety precautions necessary for handling raw wastewater samples.

Transfer sludge sample (within secondary container) from the refrigerator to the fume hood. Remove the sample bottle from the secondary container and unseal the bottle by removing the affixed Parafilm.




- 3 Prepare aliquots of sludge. Invert the bottle of sludge several times to re-suspend contents, then carefully open it. Using a fresh 50 mL serological pipette, aspirate and dispense 20 mL of sludge into a 50 mL centrifuge tube. Repeat for desired number of sample replicates. For a negative control, add 20 mL of 1X PBS to a centrifuge tube using a fresh 50 mL serological pipette.

10m

### Note

EHS recommended limiting sample volume to 40 mL in each tube to reduce the risk of leaks.



4 Add  20 mL of  1 % (v/v) Tween 20 to each centrifuge tube (including controls) for a final concentration of  0.5 % (v/v) Tween 20.


3m

5 Cap and parafilm all bottles and centrifuge tubes.


5m

#### Safety information



Return the sludge bottle to secondary containment, wipe exposed surfaces with pre-empt wipes, and return the remaining sludge to refrigeration.

6 Place all centrifuge tubes on a vortexer using a 50 mL tube adapter. Shake for  1000 rpm, 00:01:00

2m

7 Transfer all centrifuge tubes from the vortexer to a sonication bath, and sonicate for  00:01:00 at 40 kHz. Use a paper towel to dry the tubes when finished.

1m

8 Transfer all centrifuge tubes from the fume hood to a centrifuge equipped with the appropriate rotor and/or adapters (ex: Beckman Coulter Avanti J series with JA-14.50 rotor) . Centrifuge the samples at  10000 rpm, 4°C, 00:05:00 . After centrifugation is complete, wait  00:10:00 (as recommended by EHS) to allow aerosols to settle before opening the centrifuge. Remove samples from the centrifuge and return them to the fume hood.

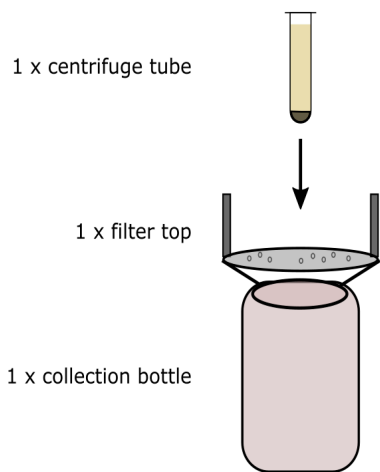
15m

9 In the fume hood, prepare a separate 0.45 um vacuum filtration apparatus for each sample and control by attaching the filtration unit to a clean pyrex bottle.

5m

10 Decant the supernatant from the sludge sample centrifuge tube directly into a 0.45 um vacuum filtration top attached to a sample collection bottle, taking care not to dislodge the pellet.

1m



The centrifuge tube contains 40 mL of diluted sludge sample. The total volume of the sample is filtered and collected in the bottle.

- 11 Begin vacuum filtration by capping the vacuum filtration top and opening the vacuum line. When complete, cap the pyrex bottle and set aside. Repeat for each sample replicate.

3m

#### Expected result

The filtrate volume will vary depending on the amount of solid material in the sample.

- 12 For the negative control centrifuge tube, decant directly into a 0.45  $\mu$ m vacuum filtration top. There should not be a pellet. Perform vacuum filtration as was done for the sludge, cap the pyrex bottle, and set aside.

2m

## Part 2: Concentration via InnovaPrep Concentrating Pipette Select

55m

- 13 Perform the "Start-up" protocol for the InnovaPrep Concentrating Pipette Select.
- Turn on the Concentrating Pipette, and navigate to "Maintenance" and then "Start-up". Follow the prompts.
  - Check that the maintenance tip is in place.
  - Place the waste line in the proper position.
  - Remove the storage fluid line and insert the foam elution canister.
  - Ensure that the screen reads "WWULTRA".

5m



14 Run the concentration protocol for the filtered sludge sample (ie, filtrate).

10m

14.1 Remove the maintenance tip and place a fresh Ultra CPT into the tip port. Lower the tip into the sample.

1m

#### Note

Ensure that the Tip is as close to the bottom of the sample bottle as possible. If necessary, the bottle can be balanced on its edge while a weighted object holds down the top of the Concentrating pipette. A bottle of PBS can be used as the weighted object.

14.2 Press "Start Run", allow the Concentrating Pipette to aspirate the waste, and wait until it beeps to signal the end of the run.

5m

#### Note

A timer will run on the display during the concentration. The Concentrating Pipette will stop aspirating and begin to beep when the Tip detects air instead of liquid sample. Concentration should take roughly 5 min, but can vary based on the consistency of the sample.

14.3 While holding a 5 mL centrifuge tube under the Tip, press "Elute" and catch the foam that is dispensed.

2m

14.4 After the foam degasses, add  400  $\mu$ L of the Zymo DNA/RNA shield reagent.

2m

#### Expected result

The eluate should be roughly 400  $\mu$ L. The Zymo DNA/RNA shield reagent is added at a 1:1 ratio of sample:reagent.

15 Run the concentration protocol for the negative control. Perform as is done for the sludge sample.

5m

#### Note

Make sure to use a fresh Tip for each sample.





16 Incubate samples with added Zymo DNA/RNA shield reagent at room temperature for

00:30:00 . If samples are sitting for longer then store at 4 °C

30m

17 Perform the "Shut Down" protocol for the InnovaPrep Concentrating Pipette Select.

- Navigate to "Maintenance" and then "Shut Down".
- Place the maintenance tip into the tip port.
- Remove the elution canister.
- Check to ensure that there is adequate storage fluid and insert the storage fluid line.
- Turn off the device and remove the waste line.

5m

### Part 3: Nucleic Acid Extraction - Zymo quick-DNA/RNA Viral Kit

6m

18 Gather the materials and reagents for the Zymo quick-DNA/RNA Viral Kit in the Biosafety Cabinet. Equilibrate samples to room temperature.

5m

#### Note

Refer to the "Guidelines" section for instructions on processing and handling RNA samples.

19 Add 1600 µL of Viral DNA/RNA buffer to the sample (a 2:1 ratio) and vortex briefly to mix.

3m

#### Note

The volume is scaled according to the manufacturers recommendation.

20 Transfer up to 700 µL of lysate into a Zymo-Spin™ IIC-XLR Column in a collection Tube and centrifuge for 12.000 x g, 00:02:00 . Discard the flow-through in the miniprep waste container.








8m

Repeat until full lysate volume is processed.

21 Add 500 µL of Viral Wash Buffer to the column, centrifuge for 12.000 x g, 00:00:30 and discard the flow-through.

30s



- 22 Repeat the previous step. 2m
- 23 Add  500  $\mu\text{L}$  ethanol (95-100%) to the column and centrifuge for  12000 x g, 00:01:00 to ensure complete removal of the wash buffer. 1m
- 24 Transfer the column to a clean collection tube, and centrifuge at  12000 x g, 00:01:00 to remove any remaining ETOH. 1m
- Note**
- This step is not included in the Zymo manual, but reduces the chance of ETOH carryover and subsequent inhibition of downstream enzymatic steps.
- 25 Carefully, transfer the column into a 1.5 mL nuclease-free tube. 1m
- 26 Add  50  $\mu\text{L}$  DNase/RNase-Free Water directly to the column matrix and incubate at RT for  00:01:00 . Centrifuge for  12000 x g, 00:00:30 to collect the eluate. 1m 30s
- 27 Make desired number of aliquots for storage. Place all extracted nucleic acids in a freezer set to  -80 °C 3m

**Note**

Optional: Perform nucleic acid quantification prior to freezing. Perform RNA or DNA quantification using the Qubit HS RNA assay kit or the Qubit 1X dsDNA Assay kit.

## Protocol references

[Innovaprep FluidPrep Concentrating Pipette Select](#)

[Zymo Research Quick-DNA/RNA Viral Kit](#)