NORTHERN ARIZONA UNIVERSITY

Applied Microbiology
&
Biotechnology Laboratory

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Standard Operating Procedure

AMBL-601-C

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Maintenance of Liquid Volume and Hydraulic Retention Time in an Open Channel Laboratory-scale Photobioreactor

METHOD SUMMARY

This procedure describes the maintenance of the operating liquid volume for the open channel photobioreactor used to produce microalgae biomass. Evaporative losses and the operating hydraulic retention time require that the volume of liquid in the reactor is maintained prior to and after any samples are collected for analyses

ENVIRONMENTAL HEALTH AND SAFETY

Hazards Assessment: This method uses a laboratory-scale photobioreactor that is mixed with a magnetically coupled rotor and overhead fluorescence lighting. Due to the proximity of these electrical devices to water, an electrical hazard exists and appropriate caution must be used at all times.

Safety Equipment and Engineering Controls: Knowing the location and being able to use the eye wash and shower station, the fire extinguisher and the first aid kit are required. The following engineering control is also required or recommended.

- The lab bench area surrounding the photobioreactor and its electrical devices must be kept dry at all times. Spills are to be wiped up immediately and when necessary, power to the devices shut off.

Personal Protective Equipment (PPE): When conducting this method, handling water sample from the photobioreactor and make-up water and nutrient-containing waters that may include wastewater is necessary, and thus the following PPE are required.

- Lab coat, eye protection, and gloves (Nitrile or latex).

Review and follow the additional procedures regarding PPE in NAU's Environmental Health and Safety's Chemical Safety Standard Operating Procedure, P16-Personal Protective Equipment (2008) and P25-Safety Glasses (2012).

Analysis-derived Wastes and Disposal: Wastes that are generated by this procedure and the appropriate method to be used for their disposal are summarized in the following table.

Waste Generated	Hazardous (Y / N)	Disposal
Waste volume of liquid sample removed from the reactor for analysis and maintaining hydraulic retention time.	N	Unused liquid volume may be rinsed down sink.

METHOD DESCRIPTION

1.0 Application

Maintaining a consistent liquid volume in a reactor is critical when collecting samples to evaluate concentration-based analytes, and for operating the reactor at a specified hydraulic retention time. A routine procedure for ensuring that this liquid volume is consistent and maintained prior to and after collecting samples for analysis avoids biasing the results of these analyses. Using a routine procedure also avoids operating at erratic or unwanted hydraulic retention times.

This procedure is intended for use with the open channel photobioreactor used to produce microalgae biomass. This unit has a liquid surface area of 4,030 cm^2, and when the liquid level is operated at 4 cm the total operating volume is 16.12 liters.

2.0 Apparatus

a. Open Channel Photobioreactor (16.12 liter unit with 4030 cm^2 of surface area)
b. 1000-mL graduated cylinder
c. 50- or 100-mL graduated cylinder
d. 500-mL beaker
e. Container (optional) for de-chlorinating make-up water when tap water is used.
f. Filtration apparatus with a reservoir and a course (40- to 60-µm) fritted glass or plastic screen filter support.

g. Suction flask with a minimum of 1000 mL capacity.

h. Glass fiber filter disks (particle retention size 1.0- µm to < 2.0- µm) without organic binder.

3.0 Reagents

a. Make-up water. Preferably, use water that has been at least de-ionized, although tap water may be used (see 2.0.e).

b. Stock feed solution.

1. Secondary clarified effluent: Collect secondary effluent from a plant that does not operate a denitrification process. This should be taken from a point that follows the secondary clarifier but at a location prior to chlorination. The collected effluent should be filtered to remove residual suspended solids.

2. Primary clarified effluent: Collect primary effluent at a point immediately following the primary clarifier so that it is representative of the flow leaving the clarifier over the effluent weir. The collected effluent should be filtered to remove residual suspended solids.

3. Anaerobic digester supernatant: Collect anaerobic digester supernatant at a point that minimizes sludge material as much as possible. This liquid should be centrifuged and filtered to remove residual suspended solids.

4. Synthetically prepared solution: A solution that provide adequate nutrients may be prepared from either a large number of algae growth media recipes or from a commercially available plant fertilizer. The solution should be filtered to remove residual suspended materials and insoluble precipitates.

5. Blended solution: A variety of waters may be blended for the purpose of attaining specific test conditions. The blended solution should be evaluated for possible chemical precipitation and filtered to remove residual suspended materials and insoluble precipitates.

4.0 Procedure

a. Turn off the drive motor to the paddle mixer and allow the liquid in the reactor to become quiescent. Allow the biomass to settle enough so that the bottom of the meniscus is visible.

b. Measure the depth of the liquid in the reactor. Record the date, time and liquid depth. Turn the drive motor back on.

c. Calculate the volume of liquid in the reactor (see 5.0.a.). Record this volume.

d. Calculate the volume of make-up water required to bring the liquid depth up to the desired operating depth (see 5.0.b.). Record this volume.

e. Measure and add the required volume of make-up water to the reactor. This should increase the liquid depth to 4 centimeters. Either dechlorinated tap water or deionized water may be used as the make-up water.

f. Carefully stir or agitate any solids that may have settled within the reactor's channel. As many of the solids as possible should be in suspension.

g. Once the solids are suspended and well distributed, the waste liquid volume may be removed from the reactor.

   1. The waste liquid volume to be removed from the reactor is based on the intended hydraulic retention time or HRT (see 5.0.c.).

   2. Remove a volume of liquid necessary to maintain the intended HRT. If wasting is done daily, an equal volume will be removed each day. If wasting is not done on a daily basis, the amount of waste volume that must be removed should reflect the accumulative volume for as many days that have passed since the last wasting (see 5.0.c.).

h. Use the waste liquid volume as the source for collecting samples used in analyses that consume, destroy, or alter the sample.

   1. Samples used for pH, alkalinity, solids, or chlorophyll will consume or alter the sample. Do not return residual sample volumes derived from these tests to the reactor.

   2. Samples used for determining optical density are not altered but when taken from the waste volume and used for this determination, should also not be returned to the reactor.

i. Add a volume of feed solution to the reactor that is equal in volume to the liquid wasted.

5.0 Calculations

a. Calculation of liquid volume from depth measurement.

   Volume in reactor (Liters) = $\frac{(4030 \times h)}{1000}$

   where, h = liquid depth, cm

b. Calculation of required make-up water volume.

   Volume of make-up water (Liters) = $16.12 - \frac{(4030 \times h)}{1000}$

c. Calculation of waste volume.

Daily volume of liquid wasted (milliliters) = $\frac{16.12 \times 1000}{HRT}$

where, *HRT* = hydraulic retention time, days

d. Calculation of feed solution volume.

The daily volume of liquid wasted = liquid volume of feed solution

6.0 Quality Control

There is no recommended quality control for this procedure.

7.0 Bibliography

None.