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| IDENTIFIERS | Oxygen Uptake Test |

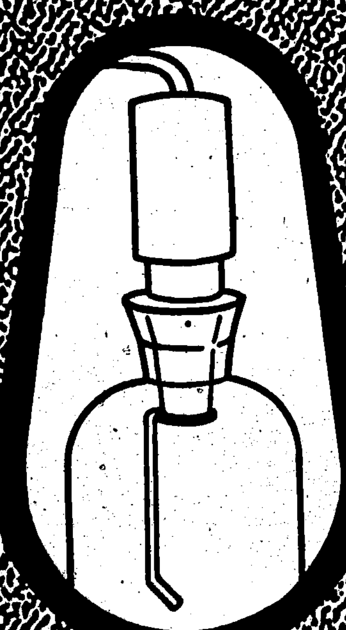
ABSTRACT

Biological waste treatment in the activated sludge process is based on the ability of microorganisms to use dissolved oxygen in breaking down soluble organic substances. The oxygen uptake test is a means of measuring the respiration rate of microorganisms in this process. Designed for individuals who have completed National Pollutant Discharge Elimination System (NPDES) level 1 laboratory training skills, this module provides waste water treatment plant operators with the basic skills and information needed to: (1) successfully run the oxygen uptake test; (2) graph its results; (3) properly perform calculations for slope, oxygen uptake rates, and specific uptake rates; and (4) obtain reliable data from the test procedure. The instructor's manual contains a statement of instructional goals, lists of instructor/student activities and instructional materials, narrative of the slide/tape program used with the module, overhead transparency masters, and student worksheet (with answers). The student workbook contains objectives, prerequisite skills needed before the module is started, sources of dissolved oxygen meters, laboratory procedures (oxygen uptake test, stabilization test, suspended solids, and volatile suspended solids), and worksheet. (Author/JN)

# Operational Control Tests
## for Wastewater Treatment Facilities



# Oxygen Uptake



## Instructor's Manual





Linn-Benton Community College
Albany, Oregon

# OXYGEN UPTAKE

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August, 1980

OXYGEN UPTAKE TEST

## INSTRUCTIONAL GOALS

Upon completion of this module the student should be able to successfully run the oxygen uptake test, graph its results, and properly perform calculations for slope, oxygen uptake rates and specific uptake rates.

## INSTRUCTOR'S ACTIVITIES

The following sequence is recommended for best use of this material:

| | Activity | Time |
|---|---|---|
| 1. | Review objectives with students. | 5 minutes |
| 2. | Have students read through the procedure. | 10 minutes |
| 3. | View and listen to the slide/tape program. | 18 minutes |
| 4. | Discuss concept of slope, slope calculations, relationship of slope to oxygen uptake, and specific uptake. | 20 minutes |
| 5. | Demonstrate the procedure. | 15 minutes |
| 6. | Assign the worksheet. | 15 minutes |
| 7. | Correct the worksheet. | 5 minutes |
| 8. | Have students perform the test. | 35 minutes |

### OTHER ACTIVITIES

The above sequence should be followed if there is ample time. If time is short and if the students have already developed and displayed good laboratory proficiencies the demonstration may be omitted. Items to emphasize during the demonstration should include:

1. Calibration of DO meters, including check of membrane.
2. Mixing of sample.
3. Check for adequate seal between stopper and flask.
4. Plotting of DO depletions against time.
5. Allowing sufficient time in the test to allow at least 1 mg/l DO depletion from beginning to end of the test.

Calculations can be discussed using the overhead in Appendix A to show different oxygen concentrations in a plot of depletions vs time. Two points in time are selected through which the plotted line passes. By subtracting the lower DO value from the high DO value and dividing that answer by the

the lower DO value from the higher DO value and dividing that answer by the time intervals between the selected points, the slope is obtained.

The overheads in Appendix B can be used to describe the calculation of uptake rate. The uptake rate is expressed normally in mg $O_2$/l/hr. Since slope is expressed as mg $O_2$/l/min., we must convert oxygen values per minute to oxygen values per hour.

Appendix C contains overheads that describe the calculation of specific uptake rates. The SUR is the uptake rate in mg $O_2$/l/hr multiplied by a factor to convert mg/l MLVSS to g/l MLVSS. This is necessary as units on the SUR value are expressed as mg/l $O_2$/l/hr/g MLVSS.

$$\text{S.U.R.} = \frac{\text{U.R. X 1000}}{\text{mg/l MLVSS}}.$$

Using different values for U.R. and MLVSS, have the students calculate the SUR. For more information on oxygen uptake see:

1. Activated Sludge Operational Control, by Environmental Technology Department, Linn-Benton Community College, Albany, Oregon 97321.

## STUDENT ACTIVITIES

1. Read objectives.
2. Read procedures.
3. View slide program.
4. Complete worksheet.
5. Perform test.
6. Record data.
7. Perform calculations.

## INSTRUCTIONAL MATERIALS LIST

1. Instructors Guide for Oxygen Uptake
2. Students Workbook for Oxygen Uptake
3. 35mm projector
4. Cassette tape player with automatic synchronization
5. Projector screen
6. Overhead screen
7. Equipment needed for Oxygen Uptake Test

## OXYGEN UPTAKE TEST

### NARRATIVE

Slide #

1. This lesson describes the Oxygen Uptake Analysis and its use in measuring the metabolic activity of organisms in aquatic systems. Theory, procedure and application are also covered.

2. The lesson was written by John F. Wooley and Dr. John W. Carnegie. Dr. Carnegie was also the project manager. Priscilla Hardin provided instructional design and art work.

3. Microorganisms use oxygen as they consume food in an aerobic aquatic system. The rate at which they use oxygen is an indicator of the biological activity of the system and is called the Oxygen Uptake Rate.

4. High oxygen uptake rates indicate high biological activity; low oxygen uptake rates indicate low biological activity.

5. In biological waste treatment facilities oxygen uptake rates are used to monitor performance of process units.

6. The oxygen uptake rate is based on a series of dissolved oxygen measurements taken on a sample over a period of time.

7. The oxygen uptake test is most valuable for plant operations when combined with volatile suspended solids data.

8. Combining oxygen uptake and volatile suspended solids data yields a value called Specific Uptake Rate.

9. Specific uptake rates describe the amount of oxygen used by the microorganisms to consume one gram of food. The specific uptake rate is reported as mg/l of oxygen used per gram of organic material per hour.

10. The specific uptake rate is valuable when comparing one aquatic system with another. The performance of one aeration basin can be compared with another or the biological activity in a stream can be studied and compared both above and below a waste outfall.

11. Equipment needed for the oxygen uptake test includes: a timer, a DO meter with submersible stirrer and temperature probe, a 300 ml BOD bottle, a magnetic stirrer with stirring bar, and a sample container. You will also need to assemble the equipment to run a volatile suspended solids test.

12. The basic oxygen uptake procedure includes 5 basic components: the collection and preparation of sample, the procedure of oxygen uptake analysis itself, the data recording, cleaning, and calculation of oxygen uptake rate. To calculate the specific uptake rate, combine the oxygen uptake rate with volatile suspended solids data.

13. Let's focus on each of these components. First is the collection and preparation of the sample. Sample collection involves four steps. First, select the sample site. Next, measure the water temperature and the dissolved oxygen concentration. Then collect a sample for analysis in the laboratory.

14. As soon as it arrives in the lab, split the sample. One portion is used in the oxygen uptake test, the other in the volatile suspended solids test. The procedures for running VSS are not covered in these materials. (Refer to the Appendix of the manual for VSS information.)

15. Sample site selection is extremely important. A poorly selected sample site, whether in an aquatic stream survey or in a wastewater treatment plant, will always produce poor data.

16. For activated sludge operations a grab sample on the aeration basin effluent prior to secondary clarification provides useful data. We will use a grab sample to illustrate the oxygen uptake procedure. Then we will look at a couple of useful variations of sample collection and preparation.

17. After the sample site has been determined, DO and temperature measurements are made at that point. These data are recorded for reference later when interpreting the results of the oxygen uptake test.

18. The two liters of sample are collected in a clean sample container. An important point to remember is that air space must be provided in the sample container. DO NOT OVER FILL!

19. This sample should be taken immediately to the lab for analysis. DO NOT STORE.

20. The purpose of immediate analysis of the sample is to prevent changes in its composition. Living organisms will continue their life processes and in doing so will change the make-up of the sample.

21. In the lab, the sample is split. At least one liter is required for the oxygen uptake test, the remainder is available for the volatile suspended solids test.

22. The procedure for Oxygen Uptake Analysis requires four basic stages. First the sample is mixed. Then, it is poured into a 300 ml BOD bottle. Next, the BOD bottle is fitted with a DO probe and placed on a stirrer. In the last stage, the meter and timer are turned on and the DO concentrations are read and recorded at one minute intervals.

23. Stage one requires that the sample be thoroughly mixed.

24. Immediately pour the sample into the 300 ml BOD bottle. Fill the bottle completely.

25. Place a PVC adapter in the BOD bottle and connect a second bottle to the first. Pour back and forth several times to insure complete mixing and aeration.

26. Put the magnetic stirring bar into the bottle and place the DO probe into the bottle's neck. Make sure the probe provides a good seal and that it is immersed in the sample.

27. Place the BOD bottle on the magnetic stirrer and turn it on.

28. Measure and record the DO concentration in the BOD bottle every minute for at least ten minutes.

29. The exact time required depends on the rate at which oxygen is used. Allow sufficient time to get at least one mg/l DO difference between the start and finish of the test.

30. After the measurements have been made and recorded the BOD bottle should be emptied and thoroughly rinsed. Any remaining sample in the sample container can be discarded and the container cleaned for future use.

31. Before proceeding with the calculations on the grab sample let's look at sample preparation for 2 additional applications of the oxygen uptake test which are useful in activated sludge operations. The two applications are called fed and unfed samples.

32. The fed sample is a mixture of primary clarifier effluent and RAS or return activated sludge. Oxygen Uptake Analysis on a fed sample is used to assess biological activity at the start of the aeration process.

33. The unfed sample is a mixture of unchlorinated secondary clarifier effluent and return activated sludge. Oxygen Uptake Analysis of an unfed sample is used to assess biological activity after aeration and settling.

34. So, to run oxygen uptake on these two mixed samples you will need to collect samples of primary effluent, return activated sludge, and unchlorinated secondary effluent.

35. For both the fed and unfed samples the objective is to create a mixed sample where the solids concentration in the mixed sample is the same as the aeration tank solids concentration.

36. The desired concentration is achieved by diluting a calculated volume of RAS with either the primary or secondary effluent.

37. In order to calculate the volume of RAS needed to make the dilution find the ATC or aeration tank concentration and the RSC or return sludge concentration. In both cases, the concentrations are found by the centrifuge test and expressed as percent.

38. Divide the ATC by the RSC and multiply by 300 to find the volume of return activated sludge needed. The 300 is the volume of the BOD bottle.

39. After the volume of RAS has been calculated mix the RAS sample and, using a graduated cylinder, transfer the calculated volume into a BOD bottle.

40. Now, if you are running a fed sample fill the BOD bottle with primary effluent. However, if you're running an unfed sample fill the BOD bottle with unchlorinated secondary effluent.

41. Then mix and aerate by pouring back and forth as before and proceed with the test as with a grab sample.

42. After running the oxygen uptake test on a fed or unfed sample check the concentration of the sample you've prepared in the BOD bottle. Do this by remixing the sample in the BOD bottle, pouring some of it into a centrifuge tube and running the centrifuge test. If the concentration varies more than one or two tenths of a percent from the ATC the oxygen uptake data may not be valid.

43. Now let's return to the data and calculations. Whichever type of sample you have used plot the oxygen values against time for each minute on a piece of graph paper.

44. A straight line is drawn so that it passes through the greatest number of plotted points. The line plotted is the curve of "best fit" in each of these examples. This line may not pass through all of the points on the graph. A lag may be observed at the start. Ignore this section when fitting the straight line.

45. Next the slope of the line must be calculated. First select two points on the plotted line, one near the start and one near the finish. The slope of the line is the change in oxygen divided by the change in time.

46. To do this first determine the change in oxygen concentration. Determine the oxygen concentration at points A and B. Subtract the oxygen concentration read at "B" from the concentration at "A". In other words, take the lower value from the higher one. This value is in milligrams per liter.

47. Next, determine the change in time. From the same two points on the plotted line, read down to find the time for those points. Subtract the time at point "C" from the time at point "D". This time interval is in minutes.

48. The slope of the line is then found by dividing the change in oxygen concentration (A - B) by the change in time (D - C).

49. Since the slope of the line compares oxygen concentration to time in minutes, we must convert time to hours in order to express the ratio as Oxygen Uptake Rate. Oxygen Uptake Rate, usually called OUR, is expressed in mg/l/hr.

50. The specific uptake rate is calculated from the data obtained in the oxygen uptake rate test and from the volatile suspended solids test.

51. Specific uptake rate equals the oxygen uptake rate divided by the mg/l of volatile suspended solids.

52. During this lesson we have described the equipment necessary to perform this test.

53. We have described the basic procedures of sample site selection, measurement of temperature and oxygen concentration at the sample site, and sample collection.

54. The Oxygen Uptake Rate test procedure was described. This procedure includes mixing the sample, transferring to a BOD bottle, and observing DO changes over a period of time.

55. And finally, the test produces two useful operational values: oxygen uptake rate (OUR) and specific uptake rate (SUR).

56. Oxygen uptake rate is used when information is needed to show the rate of biological activity in a system at a given time.

57. Specific uptake rate is used if comparisons of two systems are needed or if a single system is to be charted over a period of time.

58. The specific uptake rate can be very useful in successfully operating an activated sludge system. Let's discuss several of these applications.

59. Stabilization of waste after aeration is determined by running oxygen uptake rate on a grab sample of activated sludge.

60. Toxic or high organic loads can often be detected before severe deterioration of effluent quality occurs. Changes in the specific uptake rate on effluent samples will indicate changes in loading.

61. Feed acceptability can be determined by testing once per day at peak flow. Small plants with no industry may be able to test weekly.

62. The effect of toxic wastes can be determined by running the specific uptake rate. By adding the suspected toxic waste to a fed sample in proportions that might enter the plant, it is possible to predict the impact on the aeration basin.

63. Similarily the impact of non-toxic waste such as meat processors, breweries or canneries, can be assessed.

64. A stabilization test can be used to estimate biological activity in mixed liquor during the aeration cycle. This test is a series of oxygen uptake tests over a period of time. A fed sample is set up and oxygen uptake rates determined every 15 minutes for 2 to 5 hours or until the uptake rate levels off.

65. Minimum stabilization time is estimated using the stabilization test. For example, should one or two aeration basins be used? The procedure for the stabilization time test is included in the supplementary student materials.

66. Specific uptake rates determined on unchlorinated final effluent can be used to estimate final effluent BOD.

67. Specific uptake rates on aerobically digested sludge can be used to measure the stability of sludge prior to land application.

68. The oxygen uptake rate test is a valuable tool in the operation of aerobic systems. By using this test the operator can monitor current status, predict changes, estimate potential impacts, and assess stabilization.

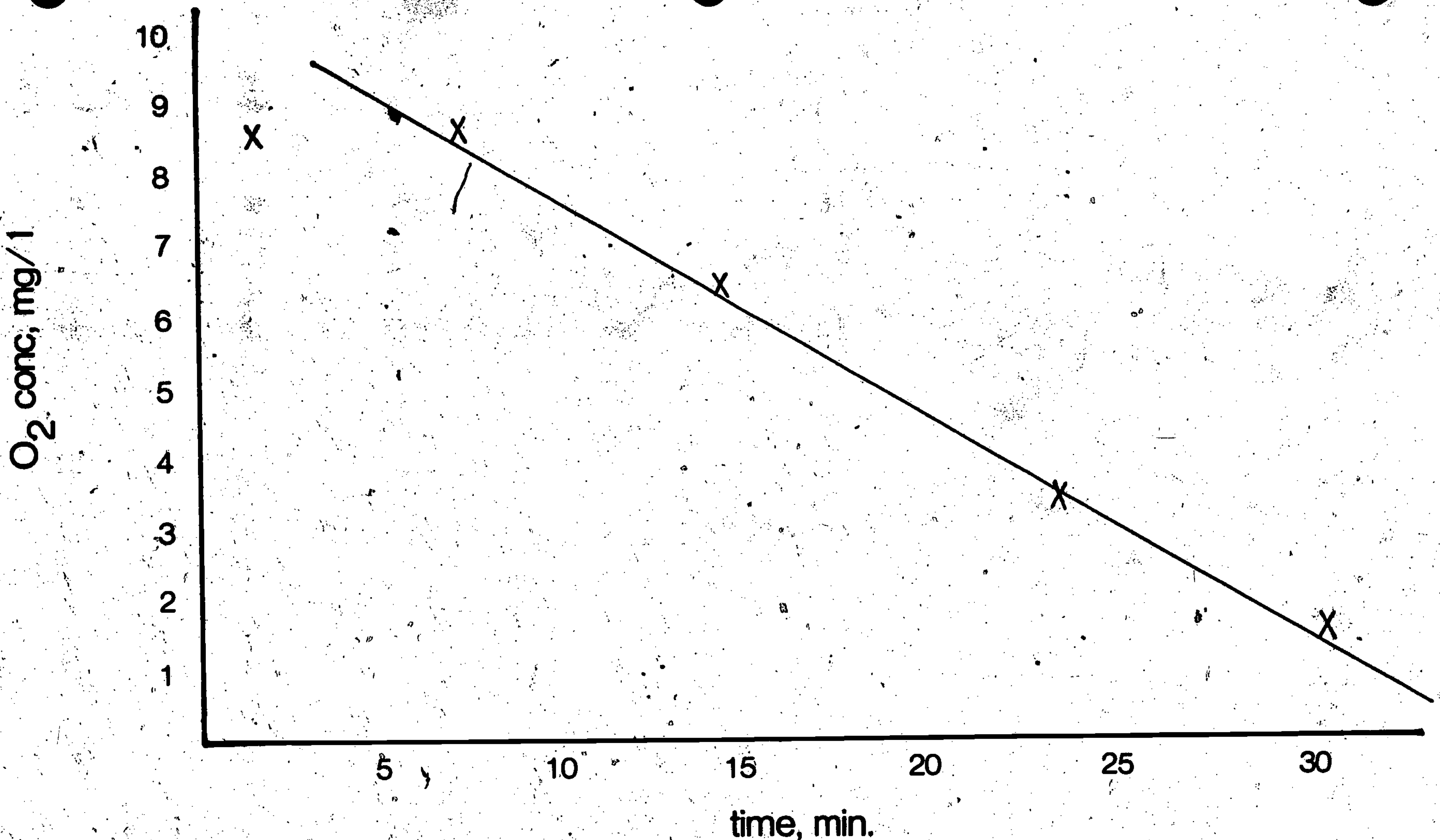
## APPENDIX A

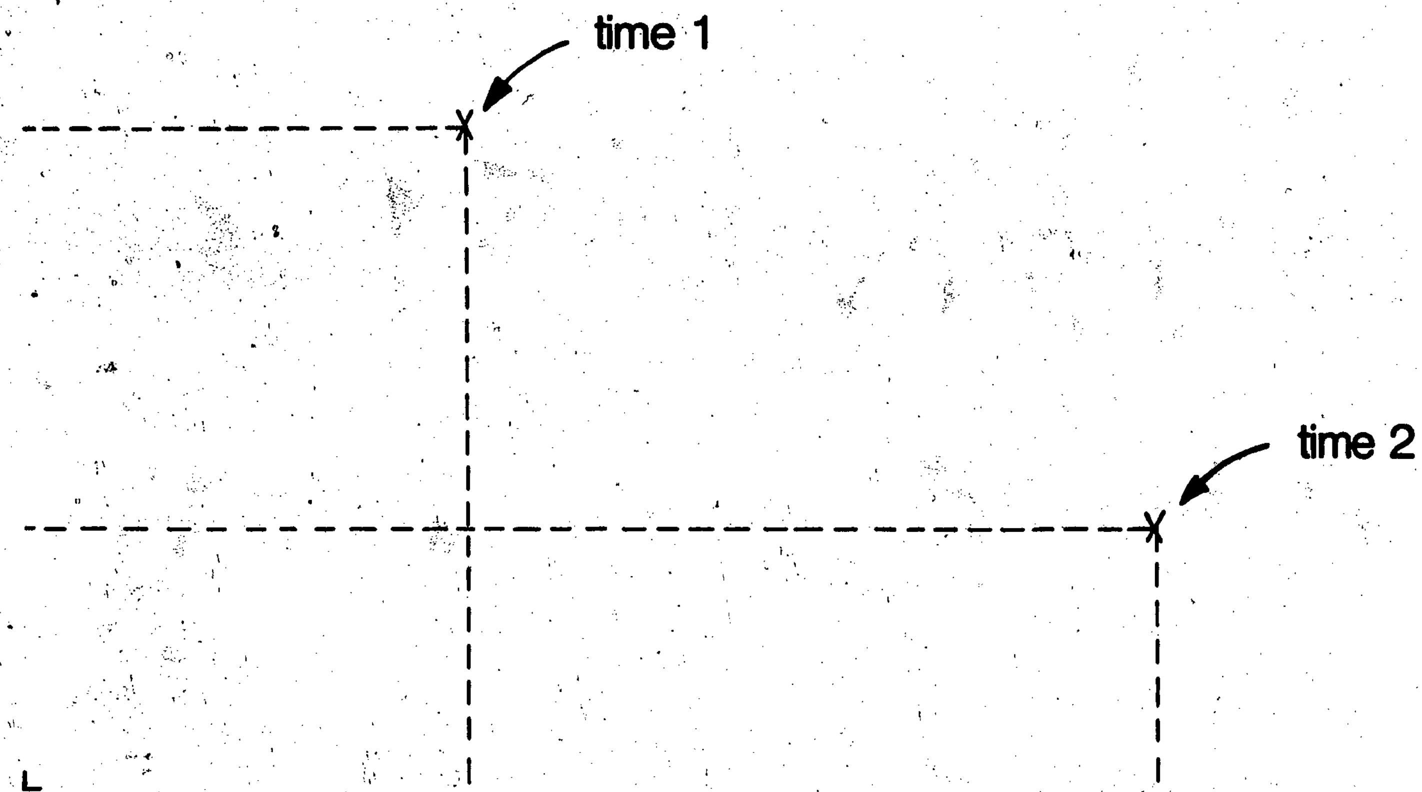
Use overhead #1 to explain the calculation of the slope of the oxygen concentration vs. time curve. Construct overhead #1 as follows:

1. Make transparencies of all figures.
2. Attach the basic concentration vs. time curve (page Ou-10) to the back of an overhead frame.
3. Overlay the transparency page Ou-11 on the first so that the guides fall on the axis and times 1 and 2 are on the straight slope line.
4. Tape the left edge to the overhead frame.
5. Overlay the transparency page Ou-12 on the first two so that the slope calculations are below the plotted data.
6. Tape the right edge to the overhead frame.

First, show the $O_2$ concentration vs. time, min. plotted data and discuss how the line of "best fit" is drawn. Then, flip over the next transparency and show the selection of time 1 and time 2. These data points should be far enough apart to allow a drop of at least 1 mg/l in $O_2$ concentration.

Finally, flip over the last transparency and go through the calculation of slope. Point out that the slope is calculated as mg/l/min.


$O_2$ conc, mg/1
10
9
8
7
6
5
4
3
2
1
5
10
15
20
25
30
time, min.


time 1
time 2

$$\text{Slope} = \frac{O_2\,(\text{time 1}) - O_2\,(\text{time 2})}{\text{time 2} - \text{time 1}} = \frac{7.5 - 3.5}{25 - 10} = \frac{4.0\ \text{mg}/1}{15\ \text{min.}}$$

$$= \frac{0.27\ \text{mg}/1}{\text{min.}}$$

APPENDIX B

For use with overhead #2 on the next page.

Since the slope of the line plotted from the data of oxygen concentration vs. time is expressed as mg/l/min. and uptake rates are expressed in mg/l/hr we must convert minutes to hours. A simple conversion formula is:

O.U.R. = Slope in mg/l/min. X 60 min./hr.

O.U.R. = mg/l/hr

# Oxygen Uptake Rate
# (OUR)

$$\text{OUR} = \frac{\text{mg/l}}{\text{hr.}}$$

$$= \text{slope, } \frac{\text{mg/l}}{\cancel{\text{min.}}} \times \frac{60\ \cancel{\text{min.}}}{\text{hr.}}$$

## APPENDIX C

Use overheads #3 and #4 to discuss specific uptake rate.

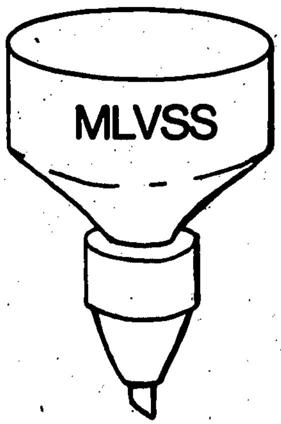
Overhead #3 illustrated the relationship between oxygen uptake rate and volatile suspended solids data. Overhead #3 also shows the formula used to calculate SUR.

Overhead #4 gives a sample SUR problem and the solution.

# SPECIFIC UPTAKE RATE

# (SUR)

$$SUR = \frac{\boxed{\text{Uptake Rate}}}{\text{MLVSS}} = \frac{UR \times 1000}{MLVSS}$$



# SAMPLE PROBLEM:

Find SUR    If: $UR = 24 \text{mg/l/hr}$

$MLVSS = 2400 \text{ mg/l}$

$$SUR = \frac{UR \times 1000}{MLVSS} = \frac{24 \times 1000}{2400}$$

$$= 10 \text{mg } O_2\text{/l/hr/g MLVSS}$$

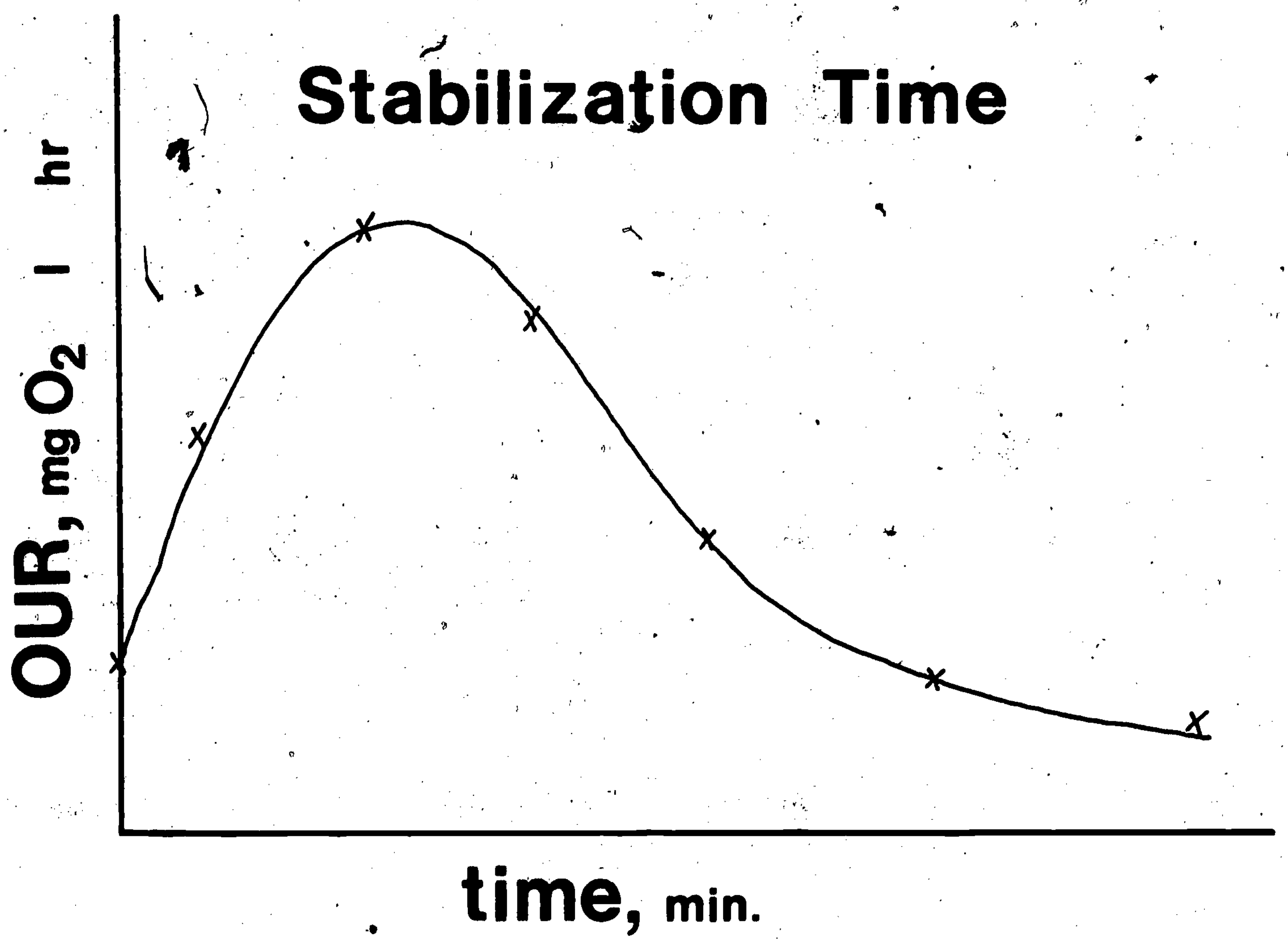
## APPENDIX D

Use overhead #5 to show the formula to calculate ml returned activated sludge (RAS) required to mix a fed or unfed sample. Point out that the aeration tank concentration (ATC) are expressed in percent by centrifuge spin. Bottle volume is 300 ml if a standard BOD bottle is used.

$$\text{Vol. of RAS, ml} = \frac{\text{ATC}}{\text{RSC}} \times \text{Bottle Vol., ml}$$

## APPENDIX E

Use overhead #6 to explain the Stabilization Time test. By plotting OUR data determined on a sample over a period of time, a curve similar to that on this overhead is obtained. As the curve levels out at a low OUR value, the sample is less active biologically and, therefore, more stable. The time required to reach that point can be read directly from the curve.


Stabilization Time
OUR, mg O2 / l hr
time, min.

## OXYGEN UPTAKE TEST

### WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. The rate at which oxygen is used in an aquatic system to break down organics is called ________.

   a)______ metabilism
   b)______ oxygen profile analysis
   c)______ decomposition
   d)__X___ oxygen uptake rate
   e)______ None of the above.

2. The oxygen uptake rate is based upon a series of ________ that are taken over a period of time.

   a)______ pH tests
   b)______ solids tests
   c)__X___ oxygen tests
   d)______ alkalinity
   e)______ temperature readings

3. Calculations combining volatile suspended solids (VSS) data and oxygen uptake rates yield ________.

   a)______ oxygen profiles
   b)______ VSS
   c)______ alkalinity data
   d)______ $CO_2$ data
   e)__X___ specific uptake rates

4. The amount of oxygen used by one gram of organic material in one hour is defined as the ________.

   a)______ pH
   b)______ alkalinity
   c)______ oxygen uptake rate
   d)__X___ specific uptake rate
   e)______ None of the above.

5. Equipment needed for the oxygen uptake test includes ________.

a)______ pH meter, turbidimeter and centrifuge
b)__X__ DO meter with submersible probe
c)______ burette, pipets, thermometer
d)______ thermometer, turbidimeter, pH meter
e)______ None of the above.

6. If S.U.R. are to be obtained, equipment for the ________ test is also necessary.

a)__X__ VSS
b)______ pH measurement
c)______ alkalinity test
d)______ hardness test
e)______ None of the above.

7. Oxygen uptake rates can be used in operational control of activated sludge systems because they show ________.

a)______ pH of the system
b)______ alkalinity of the system
c)______ hardness of the system
d)______ temperature of the system
e)__X__ organism activity

8. A series of oxygen uptake tests run over a period of time to check biological activity in the mixed liquor is often called a ________.

a)______ uptake test
b)______ specific uptake test
c)______ pH test
d)__X__ stabilization test
e)______ solids analysis

9. Information gathered from the stabilization test can be used to estimate _________.

a)__X__ feed rates
b)______ pH of sludge
c)______ alkalinity of sludge
d)______ solids concentration of sludge
e)______ buffering capacity of sludge

10. S.U.R. on aerobically digested sludge can be used to measure _________ prior to land application.

a)__X__ sludge stability
b)______ pH of sludge
c)______ alkalinity of sludge
d)______ solids concentration of sludge
e)______ buffering capacity of sludge

11. By mixing primary clarifier effluent and RAS what type of sample is prepared?

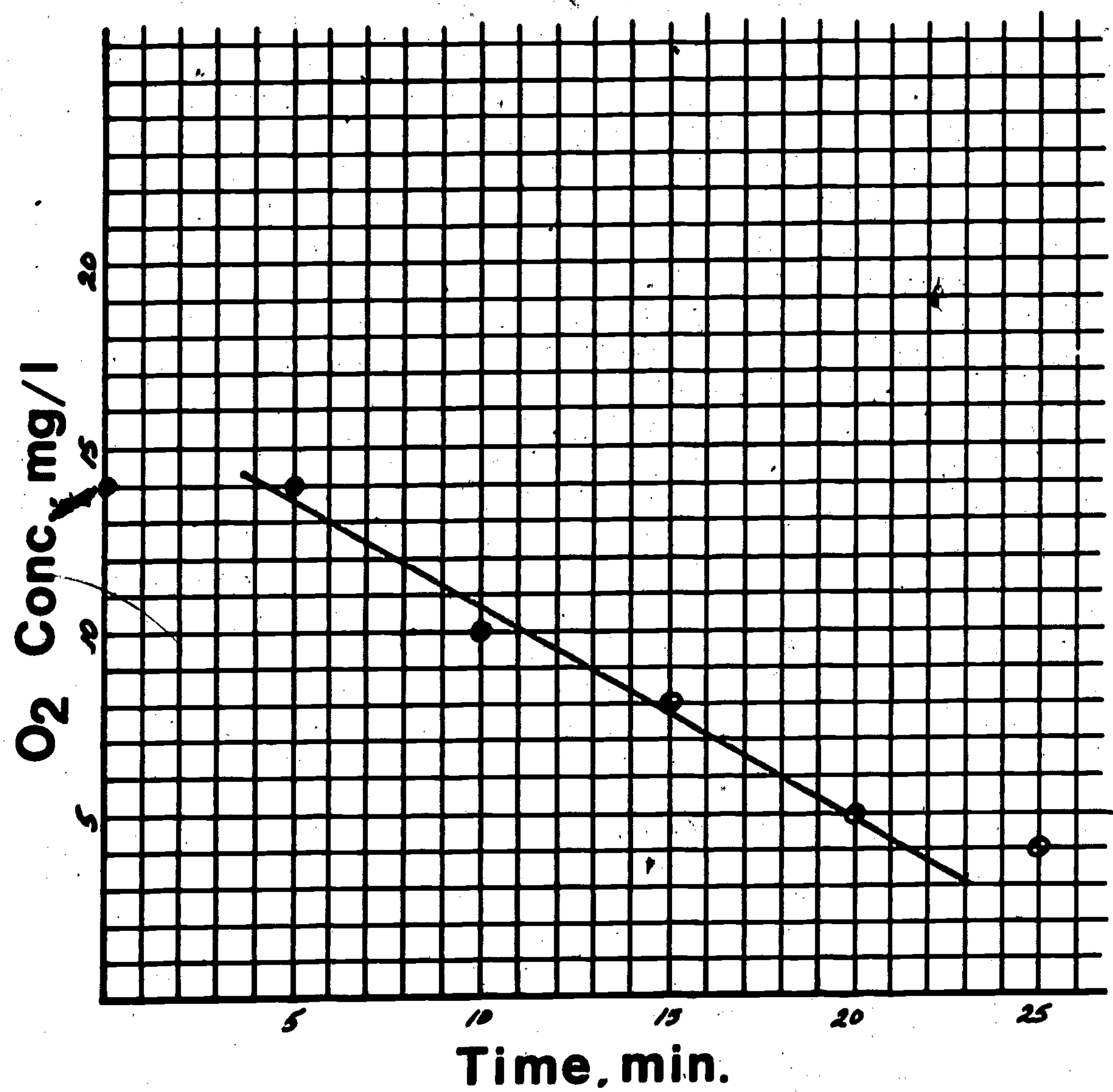
a)______ unfed
b)__X__ fed
c)______ proportional composite
d)______ grab

12. If the ATC was 3% and the RSC was 12% what volume of RAS would be required to make a 300 ml unfed sample?

a)______ 150 ml
b)______ 1200 ml
c)______ 9 ml
d)__X__ 75

13. Given the following data plot oxygen concentration vs. time.

| TIME | OXYGEN CONCENTRATION |
| --- | --- |
| 0 minutes | 14 mg/l |
| 5 minutes | 14 mg/l |
| 10 minutes | 10 mg/l |
| 15 minutes | 8 mg/l |
| 20 minutes | 5 mg/l |
| 25 minutes | 4 mg/l |



14. Using the data on problem 13 calculate the slope of the line.

$$\text{SLOPE} = \frac{\text{(Oxygen conc. at time 1) minus (Oxygen conc. at time 2)}}{\text{(time 2) minus (time 1)}}$$

*Use:*
*time 1 = 6 min*
*time 2 = 18 min*

$$Slope = \frac{13\ mg/l - 6\ mg/l}{18 min - 6 min} = \frac{7 mg/l}{12 min} = 0.58 mg/l/min$$

15. Using the information in problem 14 determine the Oxygen Uptake Rate.

$$OUR = Slope \times 60\ min/hr$$
$$= 0.58\ mg/l/\cancel{min} \times 60\ \cancel{min}/hr$$
$$= 34.8\ mg/l/hr$$

16. The VSS was determined to be 1100 mg/l in the aeration basin from which our sample was taken. Using this information plus what we have determined in problems 14 and 15 calculate the SUR.

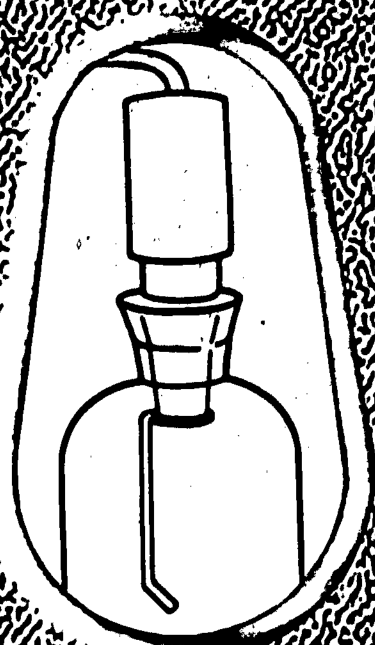
$$\text{SUR} = \frac{\text{U.R.} \times 1000}{\text{VSS}}$$

$$SUR = \frac{34.8\ mg/l/hr \times 1000\ \cancel{mg}/g}{1100\ \cancel{mg}/l}$$

$$= 31.6\ mg\ O_2/l/hr/g\ of\ VSS$$

*This l drops out because you're dealing with a 1 liter theoretical volume; ie, the SUR is the mg/l of oxygen used per hour by 1 gram of Volatile Susp. Solids.*

# Operational Control Tests
## for Wastewater Treatment Facilities



# Oxygen Uptake

## Student Workbook

Linn-Benton Community College
Albany, Oregon

# OXYGEN UPTAKE

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Instructional Design:
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Project Management
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Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under:
EPA Grant #900953010
August, 1980

# OXYGEN UPTAKE TEST

## INTRODUCTION

This module on oxygen uptake is intended to give the operator the basic information necessary to obtain relaible data from the test procedure.

The mention of any brand names should not be taken as an endorsement of that material.

This test procedure is intended to be used by individuals who have completed NPDES level 1 labortory skills training.

## OBJECTIVES

Upon completion of this module you should be able to:

1. Describe the purpose of the oxygen uptake test.
2. Describe the purpose of the Specific Uptake Rate calculation.
3. Describe the oxygen uptake test.
4. Describe what samples are mixed to make a fed and unfed sample.
5. Calculate the volume of RAS needed to make a fed and unfed sample.
6. Plot oxygen concentrations vs. time on graph paper.
7. Calculate slope and uptake rate.
8. Calculate specific uptake rate.
9. Perform the test procedure.

## PREREQUISITE SKILLS

In addition to the skills listed in the introduction, the following skills are needed for this test:

1. Knowledge of maintenance, calibration, and use of DO meter.
2. Ability to use a timer clock.

## RESOURCE LIST

1. Scientific Products
   3660 148th Ave., NE
   Redmond, WA 98052
   (206) 885-4131

   DO meter YSI
   Model 57
   #G 1670-30
   Probe, BOD bottle, YSI
   #G 1671-30
   Timer, Universal
   #C 6522-5-Timer

2. VWR Scientific, Inc.
   P.O. Box 13007, Station K
   Atlanta, GA 30324
   (404) 262-3141

   DO meter YSI
   Model 57
   #52456-210
   Probe, Self-stirring, YSI
   #52457-001
   Timer, Universal
   #62317-001

3. Sargent-Welch
   1617 East Ball Road
   Anaheim, CA 92803
   (213) 860-8584

   DO meter, YSI
   Model 57
   #S-38633-20
   Probe-BOD, Stirring
   #S-38632-42
   Clock
   #S-19760

Further information on the performance of this test may be found by obtaining the following written material:

1. Activated Sludge Operational Control, by Environmental Technology Department, Linn-Benton Community College, Albany, Oregon 97321.

# OXYGEN UPTAKE TEST

## INTRODUCTION

Biological waste treatment in the activated sludge process is based on the ability of micro-organisms to utilize dissolved oxygen in breaking down soluble organic substances.

The oxygen uptake test is a means of measuring the respiration rate of the organisms in the activated sludge process. Since it measures the oxygen used in the process, it is a useful tool in the evaluation of process performance, aeration equipment and biodegradability of the waste. So that comparisons can be made between various plants, it is usually expressed as the SUR (specific uptake rate); i.e. the amount of oxygen in mg utilized by one gram of the volatile suspended solids in the activated sludge, in one hour.

## EQUIPMENT

1. Dissolved Oxygen Meter with probe adapted to BOD bottle
2. 300 ml BOD bottle
3. Magnetic stirrer and magnetic stirring bar
4. 5 liter sample bottle
5. Timer

## PROCEDURE

1. <u>MEASURE AND RECORD DO</u>

   Using the dissolved oxygen meter measure and record the DO and temperature at the sample site.

2. <u>COLLECT 5 LITERS OF SAMPLE</u>

3. <u>FILL 300 ml BOD WITH SAMPLE</u>

4. <u>MIX AND AERATE</u>

   Place a PVC adapter in the neck of the BOD bottle and then attach a second BOD bottle upside down on the adapter. Mix by transferring sample from one BOD bottle to the other 15 times.

5. PLACE ON STIRRER WITH MAGNETIC STIR BAR

6. PLACE DO PROBE IN THE BOTTLE

Place the DO probe in the bottle making sure the stopper provides a good seal and switch on the magnetic stirrer.

7. MEASURE DO

After about one to two minutes record the DO concentration in the bottle every minute for approximately 10-20 minutes. The actual time required depends on the rate of oxygen depletion. Allow sufficient time to get at least 1 mg/l DO difference between start and finish of the test.

8. PLOT OXYGEN DEPLETION ON GRAPH PAPER

Plot the oxygen depletion against time on the graph paper and calculate the uptake rate.

CALCULATIONS

1. DO VALUES TO BE PLOTTED ON GRAPH PAPER

The dissolved oxygen values recorded every minute are plotted on the graph paper.

2. DRAW STRAIGHT LINE THROUGH POINTS

A straight line is then drawn so that it passes through the most number of points.

3. CALCULATE SLOPE

The slope can now be calculated: two points in time are selected through which the line passes. By subtracting the lower DO value from the higher and dividing the answer by the time interval selected, the slope is obtained.

## 4. CALCULATE UPTAKE RATE

The uptake rate is expressed normally in the units mg $O_2$/l/hr therefore from the slope:

Uptake Rate = mg $O_2$/l/min X 60 min/hr

## 5. CALCULATE SPECIFIC UPTAKE RATE

The Specific Uptake Rate (SUR) can now be calculated:

$$SUR = \frac{\text{Uptake Rate X 1000}}{\text{VSS (mg/l)}}$$

e.g., say volatile suspended solids = 2400 mg/l and uptake rate = 24mg/l/hr

$$SUR = \frac{24 \text{ X } 1000}{2400} = 10 \text{ mg. } O_2\text{/l/hr/g VSS}$$

VSS is normally obtained from the routine daily solids analysis.

## PREPARING FED AND UNFED SAMPLES

Definitions:

Fed Samples - A mixture of Return Activated Sludge (RAS) and primary clarifier effluent. Use raw influent if plant does not have a primary clarifier.

Unfed Sample - A mixture of Return Activated Sludge (RAS) and secondary clarifier effluent.

The Goal: To dilute RAS with either primary or secondary effluent so as to approximate the aeration tank concentration (ATC).

Procedure:

1. Determine Volume of RAS Needed

$$\text{Vol. RAS, ml} = \frac{\text{ATC}}{\text{RSC}} \times \text{ sample volume needed, ml}$$

Where ATC = aeration tank concentration

RSC = return sludge concentration

Example:

if ATC = 3%

RSC = 15%

volume needed = 300 ml BOD bottle

$$\text{Vol. RAS, ml} = \frac{3}{15} \times 300 = 60 \text{ ml}$$

2. Transfer Calculated RAS Volume to BOD Bottle

3. Fill BOD Bottle With Effluent

   Use primary effluent for fed sample. Use secondary effluent for unfed sample.

4. Run Oxygen Uptake Rate

## INTERPRETATION OF OXYGEN UPTAKE TEST RESULTS

1. UNFED - OUR's follow the load during the day and week. For mixed liquor concentrations of 2500 - 3500 ml/l. UNFED - OUR should be approximately 0.3 - 0.7 mg DO/l/min.

2. To compare OUR's on various sludges, the Specific Oxygen Uptake Rate (SOUR), a concentration independent value in mg $O_2$/hr/gm can be determined.

   A. Calculate OUR in mg $O_2$/l/hr.

   $$OUR = mg/l/min \times 60\ min/hr = mg\ O_2/l/hr.$$

   B. Divide by VSS to obtain SOUR

   $$SOUR = \frac{mg\ O_2/l/hr\ (OUR)}{mg/l\ (VSS)} \times 1000\ \frac{mg}{gm}$$

   C. Example - OUR = 0.7 mg/l/min VSS = 2500 mg/l

   $$SOUR = \frac{0.7 \times 60 \times 1000}{2500} = 16.8\ mg\ O_2/hr/gm$$

   D. Optimum UNFED - OUR is about 12-20 mg $O_2$/hr/gm

3. Low UNFED - OUR (< 0.3 mg DO/l/min; < 5 mg $O_2$/hr/gm)

   A. Indicates starved, over-oxidized sludge (appropriate value for aerobic digester)

   B. Fast settling rates

   C. Pin floc

   D. Common to extended aeration systems - old sludge

   E. Corrective Action - Increase wasting, decrease VSS.

4. High UNFED - OUR (> 0.8 mg DO/l/min; > 20 mg $O_2$/hr/gm)

   A. Indicates bulky, under-oxidized sludge (young)

   B. May go septic in clarifier

   C. Poor settling and compaction

D. Corrective Action - Increase oxidative pressures

I. Contact or step-feed mode change may be called for.
II. Flocculant aid may be necessary to achieve settling and compaction.
III. Monitor DO of return sludge and adjust to allow for maximum settlability without septicity.

5. FED - OUR's follow availability and concentration of the feed. FED samples are more apt to change than UNFED. Measurement can provide time to anticipate likely changes and make corrections. FED - OUR's will likely range from two to five (2 - 5) times the UNFED - OUR (0.6 - 3.5 mg $O_2$/l/min).

A. After feeding, OUR can be expected to increase relative to UNFED.

B. Plant may impose limit on oxygenation capacity. Most systems should be able to handle FED - OUR's of 2.0 - 2.5 mg/l/min.

I. If not, or if FED-OUR higher, all or any below:

a) improved mixing may be necessary
b) step-feeding to distribute load
c) more or modification of aerators

C. Toxic loads will depress FED relative to UNFED

I. treatment will suffer
II. coagulant or powdered activated carbon may help
III. if repeated, identify problem along collection system
IV. if feed is suspect, check by using acceptable feed such as dextrose or sucrose to assess low activity

a) If OUR increases, "bugs" are not assimilating food
b) If OUR does not change, something in waste is toxic to "bugs".

E. A small increase can be due to dilute feed, poor quality feed, sick sludge or unfavorable conditions (e.g. too long clarifier sludge detention time).

6. Load Index (LF - load factor)

A. Ratio of FED - OUR to UNFED - OUR

B. Indicates activity before and after feeding

C. Good sludge and acceptable feed increases LF > 1.0 due to no depression in FED - OUR

I. LF < 1.0 - inhibitory or toxic load

II. LF > 1.0 but < 2.0 - dilute or stabilized load

III. LF > 2.0 but < 5.0 - acceptable loading

IV. LF > 5.0 - possible $O_2$ supply problems

## STABILIZATION TEST

### INTRODUCTION

A stabilization test is a series of oxygen uptake rate tests done over a period of time on an aerated mixture of primary clarifier effluent and return activated sludge. This fed sample reflects the loading on the aeration system and measures sludge activity during the aeration cycle. This test helps the operator determine if adequate aeration time is available, if excessive oxygen demands are being placed on the system and how a new load is affecting the system. A curve illustrating the stabilization process can be drawn.

### EQUIPMENT

2 Timers
Magnetic stirrer and stir bars
300 ml BOD bottle
Dissolved oxygen meter w/ probe to fit BOD bottle
Large sample bottles
1 liter graduated cylinder
Small tank (10 liter minimum)
Aerator device (filtered compressed air)
Siphon tube

### PROCEDURE

1. <u>DETERMINE O.U.R. ON UNFED SAMPLE.</u>

   Run oxygen uptake rate on unfed sample. Mix secondary clarifier effluent and RAS as described in the procedure for preparing fed and unfed samples.

2. <u>DETERMINE VOLUME OF R.A.S. NEEDED.</u>

   Prepare at least 6 liters of fed sample. Determine volume of RAS needed by the following formula.

$$\text{RAS, liters} = \frac{\text{ATC}}{\text{RSC}} \times \text{volume needed, liters}$$

Example: ATC = 3%
RSC = 12%
Volume needed = 6 liters

$$\text{RAS, liters} = \frac{3}{12} \times 6 = 1.5 \text{ liters}$$

3. MIX R.A.S. WITH PRIMARY EFFLUENT.

In a small tank mix calculated volume of RAS with primary effluent to bring the volume up to the total desired.

4. AERATE THE FED SAMPLE.

Provide continuous aeration and mixing to the fed sample in the small tank.

5. START TIMING THE AERATION PERIOD.

6. RUN O.U.R. AT TIME ZERO.

At the start (t = 0) draw off 300 ml into a BOD bottle and run OUR.

7. RETURN SAMPLE TO TANK

after running OUR.

8. RUN O.U.R. EVERY 15 MINUTES

until the OUR approaches the unfed OUR value.

9. PLOT DATA FOR STABILIZATION CURVE.

Plot time on horizontal (x) axis and OUR on vertical (y) axis. Use standard graph paper.

# SUSPENDED SOLIDS

## INTRODUCTION

Suspended solids are those solids which can be trapped on a glass fiber filter. By this definition suspended solids will also include settleable solids. The suspended solids test is one of the primary criteria used to evaluate effluent quality. A well-run trickling filter plant should operate below 30 mg/l of suspended solids in the final effluent and an activated sludge plant below 10 mg/l suspended solids in the final effluent.

## EQUIPMENT

Gooch filtering crucible, 25 ml size
Glass fiber filter - 2.4 cm in diameter
500 ml glass filter flask
Rubber collar and glass stem for vacuum filtering
Rubber vacuum tubing
Vacuum source - either mechanical pump or water faucet aspirator vacuum
Forceps
50 ml and 100 ml graduated cylinders
Crucible tongs
Desiccator
Analytical balance - reading to 0.1 mg (0.0001 g)
Furnace, set at 550 ± 50° C.
Drying oven, set at 103° C.
Asbestos pad
Asbestos gloves
Plastic wash bottle

## PRELIMINARY PROCEDURES

1. CLEAN CRUCIBLE WITH HOT WATER AND DETERGENT.

   Rinse the crucible thoroughly with final rinse of distilled water.

2. PLACE GLASS FIBER FILTER IN CRUCIBLE.

   Make sure the rough side of the filter is up. The smooth side generally has small grid marks visible. Use forceps to handle filter discs.

3. WASH THE FILTER.

Using a plastic wash bottle with distilled water, wet the filter while applying a gentle vacuum. Use three washes of about 20 ml each.

4. DRY CRUCIBLE AND FILTER

for 1 hour at $103^{o}$ C. in dry oven.

5. IGNITE CRUCIBLE AND FILTER IN FURNACE

for 15 minutes at $550 \pm 50^{o}$ C. If volatile suspended solids are not to be run, this step may be skipped.

6. PLACE CRUCIBLE AND FILTER IN DESICCATOR.

After they have been cleaned, washed, ignited, and cool, the crucible along with its filter may be stored in the desiccator until needed.

## TESTING PROCEDURE

1. REMOVE CRUCIBLE FROM DESICCATOR.

Use crucible tongs. Crucible and filter should remain in desiccator at least 30 minutes.

2. WEIGH CRUCIBLE AND FILTER.

Record the weight of the crucible plus the filter to four decimal places as "crucible plus filter weight."

3. PLACE CRUCIBLE PLUS THE FILTER ON A RUBBER COLLAR.

First place a rubber collar and glass stem into a vacuum filtering flask. Use tongs and/or a piece of toweling to seat the crucible into the collar. Don't touch the crucible with your fingers as oil and salt residue may be left on the sides of the crucible and would add some weight that would cause error in the test.

4. SEAT GLASS FILTER WITH VACUUM.

Make sure all of the holes in the Gooch crucible are covered. Wet the filter with distilled water using the plastic wash bottle.

5. WITH VACUUM ON, APPLY SAMPLE TO CRUCIBLE.

See note at the end of this procedure regarding sample volumes.

6. RINSE FILTER.

Use distilled water to wash the solids that are clinging to the sidewall of the crucible down onto the glass fiber filter and to remove any soluble solids trapped in the glass fiber filter.

7. PLACE CRUCIBLE AND FILTER IN DRYING OVEN.

Dry the crucible and its contents for 60 minutes at 103° C. in the drying oven. Use tongs and toweling again.

8. REMOVE CRUCIBLE AND FILTER FROM DRYING OVEN.

Cool the crucible to room temperature on an asbestos pad.

9. WEIGH THE CRUCIBLE AND FILTER.

Weigh the crucible plus its contents to four decimal places and record the weight as "crucible plus filter plus sample."

10. SAVE CRUCIBLE AND FILTER AND SAMPLE

for volatile suspended solids determination. If volatile suspended solids are not to be run, discard the filter and clean the crucible.

## CALCULATIONS

EXAMPLE:

| | |
|---|---|
| Crucible plus filter plus sample | 22.6501 g |
| Crucible plus filter | 22.6245 g |
| Sample | 0.0256 g |

$$\text{Suspended Solids, mg/l} = \frac{\text{sample weight, g} \times 1000}{\text{sample volume, l}}$$

EXAMPLE: for 100 ml sample

$$\text{Suspended Solids, mg/l} = \frac{0.0256 \text{ g} \times 1000}{0.1 \text{ l}}$$

$$= 256 \text{ mg/l}$$

NOTE: Some operators have found it more convenient to use a 600 ml fritted-glass Buchner funnel, Grade C porosity, and a 9 cm glass fiber filter rather than the Gooch crucible. This alteration allows the filtration of a larger sample volume and thus gives better accuracy.

## SUGGESTED SAMPLE SIZE FOR SUSPENDED SOLIDS

| TYPE OF SAMPLE | USING GOOCH CRUCIBLE | USING BUCHNER FUNNEL |
|---|---|---|
| Raw Sewage | 2 to 25 ml | 50 to 200 ml |
| Primary Effluent | 50 ml | 200 ml |
| Final Effluent | 100 ml | 1000 ml |

# VOLATILE SUSPENDED SOLIDS

## INTRODUCTION

That portion of the suspended solids which can be burned off at 550 ± 50° C. is the volatile suspended solids. This value is considered to represent the organic load on the plant and is used more frequently than Volatile Total Solids.

After the final weighing of the crucible for the suspended solids test, the sample can be ignited to burn off the volatile suspended organics.

## EQUIPMENT

Same as for Suspended Solids

## PROCEDURE

1. <u>OBTAIN CRUCIBLE PLUS SAMPLE.</u>

The crucible with filtered sample from the suspended solids is used for this test. Even if you are not interested in the suspended solids, the value must be determined in order to calculate volatile suspended solids.

2. <u>PLACE CRUCIBLE PLUS FILTER PLUS SAMPLE IN MUFFLE FURNACE.</u>

Use the asbestos glove and long tongs. Ash the sample for 60 minutes at 500 ± 50° C. <u>DO NOT</u> exceed 600° C. Sixty minutes will usually be sufficient to reach a constant weight. If a constant weight can be reached in less time, that is also satisfactory.

3. <u>REMOVE CRUCIBLE FROM FURNACE.</u>

Allow the crucible to cool on an asbestos pad for 15 minutes.

4. PLACE CRUCIBLE IN DESICCATOR.

Use the crucible tongs for this procedure. Leave the crucible in the desiccator for 30 minutes.

5. WEIGH CRUCIBLE ON AN ANALYTICAL BALANCE.

Weigh the crucible as quickly as possible to four decimal places. Record the weight as "crucible plus ash weight."

## CALCULATIONS

EXAMPLE: 50 ml sample (0.050 l)

| | |
|---|---|
| Crucible plus filter plus sample | 22.6501 g |
| Crucible plus ash weight | 22.6451 g |
| Weight of volatile suspended solids | 0.0050 g |

NOTE: Sample volume is same as that for the suspended solids test.

VOLATILE SUSPENDED SOLIDS

$$\text{mg/l} = \frac{\text{weight of volatile suspended solids, g} \times 1000}{\text{sample volume, l}}$$

EXAMPLE:

$$\text{VOLATILE SUSPENDED SOLIDS, mg/l} = \frac{0.0050 \text{ g} \times 1000}{0.050 \text{ l}}$$

$$= 100 \text{ mg/l}$$

PERCENT VOLATILE SOLIDS

To calculate the percent volatile suspended solids in the sample, use the following formula:

$$\text{\% VOLATILE SUSPENDED SOLIDS} = \frac{\text{mg/l volatile suspended solids}}{\text{mg/l suspended solids}} \times 100$$

$$= \frac{100 \text{ mg/l}}{256 \text{ mg/l}} \times 100$$

$$= 39\%$$

OXYGEN UPTAKE DATA

DATE________________

Technician________________ Sample No.________________

Sample Point________________ Sample Time________________

Air Temp.________ Water Temp.________ Sample Site D.O.________________

| Time in Min. | Oxygen Conc. in mg/l | Time in Min. | Oxygen Conc. in mg/l | Time in Min. | Oxygen Conc. in mg/l |
|---|---|---|---|---|---|
| 1 | | 21 | | 41 | |
| 2 | | 22 | | 42 | |
| 3 | | 23 | | 43 | |
| 4 | | 24 | | 44 | |
| 5 | | 25 | | 45 | |
| 6 | | 26 | | 46 | |
| 7 | | 27 | | 47 | |
| 8 | | 28 | | 48 | |
| 9 | | 29 | | 49 | |
| 10 | | 30 | | 50 | |
| 11 | | 31 | | 51 | |
| 12 | | 32 | | 52 | |
| 13 | | 33 | | 53 | |
| 14 | | 34 | | 54 | |
| 15 | | 35 | | 55 | |
| 16 | | 36 | | 56 | |
| 17 | | 37 | | 57 | |
| 18 | | 38 | | 58 | |
| 19 | | 39 | | 59 | |
| 20 | | 40 | | 60 | |

Operator: ______________

# OXYGEN UPTAKE RATE WORKSHEET

Date: __________

## Aeration Tank (Unfed)

| Time (min) | DO (mg/l) | ΔDO (mg/l) | Temp °C | |
|---|---|---|---|---|
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 30 | | | | |

Sample Source:

| | |
|---|---|
| Time | |
| Temp | |
| pH | |
| ATC | |
| RSC | |
| MLSS | |
| MLVSS | |
| RSS | |
| RVSS | |
| Influent Flow | |

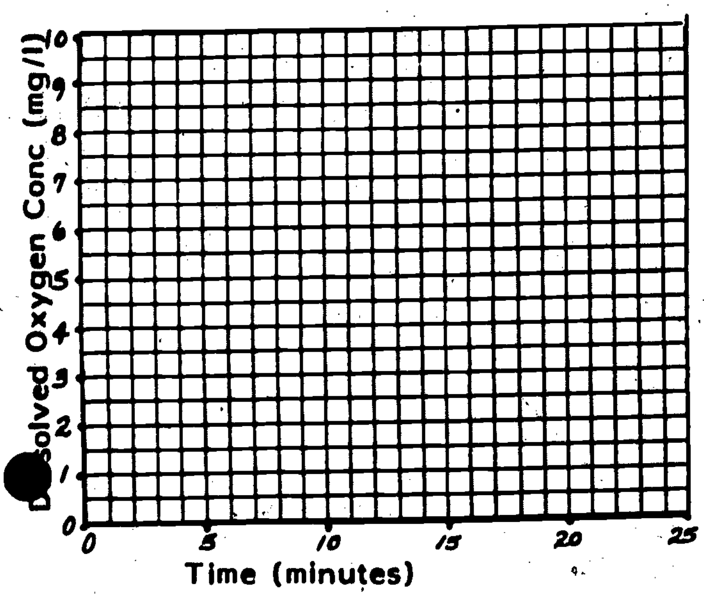
## Return Sludge + Influent (Fed)

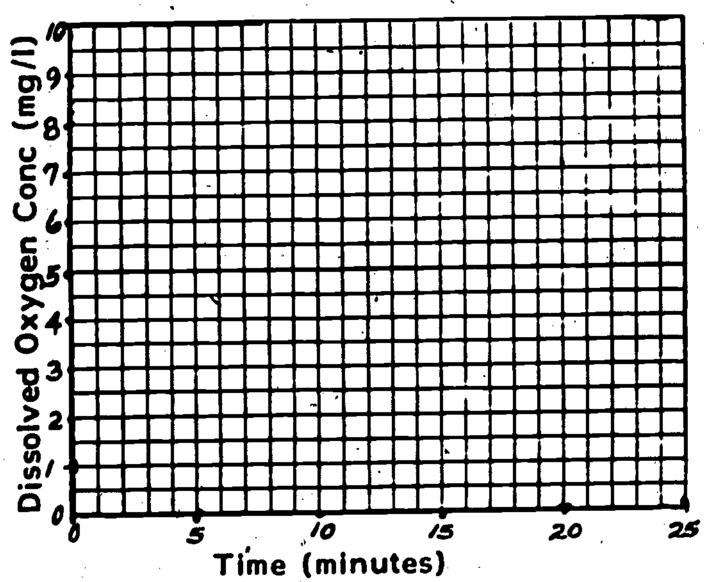
| Time (min) | DO (mg/l) | ΔDO (mg/l) | Temp °C | |
|---|---|---|---|---|
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 30 | | | | |

Sample Source:

| | |
|---|---|
| Time | |
| Temp | |
| RSF | |
| ATC | |
| RSC | |

$\frac{ATC}{RSC} \times 300 =$ Volume of RSC for fed sample



## SAMPLE DATA SHEET

At Sample Point

OXYGEN UPTAKE DATA — DATE 9/20

Technician JC — Sample No. 3

Sample Point Aer. Basin #1 — Sample Time 9:30a

Air Temp. 28°C Water Temp. 10°C — Sample Site D.O. 8.1

| Time in Min. | Oxygen Conc. in mg/l | Time in Min. | Oxygen Conc. in mg/l | Time in Min. | Oxygen Conc. in mg/l |
|---|---|---|---|---|---|
| 1 | 6.7 | 21 | | 41 | |
| 2 | 5.9 | 22 | | 42 | |
| 3 | 5.6 | 23 | | 43 | |
| 4 | 5.2 | 24 | | 44 | |
| 5 | 4.8 | 25 | | 45 | |
| 6 | 4.5 | 26 | | 46 | |
| 7 | 4.2 | 27 | | 47 | |
| 8 | 3.9 | 28 | | 48 | |
| 9 | 3.6 | 29 | | 49 | |
| 10 | 3.3 | 30 | | 50 | |
| 11 | 3.0 | 31 | | 51 | |
| 12 | | 32 | | 52 | |
| 13 | | 33 | | 53 | |
| 14 | | 34 | | 54 | |
| 15 | Unfed Sample | 35 | | 55 | |
| 16 | MLSS = 1500 mg/l | 36 | | 56 | |
| 17 | | 37 | | 57 | |
| 18 | | 38 | | 58 | |
| 19 | | 39 | | 59 | |
| | | 40 | | 60 | |

DO values in BOD bottle

At Least 1 mg/l DO drop

Addition Notes

PROCEDURE SUMMARY

PROCEDURE

1. Measure DO and temperature
2. Collect 5 liters of sample
3. Fill BOD bottle
4. Mix and aerate
5. Attach probe on stirrer
6. Measure DO change
7. Plot DO depletion vs. time

CALCULATIONS

$$\text{Slope} = \frac{\text{change in DO, mg/l}}{\text{change in time, min.}}$$

$$\text{Uptake Rate} = \text{slope, mg/l/min} \times 60 \frac{\text{min}}{\text{hour}}$$

$$\text{SUR} = \frac{\text{Uptake Rate} \times 1000}{\text{VSS, mg/l}} = \text{mg } O_2\text{/l/hr}$$

---

Fed Sample: pri. clar. eff. + RAS

Unfed Sample: sec. clar. eff. + RAS

Vol. RAS needed for 300 ml BOD bottle: $\text{RAS, ml} = \frac{\text{ATC,\%}}{\text{RSC,\%}} \times 300$

**Oxygen Uptake Test**

The above procedure summary is designed as a laboratory aid. It may be cut out and attached to a 5" X 7" index card for convient reference at the laboratory bench. To protect the card you may wish to cover it, front and back, with clear, self-adhesive shelf paper or similar clear material.

# OXYGEN UPTAKE TEST

## WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. The rate at which oxygen is used in an aquatic system to break down organics is called __________.

   a)_______ metabilism

   b)_______ oxygen profile analysis

   c)_______ decomposition

   d)_______ oxygen uptake rate

   e)_______ None of the above.

2. The oxygen uptake rate is based upon a series of __________ that are taken over a period of time.

   a)_______ pH tests

   b)_______ solids tests

   c)_______ oxygen tests

   d)_______ alkalinity

   e)_______ temperature readings

3. Calculations combining volatile suspended solids (VSS) data and oxygen uptake rates yield __________.

   a)_______ oxygen profiles

   b)_______ VSS

   c)_______ alkalinity data

   d)_______ $CO_2$ data

   e)_______ specific uptake rates

4. The amount of oxygen used by one gram of organic material in one hour is defined as the __________.

   a)_______ pH

   b)_______ alkalinity

   c)_______ oxygen uptake rate

   d)_______ specific uptake rate

   e)_______ None of the above.

5. Equipment needed for the oxygen uptake test includes ________.

a)______ pH meter, turbidimeter and centrifuge
b)______ DO meter with submersible probe
c)______ burette, pipets, thermometer
d)______ thermometer, turbidimeter, pH meter
e)______ None of the above.

6. If S.U.R. are to be obtained, equipment for the ________ test is also necessary.

a)______ VSS
b)______ pH measurement
c)______ alkalinity test
d)______ hardness test
e)______ None of the above.

7. Oxygen uptake rates can be used in operational control of activated sludge systems because they show ________.

a)______ pH of the system
b)______ alkalinity of the system
c)______ hardness of the system
d)______ temperature of the system
e)______ organism activity

8. A series of oxygen uptake tests run over a period of time to check biological activity in the mixed liquor is often called a ________.

a)______ uptake test
b)______ specific uptake test
c)______ pH test
d)______ stabilization test
e)______ solids analysis

9. Information gathered from the stabilization test can be used to estimate ________.

a)______ feed rates

b)______ pH of sludge

c)______ alkalinity of sludge

d)______ solids concentration of sludge

e)______ buffering capacity of sludge

10. S.U.R. on aerobically digested sludge can be used to measure ________ prior to land application.

a)______ sludge stability

b)______ pH of sludge

c)______ alkalinity of sludge

d)______ solids concentration of sludge

e)______ buffering capacity of sludge

11. By mixing primary clarifier effluent and RAS what type of sample is prepared?

a)______ unfed

b)______ fed

c)______ proportional composite

d)______ grab

12. If the ATC was 3% and the RSC was 12% what volume of RAS would be required to make a 300 ml unfed sample?

a)______ 150 ml

b)______ 1200 ml

c)______ 9 ml

d)______ 75

14. Using the data on problem 13 calculate the slope of the line.

$$\text{SLOPE} = \frac{\text{(Oxygen conc. at time 1) minus (oxygen conc. at time 2)}}{\text{(time 2) minus (time 1)}}$$

15. Using the information in problem 14 determine the Oxygen Uptake Rate.

16. The VSS was determined to be 1100 mg/l in the aeration basin from which our sample was taken. Using this information plus what we have determined in problems 14 and 15 calculate the SUR.

$$\text{SUR} = \frac{\text{U.R. X 1000}}{\text{VSS}}$$