DOCUMENT RESUME

ED 230 395 SE 041 595

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TITLE Aerobic Digestion. Sludge Treatment and Disposal Course #166. Instructor's Guide [and] Student Workbook.
INSTITUTION Envirotech Operating Services, San Mateo, CA.; Linn-Benton Community Coll., Albany, Oreg.
SPONS AGENCY Office of Water Program Operations (EPA), Cincinnati, Ohio. National Training and Operational Technology Center.
PUB DATE Aug 80
GRANT EPA-900953010
NOTE 37p.
AVAILABLE FROM Linn-Benton Community College, 6500 SW Pacific Blvd., Albany, OR 97321 ($1. student workbook, $2. instructor's guide, cost per entire set of slide-tape, 1 student workbook and 1 instructor's guide is $75. per unit); EPA/Instructional Resources Center, 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212, prices from EPA are available upon request.
PUB TYPE Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Instructional Materials; Postsecondary Education; *Sludge; Teaching Guides; *Training Methods; *Waste Disposal; *Waste Water; *Water Treatment
IDENTIFIERS *Aerobic Digestion

ABSTRACT

This lesson is a basic description of aerobic digestion. Topics presented include a general process overview discussion of a typical digester's components, factors influencing performance, operational controls, and biological considerations for successful operation. The lesson includes an instructor's guide and student workbook. The instructor's guide contains a description of the lesson, estimated presentation time, instructional materials list, suggested sequence of presentation, reading lists, objectives, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains plant flow diagrams, objectives, glossary, discussion of aerobic digestion, references, and worksheet. (JN)

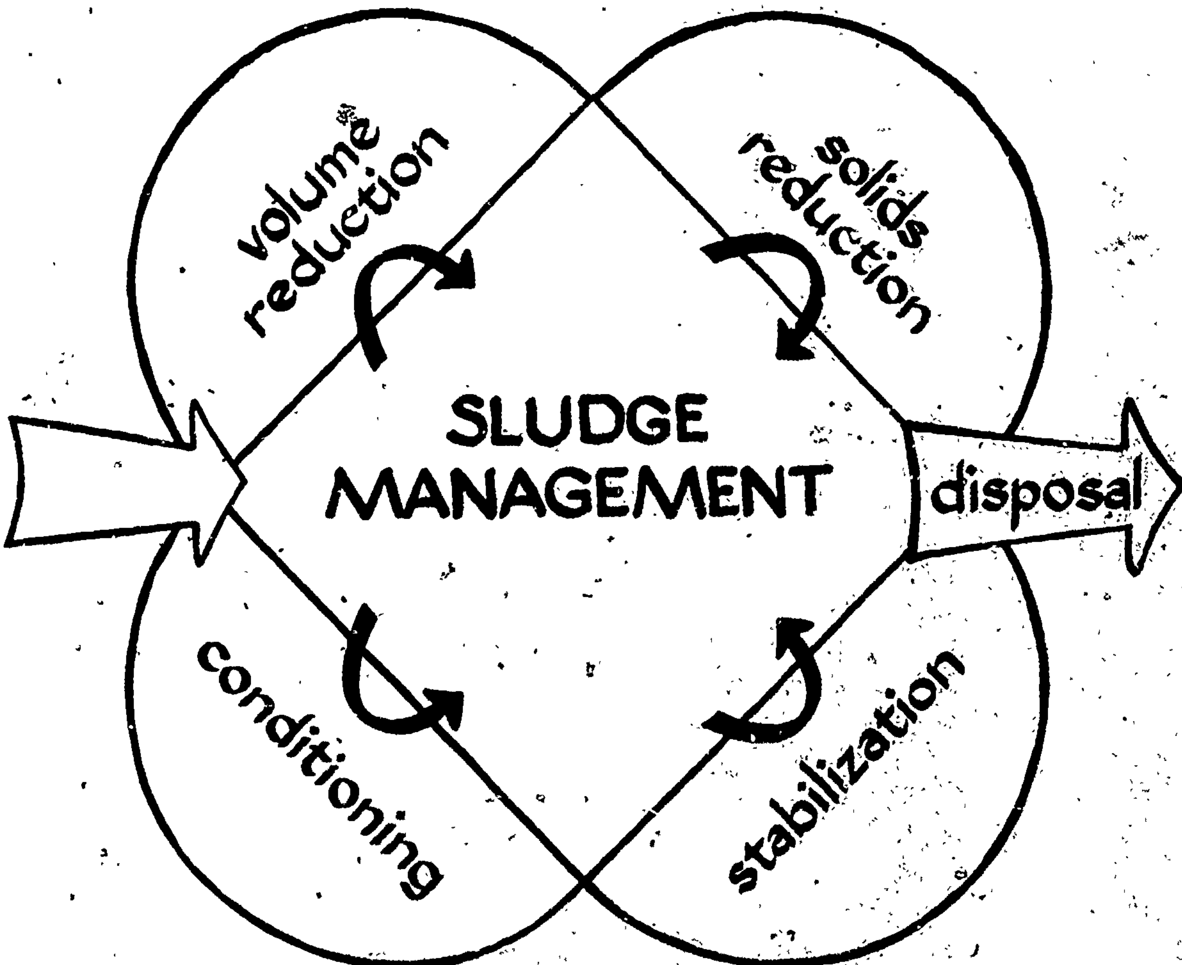
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

AERUBIC DIGESTION



INSTRUCTOR'S GUIDE

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

AEROBIC DIGESTION

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Developed Under:
EPA Grant #900953010
Augst 1980

AEROBIC DIGESTION

CONTENTS

AEROBIC DIGESTION

Lesson Description

This lesson is a basic description of aerobic digestion. It includes a general process overview discussion of a typical digester's components. the factors influencing performance, operational controls and an emphasis on the biological considerations of successful operation. Depending on the background of the student, it may be necessary to preface this module with a short review of the activated sludge process so an understanding exists to tie this type of solids handling with the origin and physiology of aerobic biological sludge. The student should be familiar with the information contained in "Sludge Characteristics" and "Sludge Conditioning" prior to learning this module. The WPCF Basic and Intermediate course may also be used to cope with a student's deficiency in understanding the fundamentals of aerobic biological treatment - a prerequisite for studying "Aerobic Digestion."

Estimated Time

Student Preview	5-10 minutes
Presentation	30-40 minutes
Discussion	5-10 minutes
Worksheet	20-30 minutes

Instructional Materials List

1. Student Text "Aerobic Digestion"
2. Slide Set "Aerobic Digestion"
3. Slide Projector and Screen
4. Chalkboard and chalk or flipchart and marking pens - for informal discussion periods.
5. Examples of lab equipment for process control. Settleometer, timer, centrifuge, D.O. meter and BOD bottle for respiration rate, sample of aerobically digested sludge.

Suggested Sequence of Presentation

1. Assign reading.
2. Lecture and demonstration using slide format and outline. The material may also be presented in a slide/tape mode using a Wollensak cassette projector. The tape has a non-audible cue to automatically advance and synchronize the slides.

3. Demonstrate lab equipment.
4. Open discussion - encourage questions and comments.
5. Assign worksheet.
6. Review worksheet.

Required Reading

EPA Course #166 "Aerobic Digestion"

Reference Reading

EPA Course #166 "Sludge Characteristics," "Sludge Conditioning, " "Lab Procedures."

Process Design Manual for Sludge Treatment and Disposal, U.S.E.P.A., September 1979, EPA 625/1-79-011

AEROBIC DIGESTION

Objectives

Upon completion of this lesson, the student should be able to do the following:

1. Be able to describe, in general terms, the aerobic digestion process.
2. Know that aerobic digestion is an application of the activated sludge process of extended aeration.
3. Know that aerobic digestion is used on primary and secondary sludges, but secondary is more typical.
4. Be able to list 4 of 6 criteria affecting the performance of the digester. Acceptable answers include:

   sludge type
   digestion time
   digestion temperature
   volatile solids loading
   quantity of air supplied
   dissolved oxygen concentrations

5. Know that digestion time is a function of digester capacity (volume) and rate of sludge feed.
6. Know the effect of temperature on digestion is that a two-fold increase in biological activity occurs for every 10°C rise in temperature.
7. Know that aerobic digesters typically operate at ambient temperatures.
8. Know that digestion is faster at warmer temperatures.
9. Be able to state that volatile solids loading is a measure of the quantity of organic matter applied to the digester per cubic foot of digester capacity.
10. Be able to state that the quantity of air required for digestion is used to insure mixing and a DO residual of 1-2 mg/l.
11. Know that there are two types of aeration mechanisms, diffused air and mechanical aerators.
12. Be able to list the three daily lab tests to be performed on the influent and effluent streams to be:

    suspended solids
    volatile suspended solids
    pH

13. Know that DO and temperature should be measured daily.
14. Be able to describe the use of the DO probe for measuring oxygen uptake rates.

15. List 3 of 4 influences which may cause biological upset. The acceptable answers include:

    equipment malfunctions
    changes in influent characteristics
    changes in operating modes.
    changes in temperature

16. Be able to state the effect of excessive sludge flows on digestion time and solids loading.

17. Be able to describe the corrective action that should be taken when excessive oxygen uptake rates are experienced to be a reduction in the volatile solids loading and an increased sludge detention time.

18. Be able to describe typical foam characteristics.

19. Be able to describe the effect of low DO on filamentous organisms in the digester.

20. Be able to describe a solution to foaming when DO control is not effective.

21. Be able to recall that the measure of proper digester function is a decrease in volatile solids content of the sludge.

22. Be able to state that a decrease in volatile solids destruction indicates that either digestion times are too short or volatile solids loadings are too high.

AEROBIC DIGESTION

LECTURE OUTLINE

I. Aerobic Digestion
   A. Sludge Organics $\xrightarrow{O_2}$ Stable End Products.
   B. Mass and Volume Reduced
   C. Application of A/S process - extended aeration
   D. 1^o and 2^o sludge - aerobically digested

II. Factors Affecting Operation
   A. Sludge Type - Influent characterisitics (little control
   B. Digestion Time - Rate of low governs
      - Degree of thickening
      - $\frac{\text{Vol. of Dig.}}{\text{Sludge flow/day}}$
   C. Digestion temperature - best at 18^oC Change of 10^oC = two fold effect
      - ambient operation
   D. Volatile Solids Loading - .07 lb - 0.20 lb vss/day/ft^3
   E. Quantity of air supplied - mixing, 1-2 mg/l D.O.
   F. D.O. Conc. - Measure w/D.O. probe
      - Respiration rate 1-2 mg/l

III. Observations
   A. No obnoxious odors - decanting may cause odors
   B. foam - dary, greasy tan

IV. Aeration Mechanisms
   A. Difussed air
   B. Mechanical

V. Daily lab tests
   A. pH - nitrification pH down - gradual over 1 week
      - keep pH at 6.0
   B. Suspended solids
   C. Volumetric suspended solids

VI. Interpretation of Respiration Rate
   A. If D.O. residual goes up and respiration rate goes down, this indicates inhibition of biomass.

VII. Biological upset causes

A. pH

B. overloading volatile solids

C. overloading hydraulic

D. Change in influent characterisitcs

E. Equipment malfunctions

F. Change operating modes

Narrative

Slide #

1. This module covers aerobic digestion. The module covers the equipment and theory of the process and reviews the factors affecting process operation.

2. The module was written by Mr. Paul H. Klopping. The instructional development was done by Priscilla Hardin. Mr. Klopping was also the Project Director.

3. The main purpose of aerobic digestion is the stabilization of sludge organics.

4. At the same time, the mass and volume of sludge is reduced and the sludge is conditioned for further solids handling.

5. Aerobic digestion is an application of the activated sludge process in which the digester is operated with an extended aeration time.

6. Primary sludge, secondary sludge and mixtures of the two can be aerobically digested. Most commonly, however, aerobic digesters are used to stabilize secondary sludge.

7. An aerobic digester is simply a tank equipped with an air supply much like an aeration basin. Air is typically introduced by mechanical means such as a floating surface aerator

8. or compressed air is introduced through a diffuser mechanism.

9. This module will feature a mechanical aerator; operational principles are the same, regardless of the type of aeration system.

10. Important components of the aerobic digester include piping for sludge feed, for supernatnat draw-off, for sludge withdrawal, and for tank drain.

11. Supernatant draw-off is called decanting. The supernatant that is decanted from the digesting sludge is returned to the headworks of the plant.

12. The digester supernatant is a sidestream containing BOD and suspended solids which influences operation of the entire treatment plant when it is returned to the headworks.

13. Most digesters operate on a continuous cycle. The digester may receive sludge continuously or for a portion of the day. When the digester is full, the air supply is shut off for several hours, during which time sludge settles leaving a clear supernatant. This is then decanted back to the headworks, making room in the digester for more sludge.

14. Aerobic Digestion is influenced by a number of performance factors. These include:- sludge type, digestion time, digestion temperature, volatile solids loading, quantity of air supplied, and dissolved oxygen concentrations in the digester.

15. "Sludge type" refers to the influent characteristics of the solids sent to the digester for stabilization. Very little control can be exerted over the chemical and biological composition of this sludge.

16. Digesters typically handle secondary sludges which are composed primarily of biological cells produced in the activated sludge or trickling filter processes. This biological sludge is aerated; in the absence of a food supply, in the digester. The biological matter partially breaks down to carbon dioxide and water, with a net decrease in sludge mass.

17. Digestion time is determined by the rate of sludge flow into the digester, which has a known volume.

18. As the flow to the digester increases.

19. Digestion time is calculated according to the following formula:

$$\text{Digestion time, days} = \frac{\text{Digester volume, gal}}{\text{Sludge Flow, gal/day}}$$

20. The degree to which sludge is thickened prior to being fed into the digester has an effect on the digestion time.

21. Temperature also has a significant effect on sludge digestion. As a general rule, biological activity increases two-fold for every 10^{0} Celcius rise in temperature. Aerobic digesters work best at temperatures above 18^{0} Celcius.

22. Most digesters are unheated. Detention time must be increased during cold weather. As weather warms up; stabilization occurs more rapidly and less digestion time is required.

23. Volatile solids loading is a measure of the quantity of organic material applied to the digester.

24. Volitile Sludge Solids or VSS loadings typically range from 0.07 lb to 0.02 lb/day/cu ft.

25. Volatile sludge solids loading is influenced by the concentration and volume of sludge placed in the digester.

26. Loadings are unique for each facility, and are influenced by the type of sludge and digestion temperature.

27. The quantity of air required for digestion is expressed as cfm of air/1000 cu ft of digester volume, or as horsepower per 1,000 cu ft when mechanical aerators are used.

28. The air requirements are governed by the need to keep the contents of the tank completely mixed and maintain a dissolved oxygen concentration of 1-2 mg/l in all parts of the tank.

29. Air requirements vary from time to time, depending on the sludge type, temperature, concentration and activity of the digesting sludge.

30. Dissolved oxygen is best measured with a portable DO probe. Measurements should be made at several locations within the tank to insure that at least 1 mg/l of free oxygen is present in all locations.

31. DO measurements are also useful in determining the activity of the microorganisms within the digester. In this case, oxygen uptake measurements are made.

32. The oxygen uptake determination requires the use of a sealed container into which a DO probe and a mixer are inserted. Typically, a BOD bottle, magnetic stirrer and DO probe are used.

33. The oxygen uptake rate decreases as the sludge becomes more stabilized.

34. Like any well-operating aerobic biological system, the digester should be relatively free of obnoxious odors. Some foul odors may be present immediately after aeration is resumed following the time when aerators were off for decanting supernatant.

35. The surface typically accumulates a small amount of foam. This foam is usually several inches thick, and has a dark tan greasy appearance.

36. Standard operation includes feeding sludge to the digester on as continuous a basis as possible and monitoring the process. The test results are the basis for good process control.

37. Regular laboratory analysis on the influent and effluent streams should include: suspended solids, volatile suspended solids, and pH. Dissolved oxygen concentrations and temperature if the digesting sludge should be monitered daily.

38. On an intermittent basis, the influent and effluent streams should be sampled for alkalinity, total and soluble COD, ammonia-nitrogen, nitrite and nitrate nitrogen.

39. Typical performance is summarized in the next three slides. Both primary and secondary sludges can be aerobically digested. Primary sludge requires a longer digestion time than secondary sludge because the organic solids found in primary sludge are more difficult to break down under aerobic conditions.

40. Loading is based on the pounds of volatile solids being sent to the digester and the size of digester in cubic feet. Loading rate is similar for primary and secondary sludges.

41. Volatile solids destruction is slightly greater for primary sludge.

42. When an aerobic digester reaches steady state, the oxygen uptake rate and the residual DO should be relatively constant from day to day.

43. However, aerobic digesters are subject to the same upsets which affect all biological systems. These may be caused by equipment malfunctions, changes in influent characteristics, changes in operating modes and changes in temperature. Good indicators, especially in times of upset, are the dissolved oxygen measurements and the oxygen uptake determinations.

44. If the residual DO increases significantly, this may suggest that the air rate is excessive or the oxygen uptake rate has decreased indicating the microorganisms are less active.

45. If the uptake rate is in the normal range, then the microorganisms are working properly and the increase in DO is most likely due to high air rates to the digester.

46. Air discharge rates should be adjusted to maintain a DO of 1-2 mg/l.

47. If the oxygen uptake rate is significantly lower than normal, something may be inhibiting the microorganisms. Temperature and pH should be checked. Significant decreases in temperature and pH are inhibitory.

48. If temperature is normal and the pH drops, the cause may be nitrification or changes in the influent sludge characteristics.

49. When caused by nitrification, the decrease in pH will be gradual over about a week's time, pH should not be allowed to drop much below 6.0.

50. If the DO residual drops significantly, air discharge rate should be adjusted to increase the residual DO to 1-2 mg/l.

51. If higher than normal oxygen uptake rates are also noted, volatile sludge solids loading rate to the digester may be higher than normal.

52. As long as sufficient air capacity exists to meet air requirements at higher loading rates, the system can still operate, but critical operating parameters should be closely tracked. These include: temperature, pH and digestion time. If low DO exists and the aeration system is operating at full capacity, flow and loading to the digester should be decreased.

53. Excessive sludge flows reduce the time of digestion and may increase the volatile sludge loading to the point where the digester is operating out of the recommended range of operation.

54. Adjustments should be made to the flows and volatile sludge solids loading to bring the operation back within normal ranges.

55. Aerobic digesters are often plagued with foaming problems. If excessive foam develops, air discharge rate and residual DO should be checked.

56. If they are high, the problem may be related to excessive turbulence. The air discharge rate should be reduced to the lowest rate which maintains adequate DO and mixing.

57. Low DO is conducive to filamentous bacterial growth in the digester. This may aggrevate foam problems and reduce the settleability of the sludge, making it difficult to decant supernatant.

58. Foaming problems may also be realted to influent characteristics and defoaming agents may be needed to suppress the foam. In summary, foaming in biological systems can be caused by a variety of conditions and generally constitutes a complex problem.

59. Both the digestion time and volitile sludge solids loading should be maintained within ranges found to be suitable for each particular facility. A review of daily influent and effluent amounts of volatile sludge solids indicates whether or not the digester is efficiently converting organic matter to stabilized end products.

60. Aerobic digesters are a common means of handling excess secondary sludges prior to ultimate disposal. They provide moderate stabilization of biological solids providing that climatic conditions are favorable.

AEROBIC DIGESTION
WORKSHEET

1. Which treatment process does aerobic digestion most closely resemble?

   ______ a. Trickling Filtration
   __X__ b. Activated Sludge
   ______ c. Sedimentation
   ______ d. Anaerobic Digestion
   ______ e. Disinfection

2. Aerobic digestion is:

   __X__ a. used on primary and secondary sludges.
   ______ b. most commonly used on primary sludges.
   __X__ c. most commonly used on secondary sludges.
   ______ d. is not commonly used on any sludge.

3. Choose four factors which affect the operation of an aerobic digester.

   ______ a. Clarifier overflow rate
   __X__ b. Temperature
   __X__ c. Volatile solids loading
   __X__ d. D.O. concentration
   __X__ e. Detention time
   ______ f. Weir overflow rate

4. What governs the digestion time of an aerobic digester?

   __X__ a. Digester volume
   __X__ b. Rate of sludge feed
   __X__ c. Rate of sludge withdrawal
   __X__ d. Rate of supernatant withdrawal
   ______ e. None of the above

5. When the temperature of a digester increases 10°C, biological activity:

   ______ a. decreases by a factor of 10.
   ______ b. increases by a factor of 10.
   ______ c. decreases by a factor of 2.
   __X__ d. increases by a factor of 2.

6. Aerobic digesters are:

    ______ a. usually heated

    __X__ b. operated at existing air temperature.

7. If loading stays the same, an aerobic digester works faster at stabilizing solids during:

    ______ a. the winter.

    __X__ b. the summer.

8. An aerobic digester has a volume of 34,000 cubic feet. Each day, 2,000 lbs of volatile matter is added. What is the volatile solids loading? (answers are in lbs organic matter per cubic foot of digester capacity.)

    ______ a. .01

    ______ b. .02

    ______ c. .04

    __X__ d. .06

    ______ e. .08

9. What is a good Dissolved Oxygen residual that should be maintained in an aerobic digester to enhance mixing as well as aerobic conditions?

    ______ a. 0.5 - 1.0 mg/l

    __X__ b. 1.0 - 2.0 mg/l

    ______ c. 4.0 - 8.0 mg/l

    ______ d. greater than 10 mg/l

    ______ e. None of the above.

10. Choose three daily lab tests that should be performed on the influent and effluent streams of a digester.

    ______ a. Chlorine residual

    __X__ b. pH

    __X__ c. Suspended solids

    ______ d. Fecal coliform

    __X__ e. Volatile suspended solids

11. How often should dissolved oxygen and temperature be measured in operating an aerobic digester?

    __X__ a. Daily

    ______ b. Weekly

    ______ c. Monthly

    ______ d. Hourly

    ______ e. They don't need to be monitored.

12. Choose three causes of biological upset.

______ a. Maintaining D.O. at 2.0 mg/l

______ b. Shutting off air for 1-2 hours to decant digester.

______ c. Change in influent characteristics

__X__ d. Increase volatile solids loading

__X__ e. Temperature drops from 18°C to 9°C.

__X__ f. pH shifts from 6.8 to 7.2.

13. If excessively high oxygen uptake rates occur in a digester, choose two corrective actions.

______ a. Increase volatile solids loading.

__X__ b. Increase air discharge rates.

__X__ c. Decrease volatile solids loading.

______ d. Decrease air discharge rates.

______ e. Add raw sludge from the primary clarifier.

14. What is the typical foam appearance on a aerobic digester?

______ a. White, crisp, billowy.

______ b. Black.

______ c. There shouldn't be any foam.

__X__ d. Dark tan, leathery, greasy.

______ e. Frothy, tan, 2-3 feet deep.

15. A decrease in volatile solids destruction indicates that:

______ a. performance is improving.

______ b. performance is approaching biological equilibrium.

__X__ c. volatile solids loadings are increasing.

______ d. volatile solids loadings are decreasing.

______ e. digestion times have gotten longer.

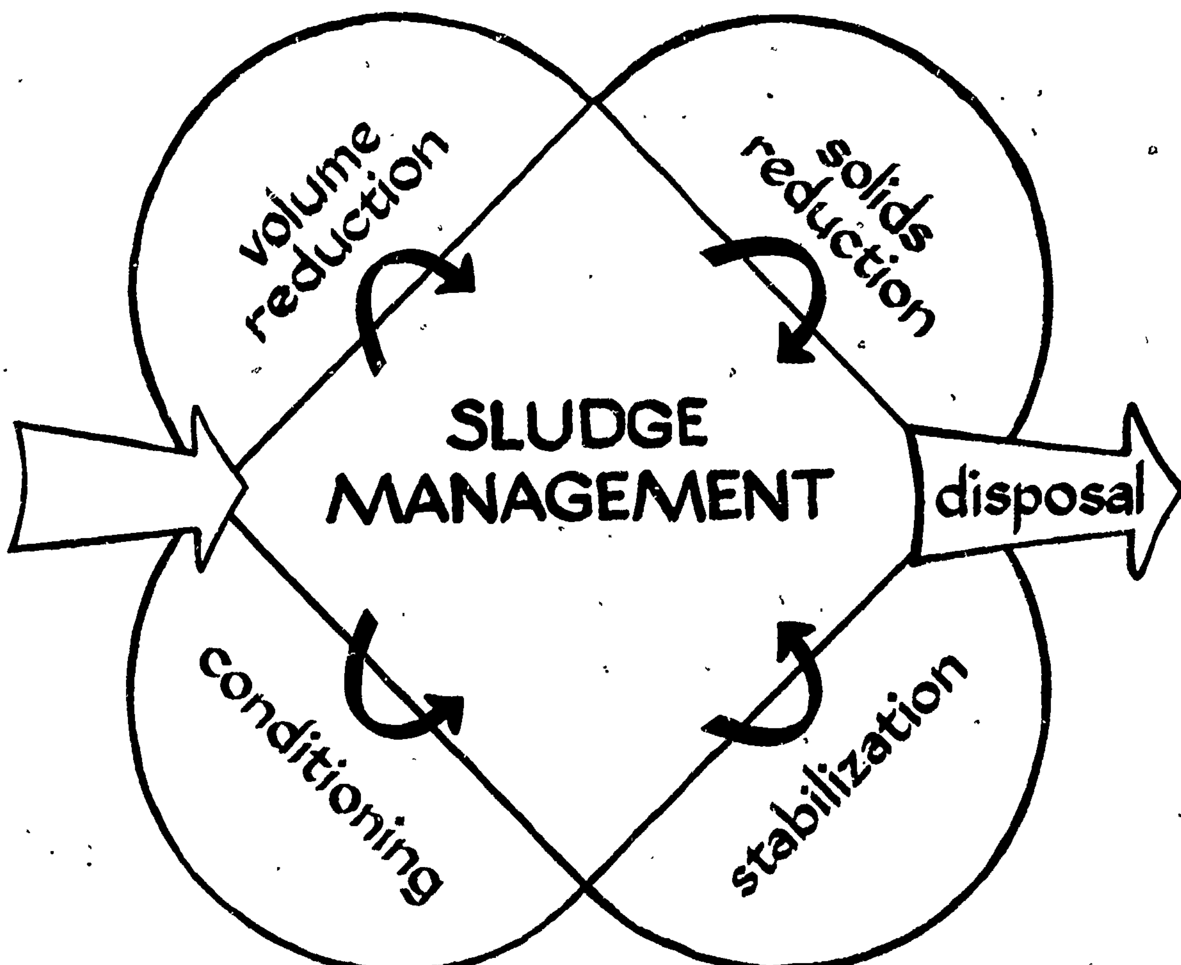
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

AEROBIC DIGESTION



SE 041 595

STUDENT WORKBOOK

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

AEROBIC DIGESTION

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AEROBIC DIGESTION

CONTENTS

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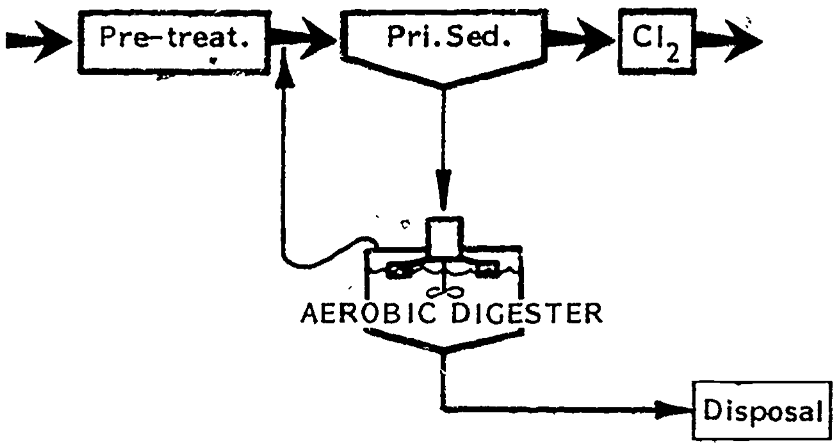
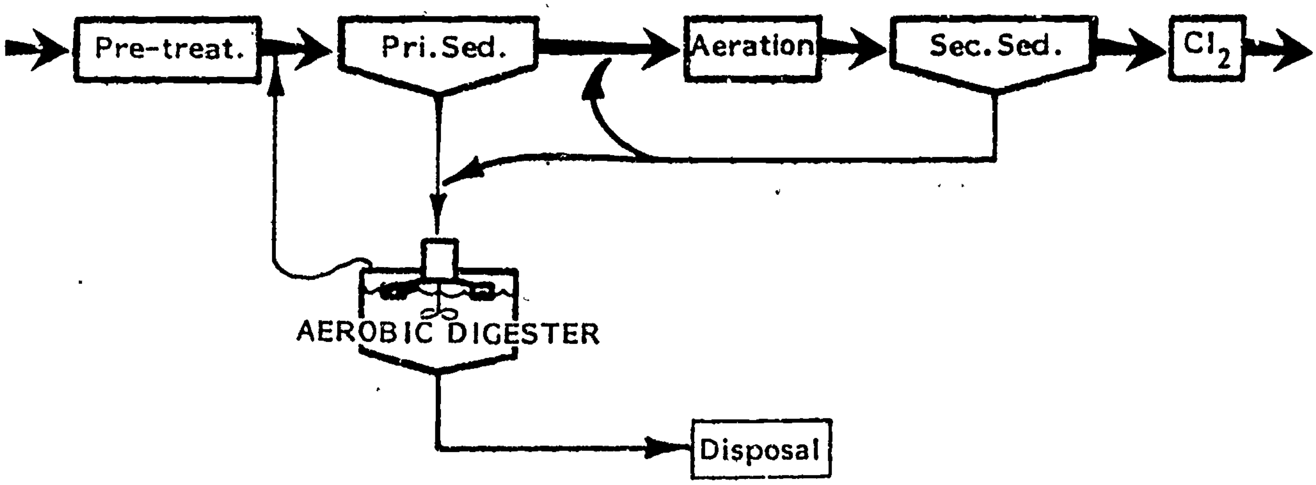
PLANT FLOW DIAGRAMS

PRIMARY PLANT



SECONDARY PLANT



AEROBIC DIGESTION

Objectives

Upon completion of this lesson, the student should be able to do the following:

1. Be able to describe, in general terms, the aerobic digestion process.
2. Know that aerobic digestion is an application of the activated sludge process of extended aeration.
3. Know that aerobic digestion is used on primary and secondary sludges, but secondary is more typical.
4. Be able to list 4 of 6 criteria affecting the performance of the digester. Acceptable answers include:

   sludge type
   digestion time
   digestion temperature
   volatile solids loading
   quantity of air supplied
   dissolved oxygen concentrations

5. Know that digestion time is a function of digester capacity (volume) and rate of sludge feed.
6. Know the effect of temperature on digestion is that a two-fold increase in biological activity occurs for every 10°C rise in temperature.
7. Know that aerobic digesters typically operate at ambient temperatures.
8. Know that digestion is faster at warmer temperatures.
9. Be able to state that volatile solids loading is a measure of the quantity of organic matter applied to the digester per cubic foot of digester capacity.
10. Be able to state that the quantity of air required for digestion is used to insure mixing and a DO residual of 1-2 mg/l.
11. Know that there are two types of aeration mechanisms, diffused air and mechanical aerators.
12. Be able to list the three daily lab tests to be performed on the influent and effluent streams to be:

   suspended solids
   volatile suspended solids
   pH

13. Know that DO and temperature should be measured daily.
14. Be able to describe the use of the DO probe for measuring oxygen uptake rates.

15. List 3 of 4 influences which may cause biological upset. The acceptable answers include:
    - equipment malfunctions
    - changes in influent characteristics
    - changes in operating modes
    - changes in temperature

16. Be able to state the effect of excessive sludge flows on digestion time and solids loading.

17. Be able to describe the corrective action that should be taken when excessive oxygen uptake rates are experienced to be a reduction in the volatile solids loading and an increased sludge detention time.

18. Be able to describe typical foam characteristics.

19. Be able to describe the effect of low DO on filamentous organisms in the digester.

20. Be able to describe a solution to foaming when DO control is not effective.

21. Be able to recall that the measure of proper digester function is a decrease in volatile solids content of the sludge.

22. Be able to state that a decrease in volatile solids destruction indicates that either digestion times are too short or volatile solids loadings are too high.

GLOSSARY

Aerator - A structure, round or rectangular, built for the purpose of aerating and mixing activated sludge liquor, (also called a reactor).

Air Diffusers - Devices for breaking up air into fine bubbles of water for the purpose of transferring a part of the oxygen in the air to the liquid surrounding bubble.

Decant - Removing liquid from the top.

Digested sludge - Sludge digested under either aerobic or anaerobic conditions until the volatile content has been reduced to the point at which the solids are relatively nonputrescible and inoffensive.

Dissolved oxygen - Usually designated as D.O. The oxygen dissolved in sewage, water, or other liquid, generally expressed MG/L or percent of saturation.

Headworks - The area of a treatment facility where wastewater is first processed.

Respiration - The physical and chemical processes by which an organism supplies its cells and tissues with oxygen needed for metabolism and relieves them of carbon dioxide formed in energy-producing reactions.

Sidestream - A flow originating within a treatment plant which is piped from one processing area to another. Supernate from a digester, when returned to the headworks, is a "sidestream." Sidestreams must be measured to account for their BOD, TSS and quantity.

AEROBIC DIGESTION

*Modification of activated sludge process

*Biological stabilization of secondary sludge

The main purpose of aerobic digestion is the stabilization of sludge organics. At the same time, the mass and volume of sludge is reduced and the sludge is conditioned for further solids handling. Aerobic digestion is an application of the activated sludge process in which the digester is operated with an extended aeration time. Primary sludge, secondary sludge and mixtures of the two can be aerobically digested. Most commonly, however, aerobic digesters are used to stabilize secondary sludge.

COMPONENTS

*Aeration mechanism
. . . Mechanical
. . . Diffused Air

An aerobic digester is simply a tank equipped with an air supply much like an aeration basin. Air is typically introduced by mechanical means such as a floating surface aerator or compressed air is introduced through a diffuser mechanism. This module will feature a mechanical aerator; operational principles are the same, regardless of the type of aeration system.

*Decant mechanism

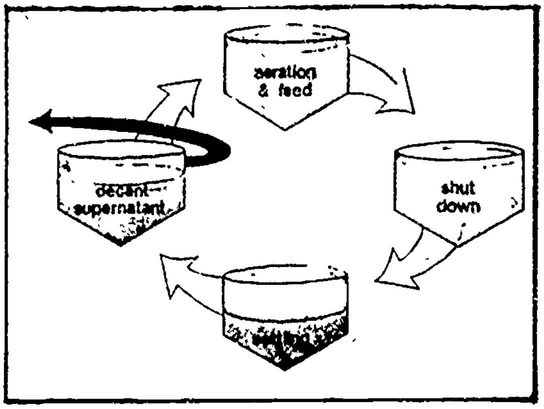
Important components of the aerobic digester include piping for sludge feed, for supernatant draw-off, for sludge withdrawal and for tank drain. Supernatant draw-off is called decanting. The supernatant that is decanted from the digesting sludge is returned to the headworks of the plant.

*Sidestream
. . . BOD
. . . Suspended Solids

Digester supernatant is a sidestream containing BOD and suspended solids which influences operation of the entire treatment plant when it is returned to the headworks.

Most digesters operate on a continuous cycle. The digester may receive sludge continuously or for a portion of the day. When the digester is

NORMAL SEQUENCE OF OPERATIONS



full, the air supply is shut off for several hours, during which time sludge settles leaving a clear supernatant. This is then decanted back to the headworks, making room in the digester for more sludge.

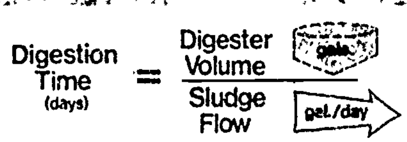
PERFORMANCE FACTORS

Aerobic Digestion is influenced by a number of performance factors. These include:

(1) Sludge Type
(2) Digestion Time
(3) Digestion Temperature
(4) Volatile Solids Laoding
(5) Quantity of Air Supplied
(6) Dissolved Oxygen Concentrations in The Digester

*Sludge Type

"Sludge Type" refers to the influent characteristics of the solids sent to the digester for stabilization. Very little control can be exerted over the chemical and biological composition of this sludge. Digesters typically handle secondary sludges which are composed primarily of biological cells produced in the activated sludge or trickling filter processes. This biological sludge is aerated, in the absence of a food supply, in the digester. The biological matter partially breaks down to carbon dioxide and water, with a net decrease in sludge mass.

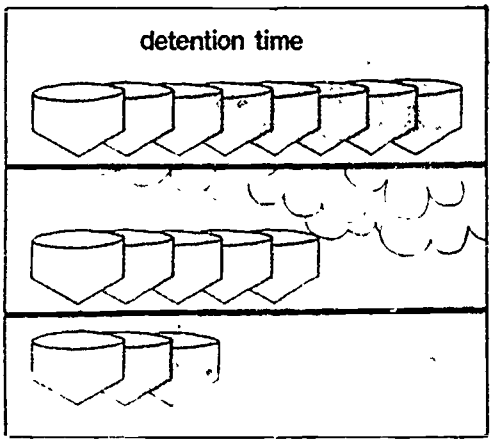


Digestion time is determined by the rate of sludge flow into the digester, which has a known volume. As the flow to the digester increases, the time allowed for digestion decreases. Digestion time is calculated according to the following formula:

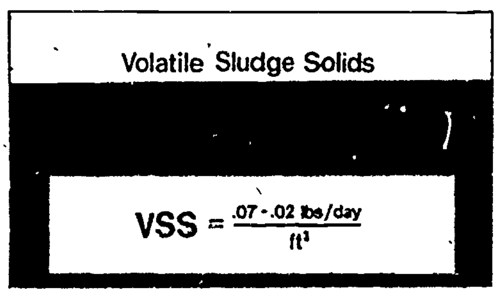
$$\text{Digestion Time, days} = \frac{\text{Digester volume, gal}}{\text{Sludge Flow, gal/day}}$$

The degree to which sludge is thickened prior to being fed into the digester has an effect on the digestion time.

*Effect of Temperature



Temperature also has a significant effect on sludge digestion. As a general rule, biological activity increases two-fold for every 10°C rise in temperature. Aerobic digesters work best at temperatures above 18°C. Most digesters are unheated. Detention time must be increased during cold weather. As weather warms up, stabilization occurs more rapidly and less digestion time is required.



Volatile solids loading is a measure of the quantity of organic material applied to the digester. Volatile Sludge Solids (VSS) loadings typically range from 0.07 lb to 0.20 lb VSS/day/cu ft. Volatile sludge solids loading is influenced by the concentration and volume of sludge placed in the digester. Loadings are unique for each facility, and are influenced by the type of sludge and digestion temperature.

*Air Requirements
. . . D.O. 1-2 mg/l

The quantity of air required for degestion is expressed as cfm of air/1000 cu ft of digester, volume, or as horsepower per 1,000 cu ft when mechanical aerators are used. The air requirements are governed by the need to keep the contents of the tank completely mixed and maintain a dissolved oxygen concentration of 1-2 mg/l in all parts of the tank. Air requirements vary from time to time, depending on the sludge type, temperature, concentration and activity of the digesting sludge.

*Oxygen Uptake Rate

How fast are the bugs breathing?

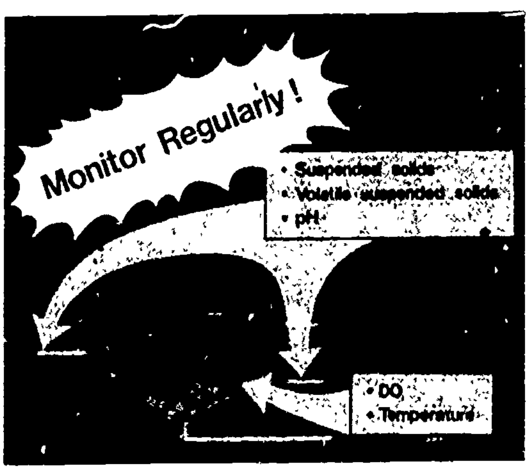
Dissolved oxygen is best measured with a portable DO probe. Measurements should be made at several locations within the tank to insure that at least 1 mg/l of free oxygen is present in all locations. DO measurements are also useful in determining the activity of the microorganisms within the digester. In this case, oxygen uptake measurements are made. The oxygen uptake determination requires the use of a sealed container into which a DO probe and a mixer are inserted. Typically, a BOD bottle, magnetic stirrer and DO probe are used.

The oxygen uptake rate decreases as the sludge becomes more stabilized.

Like any well-operating aerobic biological system, the digester should be relatively free of obnoxious odors. Some foul odors may be present immediately after aeration is resumed following the time when aerators were off for decanting supernatant.

*Foam

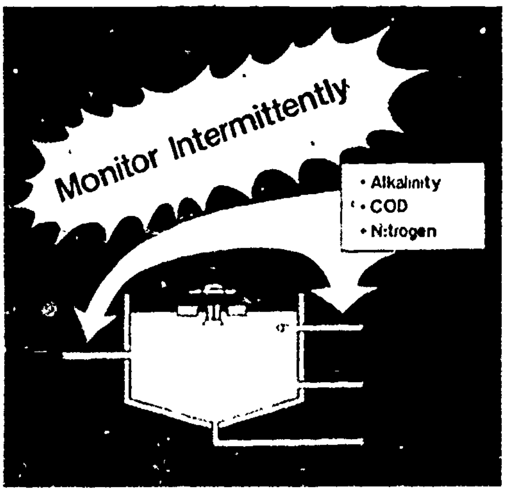
The surface typically accumulates a small amount of foam. This foam is usually several inches thick, and has a dark tar greasy appearance.



Standard Operation includes feeding sludge to the digester on as continuous a basis as possible and monitoring the process. The test results are the basis for good process control. Regular laboratory analysis on the influent and effluent streams should include:

(1) Suspended solids
(2) Volatile suspended solids
(3) pH

Dissolved oxygen concentrations and temperature



of the digesting sludge should be monitored daily. On an intermittent basis, the influent and effluent streams should be sampled for alkalinity, total and soluble COD, ammonia-nitrogen, nitrite and nitrate nitrogen.

Typical performance is summarized in the following table:

Typical Performance			
Sludge Type	Digestion Time(days)	Volatile Sus. Solids Loading lb VSS/cu ft/day	% V.S.S. Destruction
Primary	15 - 20	.08-.20	25-50
Secondary	10 - 15	.08-.20	25-40

Both primary and secondary sludges can be aerobically digested. Primary sludge requires a longer digestion time than secondary sludge because the organic solids found in primary sludge are more difficult to break down under aerobic conditions.

LOADING
*VSS/ft^3/day

Loading is based on the pounds of volatile solids being sent to the digester and the size of digester in cubic feet. Loading rate is similar for primary and secondary sludges. Volatile solids destruction is slightly greater for primary sludge.

INDICATORS OF STABLE OPERATION

When an aerobic digester reaches steady state, the oxygen uptake rate and the residual DO should be relatively constant from day to day.

However, aerobic digesters are subject to the same upsets which affect all biological systems. These may be caused by equipment malfunctions, changes in influent characteristics, changes in operating modes and changes in temperature. Good indicators, especially in times of upset, are the dissolved oxygen measurements and the oxygen uptake determinations.

MONITOR D.O.

If the residual DO increases significantly, this may suggest that the air rate is excessive or the oxygen uptake rate has decreased indicating the microorganisms are less active. If the uptake rate is in the normal range, then the microorganisms are working properly and the increase in DO is most likely due to high air rates to the digester. Air discharge rates should be adjusted to maintain a DO of 1-2 mg/l.

WATCH OXYGEN UPTAKE RATE

If the oxygen uptake rate is significantly lower than normal, something may be inhibiting the microorganisms. Temperature and pH should be checked. Significant decreases in temperature and pH are inhibitory. If temperature is normal and the pH drops, the cause may be nitrification or changes in the influent sludge characteristics. When caused by nitrification, the decrease in pH will be gradual over about a week's time. pH should not be allowed to drop much below 6.0.

DROPPING D.O.?

If the DO residual drops significantly, air discharge rate should be adjusted to increase the residual DO to 1-2 mg/l. If higher than normal oxygen uptake rates are also noted, volatile sludge solids loading rate to the digester may be higher than normal. As long as sufficient air capacity exists to meet air requirements at higher loading rates, the system can still operate, but critical operating parameters should be closely tracked. These include: temperature, pH and digestion time. If low DO exists and the aeration system operating at full capacity, flow and loading to the digester should be decreased.

EXCESSIVE LOADING?

Excessive sludge flows reduce the time of digestion and may increase the volatile sludge loading to the point where the digester is operating out of the recommended range of operation. Adjustments should be made to the flows and volatile sludge solids loading to bring the operation back within normal ranges.

FOAMING PROBLEMS?

Aerobic digesters are often plagued with foaming problems. If excessive foam develops, air discharge rate and residual DO should be checked. If they are high, the problem may be related to excessive turbulence. The air discharge rate should be reduced to the lowest rate which maintains adequate DO and mixing. Low DO is conductive to filamentous bacterial growth in the digester. This may aggrivate foam problems and reduce the sttleability of the sludge, making it difficult to decant supernatant

Foaming problems may also be related to influent characteristics and defoaming agents may be needed to suppress the foam. In summary, foaming in biological systems can be caused by a variety of conditions and generally constitutes a complex problem.

Both the digestion time and volitile sludge solids loading should be maintained within ranges found to be suitable for each particular facility. A review of daily influent and effluent amounts of volatile sludge solids indicates whether or not the digester is efficiently converting volatile (organic) matter to stabilized end products.

Aerobic digesters are a common means of handling excess secondary sludges prior to ultimate disposal. They provide moderate stabilization of biological solids providing that climatic conditions are favorable.

References

EPA Course #166 "Aerobic Digestion".

EPA Course #166 "Sludge Characteristics," "Sludge Conditioning," "Lab Procedures."

Process Design Manual for Sludge Treatment and Disposal, U.S.E.P.A., September 1979, EPA 625/1-79-011.

AEROBIC DIGESTION
WORKSHEET

1. Which treatment process does aerobic digestion most closely resemble?

______ a. Trickling Filtration
______ b. Activated Sludge
______ c. Sedimentation
______ d. Anaerobic Digestion
______ e. Disinfection

2. Aerobic digestion is:

______ a. used on primary and secondary sludges.
______ b. most commonly used on primary sludges.
______ c. most commonly used on secondary sludges.
______ d. is not commonly used on any sludge.

3. Choose four factors which affect the operation of an aerobic digester.

______ a. Clarifier overflow rate
______ b. Temperature
______ c. Volatile solids loading
______ d. D.O. concentration
______ e. Detention time
______ f. Weir overflow rate

4. What governs the digestion time of an aerobic digester?

______ a. Digester volume
______ b. Rate of sludge feed
______ c. Rate of sludge withdrawal
______ d. Rate of supernatant withdrawal
______ e. None of the above

5. When the temperature of a digester increases 10°C, biological activity:

______ a. decreases by a factor of 10.
______ b. increases by a factor of 10.
______ c. decreases by a factor of 2.
______ d. increases by a factor of 2.

6. Aerobic digesters are:

_____ a. usually heated.

_____ b. operated on existing air temperature.

7. If loading stays the same, an aerobic digester works faster at stabilizing solids during:

_____ a. the winter.

_____ b. the summer.

8. An aerobic digester has a volume of 34,000 cubic feet. Each day, 2,000 lbs of volatile matter is added. What is the volatile solids loading? (answers are in lbs organic matter per cubic foot of digester capacity.)

_____ a. .01

_____ b. .02

_____ c. .04

_____ d. .06

_____ e. .08

9. What is a good Dissolved Oxygen residual that should be maintained in an aerobic digester to enhance mixing as well as aerobic conditions?

_____ a. 0.5 - 1.0 mg/l

_____ b. 1.0 - 2.0 mg/l

_____ c. 4.0 - 8.0 mg/l

_____ d. Greater than 10 mg/l

_____ e. None of the above.

10. Choose three daily lab tests that should be performed on the influent and effluent streams of a digester.

_____ a. Chlorine residual

_____ b. pH

_____ c. Suspended solids

_____ d. Fecal coliform

_____ e. Volatile suspended solids

11. How often should dissolved oxygen and temperature be measured in operating an aerobic digester?

_____ a. Daily

_____ b. Weekly

_____ c. Monthly

_____ d. Hourly

_____ e. They don't need to be monitored.

12. Choose three causes of biological upset.

_____ a. Maintaining D.O. at 2.0 mg/l

_____ b. Shutting off air fro 1-2 hours to decant digester.

_____ c. Change in influent characteristics

_____ d. Increase volatile solids loading

_____ e. Temperature drops from 18^{o}C to 9^{o}C.

_____ f. pH shifts from 6.8 to 7.2.

13. If excessively high oxygen uptake rates occur in a digester, choose two corrective actions.

_____ a. Increase volatile solids loading.

_____ b. Increase air discharge rates.

_____ c. Decrease volatile solids loading.

_____ d. Decrease air discharge rates.

_____ e. Add raw sludge from the primary clarifier.

14. What is the typical foam appearance on a aerobic digester?

_____ a. White, crisp, billowy.

_____ b. Black.

_____ c. There shouldn't be any foam.

_____ d. Dark tan, leathery, greasy.

_____ e. Frothy, tan, 2-3 feet deep.

15. A decrease in volatile solids destruction indicates that:

_____ a. performance is improving.

_____ b. performance is approaching biological equilibrium.

_____ c. volatile solids loadings are increasing.

_____ d. volatile solids loadings are decreasing.

_____ e. digestion times have gotten longer.