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ABSTRACT

Composting is a lesson developed for a sludge treatment and disposal course. The lesson discusses the basic theory of composting and the basic operation, in a step-by-step sequence, of the two typical composting procedures: windrow and forced air static pile. The lesson then covers basic monitoring and operational procedures. The instructor's manual contains a brief description of the lesson, estimated time, instructional materials list, suggested sequence of presentation, required reading list, reference reading list, objectives, lecture outline, narrative of the slide/tape program used with the lesson, and student worksheet (with answers). The student workbook contains objectives, plant flow diagrams, glossary, subject matter, list of references, and worksheet. Subject matter is grouped under the following headings: background, basic theory, windrow, forced air system, and operations. (Author/JN)

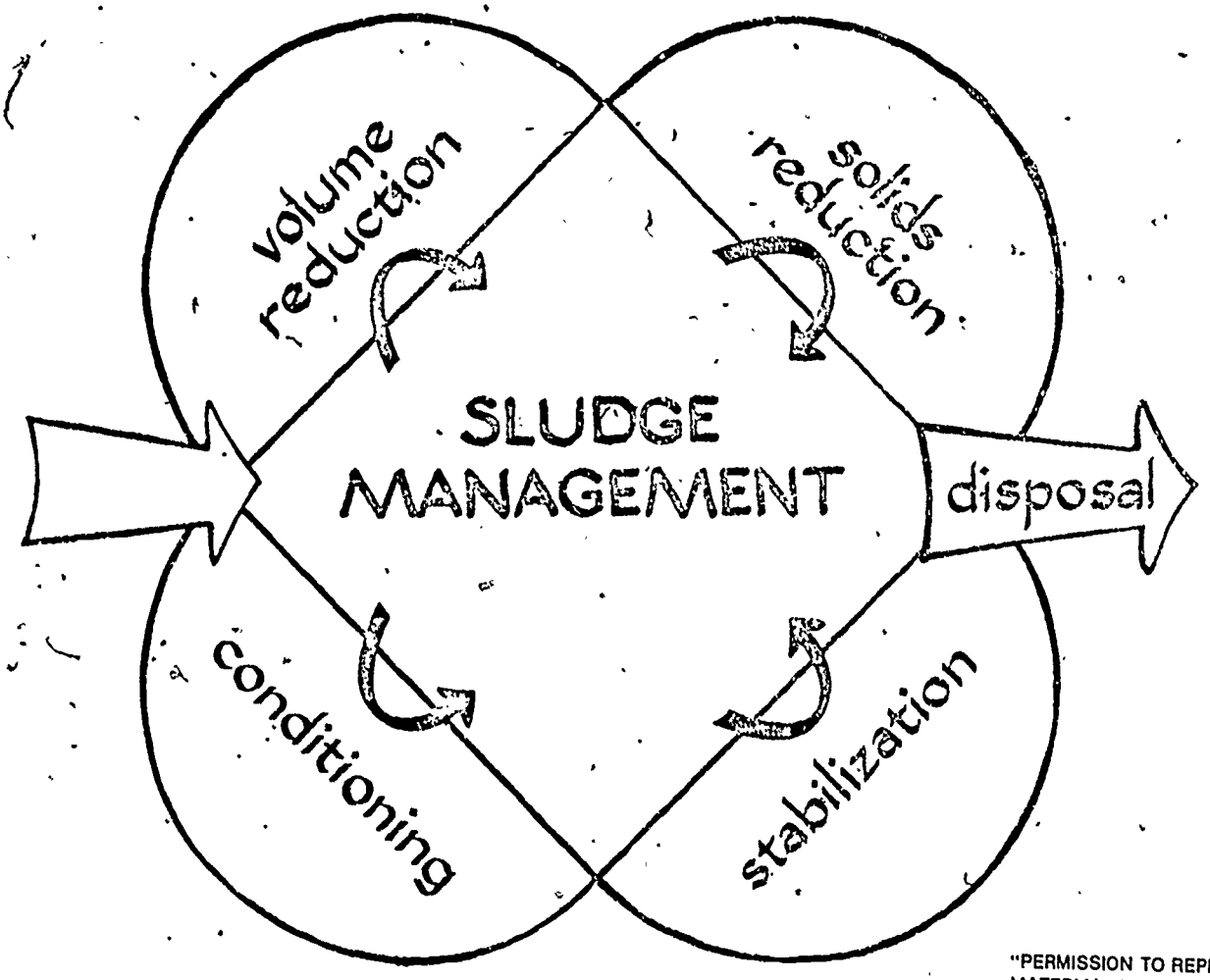
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

COMPOSTING



INSTRUCTOR'S GUIDE

Prepared by
Linn-Benton Community College
and
Envirotech Operating Services

COMPOSTING

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COMPOSTING

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COMPOSTING

Lesson Description

This lesson discusses the basic theory of composting and the basic operation, in a step by step sequence, of the two typical procedures: windrow and forced air static pile. The lesson then covers basic monitoring and operational procedures.

Estimated Time

Student preview of objectives and written materials	20-30 minutes
Presentation of Materials	13 minutes
Worksheet	10 minutes
Correct worksheets and discussion	10-15 minutes

Instructional Materials List

1. Student text "Composting"
2. Slide/tape set "Composting"
3. 35 mm slide projector
4. Cassette tape player with automatic syncronization
5. Screen
6. Samples of composed sludge and samples of bulking agent

Suggested Sequence of Presentation

1. Assign reading - emphasize process diagrams, glossary, and objectives.
2. Show slide/tape program or lecture using the slide presentation.
3. Open discussion, concentration on the appearance and advantages of composted sludge.
4. Assign worksheet.
5. Correct worksheet.

Required Reading

Student Text Material - "Composting"

Reference Reading

"Operations Manual - Sludge Handling and Conditioning" Chapter 17, 1978, U.S. EPA 430/9-78-002.

"Process Design Manual for Sludge Treatment and Disposal" Chapter 12, 1979, U.S. EPA 625/1-79-001.

Objectives

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

1. State into which of the four basic solids management divisions composting fits.
2. Recall the typical temperature range for a typical composting pile.
3. List the most typical order of five basic steps involved in composting.
4. List three materials used as bulking agents.
5. Recall the time involved for biological decomposition of sludge in the compost pile and in the curing pile.
6. State the mix ratio between sludge and bulking agent for the windrow method.
7. Recall the desired sludge moisture level for the windrow method.
8. Recall the typical moisture level of composted sludge.
9. State the desired oxygen range for a well operated forced air system.
10. Recall the origin of the two side streams produced by composting.
11. Recall the frequency for monitoring temperature, oxygen, bacteria, nitrogen and percent moisture in the compost pile.
12. Recall two visual clues to operational problems.
13. List the three areas considered as operational controls for composting.
14. List three of the four sludge characteristics important to composting.
15. Recall the two major environmental factors affecting composting.

COMPOSTING

LECTURE OUTLINE

I. Introduction
   A. Means of stabilization
      1. Raw sludge
      2. Digested sludge
      3. Temperature - 55 to 60° C.
         a. Kill most pathogenic organisms
   B. Basic Process
      1. Mix bulking agent with sludge
         a. bulking agents: 1) wood chips
            2) bark chips
            3) shreaded tires
            4) compost of other organic materials
      2. Promote biological decompositive of sludge
      3. Bulking agent screened from the stabilized sludge
      4. Stabilized sludge disposed of in land application
      5. Bulking agent reused
   C. Methods
      1. Windrow
         a. natural
      2. Forced air static pile

II. Equipment
   A. Windrow
      1. Windrow turner
      2. Dump truck
      3. 4 cubic yard front end loader
      4. Drum screen
   B. Forced Air Static Pile
      1. 4 cubic yard front end loader
      2. Dump truck
      3. Blower and pipe
      4. Large mixer
      5. Drum screen

III. Typical Operating Procedures

A. Two types

B. Windrow

1. 20-25% dewatered sludge
2. Mix with bulking agent 2.5 - 3.0 parts bulking agent to 1 part sludge
   a. 17-21 cubic yards bulking agent, 1 ton dry sludge
3. Lay base of bulking agent
   a. 18-24" deep - 8-15' wide
   b. dump sludge on bulking agent
   c. mix by back draging
      i. use front end loader
      ii. need homogeneous mix
4. Form windrow
   a. Triangular cross section
   b. 6 to 8 feet wide
   c. 5 to 6 feet high
5. Composting
   a. turn daily
   b. monitor temperature - should reach 50° C. in a few days
   c. mix for 2 to 3 weeks
   d. flatten windrows allow drying - approximately 21 days from mix to dry
6. Removal
   a. move to curing pile
      i. curing - continuation of stabilization and drying
      ii. approximately 30 days for curing
7. Screening
   a. not always necessary
   b. removes coarse bulking agent
   c. reuse screened out material
      i. moisture should be below 40 to 50%
   d. compost - 40 to 50% moisture, 40% volatile solids
   e. may be before or after curing

C. Forced Air Static Pile
   1. Lay out pipe
      a. 4" sed. 40 steel
      b. 7 feet on center
      c. parallel across pile
      d. plug on end
      e. connect to header with 'Y's
   2. Blower connection - blower to remove air, not force it in
      a. cover discharge with 5 cubic yards of bulking agent
         i. deodorization
   3. Lay down base
      a. 6 to 12" of bulking agent
         i. moisture below 40 - 50%
         ii. don't build during rain
   4. Spread sludge
   5. Mix sludge
   6. For pile
      a. 7 - 10 feet high
      b. extend beyond end of pipes 5 feet
      c. cover mixed pile 1 - 2 feet of bulking agent
         i. deodorizing
   7. Adjust blower
      a. O_2 levels should be 5-15% within the pile
   8. Allow composting
      a. temperature should be 60° C.
      b. 2 to 3 weeks
   9. Remove pile for curing
   10. Allow curing
      a. approximately 30 days
   11. Screen bulking agent

D. Side Streams
   1. Source
      a. storm runoff

b. excess water

2. Collection

a. collected in lagoon

b. piped to sewage treatment plant

IV. Environmental Factors Affecting Composting

A. Sludge Characteristics

1. Volatility of Sludge (VSS)
2. Moisture Content - percent moisture
3. Ratio of Carbon to Nitrogen
4. Heavy Metals

B. Environmental Conditions

1. Air Temperature
2. Precipitation
   a. amount
   b. frequency

C. Operational Control

1. Laboratory Analysis
   a. sludge
      i. VSS
      ii. percent moisture
      iii. quantity
      iv. nitrogen
      v. total organic carbon
      vi. pH
      vii. heavy metals
   b. compost and curing piles
      i. temperature - daily
      ii. oxygen - bi-weekly
      iii. bacteria - weekly
      iv. nitrogen - weekly
      v. percent moisture - weekly

c. side stream

i. quantity

ii. BOD

iii. suspended solids

iv. nitrogen

2. Physical Observations

a. odors

b. changes in color

c. changes in shape

3. Physical Adjustments - To Maintain Oxygen and Temperature Levels

a. windrow - turning daily

b. static pile - adjustments to the blowers

V. Safety Considerations

A. Operator Contact With Pathogens

B. Heavy Equipment

1. Composting - the theory and basic operations.

2. This program was written by Mr. E. E. "Skeet" Arasmith, instructional development was done by Priscilla Hardin. Paul H. Klopping was the project manager.

3. Composting is a process that has been used since the early 1900's to stabilize municipal waste. Therefore, in the overall sludge management program it is considered a stabilization process.

4. Although composting has been used since the early 1900's, it was not until the 1930's that Sir Albert Howard conducted major research on the process including its application with municipal waste.

5. His early findings indicated that composting not only helped to stabilize waste but produced a byproduct that was highly beneficial as a soil conditioner.

6. During this lesson we will look at the theory of composting, the basic sequence, the common adaptions to municipal waste, and finally, we will discuss typical operation and safety guidelines.

7. Let's start by considering the theory of the process.

8. Sludge composting is a means of further stabilizing raw or digested sludge by means of aerobic thermophilic decomposition.

9. During the decomposition process, temperatures will reach 55^{0} to 60^{0} C. Thus, pathogenic organism numbers will be reduced to tolerable risk levels and nuisance odors will be virtually nonexistant.

10. The process of adding compost to soil will improve the physical properties of the soil, increasing water retention, permeability, and aeration while reducing soil surface crusting.

11. The end product will also help to furnish basic nutrients and trace elements for crops.

12. There are two basic processes of composting waste sludge: windrow and forced air static pile. However, each follows the same basic sequence. Let's look at the basic sequence first and then at each of the individual processes.

13. The sequence consists of five steps: mixing sludge with bulking agent, allowing decomposition, screening out the bulking agent, curing, and disposal of the compost. This sequence can, however, be varied especially with the screening step which may come before or after the curing step.

14. Wet sludge is too compact to allow aerobic activity. Therefore, it is mixed with a bulking agent. Typical bulking agents are wood chips, bark chips, shredded tires, and compost of other organic material. The method of mixing is determined by the type of process being used and will be discussed later.

15. After mixing and shaping the compost pile, biological activity is allowed to proceed. This could take from 2 to 4 weeks for major decomposition.

16. The bulking agent may then be screened from the compost. The compost is then allowed to cure for 30 days.

17. After 30 days the compost is disposed of via land application.

18. So much for the basics. Let's look at the two methods and consider their peculiarities.

19. The windrow method is the more natural of the two methods. The windrow formation and mixing are done at the same time. First, a layer of bulking agent is laid down 18 to 24 inches deep and 8 to 15 feet wide.

20. Next, a layer of 20 to 25 percent sludge is placed over the bulking agent. The volume of sludge is adjusted so that the mixed ratio of 2½ to 3 parts bulking agent to 1 part sludge is achieved.

21. After mixing to obtain a homogeneous mixture, a grader or a special windrow turner is used to further mix the material and form a windrow that is 6 to 8 feet wide and 5 to 6 feet tall.

22. During the next 2 to 4 weeks the pile is turned and monitored for temperature daily.

23. The temperature should reach at least 50° C. After several days it will begin to drop.

24. The windrow should now be spread and allowed to dry for approximately 6 days.

25. The bulking agent is then removed by use of a drum screen or similar device.

26. The bulking agent is reused and the compost is placed in a curing pile for further stabilization. This usually requires approximately 30 days.

27. After curing, the compost containing 40 to 50 percent moisture and about 40 percent volatile solids is disposed of by land application.

28. The forced air static system improves the overall efficiency of the stabilization process by increasing air movement.

29. In this system a series of perforated 4 inch pipes are layed on 7 foot centers across the pile. One end of the pipe is plugged and the other is connected to a header and a blower.

30. A bulking agent base of 6 to 12 inches is layed over the pipes.

31. Using special equipment sludge, and bulking agent are blended together to make a mixture which contains 40 to 50 percent moisture.

32. Using a front-end loader, the mixture is formed into a pile 7 to 10 feet high and extending 5 feet beyond the ends of the pipe.

33. The pile is then covered with a layer of bulking agent approximately 12 inches thick.

34. The blower draws air through the pile supplying oxygen for stabilization. To reduce air exhaust odors a pile of bulking agent filters the air.

35. The blower is used to control the oxygen levels within the pile to be about 5 to 15 percent.

36. The temperature should now climb to 60^{0} C. and remain there 2 to 5 weeks; after which time it will begin to fall.

37. Curing requires approximately 30 days. Screening may be done either before or after curing, depending upon the bulking agent and the disposal method. After curing, the compost is placed on the land.

38. During the process of decomposition there is the production of sidestreams from two sources. Storm water runoff

39. and excess water from the sludge or bulking agent.

40. These sidestreams should not be allowed to enter the surface or ground water supplies, but be collected and sent to a stabilization pond or piped to an existing sewage treatment plant for further treatment.

41. A number of factors affect the composting operation.

42. These factors can be divided into three catagories: sludge characteristics, environmental conditions, and operational control.

43. Sludge characteristics would include volatility of the sludge, moisture content, the ratio of carbon to nitrogen, and the presence of heavy metals.

44. Environmental conditions would include air temperature and precipitation, both amount and frequency.

45. The operational control area can further be divided into three sections: routine laboratory analysis, physical observations, and mechanical adjustments.

46. Routine laboratory analysis would include monitoring the sludge, the compost and curing piles, and the side stream.

47. The sludge should be monitored for the characteristics mentioned above. The compost and curing piles monitoring should include daily checks for temperature, biweekly analysis of oxygen levels, and weekly analysis for bacteria, nitrogen, and percent moisture.

48. The sidestream must be checked for quanity, BOD, suspended solids, and nitrogen.

49. Physical observations include checking for offensive odors and changes in color or shape of the compost and curing piles. The presence of offensive odors or sudden changes in shape could indicate a problem with proper oxygen and/or temperature levels.

50. The major operational goal is to maintain proper oxygen and temperature levels. You should keep in mind that temperature levels are usually a reflection of oxygen levels within the compost pile.

51. The oxygen level is controlled mechanically by turning the windrow or by blower adjustments on the static pile.

52. The main safety consideration is operator contact with pathogenic organisms and the obvious problems associated with operating heavy equipment.

53. In conclusion then we should review what has been covered so far. First, we looked at the theory of the composting process.

54. Then we discussed the process itself.

55. We looked then at the two major process variations.

56. And finally, we previewed the monitoring requirements and operational controls.

57. Remember that composting is a biological process subject to all of the idiosyncrasies of any biological system, but if given proper care, should perform in a predictable manner.

COMPOSTING

WORKSHEET

Place an "X" in the space next to the most correct answer. In some questions there may be more than one answer.

1. In the overall sludge management process, composting is considered a:

   ____ a. volume reduction process.
   ____ b. solids reduction process.
   __X__ c. stabilization process.
   ____ d. conditioning process.
   ____ e. All of the above.

2. A typical composting pile should reach a temperature of:

   ____ a. 50 - 55° C.
   ____ b. 55 - 60° C.
   __X__ c. 60 - 65° C.
   ____ d. 65 - 70° C.
   ____ e. None of the above.

3. Arrange the five steps below in the typical order for composting of sewage sludge.

   __4__ a. Dispose of compost.
   __2__ b. Allow decomposition.
   __1__ c. Mix with bulking agent.
   __3__ d. Screen out bulking agent.
   __5__ e. Allow curing.

4. Which materials below are typical bulking agents for composting?

   ____ a. Straw
   __X__ b. Wood Chips
   ____ c. Ground Glass
   ____ d. Asphalt
   __X__ e. Bark Chips
   __X__ f. Shreaded Tires
   ____ g. Shreaded Steel Bars

5. A compost pile will decompose sludge in about:

X a. 2 to 3 weeks.

_____ b. 1 to 2 weeks.

_____ c. 3 to 5 weeks.

_____ d. 4 to 5 weeks.

_____ e. None of the above.

6. The ratio of bulking agent to sludge in the windrow method should be:

_____ a. 1.5 to 3.0.

_____ b. 2.0 to 2.5.

X c. 2.5 to 3.0.

_____ d. 3.0 to 5.0.

_____ e. None of the above.

7. For best results sludge mixtures applied to the windrow system should be between:

_____ a. 5 and 15% sludge.

X b. 20 and 25% sludge.

_____ c. 3 and 8% sludge.

_____ d. 25 and 30% sludge.

_____ e. None of the above.

8. Well composted sludge should have a moisture level between:

X a. 40 and 50%.

_____ b. 50 and 70%.

_____ c. 30 and 40%.

_____ d. 20 and 40%.

_____ e. None of the above.

9. The oxygen level in a well operated forced air system should be between:

_____ a. 1 and 3%.

_____ b. 3 and 5%.

X c. 5 and 15%.

_____ d. 10 and 20%.

_____ e. All of the above.

10. Identify the sources of the two side streams that are produced during composting:

__X__ a. Excess water in the sludge.
_____ b. Domestic sewage.
_____ c. Sanitary sewers.
_____ d. Infiltration.
_____ e. Wash down water.
__X__ f. Storm water.
_____ g. None of the above.

11. Within the compost pile, indicate frequency for monitoring the following items by using these symbols: H - hourly; S - shift; D - daily; B - bi-weekly; W - weekly; M - monthly.

__D__ temperature
__B__ oxygen
__W__ bacteria
__W__ nitrogen
__W__ percent moisture

12. Operational problems may be found by visual inspection. Two visual clues to problems would be:

_____ a. length.
__X__ b. shape.
__X__ c. color.
_____ d. size.
_____ e. steam.

13. Sludge is actually allowed to decompose in the curing pile for:

_____ a. 15 days.
__X__ b. 30 days.
_____ c. 20 days.
_____ d. 60 days.
_____ e. None of the above.

14. Operational controls of a compost pile can be divided into three areas. They would be:

__X__ a. laboratory analysis
_____ b. sludge characteristics
_____ c. environmental considerations
_____ d. safety considerations
__X__ e. mechanical adjustments
_____ f. cost
__X__ g. physical observations

15. Identify three characteristics of sludge that are important to composting.

__X__ a. heavy metals
__X__ b. volatile suspended solids
_____ c. capillary rise time
__X__ d. carbon to nitrogen ratio
_____ e. temperature
_____ f. specific resistance
_____ g. nitrogen to pot ash ratio
__X__ h. percent moisture

16. Two major environmental factors affect composting. They are:

__X__ a. precipitation
_____ b. wind direction
_____ c. humidity
__X__ d. air temperature
_____ e. wind speed

XT-164 (CP)

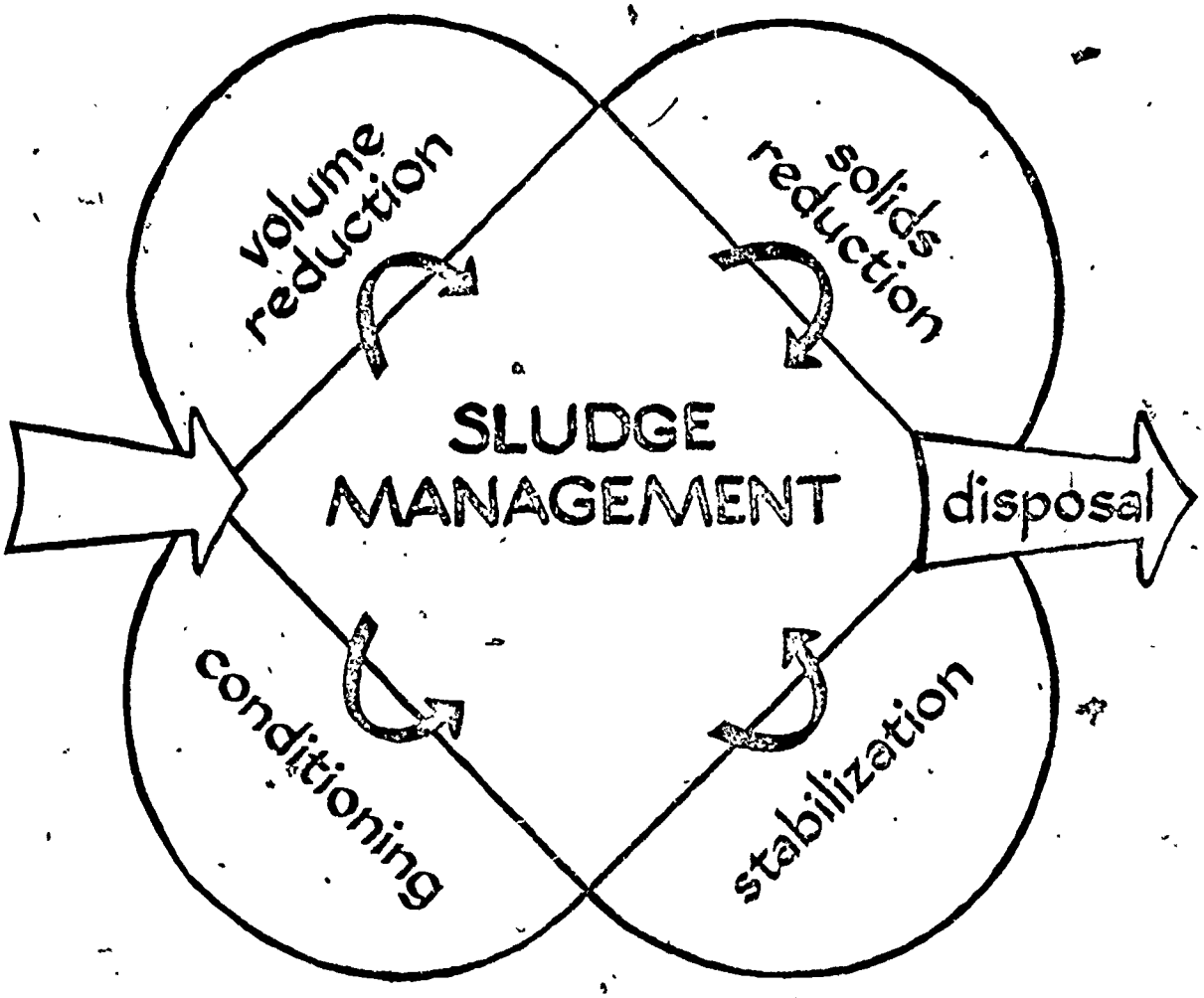
SLUDGE TREATMENT

and

DISPOSAL

COURSE # 166

COMPOSTING



STUDENT WORKBOOK

Prepared by
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and
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COMPOSTING

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COMPOSTING

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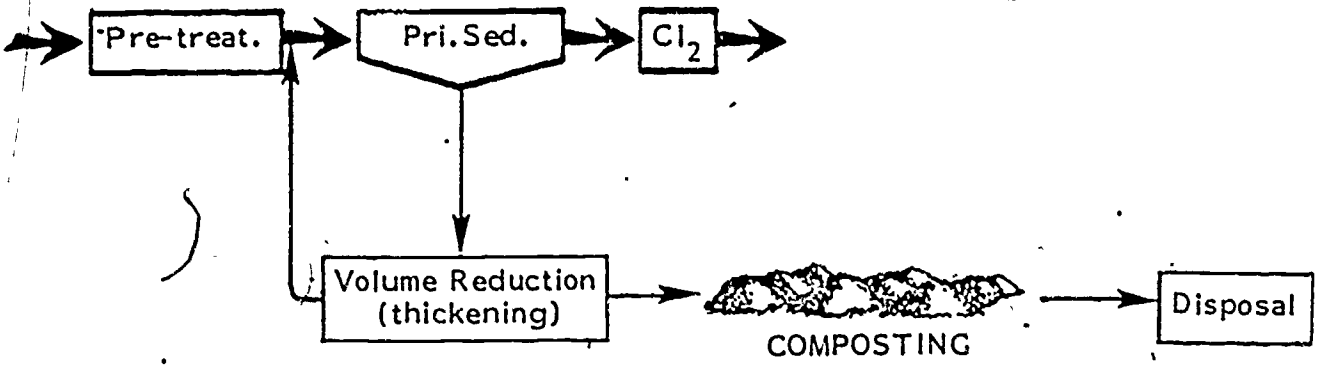
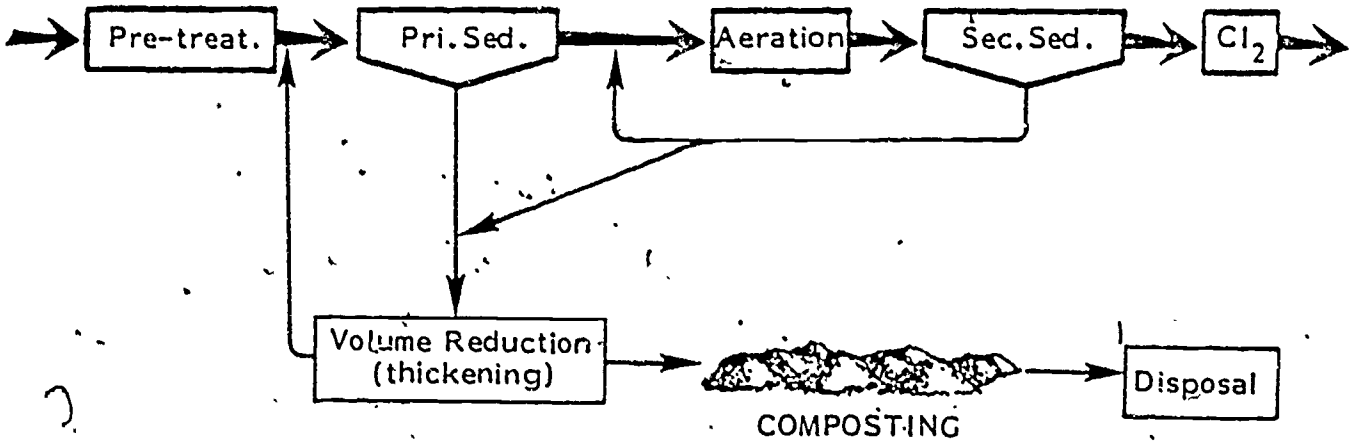
PLANT FLOW DIAGRAMS

PRIMARY PLANT



SECONDARY PLANT



COMPOSTING

Objectives

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

1. Recall which of the four major processes includes composting.
2. Recall the temperature range for a typical composting pile.
3. List in the correct order the four basic steps involved in composting.
4. List three materials used as bulking agents.
5. Recall the time involved for biological decomposition of sludge in a compost pile.
6. State the mix ratio between sludge and bulking agent for the windrow method.
7. Recall the desired sludge moisture level for the windrow method.
8. Recall the moisture level of composted sludge.
9. State the oxygen range for a well operated forced air system.
10. Recall the two side streams produced by composting.
11. Recall the frequency for monitoring temperature, oxygen, bacteria, nitrogen and percent moisture.
12. Recall two visual clues to operational problems.

COMPOSTING

Glossary

. Bulking agent - Material such as sawdust, shreaded tires and wood chips mixed with sewage sludge to allow easy air contact with the sludge.

Composting - A aerobic biological process of stabilizing organic material.

COMPOSTING

Composting is a process that has been used since the early 1900's to stabilize municipal waste. Therefore, in the overall sludge management program it is considered a stabilization process.

STABILIZATION

- Soil Conditioner

Although composting has been used since the early 1900's, it was not until the 1930's that Sir Albert Howard conducted major research on the process including its application with municipal waste.

His early findings indicated that composting not only helped to stabilize waste but produced a byproduct that was a highly beneficial soil conditioner.

During this lesson we will look at the theory of composting, the basic sequence, the common adaptions to municipal waste, and finally, we will discuss typical operation and safety guidelines.

Let's start by considering the theory of the process.

AEROBIC THERMOPHILIC DECOMPOSTING

- 55 - 60° C.
- Reduce Pathogens
- No Odors

Sludge composting is a means of further stabilizing raw or digested sludge by means of aerobic thermophilic decomposition.

During the decomposition process, temeratures will reach 55° to 60° C. Thus, pathogenic organism numbers will be reduced to a tolerable risk level and nuisance odors will be virtually nonexistant.

IMPROVED SOIL PROPERTIES

- Increased Soil Water Retention
- Permeability
- Aeration
- Decrease Crusting
- Basic Nutrients

The process of adding compost to soil will improve the physical properties of the soil, increasing water retention, permeability, and aeration while reducing soil surface crusting.

The end product will also help to furnish basic nutrients and trace elements for crops.

BASIC PROCESS

There are two basic processes of composting waste sludge: windrow and forced air static pile. However, each follows the same basic sequence. Let's look at the basic sequence first and then at each of the individual processes.

5 STEPS

- Mixing Sludge
- Decomposition
- Screening
- Curing
- Disposal

The sequence consists of five steps: mixing sludge bulking agent, allowing decomposition, screening out the bulking agent, curing, and disposal of the compost. This sequence can, however, be varied, especially with the screening step which may come before or after the curing step.

BULKING AGENTS

- Wood Chips
- Bark Chips
- Shredded Tires
- Other Compost

Wet sludge is too compact to allow aerobic activity. Therefore, it is mixed with a bulking agent. Typical bulking agents are wood chips, bark chips, shredded tires, and compost of other organic material. The method of mixing is determined by the type of process being used and will be discussed later.

2 - 4 WEEKS DECOMPOSITION

After mixing and shaping the compost pile, biological activity is allowed to proceed.

This could take from 2 to 4 weeks for major decomposition.

The bulking agent may then be screened from the compost. The compost is then allowed to cure for 30 days.

30 DAY CURING

After 30 days the compost is disposed of via land application.

So much for the basics. Let's look at the two methods and consider their peculiarities.

WINDROW METHOD

The windrow method is the more natural of the two methods. The windrow formation and mixing are done at the same time. First, a layer of bulking agent is laid down 18 to 24 inches deep and 8 to 15 feet wide.

BULKING AGENT

18 - 24" deep

8 - 15' wide

20 - 25% Sludge

2½ - 3 : 1 Bulking Agent to Sludge

Next, a layer of 20 to 25 percent sludge is placed over the bulking agent. The volume of sludge is adjusted so that the mixed ratio of 2½ to 3 parts bulking agent to 1 part sludge is achieved.

After mixing to obtain a homogeneous mixture, a grader or a special windrow turner is used to further mix the material and form a windrow that is 6 to 8 feet wide and 5 to 6 feet tall.

During the next 2 to 4 weeks the pile is turned and monitored for temperature daily.

TEMPERATURE - 50° C.

The temperature should reach at least 50° C. After several days it will begin to drop.

DRY 6 DAYS

The windrow should now be spread and allowed to dry for approximately 6 days.

The bulking agent is then removed by use of a drum screen or similar device.

CURE 30 DAYS

The bulking agent is reused and the compost is placed in a curing pile for further stabilization. This usually requires approximately 30 days.

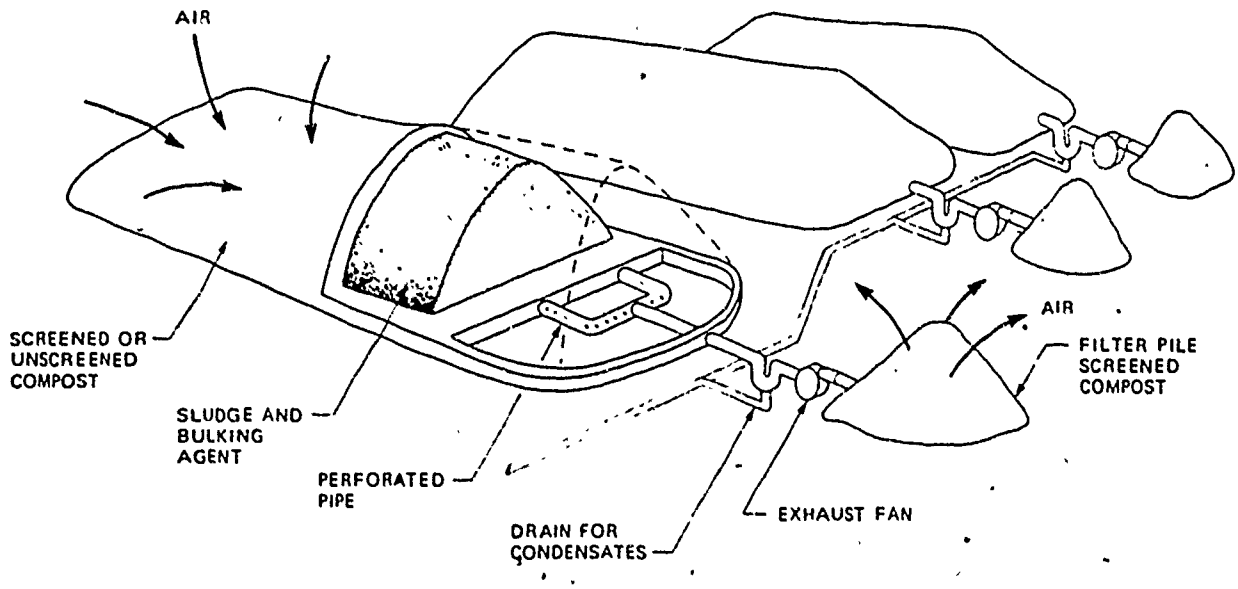
COMPOST

40 - 50% Moisture
40% Volatile Solids

After curing, the compost containing 40 to 50 percent moisture and about 40 percent volatile solids is disposed of by land application.

FORCED AIR DIAGRAM

The forced air static system improves the overall efficiency of the stabilization process by increasing air movement.



CONFIGURATION OF INDIVIDUAL AERATED PILES

4" PIPE

7 FOOT CENTERS

In this system a series of perforated 4 inch pipes are laid on 7 foot centers across the pile. One end of the pipe is plugged and the other is connected to a header and a blower.

BULKING AGENT BASE

6 - 12"

A bulking agent base of 6 to 12 inches is layed over the pipes.

BLEND

40 - 50% Moisture

Using special equipment, sludge and bulking agent are blended together to make a mixture which contains 40 to 50 percent moisture.

PILE

7 - 10 Feet High

Using a front-end loader, the mixture is formed into a pile 7 to 10 feet high and extending 5 feet beyond the ends of the pipe.

The pile is then covered with a layer of bulking agent approximately 12" thick.

The blower draws air through the pile supplying oxygen for stabilization. To reduce air exaust odors a pile of bulking agent filters the air.

OXYGEN

5 - 15%

The blower is used to control the oxygen levels within the pile to about 5 to 15 percent.

TEMPERATURE

60° C.

2 - 5 Weeks

The temperature should now climb to 60°C. and remain there for 2 to 5 weeks; after which time it will begin to fall.

CURE 30 DAYS

Curing requires approximately 30 days. Screening may be done either before or after curing, depending upon the bulking agent and the disposal method. After curing, the compost is placed on the land.

SIDE STREAMS

- Storm Water Runoff
- Excess Water

During the process of decomposition there is the production of sidestreams from two sources. Storm water runoff and excess water from the sludge or bulking agent.

SIDE STREAM TREATMENT

These sidestreams should not be allowed to enter the surface or ground water supplies, but be collected and sent to a stabilization pond or piped to an existing sewage treatment plant for further treatment.

OPERATIONS

- Sludge Characteristics
- Environmental Conditions
- Operational Control

A number of factors affect the composting operation.

These factors can be divided into three catagories: sludge characteristics, environmental conditions, and operational control.

CHARACTERISTICS

- Volatility
- Moisture Content
- Ratio Carbon to Nitrogen
- Heavy Metals

Sludge characteristics would include volatility of the sludge, moisture content, the ratio of carbon to nitrogen, and the presence of heavy metals.

Environmental conditions would include air temperature and precipitation, both amount and frequency.

OPERATIONAL CONTROL

- Lab Analysis
- Physical Observations
- Mechanical Adjustments

The operational control area can further be divided into three sections: routine laboratory analysis, physical observations, and mechanical adjustments.

Routine laboratory analysis would include monitoring the sludge, the compost and curing piles, and the side stream.

The sludge should be monitored for the characteristics mentioned above. The compost and curing piles monitoring should include daily checks for temperature, bi-weekly analysis of oxygen levels, and weekly analysis for bacteria, nitrogen, and percent moisture.

The sidestream must be checked for quanity, BOD, suspended solids, and nitrogen.

Physical observations include checking for offensive odors and changes in color or shape of the compost and curing piles. The presence of offensive odors or sudden changes in shape could indicate a problem with proper oxygen and/or temperature levels.

OPERATIONAL GOALS

- Oxygen
- Temperature

The major operational goal is to maintain proper oxygen and temperature levels. You should keep in mind that temperature levels are usually a reflection of oxygen levels within the compost pile.

SAFETY

The main safety consideration is operator contact with pathogenic organisms and the obvious problems associated with operating heavy equipment.

SUMMARY

In conclusion, we should review what has been covered so far. First, we looked at the theory of the composting process.

Then we discussed the process itself.

We looked at the two major process variations.

And finally, we previewed the monitoring requirements and operational controls.

Remember that composting is a biological process subject to all of the idiosyncrasies of any biological system, but if given proper care, should perform in a predictable manner.

COMPOSTING

References

1. Operations Manual - Sludge Handling and Conditioning, Washington D.C., 1978, U.S. EPA 430/9-78-002.

2. Process Design Manual for Sludge Treatment and Disposal, Technology Transfer, 1979, U.S. EPA 625/1-79-001.

COMPOSTING

WORKSHEET

Place an "X" in the space next to the most correct answer. In some questions there may be more than one answer.

1. In the overall sludge management process, composting is considered a:

   _____ a. volume reduction process.
   _____ b. solids reduction process.
   _____ c. stabilization process.
   _____ d. conditioning process.
   _____ e. All of the above.

2. A typical composting pile should reach a temperature of:

   _____ a. 50 - 55° C.
   _____ b. 55 - 60° C.
   _____ c. 60 - 65° C.
   _____ d. 65 - 70° C.
   _____ e. None of the above.

3. Arrange the five steps below in the typical order for composting of sewage sludge.

   _____ a. Dispose of compost.
   _____ b. Allow decomposition.
   _____ c. Mix with bulking agent.
   _____ d. Screen out bulking agent.
   _____ e. Allow curing.

4. Which materials below are typical bulking agents for composting?

   _____ a. Straw
   _____ b. Wood Chips
   _____ c. Ground Glass
   _____ d. Asphalt
   _____ e. Bark Chips
   _____ f. Shreaded Tires
   _____ g. Shreaded Steel Bars

5. A compost pile will decompose sludge in about:

_____ a. 2 to 3 weeks.
_____ b. 1 to 2 weeks.
_____ c. 3 to 5 weeks.
_____ d. 4 to 5 weeks.
_____ e. None of the above.

6. The ratio of bulking agent to sludge in the windrow method should be:

_____ a. 1.5 to 3.0.
_____ b. 2.0 to 2.5.
_____ c. 2.5 to 3.0.
_____ d. 3.0 to 5.0.
_____ e. None of the above.

7. For best results sludge mixtures applied to the windrow system should be between:

_____ a. 5 and 15% sludge.
_____ b. 20 and 25% sludge.
_____ c. 3 and 8% sludge.
_____ d. 25 and 30% sludge.
_____ e. None of the above.

8. Well composted sludge should have a moisture level between:

_____ a. 40 and 50%.
_____ b. 50 and 70%.
_____ c. 30 and 40%.
_____ d. 20 and 40%.
_____ e. None of the above.

9. The oxygen level in a well operated forced air system should be between:

_____ a. 1 and 3%.
_____ b. 3 and 5%.
_____ c. 5 and 15%.
_____ d. 10 and 20%.
_____ e. All of the above.

10. Identify the sources of the two side streams that are produced during composting:

_____ a. Excess water in the sludge.
_____ b. Domestic sewage.
_____ c. Sanitary sewers.
_____ d. Infiltration.
_____ e. Wash down water.
_____ f. Storm water.
_____ g. None of the above.

11. Within the compost pile, indicate frequency for monitoring the following items by using these symbols: H - hourly; S - shift; D - daily; B - bi-weekly; W - weekly; M - monthly.

_____ temperature
_____ oxygen
_____ bacteria
_____ nitrogen
_____ percent moisture

12. Operational problems may be found by visual inspection. Two visual clues to problems would be:

_____ a. length.
_____ b. shape.
_____ c. color.
_____ d. size.
_____ e. steam.

13. Sludge is actually allowed to decompose in the curing pile for:

_____ a. 15 days.
_____ b. 30 days.
_____ c. 20 days.
_____ d. 60 days.
_____ e. None of the above.

14. Operational controls of a compost pile can be divided into three areas. They would be:

_____ a. laboratory analysis
_____ b. sludge characteristics
_____ c. environmental considerations
_____ d. safety considerations
_____ e. mechanical adjustments
_____ f. cost
_____ g. physical observations

15. Identify three characteristics of sludge that are important to composting.

_____ a. heavy metals
_____ b. volatile suspended solids
_____ c. capillary rise time
_____ d. carbon to nitrogen ratio
_____ e. temperature
_____ f. specific resistance
_____ g. nitrogen to potash ratio
_____ h. percent moisture

16. Two major environmental factors affect composting. They are:

_____ a. precipitation
_____ b. wind direction
_____ c. humidity
_____ d. air temperature
_____ e. wind speed