This instructor's guide contains materials needed to teach a two-lesson unit on the structure and components of facultative lagoons, the biological theory of their operation, and factors affecting their operation. Control testing recommendations, maintenance guidelines, and troubleshooting hints are also provided. These materials include: (1) an overview of the two lessons; (2) lesson plans; (3) lecture outline (keyed to a set of slides which accompany the unit); (4) student worksheet (with answers); and (5) two copies of a final quiz (with and without answers). The first lesson is a review of microbiology, components, and operational mod. The second lesson covers process control, maintenance, and tr. lushing. (JN)
Facultative Lagoons

Instructor's Guide

Linn-Benton Community College
Albany, Oregon
1984
# FACULTATIVE LAGOONS
## Instructor's Guide

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FACULTATIVE LAGOONS

Overview of Lessons

This unit on facultative lagoons covers the structure and components, the biological theory of operation, factors affecting operation, control testing recommendations, maintenance guidelines, and troubleshooting hints. This unit is divided into two lessons. Lesson I is a review of microbiology, components, and operational modes. Lesson II covers process control, maintenance and troubleshooting. Both lessons are accompanied by 35 mm slides.

Lesson Plans

Lesson I - Microbiology, Components, and Operational Modes
- Have students read text material ahead of time if possible.
- Lecture from outline with slide support (40 - 45 min).
- Explain calculation of organic loading rate and seepage rate on chalk board or with overhead (15 - 20 min).

Lesson II - Process Control and Maintenance
- Assign text material ahead of time if possible.
- Lecture from outline using slide support up to slide #2.25 (30 min).
- Present math calculations on chalk board or overhead (15 - 20 min).
- Return to lecture from outline at slides #2.26 (15 min).
- Assign worksheet (20 - 25 min).
- Correct and discuss worksheet (20 - 25 min).
- Assign Final Quiz (20 min).
Lesson Plans Cont.

Other Suggestions

- Supplement with slides of real lagoons and real problems.
- Display examples of weeds and algae for microscopic and non-microscopic observation.
- Collect samples of influent and effluent to compare characteristics.
- Arrange a field trip to a lagoon to make the recommended visual observations. Have students measure D.O., pH and temperature on influent and effluent. Discuss potential flow pattern variations.
- Have samples of trend charts showing D.O., pH, and temperature diurnal fluctuations.
FACULTATIVE LAGOONS

Lesson I - Microbiology, Components, and Operational Modes

Slide #

#1.1 & #1.2 Title and Credit Slides

#1.3 Definition of facultative lagoon

- General structure
- General flow
- General statement of theory

#1.4 Outline slide - Microbiology

#1.5 Major groups of microorganisms that will be found in a facultative lagoon

#1.6 Vertical zonation - aerobic, facultative, and anaerobic

#1.7 Aerobic Zone

- Aeration of this zone accomplished by photosynthesis and wind action

#1.8 Food Supply

- Dissolved and suspended food enters system

- Dissolved food in aerobic and facultative zones, suspended in facultative and anaerobic zones

#1.9 Aerobic stabilization of food

- Bacteria consume food (nutrients) and oxygen to produce new cells and inorganic byproducts

#1.10 Photosynthesis is aerobic zone

- Algae consume inorganic nutrients and use sun's energy to produce new cells and oxygen
Symbiotic interrelationship between bacteria and algae

Dissolved oxygen concentration is a diurnal cycle

Algae consume oxygen all the time but produce oxygen only during the day when the sun is shining

Food supply to anaerobic zone

Anaerobic stabilization

Anaerobic bacteria consume nutrients and use chemically bound oxygen to produce new cells and by-products

Organisms found in each zone

Aerobic - algae, protozoa, and bacteria
Facultative - protozoa, bacteria, and worms
Anaerobic - bacteria

Outline Slide - Components

General appearance

Dikes - material, size, and depth
Lagoon bottom - smooth, flat, leakage
Inlets - edge, enter, and multiple
Outlet Structures -
Surface or sub-surface
Short circuiting

Associated processes

Meters, pre-treatment, and disinfection

Outline Slide - Modes of Operation (Single and Multiple Cell)

Multiple Cell - series and parallel
#1.25 Flow alternatives
   Flow recycle
   Flow transfer

#1.26 Flow alternatives with multiple cell systems

#1.27 Designs for controlling effluent flow
   Continuous
   Controlled
   No discharge

#1.28 Outline slide - Summary

#1.29 Summary of microbial stabilization

#1.30 Summary of components

#1.31 Summary of operational modes
Lesson II - Process Control and Maintenance

Slide #

#2.1 & #2.2

#2.3

#2.4

#2.5

#2.6

#2.7

#2.8

#2.9

#2.10

#2.11

#2.12

#2.13

#2.14

Outline

Title and Credit Slides

Outline slide for Lesson II

Factors affecting treatment - preview slide

Natural, physical, and chemical

Natural - wind

Mixing, D.O., shortcircuiting

Natural - temperature

D.O. vs growth

Natural - rainfall

effects on detention time, concentration and volume

Natural - sunlight

penetration vs D.O.

Physical - flow patterns and depth

Physical - organic overloading

low D.O., short detention time, and poor stabilization

Series - Best for:

warm climates

lower loading

reduced algae in effluent

Parallel - Best for:

cold weather

higher loading

distributing load

When to use recycle and transfer flow patterns

Chemical - D.O., nutrients, and pH
2.15 pH - affected by the presence of carbon dioxide creating carbonic acid

2.16 pH is depressed when bacteria respire because they release carbon dioxide

2.17 pH is raised when algae consume carbon dioxide during photosynthesis

2.18 Outline slide - Control Tests

2.19 Respiration Rate vs. Photosynthesis

Control tests used to maintain balance so that pH does not change radically

2.20 Sampling sites

Influent, effluent, and pond

2.21 Sample for loading at influent

Record flow, run pH, BOD, suspended solids, and temperature tests

2.22 Determine pond status by sampling in the pond itself

Run D.O., temperature, pH; observe microorganisms and run oxygen uptake test

2.23 Determine effluent quality by sampling effluent

Run BOD, suspended solids, residual chlorine, fecal coliforms, and nitrogen and record flow

2.24 Outline slide - Operations and Maintenance; Calculations

2.25 Transition Slide - (Use to introduce calculations and move to overhead or chalk board)

2.26 Outline slide - Operations and Maintenance; Observations, PM Program, and Recordkeeping

2.27 Observations of pond conditions

Color, surface, weeds, and odor
#2.28 Observations of structural conditions
   Buildings, dike, fences, and grounds

#2.29 Preventative Maintenance
   Pumps, grinders, meters, chlorinators

#2.30 Recordkeeping

#2.31 Outline slide - Problems

#2.32 Nuisances - weeds, insects, and odors

#2.33 Nuisances - dike vegetation and burrowing animals

#2.34 Problems in the pond itself
   Excessive algae growth

#2.35 Problems with effluent quality
   High BOD and suspended solids

#2.36 Summary of factors affecting treatment

#2.37 Summary of sampling
FACULTATIVE LAGOONS

Answers to Worksheet

1. The three vertical zones in a facultative lagoon are:
   - aerobic
   - facultative
   - anaerobic

2. Oxygen is supplied to a facultative lagoon by wind and photosynthesis.

3. In the symbiotic relationship between algae and bacteria, algae produce oxygen which is used by the aerobic bacteria. The bacteria produce carbon dioxide as a by-product which is used by the algae.

4. The only control parameter for a single cell lagoon is water depth.

5. A parallel flow pattern is used when there is cold weather, high loadings and to distribute load evenly.

6. A series flow pattern is used when there is warm weather, lower loadings and to reduce algae in effluent.

7. Cold temperatures combined with short days will decrease microbial and algae metabolism.

8. The phenomenon of warm bottom water rising to the surface in the spring when the ice cover melts is called spring turnover.

9. When carbon dioxide accumulates, the pH will decrease.

10. A sparkling green color usually indicates basic pH levels.

11. List the tests that should be performed on the pond influent.

   Flow
   pH
   BOD
   Suspended solids
   Temperature

1-FL-9
12. List the tests that should be done on the pond effluent.

- BOD
- Suspended solids
- Chlorine residual
- Fecal coliforms
- Nitrogen
- Flow

13. List the tests that should be done on the pond itself.

- D.O.
- Temperature
- pH
- Oxygen Uptake Rate
- Microorganism Observation

14. Calculate the organic loading rate for a lagoon with the following characteristics:

- Length = 500 ft.
- Width = 500 ft.
- Influent BOD = 130 mg/l
- Flow = 175,000 gal/day

**Organic Loading, lbs BOD/day** = \( \text{Infl BOD, mg/l} \times \text{Flow, MGD} \times 8.34 \)

\[ = 130 \times 0.175 \times 8.34 \]
\[ = 190 \text{ lbs BOD/day} \]

**Surface Area, acres** = \( \frac{\text{length, ft} \times \text{width, ft}}{43,560 \text{ ft}^2/\text{acre}} \)

\[ = \frac{500 \times 500}{43,560} \]
\[ = 5.74 \text{ acres} \]

**Organic Loading Rate, lbs BOD/acre/day** = \( \frac{\text{Organic Loading, lb BOD/day}}{\text{Surface Area, acres}} \)

\[ = \frac{190 \text{ lb BOD/day}}{5.74 \text{ acres}} \]
\[ = 33 \text{ lb BOD/acre/day} \]
15. Calculate seepage rate for the following conditions:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
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<tbody>
<tr>
<td>Influent</td>
<td>60,000,000 gal/yr</td>
</tr>
<tr>
<td>Effluent</td>
<td>57,500,000 gal/yr</td>
</tr>
<tr>
<td>Precipitation</td>
<td>26 inches/yr</td>
</tr>
<tr>
<td>Evaporation</td>
<td>16 inches/yr</td>
</tr>
<tr>
<td>Surface Area</td>
<td>250,000 sq. ft.</td>
</tr>
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</table>

Convert everything to inch/day:

- **Inf, inch/day**: \(rac{60,000,000 \text{ gal/yr}}{250,000 \text{ ft}^2 \times 228} = 1.05 \text{ inch/day}\)
- **Eff, inch/day**: \(rac{57,500,000 \text{ gal/yr}}{250,000 \text{ ft}^2 \times 228} = 1.03 \text{ inch/day}\)
- **Precipitation**: \(rac{26 \text{ inches/yr}}{365 \text{ days/yr}} = 0.07 \text{ inch/day}\)
- **Evaporation**: \(rac{16 \text{ inches/yr}}{365 \text{ days/yr}} = 0.04 \text{ inch/day}\)

SEEPAGE = [Inf + Prec] - [Eff + Evap]

= \([1.05 + 0.07] - [1.03 + 0.04]\)

= 1.12 - 1.07

= 0.05 inch/day
FACULTATIVE LAGOONS

Final Quiz

Multiple Choice: For each question select the best answer(s) and place an "X" in front of the appropriate letter.

1. Lagoon organic loading is expressed as:
   ___ a. lbs BOD/day
   ___ b. lbs BOD/ft³/day
   ___ c. lbs BOD/acre/day
   ___ d. lbs BOD/1000 ft/day
   ___ e. lbs BOD/gal/min

2. A facultative lagoon system has three zones of treatment. These are:
   (choose 3)
   ___ a. aerobic
   ___ b. intermediary
   ___ c. facultative
   ___ d. anaerobic
   ___ e. extended

3. Oxygen in a facultative lagoon is supplied from two sources. These are:
   (choose 2)
   ___ a. algae
   ___ b. mechanical mixers
   ___ c. diffused air
   ___ d. wind and wave action
   ___ e. windmills

4. Subsurface withdrawal is beneficial as it:
   ___ a. allows the operator to draw off the water layer with less algae concentrations
   ___ b. allows the operator to draw off the bottom waters when 'spring turnover' occurs
   ___ c. allows the operator to exercise depth control
   ___ d. all of the above
   ___ e. none of the above
5. Single cell lagoons have only one process control parameter. This is:
   a. mode change
   b. flow
   c. depth
   d. algae control
   e. weed control

6. Multiple cell lagoons have three possible treatment stages. These are: (choose 3)
   a. secondary stage
   b. tertiary stage
   c. recycle stage
   d. primary stage
   e. anaerobic stage

7. Which treatment stage is similar to a primary clarifier and mixed liquor basin in an activated sludge plant?
   a. recycle
   b. secondary
   c. primary
   d. tertiary
   e. anaerobic

8. Which stage is used for settling?
   a. secondary
   b. recycle
   c. primary
   d. tertiary
   e. anaerobic

9. Which stage is used for algae removal and often nutrient removal?
   a. secondary
   b. recycle
   c. primary
   d. tertiary
   e. anaerobic

10. Multiple cell lagoons also offer 2 modes of operation. These are: (choose 2)
    a. parallel
    b. recirculation
    c. series
    d. reaeration
    e. stabilization
11. The mode usually used for higher loading conditions because it offers longer detention times in the primary stage and better distribution of solids is:
   a. parallel
   b. recirculation
   c. series
   d. reaeration
   e. stabilization

12. "Spring turnover", a normal annual lagoon event:
   a. causes a sudden increase in effluent algae populations.
   b. causes a sudden decrease in effluent turbidity.
   c. causes a sudden increase in effluent turbidity.
   d. has no significant importance on effluent quality.
   e. is a continuous event.

13. A rapid increase in temperature will temporarily:
   a. result in a more turbid effluent
   b. result in a clearer effluent
   c. affect anaerobic metabolism
   d. have no effect on lagoon treatment
   e. none of the above

14. Higher DO's would be expected:
   a. early morning
   b. early evening
   c. midnight
   d. late afternoon
   e. all day

15. An acidic pH condition can be corrected by:
   a. copper sulphate
   b. sodium nitrate
   c. letting the cell rest for a few days
   d. all of the above
   e. none of the above

16. A yellowish-green lagoon appearance is indicative of:
   a. an alkaline condition
   b. an acidic condition
   c. a healthy, normal lagoon
   d. an excessive filamentous condition
   e. the presence of blue-green algae and duckweed
17. During months high in algae concentrations heavy chlorination of the effluent will:
   a. cause a decrease in BOD
   b. cause an increase in BOD
   c. cause an increase in TSS
   d. have no effect on BOD or TSS
   e. increase fecal coliform count

18. Odor control may include:
   a. mode change to parallel
   b. increase DO
   c. masking agents
   d. all of the above
   e. none of the above

19. DO can be supplemented by:
   a. sodium nitrate
   b. aeration devices
   c. recirculation of pond effluent
   d. both a & b
   e. all of the above

20. Cattails can be controlled most effectively by:
   a. pulling in late summer after they bloomed and have colonized
   b. lowering water level and cut when the flowering heads are 1/2 to 2/3 formed in early spring
   c. lowering water level and allowing sheep or goats to graze
   d. both b & c
   e. all of the above
FACULTATIVE LAGOONS

Answers for Final Quiz

Multiple Choice: For each question select the best answer(s) and place an "X" in front of the appropriate letter.

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I-FL-18
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