This document is an instructional module package prepared in objective form for use by an instructor familiar with operation and maintenance of a trickling filter wastewater treatment plant. Included are objectives, instructor guides, student handouts and transparency masters. This is the second level of a three module series and considers types of filters, filter loadings, recirculation ratios, design evaluation and normal and abnormal conditions. References needed are listed on the summary pages at the first of the module. (Author/RH)
INTERMEDIATE TRICKLING FILTERS

Training Module 2.111.3.77

Prepared for the

Iowa Department of Environmental Quality
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Des Moines, Iowa  50319

by

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September, 1977
SUMMARY

Module Number: 113H22
Module Title: Intermediate Trickling Filters

Apx. Time: 20 Hours

Submodule Titles:
1. Types of Trickling Filters and Their Application.
2. Hydraulic Loadings for Filters.
3. Organic Loadings for Filters.
4. Recirculation Ratios - Calculation.
6. Materials and Design of Filters.
7. Abnormal Trickling Filter Performance.
8. Field Work and Visit to Two Trickling Filter Systems.

Overall Objectives: The trainee will be able to calculate organic loadings, recirculation ratios and % removal for trickling filter operations. The trainee will also identify types of filters, normal and abnormal performance by correctly completing 70% or more of the corresponding examination section.

Instructional Aids: Overhead Transparencies
Handouts and Workbooks
Diagrams
Check Lists
Instructor Key Points

Instructor Approach: Submodules 1-7
Lecture and Discussion
Submodule 8
Demonstration, Discussion and Short Lecture

References:
1) WPCF - MOP 11, 1977. "Operation of Wastewater Treatment Plants".
2) Fair, Geyer, and Okun. "Water and Wastewater Engineering".
3) EPA-Technology Transfer Series - "Land Disposal of Sludge, Estimating Laboratory Needs for Wastewater Treatment Plants".
2) R. Antonie, 1976. "Fixed Biological Surfaces—Wastewater Treatment".
11) NAVFAC-1969. "NTTC Course 216, Intermediate Sewage".

ADDITIONAL COMMENT

1) Instructor will follow detailed audio visual presentations and checklists—distributing material to trainee as indicated.

2) Instructor will evaluate trainee objectives accomplishment by (a) field trip assignment, and (b) 50 question examination (written) at end of the basic trickling filter module. All six of the sub-modules use the same type of instructional aids and instructional approach and references.
Module No. 113H22

Module Title
Intermediate Trickling Filters

2 Hours (1 & 2 of 20)

Submodule Title:
Types of Trickling Filters and Their Application.

Objectives:
The trainee will:

1) Describe the four types of trickling filters.
2) Identify normal characteristics of each of the four types of trickling filters.
3) List examples of uses of the four types of trickling filters in wastewater treatment.
4) List expected performance levels for the four types of trickling filters and differences expected among the four.
5) List area communities or industries using each of the four types of trickling filters.
6) Describe the terms: hydraulic loading, organic loading, and wetting rate.
7) Describe energy uses for support systems used for the four trickling filter types.

END
<table>
<thead>
<tr>
<th>Overhead Slide #</th>
<th>Slide Description</th>
<th>Instructor Key Points</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Trickling Filter Does Not &quot;Filter</td>
<td>1) Stress Aerobic, Biological Action From Previous Module-Review</td>
</tr>
<tr>
<td>2</td>
<td>Food (Sewage)</td>
<td>1) Reemphasize aerobic Nature and Process Function of Converting Non-settleable Solids To Settleable Solids (Humus)-Review</td>
</tr>
<tr>
<td></td>
<td>Oxygen (air)</td>
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<td></td>
<td>Bugs (growth on media)</td>
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<tr>
<td>3</td>
<td>BOD/N/P</td>
<td>1) Reemphasize this Concept - Review</td>
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<td>100/2/1</td>
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<tr>
<td>4</td>
<td>Trickling Filter Optimum Conditions</td>
<td>1) No Toxics, Sewer Use Ordinance Enforced and Correct Conditions Essential for Optimum Filter Action (Review)</td>
</tr>
<tr>
<td>5</td>
<td>Trickling Filter Types by Application Rates</td>
<td>1) Read Slide-Refer To WPCF MOP 11, (reference), 2) Discussion of Each Type Will Follow</td>
</tr>
<tr>
<td></td>
<td>1) &quot;Roughing &quot; Filter</td>
<td></td>
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<tr>
<td></td>
<td>2) Low Rate</td>
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<td></td>
<td>3) High Rate</td>
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<td></td>
<td>4) &quot;Super&quot; High Rate</td>
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<tr>
<td>6</td>
<td>Roughing Filter: Rock or Plastic Media Up to 20 Ft. Deep Used to Pretreat High BOD Wastes</td>
<td>1) Word Slide-Define Term-Give Specifics of Unit 2) Explain &quot;mgd&quot; million gallons/day 3) Explain gpd and ft.² 4) Explain the terms hydraulic (flow) and organic (solids) loadings</td>
</tr>
<tr>
<td></td>
<td>Hydraulic Loading 60-180 mgd/acre OR 1400 to 4200 gpd/ft.²</td>
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<td>Organic Loading 100°lb/BOD/day/1000 cu.ft.</td>
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Continued......
<table>
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<tr>
<th>6 cont'd</th>
<th>May or May Not Have Recirculation</th>
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<tbody>
<tr>
<td>7</td>
<td>Examples of Roughing Filter Uses:</td>
</tr>
<tr>
<td></td>
<td>1) Breweries</td>
</tr>
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<td></td>
<td>2) Food Processing Wastes</td>
</tr>
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<td>3) Poultry, Evisceration, Slaughtering Wastes</td>
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<td></td>
<td>4) Milk, Cheese &amp; Whey Processes</td>
</tr>
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<td></td>
<td>5) Toxic Waste Handling (Phenols)</td>
</tr>
</tbody>
</table>

| 8 | Normal "Roughing Filter Performance" What is Expected? |
| 9 | Expected Performance: |
| | 1) Low % Removal of BOD, (40 to 65%) but Very High Total Removal |
| | 2) Low Nitrate Levels Some Nitrite and Ammonia or Ammonium Ion Present |
| | 3) Some Odors (Difficult to Keep Aerobic) Few Flies |
| | 4) Sloughing - Usually Continuous |

| 10 | Where Have You Seen Roughing Filters Used? |
| 5) Stress Recirculation Idea as Key to Optimum Trickling Filter BOD Removal |
| | 1) Stress High BOD of These Industries. Examples of up to 100,000 ppm BOD. |
| | 2) Describe Use of Trickling Filter for Treatment of Phenolic Wastes. Small Levels of Phenol Gradually Increased to Higher Levels. |
| | 1) Ask question (Word Slide) |
| | 1) Show that BOD to Filter of 1000 mg/l with 500 mg/l in Effluent is only 50% Removal, But Represents Many Pounds (4170)/Day of BOD Removed. |
| | 2) Review Nitrification Process $\text{NH}_4^+ \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{NO}_5$ Only Partially Complete |
| | 3) Stress BOD and Oxygen Relationship |
| | 4) Define "Sloughing" and Why Continuous. Redefine "Humus" |

1) Stimulate Class Participation in Where Roughing Filters are Used and What Problems are Observed. |
2) Instructor Should be Familiar With Specific Roughing Filter Installations and Those Close to Area, if Possible.
11. Low Rate Filters:
(Same as "Standard" Rate)
"Usually Rock Media.
.6 to 8 Feet Deep.
Used in Domestic Sewage Treatment.
Hydraulic Loading:
1 to 4 mgd/acre OR
25 to 90 gpd/sq.ft.
Organic Loading:
200 to 1000 lb. BOD/day/
acre ft. OR
5 to 25 lb. BOD/day/1000
cu. ft.
Usually Does Not Have
Recirculation.
Usually Has Dosing Tanks,
or Siphon.

12. Normal/Low Rate Filter
Performance.
What is Expected?

13. Expected Performance:
1) High BOD Removal 85-90%.
2) Seasonal Variation in
Performance.
3) High Nitrate (NO₃) Levels-
Low Nitrite and Ammonia
4) Some Odors—Some Filter Flies
5) Sloughing—Intermediate
and Seasonal in Nature.

14. Where are Standard or Low-Rate
Trickling Filter Plants Located
Near Here?

1. Discuss Problems with
Rock-Breaking, Clogs, etc.
2. Define "Domestic" as 204
ppm BOD, 0.17 pounds/
capita/day.
3. Answer questions about
Hydraulic and Organic Loads
(Terminology Only).
4. Dosing Siphon Means
Standard Rate

1. Ask Question (Word Slide)

1. Stress Seasonal and
Uncontrollable Operation.
2. Re-emphasize Nitrification.
3. Odor Control—Good
Housekeeping—Aerobic
Conditions Maintained.
4. Fly Control Discussed Later.
5. Humus and "Slugs"
Obtained—(Not a particular
problem unless snails—
discussed later).

1. Stimulate Class Partici-
pation in Locations,
Problems, Solutions, etc.
2. Instructor Should Be
Familiar With the Plants
In the Area.
| 15 | "High Rate Trickling Filters"
|    | Usually Rock Media.
|    | 3 to 8 feet Deep.
|    | Used in Domestic and Industrial Waste Treatment.
|    | Hydraulic Loading: 5 to 40 mgd/acre
|    | 100 to 900 gpd/ft.
|    | Organic Loading: 1000 to 1300 lb./BOD/day/acre ft. OR 25 to 300 lb. BOD/day/1000 ft. 3
|    | Almost always has Recirculation.
|    | No Dosing Tanks.
|    | Requires Pumping and Electrical Costs.

| 16 | Normal "High Rate" Filter Performance. What is Expected?
| 17 | Expected Performance:
|    | 1) Good BOD Reduction 85-90%
|    | 2) Seasonal Variations Not as Great as Low Rate but Still Exist.
|    | 3) Good Nitrification, However, Some Nitrite and Ammonia Present.
|    | 4) Few Odors and Few Flies, But Depends Upon Operational Control.
|    | 5) Sloughing—Continuous—Seasonal Variation

1) Stress Difference Between Low and High Rate Filters
2) Answer Questions on Concept of Hydraulic and Organic Loading.
3) Discuss Energy Considerations for High vs Low Rate Filters, Pumping & Electricity Costs

1) Ask Question (Word Slide)

1) Use Word Slides and Stress Key Points.
| 18 | Where Are "High Rate" Trickling Filter Plants Located? | 1) Word Slide-Ask Question  
2) As Before- Locations, Problems, Solutions  
3) Instructor Familiar With Area Plants. |
|---|---|---|
| 19 | "Super High Rate" Trickling Filters:  
Usually Plastic Media.  
Up to 40 feet  
Used in Many Domestic and Industrial Applications.  
Hydraulic Loading:  
15 to 90 mgd/acre.  
350 to 1000 gpd/ft.²  
Organic Loading:  
300 lb.BOD/day/1000 ft.³  
Usually Has Recirculation.  
No Dosing Tanks.  
Requires Pumping and Electrical costs.  
Forced Ventilation Often Used.  
"Wetting Rate" of 0.6 gal/min/ft²  
Important in Many Plants. | 1) Stress These as The Trickling Filters Being Installed at Most New Trickling Filter Plants.  
2) Plastic Forms Good Surface for Growth.  
3) Emphasize Hydraulic and Organic Loads  
4) Stress "Wetting Rate" Concept.  
5) Stress Energy Concept of Electrical and Pumping Costs and Forced Ventilation Costs (where used). |
| 20 | Normal Performance of "Super High Rate Filters"  
What is Expected? | 1) Ask Question, Word Slide |
| 21 | Expected Performance for "Super High Rate Filters".  
What is Expected?  
1) Good BOD Removal 65-90% - Depends Upon Loading  
2) Some Seasonal Variation  
3) Intermediate to Excellent Nitrification-Depends on Loading.  
4) Few Odore, Few Flies  
5) Sloughing Continuous (Seasonal)  
6) Media Breaking and Clogging Less common than Rock Media  
7) Towers (40 ft.) Often Used- Filter Ventilation Can Be A Problem. - If Septic-Problem! | 1) Stress Loadings vs Performance for Each Item
|   | Where are "Super High Rate" Filters Located? | 1) Ask Question as Before  
<table>
<thead>
<tr>
<th></th>
<th>2) Instructor Input</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>23</td>
<td>What are the Four Basic Types of Trickling Filters?</td>
<td>1) Ask Question</td>
</tr>
</tbody>
</table>
|   | Right!  
|   | 1) "Roughing Filter"  
|   | 2) Low Rate or Standard Filter  
|   | 3) High Rate Filter  
|   | 4) "Super High Rate" Filter |   |
| 25 | How do We Classify Filters? | 1) Word Slide |   |
|   | Right!  
|   | 1) Rock or Plastic Media  
|   | 2) Depth  
|   | 3) Uses  
|   | 4) Hydraulic Loading  
|   | 5) Organic Loading  
|   | 6) Recirculation  
|   | 7) Support Systems - Pumps, Forced Ventilation, etc.  
|   | 8) Expected Performance |   |
| 27 | Questions? | 1) Instructor Use Remaining Time with Questions and/or Discussion |   |

END
### SUMMARY

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
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<tr>
<td>113/22</td>
<td>Intermediate Trickling Filters</td>
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<th>Apx. Time</th>
<th>Submodule Title</th>
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<tr>
<td>Hours 3 &amp; 4</td>
<td>Hydraulic Loadings for Filters</td>
</tr>
<tr>
<td>2 Hours</td>
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#### Objectives:

The Trainee Will:

1. Calculate areas of a circle and rectangle.
2. Calculate trickling filter acres when given rectangular and circular measurement of length.
3. Identify units of flow commonly used in trickling filter application.

#### Instructor Aids:

- Overhead Projector with Acetate Roll and Felt Tip Marker (Alternate-use chalk board).
- Handout and Workbook
- One Overhead Transparency

#### Instructor Approach:

Instructor, seated, will write and work examples on overhead projector acetate film. Have trainee work examples in workbook.
Instructor will be seated at overhead projector and lead discussion and trainee work as follows.

<table>
<thead>
<tr>
<th>Item</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Hydraulic Loading</strong> - volume/time/area</td>
<td>Explain concept of hydraulic load - optimum removal with correct load</td>
</tr>
<tr>
<td></td>
<td>Example</td>
<td>Explain area is square units</td>
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<td>gal/minute/ft.$^2$</td>
<td>Explain foot x foot gives ft.$^2$ or sq. ft. same as feet x feet = sq. ft.</td>
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<td>or</td>
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<td>million gal/day/acre</td>
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<td>mgd/acre</td>
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<td>or</td>
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<td>gallons/day/Sq. ft.</td>
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<td>Questions?</td>
<td>Explain: gpm, mgd, cfs, as terms of flow</td>
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<td>Item #</td>
<td>Instructor Writes the Following:</td>
<td>Instructor Key Points of Emphasis:</td>
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<tr>
<td>2</td>
<td>1 acre = 43,560 ft.²</td>
<td>Length x width gives surface area</td>
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<td>or</td>
<td>or</td>
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<td></td>
<td>208.7 ft.</td>
<td>208.7 × 208.7 = 43,560 ft.²</td>
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<td>Allow apx. 3 or 4 minutes</td>
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<td></td>
<td></td>
<td>to have trainee get answer by</td>
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<td></td>
<td></td>
<td>slide rule, calculator, hand math</td>
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<tr>
<td></td>
<td>Step 1</td>
<td>Emphasize importance of units</td>
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<tr>
<td></td>
<td>Now - calculate how many</td>
<td>and factor cancellation</td>
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<td></td>
<td>acres are in surface with a</td>
<td>concept. e.g.</td>
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<tr>
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<td>length of 500 ft. and a width</td>
<td>ft.² = acres</td>
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<td></td>
<td>of 500 ft.</td>
<td>ft.²/acre</td>
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<td>500 ft. x 500 ft.</td>
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<td></td>
<td>Area = length x width</td>
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<td></td>
<td>area = 500 ft. x 500 ft.</td>
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<td>area = 250,000 ft.²</td>
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<td>Step 2</td>
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<td></td>
<td>1 acre = 43,560 ft.²</td>
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<td>so</td>
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<td></td>
<td>500,000 ft.² / 43,560 ft.²/acre</td>
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<td></td>
<td>11.5 acres</td>
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<td>Questions?</td>
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<p>| 14 |</p>
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<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis:</th>
</tr>
</thead>
</table>
| 3      | To calculate surface area of a rectangle:  
Area = length x width  
Area = sq. units  
sq. ft.  
acres  
meters\(^2\)  
inches\(^2\)  
Another Example:  
A trickling filter 25 ft. long and 20 ft. wide, has what surface area?  
Solution:  
\[ A = l \times w \]  
\[ A = 25 \text{ ft.} \times 20 \text{ ft.} \]  
\[ A = 500 \text{ ft.}^2 \]  
or  
\[ 500 \text{ sq. ft.} \]  
Questions? | Define rectangle  
ft. x ft. = ft.\(^2\)  
or  
sq. ft. |
<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes the Following:</th>
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<tbody>
<tr>
<td>4</td>
<td>Ask students to find area of a trickling filter 200 ft. long and 400 ft. wide. Also, how many acres?</td>
<td>Wait 5 minutes after giving problem - give individual help - then work with overhead.</td>
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<tr>
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<td><strong>Solution</strong></td>
<td>Look for &quot;lost look&quot; on faces or those not working problem.</td>
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<td></td>
<td>$A = lw$</td>
<td>Two concepts (a) surface area of rectangle and (b) calculation of acres - the point</td>
</tr>
<tr>
<td></td>
<td>$A = 200 \text{ ft.} \times 400 \text{ ft.} = 80000 \text{ ft}^2$ and $80,000 \text{ ft}^2 = 1.8 \text{ acres}$</td>
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<tr>
<td>Item #</td>
<td>Instructor Writes the Following:</td>
<td>Instructor Key Points of Emphasis:</td>
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</table>
| 5      | **Draw a circle**<br><br>**Show radius and diameter**<br><br>**Area = \( \pi R^2 \)**<br>**\( \pi = 3.14 \) (no units)**<br>**R = radius**<br>**R \times R = square units**<br>**so**<br>**A = 3.14 \times R \times R**<br>**or**<br>**A = 3.14 \times \text{ft.}^2**<br>**Other area units**<br>**Example:**<br><br>**d = 60 \text{ ft.}**<br>**Trickling filter diameter = 60 \text{ ft.}** Find the area in square feet and the acres.<br>**Step 1**<br><br>**d = 2R**<br>**60' / 2 = 30 \text{ ft.} = radius**<br>**radius = 30 \text{ ft.}**<br><br>**A = \pi R^2**<br>**so**<br>**A = 3.14 \times 30 \times 30 \text{ ft.}^2**<br>**Work Out**<br>**Check to see if decimals can be handled.** | **R = radius = \( \frac{1}{2} \times d \)**<br>**d = diameter = 2 \times R**<br><br>**Can determine in a plant by (a) estimating walking, etc. (b) tape measure and (c) blueprints (scale)**<br><br>"Pie are round, cornbread is square. Corny, by it works!"
Item 5 continued

3.14
x 30'
104.20 ft.

and

104.2 ft.
3.14
x 30 ft.
3126.0 sq. ft.

Answer = 31260 ft.²

Questions?

Calculate Areas?

\[
\frac{3126 \text{ ft.}^2}{43560 \text{ ft.}^2/\text{acre}} = 0.72 \text{ acres}
\]

Questions?

One More Example:

Trickling Filter with 200 ft. diameter is how many surface acres?

\[ A = \pi R^2 \]

\[ A = 3.14 \times 100' \times 100' \]

Area = 31,400 ft.²

\[ \text{Acres} = \frac{31,400 \text{ ft.}^2}{43,560 \text{ ft.}^2/\text{acre}} = .72 \text{ acres} \]

Questions?
### Instructor Writes the Following:

**Hydraulic Loading:**

\[
\text{volume} / \text{time} / \text{area}
\]

**IF:**

2 gal. flowed to a filter each minute that was 1 ft. long x 1 foot wide, what is the hydraulic loading?

- volume = 2 gal.
- time = 1 minute
- area = 1 ft. \(\times\) 1 ft. = 1 ft.\(^2\)

so

- hydraulic load = \(2 \text{ gpm/ft.}^2\)

or

1 million gallons flowed to a filter 208.7 ft. long and 208.7 ft. wide. What hydraulic loading in mgd/acre and gpd/ft.\(^2\) went to the filter?

1 mgd = 1,000,000 gpd

**Step 1**

- \(\text{hydraulic load} = \frac{\text{volume/time/area}}{1,000,000 \text{ gpd/day}}\)

- Area = 208.7 ft. \(\times\) 208.7 ft.

Area = 43,560 ft.\(^2\)

so

- \(\text{Loading} = \frac{1,000,000 \text{ gal/day}}{43,560 \text{ ft.}^2}\)

Loading = 22.9 gpd/ft.\(^2\)

- \(\frac{43,560 \text{ ft.}^2}{? \text{ Acres}}\)

- \(\frac{43,560 \text{ ft.}^2}{\text{acre}} = 1 \text{ acre}\)

So loading is

1 mgd/acre \(\text{(low rate)}\)

**Questions?**

<table>
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<th>Instructor Key Points of Emphasis</th>
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Compare to minimum "wetting rate" for plastic media filters.

Fixed nozzles:

Review this conversion

Ask if low or high rate (Low)
<table>
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</table>
| 7.    | Calculate the hydraulic loading to a trickling filter as mgd/acre and gpd/ft.² If the filter is 100 ft. long and 100 ft. wide and receives 2,500,000 gal of sewage each day? **Solution:**   
  **Step 1**  
  2,500,000 gal/day is 2.5 MGD   
  **Step 2**  
  Area = 100' x 100' = 10,000 ft²  
  Acre = 10,000 ft² / 43,560 ft²/acre = 0.23 Acres  
  2.5 MGD / 0.23 Acre  
  or  
  2.5 MGD = 11 MGD/acre  
  **Step 3**  
  find gpd/ft²  
  2,500,000 gpd  
  Area = 10,000 ft²  
  so  
  2,500,000 gpd / 10,000 ft² = 0.250 gpd/ft²  
  **Low Rate or High Rate?**  
  **Questions?** | **Write the Problem.**  
  **Wait 5 minutes**  
  **Assist non-workers or confused trainees.**  
  **High Rate (See Table)** |
<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis</th>
</tr>
</thead>
</table>
| 8      | Given a circular filter diameter of 200 ft. and flow = 5,000,000 gpd  
Find:  
Hydraulic loading in gpd/ft.² and mgd/acre  
Also, what type of filter is it? Low? High? Super High?  
Solution:  
Hydraulic Loading:  
5,000,000 gpd = 5 MGD  
diameter = 200 ft.  
radius = 200 ft. = 100 ft.  
\[ A = \pi R^2 \]  
\[ A = 3.14 \times 100\text{'} \times 100\text{'} = 31,400\text{ft}^2 \]  
so  
Loading in gpd/ft.² is:  
\[ \frac{5,000,000 \text{ gpd}}{31,400 \text{ ft.}^2} = 159 \text{ gpd/ft.}^2 \]  
Loading in MGD/acre  
MGD = 5.0  
Acre = ?  
\[ \text{Area} = 31,400 \text{ ft.}^2 \]  
\[ \text{Acres} = \frac{31,400 \text{ ft.}^2}{43,560 \text{ ft.}^2/\text{acre}} = 0.72 \text{ Acres} \]  
\[ \text{Loading} = \frac{5.00 \text{ MGD}}{0.72 \text{ acres}} \]  
\[ \text{Loading} = 6.5 \text{ MGD/acre} \]  
Low or High Rate? (High)  
Questions? | Give Problem.  
Wait 5-10 minutes.  
Help Problem Trainees.  
Work Together Using Projector  
Review this step |
If time permits - have trainees work the following:

<table>
<thead>
<tr>
<th>Problem #</th>
<th>Details</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flow = 3 MGD&lt;br&gt;Diameter of T.F. = 235 ft.&lt;br&gt;Find MGD/acre&lt;br&gt;What type of filter?</td>
<td>3.0&lt;br&gt;Low</td>
</tr>
<tr>
<td>2</td>
<td>Flow = 3 MGD&lt;br&gt;Diameter = 100 ft.&lt;br&gt;Find MGD/acre&lt;br&gt;What type of filter</td>
<td>16.7&lt;br&gt;High</td>
</tr>
<tr>
<td>3</td>
<td>Flow = 10,000,000 gpd&lt;br&gt;Diameter = 160 ft.&lt;br&gt;Find gpd/ft.²&lt;br&gt;What type of filter</td>
<td>497 gpd/ft.²&lt;br&gt;Super High</td>
</tr>
<tr>
<td>4</td>
<td>How large should 2 trickling filters be to handle 10 MGD of sewage if they are designed as low rate filters? (acres &amp; diameters)</td>
<td>[ \frac{10 \text{ mgd}}{2} = 5 \text{ mgd} \text{ each} ]&lt;br&gt;So, no smaller than 1.25 acres each or 132 ft. diameter</td>
</tr>
</tbody>
</table>
### SUMMARY

<table>
<thead>
<tr>
<th>Module No.</th>
<th>Module Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>113H22</td>
<td>Intermediate Trickling Filters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apx Time</th>
<th>Submodule Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hours</td>
<td>Organic Loadings for Filters</td>
</tr>
<tr>
<td>Hours 5 &amp; 6</td>
<td></td>
</tr>
</tbody>
</table>

#### Objectives:

The trainee will:

1. Calculate volumes of rectangles and cylinders.
2. Calculate Trickling Filter volumes when given filter measurements.
3. Calculate organic loadings as commonly found in trickling filters.
4. Identify and calculate "acre feet"
5. Convert mg/l to pounds/day, given flow.

#### Instructor Aids:

- Overhead projector with acetate roll and felt tip markers (alternate: use chalkboard.
- Handout and workbook.
- One overhead transparency.

#### Instructor Approach:

Instructor seated, will write and work examples on overhead projector acetate film. Have trainee work examples.
<table>
<thead>
<tr>
<th>Item</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis</th>
</tr>
</thead>
</table>
| 1    | **Organic Loading (Food)**  
      pounds of BOD/day/volume  
      Examples:  
      lbs.BOD/day/acre-foot  
      and  
      lbs.BOD/day/1000 cu.ft.  
      Questions? | 1) Food to media volume assures optimum operation  
2) Too much is poor  
3) Too little is poor  
4) Septic or poor growth |
<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis:</th>
</tr>
</thead>
</table>
| 2      | Acre = 43,560 ft²  
1 acre foot = 43,560 ft²  
\[
\text{Example:}
\]
\[
\text{Trickling Filter is 230 ft. in diameter (118 ft. radius) and 7 feet deep. How many acre feet does it contain?}
\]
\[
\text{Solution:}
\]
\[
\text{Area} = \pi r^2
\]
\[
A = 3.14 \times 118' \times 118'
\]
\[
A = 43,721 \text{ sq. ft.}
\]
\[
\text{Acres} = \frac{43,721 \text{ ft.}^2}{43,560 \text{ ft.}^2/\text{acre}} = 1.0 \text{ acre}
\]
\[
\text{Acres} \times \text{ft. deep} = \text{acre feet}
\]
\[
1.0 \times 7.0 = 7.0 \text{ acre feet}
\]
|      | 1) Review                                | 2) Work together with class |
|      |                                          | 3) Allow class 5 minutes to work, then work together |
|      |                                          | 208.7' |
|      |                                          | 208.7' |
|      | Contents of box = 1 acre/foot            | 1' deep |
|      | (1 acre foot=43,560 cu. ft.)            |        |
|      | Example 2:                              | 100' x 100' |
|      | A square filter 100 ft. long and 10 ft. deep contains how many acre feet? | Area = 1 x w | Area = 10,000 sq. ft. |
|      |                                          | Acres = 10,000 ft² |
|      |                                          | 43,560 ft²/acre |
|      |                                          | Acres = 0.23 |
|      |                                          | Acre feet = acres x ft. deep |
|      |                                          | acre feet = 0.23 x 10 = 2.30 ac. ft. |
Instructor Writes the Following:

<table>
<thead>
<tr>
<th>Item</th>
<th>Organic Loading requires pounds of BOD₅/day. Given mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>lbs. BOD₅ = 8.34 x mgd x mg/l BOD/day</td>
</tr>
</tbody>
</table>

Example:
Influent to filter is 135 ppm BOD₅. The flow is 1 MGD. The pounds/day of BOD is found:

\[ \text{lbs/day BOD₅} = 8.34 \times 135 \text{ mg/l} \times 1 \text{ MGD/day} \]

or

\[ \text{lbs/day BOD₅} = 1126 \text{ lbs/day} \]

Example 2:
Influent to filter is 180 mg/l. What is lbs. BOD/day for a 3 MGD flow?

Solution:

\[ \text{lbs. BOD₅} = 8.34 \times 3 \text{ MGD} \times 180 \text{ mg/l/day} \]

\[ \text{lbs./day} = 4,504 \]

Questions?

Instructor Key Points of Emphasis:

1) This may be a review for some trainees and new material for others.

2) Just to be sure

3) Allow 5 minutes to work; then work together.
<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes the Following:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Organic Loading is lbs. BOD5/day per acre foot or per 1000 cu. ft. of filter.</td>
</tr>
</tbody>
</table>

**Example 1:**

1126 lbs. of BOD/day is loaded (applied) to our 236' filter, 7' deep (7 acre ft.). What is the loading?

1126 lbs. BOD/day per acre ft. or

\[
\frac{1126 \text{ lbs. BOD/day}}{7 \text{ acre ft.}} = 161 \text{ lbs BOD/day/acre ft.}
\]

(low rate filter and low loading)

**Example 2:**

If 4,504 lbs. BOD is applied to the square filter 100' each side, what is the organic loading in lbs. BOD/day/acre ft.? And what type filter is this?

**Solution:**

\[
\frac{4,504 \text{ lbs/day}}{2.3 \text{ acre ft.}} = 1958 \text{ lbs/day/acre ft.}
\]

(Super High Rate Filter)

or

3 MGD - flow for 0.23 acres

\[
3 \text{ MGD} = \frac{1370 \text{ mgd/acre'ft.}}{0.23 \text{ acres}}
\]

Hydraulic load means a high rate with abnormal load (industry?) of BOD to the filter.

Questions?

---

1) Review

2) Allow 5 minutes to work, then work together.

3) Discuss which type of industry might give this overload.
<table>
<thead>
<tr>
<th>Item</th>
<th>Instructor Writes the Following:</th>
<th>Instructor Key Points of Emphasis:</th>
</tr>
</thead>
</table>
| 5    | Another way of expressing organic loading is: lbs.BOD5/day 1000 cu.ft. of filter. So To find volume of filter (cu. ft.) just find area (as before) and multiply by depth. Or V in ft.$^3$ = Area, ft.$^2$ x ft. deep. Example 1: Filter with diameter of 236 ft. (area of 43,721 ft.$^2$) that is 7 ft. deep has a volume of? V = area x depth or V = 43,721 ft.$^2$ x 7 ft. V in ft.$^3$ = 306,047 ft.$^3$ or 306,047 ft.$^3$ = 306 units of 1000 ft.$^3$/unit 1000 ft.$^3$. To find organic loading in lbs.BOD5/day 1000 cu. ft. Simply Divide: $\frac{1126 \text{ lbs.BOD5/day}}{306 \text{ units of 1000 ft}^3}$ or $1126 = 3.68 \text{ lbs.BOD5/day per 1000 ft}^3$. So (Low rate filter with low BOD loading) Questions? Continued: ......... Expect Some
An example, to be sure.

4,504 lbs. BOD5/day
(example above)

applied to the square filter
100 ft. each side, that is 10 ft. deep.

Find (1) the organic load in
pounds of BOD5/day
1000 cubic feet
(2) the type of filter (high, low, super high)
(3) is it correctly loaded?
Yes?
No?
Why?

Solution:

Step 1

\[ V = \text{Area}(ft^2) \times \text{depth in ft.} \]

\[ V = 10,000 \text{ ft}^2 \times 10' = 100,000 \text{ ft}^3 \]

To find units of 1000 cu.ft.

\[ 100,000 \text{ ft}^3 = 100 \text{ units of } 1000 \text{ cu.ft.} \]

Step 2

Organic loading = 
lbs. BOD5/day
units of 1000 cu.ft.

Organic Loading = 
4,504 lbs. BOD5/day
100 units of 1000 cu.ft.

Organic Loading = 
45 lbs. BOD5/day
1000 cu.ft.

Filter is high rate or super high rate (loaded very low)

Questions?

Allow 5 minutes to work, then work together.

Show Overhead Slide #1
<table>
<thead>
<tr>
<th>Type of Filter</th>
<th>Organic Loading-units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lbs. BOD/day/acre ft.</td>
</tr>
<tr>
<td>Low Rate</td>
<td>200-1000</td>
</tr>
<tr>
<td>High Rate</td>
<td>1000-1300</td>
</tr>
<tr>
<td>Super High Rate</td>
<td></td>
</tr>
</tbody>
</table>

* MOP II-WPCF Guidelines (1977)
If time permits, have trainee work the following examples:

<table>
<thead>
<tr>
<th>Problem #</th>
<th>Details</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 1         | Flow = 3 MGD  
Diameter = 236 ft  
Depth = 10 ft  
BOD = 100 mg/l to filter  
Find lbs.BOD/day/acre foot  
What type of filter? | 250 lbs.BOD<sub>5</sub>/day/acre ft.  
Low Rate |
| 2         | Flow = 100 MGD  
5 Filters loaded equally  
BOD = 130 mg/l to filters  
Find the area of each filters  
to give a loading of 10 lbs.  
of BOD/day/1000 ft<sup>3</sup> of media | 2,168,000 ft<sup>3</sup> for each of the  
5 filters: each 232 ft. square  
and 40 ft. deep.  
Super Big! |
| 3         | Flow = 2 MGD  
BOD = 400 ppm to filter  
Filter = 40 ft. sq. and  
20 ft. deep.  
What type of filter  
is this and is it overloaded? Why? | Super High Rate (Plastic)  
Organic Load is:  
6672 lbs/day = 209 lbs/BOD<sub>5</sub>  
32 units of 1000  
Organic load OK  
Hydraulic load:  
2,000,000 gpd = 1250 gpd  
1600 ft<sup>2</sup> per ft<sup>2</sup>  
Hydraulic loading overloaded (Slightly) |
# SUMMARY

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
<th>Submodule Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>113H22</td>
<td>Intermediate Trickling Filters</td>
<td>Recirculation Ratios - Calculation</td>
</tr>
<tr>
<td>Apx. Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours 7&amp;8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Objectives

The Trainee Will:

1. Recognize and list the reasons for using recirculation in a trickling filter operation.
2. List common BOD concentrations to a trickling filter and corresponding recirculation ratios.
3. Define recirculation rate and calculate corresponding numerical values.
4. Demonstrate a working knowledge of operational control for a trickling filter by completion of an example problem.

## Instructor Aids:

- Overhead projector with acetate roll and felt tip marker (alternate-use chalkboard)
- Handout and workbook
- Overhead transparencies

## Instructor Approach:

Instructor will present overhead slides and work examples. Have trainee work examples in workbook.
**LESSON OUTLINE**
Hours 7 & 8 of 20
Recirculation Ratios - Calculations

<table>
<thead>
<tr>
<th>Item #</th>
<th>Overhead or Write</th>
<th>Key Instructor Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recirculation - Why?</td>
<td>Ask question, lead discussion</td>
</tr>
</tbody>
</table>
| 2      | Recirculation:  
1) Used for high or super high filters  
2) Improves hydraulic and organic loadings (if needed)  
3) Improves efficiency | Review Filter types  
Review wetting rate, BOD, and hydraulic loading.  
Will cover in next lesson, exact amount |
| 3      | Typical BOD Removal:  
Primary 35%  
Influent 204 mg/l BOD  
(.17 lbs/capita/day and 100 gpd)  
What is normal BOD to filter? | Review these concepts.  
Recalculate if req'd.  
pounds = 8.34 x mgd x mg/l  
Have trainees answer. |
| 4      | Right! 130-135 mg/l  
65% of 204 = 132 | Review, word slide |
| 5      | Higher the BOD....  
Greater the recirculation! | Word slide |
| 6      | EPA Table  
Recirculation rate for maximum BOD of settled wastewater  
| **BOD mg/l** | **1/Recirculation Ratio** |
| 130    | 1:1 |
| 170    | 2:1 |
| 220    | 3:1 |
| 260    | 4:1 |
Recirculation ratio defined as total number of times wastewater returned plus 1.

Example:

<table>
<thead>
<tr>
<th>Recirculation Ratio</th>
<th>mgd. Total Flow</th>
<th>mgd. Recirculation Hydraulic Load to Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>(1+1)x5=10</td>
<td></td>
</tr>
<tr>
<td>2:1</td>
<td>(1+2)x5=15</td>
<td></td>
</tr>
<tr>
<td>3:1</td>
<td>(1+3)x5=20</td>
<td></td>
</tr>
<tr>
<td>4:1</td>
<td>(1+4)x5=25</td>
<td></td>
</tr>
<tr>
<td>5:1</td>
<td>(1+5)x5=30</td>
<td></td>
</tr>
</tbody>
</table>

Questions?
What hydraulic loading would a 3 mgd flow with a 4 to 1 recirculation ratio be?

25 mgd - Right!
OR
Flow = 3mgd x (1+4)
Flow = 3mgd x 5 = 15 mgd

What BOD range would you expect the trickling filter influent to be?

Right! apx. 260 mg/l

(Write on overhead)
If a wastewater flow of 8 mgd contains 20,100 pounds of BODs, what total flow in mgd would you expect to treat? Why?
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Work on overhead, seated</td>
</tr>
<tr>
<td></td>
<td>$1 \text{ lb} \cdot \text{BOD}_5/\text{day} = 8.34 \times \text{mgd} \times \text{mg/l BOD}_5$</td>
</tr>
<tr>
<td></td>
<td>$20,100 \text{ lb/day} = 8.34 \times 8 \text{ mgd} \times \text{mg/l BOD}_5$</td>
</tr>
<tr>
<td></td>
<td>$20,100 \text{ lb/day} = \text{mg/l BOD}_5$</td>
</tr>
<tr>
<td></td>
<td>and</td>
</tr>
<tr>
<td></td>
<td>$20,100 = 304 \text{ mg/l BOD}$</td>
</tr>
<tr>
<td></td>
<td>66.7%</td>
</tr>
<tr>
<td></td>
<td>Questions?</td>
</tr>
<tr>
<td>14</td>
<td>Continue to work and review</td>
</tr>
<tr>
<td></td>
<td>304 mg/l BOD to filter</td>
</tr>
<tr>
<td></td>
<td>optimum recirculation is</td>
</tr>
<tr>
<td></td>
<td>8 opting total flow expected:</td>
</tr>
<tr>
<td></td>
<td>Flow $= 8 \text{ mgd} \times (&gt; 4 + 1)$</td>
</tr>
<tr>
<td></td>
<td>Flow $= &gt; 40 \text{ mgd}$</td>
</tr>
<tr>
<td></td>
<td>Questions?</td>
</tr>
<tr>
<td>15</td>
<td>Word slide, summary</td>
</tr>
<tr>
<td></td>
<td>Remember</td>
</tr>
<tr>
<td></td>
<td>higher BOD-higher recirculation</td>
</tr>
<tr>
<td></td>
<td>high rate filters of super high</td>
</tr>
<tr>
<td></td>
<td>improve loading</td>
</tr>
<tr>
<td></td>
<td>improve efficiency</td>
</tr>
</tbody>
</table>
|   | \begin{align*}
|   | \text{pounds} &= 8.34 \times \text{mgd} \times \text{mg/l} \\
|   | \text{day} \\
|   | \text{Total flow} &= \text{influent flow} \times \text{recirculation ratio} + 1 \\
|   | \% \text{Removal} &= \frac{\text{in} - \text{out}}{\text{in}} \times 100 \\
|   | Questions? |
STUDENT WORK EXERCISE
1 Hour (Hour 8)
Recirculation Ratios Includes Hydraulic & Organic Loadings

Problem 1:

Given flow to plant = 12 mgd
Plant influent total lbs. BOD5/day = 48,000
% Removal in primary plant = 38%
Plant has four high rate filters with 300 ft. diameters
Recirculation is practiced. Plant is mechanically in good working order.

Question: What recirculation ratio would you recommend for best plant performance? Why?
Also
1) What is the number of pounds of BOD5/day to each of the filters?
2) What is the mg/l BOD to each filter?
3) What is the total flow into all four filters in mgd?
4) What is the hydraulic loading (after recirculation) for each filter?
5) What is the organic loading (after recirculation) for each filter?

(You have up to 1 hour to finish)
If you finish early, see the instructor to check your answer

Problem 2: (For Fast Finishers of Problem 1)

Given the following:
BOD into plant = 1000 mg/l
Primary removal = 52%
Plant flow = 1 mgd
Filters (there are 2) plastic media
Towers 40 ft. wide and 20 ft. long and 20 ft. deep

1) Would you operate the filters in parallel or series? Why?
2) What recirculation rates would you use in your operation? Why?
SUMMARY

Module Number
113H22

Module Title
Intermediate Trickling Filter

Apx. Time
2 Hours
Hours 9 & 10

Submodule Title
Measuring Trickling Filter Performance

Objectives

- The Trainee will:

  1) Recognize and list the performance of a trickling filter using the parameters of settleable solids, suspended solids, dissolved oxygen, BOD/COD, nitrogen species, and pH.

  2) Calculate a materials balance for an example trickling filter plant.

  3) Calculate the estimated efficiency of a trickling filter performance using various recirculation ratios.

  4) Work a typical problem to find optimum recirculation to achieve desired trickling filter performance.

Instructor Approach: Overhead transparencies and work at overhead projector

END
# LESSON OUTLINE

## Measuring Trickling Filter Performance

**Hours 9 & 10 of 20**

<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Writes or Uses the Following:</th>
<th>Instructor Key Points of Emphasis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trickling filter converts non-settleable to settleable solids.</td>
<td>Emphasize secondary settling function</td>
</tr>
<tr>
<td>2</td>
<td><strong>Aerobic Treatment</strong>&lt;br&gt;Needs&lt;br&gt;Food (Sewage)&lt;br&gt;Oxygen (air)&lt;br&gt;Bugs (Bacteria + Others)</td>
<td>Review from Module 1</td>
</tr>
<tr>
<td>3</td>
<td><strong>Trickling Filter Performance measured by:</strong>&lt;br&gt;1) Solids-suspended (settleable)&lt;br&gt;2) BOD/COD reduction&lt;br&gt;3) Solids produced (humus)&lt;br&gt;4) Nitrogen oxidized&lt;br&gt;5) Recirculation ratio-hydraulic &amp; organic loads&lt;br&gt;6) Oxygen-near saturation&lt;br&gt;7) No abnormal problems (odors, snails, ponding, etc.)</td>
<td>Word slide, review as written&lt;br&gt;Answer questions</td>
</tr>
<tr>
<td>4</td>
<td><strong>Typical trickling filter treatment plant.</strong></td>
<td>Review flows and reference to the following example</td>
</tr>
<tr>
<td>5</td>
<td><strong>Solids to Filter</strong>&lt;br&gt;Suspended Solids Settleable Solids&lt;br&gt;35-45% of Trace plant influent&lt;br&gt;Typical Plant-suspended solids 40% of 300 mg/1 = 120 mg/1 (Non-settleable, colloidal)&lt;br&gt;OR continued.....</td>
<td>Review settleable solids removed in primary&lt;br&gt;Suspended solids lbs/day is important</td>
</tr>
</tbody>
</table>

**Typical Plant-suspended solids 40% of 300 mg/1 = 120 mg/1 (Non-settleable, colloidal)**

38
For 1 mgd flow:

lbs.ss/day = 8.34 x 1 mgd x 120 mg/l
lbs.ss/day = 1000 lbs./day
(converted to humus)

Normal Performance:

Low settleable solids and low suspended solids in effluent.

BOD/COD

Primary removal 35-40%
Trickling filter influent 65% of 204 mg/l = 132 mg/l

For 1 mgd flow:
lbs.BOD5/day = 8.34 x 1 mgd x 132 mg/l
lbs. BOD5/day = 1100 lbs./day

Total BOD removed apx. 80-90% of plant influent.
If influent is 204 ppm, 85% removal leaves 15%.
15% of 204 mg/l = 30 mg/l
Normal BOD expected 25-50 mg/l AND
BODult. ≈ 1.6 BOD5
BODult. ≈ COD

Solids produced (humus) from oxidation of dissolved and non-settleable suspended solids.
Simple calculation:

Part 1

Suspended solids:
Plant influent 300 mg/l
Primary effluent 105 mg/l (to filter)
Primary effluent 30 mg/l (from filter)(90% removal)

Filter removal:
105 mg/l - 30 = 75 mg/l
lbs.ss/day = 75 mg/l x 8.34 x 1 mgd
lbs.ss/day = 626 lbs/day (sludge)
Part 2

BOD oxidation:
BOD into plant 204 mg/l
Primary effluent 132 mg/l
(to filter)
Leaving Plant 30 mg/l
BOD removed on filter:
132 - 30 = 102 mg/l

1 lb. of BOD produces 0.77 lbs.
of sludge.

lbs. BOD/day removed = 8.34 x 1 mg/l x
102 mg/l

lbs. BOD/day = 851 lbs./day

1 lb. BOD gives 0.77 lbs. sludge
So
851 x .77 = 655 lbs. sludge/day

Sludge from ss = 626 lbs/day
Sludge from BOD = 655 lbs./day

Total = 1281 lbs/day

(dry sludge based on 204 mg/l BOD
and 300 mg/l suspended solids)

Sludge Volume

lbs (dry) x 100 = lbs/wet
so
1281 lbs (dry) x 100 = 25620 lb/wet

25,620 lbs (wet) = 3071 gal.

8.34 lbs/gal

So - expect to pump

apx. 3071 gal sludge (95% water)
Nitrogen Oxidized:

1) Find nitrogen in plant influent (say, 25 mg/l)

\[ 1 \, \text{mgd} = 209 \, \text{lbs/day} \]

2) Estimate 99% conversion

99% of 209 lbs = 207 lbs.
Removed - 2 lbs. left
OR

.25 mg/l left

But

1 lb. NH\textsubscript{3} gives 4 lbs of Nitrate- (NO\textsubscript{3})

Normal values 20-50 mg/l

Recirculation Ratio & Performance

National Research Council Formula:

\[ E = \frac{100}{1 + 0.0085 \sqrt{W/VF}} \]

Where

E = % Removal BOD\textsubscript{5}
W = BOD load lbs/day
F = Recirculation Factor
V = volume of filter media (acre-feet)

AND

F = Recirculation Factor

\[ F = \frac{1 + r}{(1 + 0.01r)^2} \]

r = recirculation ratio

See Metcalf & Eddy Reference

Keep the trainees calm—tell them not to panic—that you will work out step by step
Example 1:

Given:
Flow = 250,000 gpd
Filter diameter = 96 feet
Depth = 6 feet (acre feet = 1)
BOD to filter = 175 mg/l
(lbs. BOD₅ = 366/day)

\[
E = \frac{100}{1 + 0.0085 \sqrt{W/VF}}
\]

\[
E = \frac{100}{1 + 0.0085 \sqrt{366/1} \times 1}
\]

\[
E = \frac{100}{1 + 0.0085 \sqrt{366}}
\]

\[
E = \frac{100}{1 + 0.0085 \times 19.1}
\]

\[
E = \frac{100}{1 + .165}
\]

\[
E = \frac{100}{1.165} = 61\%
\]

61% of the BOD will be removed
or 100 - 61 = 39% left
Effluent will be:
39% of 175 mg/l = 68 mg/l

Show how to do square root.

Show how to find 0.0085 x 19.1

Questions
Example 2:
Assume a 1:1 Recirculation ratio:
(Same data)

\[ F = \frac{1 + r}{(1 + 0.01r)^2} \]

\( F \) = Recirculation factor

\[ F = \frac{1 + 1}{1 + (0.1 \times 1)^2} \]

\[ F = \frac{2}{1 + 1.21} \]

\[ F = \frac{2}{1.21} = 1.65 \]

\[ E = \frac{100}{1 + 0.0085 \sqrt{366/1 \times 0.90}} \]

\[ E = \frac{100}{1 + 0.0085 \sqrt{407}} \]

\[ E = \frac{100}{1 + 0.0085 \times 20.2} \]

\[ E = \frac{100}{1 + 0.17} \]

\[ E = 100 = 85\% \]

\[ 100 - 85 = 15\% \text{ left} \]

15\% of 175 mg/1 = 26 mg/1 BOD

One extra pass reduced BOD from 68 mg/1 to 26 mg/1.
Example 3: Recirculation ratio of 2:1 (same data),

\[ F = \frac{1 + 2}{1 + 0.1 \times 2} \]

\[ F = \frac{3}{1.2} \]

\[ F = 2.5 \]

AND

\[ E = \frac{100}{1 + 0.0085 \sqrt{366/1 \times 2.5}} \]

\[ E = \frac{100}{1 + 0.0085 \sqrt{147}} \]

\[ E = \frac{100}{1 + 0.0085 \times 12.1} \]

\[ E = 100 \]

\[ E = \frac{100}{1 + 1.103} \]

E = 91% 

BOD\(^i\): 9% of 175 = 16 mg/l

<table>
<thead>
<tr>
<th>Recirculation Ratio</th>
<th>Removal</th>
<th>mg/l BOD in Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>1:1</td>
<td>85</td>
<td>26</td>
</tr>
<tr>
<td>2:1</td>
<td>91</td>
<td>16</td>
</tr>
</tbody>
</table>

Conclusion: Summarize and ask Questions

Material Balance Slide: Explain slide

END
STUDENT HANDOUT

Problem to be Worked

Given the following:

Flow = 1,250,000 gpd
Filter diameter = 320 feet
Depth = 7 ft.
BOD to filter = 200 mg/l
suspended solids = 280 mg/l
(to filter
High rate filter

FIND:

1) The solids removed as sludge, (assuming
a 5% sludge & 95% water in gallons/day)

2) The % removal for BOD5
a. no recirculation
b. 1:1 recirculation ratio
c. 1:2 recirculation ratio
d. 1:3 recirculation ratio
e. 1:4 recirculation ratio

3) What values would you expect for
nitrate levels and dissolved oxygen levels?

Asbign in class, have

(answers)

Help Trainee with
problems on individual
basis

Answers:

a. 

b. 

c. 

d. 

e. 

Nitrate: high depends
on plant influent
20-50 mg/l
DO: near saturation
depends upon temperature
## SUMMARY

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Module Title</th>
<th>Submodule Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>113H22</td>
<td>Intermediate Trickling Filters</td>
<td>Materials and Design of Filters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apx, Time</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours 11, 12, 13 of 20</td>
<td>3 Hours</td>
</tr>
</tbody>
</table>

### Objectives:

The Trainee Will:

1. List the trickling filter growth pattern and trend to high rate filters
2. List the five key items in a Trickling Filter operation
3. List a comparison of high and low rate filters
4. List design guidelines for high and low rate trickling filter components
5. Explain design differences between low and high rate filters
6. Using a Trickling Filter design nomograph - solve three typical trickling filter design-size problems
7. Discuss and describe industrial applications of Trickling Filter treatment
8. List common design information regarding biological filters

### Instructor Aids:

Overhead Projector, Transparencies, "Handbook of Trickling Filter Design" by Public Works Publications

Handout (cost $1.60) from Public Works Publications, 200 South Broad Street, Ridgewood, New Jersey 07451

### Instructor Approach:

Hour 1 - Either at home (best) or in class, read the handout cover-to-cover
Hour 2 - Follow outline, Hour 3 - Problems
LESSON OUTLINE
Hour 11 of 20 (1 Hour)
Materials and Design of Filters

<table>
<thead>
<tr>
<th>Item #</th>
<th>Instructor Will:</th>
<th>Instructor Key Points of Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Assign and have trainees read &quot;Handbook of Trickling Filter Design&quot; by Public Works Publications (26-page Handout) Best if done at home before class.</td>
<td>Encourage them to read it and to re-read if required.</td>
</tr>
</tbody>
</table>

END (Hours 11)
<table>
<thead>
<tr>
<th>Item #</th>
<th>Lecture - No audiovisuals</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Instructor Comment</td>
</tr>
<tr>
<td></td>
<td>1. Ask question - How Many of You Read Publications? (some will not have read)</td>
</tr>
<tr>
<td></td>
<td>2. Explain that you will now review page by page.</td>
</tr>
<tr>
<td></td>
<td>3. Begin by explaining who wrote this publication and where. To get more copies (bottom of page on foreword) Cost - $1.60</td>
</tr>
<tr>
<td>2</td>
<td>Foreword</td>
</tr>
<tr>
<td></td>
<td>1. Rapid Growth of Trickling Filter Use in U.S.</td>
</tr>
<tr>
<td></td>
<td>2. Indicate What the Trickling Filter Floor Institute is all about.</td>
</tr>
<tr>
<td></td>
<td>3. Indicate most filter design today is going to plastic media rather than rock.</td>
</tr>
<tr>
<td>3</td>
<td>Wastewater treatment with trickling filters Page 2</td>
</tr>
<tr>
<td></td>
<td>1. Covers aerobic treatment (food, bugs, air (Oxygen)-questions</td>
</tr>
<tr>
<td></td>
<td>2. Filter needs:</td>
</tr>
<tr>
<td></td>
<td>(1) Pre-treatment of harsh wastes</td>
</tr>
<tr>
<td></td>
<td>(2) Good distribution of wastewater</td>
</tr>
<tr>
<td></td>
<td>(3) Good filter media</td>
</tr>
<tr>
<td></td>
<td>(4) Good underdrain</td>
</tr>
<tr>
<td></td>
<td>(5) Good ventilation</td>
</tr>
<tr>
<td></td>
<td>(Most problems in these areas)</td>
</tr>
<tr>
<td></td>
<td>3. Types of Filters - High, Low, &quot;Super High&quot;</td>
</tr>
<tr>
<td></td>
<td>4. Loadings Reviewed, as well as depth (covered before) Organic vs Hydraulics</td>
</tr>
<tr>
<td></td>
<td>5. Ask if abbreviations understood</td>
</tr>
<tr>
<td></td>
<td>6. Explain WPCF MOP 11 reference as cited Who WPCF is and types of manuals available</td>
</tr>
</tbody>
</table>
7. Review 30% removal by B.O.D.

8. Ask if terms (page 3) "Single stage filter", recirculation, primary clarifier, secondary clarifier are understood.


10. Other units of Expression - Questions?

11. Comparison of Filter Types
   Key Point - Same design for construction of low and high rate filters - Plastic different construction - Review of effluent quality - Questions?
   Key idea design made to fit objectives of treatment.

12. Pre-treatment: Summary (page 3)
   Primary clarifier design:
   2-hour detention time (explain if needed)
   (variation in different states)
   Surface overflow rates and depth (vary with state)
   Help balance "shock" hydraulic, organic and toxic loads to filter
   Emphasize sewer use ordinance as key to pre-treatment

13. Intermediate and Post-treatment
   Review - that they have limited use

14. Effect of Temperature
   Trickling filters work best in warm climates
   May be covered
   Cold weather - lose B.O.D. Removal and ice
   Key Point - Provide bleed valves as listed
   B.O.D. of effluent often is 20% greater in winter
   Design solution make filter "43%" larger
   Northern U.S. design 25% bigger than Southern U.S.
   design
   Often 3 weeks required to get good film on Trickling Filters - If cold, longer

15. Applicability (page 4)
   Trickling Filters work on weak or strong domestic or industrial wastes.
Media, Drainage and Ventilation (page 5)

1. **Five Essentials of Filter**
   - (1) Basic filter support
   - (2) Underdrain blocks
   - (3) Retaining walls
   - (4) Media
   - (5) Distribution system

2. **Filter Floor and Center Channels:**
   - Firm and uniform base - Concrete on well-compacted earth - 4 to 6" thick light re-enforcement
   - Floor slope important - Use normal flow charts for design (paraphrased)

3. **Center channels** - 8-inch pipe for standard rate filter, high rate 16 or 18-inch pipe.
   - Configuration of center channels
   - Extend center channel through filter wall into cleanout box - Questions

---

**Underdrain Blocks (page 6):**

1. Stress importance of good ventilation.

2. Review types of blocks and who makes them, dimensions, etc.

3. Review ASTM Specs C159
   - (Who ASTM is and Specs, etc.)

4. Review contractor's "Specs" - laid in dry mortar bed on filter floor before stone is placed, composition of mortar, angles, etc. - Questions?

---

**Filter Design:**

1. **Depth** 3 to 10 feet (plastic to 40 feet)

2. **Walls** - reinforced concrete - 8 to 12 inches thick
   - No walls is a poor idea!

3. **Media:**
   - Review Specs as listed
   - Clean washed - 2½ inch commonly used
   - Uniform size - Explain Table 1
   - Plastic discussed - Light - High loading possible
   - Good ventilation
   - Media placed on filter - technique very important
   - belt conveyor - Questions?
Distributors

Review manufacturer's list - Questions?
Standard Specifications - Example - Questions?
(Pages 9 & 10)

Standard Rate Filters (Page 11)

1. Review loadings - B.O.D. < 600 pounds/acre foot
2. Trend toward high rate
3. Average depth 6 feet
4. Loading not depth key to nitrification
5. Hydraulic loadings - Average 1.8 mgd, but no "fixed standard"
6. Ask Question - Page 11 - Can you work (3.5 acres of filter required)?
7. Organic load often governs hydraulic loading
8. Media, underdrains, distributors discussed before
9. Rotary distributor (page 12) will operate with minimum discharge 40% of maximum, will handle flows 2½ times minimum - requires 2½ to 4 feet of head
10. Dosing tanks (page 12) - dt - 2 minutes at 2 times the average rate of flow.
   Drawdown 10 inches but < 12 inches.
11. Pre-treatment as discussed before
12. Filter performance as before
13. Design efficiency (NRC Formula) - As worked before Questions?

A Nomographic Solution For Design (Page 13)

1. Purpose to reduce time in finding size of Trickling Filter units (gives fast/rough answers)
2. Also used for estimating B.O.D. removal
3. To use you must know:
   (1) % B.O.D. removal, desired
   (2) Pounds of B.O.D./day applied
   (3) Hydraulic load - mgd
4. Step 1 - Step 2 - Step 3 - Step 4 - Step 5
   Step 6 - Step 7
   Read sections and do, using nomograph
   Taken from book and placed on blackboard
   Do it stepwise with an example - Questions?
5. Have students use nomograph to solve the three following problems:

Problem 1

1 MGD flow, 192 mg/l B.O.D.\textsubscript{5} - want 55% removal
Effluent = 82 mg/l

Problem 2

70% removal desired - Flow = 5 MGD
B.O.D.\textsubscript{5} to filter 135 mg/l
Find the diameter and depth of standard rate filter
Answer = 200' - 3\frac{1}{2}' deep

Problem 3

Find the optimum removal (% B.O.D.) expected from a filter 167 feet in diameter, 7 feet deep, recirculation ratio of 2:1 with 2 MGD flow and B.O.D. to filter of 102 mg/l
Answer

Answer
Solution - Problem 1
(Red Lines)
55% Removal desired

1600 lbs. B.O.D./day applied
a mgd, B.O.D.5 = 192 mg/l

Step 1 - Select correct lat. (40° & 45°) through RT - intersects at 5,200 pounds applied/acre-foot

Step 2 - Connected 5,200 lbs./acre foot to 1600 lbs. B.O.D./day (Red line) - Noted intersection at point D

Step 3 - Followed parallel line point D to point G
Gave solution diameter = 50 feet, approximately 4 feet deep.
**Solution - Problem 2**

1. Select correct (Lats. 40° & 45° N)

2. 70% removal gives 2,000 pounds of B.O.D. applied per acre foot
   Flow = 5 mgd, mg/l B.O.D. to filter = 135 pounds
   B.O.D. 5/day = 5630

3. Connected 2,000 on top to 5630 (estimated on scale)
   On bottom (just left of point C)

4. Found point on Line RR
   Approximately 2 inches below RR-TT intersection

5. Followed parallel line to TT (approximately 1 3/4" up from RR-TT intersection)

**ANSWER: Solutions -**

- **Low Rate Filter**
  - Diameter - 200 ft.
  - Depth - 3½ ft.
Solution - Problem 3

Given: Filter diameter 167 feet, depth 7 feet
Recirculation ratio = 2:1
Pounds applied to filter = 1700
Pounds B.O.D. /day
Flow = 2 MGD, B.O.D. to filter = 102 mg/l

To find the % B.O.D. removal (optimum)

Follow green lines to Point A - Gives 85% removal
Design of High Rate Filters (Page 16)

1. High Rate means recirculation practiced.

2. Review organic and hydraulic loadings.

3. Review types of high rate filters discussed with various recirculation (Page 17)

4. Define "single stage" vs "two stage" filters
   single stage = parallel operation
   two stage = series

5. Recirculation and performance
   (Previous lesson) Brief review - Questions?
   Cover B.O.D. removal curve (10 state standards)

6. Cite references as listed (Pages 18 & 19)

7. Clarifiers: Detention time - 2 hours
   Overflow rates - 650 to 800 gpd/ft²
   EPA now requires scum removal!

8. Treatment results - Covered before, but review these seven items - they are important!

Industrial Waste Applications Review Examples: (Pages 20 & 21)

1. Cannery wastes
2. Dairy wastes
3. Fermentation wastes
4. Distillery wastes
5. Yeast factory wastes
6. Slaughterhouse and meat packing
7. Textile wastes
8. Pharmaceutical wastes
9. Phenolic wastes
10. Pulp and paper
11. Metal finishing

Ask trainees where industrial applications exist in the area near the course location.

Stimulate discussion (5 or 10 minutes)
"Design Considerations For Biological Filters"
(Optional - time may be short)

1. Review NRC formulae for single vs second stage filters.
2. Review 6 items on page 22 and 3 recirculation advantages on page 23.
3. Review charts (Pages 24 & 25) if time permits
4. Review conclusions on page 26 - very important! 8 key ideas!

Questions?

END
(Hour 13 of 20)
## SUMMARY

<table>
<thead>
<tr>
<th>Module No.</th>
<th>Module Title</th>
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</thead>
<tbody>
<tr>
<td>113H22</td>
<td>Intermediate Trickling Filters</td>
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<table>
<thead>
<tr>
<th>Apx. Time</th>
<th>Submodule Title</th>
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<tbody>
<tr>
<td>1 hour</td>
<td>Abnormal Trickling Filter Performance</td>
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<table>
<thead>
<tr>
<th>Objectives:</th>
<th>The Trainee will:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1) Recognize and list abnormal trickling filter performance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructor Aids:</th>
<th>Instructor Approach:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead projector</td>
<td>Instructor will present overhead slides and lead discussion.</td>
</tr>
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</table>

END
<table>
<thead>
<tr>
<th>Item #</th>
<th>Overhead or Write</th>
<th>Key Instructor Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Abnormal Performance in:</td>
<td>way slide - Read</td>
</tr>
<tr>
<td>2</td>
<td>Personnel</td>
<td>1)</td>
</tr>
<tr>
<td>3</td>
<td>Grounds, Maintenance &amp; Records</td>
<td>2)</td>
</tr>
<tr>
<td>4</td>
<td>Filter operations</td>
<td>3)</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>4)</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>5)</td>
</tr>
</tbody>
</table>

Personnel? | Stimulate discussion of what to look for in personnel area. (5 minutes)

Personnel observations:
1) Personal appearance | Beards, clean, etc.
2) Attitude and motivation | Do they want to do a good job?
3) Technical skill | Trained ± qualified
4) Certified? | Legal aspects and personal value of?
5) Walking tour with operator talking | Discuss

Grounds & Maintenance Look For What | Ask questions Lead discussion

Grounds, Maintenance and Records:
1. Grounds well kept? Flowers, grass, trees | Good motivation Good housekeeping
2. Media condition - Green or other | Industrial loads Non-compliance with sewer use ordinance
3. Buildings painted, well-lit, well-maintained | Pride in operation
4. Records - both operation and reporting are proper.

5. Laboratory procedures correct? Using standardized procedures for permit data and reproducible O&M testing procedures

6) Emphasize type of records needed and not being a "pencil chemist"

5) Stress difference in types and need for "Standard Methods" in areas

6) Discuss trainee experience in these areas

6. Filter Operations Common Deficiencies

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Media problems - Anaerobic, Grease, Broken, etc.</td>
</tr>
<tr>
<td>2.</td>
<td>Leaks around seals</td>
</tr>
<tr>
<td>3.</td>
<td>Improper distribution of sewage, flow not evenly split, clogged nozzles, splash plates incorrect</td>
</tr>
</tbody>
</table>
| 4. | Poor B.O.D. removal
Poor Nitrogen (NO₃) Production
Poor Solids Removal
Poor D.O. Level in Effluent, Why?|

1) Discuss

1) Review how to correct

1) Discuss importance of proper distribution

1) Question word slide

2) Lead discussion of one at a time

7. Filter Septic - Poor D.O.

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
</table>
|   | Clogged Vents
Toxic Waste
Kill of Biological Forms|

1) Discuss each

8. Poor Solids Removal
Seasonal Variation
Grease Problems
Poor Secondary Settling

1) Discuss - Have they seen examples of each?

9. Poor Nitrogen Oxidation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃ → NO₂ → NO₃</td>
<td></td>
</tr>
</tbody>
</table>
Low Oxygen Supplied
B.O.D./N/P ratio off
Hydraulic loading and/or organic loading incorrect |

1) Word Slide
10 Poor B.O.D. Removal
- All of the above
- Low Oxygen
- Industrial Loads
- B.O.D./N/P off
- Media problems
- Distribution problems
- Final B.O.D. 25 to 50 mg/l

11 Common Problems
- Ponding
- Odors
- Filter Flies
- Snails
- Uneven Distribution
- Industrial Shock Loads
- Heavy Sloughing of Growth

12 Process Control Testing
- B.O.D. daily
- Suspended Solids daily
- Dissolved Oxygen daily
- Option: C.O.D.
- Nitrates/Nitrites/NH₃ daily

13 Other Useful Tests
- Temperature
- Flow
- Odors (Sulfides)
- Media Inspection
- Snails and other growth
- Organic/Hydraulic Loads

14 What Have You Seen?
- Problems?

15 Questions?

END
SUMMARY

Module No. 113H22
Module Title: Intermediate Trickling Filters

Submodule Title: Field Work and Visit to a Trickling Filter System

Apx. Time: 6 Hours (15, 16, 17, 18, 19, 20 of 20)

Objectives:
The Trainee will:

1) Demonstrate the ability to organize a field visit to a Trickling Filter Plant when given:
   (1) the plant plans (as built)
   (2) the O & M Manual
   (3) copies of the NPDES monthly report
   (4) copies of the O & M monthly log

2) Calculate the organic loading, hydraulic loading, the recirculation ratio, the efficiency obtained and the theoretical efficiency of the plant.

3) Recognize and list normal and abnormal behavior in the Trickling Filter Plant visited.

Instructor Aids:
1) An intimate knowledge of the high-rate Trickling Filter Plant to be visited

2) Copies (2 at least) of the plant plans (as built drawings) to be visited.

3) 2 copies of the plant O & M Manual

4) One copy for each trainee of the O & M daily log for the preceding month and the last NPDES monitoring report.
Instructor Approach:

1) Instructor should visit the plant (a high rate Trickling Filter Plant with recirculation and either parallel or series filter operation) long before classwork. Should know plant, personnel, financial constraints, performance, equipment. Copies of the trainee materials tested above must be obtained long before class use.

2) Make arrangements for visit, transportation tour, and trainee assignment before visit.

3) Lecture/discussion before and after tour (4 hours) - of 1 hour each - total 6 hours (could be longer).
<table>
<thead>
<tr>
<th>Item</th>
<th>Instructor Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Before starting this section the trainees should have several days to review the materials for the plant to be visited.</td>
</tr>
</tbody>
</table>
| 2    | **Hour 1 - Day of Field Trip**  
Review objectives of the 6 hours  
Review plant data - Answer questions  
Review expected form to be turned in to instructor  
Review details of days traveled, when, where, behavior expected, etc.  
Waiver of liability for each trainee (if required)  
Board Transportation (large group - bus preferred) |
| 3    | Outside plant gate - stop bus, detail topography, general plant appearance, etc. - short discussion  
Park bus out of the way  
Keep group together  
Introduce to tour person or operator  
Tour plant (encourage questions)  
Emphasize organic loading  
Removal  
Hydraulic loading  
Size of filters  
Size, condition of secondary clarifiers |
| 4    | Assemble group in quiet place with plant superintendent or operator - (allow time for questions)  
Let students "look around" for approximately 30 minutes to help get information for form to be completed  
Thank Superintendent and operators for visit - encourage trainees to thank them also  
Re-board bus - Do head count (time apx. noon) |
5
Take group to restaurant (or back to classroom) with a meeting room (pre-arranged)
Over lunch, de-brief students about plant
A good technique is to sketch out on acetate film on overhead or use blackboard or carry your own flip-chart and felt tip marker

6
Go through student form – item by item –
Stimulate student observations and comment
Check calculations required
Summarize Module
Questions?

END
**INTERMEDIATE TRICKLING FILTER FIELD TRIP**

Students Complete

<table>
<thead>
<tr>
<th>Name</th>
<th>Class</th>
<th>Date</th>
</tr>
</thead>
</table>

1. **Plant Background Information**

<table>
<thead>
<tr>
<th>Name of Town</th>
<th>Population</th>
<th>Date plant constructed</th>
<th>State</th>
<th>Major industries</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Design Flow</th>
<th>Type of Collection System</th>
<th>Infiltration/Inflow</th>
<th>Unusual flow or toxics or shock loads</th>
<th>Collection system problems</th>
<th>Plant grounds and buildings and personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **Describe pre-treatment used:**

3. **Describe primary treatment units:**

4. **Problems observed before pre-treatment:**

5. **Type of Trickling Filter**

<table>
<thead>
<tr>
<th>Low Rate</th>
<th>High Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>Diameter</td>
</tr>
<tr>
<td></td>
<td>Type of media</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of units</th>
<th>Mode of operation</th>
<th>Recirculation volume pumped</th>
<th>Recirculation ratio</th>
<th>Volume of filter</th>
<th>Hydraulic loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>parallel</td>
<td>#1</td>
<td>#2</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>B.O.D. into:</th>
<th>Filter #1</th>
<th>Filter #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.O.D. out:</td>
<td>Filter #1</td>
<td>Filter #2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% Removal (B.O.D.)</th>
<th>#1</th>
<th>#2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>
Intermediate Trickling Filter Field Trip
Students Complete
Page 2

Actual volume of sludge pumped ______ gpd ______ solids
Calculated volume of sludge ______ gpd

Theoretical nomograph % removal expected: ______ % Why different? ______

6. Trickling Filter effluent quality:
B.O.D. ______
Suspended Solids ______
PH ______
D.O. ______ NO2 ______ NO3 ______
NH3 ______
Grease Level ______

7. Plant problems and abnormal performance observed:

<table>
<thead>
<tr>
<th>Item Observed:</th>
<th>Reason For Problem:</th>
<th>I would solve the Problem by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
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</tr>
</tbody>
</table>
Examination Questions
Intermediate Trickling Filters
Module 113H22 (20 Hours)

Name ___________________________ Date ___________________________

1. Three classes of trickling filters are:
   1. ___________________________
   2. ___________________________
   3. ___________________________

2. ___________________________ loading and ___________________________ loading are terms used to classify trickling filters.

3. Three industrial uses of trickling filter applications are:
   1. ___________________________
   2. ___________________________
   3. ___________________________

4. Normal depth for a rock trickling filter would be ___________________________
   and would depend upon the filter ___________________________.

5. A normal %BOD₅ removal expected for a well-designed and operating trickling filter would be ___________________________.

6. A trickling filter will normally give better removals of BOD₅ in the winter or in the summer? ___________________________.

7. ___________________________ is a term related to loss of filter growth or slime in a trickling filter.

8. "Wetting Rate" is an important consideration in trickling filters.

9. A "shock" load on a trickling filter is a ___________________________.

10. gal/min/ft² and million/gal/day acre are units of ___________________________ loading on a trickling filter.
11. Calculate the number of acres on a surface 500 ft. long and 500 ft. wide. (show work)

_________________ acres

12. One million gallons of wastewater flowed to a filter 209 ft. long and 209 ft. wide in one day. What is the loading in gpd/ft²? (show work)

_________________

13. Find the loading in mgd/acre for a trickling filter that receives 5,000,000 gal. each 24 hours and has 200 ft. diameter. (show work)

_________________ mgd/acre

14. Lbs. BOD/day/acre-foot and lbs. BOD/day/1000 cu. ft. of media are examples of ____________________ loadings.

15. Find the loading on a filter that receives 4,504 pounds of BOD5/day and is 100 ft. square and 10 ft. deep.

_________________
16. If the influent to a filter is 180 mg/l and a flow of 3 MGD, how many pounds of BOD₅ are received each day on the filter?

17, 18, 19. If the flow to a trickling filter is 3 MGD with a diameter of 236 feet and 10 ft. deep, find the pounds of BOD₅/day/acre ft.

What type of filter is it?

Why?

20. The greater the __________________________ to a filter the greater the recirculation.

21. __________________________ rate filters use recirculation.

22. If an influent wastewater flow is 10 MGD and the recirculation ratio is 2 to 1, what is the total wastewater flow to the filter? (show work)

23. If you treated 7 MGD of wastewater containing 19,500 lbs. BOD₅ each day, what would be the BOD₅ concentration in mg/l? (show work)

______________________________ mg/l BOD₅

24. Normal removal of BOD₅ in a primary plant before reaching the trickling filter would be _______ % and apx. _______ % for the suspended solids.
25. Explain the relationship between BOD$_5$, BOD$_{ultimate}$, and COD in 25 words or less.

26. How many gallons of sludge (5% solids) would you expect for 700 pounds of trickling filter-humus?

27. Oxidation of nitrogen proceeds from ammonia to ____________

28, 29, 30. Given the formula:

\[
E = \frac{100}{1 + 0.0085 \sqrt{W/\text{VF}}}
\]

Find the % removal for a flow of 250,000 gpd,
Trickling filter diameter is 96 ft.
Depth = 6 ft. (acre feet = 1)
BOD to filter = 175 mg/l
(Lbs. BOD$_5$ = 366/day
(Recirculation = 0)
31. Assuming a recirculation ratio of 3:1, in the above problem, what would be the % removal of BOD?

32. 

33. A trickling filter must be evaluated in conjunction with a ____________, since these units function as a single unit.

34. List two problems with O & M of a trickling filter in extremely cold climates:
   1. ____________
   2. ____________

35. List the five component parts of a trickling filter.
   1. ____________
   2. ____________
   3. ____________
   4. ____________
   5. ____________

36. Where would you find design specifications on materials used in constructing a trickling filter?

37. 38, 39: Using the nomograph as published by "Public Works Publications" size a trickling filter plant design for 1 MGD, 192 mg/l BOD, wanting a 55% removal.

39. 

40. List three examples of abnormal trickling filter performance.
   1. ____________
   2. ____________
   3. ____________
41. List items used to evaluate personnel utilized in a trickling filter plant:
   1. 
   2. 
   3. 

42. List three items to be evaluated with grounds, maintenance, and records in a trickling filter plant.
   1. 
   2. 
   3. 

43. List three sources of odors in a trickling filter plant operation.
   1. 
   2. 
   3. 

44. The use of masking agents is not a recommended procedure at a trickling filter plant. True ______ False ______

45. List three important process control laboratory tests for trickling filter operations:
   1. 
   2. 
   3. 

46. The term "as built drawing" means: ____________________________

47. List two pretreatment problems that interfere with good trickling filter performance.
   1. 
   2. 

48, 49, 50. Discuss how you would organize a field inspection visit to a treatment plant. (Who would you call? Why? What records would you look at? Why? What would you evaluate? Why?) 50 words or less:


51, 52, 53. Write a word relationship for aerobic sewage treatment, explaining what happens when the system goes septic. (50 words or less)
57, 58, 59. Why is establishment and enforcement of a sewer use ordinance important in good trickling filter performance? (50 words or less)

60. List two things that a well maintained trickling filter plant, with flowers, etc. would indicate to you.

1. 
2. 

Does it mean the effluent is meeting NPDES requirements?  
Yes  No  

Why
SLIDE 1

TRICKLING FILTER

DOES NOT "FILTER"
SLIDE 2

FOOD (SEWAGE)

OXYGEN (AIR)

BUGS (GROWTH ON MEDIA)
Slide 4

Trickling Filter

Optimum Conditions
TRICKLING FILTER TYPES BY APPLICATION RATES:

1) "ROUGHING" FILTER
2) LOW RATE
3) HIGH RATE
4) "SUPER" HIGH RATE
ROUGHING FILTER:

ROCK OR PLASTIC MEDIA

UP TO 20 FEET DEEP

USED TO PRETREAT HIGH BOD WASTES

HYDRAULIC LOADING:
60 TO 180 MGD/ACRE OR
1400 TO 4265 GPD/FT,²

ORGANIC LOADING:
≥ 100 LB/BOD/DAY/1000 CU. FT.

MAY OR MAY NOT HAVE RECIRCULATION
SLIDE 7

EXAMPLES OF ROUGHING, FILTER USES:

1) BREWERIES

2) FOOD PROCESSING WASTES

3) POULTRY, EVICERATION, SLAUGHTERING WASTES

4) MILK, CHEESE & WHEY PROCESSES

5) TOXIC WASTE HANDLING (PHENOLS)
NORMAL "ROUGHING FILTER PERFORMANCE"

WHAT IS EXPECTED??
SLIDE 9

EXPECTED PERFORMANCE:

1) Low % REMOVAL OF BOD, (40 to 65) BUT

VERY HIGH TOTAL REMOVAL

2) LOW NITRATE LEVELS SOME NITRITE AND AMMONIA OR

AMMONIUM ION PRESENT

3) SOME ODORS (DIFFICULT TO KEEP AEROBIC) FEW FLIES

4) SLOUGHING - USUALLY CONTINUOUS
SLIDE 10

WHERE HAVE YOU SEEN ROUGHING FILTERS USED?
LOW RATE FILTERS:
(SAME AS "STANDARD" RATE)

USUALLY ROCK MEDIA

6 TO 8 FEET DEEP

USED IN DOMESTIC SEWAGE TREATMENT

HYDRAULIC LOADING:
1 TO 4 MGD/acre OR
25 TO 90 GPD/sq. ft.

ORGANIC LOADING:
200 TO 1000 LB. BOD/DAY/acre ft. OR
5 TO 25 LB. BOD/DAY/1000 CU. FT.

USUALLY DOES NOT HAVE RECIRCULATION

USUALLY HAS DOSING TANKS OR SIPHON
NORMAL LOW RATE FILTER PERFORMANCE

WHAT IS EXPECTED?
EXPECTED PERFORMANCE:

1) HIGH BOD REMOVAL 85-90%

2) SEASONAL VARIATION IN PERFORMANCE

3) HIGH NITRATE (NO₃) LEVELS - LOW NITRITE AND AMMONIA

4) SOME ODORS - SOME FILTER FLIES

5) SLOUGHING - INTERMEDIATE AND SEASONAL IN NATURE
WHERE ARE STANDARD OR LOW-RATE TRICKLING FILTER PLANTS LOCATED NEAR HERE?
HIGH RATE TRICKLING FILTERS:

USUALLY ROCK MEDIA

3 TO 8 FEET DEEP

USED IN DOMESTIC AND INDUSTRIAL WASTE TREATMENT

HYDRAULIC LOADING:

5 TO 40 MGD/ACRE

100 TO 900 GPD/FT.²

ORGANIC LOADING:

1000 TO 1300 LB./BOD/DAY/ACRE FT. OR

25 TO 300 LB. BOD/DAY/1000 FT.³

ALMOST ALWAYS HAS RECIRCULATION

NO DOSING TANKS

REQUIRES PUMPING AND ELECTRICAL COSTS.
NORMAL "HIGH RATE" FILTER PERFORMANCE.

WHAT IS EXPECTED?
EXPECTED PERFORMANCE:

1) GOOD BOD REDUCTION 85-90%

2) SEASONAL VARIATIONS NOT AS GREAT AS LOW RATE BUT STILL EXIST

3) GOOD NITRIFICATION, HOWEVER, SOME NITRITE AND AMMONIA PRESENT

4) FEW ODORS AND FEW FLIES, BUT DEPENDS UPON OPERATIONAL CONTROL

5) SLOUGHING - CONTINUOUS - SEASONAL VARIATION
WHERE ARE "HIGH RATE" TRICKLING FILTER PLANTS LOCATED?
SUPER HIGH RATE TRICKLING FILTERS:

USUALLY PLASTIC MEDIA

UP TO 40 FEET

USED IN MANY DOMESTIC AND INDUSTRIAL APPLICATIONS

HYDRAULIC LOADING:
15 TO 90 MGD/ACRE
350 TO 1000 GPD/FT.²

ORGANIC LOADING:
300 LB.BOD/DAY/1000 FT.³

USUALLY HAS RECIRCULATION

NO DOSING TANKS

REQUIRES PUMPING AND ELECTRICAL COSTS

FORCED VENTILATION OFTEN USED

WETTING RATE OF 0.6 GAL/MIN./FT.²

IMPORTANT IN MANY PLANTS
NORMAL PERFORMANCE OF "SUPER HIGH RATE FILTERS"

WHAT IS EXPECTED?
EXPECTED PERFORMANCE FOR "SUPER HIGH RATE" FILTERS:

1) GOOD BOD REMOVAL 65-90% - DEPENDS UPON LOADING

2) SOME SEASONAL VARIATION

3) INTERMEDIATE TO EXCELLENT NITRIFICATION - DEPENDS ON LOADING

4) FEW ODORS, FEW FLIES

5) SLOUGHING CONTINUOUS (SEASONAL)

6) MEDIA BREAKING AND CLOGGING - LESS COMMON THAN ROCK MEDIA

7) TOWERS (40 FT.) OFTEN USED - FILTER VENTILATION CAN BE A PROBLEM - IF SEPTIC A PROBLEM.
WHERE ARE "SUPER HIGH RATE FILTERS" LOCATED?
WHAT ARE THE FOUR BASIC TYPES OF TRICKLING FILTERS?
SLIDE 24

RIGHT.

1) "ROUGHING FILTER"

2) LOW RATE OR STANDARD FILTER

3) HIGH RATE FILTER

4) "SUPER HIGH RATE" FILTER
HOW DO WE CLASSIFY FILTERS?
SLIDE 26

1) ROCK OR PLASTIC MEDIA

2) DEPTH

3) USES

4) HYDRAULIC LOADING

5) ORGANIC LOADING

6) RECIRCULATION

7) SUPPORT SYSTEMS – PUMPS, FORCED VENTILATION, ETC.

8) EXPECTED PERFORMANCE
<table>
<thead>
<tr>
<th>HYDRAULIC LOADING</th>
<th>MGD/ACRE</th>
<th>GPD/FT(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW RATE</td>
<td>1 TO 4</td>
<td>25 TO 90</td>
</tr>
<tr>
<td>HIGH RATE</td>
<td>5 TO 40</td>
<td>100 TO 900</td>
</tr>
<tr>
<td>SUPER HIGH RATE</td>
<td>15 TO 90</td>
<td>350 TO 1000</td>
</tr>
<tr>
<td>Type of Filter</td>
<td>Organic Loading-units</td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lbs. BOD/day/acre ft.</td>
<td>pounds BOD/day/1000 cu.ft.</td>
</tr>
<tr>
<td>Low Rate</td>
<td>200-1000</td>
<td>5-25</td>
</tr>
<tr>
<td>High Rate</td>
<td>1000-1300</td>
<td>25-300</td>
</tr>
<tr>
<td>Super High Rate</td>
<td></td>
<td>up to 300</td>
</tr>
</tbody>
</table>

* MOP 11-WPCF Guidelines (1977)
SLIDE 1

RECIRCULATION

WHY?
SLIDE 2

RECIRCULATION:
1) USED FOR HIGH OR SUPER HIGH FILTERS

2) IMPROVES HYDRAULIC AND ORGANIC LOADINGS
   (IF NEEDED)

3) IMPROVES EFFICIENCY
SLIDE 3

TYPICAL BOD REMOVAL:

PRIMARY 35%

INFLUENT 204 mg/l BOD
(.17 lbs/capita/day and 100 GPDC)

WHAT IS NORMAL BOD TO FILTER?
SLIDE 4

RIGHT.

130-135 MGL

65% OF 204 = 132
SLIDE 5

HIGHER THE BOD - GREATER THE RECIRCULATION
### SLIDE 6

**Recirculation Rate for Maximum BOD of Settled Wastewater**

<table>
<thead>
<tr>
<th>BOD/mg/L</th>
<th>1/Recirculation Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>130</td>
<td>1 : 1</td>
</tr>
<tr>
<td>170</td>
<td>2 : 1</td>
</tr>
<tr>
<td>220</td>
<td>3 : 1</td>
</tr>
<tr>
<td>260</td>
<td>4 : 1</td>
</tr>
</tbody>
</table>

---

110°
Recirculation ratio defined as total number of times wastewater returned, plus 1

<table>
<thead>
<tr>
<th>MGD Flow</th>
<th>Recirculation Ratio</th>
<th>MGD Total Hydraulic Load to Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1 : 1</td>
<td>(1 + 1) x 5 = 10</td>
</tr>
<tr>
<td>5</td>
<td>2 : 1</td>
<td>(1 + 2) x 5 = 15</td>
</tr>
<tr>
<td>5</td>
<td>3 : 1</td>
<td>(1 + 3) x 5 = 20</td>
</tr>
<tr>
<td>5</td>
<td>4 : 1</td>
<td>(1 + 4) x 5 = 25</td>
</tr>
<tr>
<td>5</td>
<td>5 : 1</td>
<td>(1 + 5) x 5 = 30</td>
</tr>
</tbody>
</table>
SLIDE 8

QUESTIONS?

WHAT HYDRAULIC LOADING WOULD A 3 MGD FLOW WITH A 4 TO 1 RECIRCULATION RATIO BE?
RIGHT,

15 MGD

OR

Flow = 3 MGD \times (1 + 4)

Flow = 3 \text{ MGD} \times 5 = 15 \text{ MGD}
SLIDE 10

WHAT BOD RANGE WOULD YOU EXPECT THE TRICKLING FILTER INFLENT TO BE?
SLIDE 11

RIGHT.

APX. 260 MG/L
SLIDE 1

AEROBIC TREATMENT NEEDS:

FOOD (SEWAGE)

OXYGEN (AIR)

BUGS (BACTÉRIA + OTHERS).
SLIDE 2

AEROBIC TREATMENT
NEEDS

FOOD (SEWAGE)
OXYGEN (AIR)
BUGS (BACTERIA + OTHERS)
TRICKLING FILTER PERFORMANCE MEASURED BY:

1) SOLIDS - SUSPENDED & SETTLEABLE
2) BOD/COD REDUCTION
3) SOLIDS PRODUCED (HUMUS)
4) NITROGEN OXIDIZED
5) RECIRCULATION RATIO - HYDRAULIC & ORGANIC LOADS
6) OXYGEN - NEAR SATURATION
7) NO ABNORMAL PROBLEMS (ODORS, SNAILS, PONDING, ETC.)
SLIDE 4

TYPICAL TRICKLING FILTER SEWAGE TREATMENT PLANT

Pretreated raw sewage from collection system

Bar screen - grit chamber

Primary settling tank

Primary treatment

Primary sludge

Trickling filter distributor

Recirculation (high rate)

Underdrain

Trickling filter humus

Sludge digestion

Secondary sludge

Secondary settling tank

Secondary treatment

Chlorination tank

Effluent

Sludge-drying bed or other disposal
SLIDE 5

SOLIDS TO FILTER

<table>
<thead>
<tr>
<th>Suspended Solids (35-45%)</th>
<th>Settleable Solids (Trace)</th>
</tr>
</thead>
</table>

Plant Influent (Imhoff Cone)

Typical Plant - Suspended Solids 40% of 300 mg/L = 120 mg/L (non-settleable, colloidal)

Or

For 1 MGD Flow:

LBS. SS/DAY = 8.34 x 1 MGD x 120 mg/L

LBS. SS/DAY = 1000 LBS./DAY

Converted to Humus

Normal Performance:

Low settleable solids and low suspended solids in effluent.
BOD/COD

Primary Removal 35-40%

Trickling Filter Influent 65% of 204 mg/L = 132 mg/L

For 1 MGD flow:

\[
\text{LBS. BOD}_5/\text{DAY} = 8.34 \times \frac{1}{4} \text{MGD} \times 132 \text{ mg/L}
\]

\[
\text{LBS. BOD}_5/\text{DAY} = 1100 \text{ LBS.}/\text{DAY.}
\]

Total BOD removed apx. 80-90% of plant influent.

If influent is 204 ppm, 85% removal leaves 15%.

15% of 204 mg/L = 30 mg/L

Normal BOD expected 25-50 mg/L

\[
\text{BOD}_5 \approx 1.6 \times \text{BOD}_5
\]

\[
\text{BOD}_{ULT} \approx \text{COD}
\]
SLIDE 7.
SOLIDS PRODUCED (HUMUS) FROM OXIDATION OF DISSOLVED AND NON-
SETTLEABLE SUSPENDED SOLIDS.
SIMPLE CALCULATION:
PART 1
SUSPENDED SOLIDS:
PLANT INFLUENT 300 mg/L
PRIMARY EFFLUENT 105 mg/L (TO FILTER)
PRIMARY EFFLUENT 30 mg/L (FROM FILTER) (90% REMOVAL)
FILTER REMOVAL:
105 mg/L - 30 = 75 mg/L
LBS SS/DAY = 75 mg/L x 8.34 x 1 MGD
LBS SS/DAY = 626 LBS/DAY (SLUDGE)
PART a:2:

BOD OXIDATION:

BOD INTO PLANT 204 mg/l
PRIMARY EFFLUENT 132 mg/l (TO FILTER)
LEAVING PLANT 30 mg/l
BOD REMOVED ON FILTER:
132 - 30 = 102 mg/l

1 LB. OF BOD PRODUCES 0.77 LBS. OF SLUDGE.

LBS. BOD/DAY REMOVED = 8.34 x 1 MGD x 102 mg/l

LBS. BOD5/DAY = 851 LBS./DAY

1 LB. BOD GIVES 0.77 LBS. SLUDGE

SO

851 x .77 = 655 LBS. SLUDGE/DAY
SLIDE 9

SLUDGE FROM SUSPENDED SOLIDS = 626 LBS/DAY

SLUDGE FROM BOD = 655 LBS/DAY

TOTAL 1281 LBS/DAY

(DRY SLUDGE BASED ON 204 MG/L BOD AND 300 MG/L SUSPENDED SOLIDS)
SLIDE 10

SLUDGE VOLUME

LBS. (DRY) x 100 = LBS/WET
% SLUDGE

So

1281 LBS. (DRY) x 100 = 25620 LBS./WET

\[
\frac{25,620 \text{ LBS. (WET)}}{8.34 \text{ LBS/GAL}} = 3071 \text{ GAL.}
\]

So

EXPECT TO PUMP Apx. 3071 GAL. SLUDGE (95% WATER)
SLIDE 11

NITROGEN OXIDIZED:

1) FIND NITROGEN IN PLANT INFLUENT (SAY, 25 mg/l)

1 MGD = 209 lbs./DAY

2) ESTIMATE 99% CONVERSION

99% of 209 lbs. = 207 lbs. REMOVED

2 lbs. LEFT

OR

.25 mg/l LEFT

BUT

1 lb. NH₃ GIVES 4 LBS. OF NITRATE (NO₃⁻)

NORMAL VALUES 20-50 mg/l
SLIDE 12

RECIRCULATION RATIO AND PERFORMANCE

NATIONAL RESEARCH COUNCIL FORMULA:

\[ E = \frac{100}{1 + 0.0085 \sqrt{\frac{W}{VF}}} \]

WHERE:
- \( E \) = % REMOVAL BOD\(_5\)
- \( W \) = BOD LOAD LBS./DAY
- \( F \) = RECIRCULATION FACTOR
- \( V \) = VOLUME OF FILTER MEDIA (ACRE FEET)

AND

\[ F = \frac{1 + r}{(1 + 0.01r)^2} \]

\( r \) = RECIRCULATION RATIO
NO SLIDES 13-14
SLIDE 15

R.E.M.E.M.B.E.R.

HIGHER THE BOD, HIGHER THE RECIRCULATION.

HIGH RATE FILTERS OR SUPER HIGH RATE FILTERS

IMPROVE LOADING:

IMPROVE EFFICIENCY

POUNDS

\[ \text{POUNDS} = 8.34 \times \text{MGD} \times \text{MG/L} \times \text{DAY} \]

TOTAL FLOW = INFLUENT FLOW \times (\text{RECIRCULATION RATIO} + 1)

\% REMOVAL = \frac{\text{IN-OUT}}{\text{IN}} \times 100

QUESTIONS?

END
**CONCLUSION:**

<table>
<thead>
<tr>
<th>RECIRCULATION RATIO</th>
<th>% REMOVAL</th>
<th>MG/L BOD. IN EFFLUENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>61</td>
<td>68</td>
</tr>
<tr>
<td>1:1</td>
<td>85</td>
<td>26</td>
</tr>
<tr>
<td>2:1</td>
<td>91</td>
<td>16</td>
</tr>
</tbody>
</table>
SLIDE - 2 - 17

TYPICAL TRICKLING FILTER SEWAGE TREATMENT PLANT

Total Nitrogen 30 mg/l (NH₃)
BOD 204 mg/l
SS 300 mg/l
1 mgd

Pretreated Raw Sewage
From Collection System

35% BOD out
55% SS out

Primary Treatment

Apx. 3000 gal. sludge

Trickling Filter

Humus or Head of Plant

Apx. 3071 gal. sludge

Secondary Treatment

Effluent
BOD 25-30 mg/l
SS 30-50 mg/l
High Nitrates

Sludge Drying Bed or Other Disposal

1.5 ft²/capita served
SLIDE 1

ABNORMAL PERFORMANCE IN:
PERSONNEL
GROUNDS, MAINTENANCE & RECORDS
FILTER OPERATIONS
SLIDE 2

PERSONNEL?
SLIDE 3

-PERSONNEL OBSERVATION:

1) PERSONAL APPEARANCE
2) ATTITUDE AND MOTIVATION
3) TECHNICAL SKILL
4) CERTIFIED?
5) WALKING TOUR WITH OPERATOR TALKING
SLIDE 4.

GROUND & MAINTENANCE

LOOK FOR WHAT?
SLIDE 5

GROUNDS, MAINTENANCE AND RECORDS
1) GROUNDS WELL KEPT?  - FLOWERS, GRASS, TREES
2) MEDIA CONDITION - GREEN OR OTHER
3) BUILDINGS PAINTED, WELL-LIT, WELL-MAINTAINED
SLIDE 6

FILTER OPERATIONS COMMON DEFICIENCIES

1) MEDIA PROBLEMS - ANAEROBIC, GREASE, BROKEN VENTS, ETC.
2) LEAKS AROUND SEALS
3) IMPROPER DISTRIBUTION OF SEWAGE, FLOW NOT EVENLY SPLIT, CLOGGED NOZZLES, SPLASH PLATES INCORRECT
4) POOR B.O.D. REMOVAL POOR NITROGEN (NO₃⁻) PRODUCTION POOR SOLIDS REMOVAL POOR D.O. LEVEL IN EFFLUENT, WHY?
SLIDE 7

FILTER SEPTIC - POOR D.O.
CLOGGED VENTS
TOXIC WASTES
KILL OF BIOLOGICAL FORMS
SLIDE 8

POOR SOLIDS REMOVAL
SEASONAL VARIATION
GREASE PROBLEMS
POOR SECONDARY SETTLING
SLIDE 9

POOR NITROGEN OXIDATION

\[ \text{NH}_3 \rightarrow \text{NO}_2 \rightarrow \text{NO}_3 \]

LOW OXYGEN SUPPLIED

B.O.D./N/P RATIO OFF

HYDRAULIC LOADING AND/OR ORGANIC LOADING INCORRECT
SLIDE 10

POOR B.O.D. REMOVAL
ALL OF THE ABOVE
LOW OXYGEN
INDUSTRIAL LOADS,
B.O.D./N/P OFF
MEDIA PROBLEMS
DISTRIBUTION PROBLEMS
FINAL B.O.D. 25 to 50 MG/L
COMMON PROBLEMS

PONDING
ODORS
FILTER FLIES
SNAILS
UNEVEN DISTRIBUTION
INDUSTRIAL SHOCK (LOADS)
HEAVY SLOUGHING OF GROWTH
SLIDE 12:

PROCESS CONTROL TESTING

B.O.D. DAILY
SUSPENDED SOLIDS DAILY
DISSOLVED OXYGEN DAILY
OPTION: C.O.D.
NITRATES/NITRITES/NH₃ DAILY
SLIDE 13

OTHER USEFUL TESTS

- TEMPERATURE
- FLOW
- ODORS (SULFIDES)
- MEDIA INSPECTION
- SNAILS AND OTHER GROWTH
- ORGANIC/HYDRAULIC LOADS
SLIDE 14

WHAT HAVE YOU SEEN?

PROBLEMS?
SLIDE-15

QUESTIONS?