

University Curriculum Development for Decentralized Wastewater Management

Septic Tanks

Suggested Course Materials

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Septic Tanks

Agenda

The wastewaters generated in residences or from small commercial and institutional activities are collected and transported by the plumbing system drainpipes of these facilities directly into the septic tank. The student should have some prior knowledge of the constituents of typical household wastewater, namely the organic and inorganic compounds along with the organisms, such as bacteria and viruses. The student should be constantly reminded that the septic tank is probably the single most important treatment unit in the small scale decentralized wastewater management system and accomplishes approximately 50% of the ultimate treatment. The effluent from the septic tank then flows to a subsurface infiltration and percolation drain field in the vadose zone prior to recharging the groundwater. Each instructor may customize the material in this module to be part of a quarter (10 weeks) or semester (12 weeks) course. It is suggested that one week, three 50 minute class periods, be allocated for this material, and it should be covered very early in the quarter or semester.

- Class 1: Introduction, history, design considerations, materials of construction, structural soundness and sizing. Processes within the septic tank, settling, floatation, compartmentation, biological decomposition.
- Class 2: Tank geometry, length to width ratio, four zones of settling, vertical cylindrical tanks, meander tanks, watertightness, hydrostatic testing, vacuum testing. Appurtenances, risers and inspection ports, joints and connections, tees and baffles.
- Class 3: Effluent screens, gas deflection baffles, surge tanks, garbage grinders. Septage management, types of additives, water softeners, reverse osmosis, oils and grease, construction considerations, operation and maintenance, regulations.

Septic Tanks Overview

The traditional technologies that have been taught for years in the engineering curricula in the U.S. have emphasized the large centralized sewerage systems with large centralized sewage processing facilities. This module will point out that onsite wastewater systems, when properly designed, sited, constructed, maintained, and operated also can adequately provide the necessary environmental and public health protection.

Septic Tanks

Outline

- I. Introduction
- II. History
- III. Materials of Construction
- IV. Sizing
 - A. Volume
 - B. Septic Tank Effluent Pumps (Dosing Tank)
- V. Processes within the Septic Tank
 - A. Sedimentation
 - 1. Analysis of Discrete Particle Settling
 - 2. Compartmentation
 - B. Biological Decomposition
 - 1. Aerobic Decomposition
 - 2. Anaerobic Decomposition
 - a. Acid or Non-Methanogenic Phase
 - b. Methanogenic (Methane Producing) Phase
 - C. Solids Accumulation Rate
 - D. Buoyancy
- VI. Tank Geometry
 - A. Length to Width Ratio
 - B. Four Zones of Settling in Large Tanks
 - C. Vertical Cylindrical Tanks
 - D. Meander Tanks
- VII. Watertightness
 - A. Hydrostatic Testing
 - B. Vacuum Testing
 - C. Checking Watertightness of Existing Tank
- VIII. Appurtenances
 - A. Risers and Inspection Ports
 - B. Joints and Connections
 - C. Tees and Baffles
 - D. Effluent Screens
 - E. Gas Deflection Baffles
 - F. Surge Tanks
- IX. Garbage Grinders
- X. Septage
 - A. Septage Management
 - B. Land Application
 - C. Disposal at Wastewater Treatment Plant
- XI. Septic Tank Additives
 - A. Types of Additives
- XII. Water Softeners
- XIII. Reverse Osmosis
- XIV. Oils and Grease
- XV. Construction Considerations
 - A. Location
 - B. Bedding and Backfill
- XVI. Operation and Maintenance

- XVII. Regulations
- XVIII. Summary

Septic Tanks

Goals

To make students aware that the much maligned septic tank is actually a model of simplicity and an energy free unit that provides the first and very important pretreatment of the wastewater in small scale wastewater treatment systems.

Septic Tanks

Learning Objectives

To produce students who have a sound fundamental knowledge of settling theory and the physical, chemical, and biological processes that take place within the septic tank. To inform them about the capability of the septic tank to renovate household wastewater and to inspire them to realize that it is the most important treatment unit in the small scale wastewater treatment system.

Septic Tanks

Prerequisites

The students should have had an introductory environmental engineering course and have senior engineering or environmental health standing.

SEPTIC TANKS Evaluation Form

Reviewer: _____

We are requesting your assistance in reviewing the modules developed through the On-Site Consortium curriculum project. Please complete the following form while reviewing the materials

With a rating scale of 1 (Disagree) to 5 (Agree), please respond to the following questions

Review of printed materials:

	Disagree				Agree
The text completely covers the topic area.	1	2	3	4	5
The visuals completely cover the topic area.	1	2	3	4	5

Review of learning objectives:

1.) The module gave a clear and concise description of the septic tank.	1	2	3	4	5
2.) The module made the students aware that the septic tank is energy free and a marvel of simplicity.	1	2	3	4	5
3.) The three fundamental processes in the septic tank; physical, chemical, and biological were adequately explained.	1	2	3	4	5
4.) The four types of settling phenomena were clearly explained.	1	2	3	4	5
5.) The concept and importance of the surface overflow rate was properly demonstrated.	1	2	3	4	5
6.) The argument for lengthening the EPA recommended septic pumpout frequency was adequately justified.	1	2	3	4	5
7.) The recommendation for effluent filters or screens was justified properly.	1	2	3	4	5
8.) The question of septic tank additives was properly handled.	1	2	3	4	5

- 9.) The conclusion, that grease traps are generally unnecessary on typical households, was fairly represented. 1 2 3 4 5
- 10.) The conclusion, that grease traps are absolutely necessary on restaurant and other typical locations, was justified. 1 2 3 4 5
- 11.) It was clearly demonstrated that with proper conditions, the septic tank in conjunction with a proper soil absorption system could adequately protect the public health, safety, and welfare. 1 2 3 4 5

What specific recommendations would you provide for the text. _____

What specific recommendations would you provide for the visuals. _____

Please give specific positive or negative comments on the topic/module. _____

Septic Tanks Problem Sets

- 1.) Estimate the typical wastewater flow from a day school with a cafeteria, gym with showers, and an expected enrollment of 550 students. What size septic tank would be required? Assume 48 hour retention time. Express answer in gallons.
- 2.) A cluster sewer system serving 9 homes is being planned using onsite wastewater management systems. Three of the homes have 2 bedrooms, 4 homes have 3 bedrooms, and 3 homes have 4 bedrooms. What size single septic tank would you recommend? Assume wastewater flow of 60 gpcd and 48 hour retention time.
- 3.) While M. Mouras of France is generally credited with developing the modern septic tank, he may also have been overly optimistic about its capability. Explain the main reasons why you think he was not justified in making this claim.
- 4.) Explain what happens to the foul gases generated in the septic tank.
- 5.) Given two single compartment septic tanks of nominally equal volumes with equal flows of wastewater. Tank dimensions are as follows:

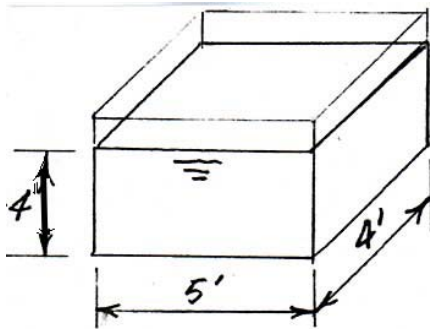
	<u>Length</u>	<u>Width</u>	<u>Depth</u>
Septic Tank A	9'6"	5'3"	4'
Septic Tank B	9'0"	4'9"	5'6"

According to settling theory, which tank should be the best in suspended solids removal? Briefly explain.

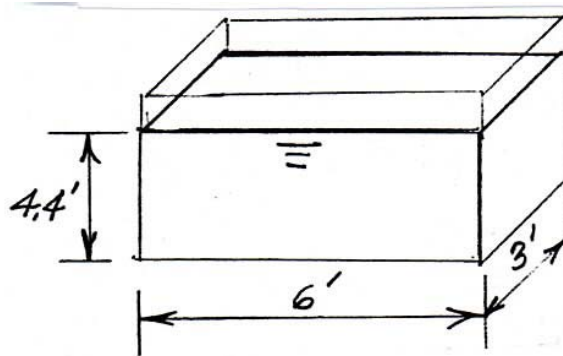
- 6.) Briefly explain the form of the nitrogen in the raw sewage flow from the household, while in the septic tank, and in the septic tank effluent.
- 7.) Describe how you might test the water tightness of a monolithic poured concrete tank in the field.
- 8.) Why is it likely that the liquid waste in a septic tank generally is anaerobic?
- 9.) Given enough time, what would be the main final constituent in the bottom accumulation of a septic tank?
- 10.) For a given wastewater, how can it be shown that suspended solids removal by settling is not a function of the depth of the septic tank?

- 11.) A 1,000 gallon septic tank serves a 3-bedroom home with 4 occupants. The inside dimensions of the rectangular septic tank are $l = 9$ ft, $w = 3.5$ ft, and the depth from the invert of the outlet pipe is 4.0 ft. Calculate the clear zone (ft.) between the bottom of the scum layer and the top of the sludge layer after 5 years of use. Assume one-third of the scum layer is above the liquid level. Show all calculations.
- 12.) For a sewage flow of 480 gal per day, according to settling theory, which of the two septic tanks shown will give the best suspended solids removal? Inlet and outlet arrangements are the same for each tank. Explain your answer.

Septic Tank A

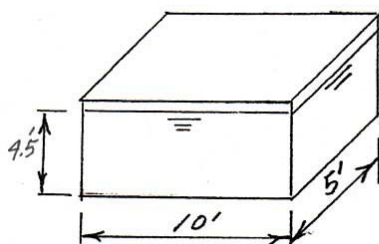


Septic Tank B

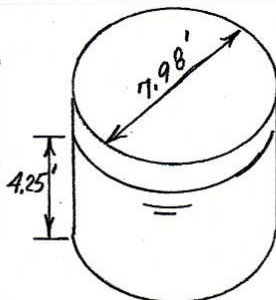


- 13.) You are friendly with two families who know you are an expert on septic tanks. One family of 4 is on a 1,000 gallon septic tank and another family of 5 is on a 1,500 gallon tank. They have asked you what septage pumping interval you would suggest. Express your answer in years.
- 14.) Explain anaerobic decomposition of the organic matter in wastewater.
- 15.) For a sewage flow of 360 gal per day, according to settling theory, which of the three septic tanks shown will give the best suspended solids removal? Explain why. Assume inlets and outlets are the same for each tank.

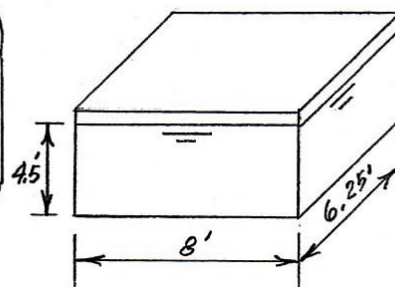
Septic Tank A



Septic Tank B



Septic Tank C



- 16.) Explain why septic tank effluent must receive further treatment, such as in a subsurface soil absorption system, before being discharged in the environment.
- 17.) An Interstate rest stop is to be located where no public sewerage facilities are available. The facility will be built on both sides of the freeway, and each side will have a separate on-site sewage disposal system. Soils indicate favorable conditions for on-site systems. Assume 48 hour retention time.

The expected design use is as follows:

Northbound side

2 gas stations (100 vehicles/day each, with 4 employees/day each)

Hotel A (58 persons)

Hotel B (75 persons)

Restaurant (200 patrons/day) conventional

Southbound side

1 gas station (150 vehicles/day, with 6 employees/day)

Hotel C (100 persons)

1 bar (75 customers/day with 4 employees/day)

Determine the size of the septic tanks required, expressed in gallons.

Septic Tanks

Problem Sets with Solutions

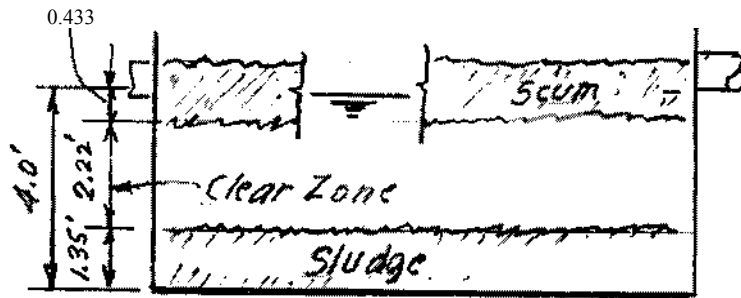
- 1.) Typical flow per student = 25.0 gpd/student from Table 5.
Total estimated flow = $(550)(25.0) = 13,750$ gpd ←
Vol. of septic tank = $13,750 \times 2 = 27,500$ gal ←
- 2.) Total number of bedrooms = $3(2) + 4(3) + 3(4) = 30$
Total flow = $30(60) = 1,800$ gpd
Vol. of septic tank = $1,800 \times 2 = 3,600$ gal ←
- 3.) Answer: a.) It does not rapidly transform all excrementious material into a homogenous fluid.
b.) The vault is not self emptying.
- 4.) Answer: They flow back out through the side sewer and up the vent through the household plumbing. Also some may escape through the risers and out through the drainfield.
- 5.) Septic Tank A Bottom area = $9.5' \times 5.25' = 49.9$ ft²
Septic Tank B Bottom area = $9.0 \times 4.75 = 42.8$ ft²
Surface Overflow Rate = $SOR = \frac{Q}{\text{Water Surface Area}}$
will be the lowest for Tank A
hence it should give the greatest SS removal
- 6.) Answer: Organic nitrogen in the raw wastewater; ammonium nitrogen in the septic tank; and ammonium in the septic tank effluent
- 7.) Answer: Fill tank up to 2 to 3 inches in the riser, let soak 24 hours, check water level because concrete may absorb some water, refill tank and check in 24 hours.
- 8.) Answer: The large microbial population will quickly deplete the dissolved oxygen.
- 9.) Answer: Lint from washing clothes and ligneous material from toilet paper, which do not decompose.
- 10.) Answer: Visualize a septic tank devoid of solids and then half full of sludge. With the same wastewater the settling velocity V_S of the suspended solids would remain constant, but since the detention time and depth are half in the latter, the same ratio of particle removal $V_R = V_S$ would be accomplished.

- 11.) Answer: $N_{SC} = 5.24 t + 12.04 = 5.24(5) + 12.04 = 38.24 \text{ gal/cap}$
 (4 occup) $N_{SC} = 4(38.24) = 152.96 \text{ gal}$
 $N_{SI} = 8.15 t + 38.82 = 8.15(5) + 38.82 = 79.57 \text{ gal/cap}$
 $N_{SI} = 4(79.57) = 318.28 \text{ gal}$
 Vol of tank = $9(3.5)(4.0) = 126 \text{ ft}^3 = 126(7.48) = 942.5 \text{ gal}$
 Bottom area of tank = $9(3.5) = 31.5 \text{ ft}^2$
 Volume per foot of depth = $31.5(1) = 31.5 \text{ ft}^3/\text{ft}$
 $\text{Vol} = (31.5) \text{ ft}^3/\text{ft} (7.48) \text{ gal}/\text{ft}^3 = 235.6 \text{ gal}/\text{ft}$

$$\text{Depth scum} = \frac{152.96 \text{ gal}}{235.62 \frac{\text{gal}}{\text{ft}}} = 0.649 \text{ ft (1/3 floats)} = 0.216 \text{ ft}$$

$$\text{Depth of sludge} = \frac{318.28 \text{ gal}}{235.62 \frac{\text{gal}}{\text{ft}}} = 1.35 \text{ ft}$$

$$\text{Submerged scum} = 2/3 (.649) = 0.433$$



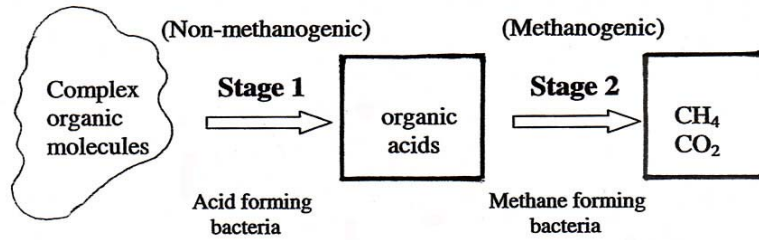
$$\text{Clear Zone} = 4.0 - 1.35 - 0.433 = 2.22 \text{ ft} = 26.6 \text{ in} \quad \leftarrow$$

- 12.) Answer: Septic Tank A: Surface Overflow Rate = $\frac{480}{(5)(4)} = 24 \frac{\text{gpd}}{\text{ft}^2}$
 Septic Tank B: $\text{SOR} = \frac{480}{(6)(3)} = 26.7 \frac{\text{gpd}}{\text{ft}^2}$

So septic tank A has the lowest overflow rate and according to theory would have the best solids removal.

- 13.) Answer: From Table 12.
 Family of 4 on a 1,000 gal tank. Pump out = 7 years
 Family of 5 on a 1,500 gal tank. Pump out = 9 years

14.) Answer: The two stages of anaerobic decomposition are as follows:



1.) **Hydrolize complex organic molecules**

starches \Rightarrow sugars
 proteins \Rightarrow amino acids
 fats \Rightarrow intact

2. **Organic acids formed; pH depressed; retards further growth**

1.) **Metabolize organic acids to CH₄ and CO₂**

2.) **Amino acids \Rightarrow NH₃ raises pH**

3.) **Fats \Rightarrow CH₄ and CO₂**

15.) Answer: Septic Tank A: Area = (5) (10) = 50 ft²

$$\text{Septic Tank B: Area} = \frac{\pi d^2}{4} = \frac{\pi(7.98)^2}{4} = 50 \text{ ft}^2$$

$$\text{Septic Tank C: Area} = 8 (6.25) = 50 \text{ ft}^2$$

Since they all have the same water surface area for the same flow, their surface overflow rate (SOR) would be the same, hence according to the settling theory alone, the solids removal would be equal.

16.) Answer: Due to the always presumed presence of pathogens. Also it constitutes an obnoxious environmental insult.

17.) Answer: From Tables 4, 5, and 6
North Bound Site

2 gas stations (100 veh/day)	2 x 100 x 12 =	2,400 gal/day
2 gas stations (4 employees)	2 x 4 x 13 =	104 gal/day
1 hotel A resort	1 x 58 x 50 =	2,900 gal/day
1 hotel B resort	1 x 75 x 50 =	3,750 gal/day
1 restaurant (200 patrons)	1 x 200 x 9 =	<u>1,800</u> gal/day
(48 hr retention time)		Q = 10,954 gal/day ←

$$\text{Septic Tank Vol}_{\text{NB}} = \frac{10,954 \times 48}{24} = \underline{21,908} \text{ gal} \quad \leftarrow$$

(continued)

South Bound Site

1 gas station (150 veh/day)	1 x 150 x 12	=	1,800 gal/day	
6 employees/day	6 x 13	=	78 gal/day	
1 hotel C resort	1 x 100 x 50	=	5,000 gal/day	
1 bar (75 customers/day)	1 x 75 x 3	=	225 gal/day	
1 bar (4 employees/day)	1 x 4 x 13	=	<u>52 gal/day</u>	
	Q =		7,155 gal/day	←

Septic Tank Vol_{SB} = 7,155 x 2 = 14,310 gal. ←