

## Abstract

The Fundamentals of Engineering Design (FED) program at New Jersey Institute of Technology (NJIT) was initiated in 1992. Since its inception, the Dean of Freshmen Studies arbitrarily assigns students to the various sections being taught. Consequently, in this introductory freshman design course, students of different majors are in the same class and the design project may not be related to the discipline of the student's choice. For freshmen, these introductory design problems are often complex and beyond the knowledge that has been developed by the students. Students do not have the technical background to delve deeply into the technical aspects of the design project. It is our experience that without a great deal of extensive classroom instruction, the environmental engineering design problem presented to the students is a complicated problem for them. Many times the design problem involves concepts that students learn in the sophomore or junior years. Therefore, to enhance the student's abilities to complete the design project, a workbook concept was developed modeled after the Freshmen Chemistry Laboratory workbooks. The workbook concept follows a block building, step by step approach to the problem solution. The student must understand the first steps before moving on to the next part of the analysis.

One example of the workbook concept is "The Siting and the Process Design of a Municipal Wastewater Facility". This project was team taught by the Civil Engineers and the Chemical Engineers. The Civil Engineers focused on the siting of the facility and the related economic, environmental and political problems. The students visited potential sites and then made a final recommendation for the best site. The Chemical Engineers guided the students through the process design concepts. The Chemical Engineers were concerned with the process concept, the material balances around the process and the process units, estimating the size of the process units and equipment and the final cost estimate of the process. The basis for this study is the material balances, the concepts of, which are taught to our chemical engineering sophomores. It is, therefore, very understandable that these new concepts are not easy, especially for freshmen who have never been exposed to these concepts. The apparent "cookbook" approach to the use of workbooks is avoided because at each step the student must decide on the value of parameters where a range of values is permissible. Thus, the student must contemplate on the effect of the choice of parameter and how it will affect the design problem. Furthermore, the student must justify the choice made with an explanation. The problem is thus open-ended and the students very quickly learn that there is no one given answer. Experience has shown that with sufficient guidance, the freshmen can solve the relatively complex problem and have an understanding of the problem and its solution, and thus having gained a very meaningful experience.

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## The Problem

Design and Locate a Municipal Wastewater Facility that meets the following specifications:

Basis of Design:

Community	-	45000 households
Household	-	3 people each
Consumption	-	80 gallons/capita/day

Wastewater Treatment Facility Specifications (Composition)

	<u>Influent, mg/L</u>		<u>Effluent, mg/L (MAX)</u>
BOD <sub>5</sub>	250	-	30
Suspended Solids (SS)	250		30

## Selection of the Process Design

Processes for wastewater treatment can be much too complex for students in the freshman year to comprehend. Hence, a simplified process is discussed which shows the essential aspects of the system, and which is more readily comprehended by the students. One such simplified process is shown in Figure 1. It entails

1. Screens
  - Remove large objects
2. Primary Sedimentation
  - Remove particulates by settling
3. Primary Vacuum Filter
  - For solids removal by filtration

**4. Aeration System**

- Convert Biochemical Oxygen Demand (BOD), an indirect measure of organic material in the wastewater to sludge

**5. Secondary Sedimentation**

- Remove sludge by settling

**6. Secondary Vacuum Filter**

- Remove sludge by filtration

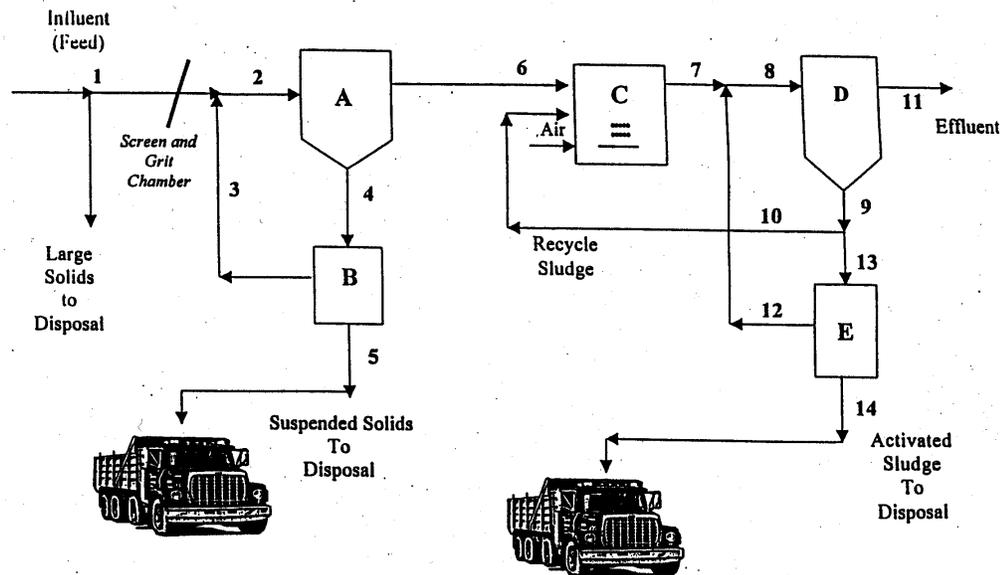
## The Solution of the Problem

The solution to the problem entails making material balances on the five units in the process. These are:

- A. Primary Sedimentation Tank for Suspended Solids
- B. Vacuum Rotary Filter For Suspended Solids
- C. Aerator (Activated Sludge Process)
- D. Secondary Sedimentation Tank For Sludge
- E. Vacuum Rotary Filter For Sludge

Figure 1

Simplified Wastewater Treatment Facility



Unit A Primary Sedimentation  
Unit B Vacuum Filter for Suspended Solids

Unit C Aerator  
Unit D Secondary Sedimentation  
Unit E Vacuum Filter for Sludge

## Aerator Analysis

### The Conventional Activated Sludge Process Reactor with Recycle and Complete Mixing

**Problem:** Design the reactor, which will reduce the BOD<sub>5</sub> in Stream 6 to less than 30 mg/L

#### 1. Calculation of the outlet BOD<sub>5</sub> from the aerator (Stream 7)

For complete mixing with recycle, activated sludge process, Sundstrom and Klei give key equations in Table 1, page 144.

Effluent waste concentration calculation:

$$S = \frac{K_m (1 + k_d \theta_c)}{\theta_c (k_o - k_d) - 1}$$

Where  $S$  = outlet BOD<sub>5</sub> concentration, mg/L (Stream 7)

$\theta_c$  = sludge age, hours. The sludge age is the sludge retention time in the reactor. How long does the sludge reside in the reactor? Sludge age should be between 3 and 14 days (Sundstrom and Klei, p 146)

$K_m$ ,  $k_d$ ,  $k_o$  are kinetic coefficients. These are given in Sundstrom and Klei, Table 6-2, p 146 for Domestic wastewater composition based on BOD<sub>5</sub>.

Calculation:

$$S = \frac{K_m (1 + k_d \theta_c)}{\theta_c (k_o - k_d) - 1}$$

Table 6-2, p 146, Sundstrom and Klei and Example Problem 6-1, p

$K_m$  = \_\_\_\_\_ to \_\_\_\_\_, mg/L

What is your decision? \_\_\_\_\_, mg/L

Why did you make this decision?

$k_d$  = \_\_\_\_\_ to \_\_\_\_\_, h<sup>-1</sup>

What is your decision? \_\_\_\_\_, h<sup>-1</sup>

Why did you make this decision?

$k_o$  = \_\_\_\_\_ to \_\_\_\_\_, h<sup>-1</sup>

What is your decision? \_\_\_\_\_, h<sup>-1</sup>

Why did you make this decision?

$\theta_c$  = \_\_\_\_\_ to \_\_\_\_\_, days

What is your decision? \_\_\_\_\_, days

Why did you make this decision?

$\theta_c$  = \_\_\_\_\_ days | \_\_\_\_\_ = \_\_\_\_\_ h

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