Water Quality Management

CE 326 Principles of Environmental Engineering
Department of Civil, Construction and Environmental Engineering
Iowa State University
Tim Ellis, Ph.D., P.E.
March 30, 2009
Announcements

• BOD and TSS Lab
  – Need to weigh solids
  – Check DO in BOD bottles

• Water Quality Management Problems - Chapter 5: 2, 6, 36, 42 (starting on page 407) due 4/8/09
Sustainability

Going down the drain

CA works to highlight waste of campus living in eyes of ISU students

By Virginia Zanov
Daily Staff Writer

Every day in the residence halls, students wake up, walk down the hall and shower.

For the first few hours in the morning, the hiss of multiple showers going at once can be heard in the hallways.

At some point in the morning, this sound evaporates, just like the steam from all those showers, and students go on with their daily routines.

The next day, the residence hall showers go through the same cycle — wake, I was, evaporate. And so it goes the next day, and the day after that.

Taking a shower is such an ingrained procedure for most people that they never think twice about it.

But Meghan Roberts, senior in civil engineering and Friley Hall community adviser, sees the simple shower as an opportunity to take care of the planet.

Roberts has pinpointed the showers in the residence halls as a part of university life that she can work on for more conservation.

The water used daily is not an unlimited resource, Roberts said.

"The water will run out," she said.

Yes, the earth is full of water — but most of it is saltwater. Fresh water, used not only to hydrate people, but also to irrigate crops and countless other things, only makes up one percent of the world’s water supply, Roberts said.

According to the World Bank’s World Water Data, 700 million people live in countries experiencing water stress or scarcity.

In an effort to help the campus community become more mindful of water usage, Roberts has taken it upon herself to measure the water flow from the shower heads in some of the residence halls.

WATER on PAGE 5

WATER

from PAGE 1

Pete Englin, director of the department of residence, said Roberts has advocated purchasing low-flow shower heads for the residence halls.

She started discussions about student testing of low-flow shower heads for a designated period of time to see if the campus community would be open to the idea.

Right now, Roberts contends that the pressure is far higher than it should be, wasting water. Roberts said her experiences in Uganda with the student group Engineers for a Sustainable World, and in Mali with the mechanical engineering department, have brought the issue of water conservation to the front of her mind.

"When I was in Mali, there was one water tank for the village," Roberts said. "And they're right on the Sahara Desert, so it was solar powered.

But the pump would only run if it was sunny that day — most of the days were sunny, but the pump would not run at night, so it wasn't able to fill back up completely with water until the next day."

The tank provided the village's daily water needs, and there was a small hand pump as well, but it was difficult to retrieve water with it.

"It was very hard to get water," Roberts said. "The ground water table there is lowering."

In Uganda, Roberts said her experiences with lack of water availability were similar.

"Quite often there were power outages and water shortages," Roberts said.

Roberts said in order to conserve water on campus, students can take shorter showers, wear some clothing items a couple times a week to reduce the laundry load, and turn the water off while brushing teeth.

She said students should have low-flow shower heads and low-flow toilets.

However, that isn't always possible since the kind of appliances students have are not always their decisions.

Englin said Roberts has been vocal about other sustainability-related issues on campus as well, such as recycling.

"The concept of recycling has always been primarily student-driven with some support from staff, and that tends to make it much more effective," Englin said.

"What she has raised as an issue is that we have an obligation as a department to raise this issue of recycling," Englin said. "Roberts has encouraged leaders in the residence halls to implement a department-wide recycling program that more actively educates students about recycling.

"Students can then leave their education when they may have not brought it with them initially," Englin said of the proposed program.

He said Roberts has been a "tremendous advocate" for sustainability issues for the last two years.

This began with her past role as Friley Hall president and continues in her current role of community assistant for Henderson.

"She came from a background where she's had a lot of life experiences in sustainability, and she's helping to inform where we need to move forward," Englin said.
Water Conservation at the Bridge Street Inn Hostel

Earthworm Envy

Image of a toilet and a sink with text overlay. Description text not visible in the image.
QUIZ

1. How many pounds of DDT do Mexico and Brazil use each year? 2M

2. What was the cost of the Cryptosporidium outbreak in Milwaukee in 1993? $55M

3. What was the cost of the Pfisteria outbreak in the Chesapeake bay in 1997? $43M

4. How many tons of chlorine is produced annually in the U.S.? 45M

5. What % of the total chlorine production is used for water treatment? 59%

6. How many tons of chloroform is produced from chlorination in the U.S. annually? 2000

7. How much money is spend on chlorinating drinking water in U.S. each year? $2.3B

8. The odds of getting the entire NCAA brackets correct are 1 in 9 x 10^16.
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BOD and DO Sag

\[ \text{BOD remaining at time, } t \]

\[ \text{BOD}_t = L_0 - L_t = L_0 (1 - e^{-kt}) \]
BOD and DO Sag

\[ \text{Do}_{\text{sat}} = 8.38 \text{ at } 25^\circ \text{C} \]

\[ D = \text{deficit } \text{Do}_{\text{sat}} - \text{Do} \]

\[ \text{initial Do} \]

\[ \text{discharge} \]

\[ \text{critical time (distance downstream)} \]

\[ \text{danger zone} \]

\[ Q_w, Q_e \]

\[ \text{r}_r = \text{rate of reaeration} \]

\[ k_d = \text{rate of deoxygenation} \]
BOD and DO Sag

\[
\frac{dD}{dt} = k_dL - k_r D
\]

\[
D = \frac{k_d La}{k_r - k_d} (e^{-k_d t} - e^{-k_r t}) + Da (e^{-k_r t})
\]

\[
t_c = \frac{1}{k_r - k_d} \ln \left[ \frac{k_r}{k_d} \left( 1 - Da \frac{k_r - k_d}{k_d La} \right) \right]
\]

- \( t_c \): time of zero oxygen deficit
- \( k_d \): deoxygenation rate, \( \text{d}^{-1} \)
- \( k_r \): reaeration rate, \( \text{d}^{-1} \)
- \( L \): ultimate BOD
- \( D \): oxygen deficit = \( \text{DO}_{sat} - \text{DO} \)
BOD and DO Sag
An industrial wastewater treatment plant discharges to a river. A fish hatchery 25 km downstream wants to use water from the river. The dissolved oxygen concentration of the fish hatchery intake has to be at least 5 mg/L to protect their hatchery operation. Is the river water satisfactory for this operation? Show all your work on this page; use back if necessary.

D = \frac{\text{initial deficit}}{\text{initial deficit}} \left( e^{-kt} - e^{-kRt} \right) + D_a \left( e^{-kRt} \right)

**Given:**

<table>
<thead>
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<th>Industrial WWTP</th>
<th>River</th>
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<tr>
<td>Flow, m³/s</td>
<td>Qw</td>
</tr>
<tr>
<td>Ultimate BOD, mg/L</td>
<td>Lw</td>
</tr>
<tr>
<td>DO, mg/L</td>
<td>LW</td>
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<tr>
<td>Temperature, °C</td>
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<tr>
<td>$k_d$ at 25°C, d⁻¹</td>
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</tr>
<tr>
<td>$k_e$ at 25°C, d⁻¹</td>
<td>0.35</td>
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<tr>
<td>Velocity, m/s</td>
<td>0.1</td>
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<tr>
<td>DO saturation concentration, mg/L</td>
<td>8.38</td>
</tr>
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</table>

\[ L_a = \frac{Q_w(L_w) + Q_r(L_r)}{Q_w + Q_r} = \frac{0.2(25) + 0.8(8)}{0.2 + 0.8} = 11.4 \text{ mg/L} \]

\[ D_a = 8.38 - \frac{0.2(6) + 0.8(7)}{0.2 + 0.8} = 8.38 - 6.8 = 1.58 \text{ mg/L} \]

\[ t = \frac{\text{distance}}{\text{velocity}} = \frac{25,000 \text{ m}}{0.1 \text{ m/s}} \times \frac{1}{60 \text{ h}} \times \frac{1}{24 \text{ h}} = 2.89 \text{ d downstream} \]
\[ D = \frac{0.25(11.4)}{0.35 - 0.25} \left( e^{-0.15(2.89)} - e^{-0.35(2.89)} \right) + 1.58 \left( e^{-0.35(2.89)} \right) \]

\[ = 28.50 \left( 0.49 - 0.36 \right) + 1.58 \left( 0.36 \right) \]

\[ = 4.27 \text{ ms} / l \]

\[ D_0 = 8.38 - 4.27 = 4.11 \text{ mg} / l \leq 5.0 \text{ mg} / l \]

\[ L_a = 0.2(20) + 0.8(8) = 10.4 \]

\[ D_A = 8.38 - (0.2(7) + 0.8(7)) = 1.38 \]

\[ D = \frac{0.25(10.4)}{0.35 - 0.15} \left( e^{-0.25(2.89)} - e^{-0.35(2.89)} \right) + 1.38 \left( e^{-0.35(2.89)} \right) \]

\[ = 3.87 \quad \text{D.O.} = 8.38 - 3.87 = 4.5 \text{ ms} / l \]
\[ h_T = h_{20}(\Theta)^{T-20} \]

**Typical value at 20°C**

- Raw sewage: 0.35 - 0.7 d\(^{-1}\)
- Treated wastewater: 0.12 - 0.23 d\(^{-1}\)
- River water: 0.12 - 0.23 d\(^{-1}\)

\[ T = \frac{Q_w(T_w) + Q_r(T_r)}{Q_w + Q_r} \]

where \( \Theta = \begin{cases} 1.135 & 4 \leq T \leq 20 \\ 1.056 & 20 \leq T \leq 30 \end{cases} \)

\[ Q_{\Theta} \] temp. coeff.

\[ \text{temp. coef.} \]