Problem of the Day
2014.Nov.26

Introduction

The Water Environment Federation is the trade organization for water professionals, including wastewater treatment operations professionals (http://wefcom.wef.org/home). Individual states, or groups of states, sponsor local chapters. On October 29, 2014, I gave a 6-hour Math for Operators Workshop at the annual conference of the Pacific Northwest Clean Water Association (PNCWA). PNCWA represents Idaho, Oregon and Washington (http://www.pncwa.org/). All operators should seriously consider joining their local association. In California it is the California Water Environment Association (http://www.cwea.org/).

Long story short: I randomly covered a series of math problems in the PNCWA workshop, and I have been requested by several attendees to send them the problems. Instead, I am going to post them here (starting with the 2014.Nov.04 Problem of the Day). They are good practice for all visitors to WWTT's Problem of the Day.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

This is the last problem from the PNCWA Workshop!

Discussion

Wastewater treatment is very expensive and getting more so at the same time ratepayers are demanding cost containment. There is a significant cost when operating a mesophilic anaerobic digester bringing the incoming sludge up to the operating temperature of the digester, typically 98-99° F. **The more water in the incoming sludge, the more expensive the heating requirement**. This is why thickening is such an important process upstream of an anaerobic digester. There is also a significant cost associated with trucking biosolids from the WWTP to the disposal site, whether it is a landfill or a land-application site. **The more water in the biosolids, the more expensive the trucking costs**. This is why dewatering is such an important process downstream of an anaerobic digester. **A key performance indicator of both thickening and dewatering processes is the percent solids recovery** or PSR (sometimes also called the **solids capture efficiency**) defined as:

$$\text{PSR, \%} = \frac{\text{lb } TS_o \cdot 100}{\text{lb } TS_i}$$

where **lb TS_o = pounds of TS in the output** coming from the thickening or dewatering unit, and **lb TS_i = pounds of TS in the input** going to the thickening or dewatering unit (for more discussion, see http://wastewatertechnologytrainers.com/wp-content/uploads/2014/10/2014.Oct_.22.pdf). To do calculations involving PSR, WWTT defines the PSR in very specific, yet practical, units. In the certification and math review classes that WWTT does, many operators are initially reluctant to embrace the use of units because it seems tedious and time consuming. While this is most certainly true when just starting to use "the railroad track," with continuing patience and practice (practice, practice, practice!!!), the use of units will become second nature and, ultimately, proven **failsafe** and **foolproof**.

Problem of the Day

Given the following information, calculate the annual cost to dispose biosolids at the landfill:

- Landfill tipping fee = $180/ton cake
- Belt filter press with a, PSR = 96%
- Belt filter press operation = 6.5 hours/day, 5 days/week
- Digested sludge flow rate = 75 gpm
- Digested sludge TS concentration = 3.6%
- Digested sludge specific gravity = 1.02
- Cake TS concentration = 22.5%
- Cake density = 66.8 lb/ft^3
- **Calculate: annual cost ($/yr) for biosolids disposal**.

Solution

It is very important to remember and get the hang of how WWTT expresses the PSR if given in a problem. In the current problem, a PSR of 96% is given. WWTT express this as:

$$96\%\ \text{PSR} = \left|\frac{96\ \text{lb}\ TS_c}{100\ \text{lb}\ TS_s}\right|$$

where TS_c is the TS (total solids) in the cake ("c" for "cake") and TS_s is the TS in the sludge ("s" for "sludge") even though the TS in the cake are the same TS in the sludge. Remember, in both thickening and dewatering the solids pass through the units unaltered and only water gets removed. In order to get a high PSR (desirable), relatively few solids should end up in the water returned to the liquid treatment train.

Notice in the problem statement the specific gravity of the digested sludge fed to the belt filter press is given, 1.02. Generally speaking, if the specific gravity is given in a problem, **you're going to use it**. I immediately put it into a small railroad track and multiply it by the density of water to calculate the density of the sludge:

1.02	8.34 lb	=	8.51 lb sldg
	gal		gal sldg

The information given in the problem statement above is repeated below expressed in the units that will make the railroad track work. Hopefully these units make sense to readers of Problem of the Day. To the extent possible, everything is labeled intuitively; for example, the density of sludge calculated above is in units of pounds of sludge per gallon of sludge (lb sldg/gal sldg) and not just "lb/gal," because then the units will be confusing. Also in the list below the digested sludge flow rate to the belt filter press, 75 gal sldg/min has been converted to 4,500 gal sldg/hr by multiplying 75 gal sldg/min x 60 min/hr = 4,500 gal sldg/hr.

Problem of the Day: Given the following information, calculate the annual cost to dispose biosolids at the landfill:

- Landfill tipping fee = $180/ton cake
- Belt filter press with a, PSR = 96% = 96 lb TS_c/100 lb TS_s
- Belt filter press operation = 6.5 hr/d, 5 d/wk
- Digested sludge flow rate = 75 gal sldg/min = 4,500 gal sldg/hr (from above)
- Digested sludge TS concentration = 3.6% = 3.6 lb TS_s/100 lb sldg
- Digested sludge density = 8.51 lb sldg/gal sldg (calculated above from specific gravity)
- Cake TS concentration = 22.5% = 22.5 lb TS_c/100 lb cake
- Cake density = 66.8 lb cake/ft^3 cake
- **Calculate: annual cost ($/yr) for biosolids disposal**.

$	=	**$180**	100 ~~lb cake~~	~~ton~~	96 ~~lb TS_c~~	3.6 ~~lb TS_s~~	8.51 ~~lb sldg~~	4,500 ~~gal sldg~~	6.5 ~~hr~~	5 ~~d~~	52 ~~wk~~
yr		~~ton cake~~	22.5 ~~lb TS_c~~	2,000 ~~lb~~	100 ~~lb TS_s~~	100 ~~lb sldg~~	~~gal sldg~~	~~hr~~	~~d~~	~~wk~~	**yr**

Since all the units have canceled except the one needed in the answer, **$/yr**, the math is done and the arithmetic gives the answer:

180 x 100 x 96 x 3.6 x 8.51 x 4,500 x 6.5 x 5 x 52 ÷ 22.5 ÷ 2,000 ÷ 100 ÷ 100 = **$894,669/yr**.

Happy calculating! Let us know how these Problems of the Day are working for you by leaving a comment.