Chapter 6

Sludge(residual) treatment

2020

Aim of sludge treatment

- Reduce the volume and bulk of sludge
- Reduce pathogens in the sludge
- Minimize the cost of disposal and transport of the sludge
- Reduce odour attraction
- Satisfy environmental requirements and public perception
- Generate energy(sometimes)

- The quantity and characteristics of sludge produced depend on the character of raw water and the wastewater treatment processes.
- Primary sludge contains inorganic solids as well as coarser organic solids.it is more granular and concentrated than secondary sludge.
- Primary sludge typically 2-6% dry solids by mass
- The mass production of primary sludge($M_{ps,in}$ $^{Kg}/_{day}$) from the primary sedimentation tank can be estimated as:

$$M_{ps}=\varepsilon*SS*Q$$

Where,ε=efficiency of the primary tank

SS=influent suspended solid concentration

Q=flow rate

- Secondary sludge mainly composed of biological solids. Its composition is more variable than primary sludge, depending on process variables(e.g attached growth process produce more particulate sludge, whereas activated sludge produces light, flocculent sludge)
- Secondary sludge is typically 0.5-2% dry solids for activated sludge processes,4-7% dry solids for attached growth processes
- The mass production rate of secondary sludge(M_{ss}) = $Y_{obs} * L * Q$

Where $Y_{obs=}$observed biomass yield

L=BOD_5 removed by secondary treatment

Q=flow rate

- The value of Y can be related to F/M ratio and is typically 0.2-0.4

Example:-Estimate the solids generated in the primary and secondary clarifiers at the secondary(activated sludge)treatment plant. Assume that the primary settling tank removes 65% of the TSS and 33% of the BOD_5.also determine the volume of each sludge, assuming 6% and 1.2% solids in the primary and secondary effluents, respectively.

Average plant flow=3785m^3/d(1Mgal/day)/L

Primary influent TSS=240mg/L

Primary influent BOD=200mg/L

Secondary effluent BOD=30mg/L

Secondary effluent TSS=24mg/L

Bacteria growth rate Y 0.23 kg (0.5 lb) sludge solids per kg (lb) BOD removed

Step 1:-Calculate the quantity of dry primary solids produced daily=1 mg/L
=1 g/m3

Primary sludge=3785 m3/d*240 g/m3*0.65/(1000 g/kg)

=590 kg/d(1300 lb/d)

Step 2:-Calculate the primary effluent TSS and BOD concentrations

TSS =240 mg/L *(1-0.65)=84 mg/L

BOD=200 mg/L *(1-0.33)=134 mg/L

Step 3. Calculate TSS removed in the secondary clarifier

Secondary (TSS) solids=3785 m3/d*(84-24)(g/m3/(1000 g/kg)

=227 kg/d(500 lb/d)

Step 4. Calculate biological solids produced due to BOD removal

BOD removed =3785 m3/d *(134-30) g/m3/(1000 g/kg)

=394 kg/d(869 lb/d)

Biological solids 394 kg/d*Y=394 kg/d*0.23 kg/kg

= 90 kg/d(198 lb./d)

Step 5. Calculate total amount of solids produced clarifier and from the whole plant (from Steps 3 and 4) from the secondary

Secondary solids =(227+90) kg/d

= 317 kg/d(698 lb./d)

Solids of the plant =Step 1+Step 5

=(590+317) kg/d

=907 kg/d(1998 lb/d)

Step 6. Determine the volume of each type of sludge, Assuming sp. gr. of sludge 1.0

Primary sludge volume $V1$ =$\frac{590\text{kg/d}}{0.06*1000kg/m^3}$= 9.8 m^3/d

Secondary sludge volume $V2$ =$\frac{317kg/day}{0.012*1000kg/m^3}$=26.4$m^3$/d

- **Sludge treatment involves a number of steps and process options, the selection and extent of which depends on factors such as**
    - **The site- specific composition of the sludge**
    - **The available of budget for sludge treatment**
    - **The intended fate of the final treated sludge**
- **Generally known processes**
    - **Thickening**
    - **Pre-treatment**
    - **Digestion(stabilisation)**
    - **Conditioning**
    - **De-watering**
    - **Thermal reduction**
    - **End-use disposal**

Sludge thickening

- **Purpose:-to reduce the sludge volume to be handled in the subsequent sludge processing units(pump, digester, dewatering equipment) and to reduce the construction and operating costs of subsequent processes.**
- **Used to remove water and increase the solids content.**

Sludge stabilization:-after sludge has thickened it requires stabilization to convert the organic solids to a more refractory or inert form

- **Purpose:-to reduce phatogens,elminate odour-causing materials, and to inhibit ,reduce, and eliminate the potential for putrefaction.**
- **Treatment processes commonly used for stabilization of wastewater sludge includes; anaerobic digestion, aerobic digestion, chemical stabilization and composting.**

- **Lime stabilization:-it involves chemical oxidation(commonly using chlorine) and PH adjustment under basic condition. Achieved by adding lime.**
- **The sludge is deodorized and microbiological activities slowed down. The sludge can then be dewatered and disposed of.**
- **The lime raises the sludge PH to 12 and the highly alkaline environment will inactive biological growth and destroy pathogens**

Sludge conditioning:-it involves chemical and physical treatment to enhance water removal. Some additional sludge conditioning processes disinfect sludge, control odour, alter the nature of solids, provide limited solid destruction and increase solid recovery.

- **Chemical conditioning:-can reduce 90% to 99% incoming sludge moisture content to 65% to 80%,depending on the nature of sludge to be treated.**
- **It results coagulation of solids and released of the absorbed water**
- **In organic compounds such as lime, quick lime, ferric chloride, alum used as chemical for the conditioning process.**

Physical conditioning:-the most commonly method is thermal conditioning.

- The process involves heating the sludge to a temperature of177 to 240 degree centigrade in a reaction vessel under a pressure of 1720 to 2760 $^{KN}/_{m^2}$ for 15 to 40min.

Sludge dewatering:-the primary objective is to reduce sludge moisture. Subsequently it reduces the cost of pumping and hauling to the disposal unit.

- Dewatered sludge is easier to handle than thickened or liquid sludge
- An advantage of dewatering is that it makes the sludge odorless
- Sludge can be dewatered by slow natural evaporation and percolation or by mechanical devices such as vacuum filtration, pressure filtration and centrifugation.

Sewage sludge biosolids:-sewage sludge processing (i.e thickening, stabilization, conditioning, and dewatering) produces a volume reduction and this decreases the capital operating costs.

- Digestion(composting)reduces the level of pathogens and odour.
- The end product of wastewater sludge treatment process is referred to as **biosolids**

Biosolids:-solid organic matter recovered from a sewage treatment process used especially as a fertilizer for plants.

- Anaerobic digestion is the most popular form of sludge treatment in the uk.it produces bio renewable energy source in the methane gas released, and can also produce a sludge that is acceptable for agricultural usage as a soil conditioning material.
- Digestion involves the degradation of sewage sludge by mixed populations of bacteria usually at 35 degree Celsius.
- A typically process involves 12 days of primary digestion at 35 degree Celsius and 14 days of secondary digestion at ambient temperatures.
- Mechanical mixing is applied to provide homogeneous conditions any reduce by pass flows of sludge
- Total require volume of digester(V) can be estimated as: $\frac{Q_1+Q_2}{t_1} + Q_2 * t_2$

Q_1=raw sludge loading rate

Q_2=digested sludge accumulation

t_1=solids retention time

t_2=digested sludge storage time

- **Digestion achieves a 50% reduction in volatile solids**
- **A secondary stage of digestion increases solid separation, collects residual gas, and remove pathogen removal.**

Advantage of anaerobic digestion

- **Can deal with strong organic liquor**

biomass retention times necessary for

weak effluents

No aeration required

up

High degree of purification

Stable process once started

operator experience

Methane gas by- product of anaerobic digestion

-usually sufficient to sustain digestion

toxic substances

-used for local power productions

Simple and economically viable

disadvantages

-increased

-slow to start-

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-needs

-sensitive to

End of chapter six