ENVIRONMENTAL ENGINEERING

Chapter 4 : Waste Water Treatment (Part 3)

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Chapter Description

- Topic
  - Sludge treatment
  - Advance wastewater treatment
- Expected Outcomes
  - Classify the treatment processes involved in wastewater treatment
  - Interpret the concept in wastewater treatment which consists of primary, secondary, sludge and advance treatment
- References

  - Peavy, H.S., Rowe, D.R. and Tchobanoglous, G., Environmental Engineering, McGraw Hill, 1985.
  - Mackenze, I.D., Introduction to Environmental Engineering, 4th Edition, Davis A. Cornell, Mc Graw Hill, 2008.
  - Sawyer, C.N. Chemistry for Environmental Engineerin. 4th Edition, McGraw Hill, 1994.
  - Martin, T.A. and David, W.H. Fundamental of Environmental Engineering. 2003.
  - Environmental Quality Act 1974 (Subsidiary Legislation), International Law Book, Service June 2002.

SLUDGE TREATMENT

Sludge treatment and disposal

- Sludge characteristics
- Sludge thickening
- Sludge digestion
- Sludge disposal

Sludge characteristics

- Sludge disposal facilities is a function of volume of sludge to be handled, cost saving attained by volume reduction.

Primary sludge	Secondary sludge
▪ From primary settling, 40 – 60% of influent solids ▪ Inorganic solids & coarser organic colloids ▪ More concentrated.	▪ Solids escape from primary settling ▪ Primary biological solids ▪ Consistency depends on treatment process

Sludge treatment – thickening

- Vacuum filtration and centrifugation – semisolid.
- Gravity thickener – horizontal agitation, suspended-culture system sludge, double solid content.
- Dissolved air flotation – flocculent nature, secondary effluent.

The quantity of solids can be determined by the following equation:

$$M_p = \xi \; x \; SS \; x \; Q$$

where M_p = mass of primary solids $\left(\frac{kg}{d}\right)$, ξ = efficiency of primary clarifier,

SS = total suspended solids in effluent $\left(\frac{kg}{m^3}\right)$, Q = flow rate $(\frac{m^3}{d})$

The volume of the primary sludge is given by:

$$V = \frac{M}{1000 \; x \; S}$$

where V = volume of sludge produced $\left(\frac{m^3}{d}\right)$,

M = mass of dry solid $\left(\frac{kg}{d}\right)$,

S = solids content expressed as a decimal fraction,

1000 = density of water $(\frac{kg}{m^3})$

***The mass of secondary solids*:**

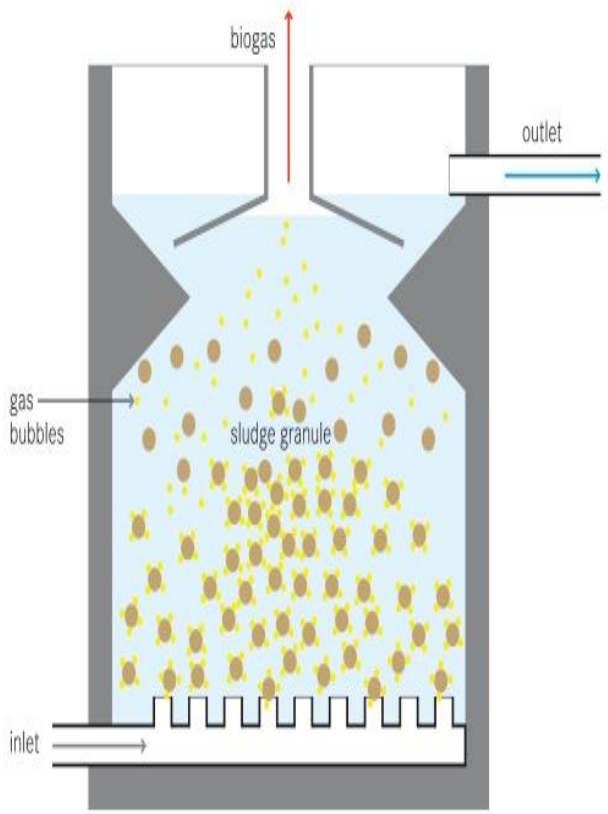
$$M_s = Y' \; x \; BOD_5 \; x \; Q$$

$$where \; M_s = mass \; of \; secondary \; solids \left(\frac{kg}{d}\right), Y' = biomass \; conversion \; factor \left(\frac{kg}{kg}\right),$$

$$BOD_5 = BOD_5 \; removed \; by \; secondary \; treatment \left(\frac{kg}{m^3}\right), Q = flow \; rate \left(\frac{m^3}{d}\right)$$

Sludge digestion

- **Anaerobic digestion** – normally for dealing primary sludge due to readily available organics that would induce a rapid growth of biomass if treated aerobically.
  - Function – convert sludge to liquids and gases
  - High rate digesters are more efficient – consists of two stage anaerobic sludge digester
  - First stage, completely mixed, second, stratified
- **Aerobic digestion** – involves stabilizing sludge wasted from aeration systems (after secondary clarifier)



Source:https://upload.wikimedia.org/wikipedia/commons/d/da/Schematic_of_the_Upflow_Anaerobic_Sludge_Blanket_Reactor_UASB.jpg

Sludge disposal

- Several options are available for ultimate disposal of wastewater sludge, which includes:

a) **Incineration** – raw sludge.

b) **Placement in sanitary landfill** – raw/digested sludge.

c) **Soil fertilizer/soil conditioner** – nonhuman consumption, liquid state (spraying, ridge & furrow, direct injection).

Advanced wastewater treatment

- Referred to as tertiary treatment.
- Nutrient removal (nitrogen and phosphorus).
- Solids removal.

Nutrient removal – nitrogen

- Results from biological decomposition of proteins and from urea discharged in body waste.
- Nitrogen converted to free ammonia or to ammonium ion.
- These two species – together termed as ammonia nitrogen.

$$NH_4^{+} \longleftrightarrow NH_3^{o} + H^{+}$$

- Ammonia nitrogen will be oxidized to nitrate

$$NH_4^{+} + \frac{3}{2}O_2 \longrightarrow NO_2^{-} + 2H^{+} + H_2O$$

$$NO_2^{-} + \frac{1}{2}O \longrightarrow NO_3^{-}$$

Nitrification by bacteria nitrosomonas and nitrobacter

- Removing ammonia – stripping with air, biological nitrification-denitrification

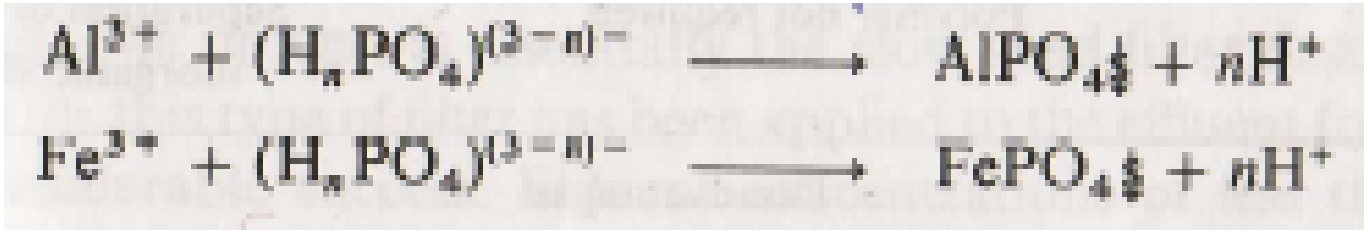
Nitrogen removal

- Air stripping - Consists of converting ammonium to the gaseous phase and then dispersing the liquid in air. Complete conversion to ammonia at pH 11, using lime.
- Nitrification – denitrification – Ammonia nitrogen converted to nitrogen gas, N_2 by biological processes. N_2 is inert and does not react with the wastewater.
- Denitrification – nitrate is reduced to N_2 gas.

$$NO_3^- + \frac{5}{6}CH_3OH \longrightarrow \frac{1}{2}N_2 + \frac{5}{6}CO_2 + \frac{7}{6}H_2O + OH^-$$

Phosphorus removal

- Most phosphate in the form of orthophosphates (negative radicals PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$)
- Removal accomplished with chemical precipitation – orthophosphates combine with trivalent aluminum / iron cations to form a precipitate:



Solid removal

1. **Suspended solids removal**
   - Several methods are available including centrifugation, air flotation, mechanical microscreening.
   - In current practice, granular media filtration is the most commonly used process (moving bed filters, pulsed bed filter).
   - Sand filters have been used to polish effluents from septic tank & other anaerobic treatment units.
2. **Dissolved solids removal**
   - Methods used includes ion exchange, microporous membrane filtration, adsorption and chemical oxidation to decrease the dissolved solids content of water.

End of Chapter 4

Author Information

Credit to the author: Dr Norhanimah Hamidi