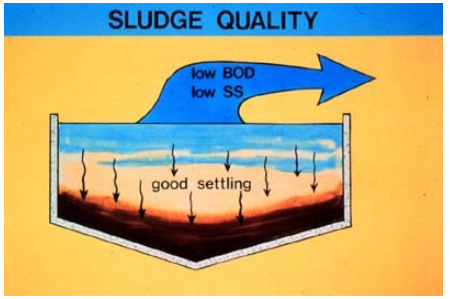

ENVE 422
TREATMENT AND DISPOSAL OF WATER AND WASTEWATER
SLUDGE

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CHEMICAL SLUDGES

Chemical sludges originate from three main sources:

1. Water Treatment,
2. Wastewater Treatment (domestic),
3. Wastewater Treatment (industrial).

- Water treatment produces alum/polymer coagulated sludge.
- For small treatment facilities like hotels, holiday resorts, small communities, etc. chemicals can be applied as the sole treatment agent. Both BOD and SS removal is achieved. Also in biological treatment, chemicals can be used in nutrient removal-N and P-especially for biologically hard to remove P.
- For industrial facilities where wastes may be toxic, non-biodegradable then lime, iron compounds or alum is applied.

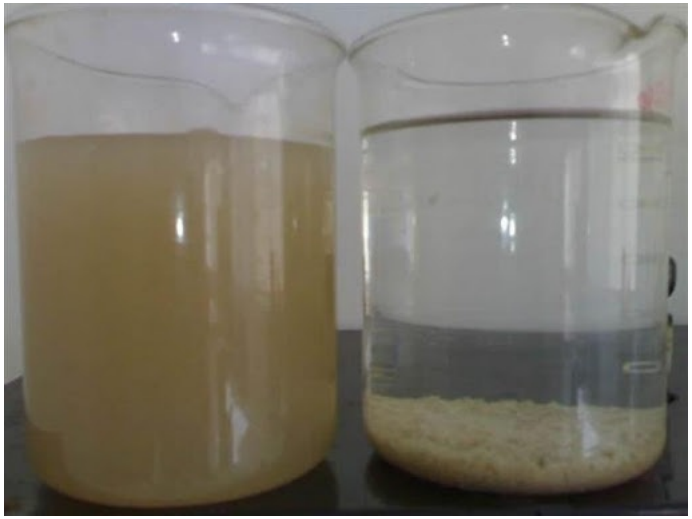
General Characteristics of Chemical Sludges

- high quantities of water
- hard to dewater
- not reactive – since they are not biological in nature (except for phosphorus removal sludge from biological treatment).

Water Treatment Alum sludge has

98 % moisture
BOD ≈ 50 mg/L
COD ≈ 500-1500 mg/L
pH ≈ 6

Treatment and Disposal: Treat as industrial sludge, dispose of them in dedicated landfills.



Typical Treatment Applications – Alum Sludge

Thickeners may be used

Rheological properties Newtonian fluid as produced

Dewatering SRF, r = 10-40*10^{12} m/kg, hard to dewater

Similar to biological sludge, SRF decreases with increasing solids concentration which is good to know.

Typical dewatering applications:

- **Centrifuges** (with polymer addition)
- **Pressure filters**

Conditioning -chemical conditioning with polymers and especially freeze / thawing is very effective.

Alum's Domestic Wastewater Treatment Applications

Phosporous removal with Alum

$Al^{3+} + PO_4^{3-} \Leftrightarrow AlPO_4 \downarrow$ insoluble ppt.

(excellent removal mechanism)

Two reactions happen at the same time:

1. $Al^{3+} + PO_4^{3-} \Leftrightarrow AlPO_4 \downarrow$ ppt.
2. $Al^{3+} + 3\ OH^- \Leftrightarrow Al(OH)_3 \downarrow$ ppt.

Total Sludge Produced at the end of the Process = Σ(1 + 2)

Aluminum recovery is possible if desired by decreasing the pH as below:

$$Al(OH)_3 + 3\ H^+ \rightarrow Al^{3+} + H_2O$$

General Properties of Iron Sludge:

Ferrous (Fe^{2+}) compounds $FeSO_4$, etc.
Ferric (Fe^{3+}) compounds $FeCl_3$

Characteristics of Iron Sludge formed:

- soft, fluffy, hard to thicken
- achievable solids concentration even with dewatering is 10-12 %
- still behaves as fluid when concentrated

Phosphorus removal: Again two reactions similar to alum treatment happen.

1. $Fe^{3+} + PO_4^{3-} \Leftrightarrow FePO_4 \downarrow$
2. $Fe^{3+} + 3\ OH^- \Leftrightarrow Fe(OH)_3 \downarrow$

Total Sludge Produced at the end of the Process = Σ(1 + 2)

Lime sludge

Two forms of lime can be used:

1. Quicklime (CaO)
2. Slaked/hydrated lime ($Ca(OH)_2$)

Typical pH = 11.5 $\rightarrow$ cabonates, phosphates, etc. will precipitate out (ex. $CaCO_3$)

Phosphorus removal when lime is added.

$Ca_5(OH)(PO_4)_3$ - calcium hydroxyl apatite

Flocs are small, calcium hydroxylapatite forms.

Properties of lime sludge

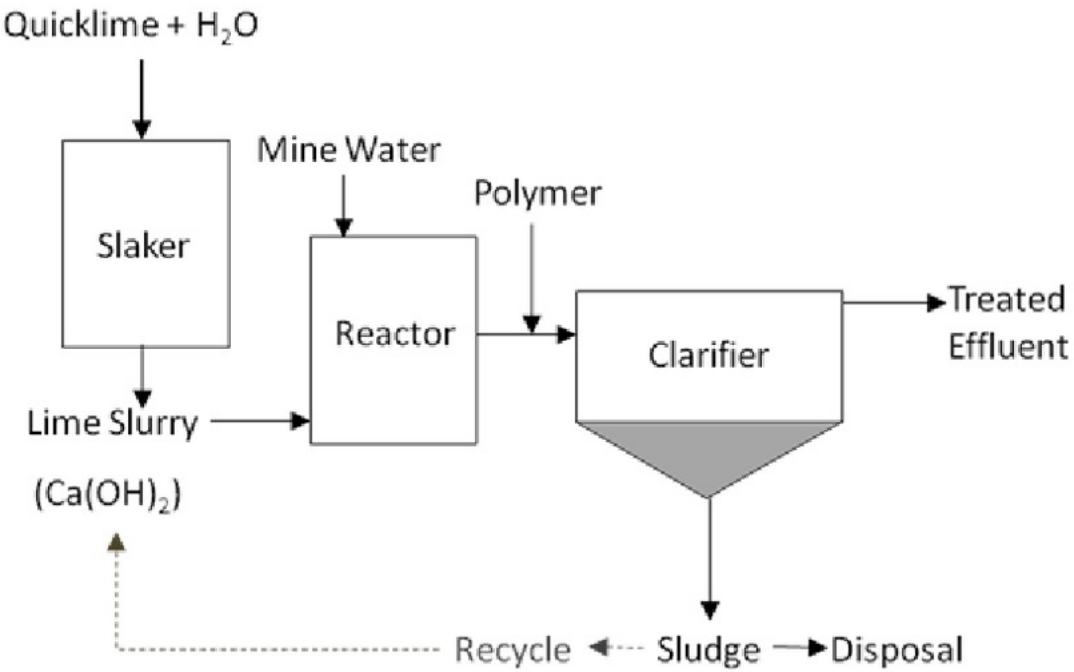
Difficult to dewater due to small floc size.

If CaO is added directly then temperature goes up. This is called the slaking process. The reaction is exothermic.

$$CaO + H_2O \Leftrightarrow Ca(OH)_2$$

Even though dangerous due to **sudden temperature increase,** CaO addition acts as a good sludge stabilization method. It destroys the pathogens by **high temperature** as well as **high pH** mechanisms. So it is a very effective method of sludge stabilization.

Lime sludge increases the pH, the permeability, and the water holding capacity of soil – if the lime treated sludge is applied to land. With these properties it acts as a good soil conditioner especially for acidic soils.



Disposal Options for Industrial (Toxic) Sludge :

- **Deep-well injection:** applied for undewatered liquid sludge. Injection is made into deeper than the water (ground water) bearing stratum impervious/confined substratum.

Problems: possibility of waste coming back to surface. If you want to reach the waste there is no way that you can do it.

- **Lanfilling:** Sludge has to be dewatered. Industrial sludges may not be dewatered easily (especially metal-oxide sludges).

- **Stabilization (Fixation)/Solidification:**

Stabilization → reduces the toxicity
Solidification → reduces the mobility.
Cement or a cement-like material or other kind of binding agent is added to sludge.
Example: Pozzolan + lime → makes a binding agent and solidifies.