COURSE: EVEN002 – ENVIRONMENTAL SYSTEMS AND PROCESSES

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REPORT ON

SOLID WASTE HANDLING FOR WASTEWATER TREATMENT PLANTS

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OBJECTIVE:

To introduce different techniques of handling solid waste resulting from wastewater treatment plants.

Wastewater solid waste (Sludge) treatment is required to reduce water and organic content . Hence the final treated waste can be safely and easily disposed or used as a useful product (fertilizer).

TABLE OF CONTENTS:

INTRODUCTION:

What is municipal wastewater?

- A combination of the liquid or water – carried wastes removed from residences, commercial and industrial establishment.
- Sewage: originates from three major sources, washing, food preparation and excretion.

Why to treat wastewater?

- Contains numerous pathogenic (disease-causing) microorganisms.
- It contains nutrients, which can stimulate the growth of aquatic plants.
- If left untreated, the decomposition of the organic materials it contains can lead to the production of large quantities of malodorous gases.

- Treated wastewater can be discharged back to the ecosystem or used for irrigation (depending on the quality of water after treatment).

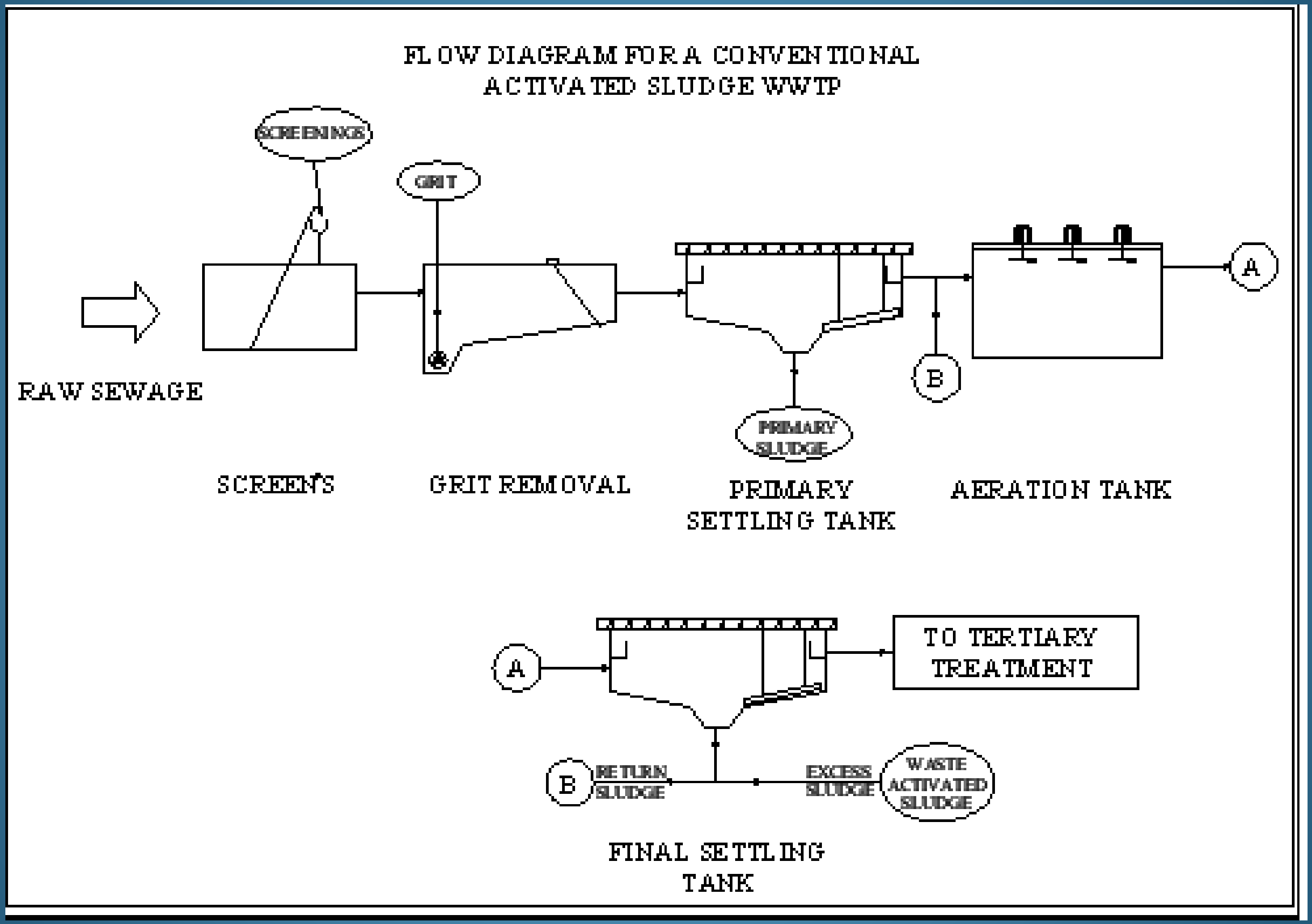
What is the composition of wastewater?

Municipal wastewater contains 99.9% water and 0.1% solids

<table>
<tr><th colspan="7">1000 000 ppm (= 1 m^3)</th></tr>
<tr><td rowspan="4">999 000 ppm water</td><td colspan="6">1000 ppm solids</td></tr>
<tr><td colspan="2" rowspan="2">700 ppm dissolved solids</td><td colspan="4">300 ppm suspended solids</td></tr>
<tr><td colspan="2">150 ppm nonsettlable matter</td><td colspan="2">150 ppm settlable matter</td></tr>
<tr><td>400ppm organic</td><td>300ppm inorganic</td><td>50ppm organic</td><td>100ppm inorganic</td><td>50ppm organic</td><td>100ppm inorganic</td></tr>
</table>

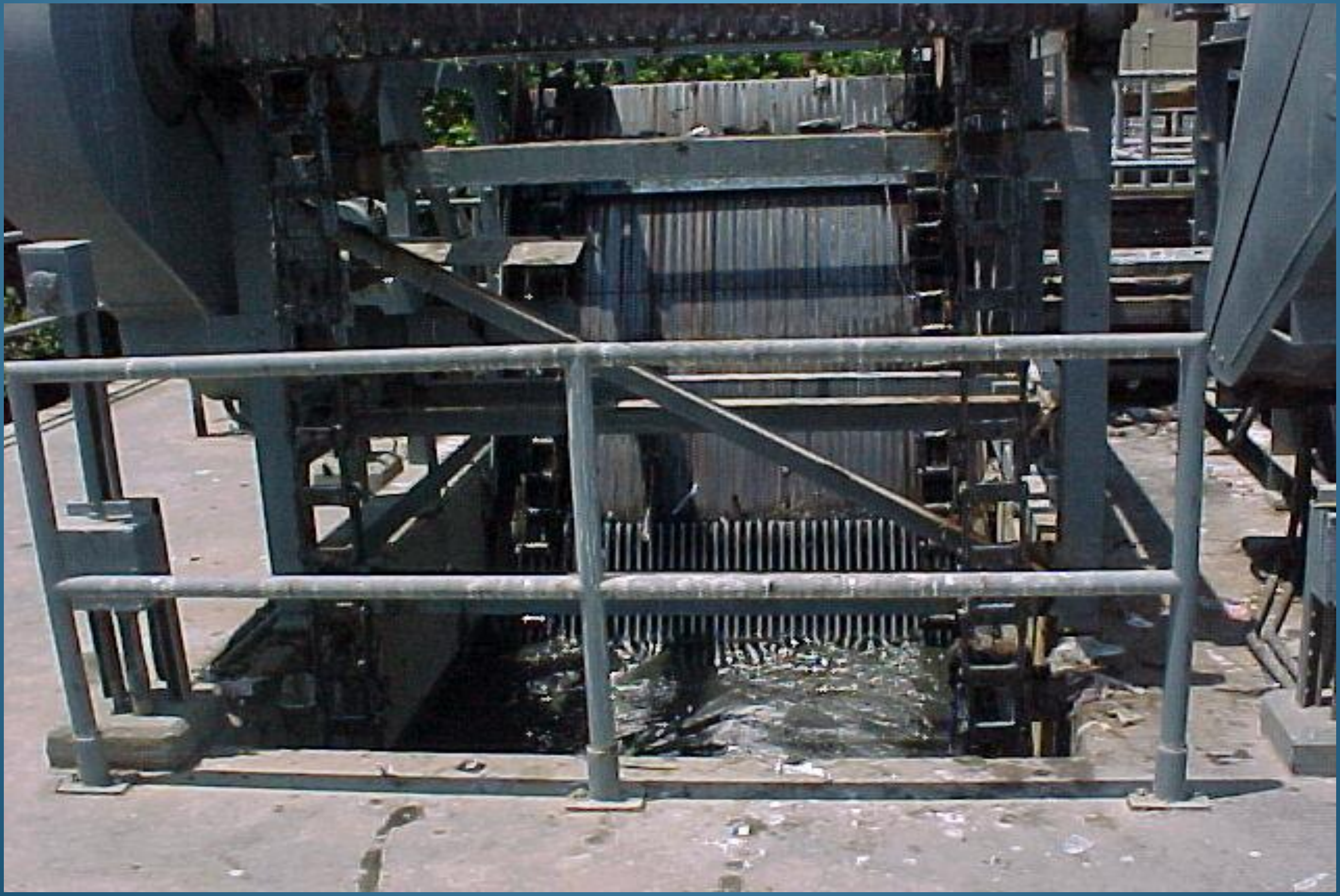
Average Composition of Domestic Wastewater mg/l (ppm)

Composition	**Explanation**	**Range (ppm)**
TS	Total Solids	700-1000
TDS	Total Dissolved Solids	400-700
TSS	Total Suspended Solids	180-300
BOD	Biological Oxygen Demand	240-420
COD	Chemical Oxygen Demand	550-700
N	Nitrogen	40-50
P	Phosphorus	10-15
Grease	------------	90-110

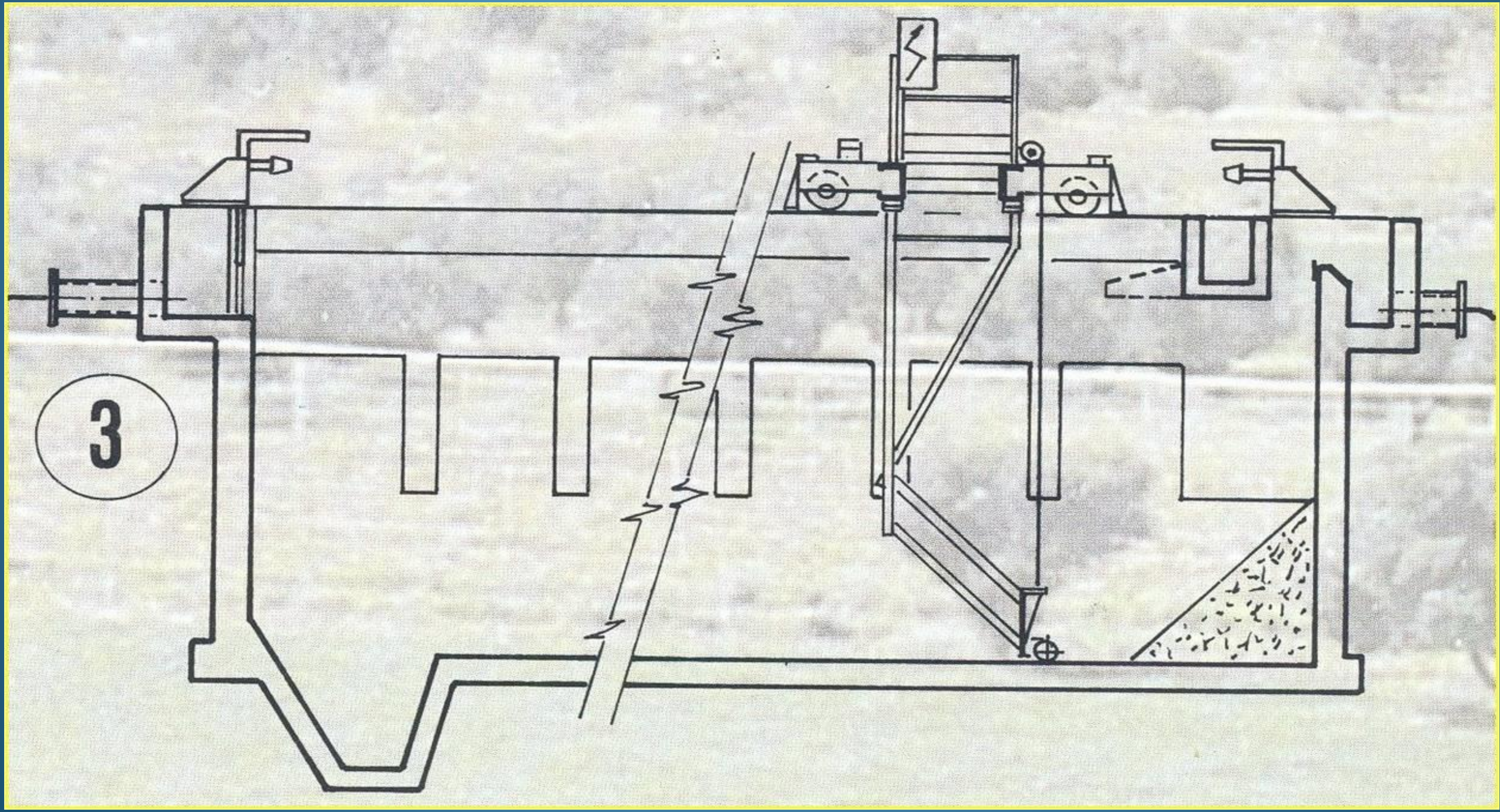

FLOW DIAGRAM FOR A CONVENTIONAL ACTIVATED SLUDGE WWTP
SCREENINGS
GRIT
A
B
PRIMARY SLUDGE
RAW SEWAGE
SCREENS
GRIT REMOVAL
PRIMARY SETTLING TANK
AERATION TANK
TO TERTIARY TREATMENT
A
B
RETURN SLUDGE
EXCESS SLUDGE
WASTE ACTIVATED SLUDGE
FINAL SETTLING TANK

SOURCES OF SOLID WASTE IN WWTP:

1- SCREENS: Removes gross pollutants from the waste stream to protect downstream operations and equipment from damage.

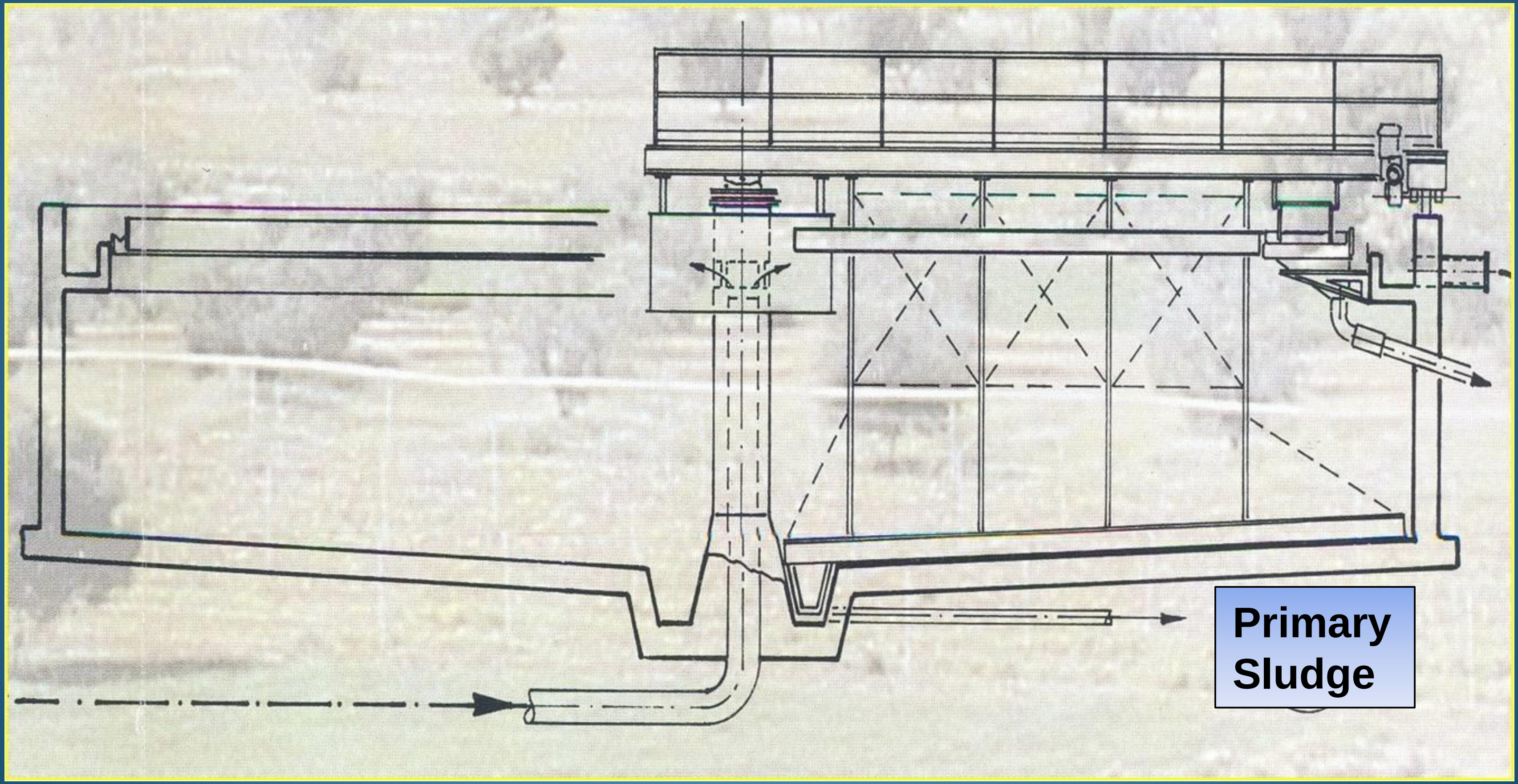


2- Grit removal tanks: Grit should be removed to prevent unnecessary abrasion and wear of mechanical equipment, grit deposition in pipelines and channels and the accumulation of grit in treatment units.




GEIGER

3- Primary Settling Tanks: Removes particles having a higher specific gravity than the liquid.



4- Final Settling Tanks: Based on the preceding biological reactor a ratio from 70 to 95% of the organic loads in WW stream are settled in the final settling tanks.

Very similar to primary settling tanks but primary settling tanks can be either circular or rectangular, while final settling tanks are usually circular (because of the higher settling efficiency in circular tanks).

- Solid Waste Quantities Estimation:

Waste Solid	Guides in Egyptian Code for Quantity Estimation	Guides in Other References (Metcalf & Eddy)
Screenings	20 lit / 1000 m^3	Average 15 lit / 1000 m^3
Grit	100 – 250 lit / 1000 m^3	4 – 200 lit / 1000 m^3
Primary Sludge	SS removal 50 – 70 % BOD removal 30 – 40 %	SS removal 50 – 70 % BOD removal 30 – 40 %
Waste Activated Sludge*	Removal Efficiency 85 – 95% of influent BOD	Removal Efficiency 85 – 95% of influent BOD

* Values for BOD removal efficiency are for the conventional activated sludge treatment system.
* Excess sludge production equation (As listed in the Egyptian code & other references):

Or $M_w = aF – bM$

Where: M_w = Excess solids produced (kg/day)

F = BOD removed = Q (BOD_{in} – BOD_{out}) (kg/day)

a = constant = 0.7.

b= constant = 0.075

M = V*MLSS = Reactor volume * Main liquor suspended solids

Example for Calculating solid waste quantities in WWTP:
Influent Data:
$Q = 100'000\ m^3/day$
$BOD_{in} = 400$ ppm
SS = 300 ppm
- Waste water treatment plant is a conventional activated sludge plant.

1- Screenings
$V_S = 20 * 100000 / 1000 = 2000$ lit / day = ***$2\ m^3/day$***

2- Grit
$V_g = 200 * 100000/1000 = 20000$ lit / day = ***$20\ m^3/day$***

3- Primary sludge (50 – 70 % SS removal – Assume 50%)
$SS_{in} = 300$ ppm $SS_{out} = 150$ ppm $SS_{removed} = 150$ ppm
Primary sludge quantity = 100000 * 150/1000 = 15000 kg/day
Sludge concentration 1 – 4% --- assume 2%
$Q_{(sludge)} = 15000 * 100 / (2*1000) =$ ***$750\ m^3/day$***

(To prepare for WAS calculation – BOD_{out} from primary settling tank should be known. (BOD removal 30 -40% - Assume 35%)
$BOD_{in} = 400$ ppm $BOD_{removed} = 140$ ppm $BOD_{out} = 260$ ppm

4- Waste Activated Sludge:

(BOD removal efficiency 85 – 95% ---- Assume 85%)

BOD_{in} = 260 ppm $BOD_{removed}$ = 221 ppm BOD_{out} = 39 ppm

Rough Estimation for Sludge produced in final settling tank:

WAS Quantity = 100000 * 221/1000 = 22100 kg/day

Sludge concentration 0.5 – 1.5 % --- assume 1%

$Q_{(WAS)}$ = ***2210 m^3/day***

Screenings:-

-For screenings disposal landfill is an appropriate solution.

- In small WWTP screenings may be disposed of by burial on the plant site.

For easier and more reliable disposal of screenings wash presses may be used:

Advantages of wash presses:

-Reduce screening volume (easier transportation).

- The washing process reduces the organic content is screening (preventing attraction of any insects (or rodents) and preventing any disagreeable odors.

Comminution:- (Note listed in the Egyptian Code)

In the contrary to screening where gross pollutants are removed from wastewater stream and handled separately, Comminuting is to cut up the solids and leave it to be handled in the downstream process.

Disadvantages of comminuting devices:

-Adversely affected by grit (Wear on the cutting surfaces and mechanisms).

-Provisions must be made to bypass comminutors in case flows exceed the capacity of comminutor or in case of power failure.

Grit:-

- Again For grit disposal landfill is an appropriate solution.

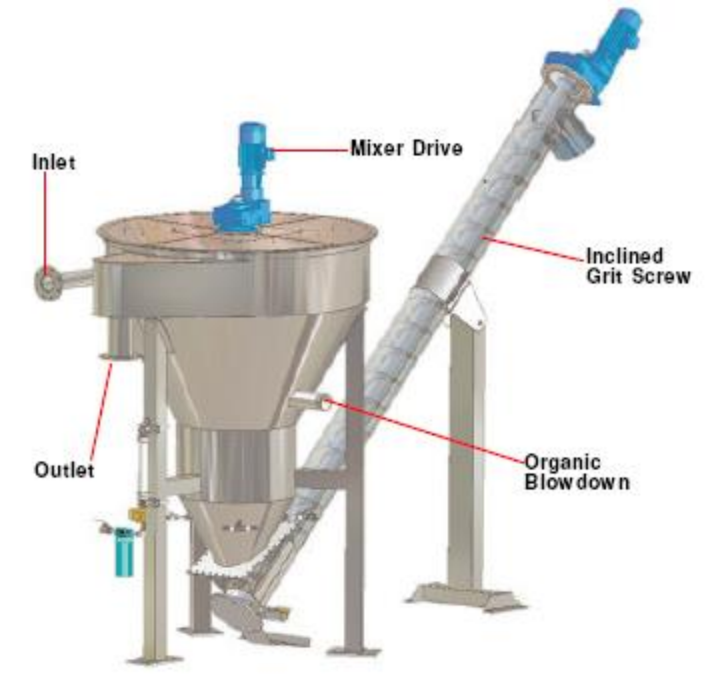
Before final disposal of grit simple process should be applied:
- Grit classifying (dewatering).
- Grit washing.

Grit Classifier

solid matter (grit) settles in the screw conveyor channel on the bottom of the basin. From there the grit is transported via the screw into a container for disposal.

Grit Washer / Classifier

Influent flow enters the unit tangentially, creating centrifugal forces that allow water and lightweight organics to discharge over an upper weir plate.
Grit and heavier materials settle to the lower conical shaped grit zone where they are gently agitated by mixer arms and washed.
From there the grit is transported via the screw into a container for disposal.



Sand Silo

Sand silos are widely used in Egypt for sand classifying. They rely on centrifugal forces to achieve separation.

Sludge Characteristics:

Sludge	Color	Solids Concentration % dry Solids	
		Range	Typical
Primary Sludge*	Grey	3 - 10	4
Activated Sludge*	Brown	0.5 – 1.5	0.75
Trickling filter sludge	Brownish	3 - 10	5
Gravity thickened sludge**	------	3 - 10	4
Digested Sludge (aerobic)**	Brown to dark brown	1.5 - 4	2.5
Digested Sludge (anaerobic)**	Dark brown to black	2.5 – 7	3.5

*Figures in table are based on a conventional activated sludge process (Primary settling)

** Figures in table are based mixed sludge (primary + activated sludge)

Sludge Treatment Techniques:

Why sludge treatment is necessary?

1- Sludge is composed of the substances responsible for the offensive character of untreated wastewater. (Concentrated pollutant).
2- Organic matter in sludge is not stable and will decompose and become offensive.
3- Only a small part of the sludge is solid matter. (Solid concentration of sludge before thickening is about 2%)
In the numerical example detailed earlier 37.1 ton/day of solids are contained in 2960 m^3/day sludge .

Therefore, the main purpose of sludge treatment is to reduce the water and organic content of sludge.

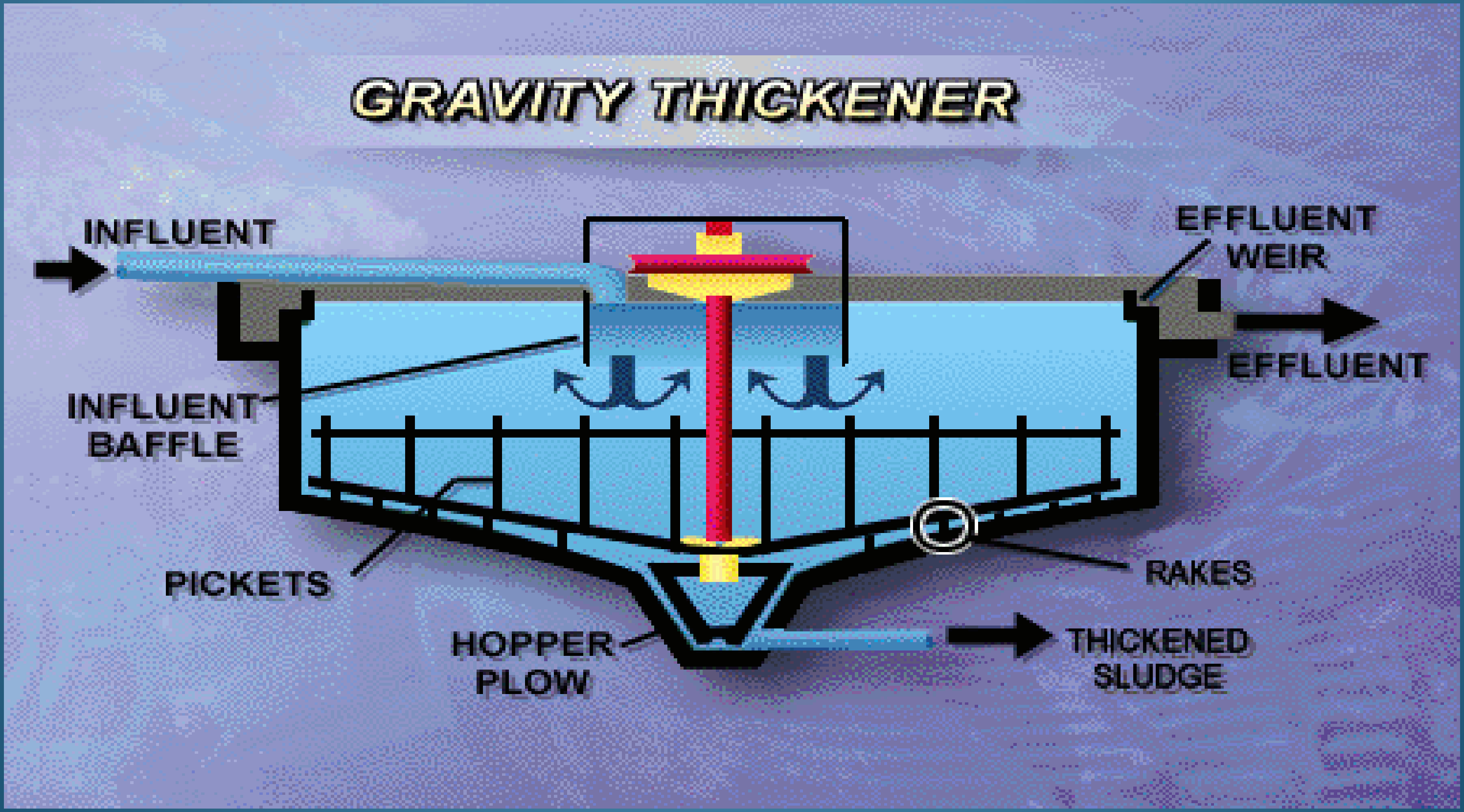
Sludge Treatment Methods

Method	Purpose	Solids%
Thickening	Concentrate sludge and reduce water content to minimize sludge volume. (reduce tank sizes in next units & chemicals required for conditioning.	4%
Dewatering	Further reduction in water content. -Reduces cost of transportation. -Sludge becomes easier to handle. -Required before final disposal (incineration or landfill). -Eliminate odors.	20 – 40%
Conditioning	To improve dewatering characteristics (specially with mechanical dewatering systems)	----
Stabilization	-To reduce pathogens. - Inhibit, reduce or eliminate putrefaction. - Eliminate offensive odors.	10%
Drying	- To further reduce water content by heating. -Required if fertilizer manufacturing is considered. -Prevents biological action.	90%

Sludge Thickening:

1- Gravity Thickening:

Sludge fed into a tank (thickener), where it remains for a lengthy retention time so that the sludge is compacted. The sludge is extracted from the bottom, while the supernatant liquid is drawn off the top.



Design Criteria: (Egyptian Code)

Retention Time : 1 – 2 days
Solids loading :
-Primary sludge only (98 – 147 $kg/m^2/day$)
-Trickling filter sludge (49 – 59 $kg/m^2/day$)
- Activated sludge only from final settling tanks (20 – 30 $kg/m^2/day$)
-Mixed primary + activated sludge (49 – 59 $kg/m^2 \cdot day$)
- Sludge concentration after thickening : 4%
Water Depth : 2.5 - 3.5 mt.

Numerical Example:

Sludge Quantities:	Primary sludge	15 ton/day	750 m^3/day
	Activated sludge	22.1 ton/day	2210 m^3/day

-Total flow rate = 2960 m^3/day
-Total solids = 37.1 ton /day
- Assume thickener retention time = 1.5 day → Thickener required volume = 4440 m^3
- Assume depth = 3.5 mt. → Area = 4440/3.5 = 1268.57 m^2
- 2 thickeners with diameter 28.5 mt. shall be required.

-Solid loading check = 37100/1268.57 = 29.24 $kg/m^2 \cdot day$. This value is lower than expected (49 – 59 $kg/m^2 \cdot day$) but this justified because the major portion of sludge is activated sludge.

-Calculating sludge & supernatant flows after thickening:

-Inlet condition: Total solids= 37.1 ton /day Total flow rate=2960 m^3/day

-Exit condition: Total solids= 37.1 ton /day Solid Conc. = 4%

Sludge flow rate of sludge = 927.5 m^3/day

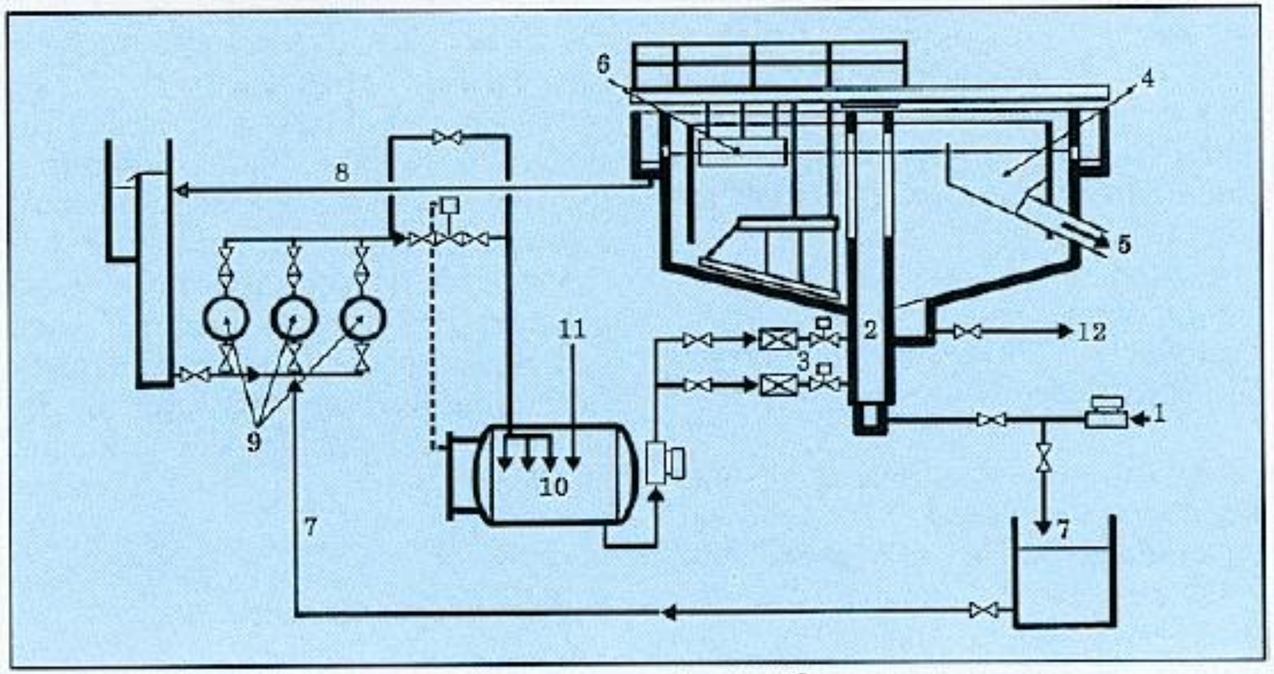
Supernatant flow rate = 2960 – 927.5 = 2032.5 m^3/day

Water content is reduced by more than 65% through thickening only.

2- Floatation Thickening:
Static thickening by settling is not very effective when applied to highly organic sludge, such as activated sludge, or other colloidal sludge, such as hydroxide sludge.

Thickening by flotation offers some significant advantages:
-reduced surface area and volume of the thickening units.
-production of more concentrated thickened sludge.

As opposed to settling, flotation is a separation procedure which is applied to particles whose density is lower than that of the liquid they are in.
- If the difference in density is naturally sufficient for separation, this type of flotation is called natural.
- **Aided flotation occurs when external** means are used to promote the separation of particles that are naturally floatable
- **Induced flotation occurs when the density** of the particle is originally higher than that of the liquid and is artificially lowered. This is based on the capacity for certain solid and liquid particles to link up with gas (usually air) bubbles .This results in particles with a density less than that of the liquid.



1 - Sludge inlet.
2 - Blending chamber.
3 - Pressure release device.
4 - Floated sludge launder.
5 - Floated sludge outlet.
6 - Scraper.
7 - Full-flow pressurization system.
8 - Water underflow outlet.
9 - Pumps.
10 - Air saturation tank.
11 - Pressurized air.
12 - Heavy sludge.

3- Mechanical Thickening:

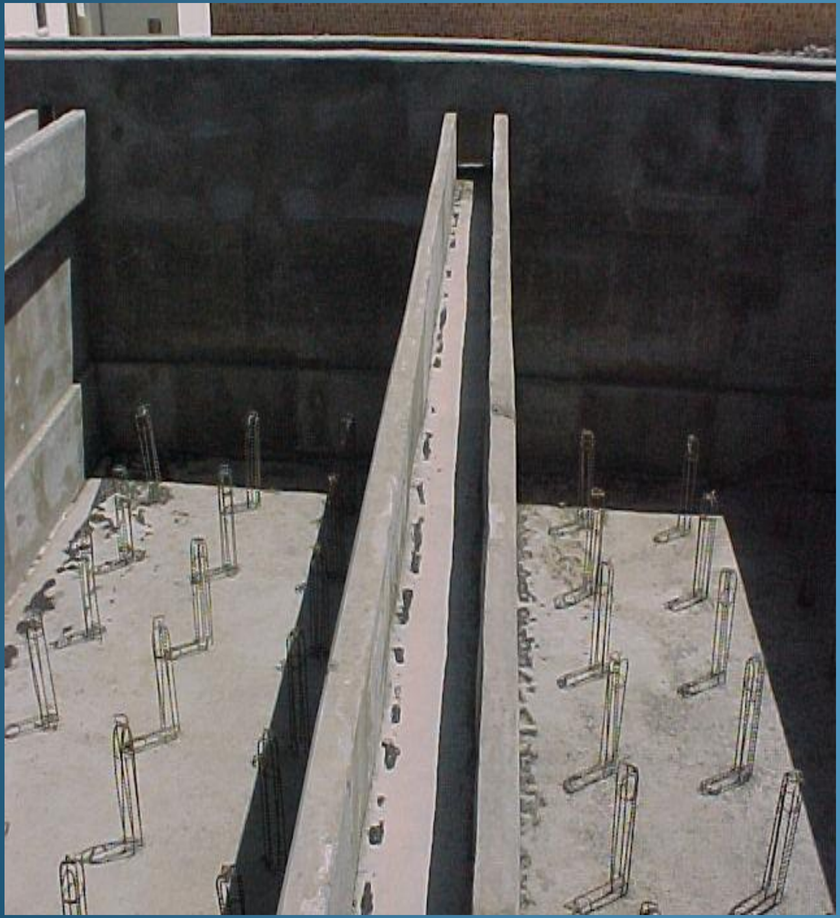
a- Centrifuge thickening.
b- Filter press thickening.
c- Belt press thickening
[Equipment shall be discussed later as dewatering techniques].

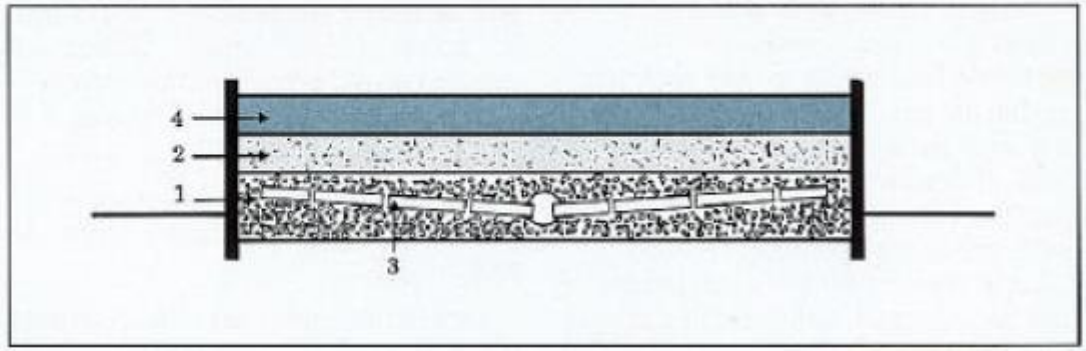
Sludge Dewatering:

1- Drying Beds:
Sludge is placed on beds in a 150 to 300 mm layer and allowed to dry. Dewatering is achieved through drainage & evaporation.

Advantage of drying beds:
-Very simple in operation (No skilled labors required).
-Running costs are minimum.
- Can achieve solid concentration 20 – 40% (but depending on weather conditions).

Disadvantage of drying beds:
-Requires large land areas.
-Initial cost is significant (concrete construction & piping).
-Depends on weather conditions.
-Odor problems.





1 – Gravel.
2 – Sand.
3 – Drains.
4 – Sludge.

Design Criteria: (Egyptian Code)

Thickness of sludge layer : 10 – 15 cm
Retention time for each layer : 4 days
Area Factor : 2

Example:

Inputs

- Total solids= 37.1 ton /day Solid Conc. = 4%

-Sludge flow rate of sludge = 927.5 m^3/day

Sludge volume in 4 days = 927.5 * 4 = 3710 m^3

Area required for beds = 3710 / 0.15 = 24733.33 m^2

Total area = Calculated area * area factor = ***49466 m^2***

Sludge output shall be 20% solid conc.

-Sludge volume = 185.5 m^3/day

- Filtrate flow = 927.5 – 185.5 = 742 m^3/day

2- Mechanical Dewatering:

a- Centrifuges:

Dewatering by centrifugal action.

Design Variables are:

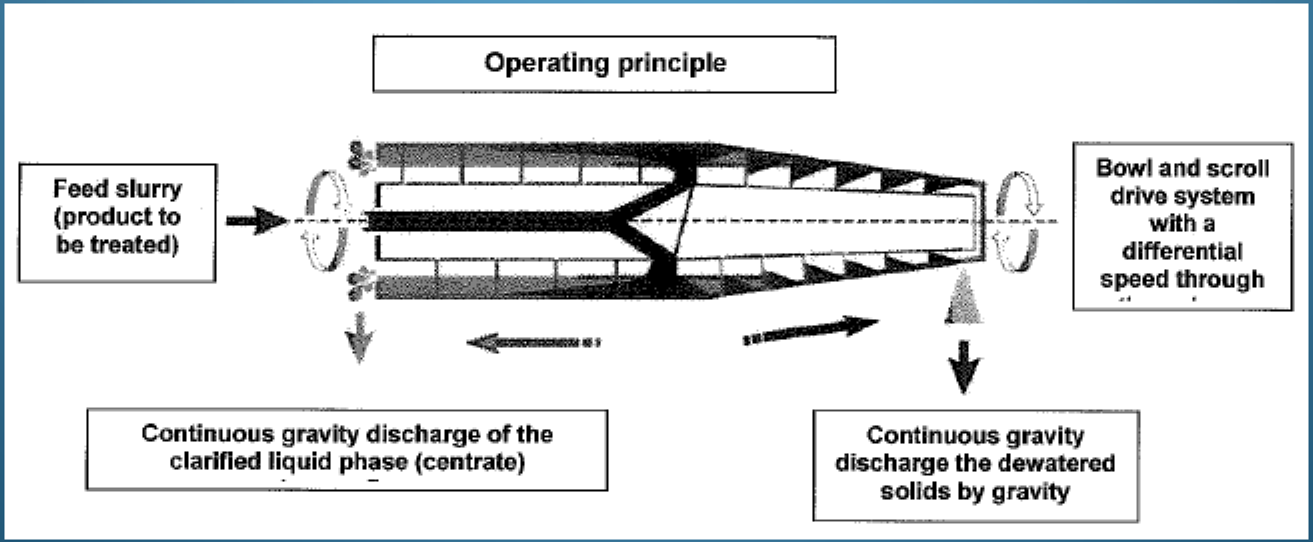
-Sludge characteristics.

- Rotational speeds (of both bowl and scroll).

-Hydraulic loading.

-Depth of liquid pool in the bowl.

-Use of polyelectrolyte to improve performance.



Advantage of centrifuge dewatering:

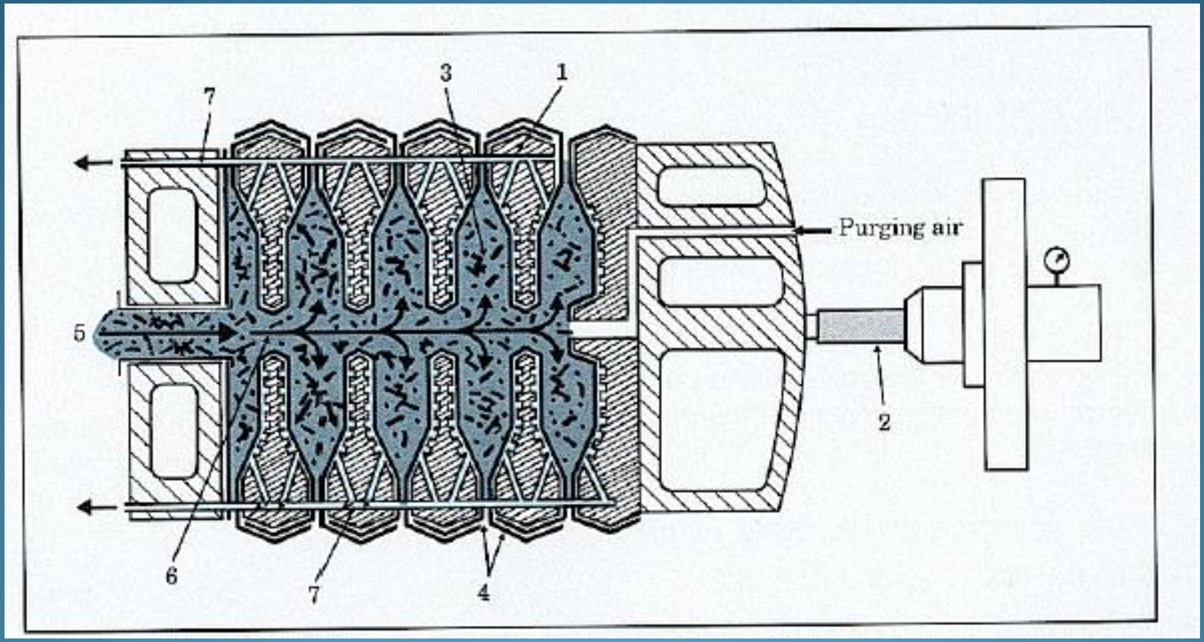
- Dewatering in compact enclosed premises to reduce smells and keep deodorization costs to a minimum.
-Effective separation of solids on very difficult sludge (low concentration).

Disadvantage of centrifuge dewatering:

-Noise problems.
-Very high consumed power (high running cost).
-Requires intensive maintenance (high running cost).
- Requires very skilled labors.
- relative sensitivity to sudden variations in quality and concentration of sludge.

b- Filter Presses:
Filtration is carried out by filter presses allowing very high pressures to be applied to the cake (5 to 15 bar and sometimes more).
This enables cake DS content to achieve levels of more than 30% on most properly conditioned sludges.

Description:
A filter comprises a set of vertical, recessed plates (1), pressed hard against each other by (a) hydraulic jack(s) (2) at one end of the set.
This vertical plate layout forms watertight (3) filtration chambers allowing easy mechanization for the discharge of cakes (filter opening).
Finely or tightly meshed (10 to 300 µm) filter cloths (4) are applied to the two grooved surfaces of these plates.
The sludge to be filtered arrives (5) under pressure in the filtration chambers through orifices (6) generally in the centre of the plates. The alignment of these orifices serves as a feed passage for the sludge.
Central feed allows even distribution of flow, pressure and better drainage of sludge within the chamber.
The filtrate is collected in the grooves at the rear of the filtration support and carried away by internal ducts (7). This form of evacuation reduces odors .



Advantage of filter press dewatering:

- Suitable for all types of sludge.

-Running costs and maintenance problems are less than those of centrifuges.

Disadvantage of filter press dewatering:

-Requires relatively skilled labors.

-Odor problems.

-Larger foot print than centrifuge.

C- Belt Presses:

The size of flocs obtained by polyelectrolyte conditioning has resulted in the development of dewatering devices specifically adapted to the treatment of waste sludge.

Advantages of belt presses

-Ease of use and good visual control during dewatering.

- Low operating and reasonable investment costs.
- Continuous process.

-Simplicity of mechanical design.

Depending on dewatering capacities of sludge, these filters allow optimization of investments. Furthermore, they represent an almost all-purpose energy-saving process:

belt filter: 10-25 kWh.t-1 of SS,

conventional filter press: 20-40 kWh.t-1 of SS,

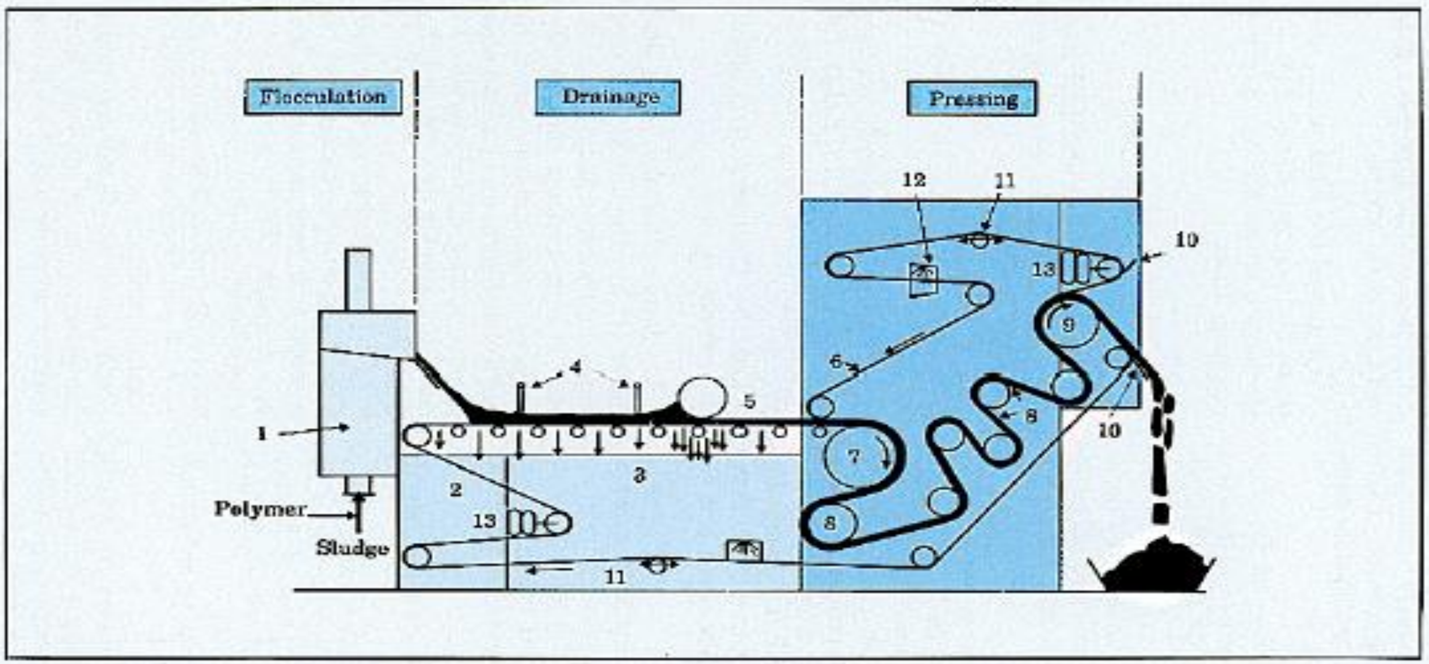
centrifuge: 30-60 kWh.t-1 of SS,

vacuum filter: 50-150 kWh.t-1 of SS.

Description:

- The sludge, which is of sufficient consistency, is trapped between two filter belts which form a wedge. They gradually compress the sludge. The "sandwich" rolls around the perforated drums and then around rollers laid out in a staggered formation.

Efficiency of dewatering depends on both the effective pressure applied on the sludge sandwich and pressing time.



1 – Mixer.
2 – Lower belt.
3 – Drainage zone
4 – Picker fence.
5 – Drainage roller.
6 – Upper belt.
7 – Perforated drum.
8 – Return rollers.
9 – Drive roller.
10 – Doctor blades.
11 – Tracking roller.
12 – Washing station.
13 – Pneumatic jacks.

d- Vacuum Presses:

This is the oldest continuous mechanical dewatering technique and currently has limited applications. The vacuum filters most commonly used to drain waste sludge are of the rotary drum.

The filtration cycle is as follows:

a - Submerged part of the drum: with the vacuum effect, sludge accumulates on the cloth and forms the cake which gradually thickens. Filtration time is 1 to 2 minutes.

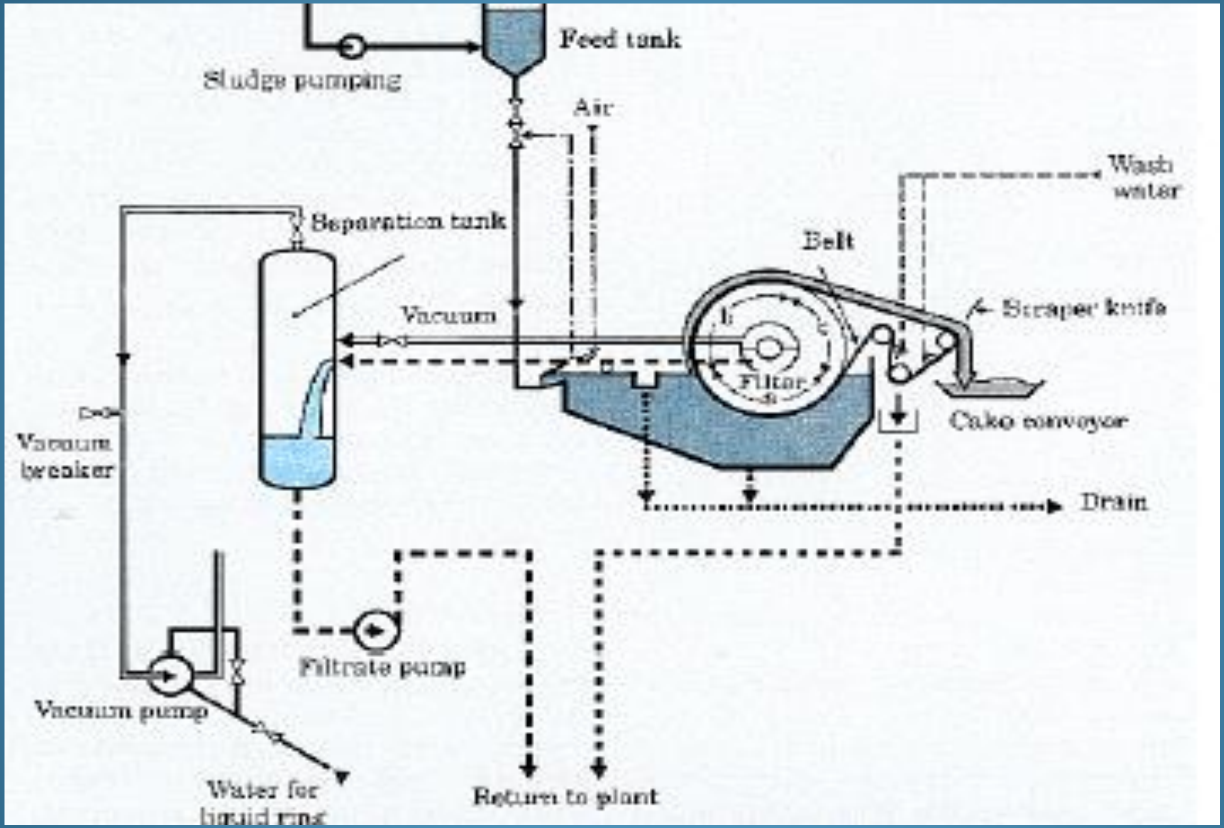
b - Upper part of the drum: the moist cake layer leaves the tank, and under vacuum conditions, is drained for a few minutes to form a cake of sufficient cohesion (or even cracked).

c - Discharge of cake: after an almost complete rotation cycle, the compartments leave vacuum conditions. Up until then the filter cloth has been applied to the drum. At this stage, the cloth detaches to enable separation and discharge of the cake. The filtration support is then washed with pressurized water.

<u>Disadvantages:</u>

-Relatively complicated and requires maintenance and skilled labor.

-Capital and running costs are high.


Feed tank
Sludge pumping
Air
Wash water
Separation tank
Belt
Vacuum
Scraper knife
Filter
Cake conveyor
Vacuum breaker
Drain
Filtrate pump
Vacuum pump
Water for liquid ring
Return to plant

Sludge Conditioning:

To ensure that all dewatering equipment is optimally used, sludge has to be flocculated, to artificially increase the size of particles.

Conditioning may be based on physical procedures (mainly thermal), but chemical alternatives are more widely used (addition of inorganic reagents or synthetic polymers).

Adequate sludge conditioning is the key factor for optimum operation of the dewatering unit.

A- Chemical Conditioning:

A1 – Inorganic Reagents:

Inorganic reagents are better adapted for dewatering by **filter presses or vacuum filters.** These are systems using surface filtration through a cake undergoing formation. The filtering support consists of a finely meshed cloth (usually less than 100-200 µm).

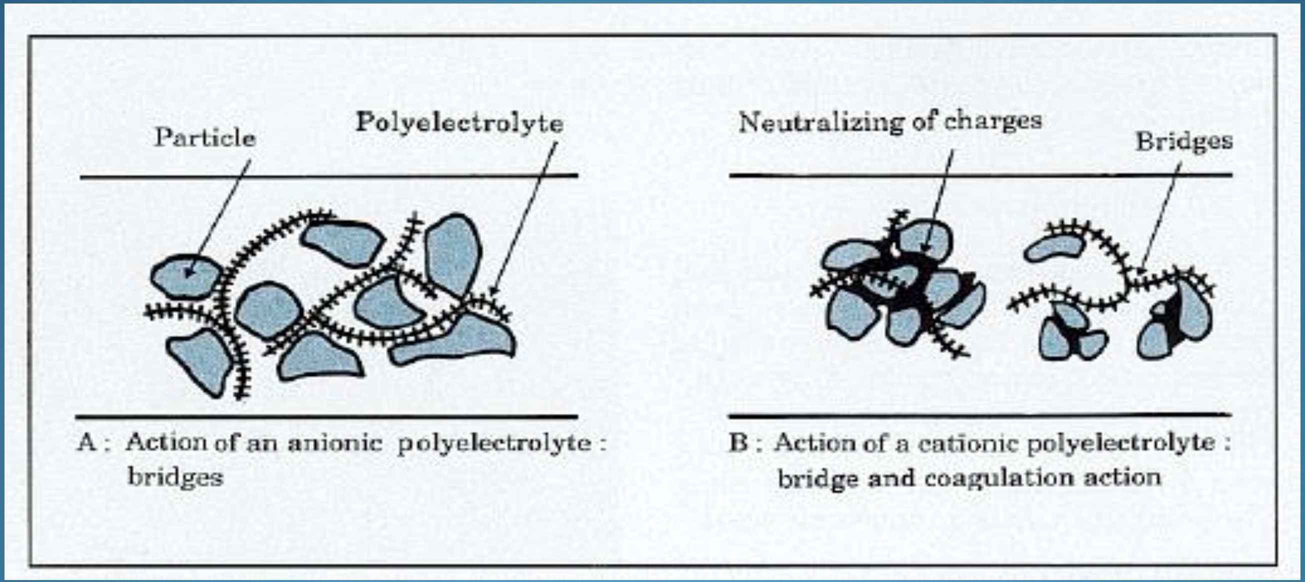
These inorganic reagents lead to the formation of fine, but mechanically stable flocs.

Fe 3+ is by far the most effective and most frequently used ion on organic sludge. (FeCl3 is generally used.)

These electrolytes have a dual action:
- coagulating action: their charge is often opposite to that of sludge particles,
-flocculating action: formation of hydrated hydroxide compounds such as [Fe(H2O)6- (OH)3]n, which act as inorganic polymers.

A2 – Organic Reagents:
- Polyelectrolyte produce extremely well-defined flocculation by formation of bridges between particles as a result of long branched chains.
- Flocculation is reinforced by a coagulating action when cationic polymers are used.
-Results in increasing in the sludge compressibility coefficient.

The structure of flocs obtained has (by polyelectrolyte) enabled:
-The development of filters incorporating a large-mesh cloth support (0.4 to 1 mm) which is less likely to become clogged. An example is **the belt filter**.
-Significant improvement in the performance of continuous **centrifuges** owing to distinct increase in the density of gathered particles.



B-Thermal Conditioning:

The bond between water and colloidal matter can also be broken by thermal methods and especially by raising the temperature of sludge. The increase to a sufficiently high temperature results in the physical structure of the sludge being irreversibly transformed, especially if it contains a high proportion of organic and colloidal matter.

Heating takes place at a temperature varying from 150 to 200°C with a heating time from 30 to 60 minutes.

Disadvantage of thermal conditioning:

- Recycling of thermal liquors.
- Production of odors.
- Periodic cleaning of heat exchanger surfaces.
- Very high capital and running cost.

Sludge Stabilization:

Only sludge with a high content of rapidly biodegradable matter undergoes the stabilization process, i.e.:
-primary sludge.
-sludge from medium-and high-rate aerobic biological treatments-excess activated sludge, trickling filter sludge.

A- Anaerobic Digestion:
Also known as methane fermentation is one of the most powerful means of destroying cells known to biology and also removes substantial quantities of organic matter.
because of ITS inherent energy saving and efficiency and low chemical requirement: ***Anaerobic digestion process is the most widely selected process.***
Two main criteria are used to measure sludge stability following stab. Include***: volatile solid content and reduction of pathogen.***

Anaerobic Bacteria MPB is active mesophilic (27 – 43) and thermophilic (45 – 65). Most An. Di. are operated in mesophilic range.

PROCESS DESIGN :

The most important factors controlling the design and operation of An. Di. are:

Tank design, The cylindrical are the most common. Dia. = 6 – 40 m., Depth = 7 – 14 m.

Di. Capacity, (Based on retention time & volumetric loading).

Di. heating and Temp. control :the optimum temp. is 35 C. it is important to maintain proper temp. by heating incoming sludge and Di. content. The total amount of input heat should balance heat loses from Di. the heat losses from Di. walls, floor, roof, piping,….

Mixing Anaerobic D. must be mixed properly to provide optimum performance. Mixing has the following beneficial effects: (1) maintain intimate contact between feed sludge and active biomass, (2) create physical, chemical and biological uniformity throughout the Di., (3) prevent surface scum. The mixing occurs by the rise of the sludge gas bubbles and the thermal convection current created by the heated sludge. However, natural mixing is not enough, additional mixing is needed. Methods of mixing include external pump circulation, internal mechanical mixing.

Gas production and utilization (0.75 – 1.12 m^3 / Kg of volatile solids reduced)

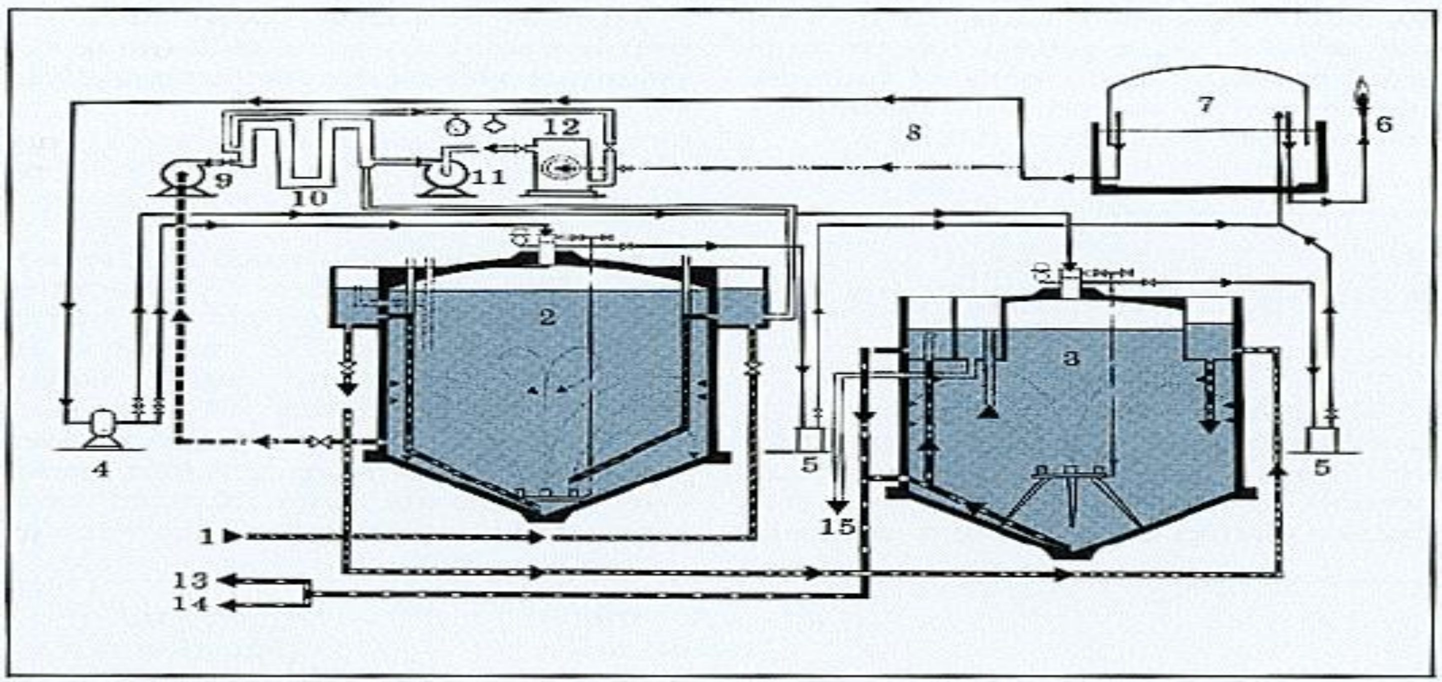
Sludge characteristics (Volatile solid content in sludge).

Disadvantages of An. Di.:

-Complex system (Digesters, Boilers, Heat exchangers, Gas holder & flares, with related piping and mechanical equipment).

-Very skilled labors required.

- Capital costs are high.



1 - Fresh sludge inlet.
2 - Primary digester.
3 - Secondary digester.
4 - Gas compressor.
5 - Moisture traps.
6 - Waste gas burner.
7 - Gas holder.
8 - To heating plant and blowers.
9 - Sludge circulation pump.
10 - Heat exchanger.
11 - Hot water pump.
12 - Boiler.
13 - To final treatment.
14 - To lagoons.
15 - Overflow.

B- AEROBIC DIGESTOR

It is common for small plants. The process involves aeration of sludge for an extended period in open tanks. The process involves direct oxidation of biodegradable matter and oxidation of microbial material. Stabilization is not complete until there has been an extended period (10 – 20 d) . The digested sludge is commonly dried on sand drying beds.

Advantages:

Simple to operate
Low capital cost
Digested sludge is odorless

Disadvantage:

Not suitable for primary sludge treatment
High operating costs

The important design considerations are:

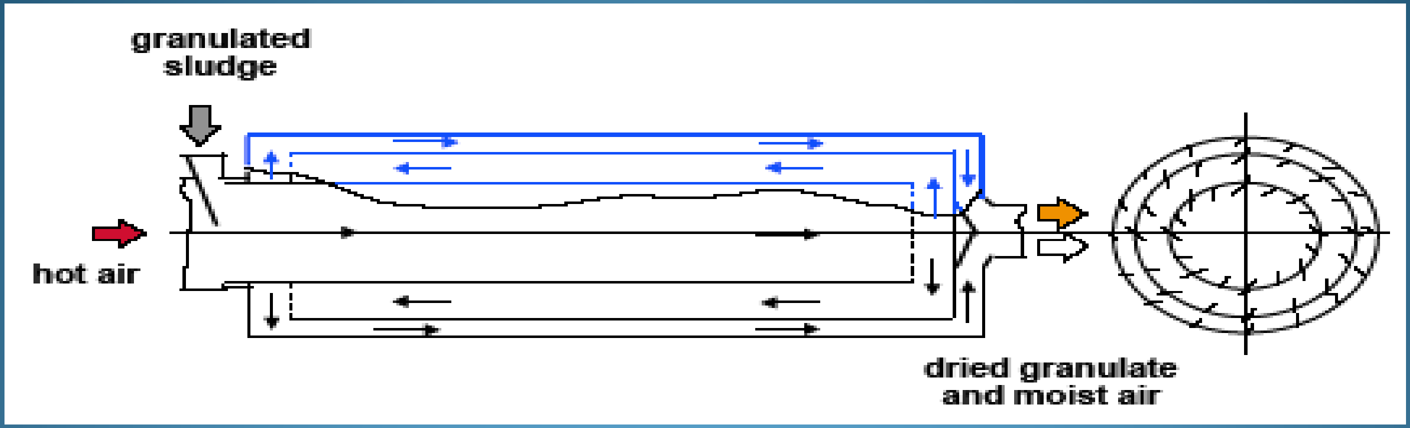
air or oxygen requirements
aeration period
temp.
biodegradable volatile solids

usually 15 days retention time is suggested. Oxygen can vary from 3 – 30 mg/h/gm VSS.

Sludge Drying:
Drying, a term generally reserved for thermal drying, comprises evaporative removal of water in sludge. Drying can be partial (residual water content from 30 to 10%) or practically total (water content from 5 to 10%).

The high costs involved in thermal energy lead to limited use of these processes of direct removal of liquid sludge.

Example of a thermal dryer:
The triple-pass drum has three concentric cylinders, and one joint axis. As the drum turns slowly, the sludge moves forward in the air stream, from the inner cylinder to the one in the centre and finally into the outer cylinder. In the process, the granulate will also roll, and this movement contributes to the formation of stable, globular granulate. The outer, insulated cylinder takes up the heat from the two inner ones, and thus the heat loss in the drying drum is minimal.
Water evaporates from the pre-formed pellets in the rotating triple-pass drum. The air stream and the drum rotation cause the material to move and remain inside the drum until it is sufficiently dry (and light) for pneumatic discharge.



The drier is not the only components of a drying or incineration plant. The main units are as follows:

The sludge feeder

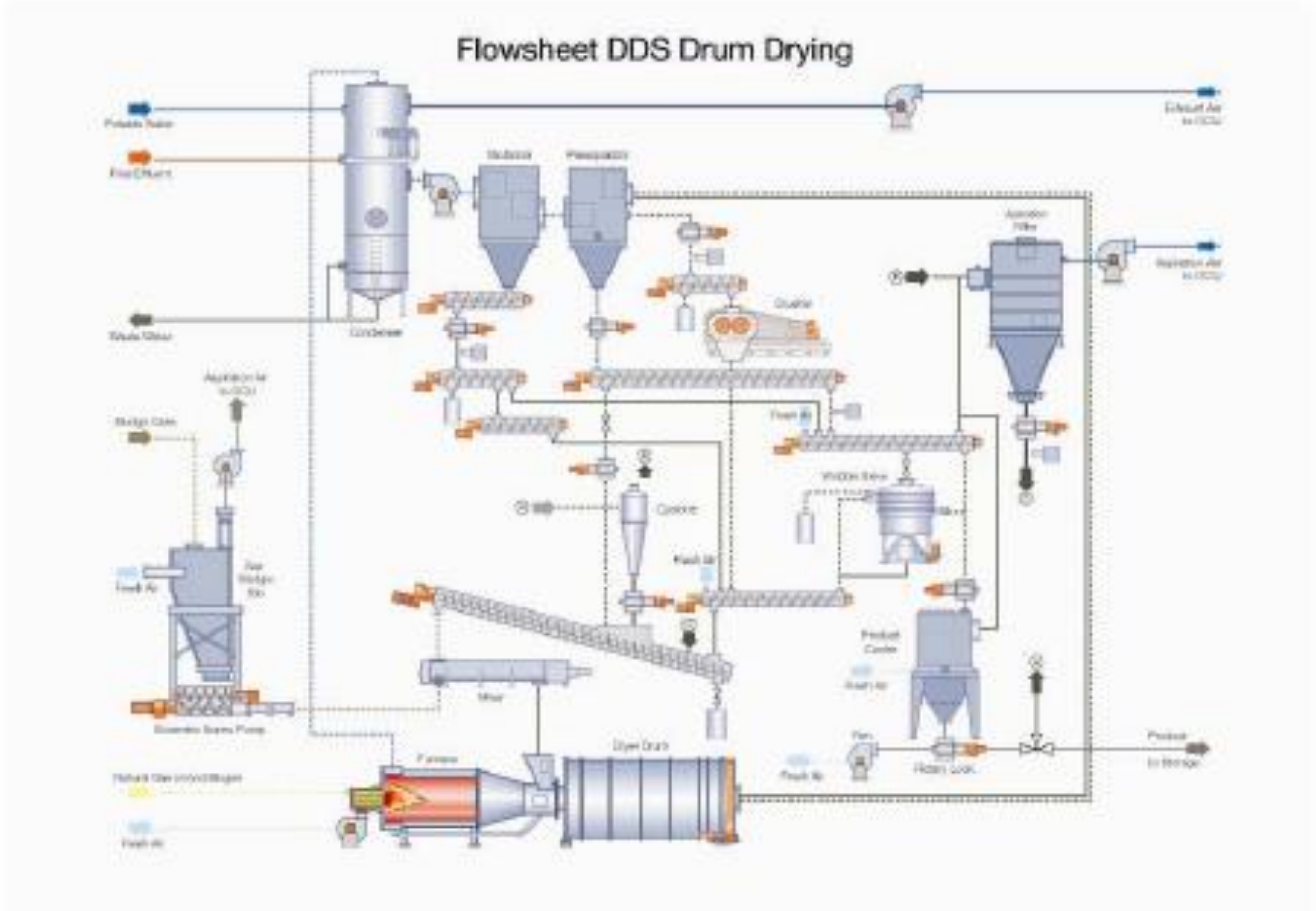
The drier proper the ventilation system(s)

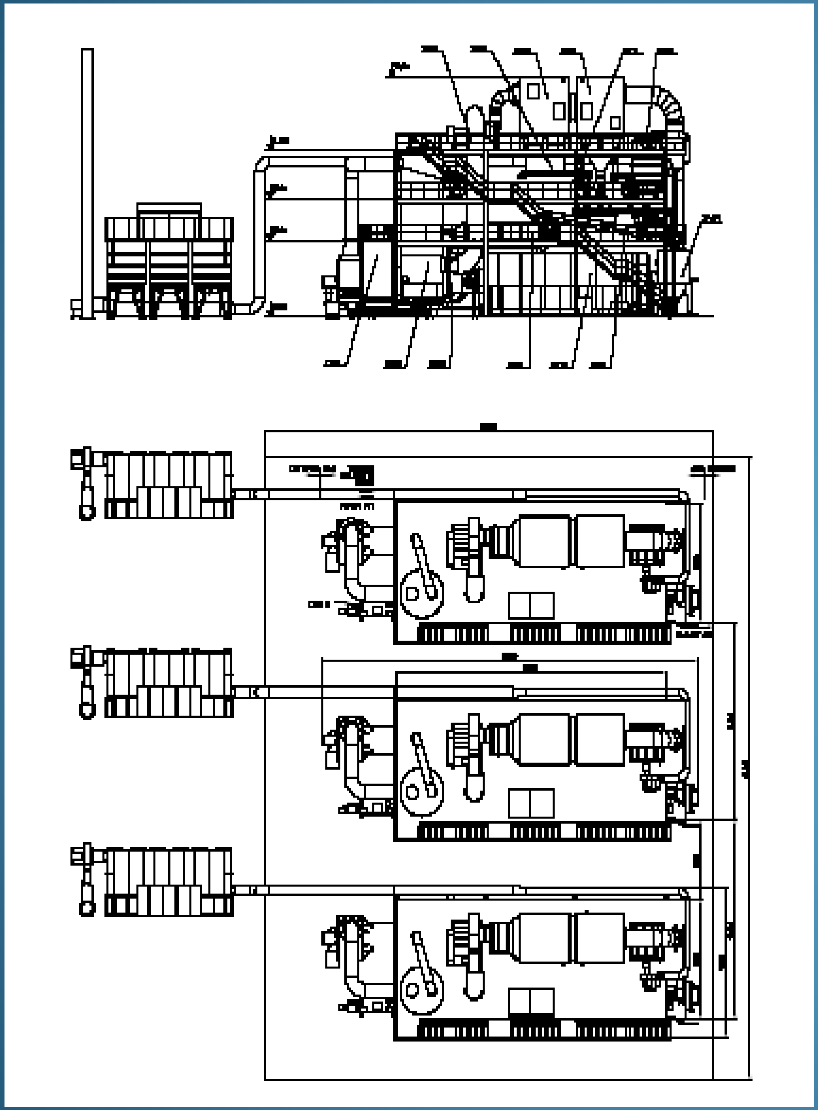
The heat recovery unit(s) often necessary

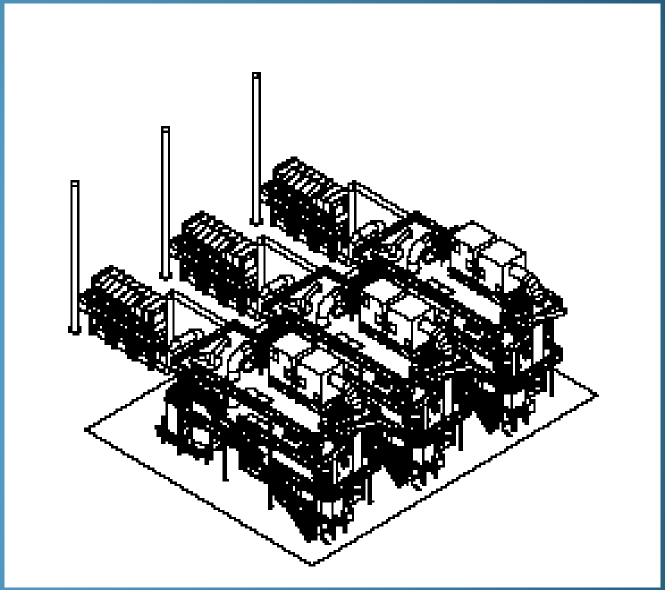
Auxiliary heat source

The drying unit control facility: temperatures, negative-positive.

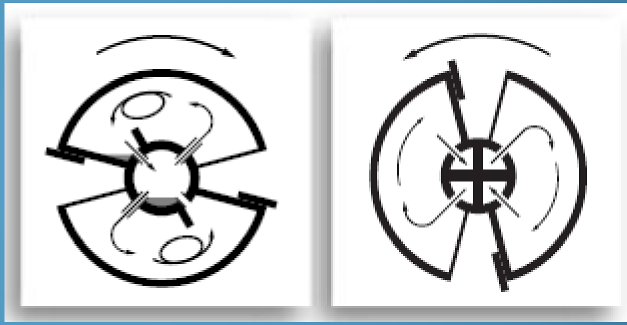
Dust Control system in outgases.


Flowsheet DDS Drum Drying





Alternatives of sludge dryers:
Paddle Dryer.



Conclusion:

Solid waste handling for wastewater treatment plant involves many varieties of techniques and products.
In order to Select the best suitable treatment process to achieve a certain final sludge quality engineering analysis should take into account:
- Available land area for project.
- Climatic conditions.
- Labor skills available.
- Capital and running costs for various alternatives.