Volume 2: Edition 11 – Sludge Wastewater Management November 30, 2022

Dear Water Warriors,

The residue that accumulates in wastewater treatment plants is called sludge (or solids).

The sludges disposed in a treatment process infect is an indicator of successful operations of an ETP as pollutant convert to Sludge.

Additional Sludge Treatments focus on reducing sludge weight and volume to reduce transportation and disposal costs.

This issue of '**Waughter**', we provide the methods to manage Sludge and its safe disposal to environment.

Nidhi Jain – Civil Engineer

## Sludge: A threat or Opportunity

Sludge Management is the most neglected process step in waste water treatment. While we do not have enough references in India to share with our readers technologies beyond Digestions, several countries have considered this as an opportunity and have reclaimed:

Energy, Nutrients (N & P), Valuable Inorganics and Metals etc.

With zero liquid discharge now practiced a lot in India, what about considering "Inorganic Salt" as future environmental threat? If yes, the high inorganics in Solid Industrial wastes can be dangerous to environment.

Technology is the answer, if you burn the sludge at temperature > 8000C i.e. temperature higher the $SiO_2$ fusion temperature, the resultant slag would be a manmade BRICK. Inert for several years.

Park it as Brick in Park Fence rather than dump sludge & Salt into an isolated site that would be an environmental issue is say 200 years.

## What is Sludge?

Sludge means mixture of Water and Suspended matter. The impurities present in water have two major classifications: Suspended & Dissolved

They also have the further classification in terms of chemistry (origin) as Inorganic and Organic. Therefore, once waste water is treated, we have sludge that contains:

iTSS – means the suspended solids that just drag along sludge and do not participate in any rection e.g. Sand, Activated Carbon type of particles.

Precipitates – that contain combination of mineral sludges e.g. any metal hydroxide {$Fe(OH)_3$ $Al(OH)_3$ etc } and precipitates that are formed be reactions ( $CaCO_3$, $CaSO_4$ $Mg(OH)_2$.$xSiO_2$ etc.

Biomass – All sCOD as well as VSS (of TSS) gets converted to Suspended Biomass that contain $C_5H_7NO_2$, Cell debris, Extracellular Polymeric Substances (EPS) etc.

## What is Sludge Consistency?

If we have 100 grams of salt in 1 litter water, we say solution strength is 100 gpl or 10% w/v. Here the point to note is due to addition of Salt, the volume of water does not change as Salt remains in Intermolecular space without effecting the water volume.

Sludge concentration say 2% therefore is a wrong term and right word is 2% Sludge Consistency that means 2 parts of Suspended matter in 98 parts of water making total mass as 100.

This small yet significant difference is understood much better when we dewater sludge and say reach 50% consistency which means 50% water & 50% Suspended matter in a mixture.

Further dewatering and drying say in sludge dryers, we start referring it as % moisture in Solids e.g. 5% moisture means 50 gm of H2O in 1 kg Solids – so the Dry matter in Sludge would be just 950 gm.

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## MAKE THE MOVE FROM MBBR & OTHER CONVENTIONAL TECHNOLOGIES

## Why the world is moving to MBR

instead of more conventional technologies:

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**Fully Automated** - Can be operated remotely

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## Sludge treatment

Sludge treatment is an important section of any wastewater treatment plant. Clarifier bottom Sediments in Clarifiers or ASP process are drawn into Sludge tank and treated. Sludge treatment is necessary to:

- To reduce the moisture content in sludge so that it is more manageable.
- To stabilize harmful microorganisms (pathogens etc.) in sludge; Often ignored and is a major cause of odour in sludge handling area and storage.
- To collect products & by-products of the treatment process e.g. the Sludge digestion may produce Biogas (Energy) and many cement industries are interested in CaSO4 and Mineral Sludge for addition during production.

These days the Sludge Moisture is gaining lots of attention due to high cost of bagging and transportation of sludge to an Off-Site Sludge management Facility.

## Sludge Treatment Units

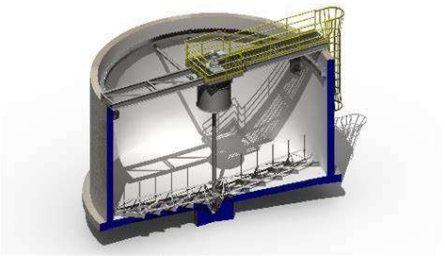
Sludge treatment describe the process used to manage and disposal of sludge produced during the treatment of wastewater. Stabilized sludge does not have an offensive odour and can be handled without causing a health hazard It consists of:

- Dewatering
  (Filter Press, Centrifuge etc.)
- Stabilization (Mass Reduction)
  (Aerobic & Anaerobic)
- Drying
  (Solar or Heat Source Assisted_
- Incineration
  (Rare)
- Sanitary Landfill
  (Often Practiced and we have agencies who are recognized and authorised by PCBs to manage Sludge from specified clusters of Industries in various geography in India)

## Thickening

Gravity Sludge thickener rely on the gravitational force and Strokes law to increase sludge consistency. Typically you can feed 0.8 – 2% sludge and expect anything between 5 – 8% sludge from the bottom of thickener. Typically Rise rate in thickener is 0.2 – 0.4 m/h with side water depth of 1.8 – 2.2 m.

The mineral sludges may give higher Sludge Consistency but be careful higher sludge consistency can create localized chocking issues resulting in resistance to sludge removal path. The equipment is best if the sludge is to be fed to Solar sludge drying beds or if the centrifuge size is governed by water loading and not solid loading. For smaller plants say < 2 MLD it's better to avoid thickeners and go direct filter press or Centrifuge.



## Filter Press – Plate & Frame Design

It is the simplest technology in sludge dewatering. The wastewater firstly will be processed by thickening and then the slurry can be pumped into the filter press.

Then the water will flow out through the filter press clothes, and waste solids are captured and stored inside the filtering chambers and finally form the filter cakes.

To ensure the best filtration performance the membrane plates will squeeze the filter cakes under the pressure of compressed air. When there is no liquid discharging, the automatic discharging device (plate shifter) will open the plate pack to discharge solids.

Dewatering Flocculants may be added to improve sludge consistency, typically ~ 18%

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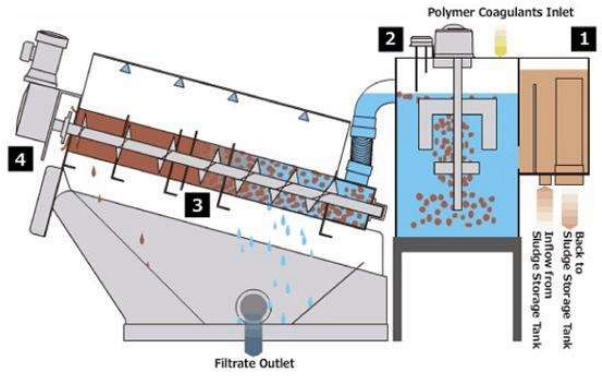
## Volute Dewatering Press – Screw Press

The devise as shown below provide an excellent dewatering option as the inclined upwards moving sludge is subjected to gravity assisted water removal.




- Dewatering Polymer is a must and this technology needs careful selection of dewatering polymer.
- To be used as only 1 specified type of sludge is to be fed and the geed is fairly consistent in composition every day.

## Centrifuge.. Thickening or Dewatering?

Centrifugation is used for both

a. Thickening
b. dewatering

of sludge, where dewatered sludge has a higher dry solids (DS) concentration.

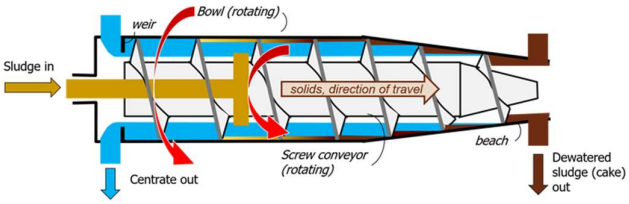
The centrifuge technologies used for each is almost identical. The key operational differences between the two functions are:

- the rotation speed employed
- the throughput, and
- the nature of the concentrated solids product generated.

Dewatering demands more energy than thickening since more water must be removed to achieve the higher solids concentrations.

## Centrifuge Thickening

The most common type of centrifuge used for dewatering applications is the solid bowl centrifuge, usually referred to as a decanter or a decanting centrifuge. Its dewatering performance and solids recovery depends on the feed sludge quality and dosing conditions.




The theory of centrifugation relates to sedimentation theory, since centrifugation acts to enhance gravity through the centrifugal force (or G force). The migration velocity of an unhindered spherical particle of diameter d under the influence of a centrifugal force is given by:

$$v_s = \frac{(\omega^2 r\,(\rho_s - \rho)d^2)}{18\mu}$$

This is the same as the Stokes Law equation from sedimentation theory, with $\omega^2 r$ replacing the gravitational constant g.

where:

ω is the angular velocity in radians/s (where frequency (Hz) = 2πω)

r is the radius of rotation in m,

Metcalf & Eddy (2014). Wastewater engineering, treatment and resource recovery, 5th ed. Provides guidelines for application of centrifuge for a variety of Wastewater sludges.

| Sludge Origin | % DS content – Feed | % DS content – Cake | Polymer dose g/kg DS | % Solids Recovered |
|---|---|---|---|---|
| Primary | 4–8 | 25–50 | 2.5–5 | ≥95 |
| Waste activated sludge (WAS) | 1–2 | 16–25 | 7.5–15 | ≥95 |
| Anaerobically-digested (AD) primary | 2–5 | 25–40 | 4–6 | ≥95 |
| Aerobically-digested WAS | 1–3 | 18–25 | 10–15 | ≥95 |
| Mixed, primary + WAS | 3–5 | 25–35 | 2.5–8 | ≥95 |
| Mixed, AD primary + WAS | 2–4 | 22–35 | 7.5–15 | ≥95 |

DS : Dry Solids
WAS : Waste Activated Sludge

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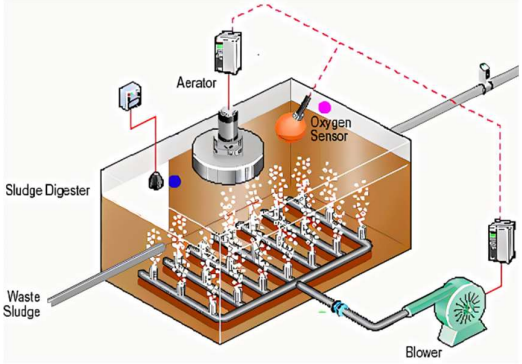
## Stabilization – Biomass Sludges

The biomass from a biological waste water treatment plant referred as WAS have several microorganisms that are still live. These can be further treated to obtain lower sludge solids (Less quantity of Dry Sludge)

Aerobic Digestion, thus refers to the degradation of the organic sludge solids in the presence of oxygen. The oxygen is introduced as fine bubbles of air into the reactor. The micro-organisms in the sludge convert the organic material to carbon dioxide and water, and the ammonia and amino species to nitrate.




In aerobic digestion there is no feedwater entering the system – and therefore no new supply of sCOD to sustain the micro-organisms – they begin to die and are used as food by other bacteria.

This stage of the process is known as endogenous respiration and is responsible for reducing the sludge organic solids concentration.

The major disadvantage with aerobic digestion is that it is energy intensive: the process consumes air and generates carbon dioxide rather than methane as the main gaseous end product.

The aeration system design for aerobic digestion is different then Aeration Tank design due to difference in viscosity of slurry and also cleanability of diffusers. The system must include the diffuser cleaning system and also maintain -Ve LSI to avoid scaling on diffusers.

For successful operation, maintain DO of ~ 1.00 mg/l minimum and expect 40 - 50% volume reduction. The resultant sludge would be lower in pathogens but still needs Disinfection.

Anaerobic Digestion, on the other side doing the same thing but differently i.e. without oxygen. This means sludge is subjected to longer retention time and achieve:

Hydrolysis is the first step in the breakdown of the feedstock. This stage sees proteins, lipids, and carbohydrates, broken down into smaller, organic molecules: amino acids, fatty acids, and sugars.

The second stage of the Anaerobic Digestion is Acidogenesis. This is where the organic molecules are then further broken down into organic acids.

Acetogenesis then takes place and creates acetic acid, hydrogen monohydride (H2), ammonium (NH4), and carbon dioxide (CO2). Finally, the last stage is Methanogenesis. It is at this stage where the bacteria give off the biogas. The biogas created is a mixture of 45-85% methane (CH4) and 15-45% carbon dioxide (CO2), depending on process variables.

Since Biomass (in Sludge) is produced by Aerobic Process, significant ( > 65% sCOD) is already converted to CO2 in Aeration tank and hence this method does not aim at energy recovery.

## Disinfection – Pathogen Control

The two low cost methods to disinfect the sludge and retard bio-degradation are addition of

1. $FeCl_3$ : Ferric Chloride Hydrolyzed in water to form positive iron complexes that neutralize negative surface charges of bacteria, allowing its aggregation and destruction of pathogens.

2. Lime : produces localized high pH conditions that stops all bacterial activities and lead biomass to self-death. This is highly effective for odor control of sludges.

A pilot plant was established by BARC to do pathogen control on dried sludge (~85% DS) to see if the treated sludge can be used as landfills or mixing with sandy soils to improve the fertility of soil. Several counties would love to buy the organic sludge waste (if pathogens are removed) as they do not have any enough irrigation land. e.g. UAE, Saudi.

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## Team Waughter

It's time to introduce a new team, that dreams:

9 years of focus on Aktion Indiaa have made us realize that we need to improve our business processes so that we can add value to customer's cause while maintaining our core value of "Knowledge Driven" organization.

Accordingly, our CEO Kushagra Srivastava moves to Sales vertical and shall be responsible for "Sales Function" for products and Equipment. He forms team with Vrushika & Ajay.

Our Chairman and Managing Director of newly formed Aktion Waughter Private Limited Sanjeev Srivastava assumes the role of mentor to the team lead by Nidhi Jain who has become the leader of the team. Nidhi & team Tejashwani, Surabhi & Kajal shall focus only on:

1. Training
2. Consulting
3. O&M services
4. Condition Assessment
5. New Technology
6. Waughter Magazine

And any other thing that you wish to consult.

Please join us in wishing all three in their new roles.

## जल जीवन जननी!!


## Our World is Waughter

The technical knowledge share attempt of Aktion Consultancy and the contents in the magazine shall be qualified by Sanjeev Srivastava our Technology Lead.

Our next edition focuses on: **"Membrane Bio Reactor – Process, Design & Operation"**

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