SCWO Technology in Sludge Treatment in Homa Bay Town

SCWO Tech Mechanism

SCWO operates under supercritical conditions, where water is heated to temperatures above its critical point (374°C) and pressures exceeding 22.1 MPa. In this unique state, water exhibits enhanced solvating properties, allowing it to efficiently dissolve and oxidize organic compounds present in the wastewater. The process involves the rapid oxidation of organic matter by hydroxyl radicals, resulting in the complete mineralization of contaminants into harmless byproducts such as carbon dioxide, water, and mineral salts.

Sludge Characterization

Conducting wastewater characterization for sludge is a crucial preliminary step before implementing SCWO tech. This process not only helps in identifying the types of sludge present but also plays a vital role in the feasibility and efficiency of SCWO technology.

Understanding Sludge Composition

Sludge from different sources contains a wide variety of organic and inorganic materials, including pathogens, heavy metals, and chemical contaminants. Characterizing wastewater allows us to understand the composition of the sludge, including the concentration and types of contaminants. This knowledge is essential for SCWO because the technology's efficiency can vary significantly based on the nature of the organic compounds present. Some compounds may require higher temperatures or longer residence times to be fully oxidized.

I managed to characterize the type of waste being received at the site for treatment and down below are my findings.

Table 1*: Type of sludge and their origin*

Type of waste	Origin	Mode of Delivery	Volume received
Fecal waste	Septic Tanks	Exhausters	120 m^3/Day
	Pit Latrines		
Domestic Wastewater	Restaurants	Connected Sewer Lines	1,500 m^3/Day
	Schools		
	Hospitals		
	Residential		
	Slaughter Houses		

- The number of exhausters emptying to the sewer ranges from between 10 to 15 in a day, each with a capacity of 8 m^3. This varies with their tariff subscription and licenses for disposal.
- The house holds connected to the sewer line is approximately 1,400 residents and this includes; schools, Hospitals, Slaughter houses and restaurants.
- Limitations to SCWO Technology is that grit, sand, stones and other debris such as sanitary towels might affect the system. These materials will need to be screened out before being fed to the SCWO tech.
- With 6 wet Tons per day, we aim at getting 10% - 15% of bio-solids for the SCOW Tech from the wastewater.

Optimizing SCWO Process Parameters

Knowing the composition of the sludge enables the optimization of SCWO process parameters. Different types of sludge may require adjustments in temperature, pressure, and oxidation time to achieve complete mineralization of contaminants. For instance, sludge with higher concentrations of heavy metals or recalcitrant organic compounds might need specific catalysts to improve the oxidation process. Preliminary characterization helps in determining these adjustments, ensuring the SCWO process runs efficiently and effectively.

Sludge parameters

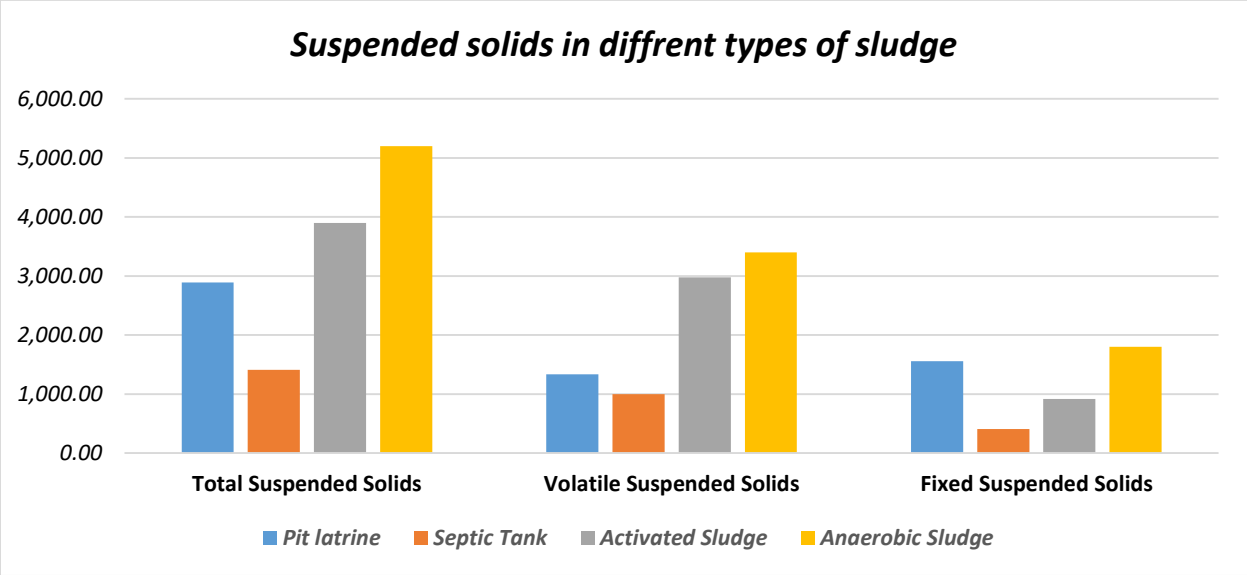
- Tests were done on the suspended solids on different type of sludge emptied at the site; Fecal, Anaerobic, Activated and Septic tank sludge.
- Tests on TSS are very crucial; Total suspended solids are composed of two components; Volatile suspended solids and Fixed suspended solids which are parameters used to determine the organic concentration of the solid portion of waste water.
- Volatile suspended solids are organic compounds of animal and plant origin while fixed suspended solids consists of non-biological/inorganic compounds such as sand, gravel and salt.
- Thermo-physical properties of SCWO makes it efficiently possible to dissolve organic compounds and gases into homogenous mixture treating a lot of tons of waste in a short period of time.

I sampled sludge from the wastewater received on site for analysis on the suspended solids. Below are my findings and explanations.

Table 1: *Data on Suspended Solids collected from the types of sludge received at the treatment site*

	Type of sludge mg/L			
Parameters	***Pit latrine***	***Septic Tank***	***Activated Sludge***	***Anaerobic Sludge***
Total Suspended Solids	2,888.89	1,409.00	3,900.00	5,200.00
Volatile Suspended Solids	1,333.33	1,000.00	2,980.00	3,400.00
Fixed Suspended Solids	1,555.56	409.09	920.00	1,800.00

Chart 1: *Data representation using a chart.*



Total Suspended Solids (TSS):

- Anaerobic Sludge has the highest TSS concentration, followed by Activated Sludge, Pit Latrine, and Septic Tank sludge.
    - Anaerobic sludge typically contains higher concentrations of organic matter and solids due to its composition and the nature of the anaerobic digestion process, which results in the accumulation of suspended solids.

- Activated sludge may have a relatively high TSS concentration due to the biological treatment processes involved, where microorganisms form flocs with suspended solids, leading to higher concentrations.
- Pit latrine sludge and septic tank sludge may have lower TSS concentrations compared to anaerobic and activated sludge, as they undergo less intensive treatment and may have fewer organic solids present especially waste from septic tanks which is primarily grey wastewater.

Volatile Suspended Solids (VSS):

- Anaerobic Sludge has the highest VSS concentration, followed by Activated Sludge, Pit Latrine, and Septic Tank sludge.
  - Anaerobic digestion processes in anaerobic sludge result in the breakdown of organic matter, releasing volatile suspended solids.
  - Activated sludge processes also involve biological decomposition, leading to the presence of volatile solids, although at a lower concentration compared to anaerobic sludge because the aeration aspect used in activated sludge help in releasing some of the volatile materials into the atmosphere faster as compared to anaerobic ponds which are deep and with anoxic zones trapping the volatile materials within the solids.
  - Pit latrine and septic tank sludge may contain fewer volatile suspended solids as they undergo less biological treatment, resulting in lower concentrations.

Fixed Suspended Solids (FSS):

- Anaerobic Sludge has the highest FSS concentration, followed by Pit Latrine, Activated Sludge, and Septic Tank sludge. Anaerobic sludge and pit latrines sludge have a higher percentage of sediments from sand and silt.

The raw the sludge, the higher the yield of stable solids that can be used in SCWO technology. Primary sludge obtained from fecal matter and sludge that has undergone less decomposition will yield better byproducts from SCWO compared to sludge treated biologically by bacteria, due to the presence of volatile solids in the sludge which will be lost in the supercritical oxidation process.

This information is crucial for the utilization of sludge in SCWO technology, as it helps to understand the energy content of the sludge that will be fed into the system.

Sources of sludge for the SCOW will primarily come from the connected sewer system networks that are all directed to the sewage treatment plant. This will further require modifications at the inlet structure to include settling tanks, grit and sand removal structures and the use of organic coagulants and flocculants to harvest sludge for the system. Further mechanisms will be implemented to thicken the sludge before it is fed to the system.

Another source of sludge will be harvested from the anaerobic ponds, involving dredging the sludge from the ponds.

Below is the data of the sludge in the ponds.

Table 2: *Capacity of the Anaerobic ponds*.

		Sludge Volume	
Anaerobic pond	***Capacity m^3***	***m^3***	***T^3***
1	10,200	7,140	6,304
2	12,750	2,550	2,251

- Anaerobic pond 1 has 70% of its total volume occupied with sludge while pond 2 is approximately 20%. This has really affected the efficiency of the system in wastewater treatment.
- SCWO technology will process approximately 6 wet tons of sludge in a day. From the data presented above we have enough sludge to sustain the system.

I also took samples of sludge from the ponds and the inlet structure trying to estimate the volume of sludge and the volume of incoming suspended solids in wastewater. Here were my findings.

Table 3: ***Suspended solids in Raw effluent and the ponds.***

	Suspended Solids mg/L		
Parameters	Raw Influent	Pond 1	Pond 2
Total Suspended Solids	4,538.46	144,476.19	68,222.22
Volatile Suspended Solids	3,500.00	91,095.24	41,222.22

- With our target processing rate of 6 wet tons per day, the suspended solids from both the raw effluent and the ponds provide sufficient material to sustain the SCWO system.

Stabilization Ponds onsite.

- **Status**: They haven't been de-sludged for more than 5 years now.
- **Mechanism**: They allow settling of larger suspended solids by gravity in wastewater to the bottom of the anaerobic pond which are deep about 4m – 5m to create anoxic conditions for anaerobic bacteria to breakdown the suspended solids creating anaerobic sludge at the end. If this sludge is not removed, its accumulation affects the efficiency of the treatment system.
- **Circular tanks**: Were used for sludge treatment but they have stalled for years now leading to accumulation of sludge in the anaerobic ponds.

Wastewater characterization is an indispensable step in the preliminary assessment for SCWO technology. It enables a tailored approach to sludge treatment, optimizing process parameters for efficiency, ensuring safety and regulatory compliance, and evaluating the economic feasibility of SCWO as a sustainable waste management solution.