High Temperature Thermal Pretreatment of Sludge To Alleviate Rate Limiting Step During Anaerobic Digestion

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Overview

- Sewage Sludge Characteristics
- Constraints of Sludge Reclamation
- Thermal hydrolysis Pretreatment
- Pretreatment augmented Anaerobic Digestion

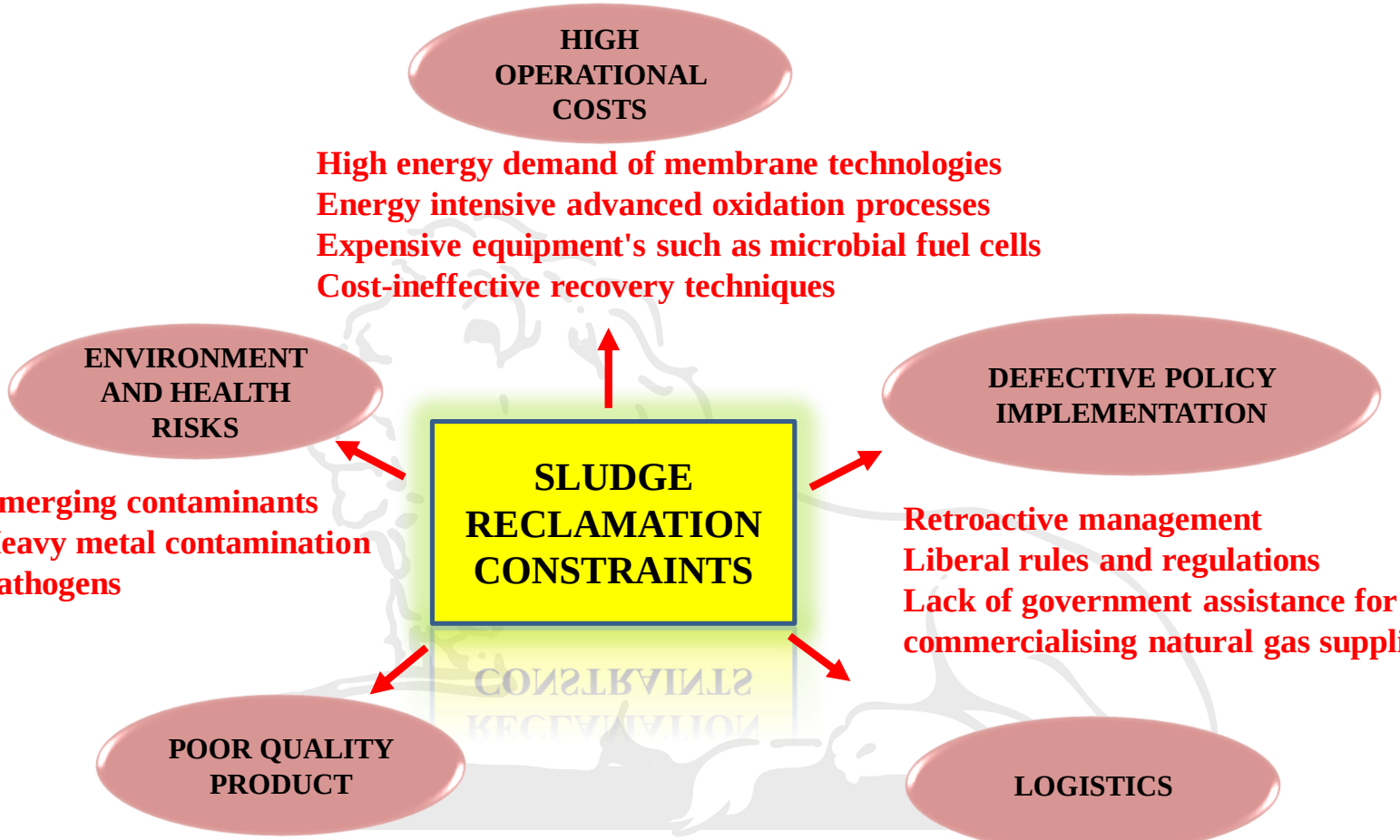
Sewage Sludge

- Residual, semi-solid material produced as a by-product during municipal or industrial wastewater.
- Rich source of carbon, nutrients, and trace elements
- Now considered as a resource rather than as waste since its calorific value is very high due to high organic load.
- However, the sludge treatment costs are much higher than that of wastewater treatment costs and thus requires much more innovative and sustainable treatment technologies.

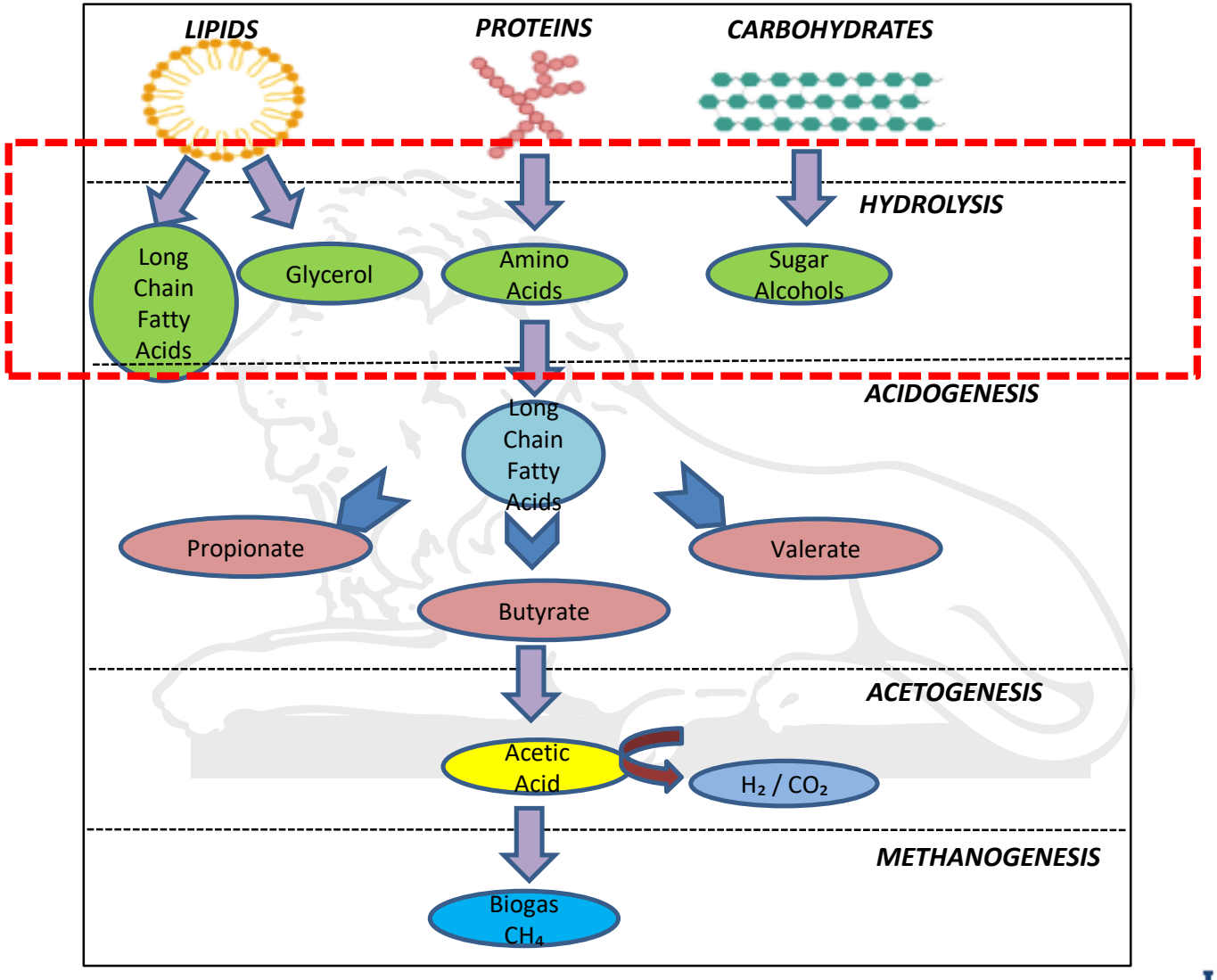
Sludge Characterization

COMPONENT	%	REMARKS
Water	≥ 90%	Water is present in association with solids (91%), as free water (~ 5%), interstitial water (~3%), surface water (~0.5%) and bound water (~0.2%)
Organic content	40-50%	Biodegradable matter (high volatile matter content); accounts for ~60% of the energy content in the raw wastewater
Inorganic content	-	Compounds containing Al, Si, Fe, Ca, Mg, Na, P
Biological Pollutants		Micro-organisms and pathogens
Toxic Organic content		PAHs (polycyclic aromatic hydrocarbons), dioxins
Toxic Inorganic content		Waste from industries, corroded pipelines, medicines, textiles, cosmetics containing Zn, Ni, Ag, Cd, Co, Cu, Hg, Cr, Pb, As etc.
Phosphorus and Nitrogen containing compound		Biomolecules such as proteins, peptides, sugars and fatty acids

Sludge Reclamation Constraints

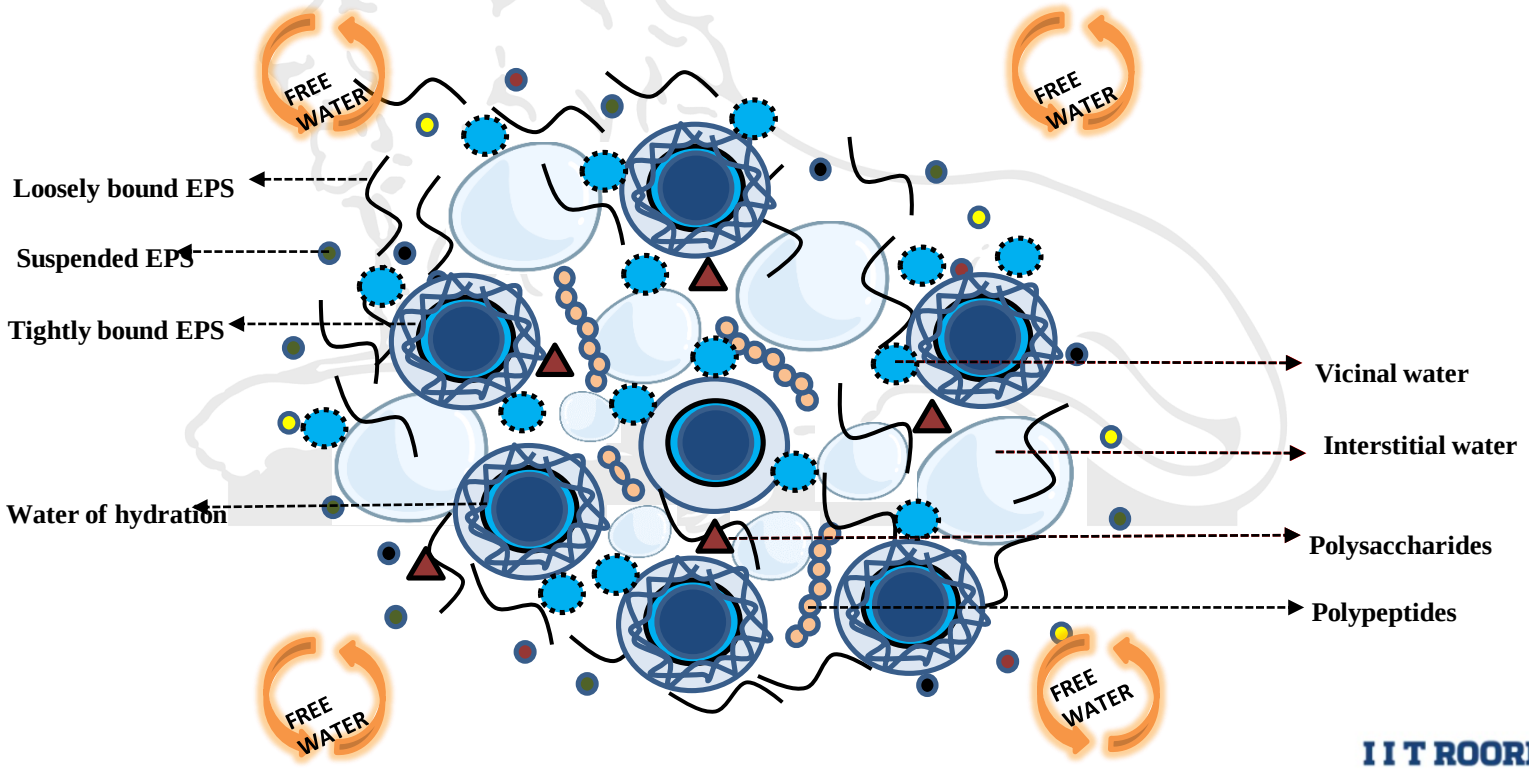


Anaerobic Digestion (AD)



Thermal Hydrolysis

- Hydrolysis is a process in which breakdown of complex organic matter into simpler organic compounds occurs.
- Pretreatment process such as thermal, helps in speeding up of the hydrolysis of complex polymers present in sludge in the form of flocs.
- Thermal pretreatment helps in cell rupturing resulting into higher solubilization of organic components.



Purpose of Treatment

HRT,

VISCOSITY REDUCTION,

REDUCE DS UPTO 8-12%

Pretreating at ≥100˚C for solubilization and homogenization of organic matter

Loosening of extracellular polysaccharides (ECPs).

Further breakdown and release of ECPs from pre-heated sludge at high temperature as well as pathogen annihilation.

Bursting of cell wall thereby releasing extra polymeric substances providing increased surface area for bacteria for action during AD.

OLR,

BIOGAS YIELD,

HIGH VS DESTRUCTION,

ENHANCED DEWATERING,

HIGH QUALITY DIGESTATE

High Temperature Thermal Pretreatment

- Thermal pretreatments helps in bypassing rate limiting step
- Stimulating organic matter degradation and enhances biogas yield.
- Pathogen removal, reduction in viscosity of digestate, enhanced disintegration of cell flocs, solubilization of organic matter, and sludge dewaterability.

- Added advantage is production of class A biosolids.
- Waste activated sludge (WAS) is comparatively more resistant to degradation than the primary sludge, due to its complex composition containing more quantities of protein and phosphorous.
- High-temperature & pressure conditions disrupts cell flocs resulting into higher solubilization, release of cell components (EPS), and methane yield.
- Applied temperature, pressure, and application time have vital effect on degree of solubilization.
- Temperatures ranging from 100-170°Cresults into higher biogas yield is obtained from solubilized fraction than from the particulate fraction. On the contrary, the rate of biodegradation of particulate fraction might remain constant or even decrease at temperatures ≥170-190°C.

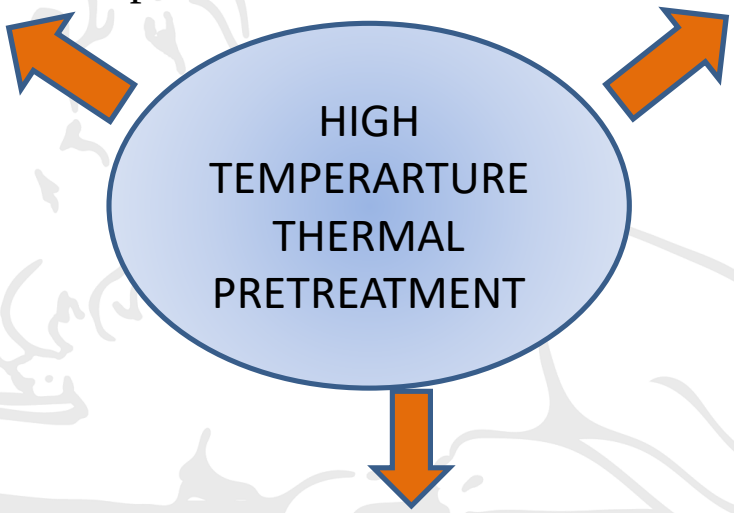
Effect Of High Temperature Pretreatment On Sludge Characteristics:

High temperature & pressure leads to **sterilization** of sludge and production of class A biosolids. **Sudden depressurization** results into **bursting of cells,** thus increases solubilization. Solubilization and methane production are dependent upon temperature and pressure.

Floc & cell distruption- Cell permeability and lysis are directly proportional to the temperatures.

Carbohydrates- **Charring of sugars**

Proteins- enhanced protein denaturation increasing ammonia inhibition during AD



Higher **biogas yield from soluble fraction between 95-170** °C. Most suitable range for biogas production is 170-190°C, even from particulate fraction.

3 MLD, ROORKEE

Parameters	Raw sludge	Cambi treated
pH	6.80	6.30
TS%	14.40	10.70
VS%	7.70	5.75
TOC%	29.96	29.80
TN%	2.20	2.50
TCOD (mg/L)	107500	108300
SCOD (mg/L)	6432	45224
% COD Solubilization	39%	
Ammonia-N (mg/L)	289	397
Total Alkalinity (mg/L)	2400	2000
Total Carbohydrates (mg/L)	7984	6913
Soluble Carbohydrates (mg/L)	168	2372
Total Proteins (mg/L)	17115	15196
Soluble Proteins (mg/L)	2400	7930
PO_4-P (mg/L)	422	672
Total Phosphate (mg/L)	2.7%	3.24%
Total Coliform (MPN/g)	$43X10^7$	$\leq 3X10^3$
Fecal Coliform (MPN/g)	$51X10^3$	<1000
Sludge Rheology	29 times decrease in viscosity of sludge after pretreatment	

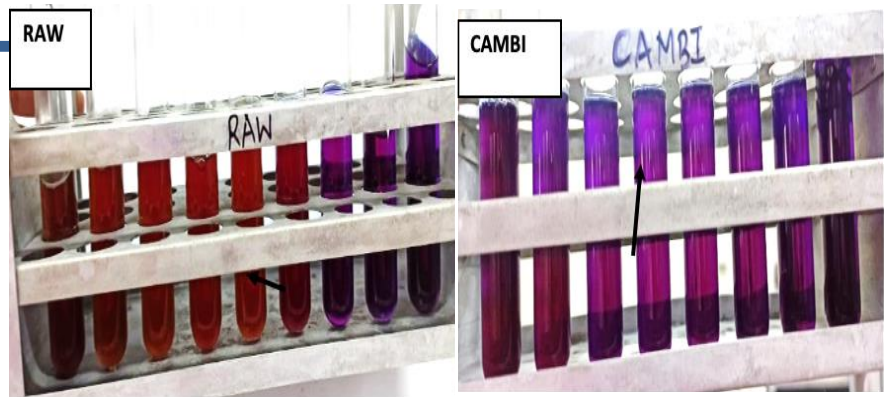
26 MLD, Lakkarghat RISHIKESH

PARAMETERS	Raw Sludge	Cambi treated
pH	6.85	6.53
TS%	14.30	9.10
VS%	8.70	5.80
TOC%	33.30	35.50
TN%	1.5%	1.8%
TCOD (mg/L)	100400	104000
SCOD (mg/L)	3650	39300
% COD Solubilization	37%	
Ammonia-N (mg/L)	184	230
Total Alkalinity (mg/L)	1800	1565
Total Carbohydrates (mg/L)	9873	8761
Soluble Carbohydrates (mg/L)	450	3876
Total Proteins (mg/L)	12817	11196
Soluble Proteins (mg/L)	1021	5741
PO_4-P (mg/L)	280	532
Total Phosphate (mg/L)	1.3%	1.45%
Total Coliform (MPN/g)	$75X10^7$	$\leq 3X10^3$
Fecal Coliform (MPN/g)	$32X10^3$	<1000
Helminths Egg (Number/4g TS)	129	Not Detected

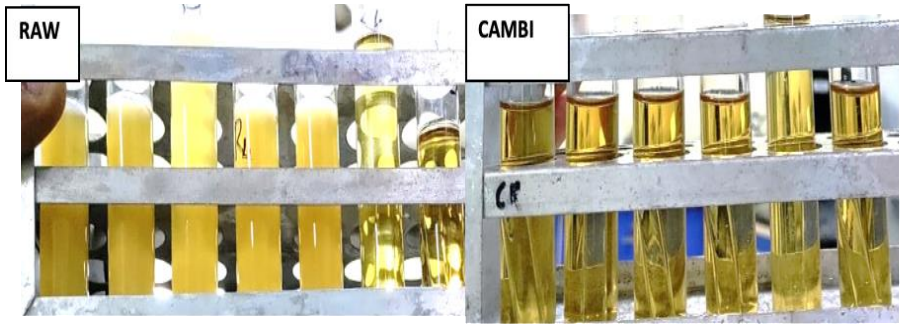
68 MLD, Jagjeetpur, HARIDWAR

PARAMETERS	Raw sludge	Cambi treated
pH	6.76	6.30
TS%	14.80	9.40
VS%	8.70	5.50
TOC%	32.20	32.20
TN%	2.10	2.40
TCOD (mg/L)	101700	101400
SCOD (mg/L)	4750	35325
% COD Solubilization	31.4%	
Ammonia (mg/L)	207	315
Total Alkalinity (mg/L)	2182	1955
Total Carbohydrates (mg/L)	8251	7965
Soluble Carbohydrates (mg/L)	1232	6876
Total Proteins (mg/L)	17320	16521
Soluble Proteins (mg/L)	2785	7741
PO_4-P (mg/L)	312	524
Total Phosphate (mg/L)	2.3%	2.7%
Total Coliform (MPN/g)	$93X10^6$	$\leq 3X10^4$
Fecal Coliform (MPN/g)	$8X10^3$	<1000
Helminths Eggs (Number/4g TS)	165	Not detected

MICROBIAL ANALYSIS



Total coliform analysis of raw and CAMBI pretreated sludge.



Fecal coliform analysis of raw and CAMBI pretreated sludge.

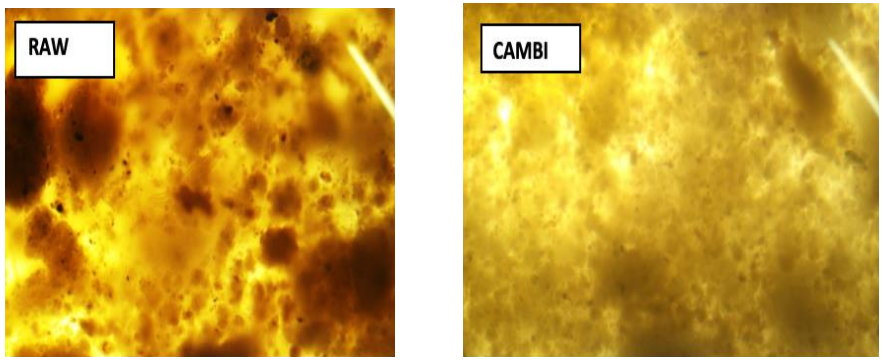
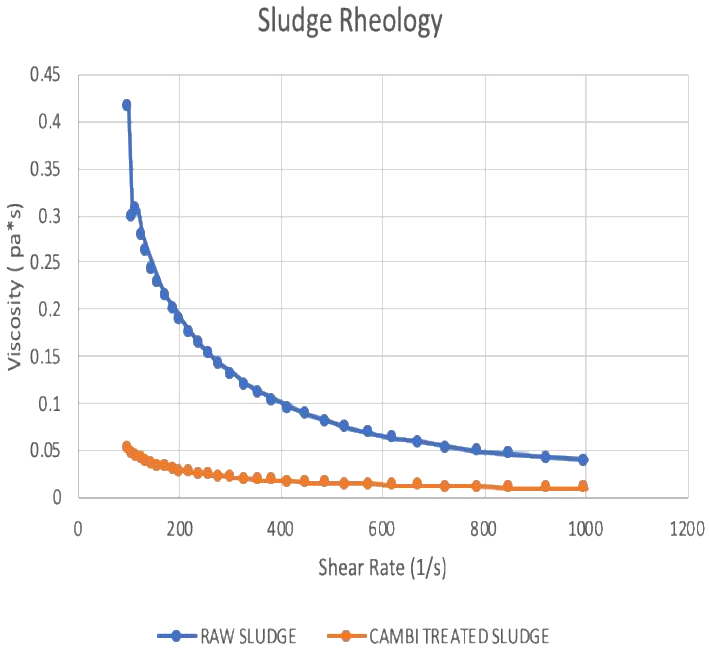


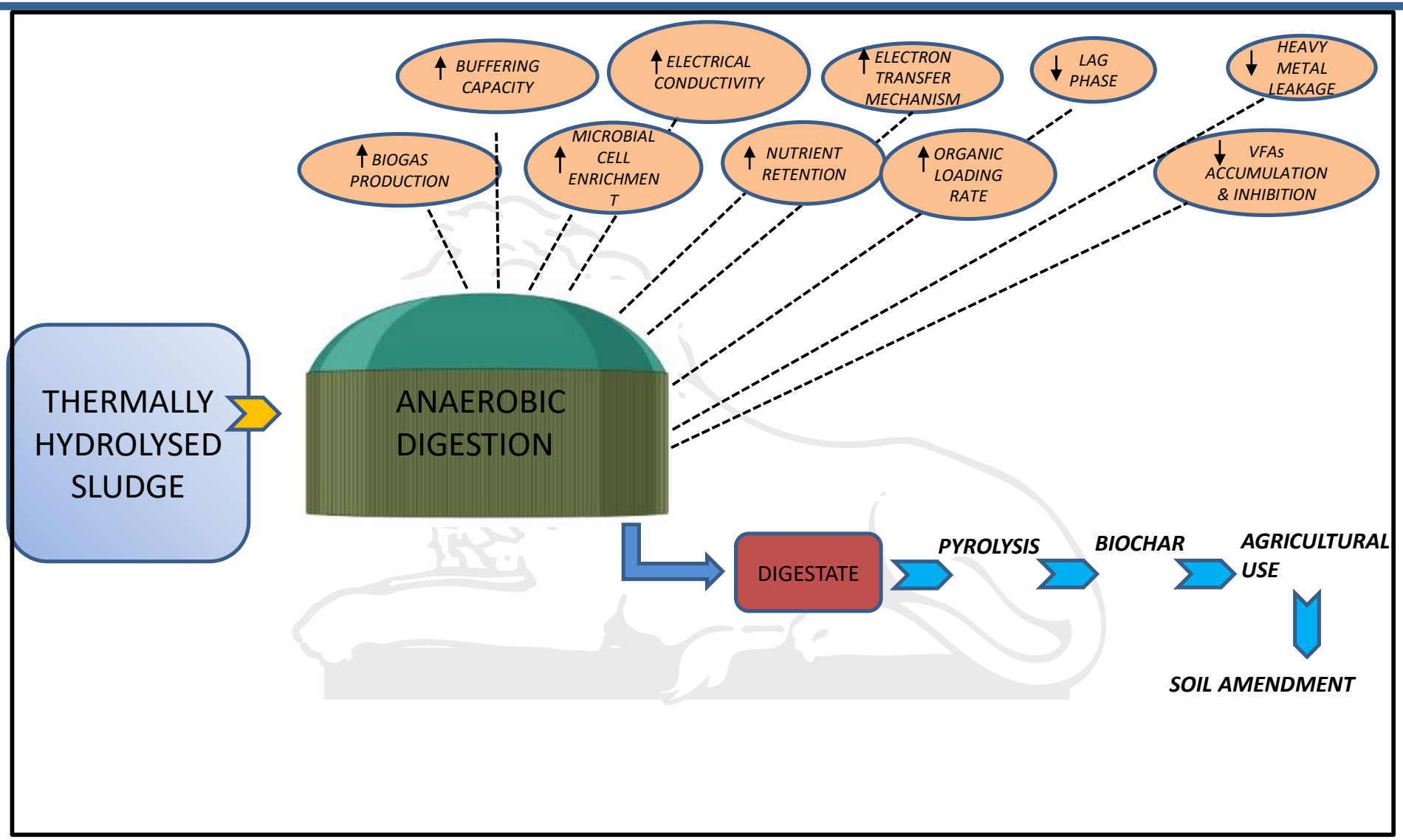
Image showing the microscopic view of helminths eggs (Raw and Cambi treated samples)

SLUDGE RHEOLOGY



≥9 times decrease in viscosity of sludge after thermal pretreatment with CAMBI

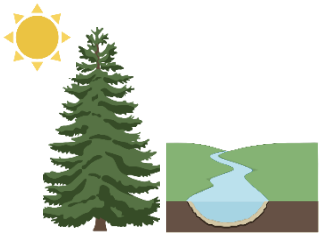
Advantages of AD & TH



Sludge Applications: Turning waste into resources

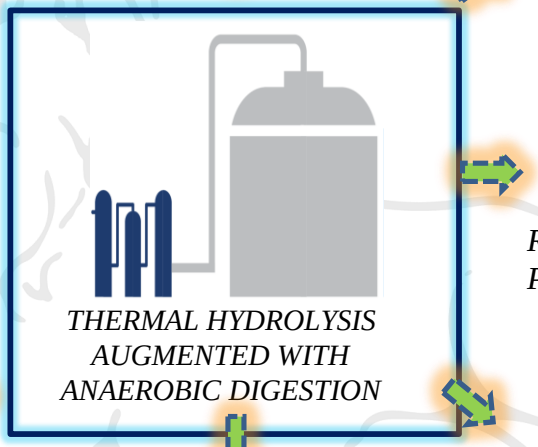
SUSTAINABLE CITIES AND COMMUNITIES

LOW CARBON FOOTPRINT AND BETTER ENVIRONMENT



CLEAN WATER AND SANITATION

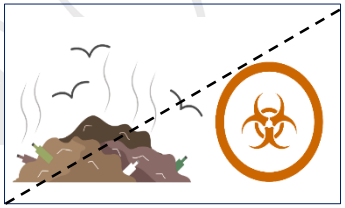
BUILDING SLUDGE-DERIVED RESOURCE RECOVERY SYSTEMS



RESPONSIBLE CONSUMPTION AND PRODUCTION

BUSINESS AND MARKETING

AFFORDABLE CLEAN ENERGY



RELIABLE PERFORMANCE

Acknowledgement

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SARASWATI 2.0 - **Identifying best available technologies for decentralized wastewater treatment and resource recovery for India**

Thank You