ONLINE COURSE FAECAL SLUDGE MANAGEMENT
DEVELOPED BY UNESCO-IHE AND SANDEC
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Key note 2.1: CHARACTERISATION OF FSM (QUALITY, QUANTITY, SOPs)

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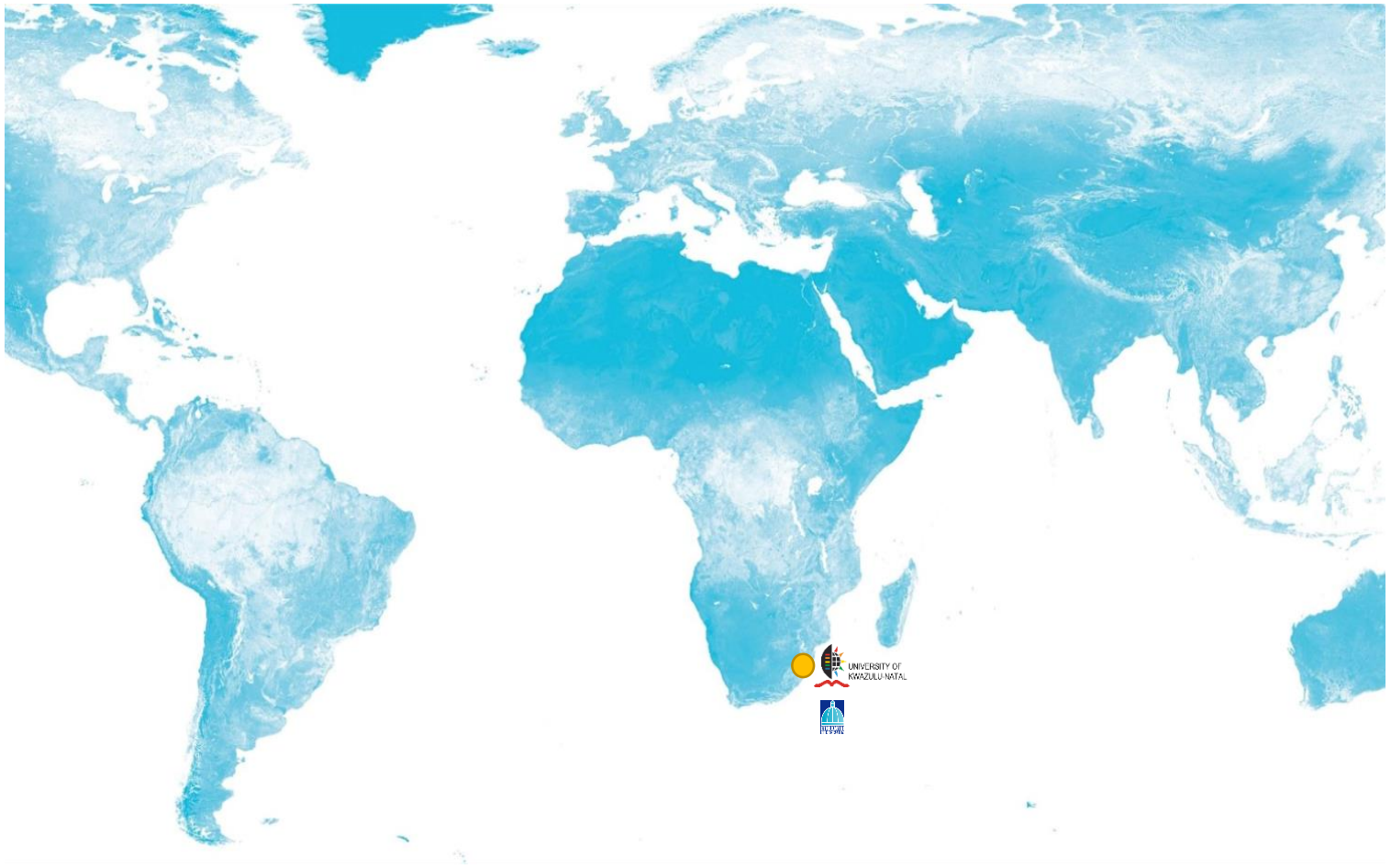
Related course material | Chapter 2 in the FSM book;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Variations in FS characteristics

FS characteristics vary depending on different factors:

- ✓ Environmental - geographical and demographic location, climate, underground water etc.
- ✓ Type of on-site sanitation technology (quality of construction)
- ✓ Age of the sludge; filling rates
- ✓ Toilet use
  - ➢ Number of users and their diet
  - ➢ Frequency
  - ➢ Dry vs wet toilets
  - ➢ “Wipers” vs “washers”
- ✓ Frequency and type of sludge collection (manual, pumping)
- ✓ Use of additives
- ✓ Trash and grey water disposal

Types of FS

From different on-site sanitation sources:

- Pit latrines
- Unsewered public ablution blocks
- Septic tanks
- Aqua privies
- Dry toilets

Depending on the age, storage and source treatment:

- Digested
- Partly digested
- Fresh

  - Wet
  - Dry

FSM treatment targets and objectives

- ✓ Main aim is safe public and environmental health including treatment, discharge, enduse or disposal.
- ✓ Treatment objectives
  - ➢ Dewatering
  - ➢ Pathogen inactivation
  - ➢ Stabilisation – organic matter and nutrients
  - ➢ Safe end-use or disposal

Important parameters for FS characterisation

Groups of properties	Property / analytical test	Equipment / method	Reason/ importance
Chemical properties	**Moisture content** **Total dry solids**	Oven 105 ºC	• Assessment of the mechanical behaviour – mixing, drying, flowing, viscosity, combusting • Migration of pathogens • Biodegradation potential
	Total volatile solids **Ash content (fixed solids)**	Furnace - 550 ºC	• Show the ratio of organic to inorganic solids that will change over time; combustion potential; biodegradability potential
	Total suspended solids	Filter, dry	• Pit emptying and processing – indicating potential settling, clogging
	COD total	Closed reflux titrimetric method, microwave	• Indicate the organic content and the biodegradability rate of the sludge contents
	pH	pH probe	• pH affects the rate of degradation of the faecal sludge and the sanitising effects of ammonia. • Indicates the corrosive effect on pit emptying and sludge treatment devices.
	Ammonia	Distillation	• Nutrient recovery; disinfection
	TKN (Total Kjeldahl Nitrogen)	Digestion and distillation	• Nutrient recovery
	K (Potassium)	Spectroquant Tests	• Nutrient recovery
	Total phosphate	Spectroquant Tests	• Nutrient recovery
	Orthophosphate		

Important parameters for FS characterisation

Group of properties	Property / analytical test	Equipment / method	Reason/ importance
Physical and mechanical	**Density (solids, dry, bulk)**	Mass balance & volume measurement (liquid volume displacement by solids)	• Pit emptying equipment & mechanical process design
	Particle size distribution (>5mm)	Wet sieving rig; Sieve shaker Set of sieves for dry and wet sieving.	• Pit emptying equipment & mechanical process design
	Particle size distribution (<5mm)	Malvern particle size analyser	• Pit emptying equipment & mechanical process design
	Sludge volume index (SVI)	30 minute settling test	• To estimate settling characteristics of sludge; pit emptying and processing
	Osmotic pressure	Osmometer	• Vapour pressure, membrane processing
	Rheological properties	Parr rheometer	• Design parameters for pit emptying equipment; extruders and mechanical treatment
	Sludge penetration resistance	Penetrometer – lab and field scale	• Design parameters for pit emptying equipment; extruders and mechanical treatment

Important parameters for FS characterisation

Group of properties	Property / analytical test	Equipment / method	Reason/ importance
Thermal properties	**Thermal conductivity**	Thermal conductivity analyser	• Drying, combusting, heating potential, thermal treatment design
	Specific heat		
	Calorific value	Calorimeter	• Combustion, heating potential
Biological properties	**Parasites content (e.g. Ascaris)**	External laboratory, microscope	• Identify the potential biohazard; Identify the need of pre-treatment before potential reuse
	Pathogens (e.g. E.*coli*)	Microscope, petri dish	• Identify the potential biohazard; Identify the need of pre-treatment before potential reuse

Challenges measuring FS properties

FS properties vary between:

- different types of on-site sanitation systems
- different toilets from one and the same type of on-site sanitation systems
- within one and the same toilet or sanitation system

So what is the correct approach?

Development of standard methods and procedures (Standard Operating Procedures)

Applicable for:

- ✓ Sampling
- ✓ Analysis
- ✓ Health and safety procedures during sampling, transportation, analysis and disposal

Importance of the SOPs

- ✓ Consistency and reliability
  - ➢within a particular study
  - ➢between different studies or regions
- ✓ Promotion of Best Practice
- ✓ Quality control
- ✓ Efficiency
- ✓ Fewer errors
- ✓ Healthy and safe work environment

Standard Operating Procedures for FS

- ✓ Currently there are no standard methods for sampling and analysis of FS
- ✓ Standard methods for water, wastewater and soil are used for FS
- ✓ These methods are not the most suitable because FS differs in its characteristics
  - ➢ in time
  - ➢ by location
  - ➢ by type of facility
- ✓ The lack of standard methods for FS results in incomparable data between different institutions

The way forward

- ✓ Need for collaboration to combine the experience of different groups around the world to get a common acceptable set of appropriate FS SOPs
- ✓ This is not a once-off task – methods are being developed and modified over time

Development of
FS SOPs
Pollution Research Group
Example

PRG expertise in FS SOPs

- Specialised sanitation laboratory

http://prg.ukzn.ac.za/laboratory-facilities

FS SOP manual

- SOP manual for FS covering
  - ✓ Administration
  - ✓ Chemical properties
  - ✓ Physical and mechanical properties
  - ✓ Thermal properties
  - ✓ Biological properties – parasites content
  - ✓ Laboratory health and safety

http://prg.ukzn.ac.za/visiting-researchers/information-for-visiting-researchers

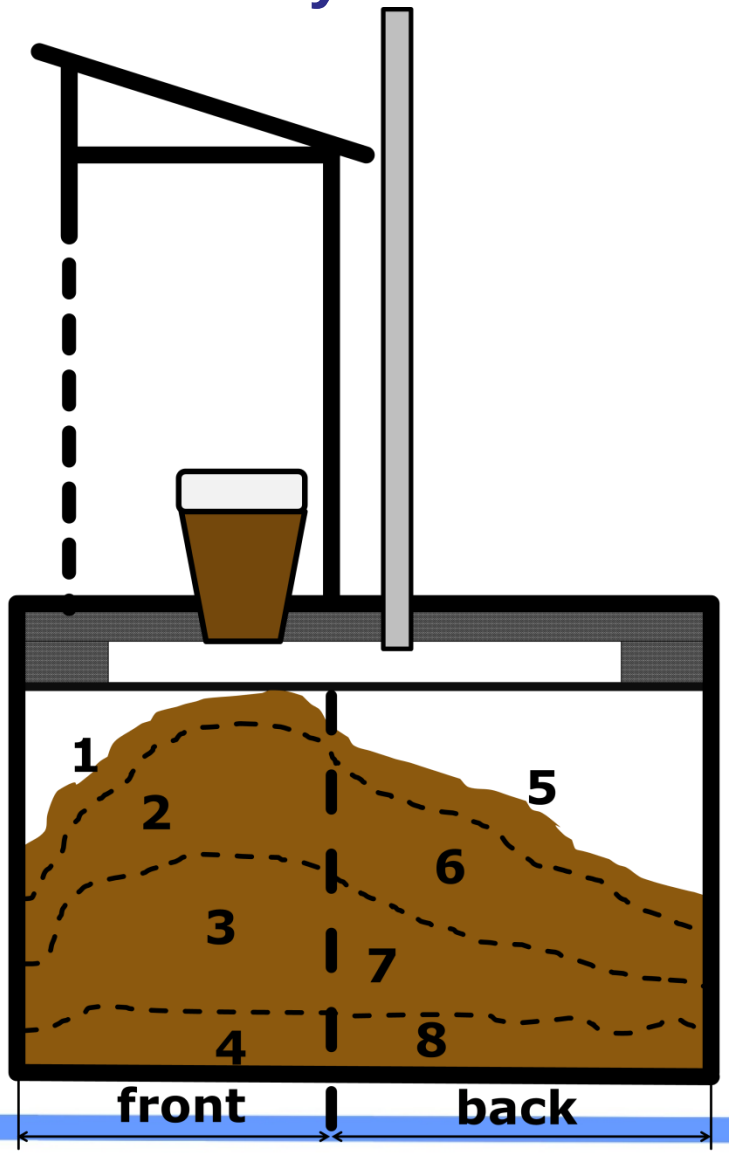
Properties of FS study

- ✓ “Mechanical Properties of Faecal Sludge”
- ✓ Objectives
  - ➢ Generate first hand data on faecal sludge characteristics from on-site dry sanitation facilities
  - ➢ Provide data for improved design and sizing of pit-emptying devices, transport and processing systems for sludge and the design of future on-site sanitation facilities

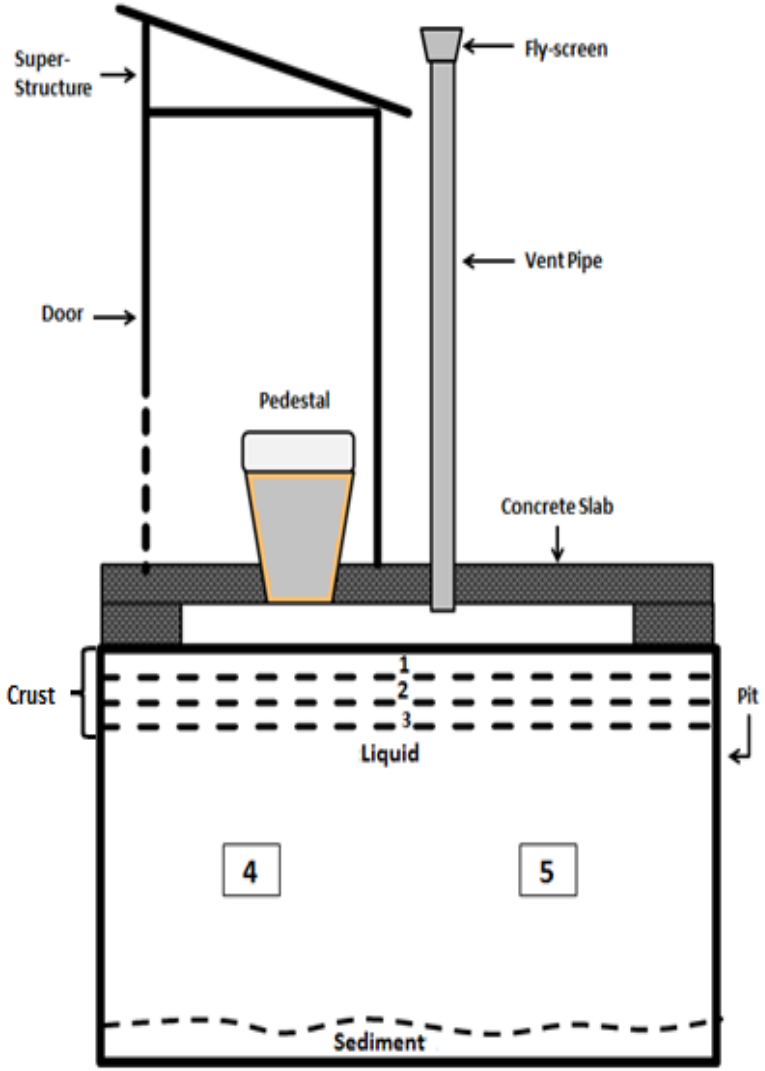
Pit emptying programme

Facility type	Characteristics	Usage level	Number of facilities sampled	Location in Durban
Household VIP latrine	Dry	Low use (<5 users/facility)	5	Besters
		High use (>5 users/facility)	5	
	Wet	Low use	5	Besters
		High use	5	
Household UDDT toilet		Low use	5	Mzinyathi
		High use	5	
Household unimproved pit latrine	Dry	Low to high use	2	Ocean Drive
Community ablution block VIP	Wet and dry	High use	9	Malacca Road
School VIP toilet block	Wet and dry	High use	4	Mzinyathi
Total			45	

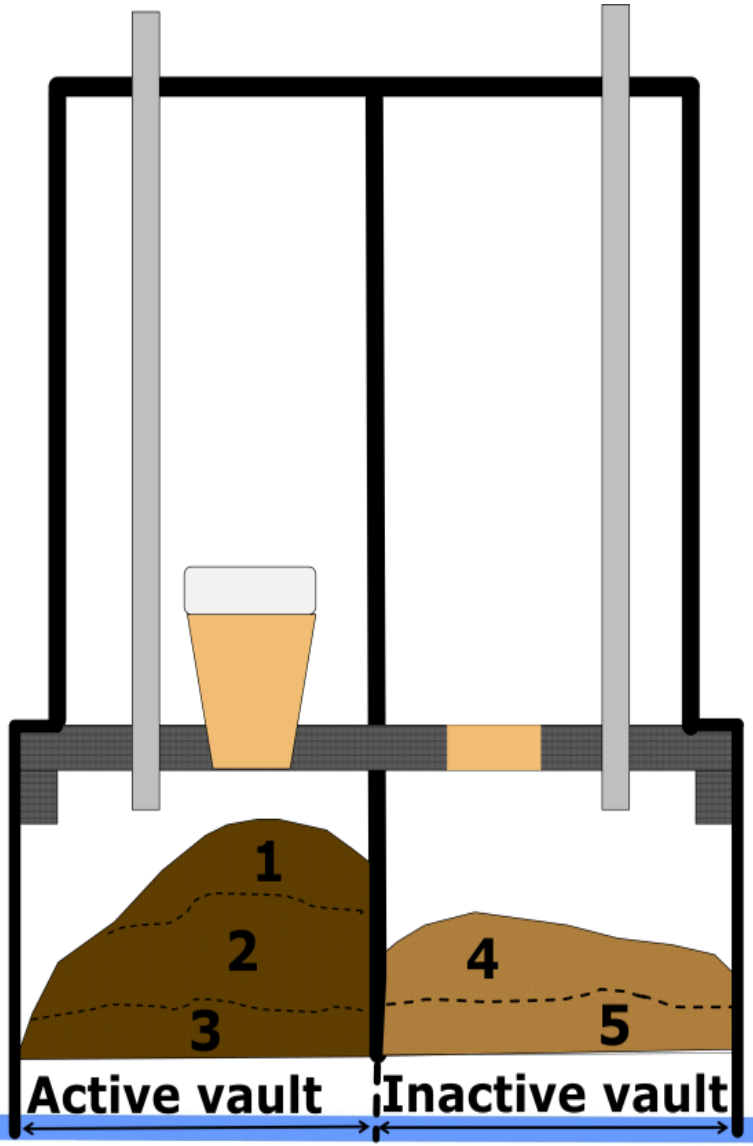
Selection of analytical samples at different depth levels – dry household VIP



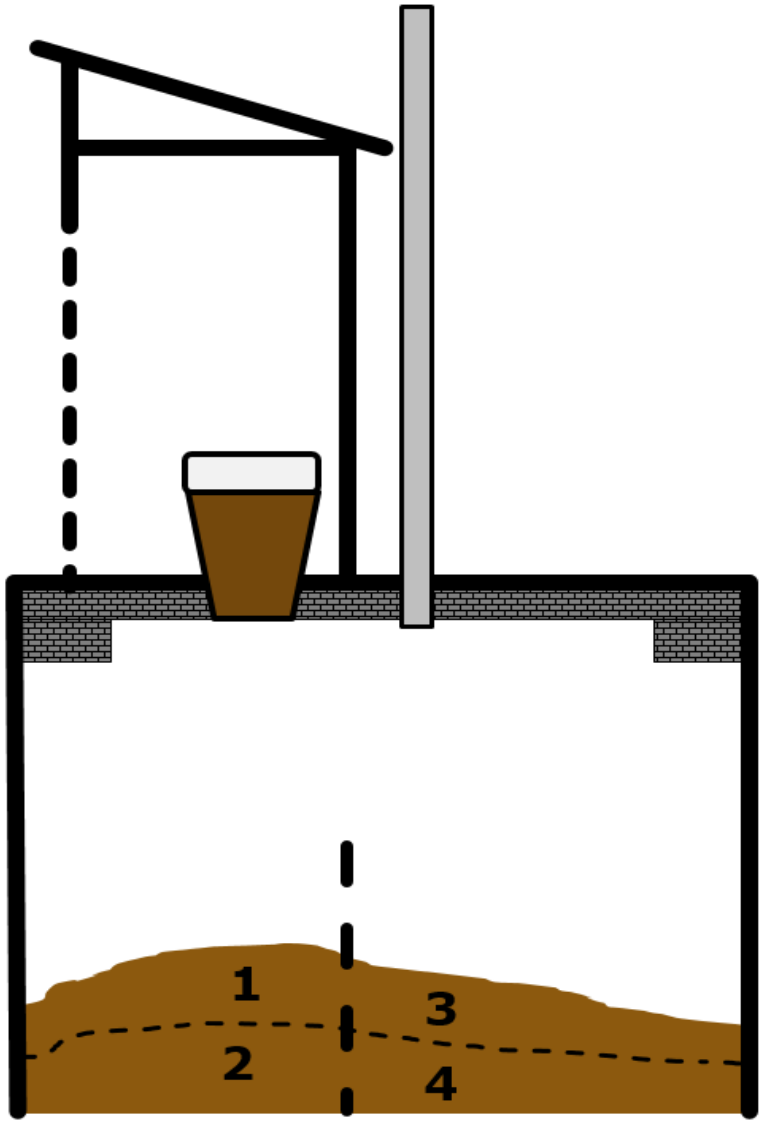
Selection of analytical samples at different depth levels – wet household VIP

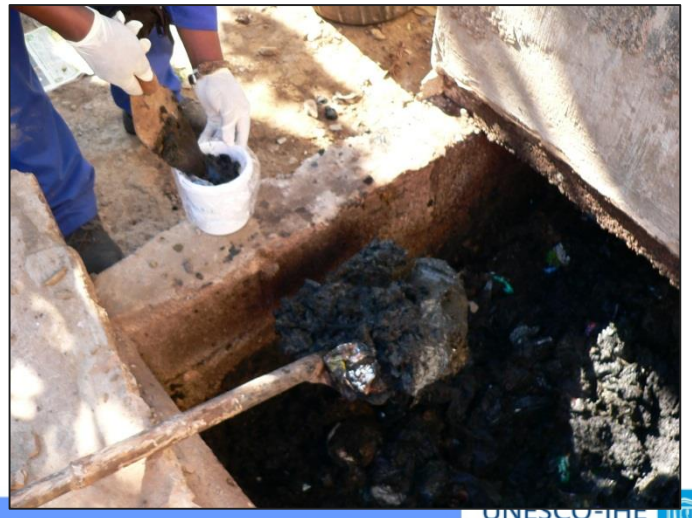


Selection of analytical samples at different depth levels – household UDDTs

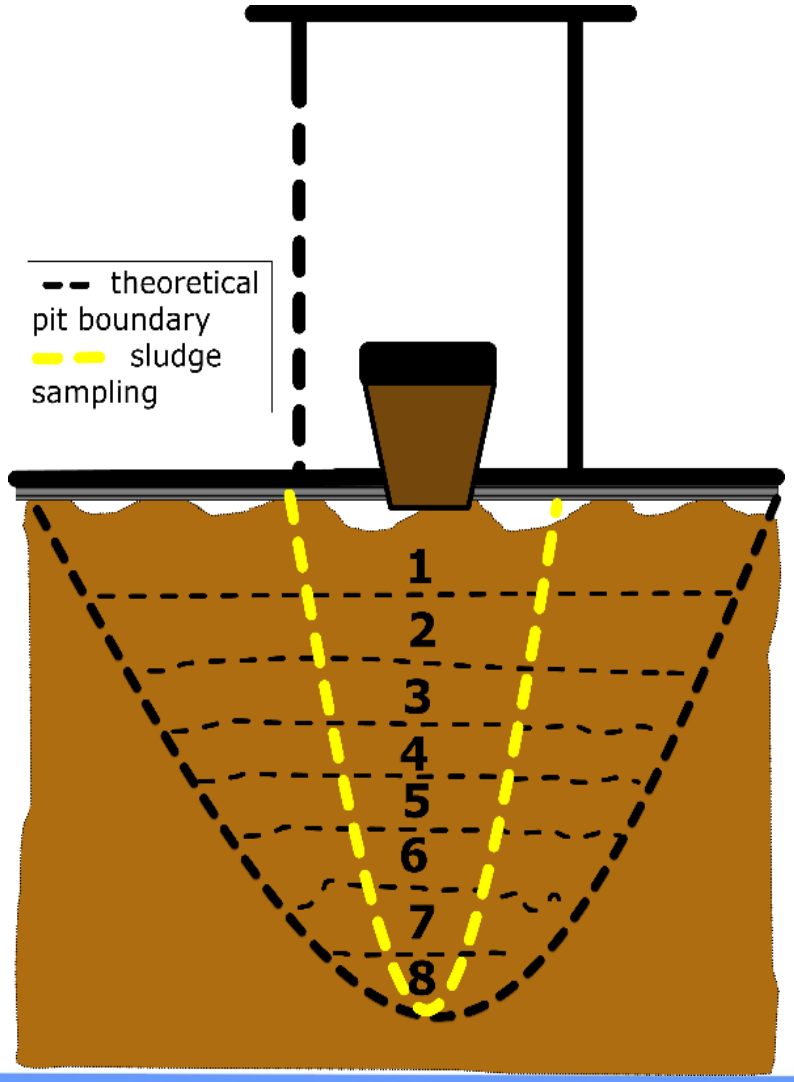


Selection of analytical samples at different depth levels – School VIP





Selection of analytical samples at different depth levels – unimproved pits



FS sampling methods

- ✓ Sampling should be based on the local FSM context
- ✓ It should fit the end use of the data
  - ➢ Different depths
  - ➢ Different sections
  - ➢ Composite sample
- ✓ Standardised methods for different types of on-site sanitation facilities
- ✓ The sampling timeline must be co-ordinated with laboratory analysis timeline – transportation, storage

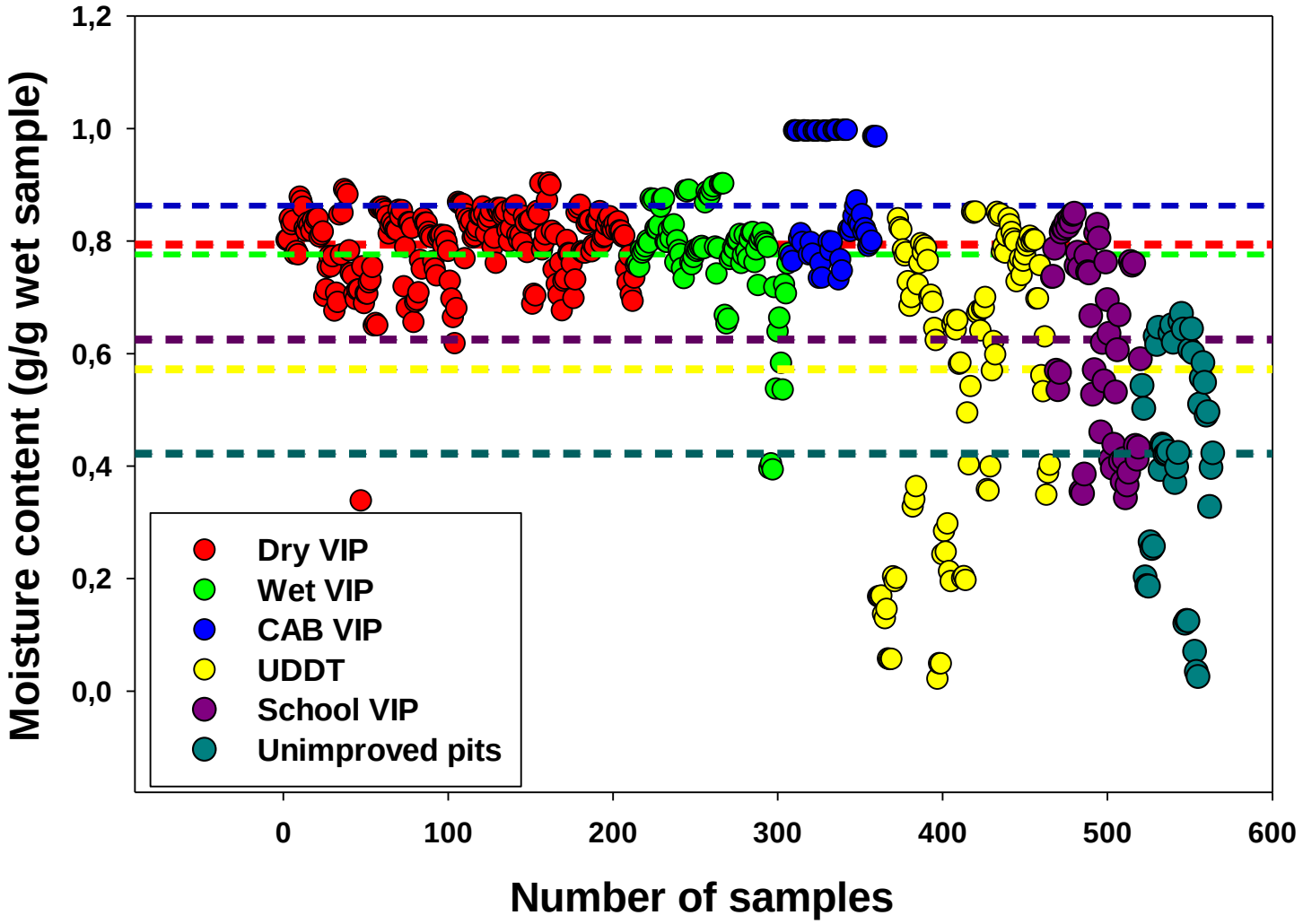
Analyses on faecal sludge

- Moisture content / Total solids
- Ash/ Volatile solids
- Suspended solids
- TKN
- Ammonia
- COD
- pH
- Nitrates/Nitrites
- Potassium
- Orthophosphates /Total phosphates

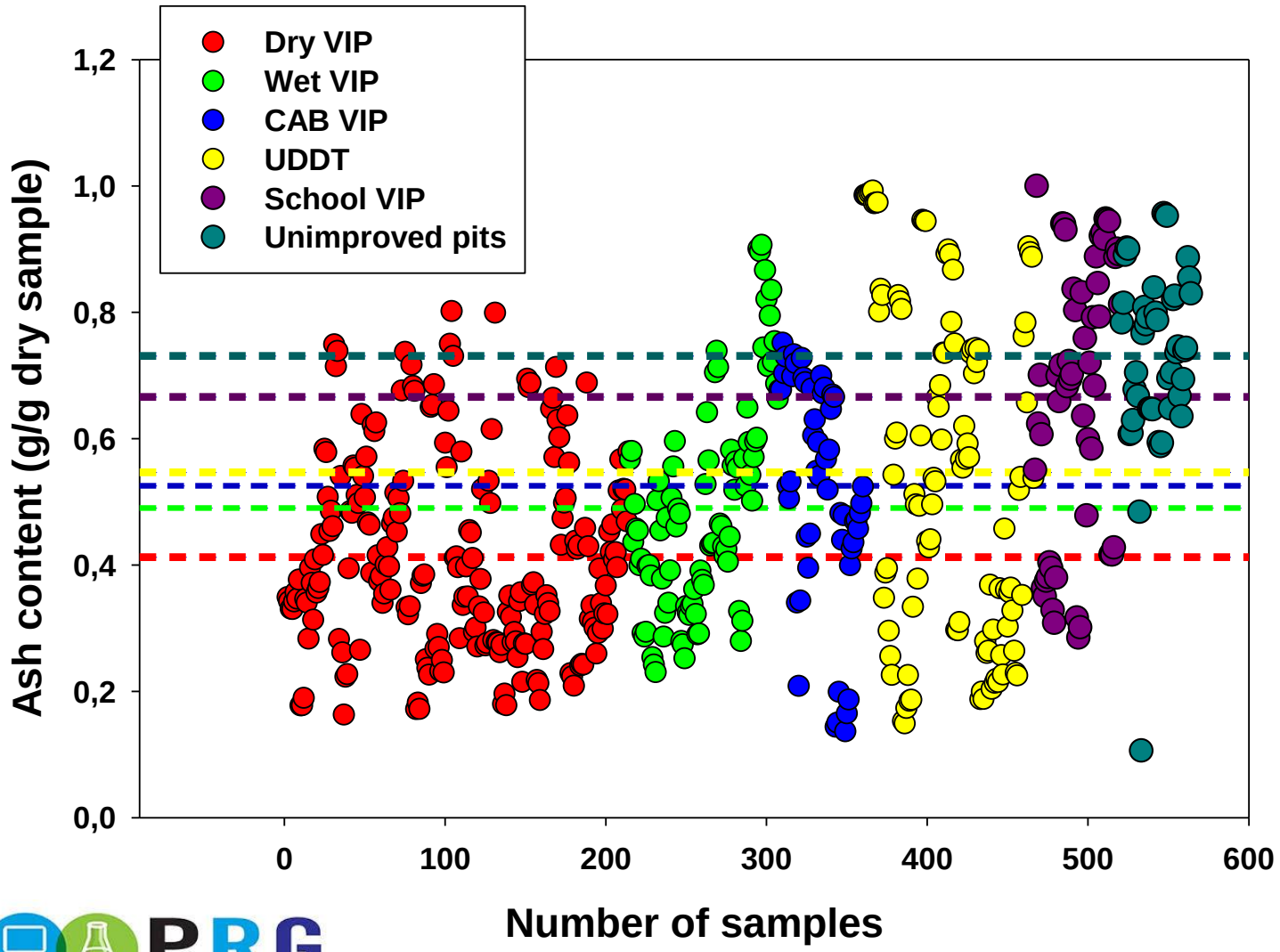
Analyses on faecal sludge

- Calorific value
- Specific heat
- Thermal conductivity
- Rheological properties (Viscosity)
- Plastic and liquid limits
- Density
- Sludge volume index
- Particle size distribution
- Ascaris / parasites content

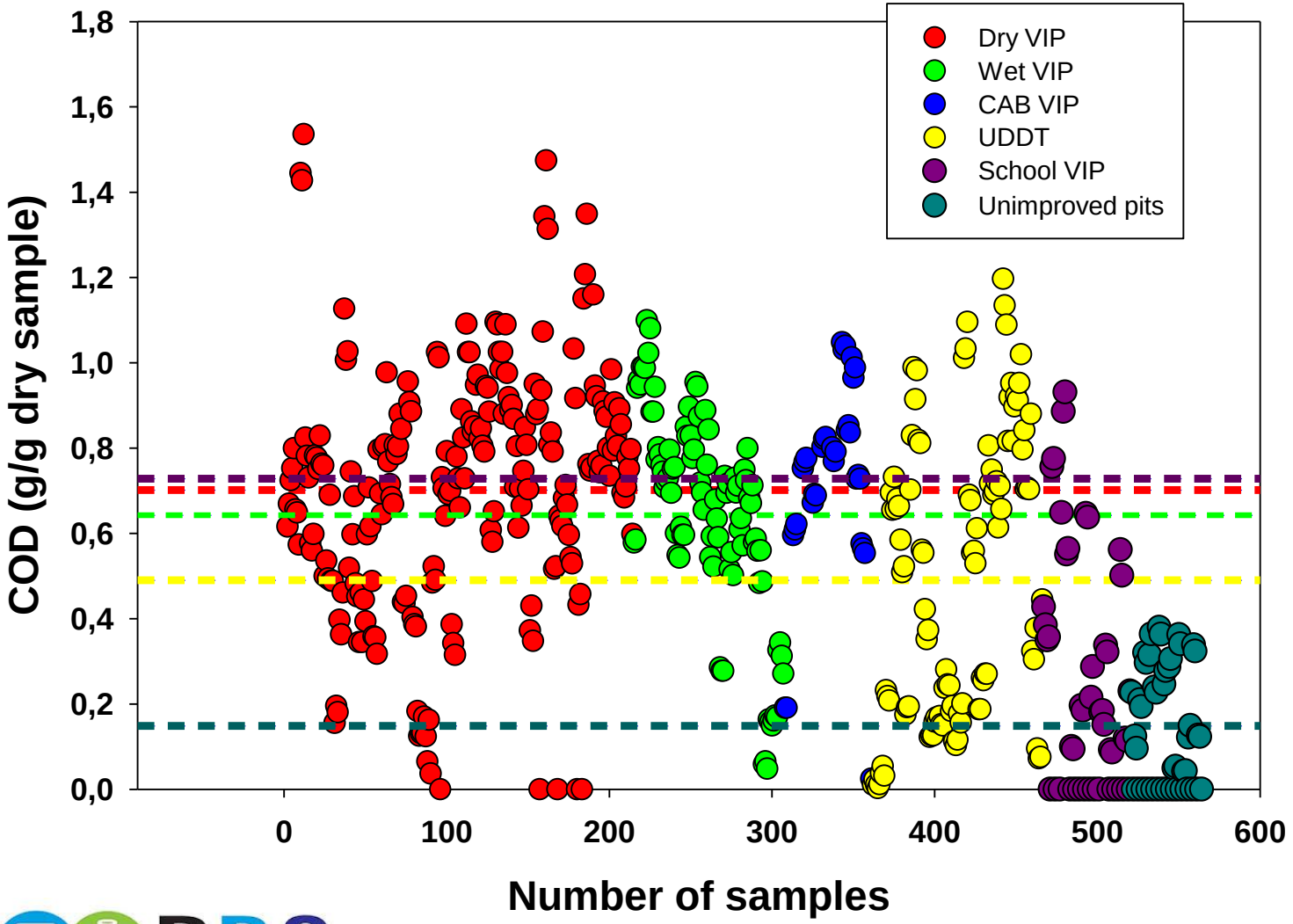
Moisture content



Ash content


Dry VIP
Wet VIP
CAB VIP
UDDT
School VIP
Unimproved pits
Ash content (g/g dry sample)
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0
100
200
300
400
500
600
Number of samples

Total COD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1,8
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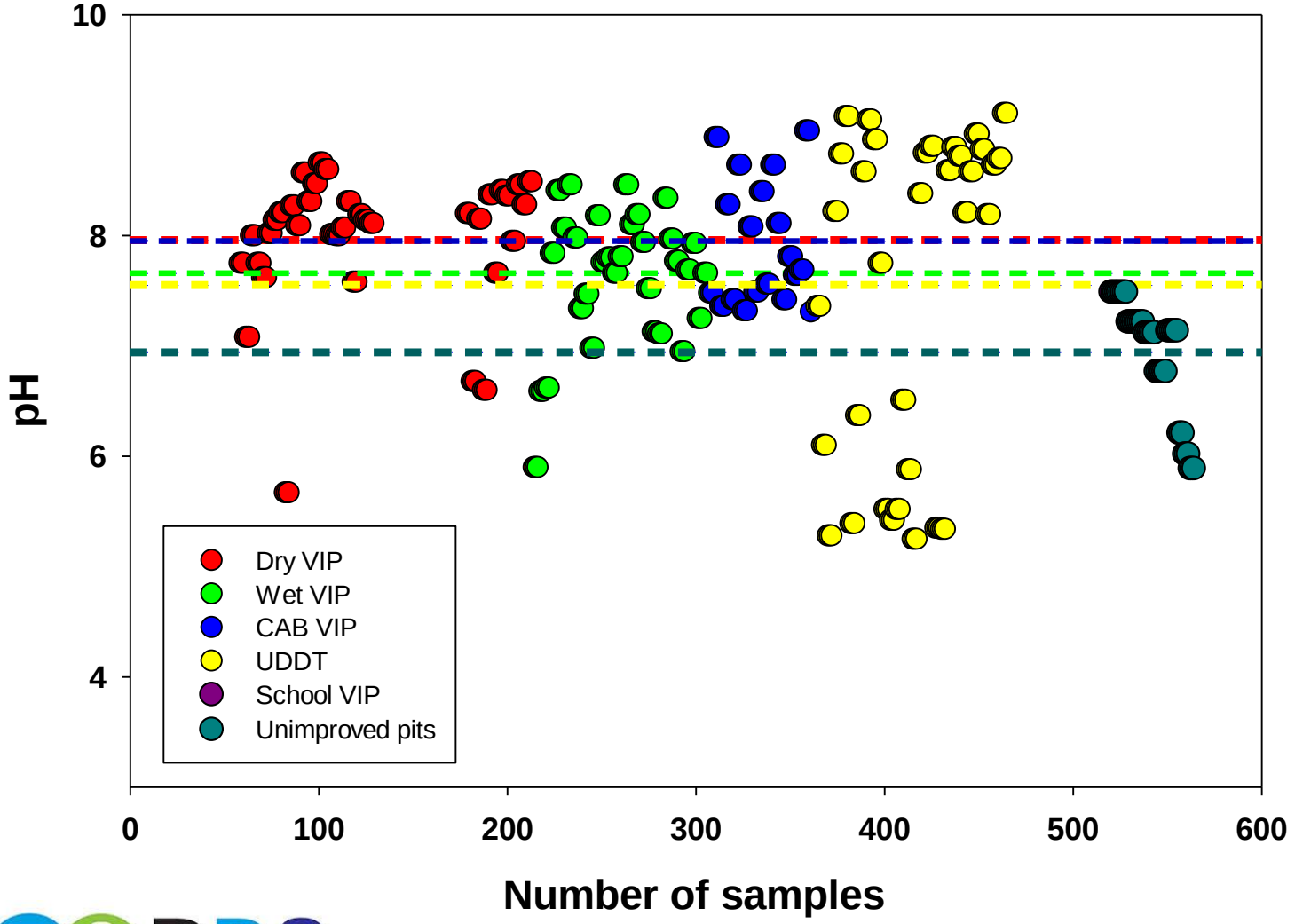
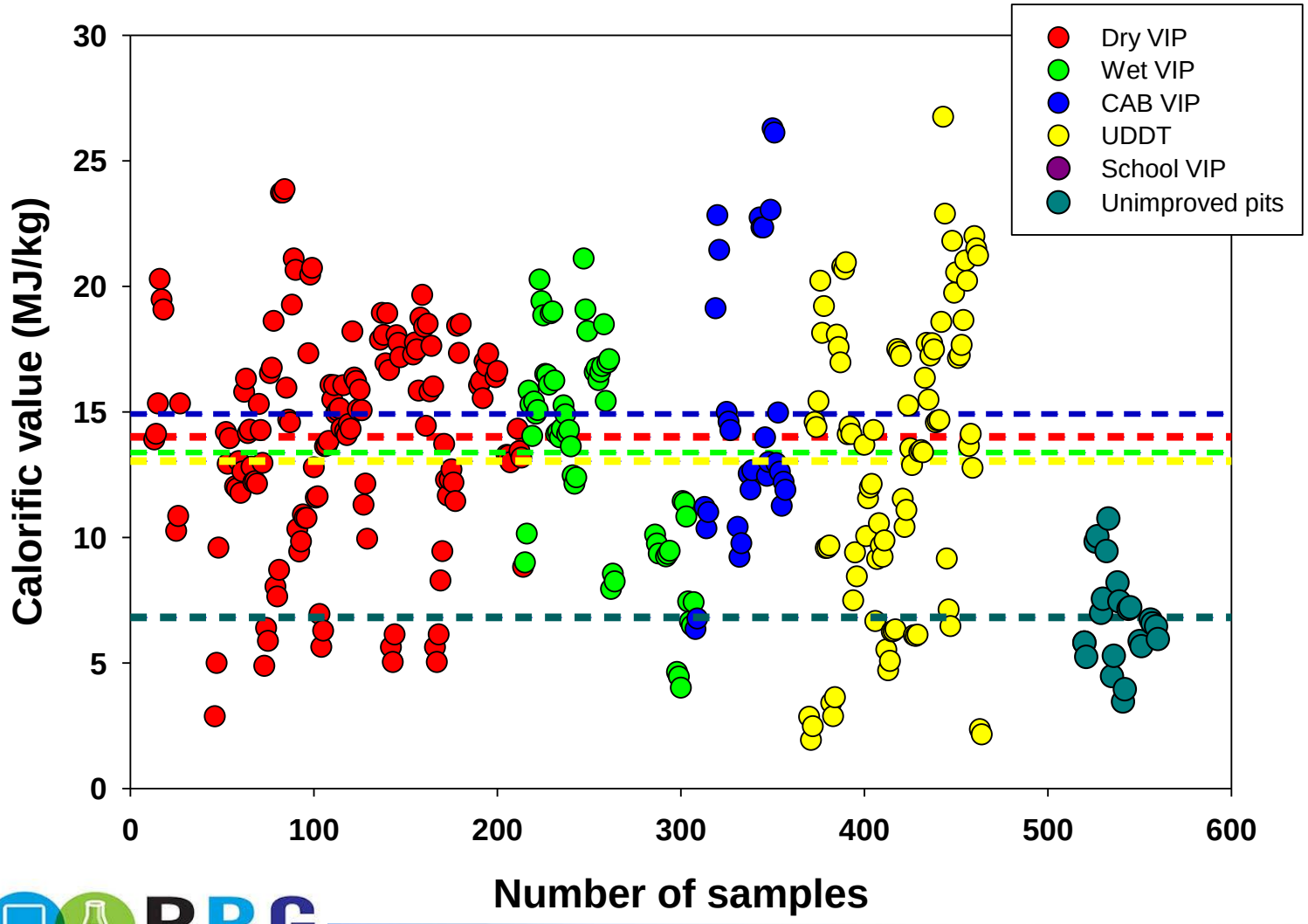
0,6
0,4
0,2
0,0
0
100
200
300
400
500
600
Number of samples

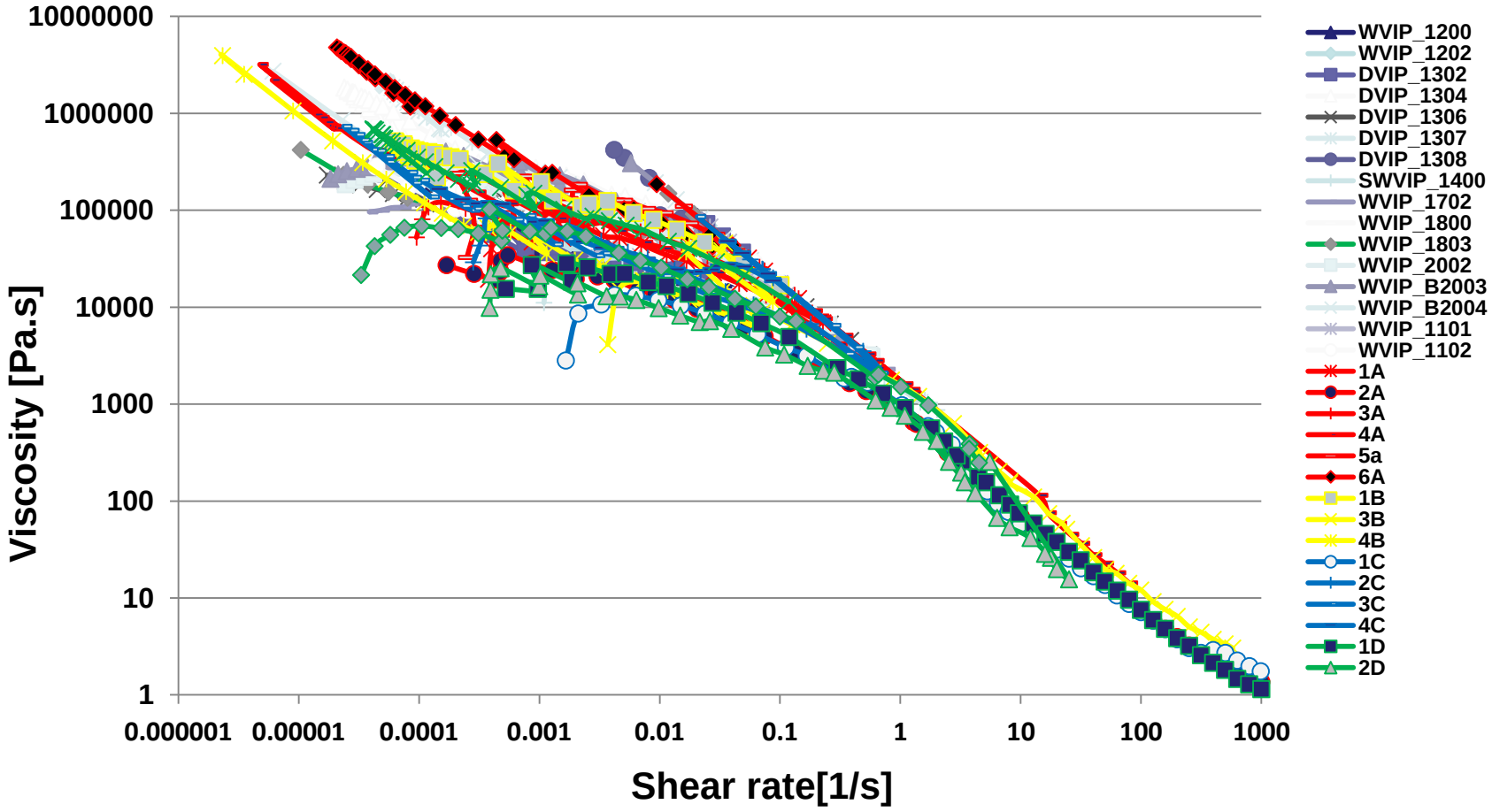
pH


10
8
6
4
pH
0
100
200
300
400
500
600
Number of samples
Dry VIP
Wet VIP
CAB VIP
UDDT
School VIP
Unimproved pits

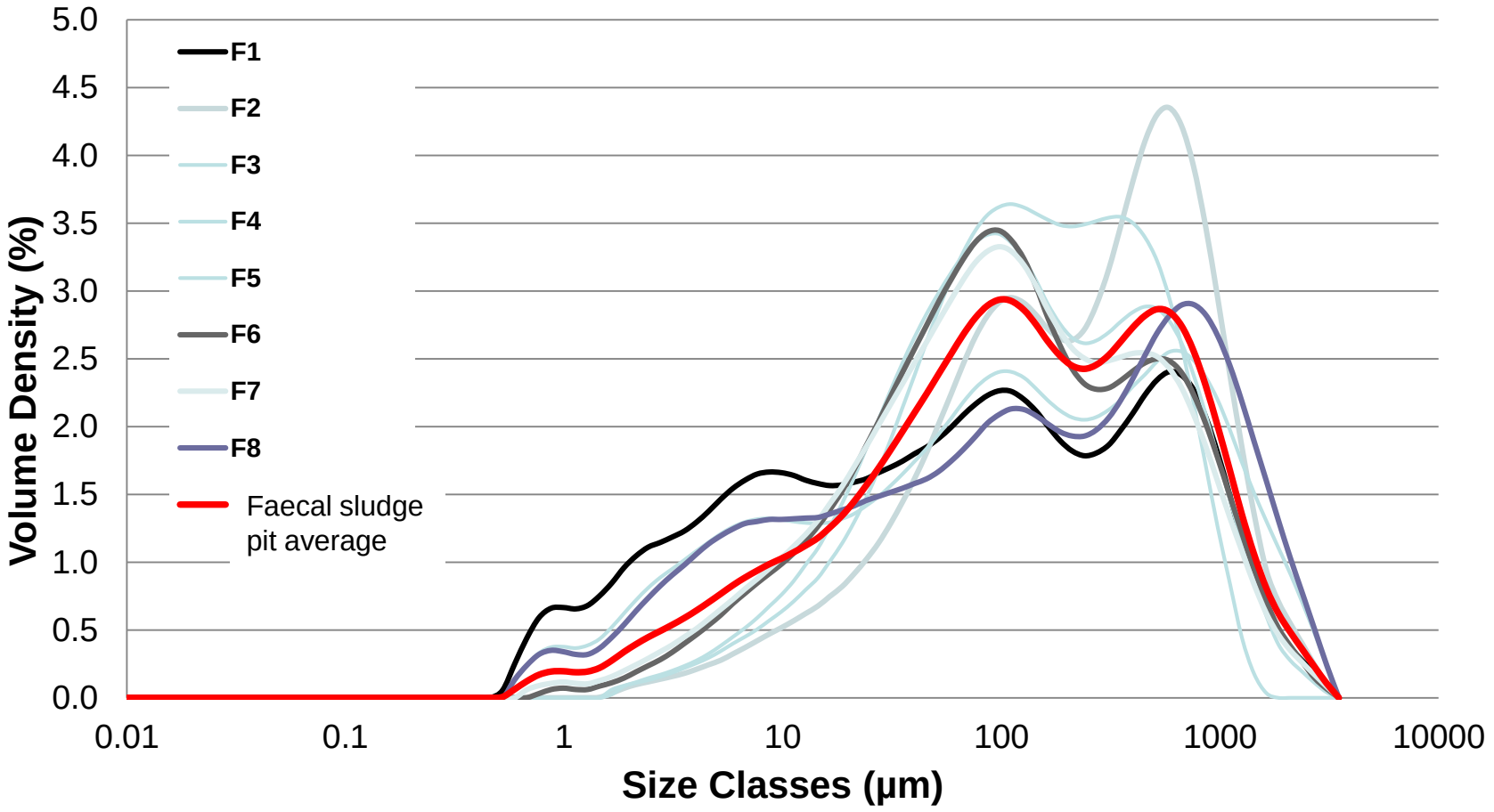
Calorific value



Rheological properties



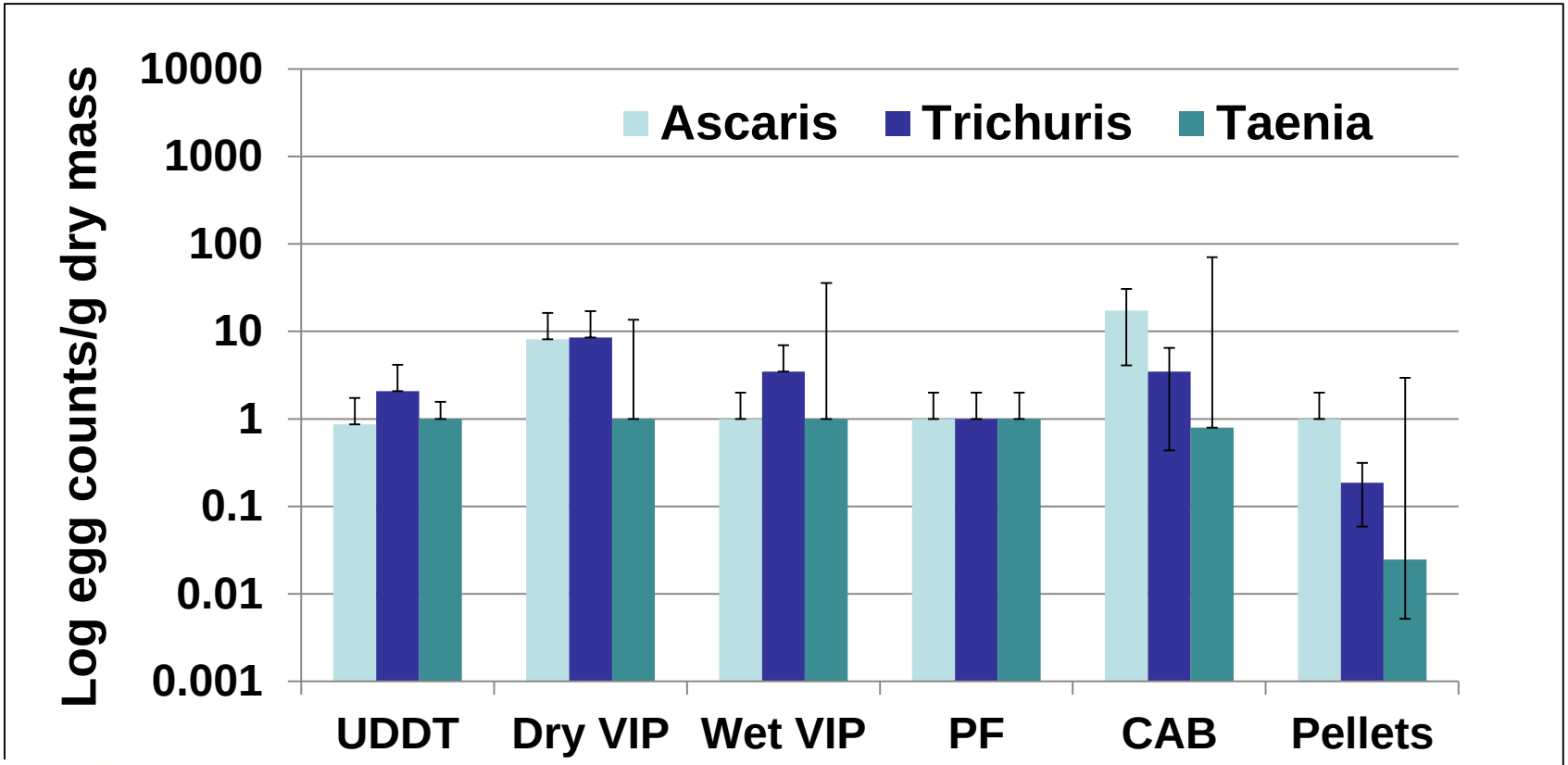
Particle size distribution



Helminth Eggs

Occurrence of Helminth Eggs in On-site Sanitation Systems in eThekwini Municipality, South Africa

N. Rodda*, C. Archer*, V. Kelly*, K. Velkushanova** and C. Buckley**



Trash content study in the FS

Trash separation and categorisation

Trash separation and categorisation

Paper

Hair / wig / braids

Plastic - soft

Menstrual products

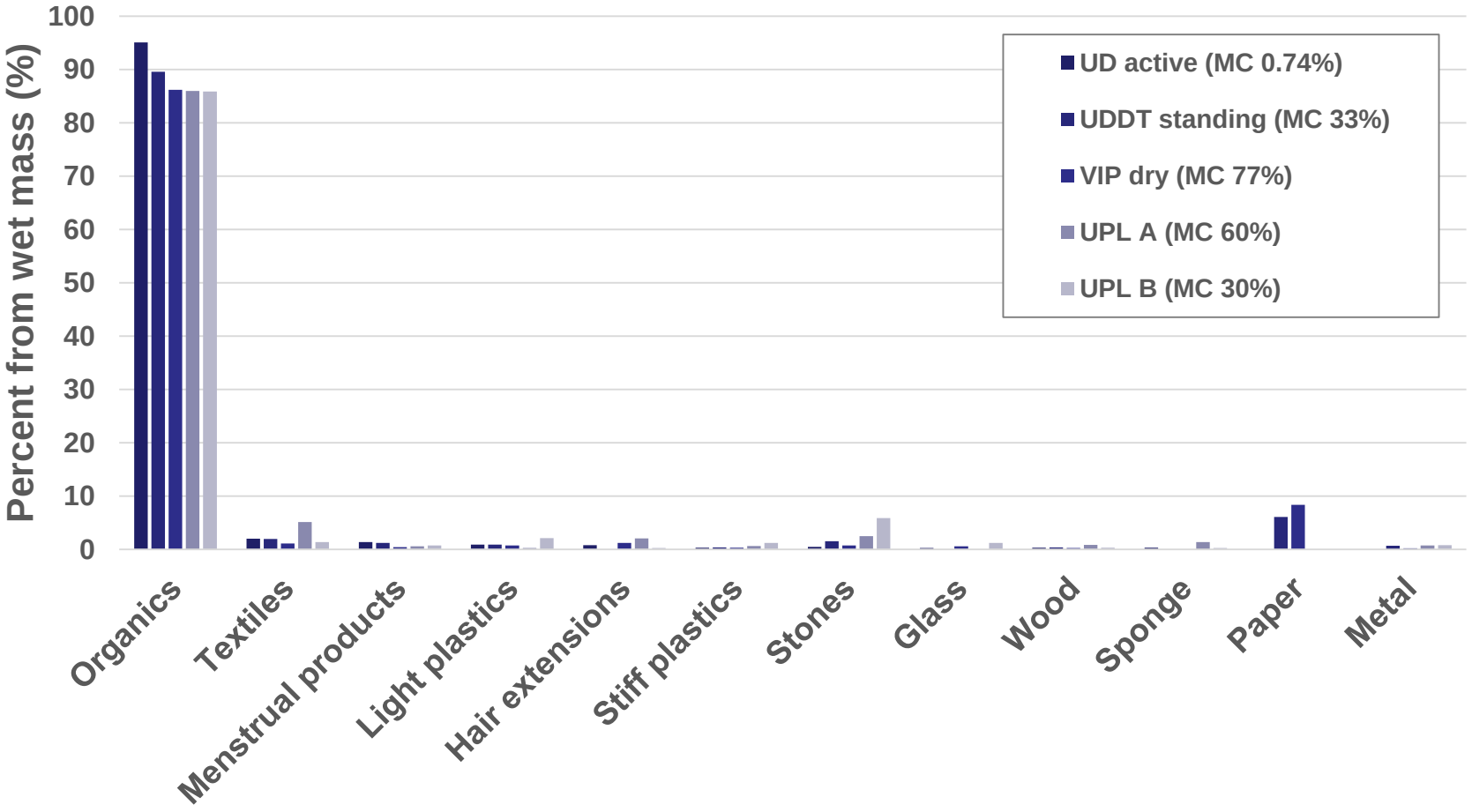
Textiles

Plastics - rigid

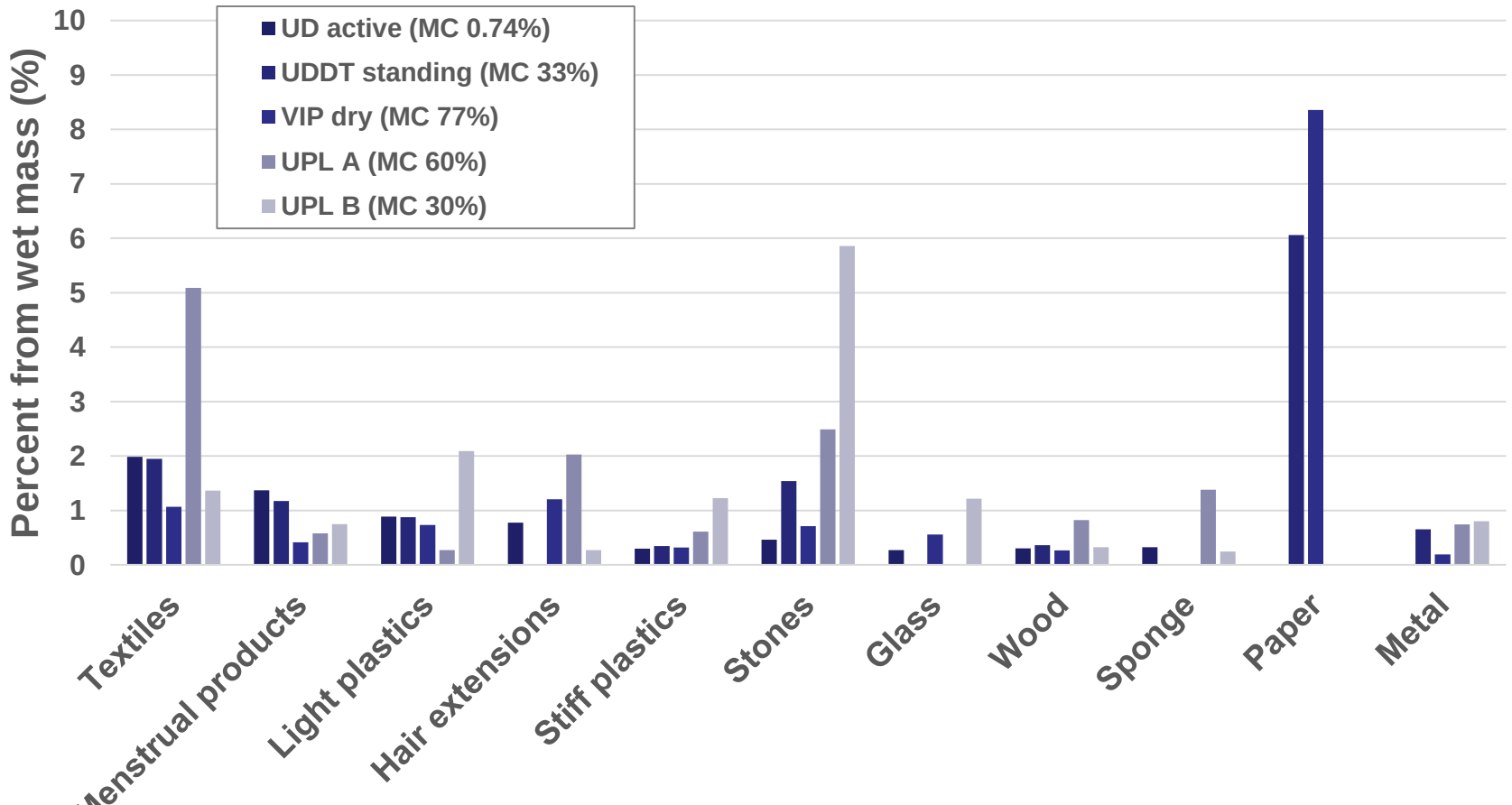
Glass

Metals

Material categories in pits from different on-site sanitation facilities



Material categories in pits from different on-site sanitation facilities



Conclusions of the study

- From the material categorisation, the “organics” category was the most prevalent (85 to 95% by wet mass)
- For VIP samples from different facilities, the average moisture content was 75 to 85%
- The moisture content of UDDT samples was lower – 61%
- The average ash content for VIPs was 0.35 to 0.55 g/g dry sample
- For standing vaults in UDDTs and aged samples from unimproved pit latrines, the ash content was higher – 0.58 to 0.66 g/g dry sample demonstrating FS stabilisation process
- The average COD was 0.60 to 0.90 gCOD/g dry sample for the most of the VIP samples
- For some UDDT and aged samples, the COD was much lower, 0.15 – 0.30 gCOD/g dry sample

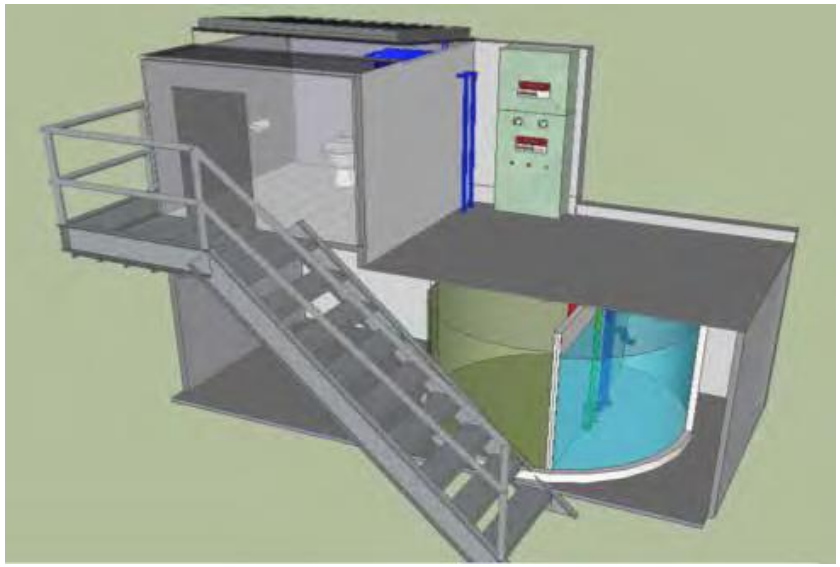
Conclusions of the study

- ✓ The average calorific value was 11 to 15 MJ/kg for the most of the analysed sanitation facilities, except for the aged stabilised samples (5 MJ/kg).
- ✓ By rheological properties, the FS demonstrates shear thinning (viscosity reduction at increasing shear stress) expected to ease the pit emptying processes
- ✓ The sludge from all sanitation facilities showed higher helminth content than the limit of <1 helminth egg/g TS set by WHO (2006)

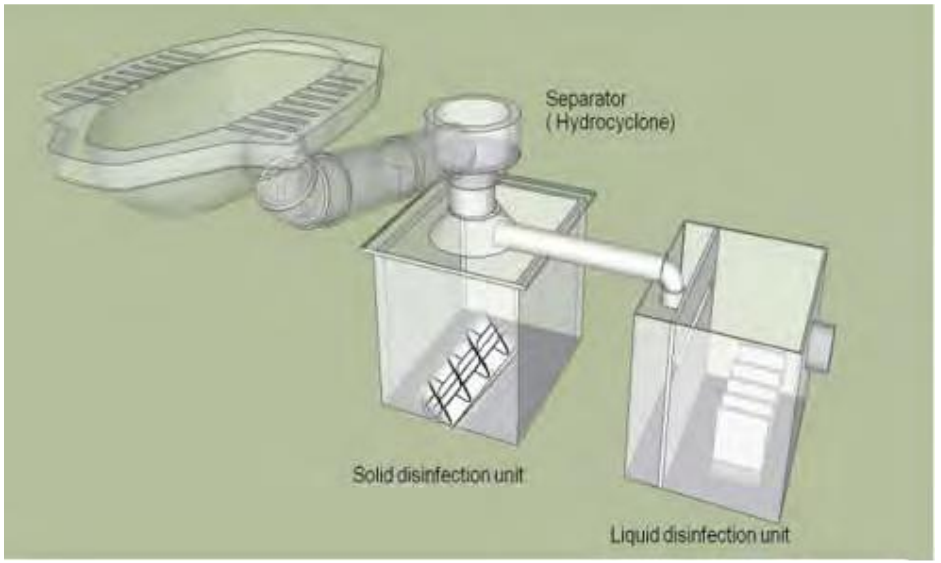
Outcomes of the study

- ✓ Development of faecal sludge sampling methods and techniques
- ✓ Development of laboratory Standard Operational Procedures for analyses on faecal sludge
- ✓ Baseline for further similar studies by other organisations in other regions
- ✓ Dissemination of crucial support information required by partner organisations, pit emptiers and designers

Asian Institute of Technology

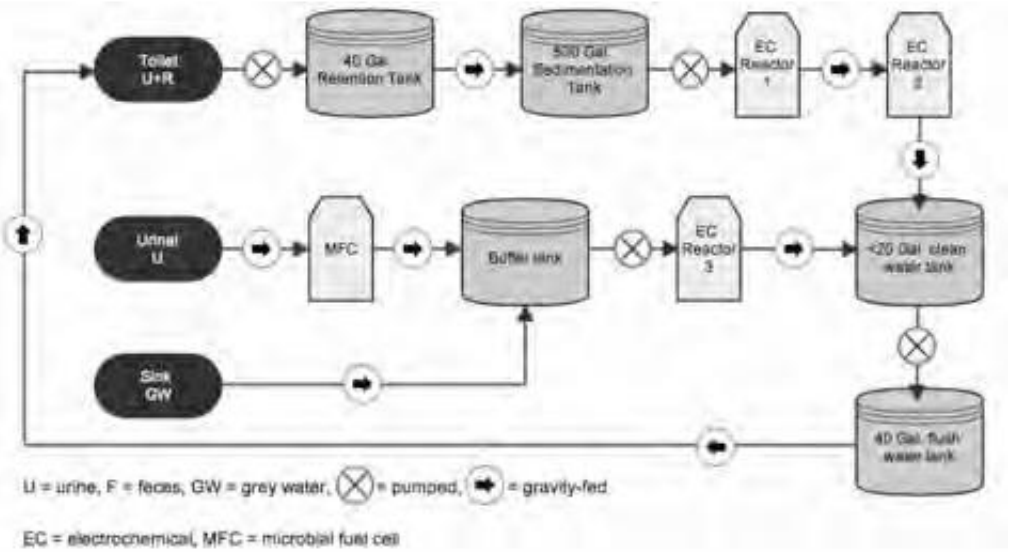


Solar septic tank



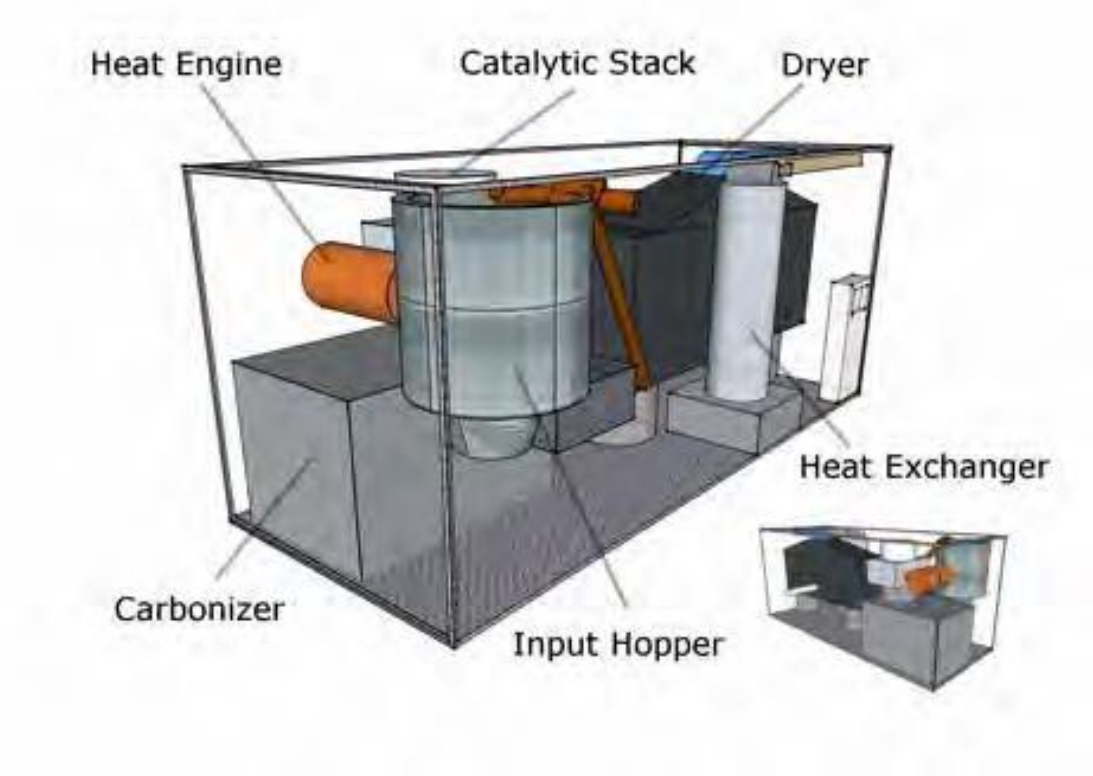
Hydrocyclone toilet

California Institute of Technology (Caltech)



Climate Foundation

Conversion of human waste into biochar using pyrolysis at community scale facility



Cranfield University

The Nano Membrane Toilet

Delft University of Technology

Sanir: Upgrading human waste with plasma-driven gasification

Duke University and the University of Missouri

Neighborhood-Scale Treatment of Sewage Sludge by Supercritical Water Oxidation

Eawag (Swiss Federal Institute of Aquatic Science and Technology), Design by EOOS

Blue Diversion toilet

FSOI Development Firms

The Fecal Sludge Omni-Ingestor (FSOI)

Janicki Industries

Omni-Processor

Loughborough University

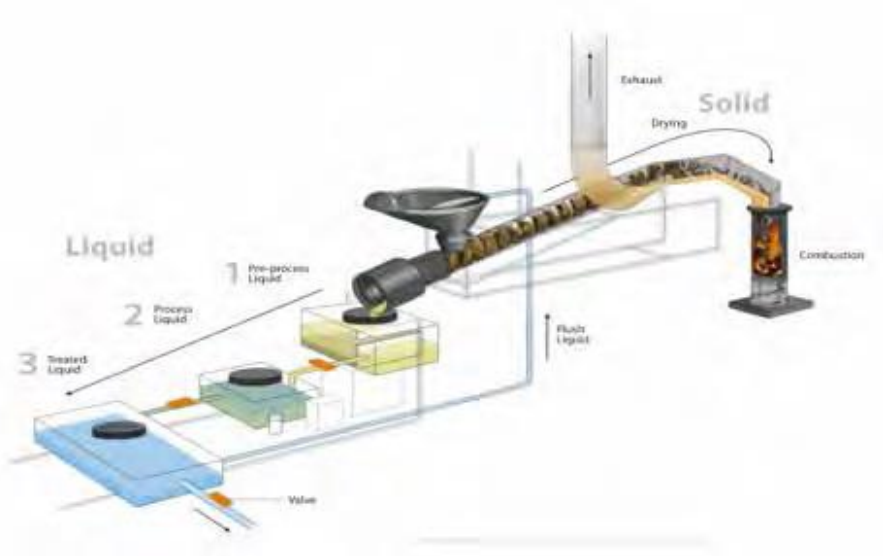
Reinventedtoilet@lboro

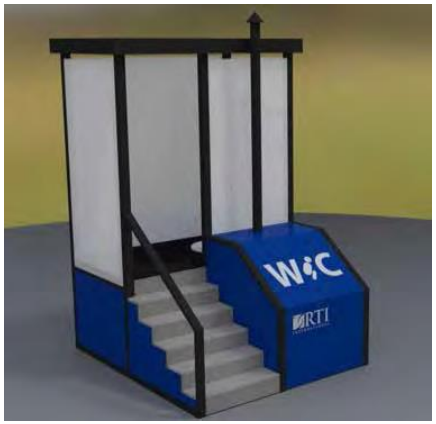
North Carolina State University

Hygienic Pit Emptying Using a Modified Auger – “The Excrevator”

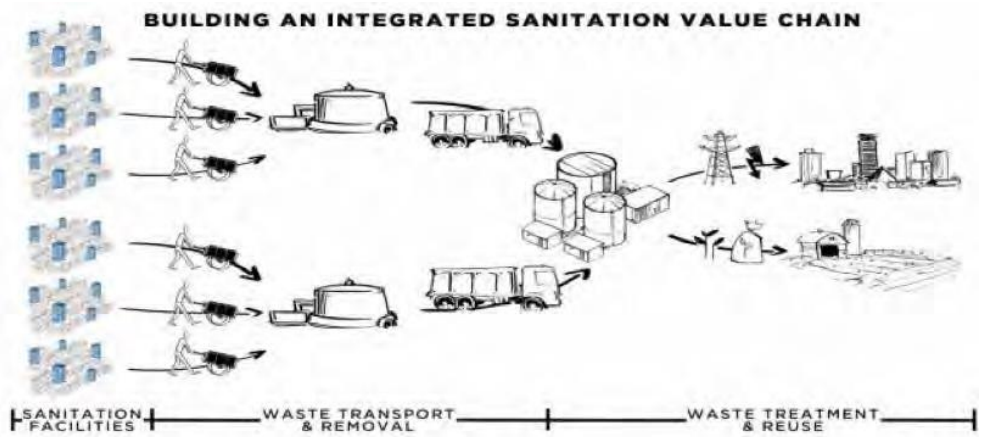
RTI International

An integrated on-site waste treatment and toilet system.





Sanergy


BUILDING AN INTEGRATED SANITATION VALUE CHAIN
SANITATION FACILITIES
WASTE TRANSPORT & REMOVAL
WASTE TREATMENT & REUSE


Fresh Life
Fresh Life
WATU WAZIMA 5
WATOTO 2


CHOO
CHOO
Fresh Life
WATU WAZIMA 5
WATOTO 2

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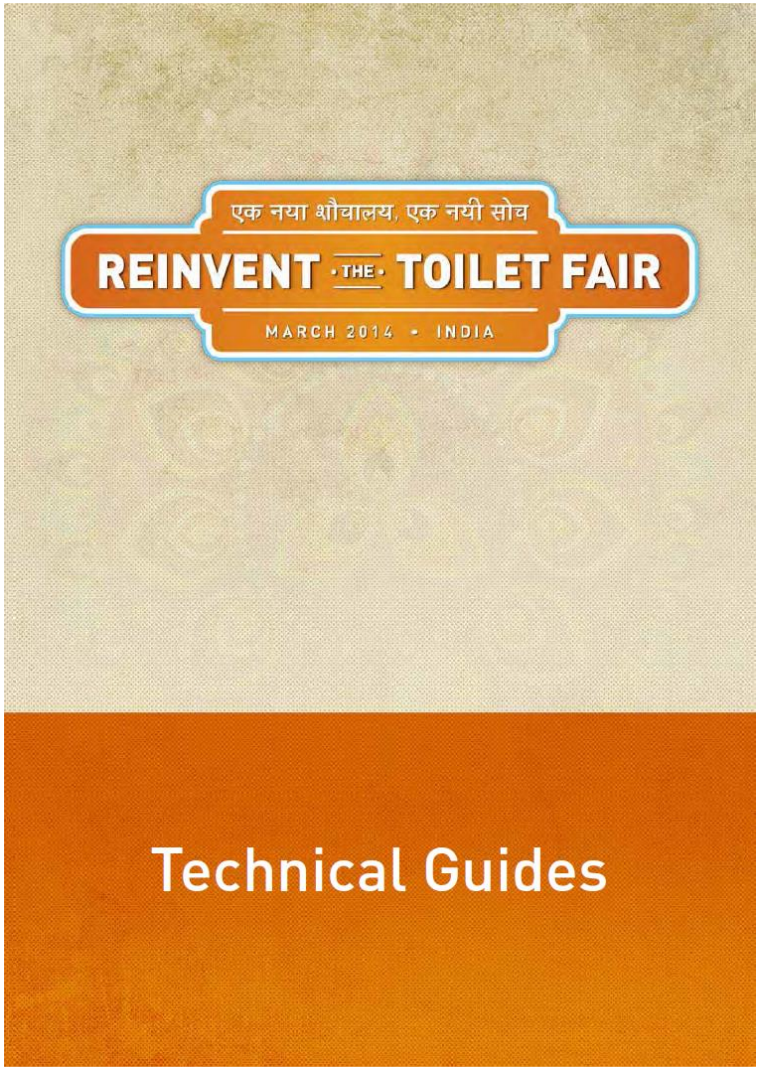

Conclusions

- ✓ Good understanding of the FS characteristics is crucial for the improved design of emptying devices, transport and processing systems for FS

- ✓ FS characteristics are a baseline for the design of innovative technologies for FS collection, transportation and processing

Conclusions

- ✓ Standard operating procedures for FS improve the data quality:
  - ➢ Consistency and reliability of the data
  - ➢ Comparability of results from different systems and regions
  - ➢ Systematic approach
  - ➢ Data base generation

Thank you!

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UNESCO-IHE
Institute for Water Education