MECHANICAL PROPERTIES OF FAECAL SLUDGE

UNIVERSITY OF KWAZULU-NATAL

BILL & MELINDA GATES foundation

Introduction

Overview

- The Bill and Melinda Gates Foundation has contracted the Pollution Research Group (PRG) at the University of KwaZulu-Natal, Durban, South Africa to carry out a study into the properties of faecal sludge from different types of on-site sanitation facilities.
- The data generated will inform the design and sizing of mechanical pit-emptying devices, transportation and processing systems for the excavated sludge, and the design of future on-site sanitation facilities.

Overview

- Characteristics of faecal sludge vary greatly between different locations and types of facilities. Faecal sludge samples from the following sanitation facilities be analysed: *wet* and *dry household ventilated improved pit (VIP) latrines*, *household urine diversion (UD) toilets*, *household unimproved pit latrines*, *community ablution block VIP latrines*, and *school VIP toilet blocks*.
- The project started in May 2012 and has a projected duration of 16 months.

Objectives of project

- Generate first hand data on faecal sludge characteristics from on-site sanitation installations;
- Establish a correlation between facility usage and sludge quantity and quality.

Types of pits

Dry VIP

Wet VIP

UD

Toilets

Dry VIP

UD

Wet VIP

Pit emptying

Pit emptying programme

Facility type	Characteristics	Usage level	Number of facilities to be sampled	Locations (Durban Metro area)
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 UD toilet		Low use	5	Mzinyathi
		High use	5	
Household unimproved pit latrine	Wet or dry	Low use	5	Cato Crest
		High use	5	
Community ablution block VIP	Dry	High use	8	Malacca Road – 8 cubicles
School VIP toilet block	Wet or dry	High use	4	To be confirmed
Totals			Approx 60	

Pit emptying – dry VIP

Pit emptying – wet VIP

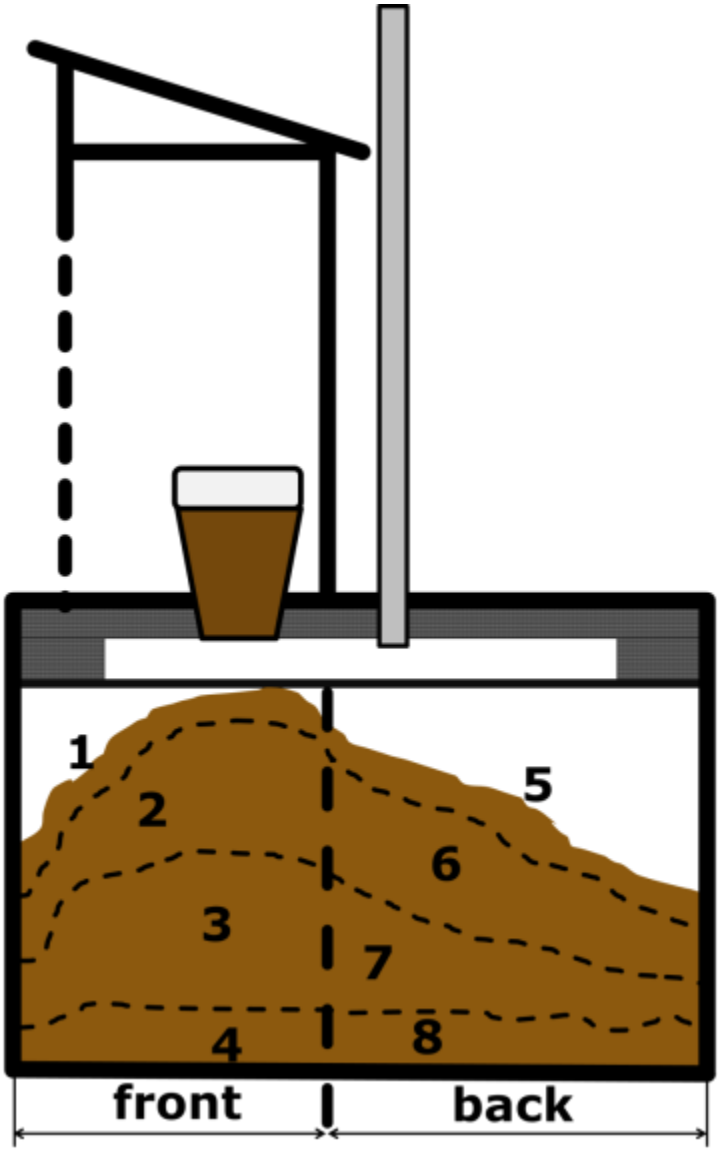
Pit emptying – wet VIP

Indication of the water level depth

Pit emptying – UD toilet

Analytical samples selection

Selection of 1L analytical samples at different depth levels of pit



Selection of samples for sorting by material type

Experimental programme

Property / analytical test	Equipment / method	Status
Rheology properties	Rheometer + building materials attachment	Delivered, start Aug 2012
Density (solids, dry, bulk)	Mass balance & volume measurement	Commencing; need to purchase additional equipment
Particle size distribution (>5mm; <5mm particle size)	Particle size analyser; Microscope	Commencing
Sludge penetration resistance & moisture content (in-situ and lab)	Penetrometer with moisture analyser	On order, start Sept 2012
Permeability; Pore water pressure	Rowe cell	To be ordered
Drying curves	Drying rig	On order, start Sept 2012
Calorific value	Calorimeter	On order, start Sept 2012
Osmotic pressure	Osmometer	On order, start Oct 2012
Thermal conductivity	Thermal conductivity analyser	Commencing
Specific heat	Thermal conductivity analyser	On order, start Sept 2012
Total dry solids	Oven 105ºC	On going
Total volatile solids	Furnace - 550ºC	On going
Total suspended solids , fixed suspended solids	Filter, dry	On going
COD total	Lab	On going
pH	pH probe	On going
Ammonia	Distillation	On going
TKN (Total Kjeldahl Nitrogen)	Digestion and distillation	On going
K (Potassium)	Lab - external	Commencing
Total phosphate	Lab - external	Commencing
Orthophosphate	Lab - external	Commencing
Ascaris content	Lab - external	Commencing

Lab equipment in use

Thermal conductivity properties

Thermal Conductivity Analyzer (Model:TCI-2-A)

Rheology properties

Reometer (Model: MCR 15)

Total and Volatile Solids

Oven Gallenkamp Hotbox

Dessicator (Model: 40l)

Fine Balance (Mettler AE 160)

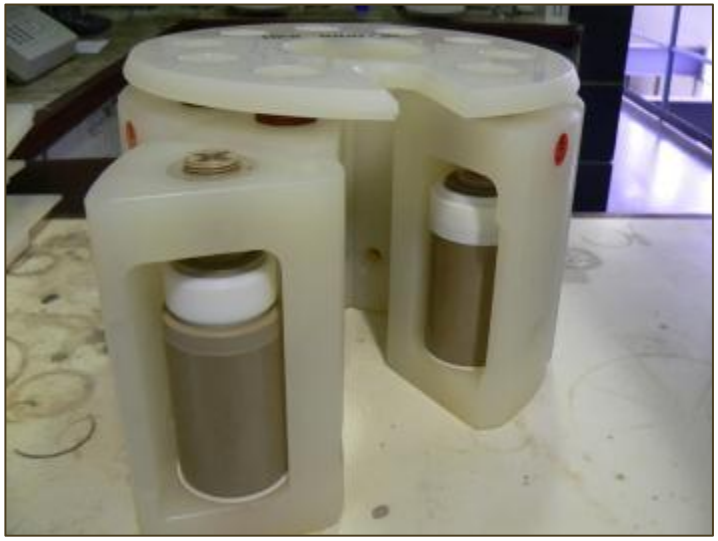
Furnace

Amonia and TKN

Distillation Unit (Model: UDK 127)

Heating Digester (Model: DK 20)

Chemical Oxygen Demand



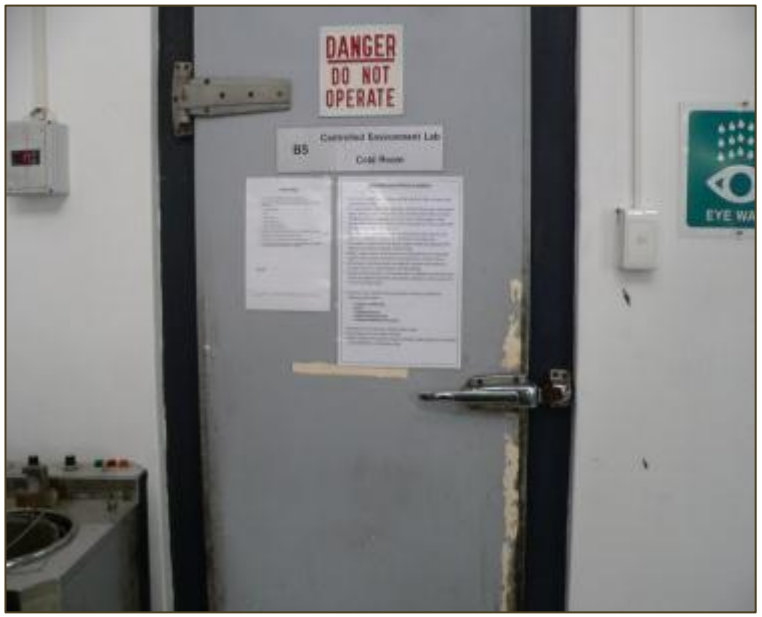
High Performance Microwave Digestion System (ETOS One)

Wet sieving rig

Lab space and facilities

Allocated lab space for analyses and disposal of faecal sludge

Cold room for storage of faecal sludge samples



Sorting of sludge samples

Preparation

Sorting

Material categories

Paper

Hair / wig / braids

Plastic - light

Feminine hygiene products

Material categories

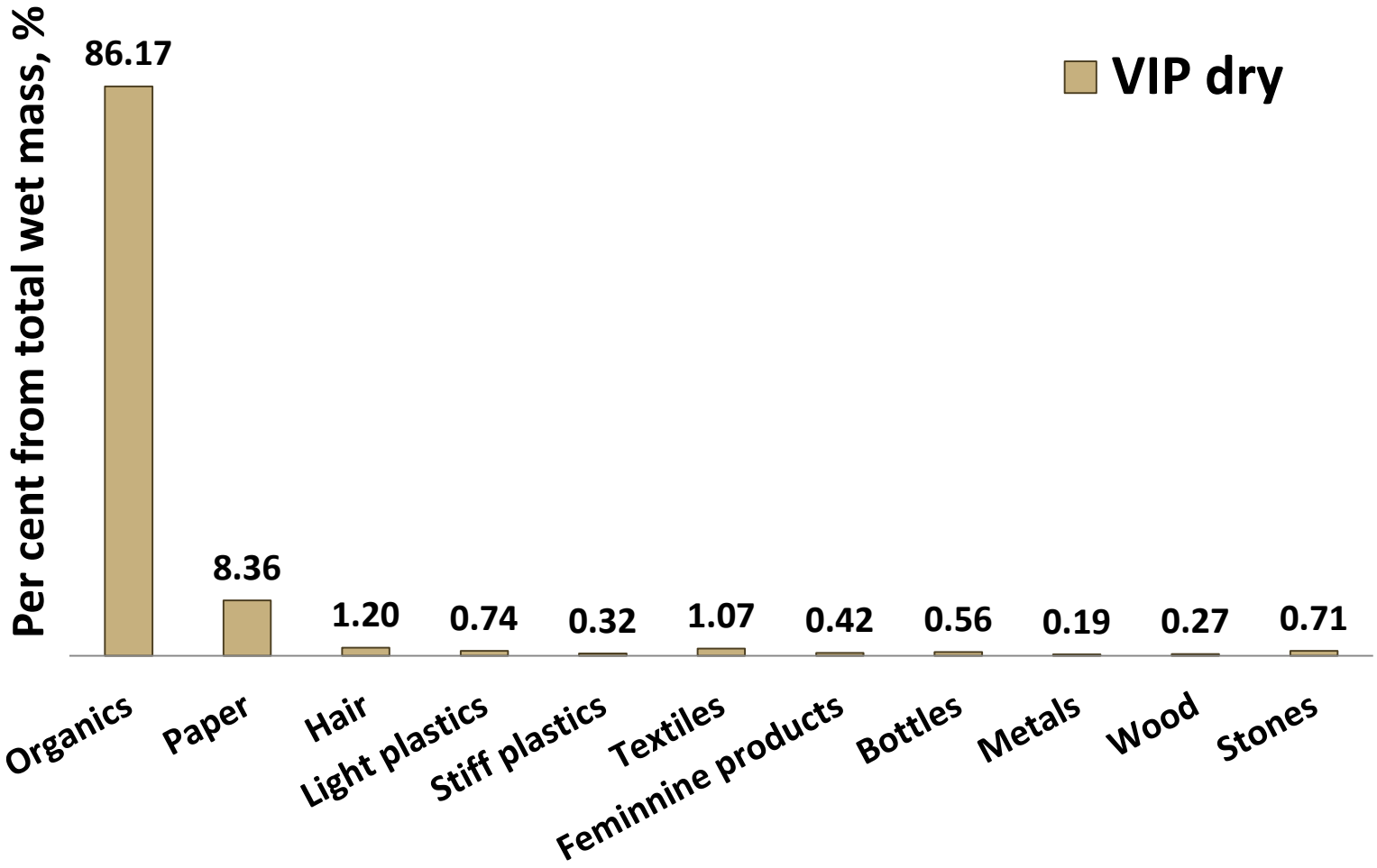
Textiles

Plastics - rigid

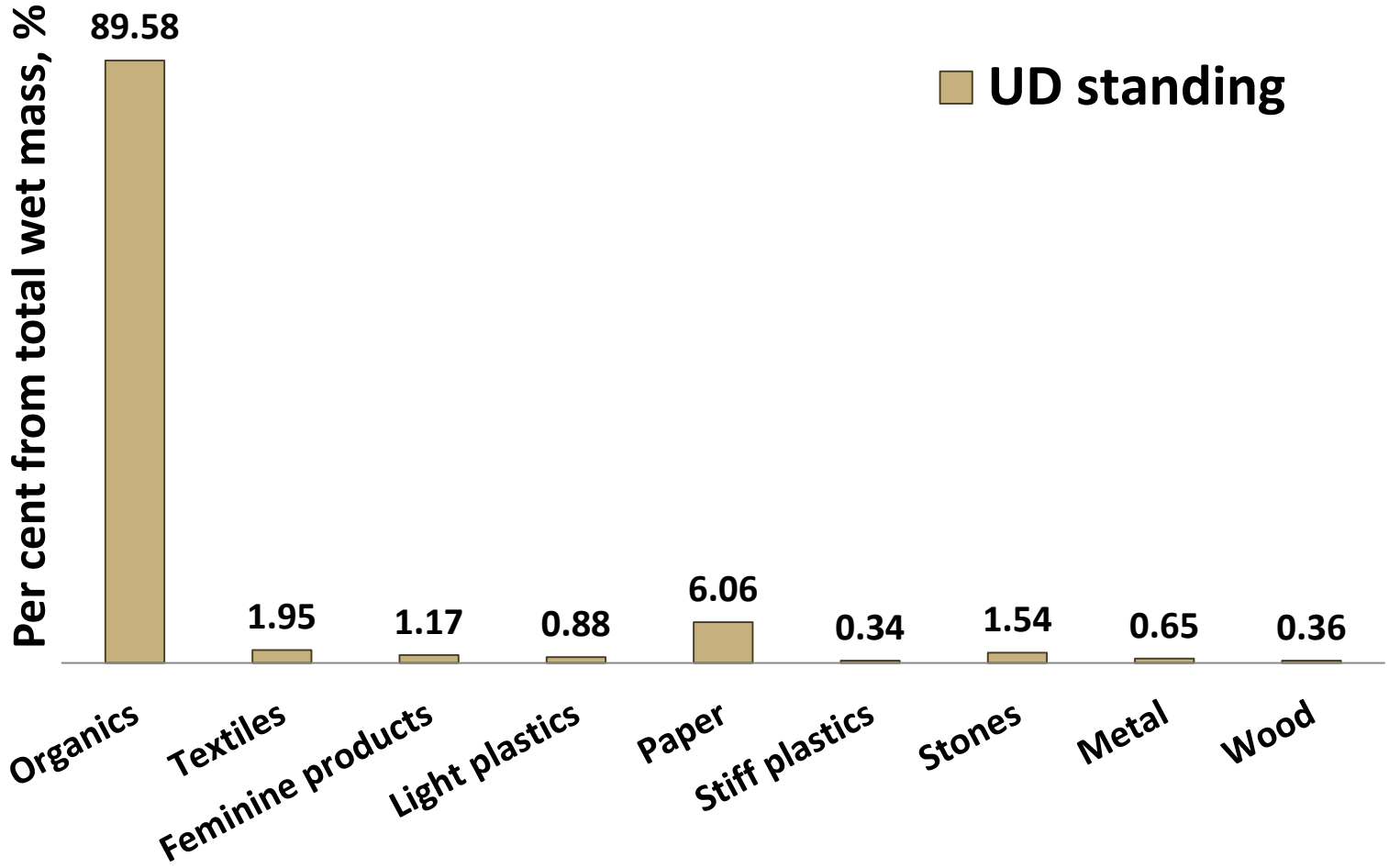
Glass

Metals

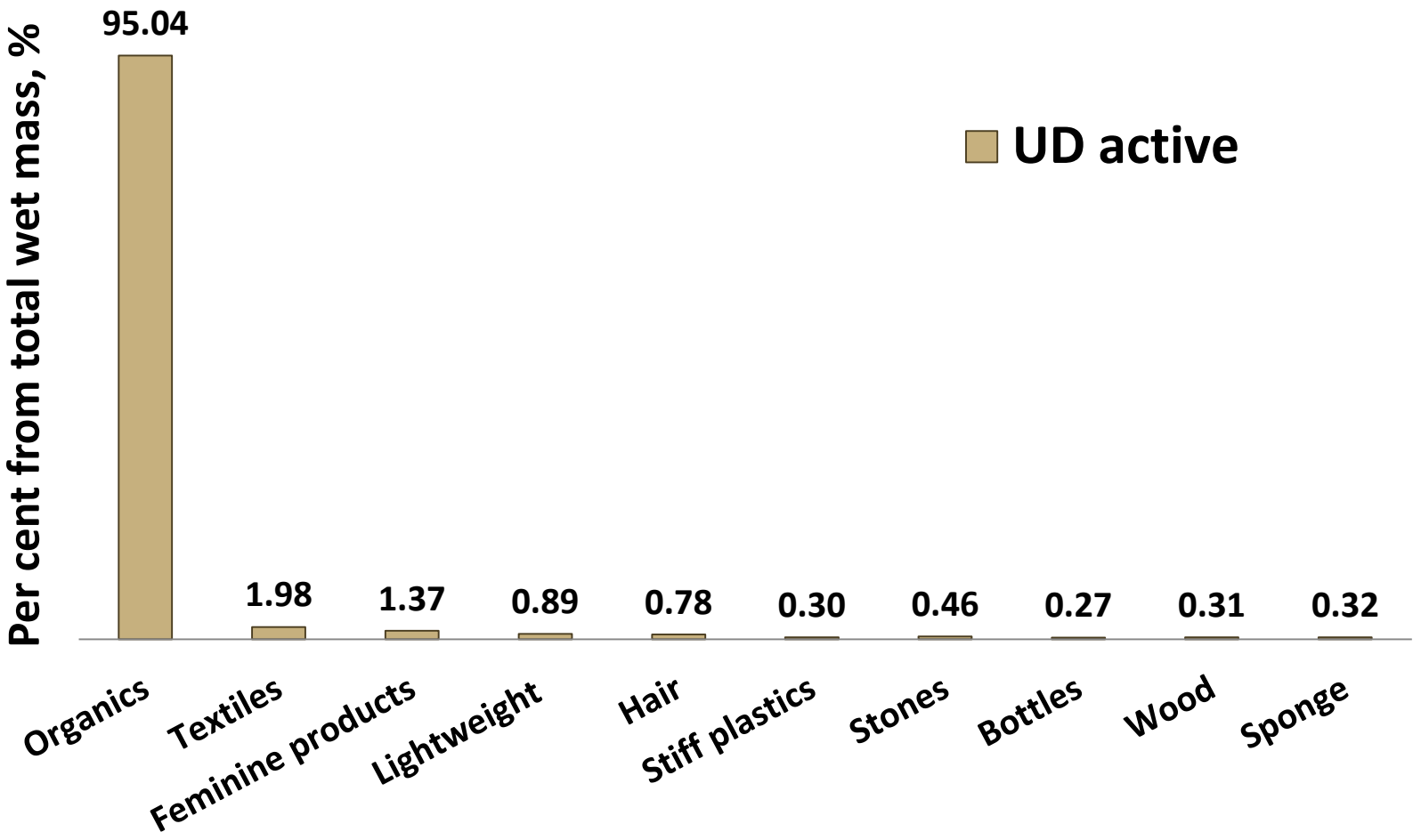
Material type distribution



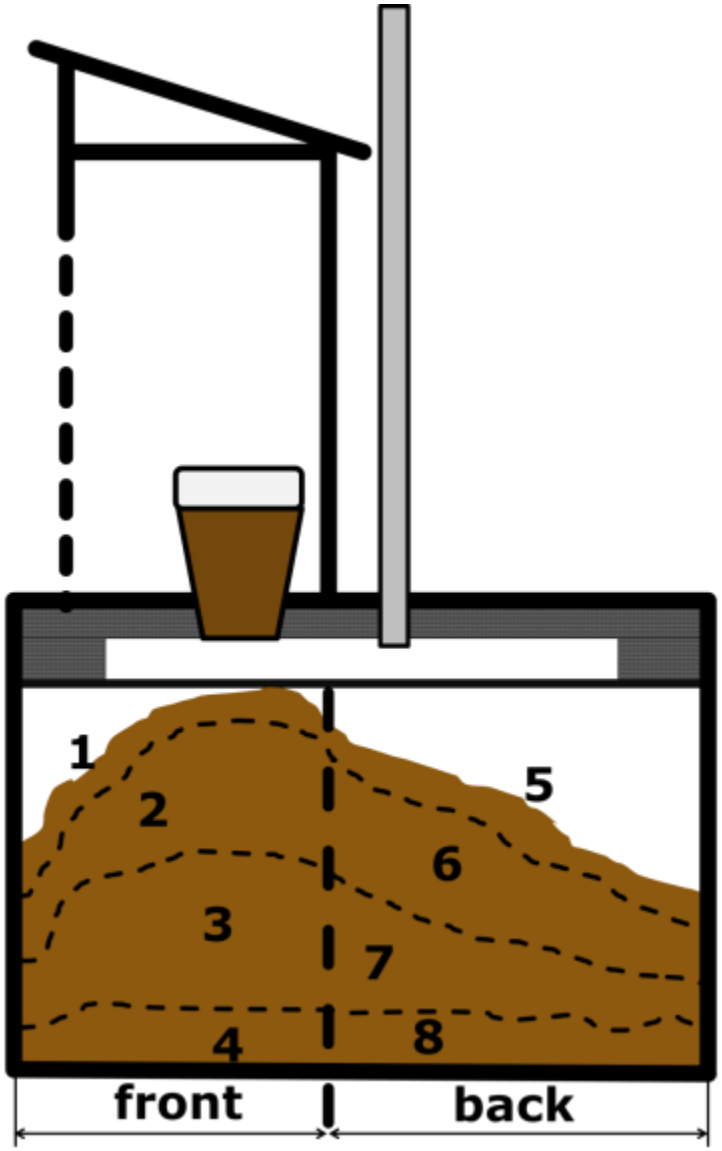
Material type distribution



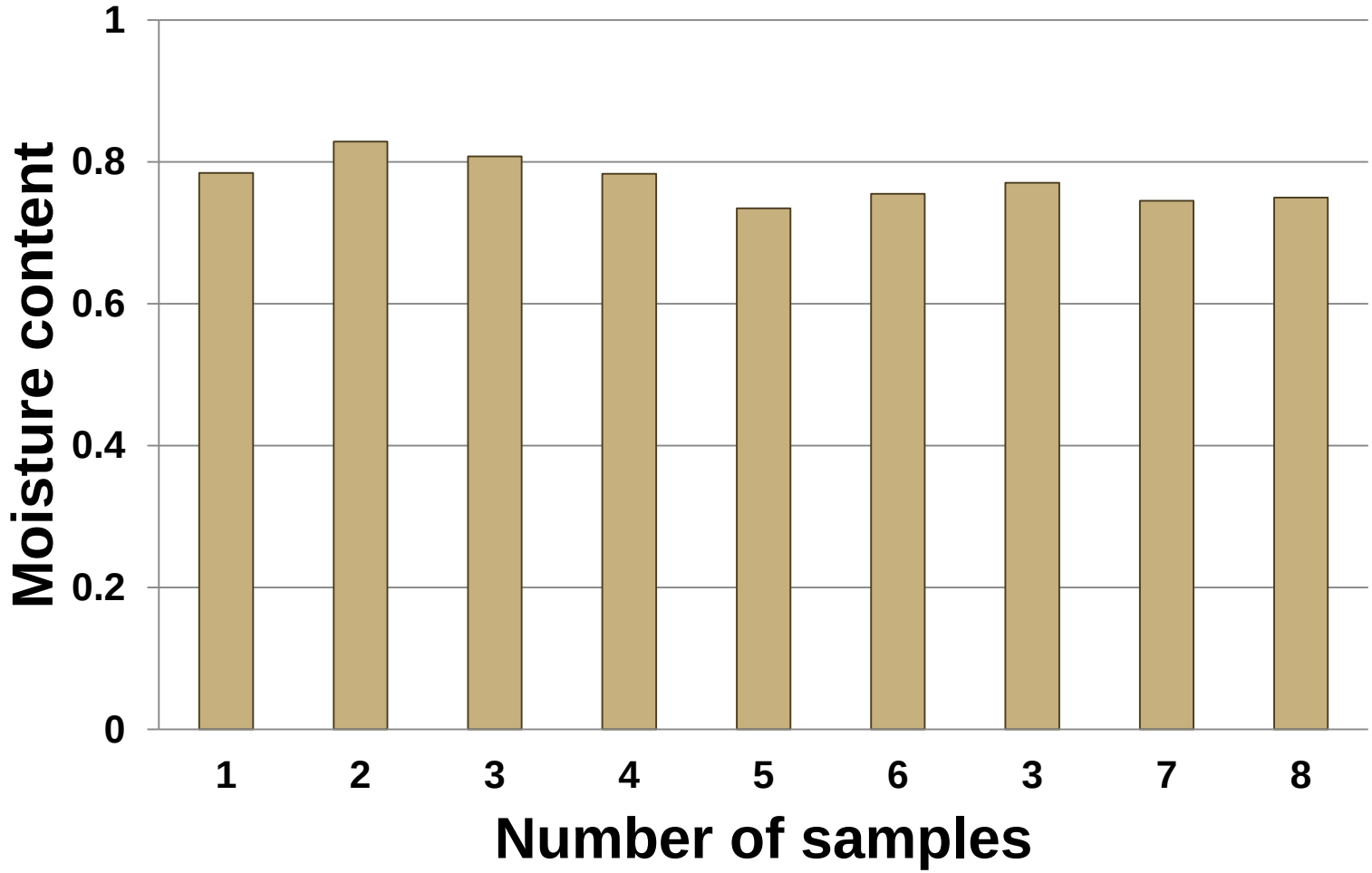
Material type distribution



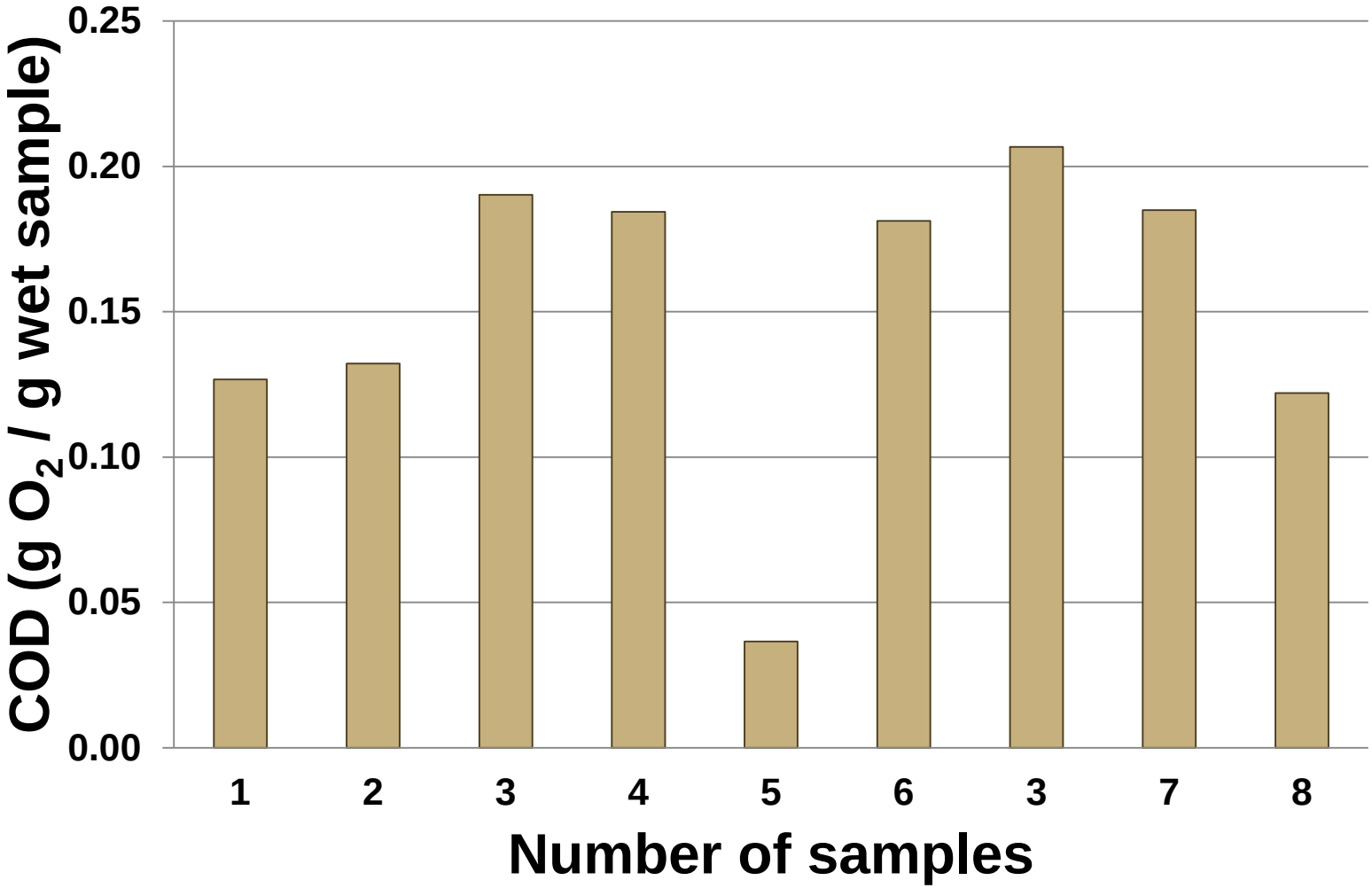
Results from chemical analyses up to date


1
2
3
4
5
6
7
8
front
back

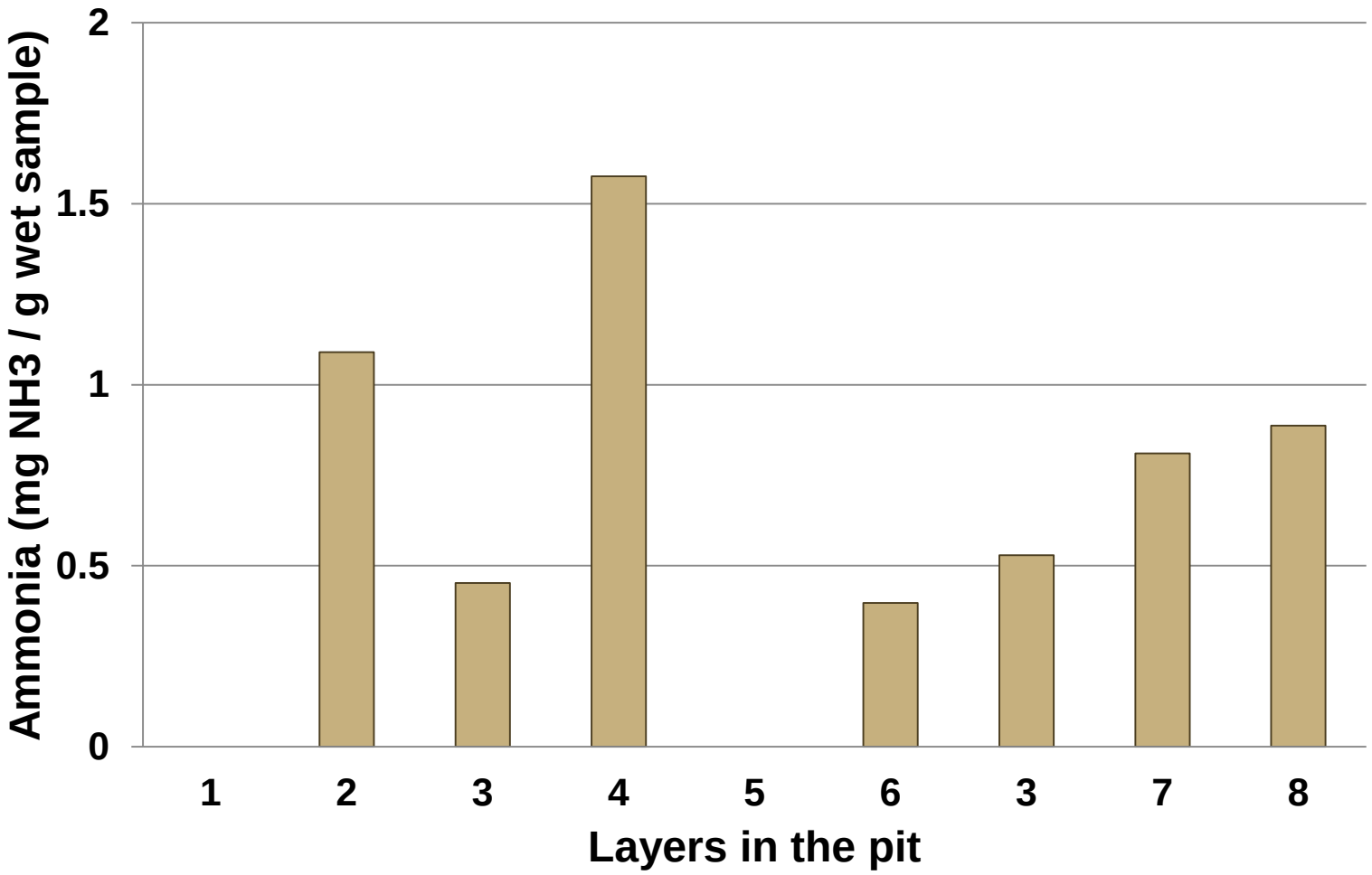
Dry VIP 1



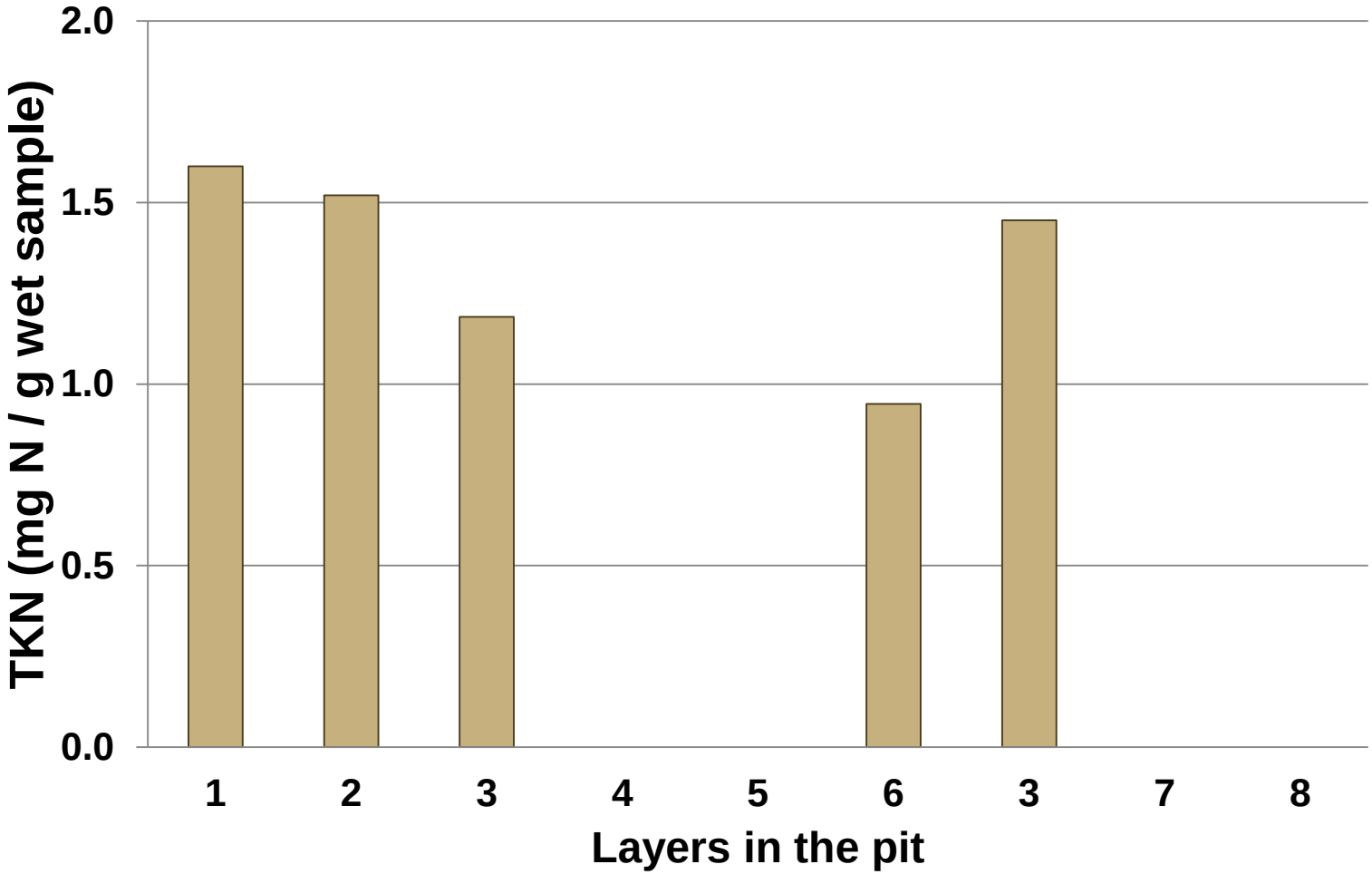
Dry VIP 1


0.25
0.20
0.15
0.10
0.05
0.00
COD (g O_2 / g wet sample)
1
2
3
4
5
6
3
7
8
Number of samples

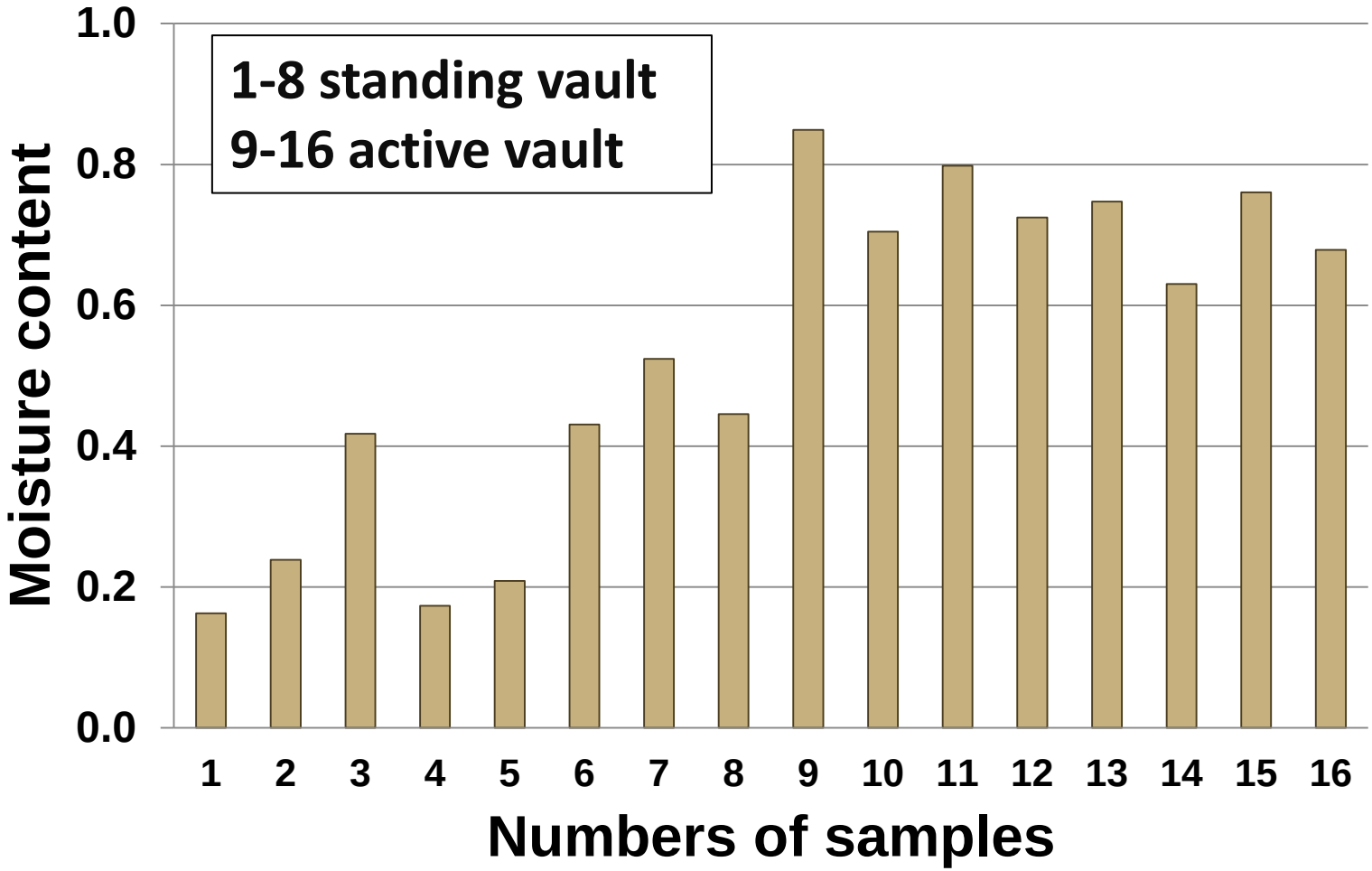
Dry VIP 1


Ammonia (mg NH3 / g wet sample)
2
1.5
1
0.5
0
1
2
3
4
5
6
3
7
8
Layers in the pit

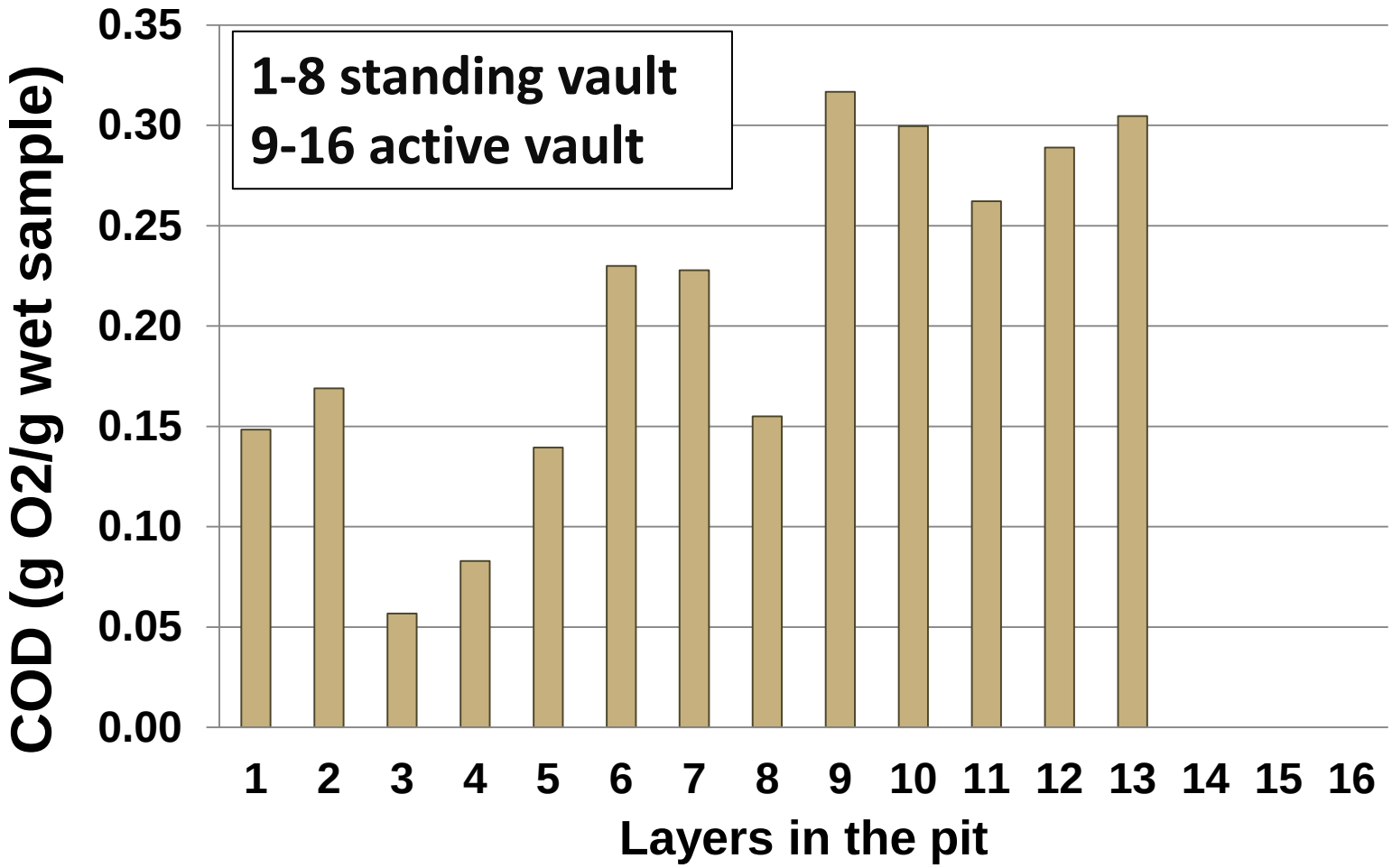
Dry VIP 1



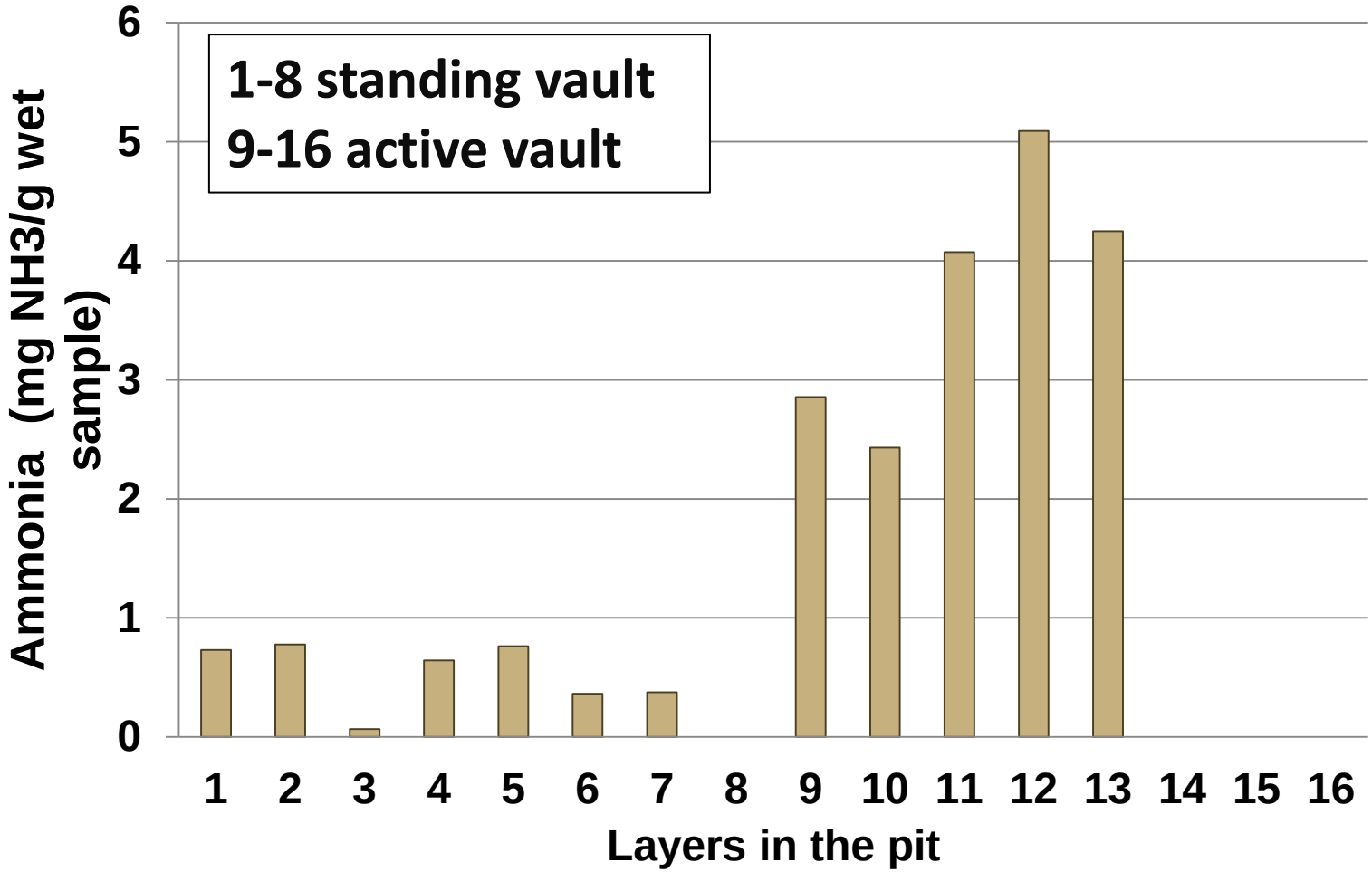
UD 1


1-8 standing vault
9-16 active vault
Moisture content
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Numbers of samples

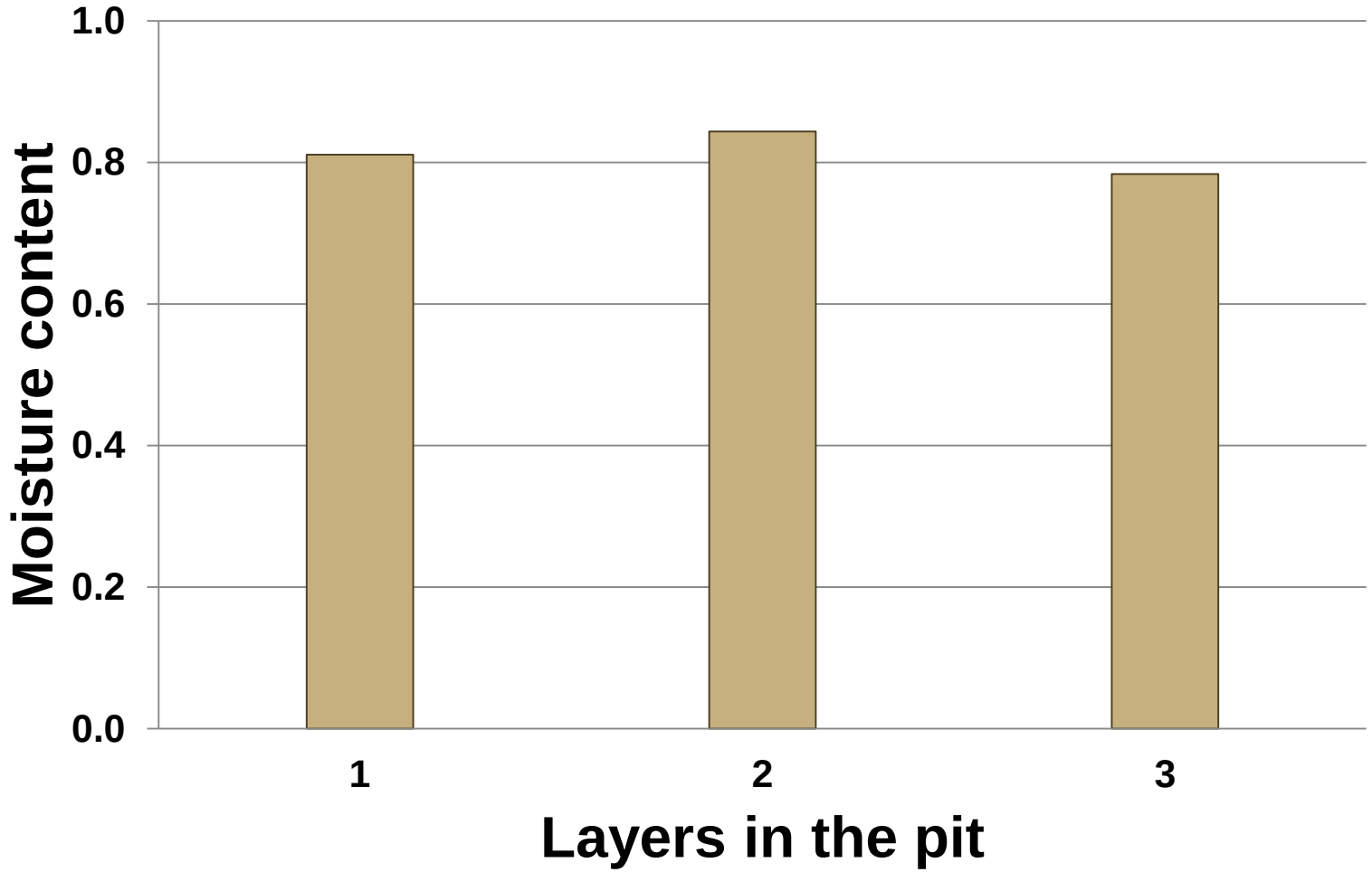
UD 1


1-8 standing vault
9-16 active vault
COD (g O2/g wet sample)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Layers in the pit

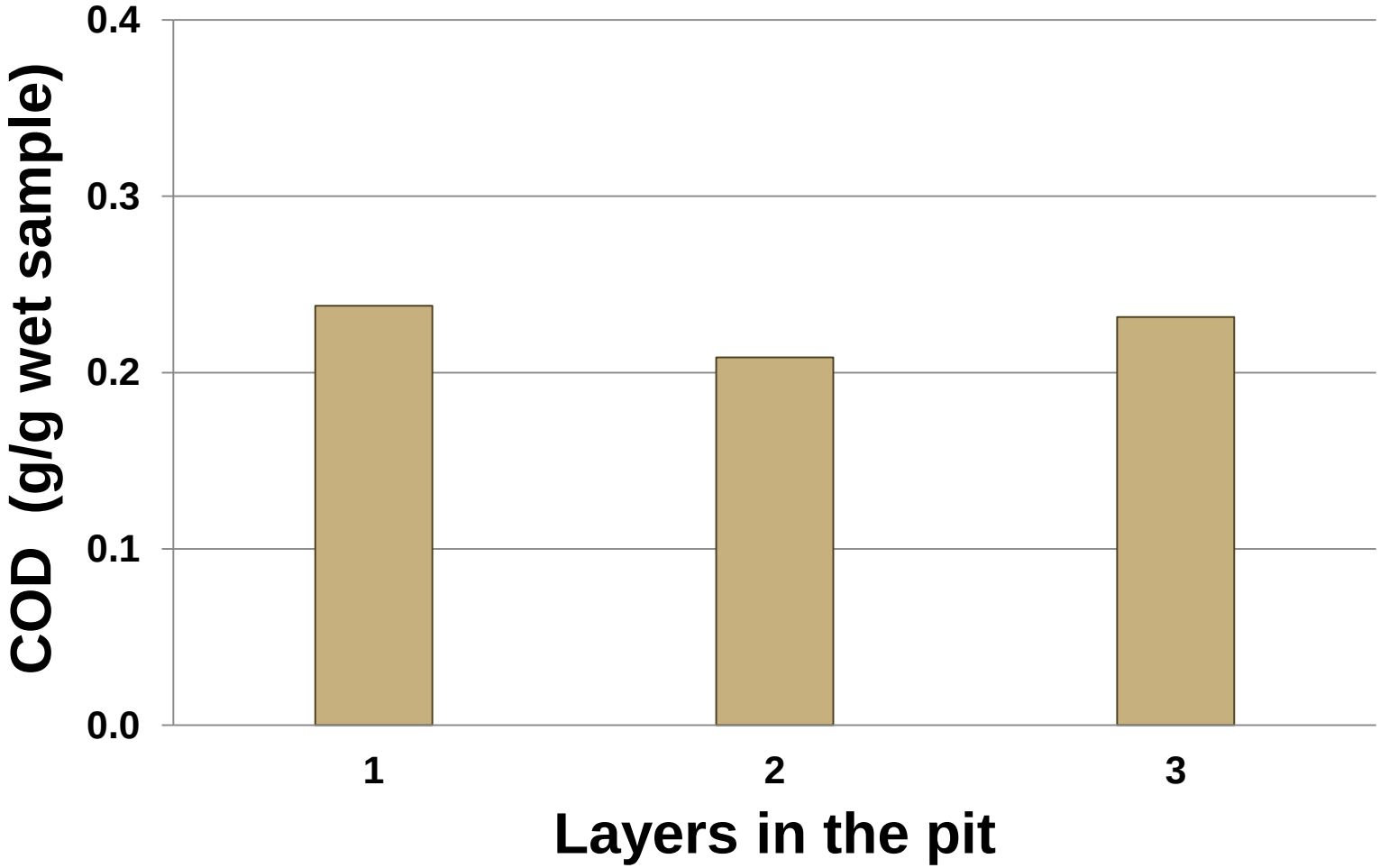
UD 1


1-8 standing vault
9-16 active vault
Ammonia (mg NH3/g wet sample)
0
1
2
3
4
5
6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Layers in the pit

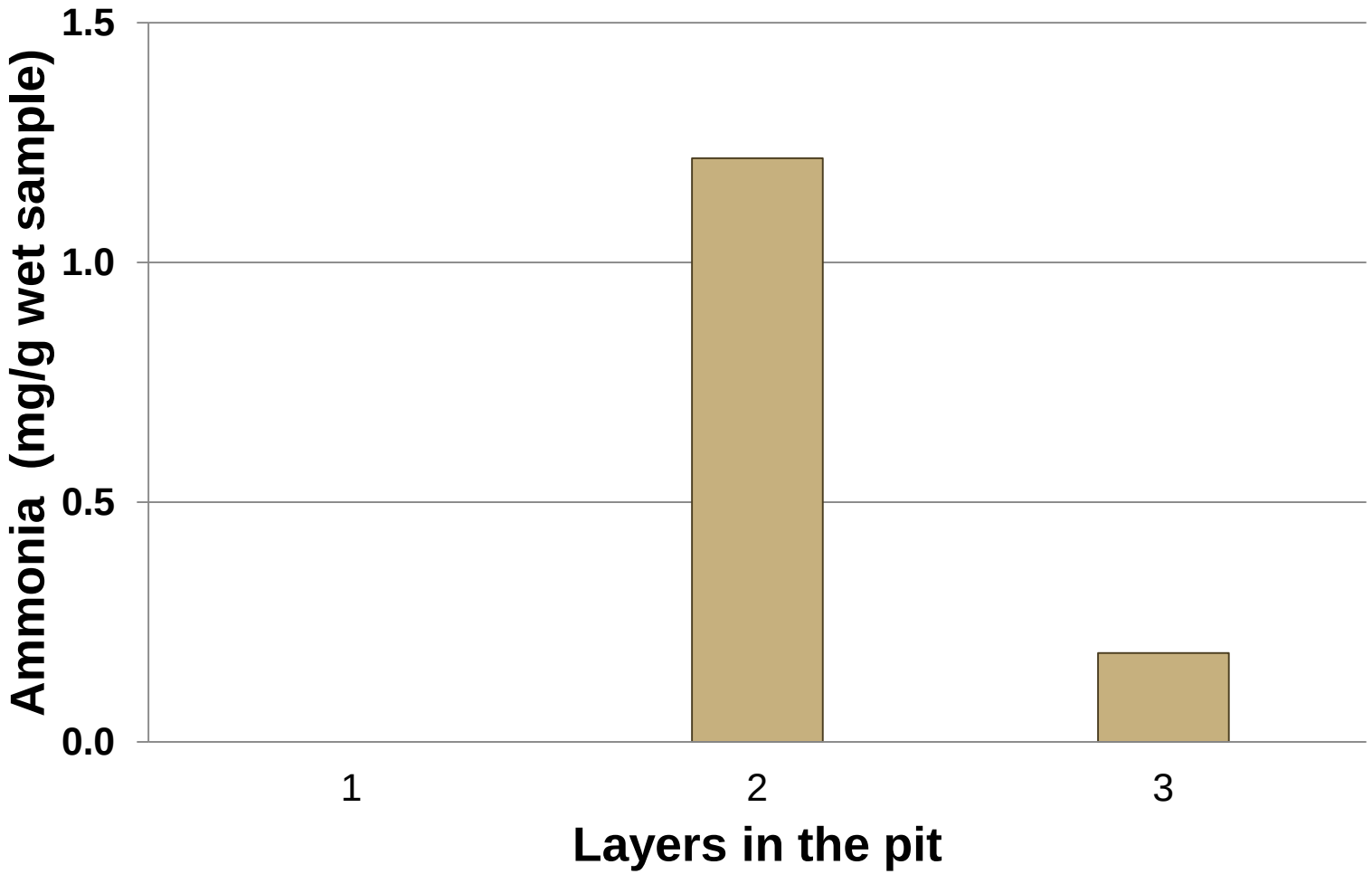
Wet VIP 1



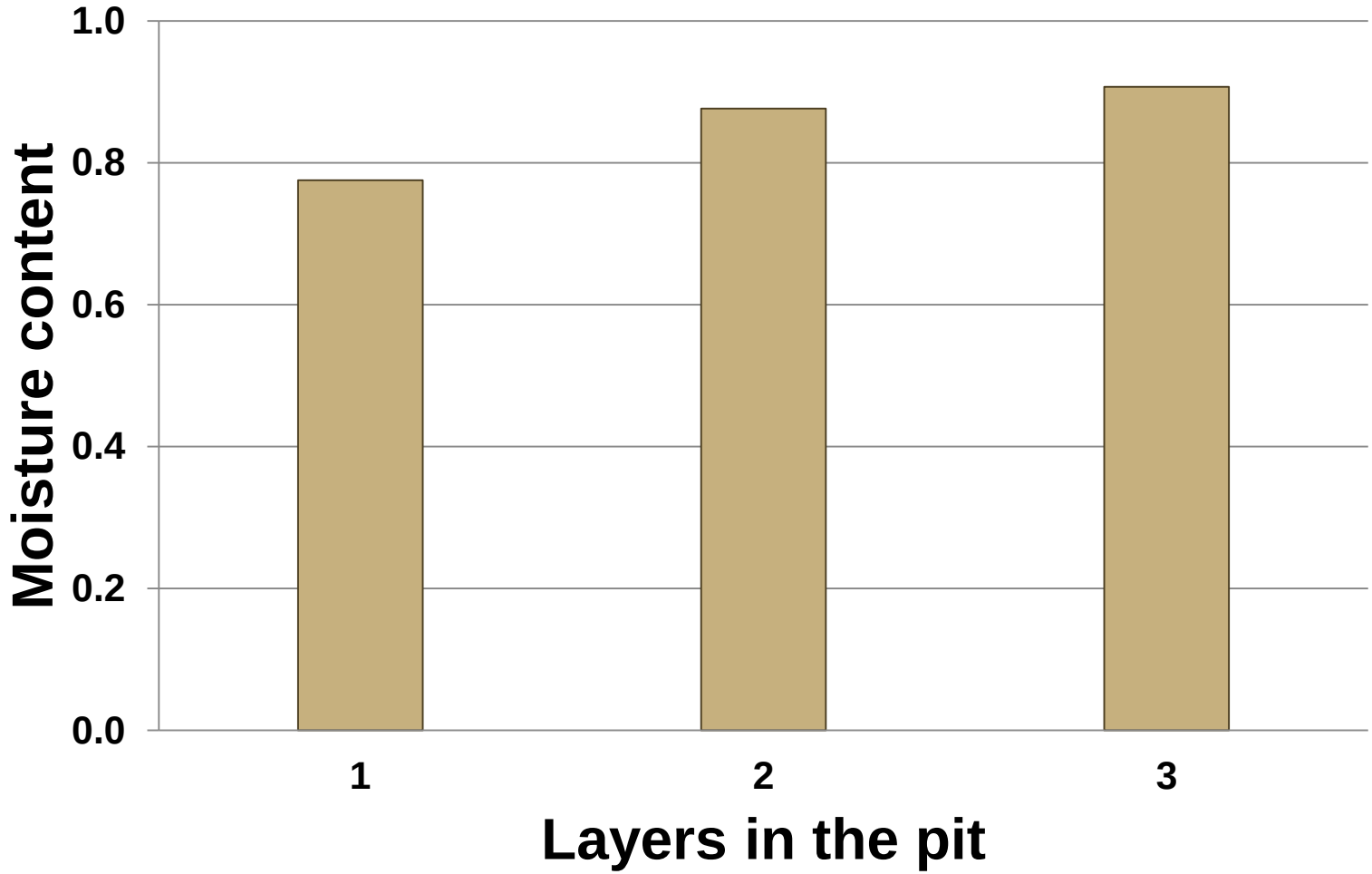
Wet VIP 1



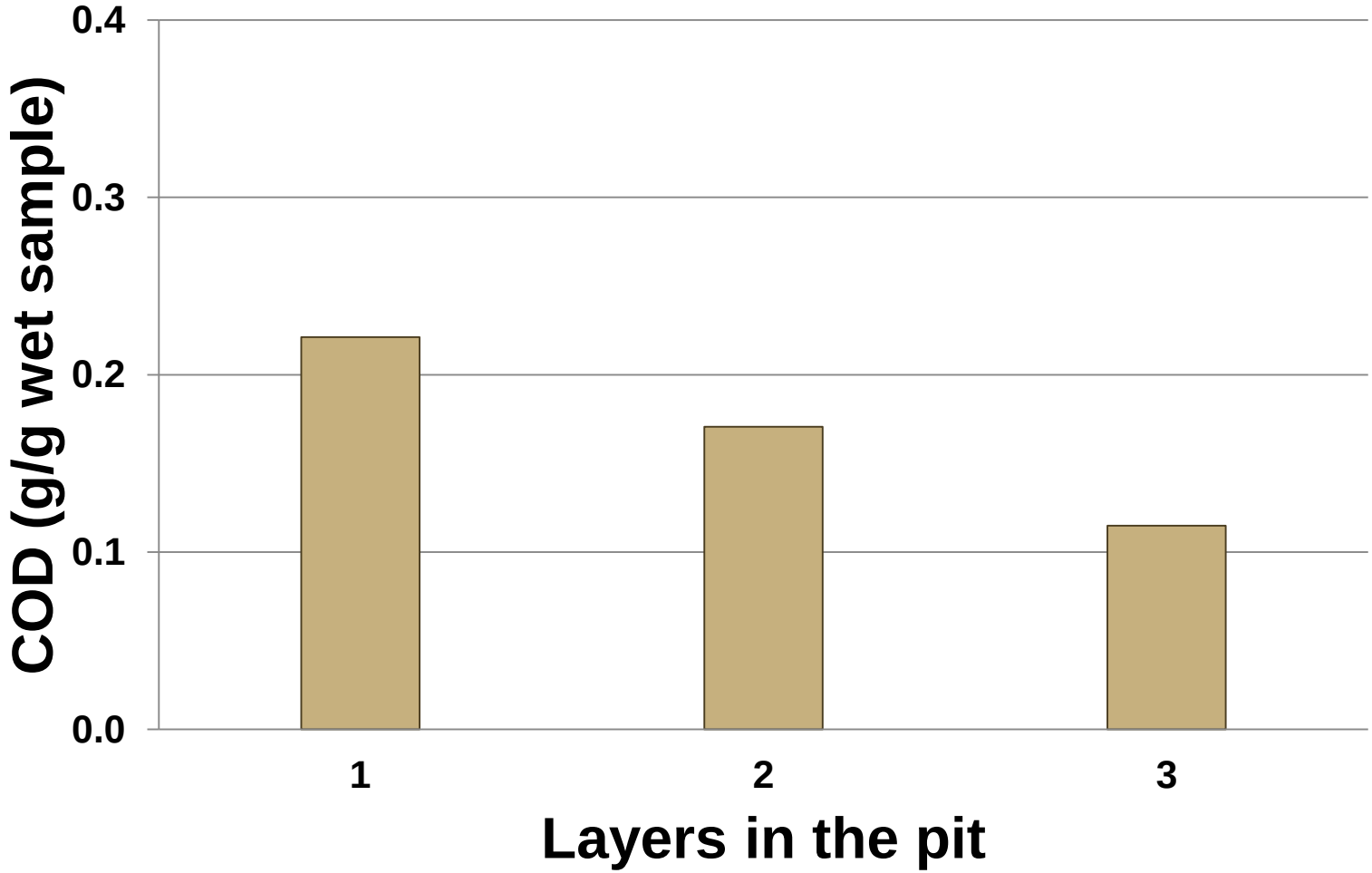
Wet VIP 1



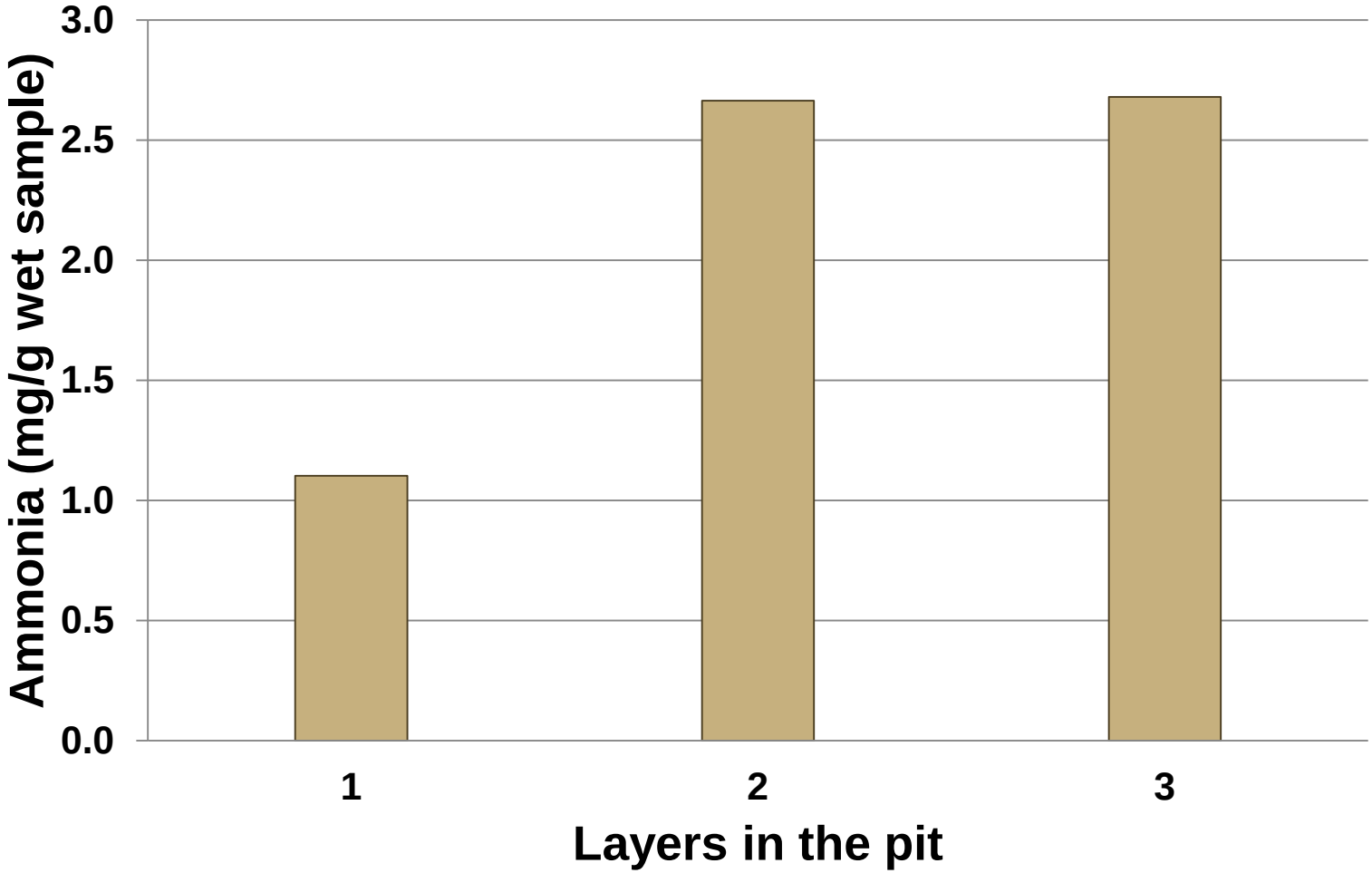
Wet VIP 2



Wet VIP 2



Wet VIP 2


3.0
2.5
2.0
1.5
1.0
0.5
0.0
Ammonia (mg/g wet sample)
1
2
3
Layers in the pit

Project team

Chris Buckley – PI

Tina Velkushanova – Project leader

Lungi Zuma – MScEng Research student

Patrick Adadzi and Chika Nwaneri – laboratory/field research assistants

Fukamela Building and Maintenance – pit emptying contractor

Please contact us for further information!

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