Pit latrine fill; key lessons learnt

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Objectives

- To analyse pit latrine contents for the identification of major targets for accelerated decomposition
- to identify the influence of pit design, pit usage, environmental conditions and location on decomposition rates and pit lifetime

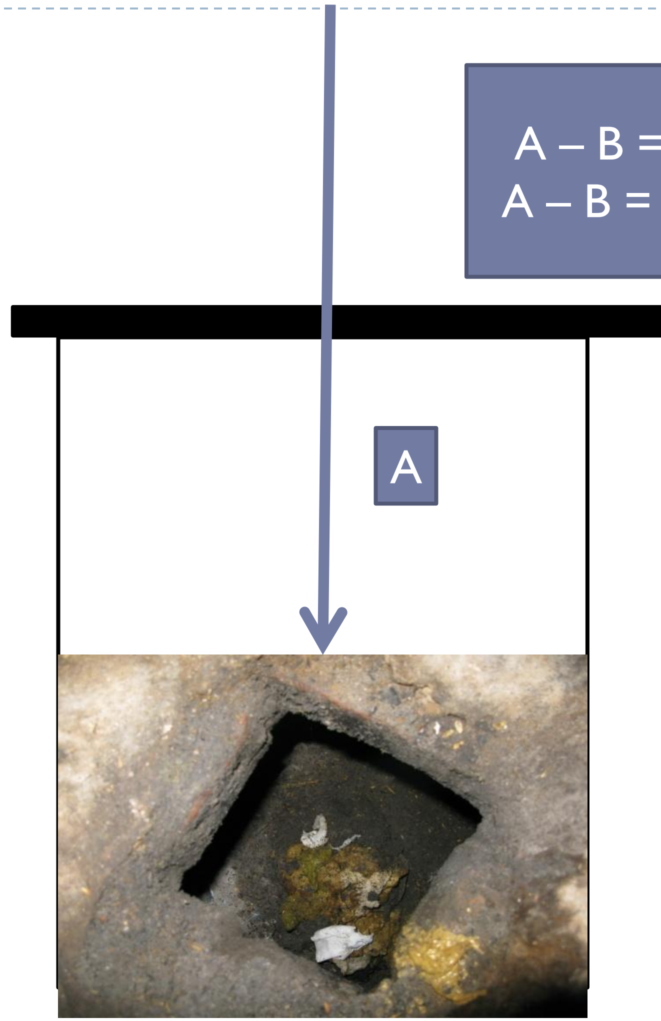
Summary

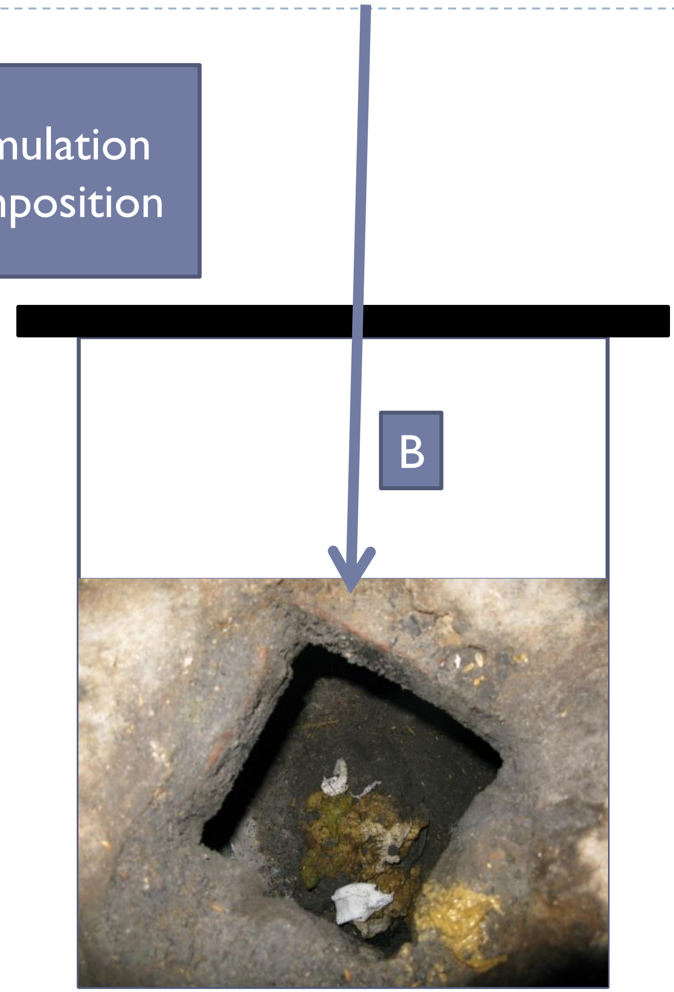
- Cross-sectional survey (35 latrines)
  - Design+Management
  - Chemical
  - Physical
  - Biodegradation
  - Microbiology
- Longitudinal survey (80 latrines)
  - Design+Management
  - Use/fill-up -> Performance
  - Chemical
  - Physical
  - Biodegradation
  - Microbiology
  - Source material information + Diet
  - Climate
  - Drainage

Latrine fill-up (1)

Fill-up (2)

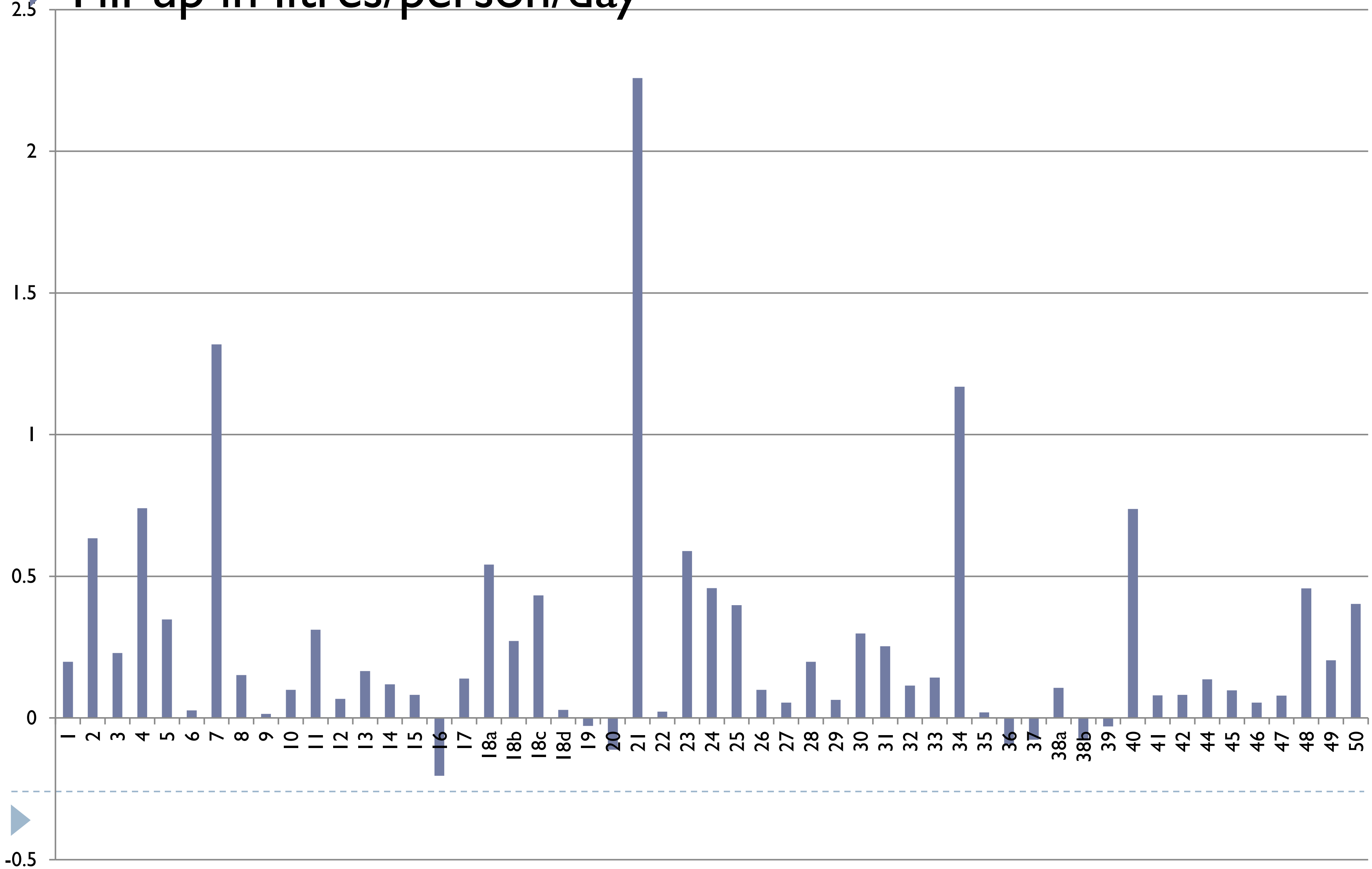
A – B = + = Accumulation
A – B = - = Decomposition

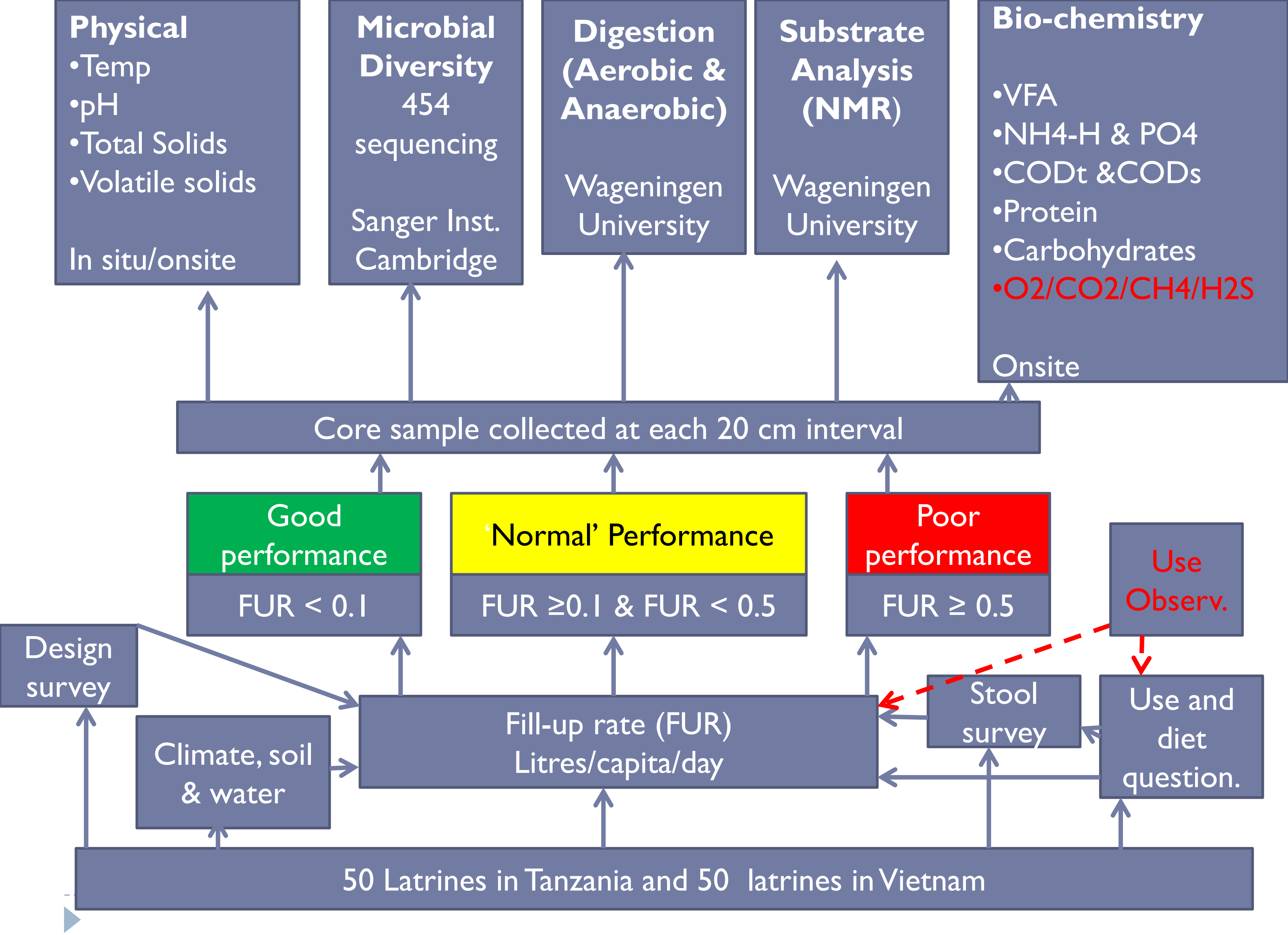




Fill-up (3)

- Fill-up in litres/person/day





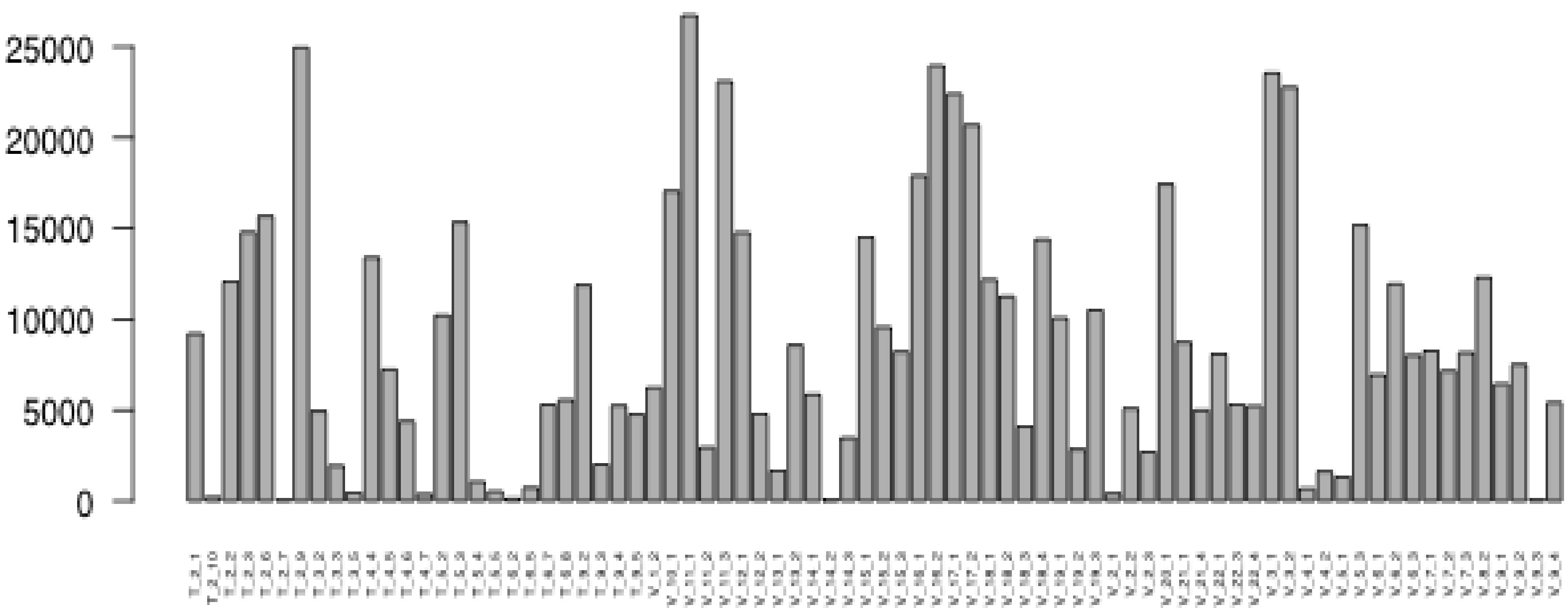
Physical
•Temp
•pH
•Total Solids
•Volatile solids
In situ/onsite
Microbial Diversity
454 sequencing
Sanger Inst. Cambridge
Digestion (Aerobic & Anaerobic)
Wageningen University
Substrate Analysis (NMR)
Wageningen University
Bio-chemistry
•VFA
•NH4-H & PO4
•CODt &CODs
•Protein
•Carbohydrates
•O2/CO2/CH4/H2S
Onsite
Core sample collected at each 20 cm interval
Good performance
FUR < 0.1
'Normal' Performance
FUR ≥0.1 & FUR < 0.5
Poor performance
FUR ≥ 0.5
Use Observ.
Design survey
Fill-up rate (FUR) Litres/capita/day
Stool survey
Use and diet question.
Climate, soil & water
50 Latrines in Tanzania and 50 latrines in Vietnam

Microbial analysis (1)

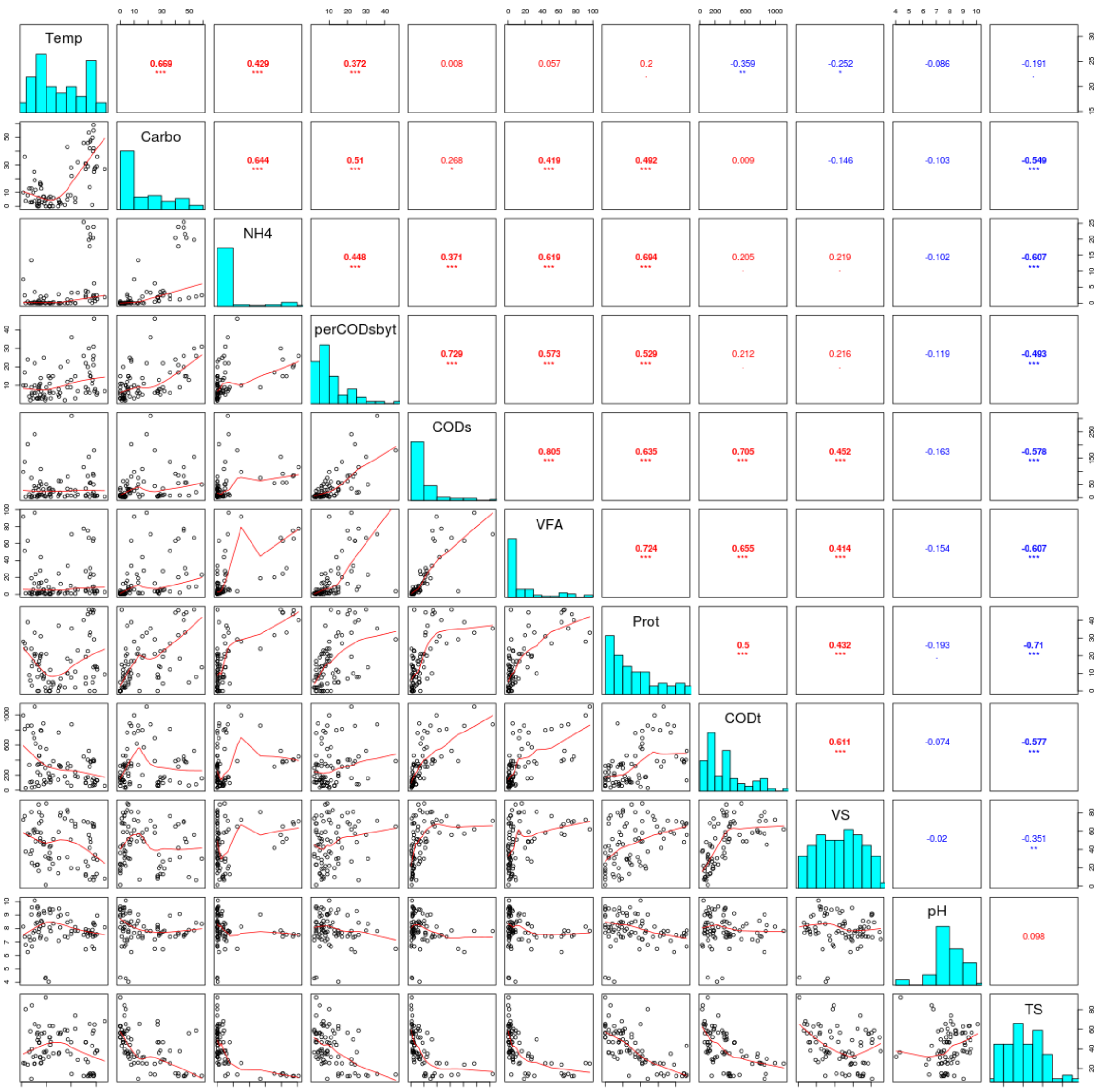
- 112 samples were sequenced
- Flowgrams were extracted insisting on exact barcode and primer matches
- Run through AmpliconNoise-Perseus pipeline
- Only 88 remained other 24 had less than 50 reads
- Assigned reads using RDP stand alone classifier
- Constructed OTUs using exact pairwise comparisons

Microbial analysis (2)

- Substantial variation in read number (min = 53, lq = 2680, median = 6818, upper = 11980, max = 26730)



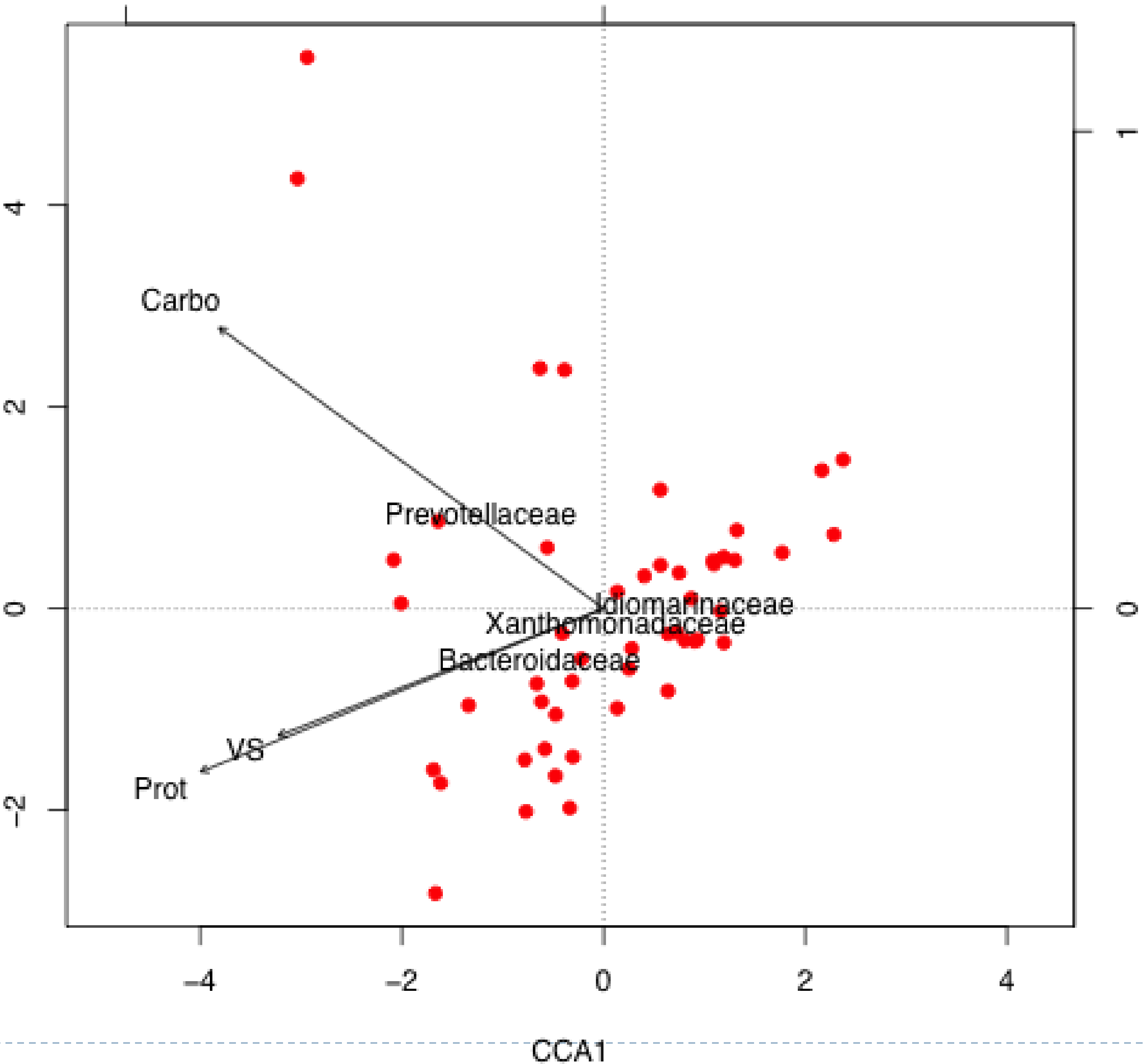
Microbial analysis (3)



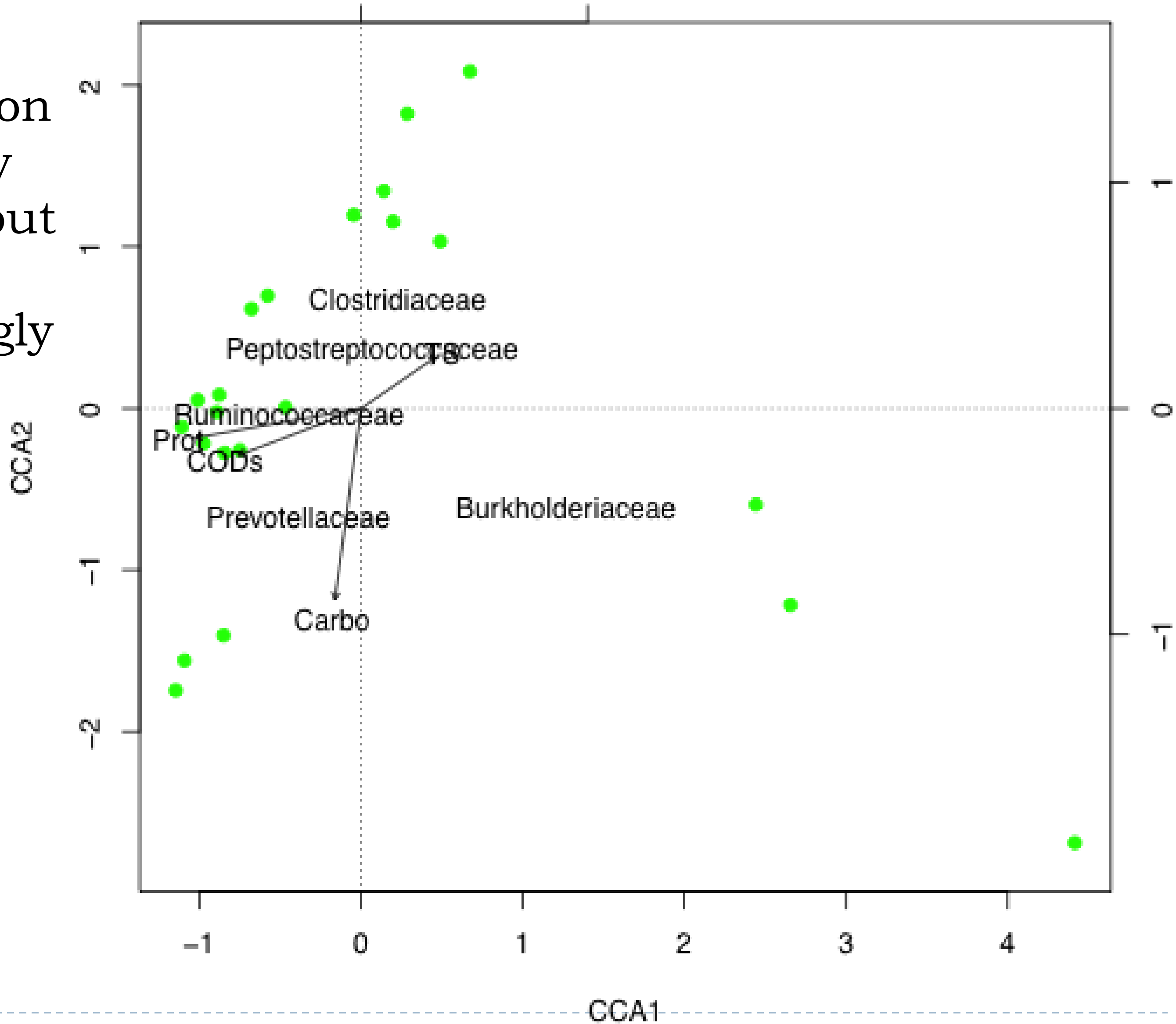
Microbial analysis (4)

	Phylum	Both	Tanzania	Vietnam	Diff	C. Diff
1	Firmicutes	39.63	37.3-50.09-67.2	29.3-35.30-42.6	14.8	28.3
2	Proteobacteria	13.1	4.3-6.36-9.3	15.1-18.56-22.8	12.2	51.7
3	Bacteroidetes	22.17	12.8-17.88-24.9	18.8-22.96-28.0	5.1	61.4
4	Synergistetes	1.02	2.9-4.27-6.4	0.2-0.37-0.6	3.9	68.9
5	Unknown	4.52	4.5-6.58-9.6	2.5-3.28-4.3	3.3	75.2
6	Actinobacteria	6.41	2.8-4.18-6.2	5.7-7.17-9.1	3	80.9
7	Deinococcus-Thermus	2.36	0.5-0.93-1.7	2.3-3.01-3.9	2.1	84.9
8	Spirochaetes	1.26	1.8-2.71-4.1	0.5-0.69-1.0	2	88.8
9	Verrucomicrobia	1.08	0.0-0.14-0.5	0.9-1.27-1.7	1.1	90.9
10	Tenericutes	2.12	0.9-1.43-2.3	1.5-2.03-2.7	0.8	92.4
11	Fibrobacteres	0.31	0.5-0.82-1.5	0.0-0.09-0.2	0.7	93.8
12	Chloroflexi	1.96	1.2-1.87-3.0	1.2-1.59-2.1	0.5	94.7
13	TM7	0.43	0.0-0.07-0.5	0.3-0.45-0.7	0.4	95.4
14	Planctomycetes	0.71	0.1-0.34-0.8	0.5-0.72-1.1	0.4	96.2
15	Fusobacteria	0.68	0.1-0.34-0.8	0.4-0.65-1.0	0.4	96.9
16	Acidobacteria	0.72	0.5-0.89-1.6	0.3-0.52-0.8	0.4	97.6
17	Lentisphaerae	0.41	0.0-0.14-0.5	0.2-0.40-0.6	0.3	98.1
18	Euryarchaeota	0.06	0.1-0.20-0.6	0.0-0.00-0.0	0.2	98.5
19	Nitrospira	0.16	0.0-0.00-0.0	0.1-0.17-0.3	0.2	98.8
20	Thermotogae	0.04	0.0-0.14-0.5	0.0-0.00-0.0	0.1	99.1
21	OD1	0.1	0.0-0.00-0.0	0.0-0.11-0.3	0.1	99.3
22	Cyanobacteria	0.24	0.0-0.14-0.6	0.1-0.24-0.4	0.1	99.5
23	Gemmatimonadetes	0.24	0.1-0.20-0.6	0.1-0.22-0.4	0.1	99.6
24	BRC1	0.12	0.0-0.14-0.6	0.0-0.09-0.2	0.1	99.7
25	OP10	0.04	0.0-0.07-0.5	0.0-0.02-0.2	0	99.8
26	WS3	0.04	0.0-0.00-0.0	0.0-0.04-0.2	0	99.9
27	Chrysiogenetes	0.06	0.0-0.07-0.5	0.0-0.04-0.2	0	100
28	Chlamydiae	0.02	0.0-0.00-0.0	0.0-0.02-0.2	0	100
29	Acidobacteria	0.72	0.5-0.89-1.6	0.3-0.52-0.8	0	100

Family composition not significantly related to depth but correlates with latrine and strongly with intrinsic environment (Carbo,VS,Prot)



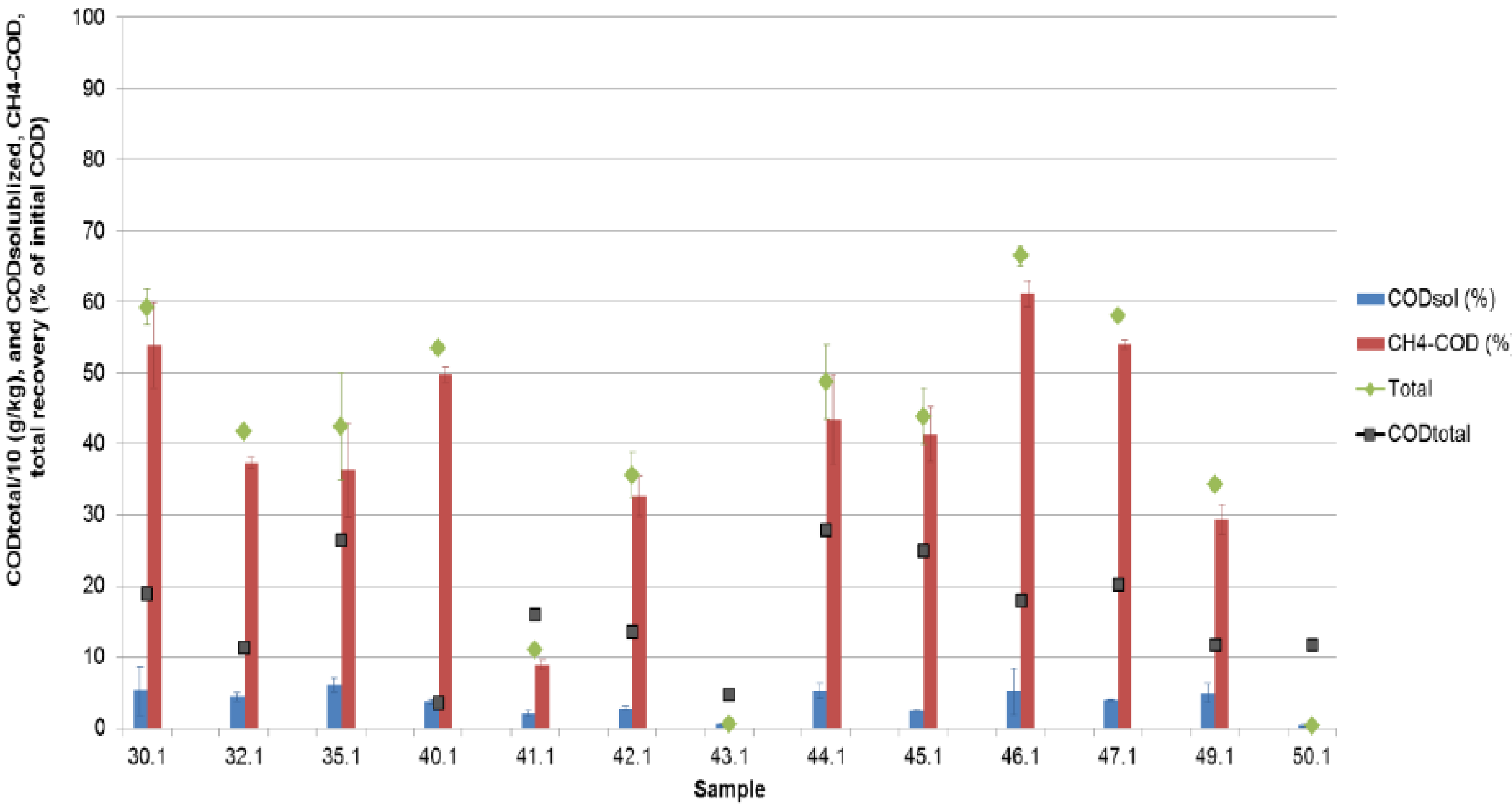
Family composition not significantly related to depth but correlates with latrine and strongly with intrinsic environment (Prot, Carbo, CODs,TS)



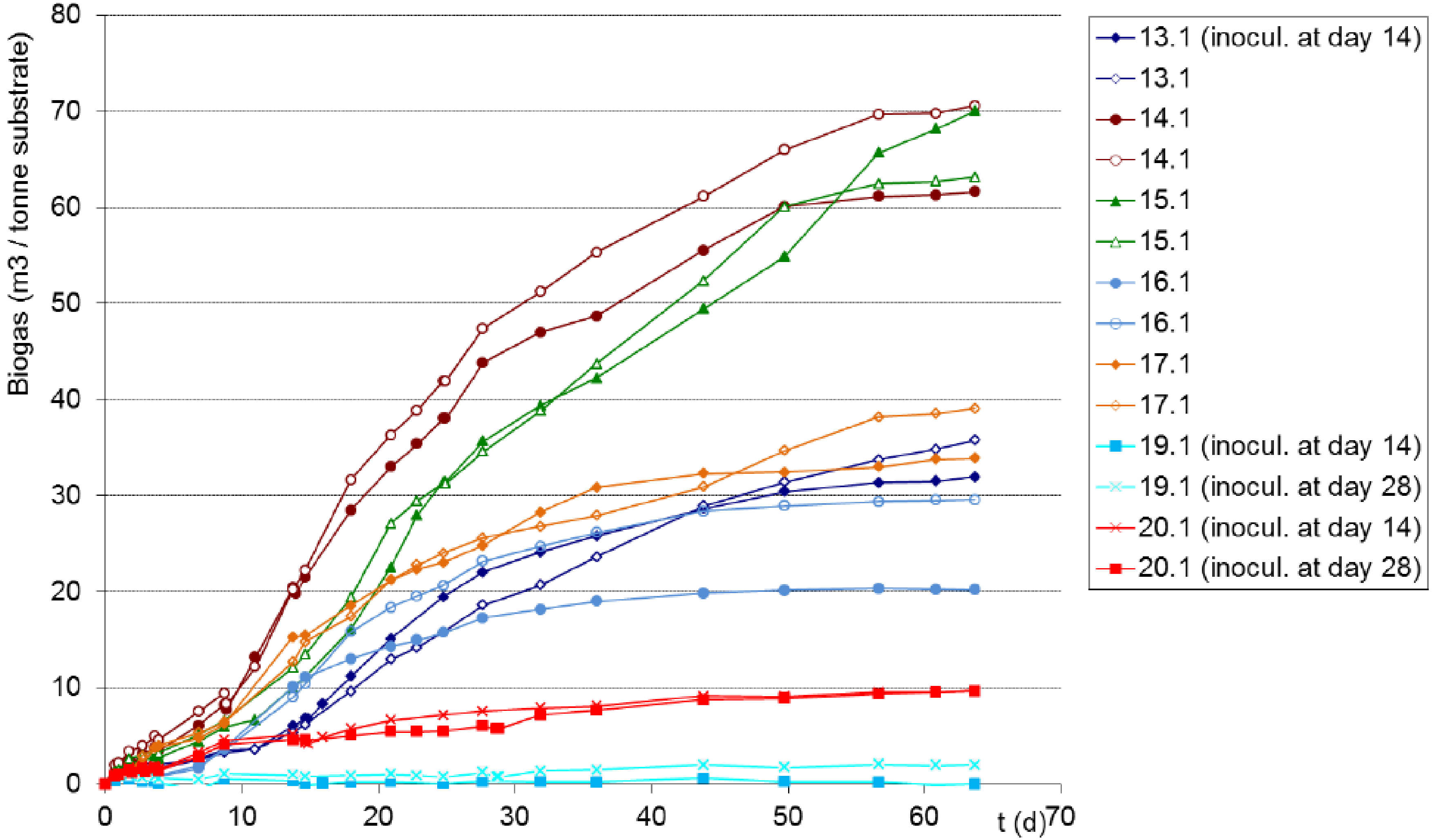
Discussion

- Environment is strongly determining microbiota
- Distinct microbiota Vietnam vs Tanzania
  - human associated enriched Tanzania vs more marine halophiles Vietnam
- Family level richness positively correlated with TS in Vietnam
- Tanzania and Vietnam
  - particular groups (possibly enriched for human associated) correlated with decomposition substrates (Carbo/Prot) and environmental organisms associated with TS
- To do:
  - Add new cross-sectional sequences
  - Correlate biodegradation results with composition
  - Longitudinal study – fill rate with composition

Biodegradation (1) remaining fraction



Biodegradation (2) – Latrine types



Fill-up modelling

- Milestone 19   31/8/2012
  - Field hydrology and column tests in Ifakara
  - Using degradation and fill-up data

- Key findings
  - Pit dimensions and number of users are key determinants of fill-up
  - Pit drainage main limiting factor
    - Pore clogging?
  - pit fill rate is not sensitive to the breakdown rate but to the products into which it breaks down

Assumptions of rate limiting steps

- **There is a fraction of faecal matter which is difficult to degrade**
  - Through characterising this material we will be able to identify whether specific organisms, or enzymes exist which could break it down and be added to the latrine
- **Environmental conditions are unsuitable to support the microbial communities needed for breakdown**
  - to alter them either through physical action (eg aeration, mixing, or adding water), or design (adding a roof, lining, improving drainage) or chemical addition (eg for pH control) or additives which provide a suitable “niche” for the right bacteria
- **There is a lack of a key microbial family needed for biodegradation**
  - (See first) + seeding of latrines with feacal material of successful pits?

Outputs (1)

	Title	Type of data	Lead author	Proposed journal
High Priority papers				
1	Pit latrine decomposition characteristics	Literature review study	Belen Torondel	Crit Rev Env Scie Techn
2	Microbial biodiversity and environment of pit latrines	Microbial,biochemistry and physical data from cross-sectional study	Belen Torondel	ISME
3	Latrine characteristics	Biochemistry, physical and use data (Tanzania and Vietnam)	Jeroen Ensink	Env Sci Tech
4	Assotiation of microbial diversity and latrines filling rate	Microbial, biochemistry, physical and fill-up data from longitudinal study	Belen Torondel	ISME
5	Meausring performance of pit latrines	Fill-up data of pit latrines, presenting data on good and poor performance +fresh stool data	Jeroen Ensink	Env SciTech
6	Modeling pit latrines	Results of hydrological testing and modelling	Lindsay Todman	Water Research
7	Biodegradation of pit latrines	Results of tests conducted by LeAF and Wageningen University	Miriam van Eekert	Water Research
8	Assotiation of methanogens diversity and latrines filling rate	Methanogens data combined with all other data from longitudinal study	Ozan Gundogdo	
9	Extending the life of the pitlatrine	Summary paper, bringing all results together	Walter Gibson	Nature/Science
Lower Priority Papers				
10	Bacteria and methanogens present in latrines and their association with diet	Cross-sectional and longitudinal data	Ozan Gundogdu	
11	Importance of pit latrines as source of fly breeding	student project	Kristen Knudson	Vect & Para
12	Is simple enough? Evaluating pit latrines	student project	Sarah Baker	Trans Royal Soc Trop Med
13	Sampling pit latrines	Practitions paper highlighting sampling and findings	Jeroen Ensink	Waterlines

Outputs (2)

G Model
TRSTMH-1665; No. of Pages 2

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Short Communication

Helminth transmission in simple pit latrines

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