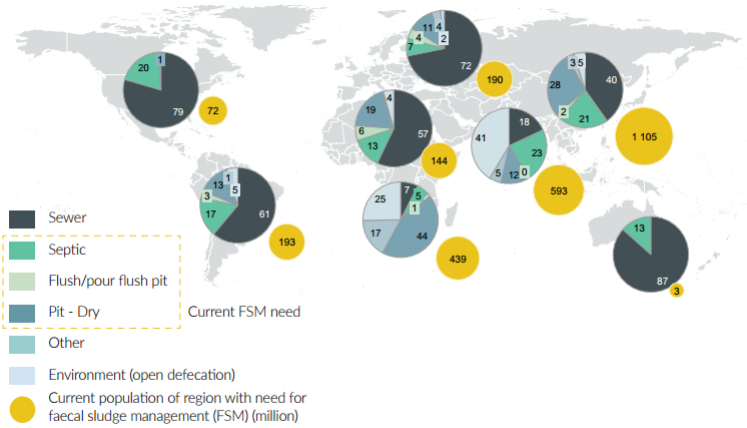
Faecal sludge management in African cities

Martin.Seidl@ENPC.fr
LEESU ENPC University Paris-Est

After Doulaye Kone (Eawag)
v2020 Post covid

Sanitation in developing countries = mixed options and technologies

Figure 5.1 Percentage of population served by different types of sanitation systems



Source: Cairns-Smith et al. (2014, Fig. 8, p. 25, based on data from WHO/UNICEF JMP). Courtesy of the Boston Consulting Group.

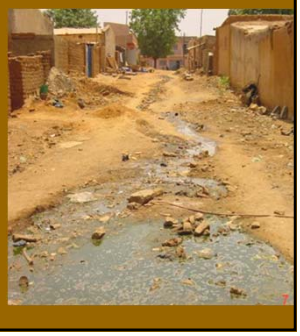
Partially sewered cities

- Business centre of large cities with high water consumption rate
- Lack of treatment sites and wastewater treatment plants
- Discharge of wastewater into natural water bodies and open canals

Cities without sewers

- Represent more than 90% of cities in developing countries
- Are very heterogeneous in urban infrastructure
- Often lack of financial and human resources for sanitation development and upgrading





Sanitation in developing countries = mixed options and technologies

Cities	Population (million)	Onsite sanitation coverage (%)	FS* produced (m3/day)	Treated FS (%)	Volume of Trucks (m3)
Hainoi	2.5	30	**250**	?	44
Danang	0.6	90	**270**	?	33
Kumasi	1.5	99	**500**	?	100
Ouagadougou	1.2	99	**600**	?	250
Dakar	2.5	60	**1300**	70	960
Bangkok	8	40	**4600**	8.5	
* 1 L FS = 100 L wastewater (solids content)					

Daily volumes

Table 1: Daily per capita volumes, BOD, TS, and TKN quantities of different types of faecal sludges. (Heinss et al., 1998)

Parameter	Septage [1]	Public toilet sludge [1]	Pit latrine sludge [2]	Fresh excreta
BOD [g/cap•day]	1	16	8	45
TS [g/cap•day]	14	100	90	110
TKN [g/cap•day]	0.8	8	5	10
Volume [l/cap•day]	1	2 (includes water for toilet cleansing)	0.15 – 0.20	1.5 (faeces and urine

[1] Estimates are based on a faecal sludge collection survey conducted in Accra, Ghana.

[2] Figures have been estimated on an assumed decomposition process occurring in pit latrines. According to the frequently observed practice, only the top portions of pit latrines (~ 0.7 ... 1 m) are presumed to be removed by the suction tankers, since the lower portions have often solidified to an extent that does not allow vacuum emptying. Hence, both per capita volumes and characteristics will range higher than in the material which has undergone more extensive decomposition.

FS characteristics

	Public toilet sludge	Septage	Sewage
Characterisation	Highly concentrated, mostly fresh FS; stored for days or weeks only	FS of low concentration; usually stored for several years; more stabilised than public toilet sludge	Tropical sewage
COD (mg/l)	20,–50,000	< 10,000	500–2,500
COD/BOD	2:1 . . . 5:1	5:1 . . . 10:1	2:1
NH_4-N (mg/l)	2,–5,000	< 1,000	30–70
TS	≥ 3.5%	< 3%	< 1%
SS (mg/l)	≥ 30,000	≈ 7,000	200–700
Helminth eggs (no./litre)	20,–60,000	≈ 4,000	300–2,000

Table 3: Characteristics of faecal sludges and comparison with tropical sewage. (Adapted from: Heinss et al., 1998, p. 4)

On-site sanitation : the (hidden) reality

Lack of regulations, illegal dumping and use of untreated FS

Mechanical emptying lacking the support of local government

Mechanical emptying (30%)

Latrines without FSM :

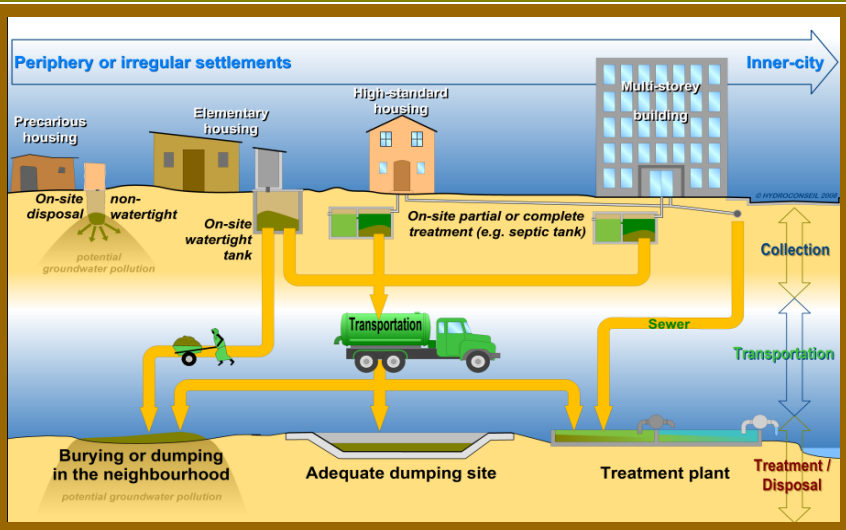
Where trucks cannot pump or households cannot pay the service

- Manual emptying (70%)
- Dumping in the street,
- Reuse in agriculture

So what should the treatment be ?

Performances et challenges

The system of faecal sludge and wastewater



Agnes Montangero SANDEC 2004

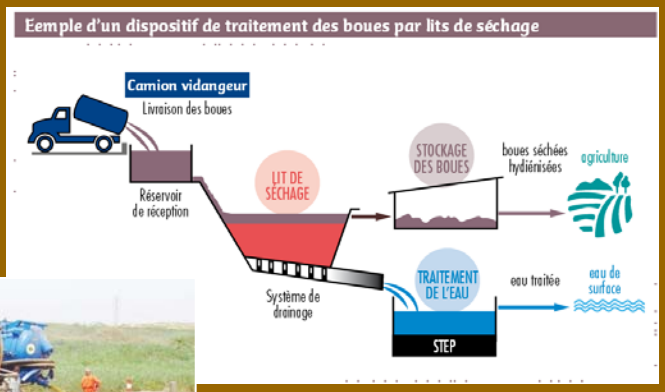
13

Emptying

	Manual Emptying	Mechanical Emptying
Advantages	+ Accessibility + Local job creation and income generation	+ Fast, and generally efficient + Minimizes health risk
Disadvantages	- Time consuming - Health hazard for workers - Hard, unpleasant work - MAPET requires some specialized repair (welding) - Requires a disposal point or discharge area (< 0.5 km) - Spillage and bad odors	- Low accessibility - Expensive capital and O&M costs (which is passed onto the customers) - Can not pump thick, dried sludge (must be manually removed) - Pumps usually only suck down to a depth of 2-3 m

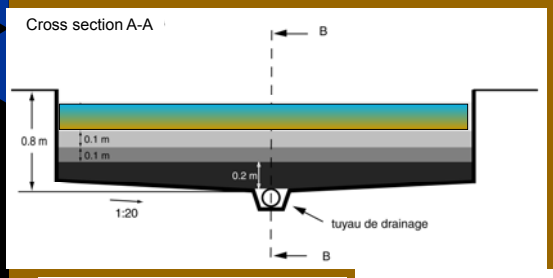
Sandec Training Tool

Conventional drying beds

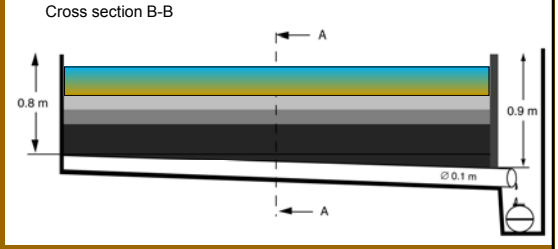


15

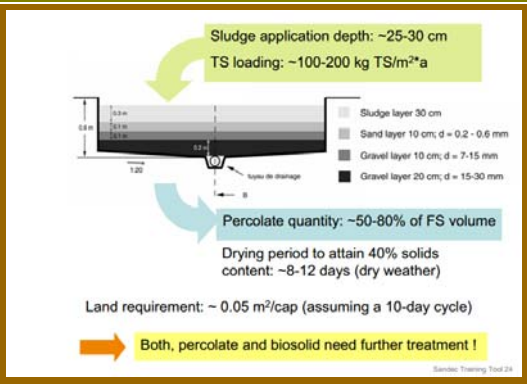
Conventional drying beds



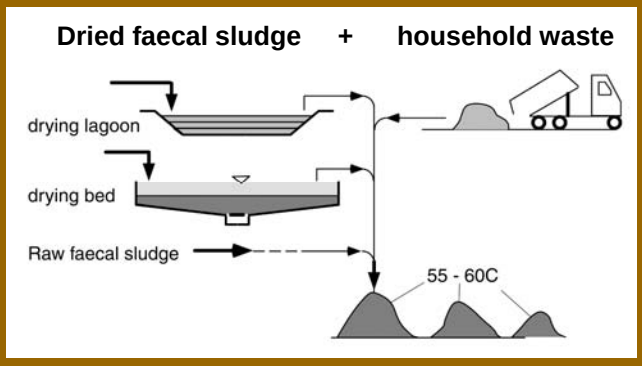
Sludge layer 30 cm
Sand layer 10 cm; d = 0.2 - 0.6 mm
Gravel layer 10 cm; d = 7-15 mm
Gravel layer 20 cm; d = 15-30 mm



Operation

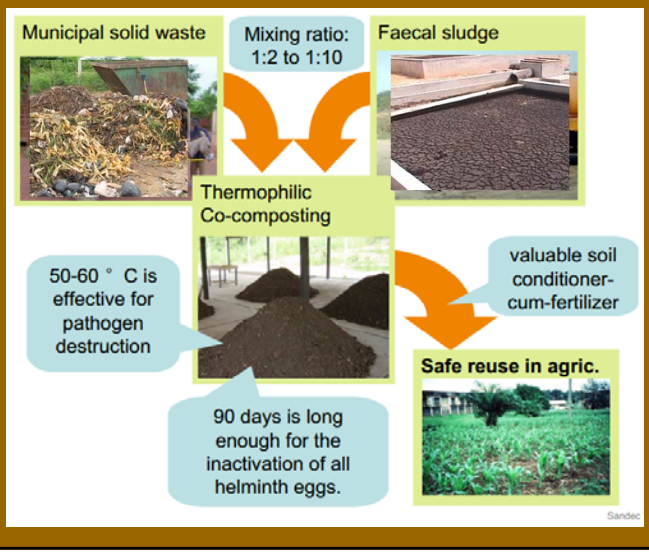


Co-composting Kumasi pilote (Ghana),

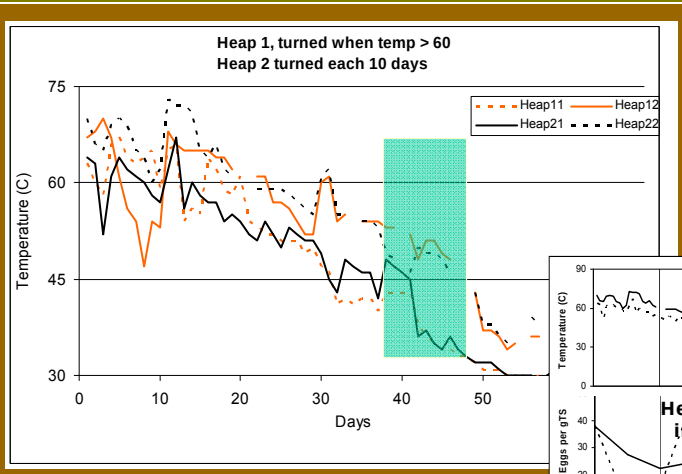


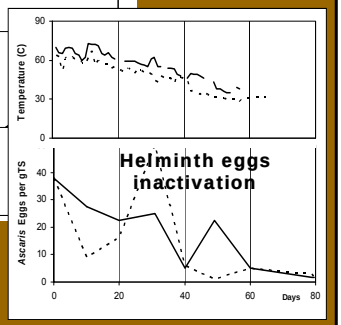
- **Stabilisation et hygienisation in one treatment**
- **Needs « clean » operation**

Methodology



Temperature pattern / hygienisation





Windrow temperature > 45 °C during 4–6 weeks

Efficiencies

- Load M 100-200 kg MS/an
- Load V 20-30 cm par cycle
- Design 0.05 m²/hbt.
- Drying time 7 - 14 days

- Volume biosolides ~ 1 %
- R MES ≥ 95 %
- R DCO 70-90 %
- R N tot 40-60 %
- R Helminthes 100 %

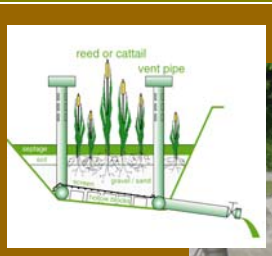
the filtration is badly impacted by low quality substrate and fresh sludge

Quality of compost

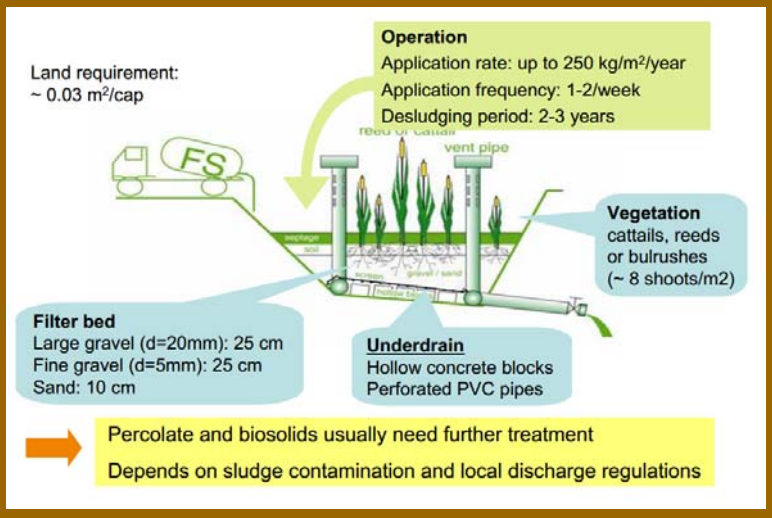
Obtained from co-composting of faecal sludge and domestic waste

Constituent	Buobai Cocompost	Litterature data (% of dry weight)	Reference
Nitrogen (as N)	**0.6 – 1.3**	1.3 – 1.6 1.3 0.35 – 0.63 0.45	Shuval et al. (1981) Obeng and Wright (1987) Kim, S.S. (1981) Byrde (2001)[3]
Phosphorus (as P2O5)	**0.3 – 5**	0.6 – 0.7 0.9	Shuval et al. (1981) Obeng and Wright (1987) Kim, S.S. (1981)
Potassium (K2O)	**0.4**	--- 1.0	Shuval et al. (1981) Obeng and Wright (1987)
Org. matter (% TVS)	**30**	12 - 30	Kim, S.S. (1981)
Carbon (C)	**15 – 20**	46 – 50 13	Shuval et al. (1981) Byrde (2001)

Reed bed filters - AIT Bangkok



Reed bed filters - opertaion



Reed bed filters - construction

Filters planted with *Typha*

Filter beds loaded with FS

Biosolides accumulated within roots of *Typha*

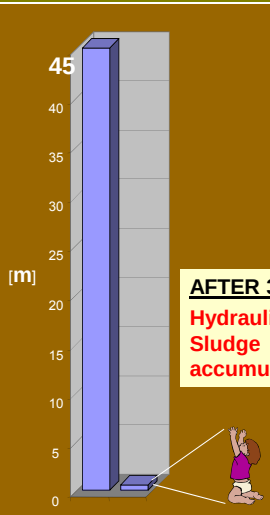
Reed bed filters - efficiency

substrate
-Coarse gravel (d=5 cm): 45 cm
-Mean gravel (d=2 cm): 15 cm
-Sand (d=0.1 cm): 10 cm

Thickness
-1 m

Surface needed
-0.03 m²/habt

Exploitation (pour BV Bangkok)
-Load: 125 - 250 kg TS/m²*y
-Frequency: 1 - 2/weeks
-Retention percolat: 2-6 days

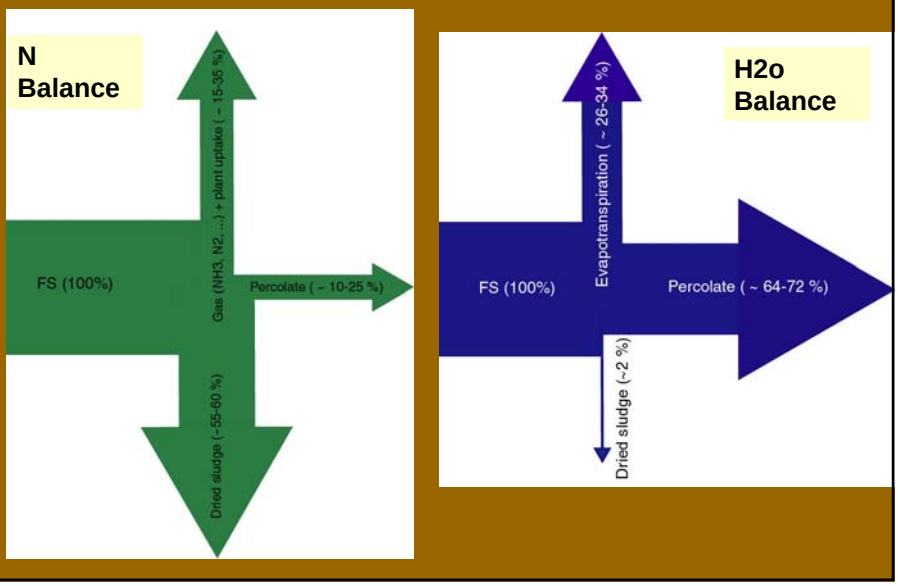


AFTER 3 YEARS

Hydraulic load	45 m
Sludge accumulation	0.55 m

- Root systems (rhizomes) make it possible to preserve the permeability and thus the capacity of dehydration of the beds during several years
- Plants evapotranspiration reinforce dehydrataion
- Stabilisation and dehydration of the biosolides in “one” stage of treatment
- Low frequency of draining of the beds is prolonged since the cycles of loading of muds extend over several years
- Plant growth need an special attention (hydrological assessment)
- Percolat: need for postprocessing according to the case
- Adapted in wet tropical climate; not tested yet in arid area

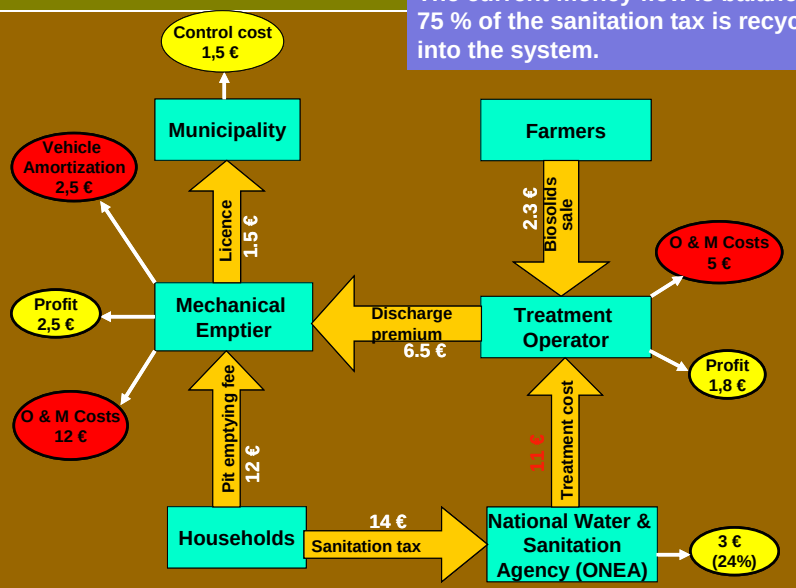
Reed bed filters - balances



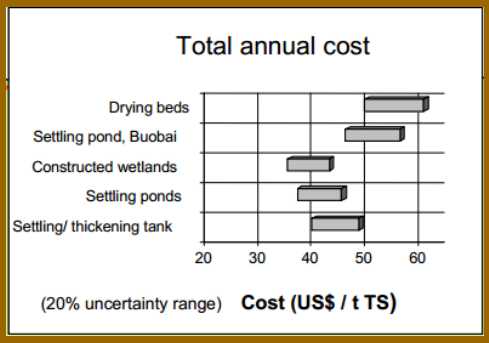
So what could the organization be ?

Financial sustainability of mechanical emptying

The current money flow is balanced if 75 % of the sanitation tax is recycled into the system.



Solutions and costs



Couts des services de vidange

D'une manière générale, les camions vidangeurs pratiquent tous des tarifs qui varient entre **32 500 F CFA et 35 000 F CFA** lorsque la fosse est moyenne, soit de 6m3.

Les marges cependant ne sont pas significatives (autour de 2 500 F CFA) pour les coûts actuellement pratiqués.

Le tarif payé par le client ne constitue pas seulement la rémunération de l'entreprise. Il comprend aussi :

- la rémunération des intermédiaires éventuels (à 1 625 F CFA),
- la redevance à payer à la station de lagunage (5 450 F CFA/ 6 m3 + 18 % de TVA),
- une taxe municipale perçue par la commune où est installée la station de lagunage.

L'investissement pour un camion est autour de 14 millions de FCFA. La marge bénéficiaire brute d'une entreprise exploitant un camion semble relativement faible :16 % du chiffre d'affaires.

HYDROCONSEIL 2002

Coûts

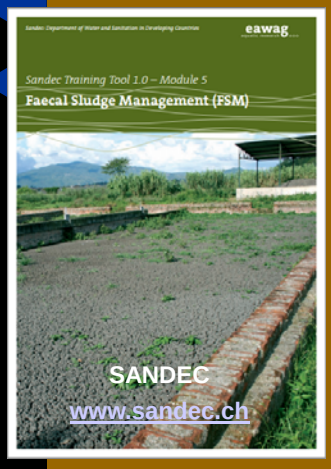
TABLEAU 8. Aide à la décision pour le choix des technologies du maillon intermédiaire de l'assainissement non collectif

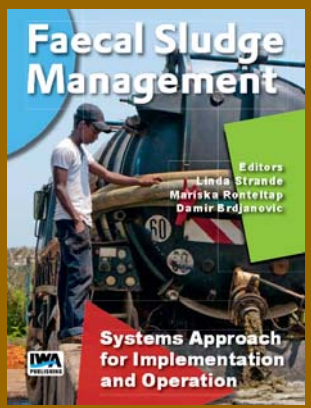
	Techniques possibles	Accessibilité	Rayon d'action	Durée de vie (ans)	Efficacité	Investissement par équipement en €	Coût annuel d'exploitation par équipement en €	Conception construction et E&M
Vidange manuelle	Seau + charrette citerne	Ruelles	< 5 km	2-10	Faible [A]	300-1000	50-150	Faible
	Pompe manuelle + charrette citerne	Ruelles	< 5 km	2-10	Elevée [B]	400-1000	50-150	Elevée
Vidange mécanique	Motopompe + charrette citerne	Ruelles	< 5 km	2-10	Elevée [B]	1000-2000	150-1000	Faible
	Camion de vidange	Voies carrossables	> 5 km	10-20	Elevée [B]	10 000 – 50 000	1 000 – 10 000	Elevée

Conclusion

Thank you for your attention

References





https://www.eawag.ch/en/department/sandec/publications/fsm-book/

https://sswm.info/