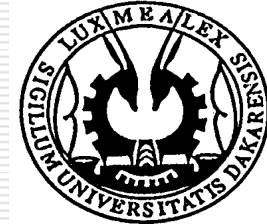


**WWW-YES 2010 France**

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# Humification performance and helminth eggs inactivation in faecal sludge dewatering bed

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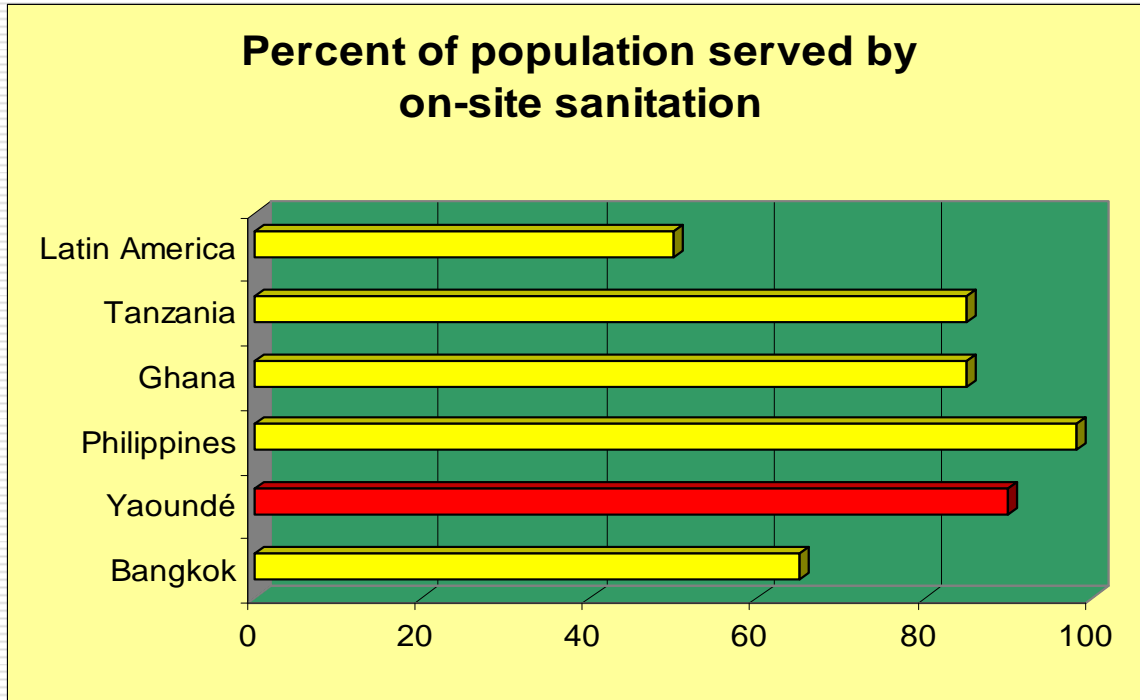
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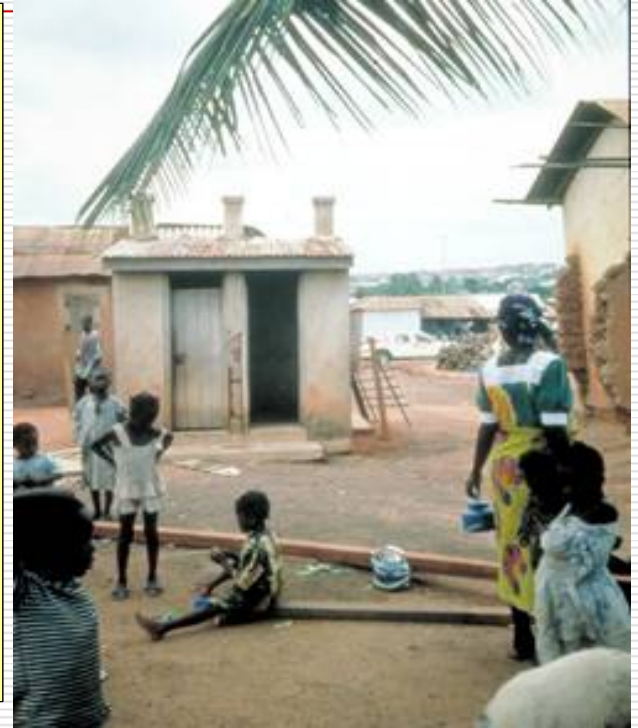
**eawag**  
aquatic research ooo



# Context : Sanitation infrastructure in developing countries

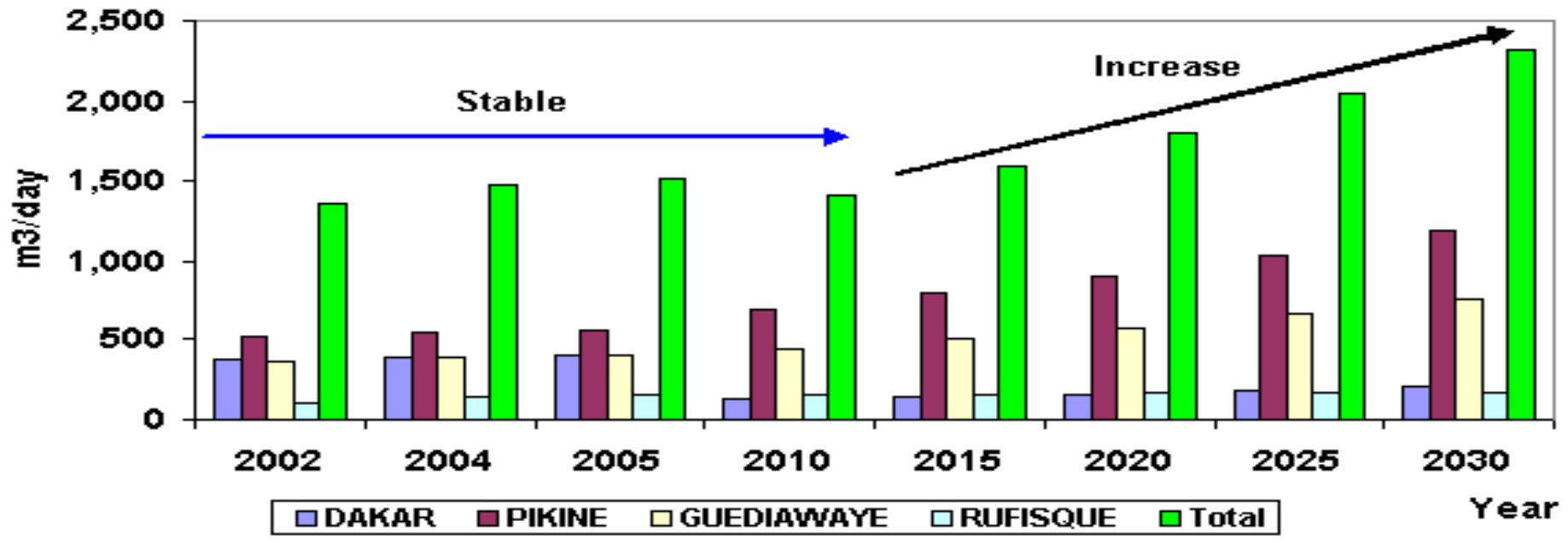


Strauss et al, 1997, modified



- Most mega and capital cities are also latrine-based!
- 2.6 billion urban dwellers use on-site sanitation (globally)!

# Consequences of MDGs in Sanitation



With the increase of on-site sanitation in Dakar, the quantities of sludge produced, estimated at 1,350 m<sup>3</sup>/day in 2007, will increase significantly if the MDGs are achieved

# Faecal sludge management

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## Manual Emptying



## Mechanical Emptying





Where the problem is...

**Anarchic discharge of faecal  
sludge collected into  
environment and use in  
agriculture**

**consequences**

- ➔ **Ecological** (eutrophication , ...)
- ➔ **Sanitary** (diarrhoia and other diseases )
- ➔ **Economic** (health costs, cleanup costs )



# However, excreta are resources !

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Nutrient	Nutrient (kg)			Required for 250 g of Cereals
	urine 500 l/an	faeces 50 l/an	Total	
N Nitrogen	4.0	0.5	4.5	5.6
P Phosphorus	0.4	0.2	0.6	0.7
K Potassium	0.9	0.3	1.2	1.2

# Challenges 1

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How to produce safe biosolids from faecal treatment units that sustain agricultural productivity?





# Challenges 2 :

How to control the cycles of C, N, P, K?





# Objectives

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## **General objective:**

This thesis aims to first follow the purification performances but also to explain the mechanisms responsible for the humification and helminth eggs inactivation in biosolids

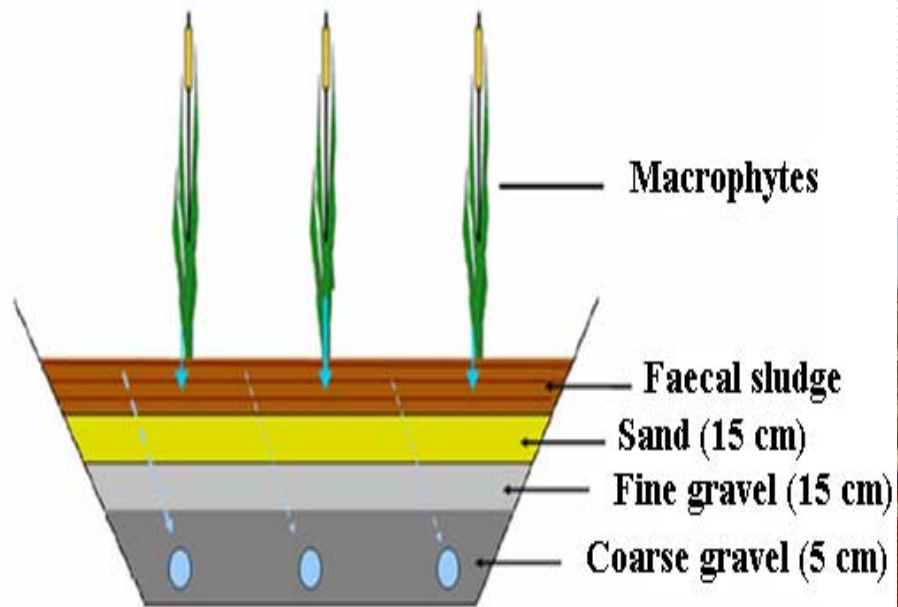
## **Specific objectives:**

- ❖ **SO1:** follow the purification performance during the different experiments;
- ❖ **SO2:** monitor the influence of residual moisture on the process of humification;
- ❖ **SO3:** follow the influence of plant type on the process of humification;
- ❖ **SO4:** follow the influence of the type of sludge on the process of humification;
- ❖ **SO5:** follow the inactivation of helminth eggs in the different experiments during the maturation phase.

# Experimental design 1: Yard-scale planted dewatering beds (Objective 1)

Surface : 4 m<sup>2</sup> (2x2)

Depth : 85 cm



**Problem:**

Difficulties to control the flow

Difficulty to do statistical analysis



# Methodologie: Pilot-scale planted dewatering beds

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- Same design like yard-scale plants
- Advantages
  - Control the inflows and outflows
  - Allowing repetition of experiments to answer statistical requirements



1: 200 Kg/m<sup>2</sup>/year, One application per week

2: 200 Kg/m<sup>2</sup>/year, Two applications / week

3: 200 Kg/m<sup>2</sup>/year, Three applications per week<sup>11</sup>

# Methodology: Implementation of experimental units

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## Four steps

- ❑ Plantation (9 cuttings / m<sup>2</sup>)
- ❑ Plants acclimatization (1-2 months)
- ❑ Scalability : 25, 50, 75, 100, 150, 200 Kg TS/m<sup>2</sup>/year (2 months)
- ❑ Operation at rated load **200 Kg TS/m<sup>2</sup>/an** (6 Months)
- ❑ Maturation period (3 months)

$$\text{Sludge loading rate (l)} = \frac{C1}{C2} \times \frac{1}{52}$$

With C1 = annual load = 200 kg MS/m<sup>2</sup>/an

C2 = average concentration of sludge delivered by trucks emptying



# Methodology: Parameters for evaluating the quality of humus

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- ❑ **Chemical criteria:** C / N ratio, cation exchange capacity (CEC), NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, report NO<sub>3</sub><sup>-</sup>/NH<sub>4</sub><sup>+</sup>, pH, ORP, conductivity, loss of ignition, analysis of substances easily biodegradable (sugars, amino acids, phenols, etc..) and readily biodegradable substances (fiber, lignin, tannins, etc..)
- ❑ **Microbiological and enzymatic criteria:** measurement of biomass and diversity, latent metabolism evaluated by the rate of respiration, measurement of enzyme activity
- ❑ **Germination test:** evaluation of phytotoxicity residual (rate of seed germination, root length) *Lepidium sativum* L. or other test plants.
- ❑ **Analytical and spectroscopic criteria:** quantity of humic or fulvic acids, humification indices (humification index, humification rate, rate of polymerization), spectroscopy: visible (E4/E6 ratio, infrared and UV)
- ❑ **Helminth eggs**

# Results 1: Characteristics of raw sludge

Parameter	TS (mg/l)	TSS (mg/g)	COD (mg/l)	TKN (mg/l)	NH4+ (mg/l)	NO3- (mg/l)	TP (mg/l)	pH	Sal (g/l)	Cond (ms/cm)	Eh (mV)
Average	4109	3187	6807	325	352.8	2.84	79.8	7.6	1.88	4.06	-163
Max	6264	5544	8456	626	845	5.7	119	7.8	3.5	6.82	-45
Min	2932	1200	4546	318	141	0.6	32	7.3	1.1	2.77	-295
Cameroon1	33400	33400	29900	1200	600			7.6		3	-59
Accra (Ghana)2	12000		7800	330							
Ouagadougou (Burkina Fasso)2	19000		13500								
Bangkok (Tailand)2	15350		15700	415							

1 Kengne et al, 20092 Strauss, 2006

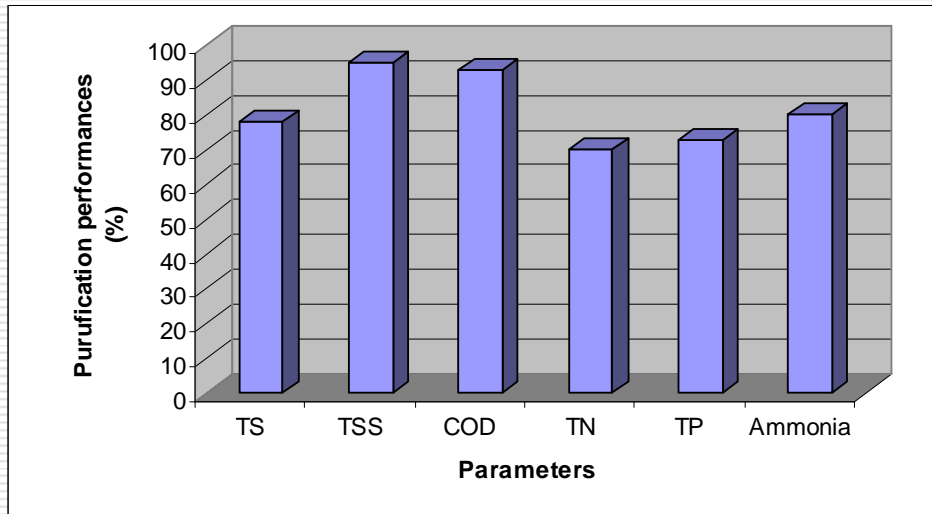
Faecal Sludge from Dakar are less concentrated (TS), then volumes to be treated with the same charge, will be higher

# Results 2: Acclimatization phase





# Purification Performances



**TS:** Total Solid, **TSS:** Total Suspended Solid, **COD:** Chemical Oxygen Demand, **TN:** Total Nitrogen, **TP:** Total Phosphorus



Good turbidity removal (TS, TSS)

Despite these high rates of purification, leachate contain loads above Senegalese discharges standards into receiving environments or WHO standards for agricultural reuse.



# Biosolids Characteristics

- **Elemental composition** (% Dry Matter)

	Nitrogen	Carbon	C/N	Hydrogen	Sulphur
DS 1st week	1.93	23.38	12.11	3.50	0.24
DS 2nd week	2.88	31.98	11.10	5.11	0.28
DS 5th week	2.93	32.40	11.05	0.84	0.34
DS 7th week	2.92	31.99	10.95	3.00	0.33
Biosolids <sup>1</sup>	2	22.6	11.3		

<sup>1</sup>: Kengne et al, 2008

Biosolids have the same characteristics as those that had a maturity period of 6 months (Kengne et al, 2008).

Hypothèse: Faecal sludge from which they are derived, may have to start their<sup>17</sup> conversion into septic tanks where they accumulate for at least six months.

# Biosolids Characteristics

- Chemical composition of sludge (% DM)

	Na <sub>2</sub> O	MgO	SiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	S	K <sub>2</sub> O	CaO
DS 1st week	0.17	1.4	27.6 4	4.24	2.17	1.03	11.2 8
DS 2 <sup>nd</sup> week	0.21	1.36	14.5 3	4.07	2.01	0.74	8.33
DS 5th week	0.24	1.34	16.6 8	4.13	2.12	0.75	9.08
DS 7th week	0.19	1.41	15.7 7	4.34	2.08	0.73	9.08
Biosolids <sup>1</sup>	0.09	0.14	-	2.3	-	0.03	1.04
Converted Sludge <sup>2</sup>	-	0.8	-	0.6	-	0.4	-

<sup>1</sup>Kengne et al, 2008 (Cameroon) <sup>2</sup>GTZ, 2005 (Egypt)

The chemical composition of these parameters in biosolids depends essentially on nature of raw sludge.

# Biosolids Characteristics

- Heavy metals content (mg/Kg TS)

	TiO <sub>2</sub>	Cr	Pb	Rb	Zn	Co	Ni	Cu
DS 1st week	276	9.3	9.8	3.1	103	3.8	1.9	29.8
DS 2nd week	239	8.4	12.7	2.7	107	1.8	1.7	28.8
DS 5th week	258	7.3	10.7	2.7	123	1.5	2.4	32
DS 7th week	264	9.4	10.9	2.6	129	2.9	2.4	33.2
EC eco label compst <sup>1</sup>		100	100		50		50	100

DS: Dry solid      <sup>1</sup>: Hogg et al, 2002

The concentration of heavy metals in biosolids is below than limits seted by EC eco label compost

# Expected results

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- ❑ Good knowledge of supply frequency, plants choice and the method of sludge pre-treatment that allow an efficient purification
- ❑ Determining the best supply frequency for sludge dehydration and mineralization
- ❑ Selection of the appropriate plant or plant association for proper sludge drying and mineralization
- ❑ Selection of the best quality of sludge, which offers a better quality of humus
- ❑ Determination of time required to inactivate helminth eggs
- ❑ Development of design criteria of planted drying beds in sub-Saharan Africa



# Thank you !

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