Central Sewer and Wastewater Treatment Systems

06.- 08. September 2010

Mtwara SuSan Workshop

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What products are we dealing with?

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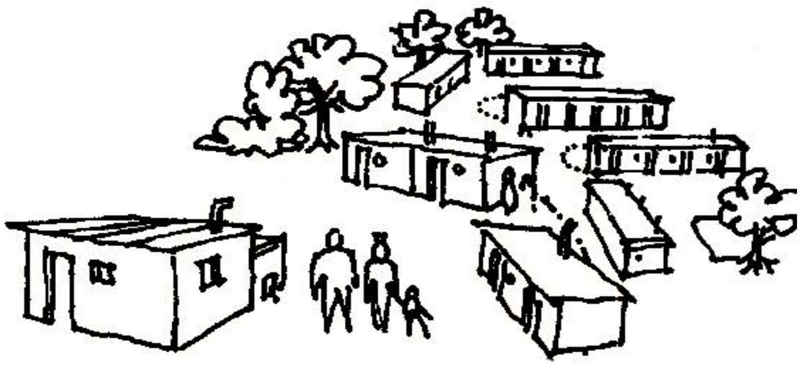


SOLID WASTE | STORMWATER | URINE | FAECES | GREYWATER

(anal cleansing water)

Processes — Collection / Storage – Transport – Treatment – Utilisation

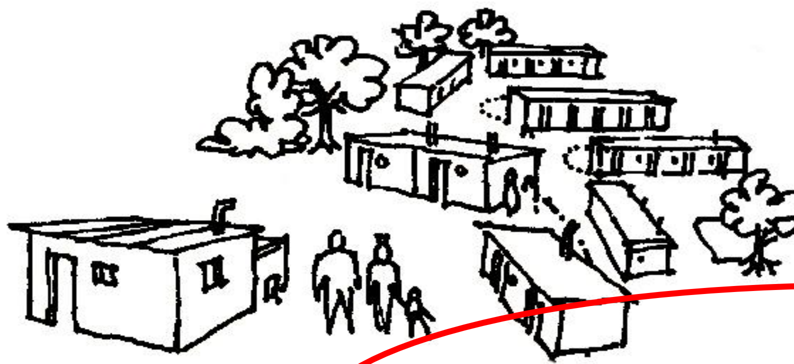
Management — Planning – Financing – Implementing
Operation & Maintenance – Regulation & Enforcement

Waterborne Sanitation

water borne = transported by water

All kinds of wastes are transported by water in a sewer system from the source to a central location for treatment and discharge.

What is the focus of this presentation?



Water supply

SOLID WASTE | STORMWATER | URINE | FAECES | GREYWATER

(anal cleansing water)

Household wastewater

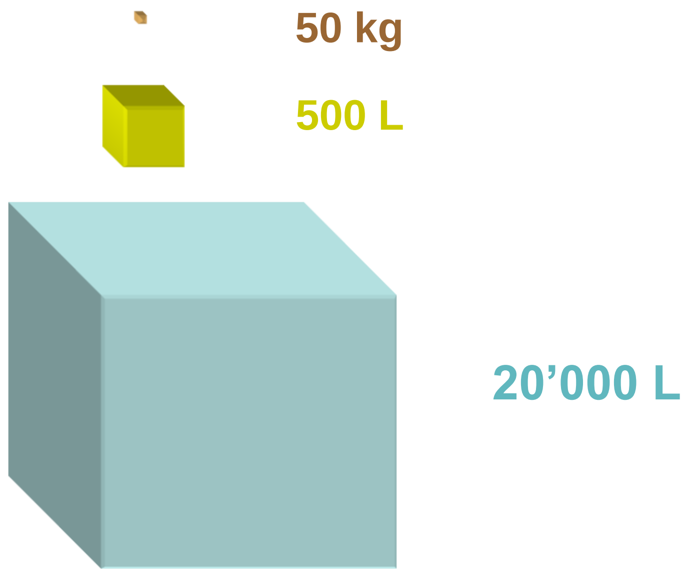
Processes — Collection / Storage – Transport – Treatment – Utilisation

Management — Planning – Financing – Implementing
Operation & Maintenance – Regulation & Enforcement

Waterborn sanitation needs water

With conventional waterborne flush-toilets, we mix

- roughly 50 kg of faecal matter (per person/year)
- roughly 500 l of urine (per person/year)
- with roughly 20.000l of clean flushwater, based on a volume of 8l per flush



If this wastewater is discharged untreated into rivers, an even higher amount of water is polluted.

Wastewater Treatment - Definition

Wastewater quality depends on source:

- households: flush toilets, bathroom, kitchen, laundry
- industry & trade: water from production and cleaning

→ This presentation concentrates on municipal wastewater (mainly household wastewater, limited share of industrial wastewater) only.

Wastewater quality and expected effluent quality define the required treatment system.

Wastewater Treatment - Target

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Depending on:

- legal situation internationally, nationally and regionally

	Ugandan Standards (mg/l)	European Commission (mg/l)	WHO Guidelines (mg/l)	Austrian Discharge Regulation (mg/l)
COD	100	125	75	75
BOD_5	50	25	25	20
Nitrogen (total)	10	15	--	10 / 5*
Phosphate	10	2	--	2
Sulphate	500	--	--	--

* max. value of 10 mg/l for plants 50 – 500 PE and 5 mg/l for plants ?500 PE

- environmental requirements (impact on environment)

International state of the art:

- removal of solid material by sedimentation
- removal of organic dissolved and floating substances by microbiological treatment
- removal of nutrients (N & P)

Central sewer system

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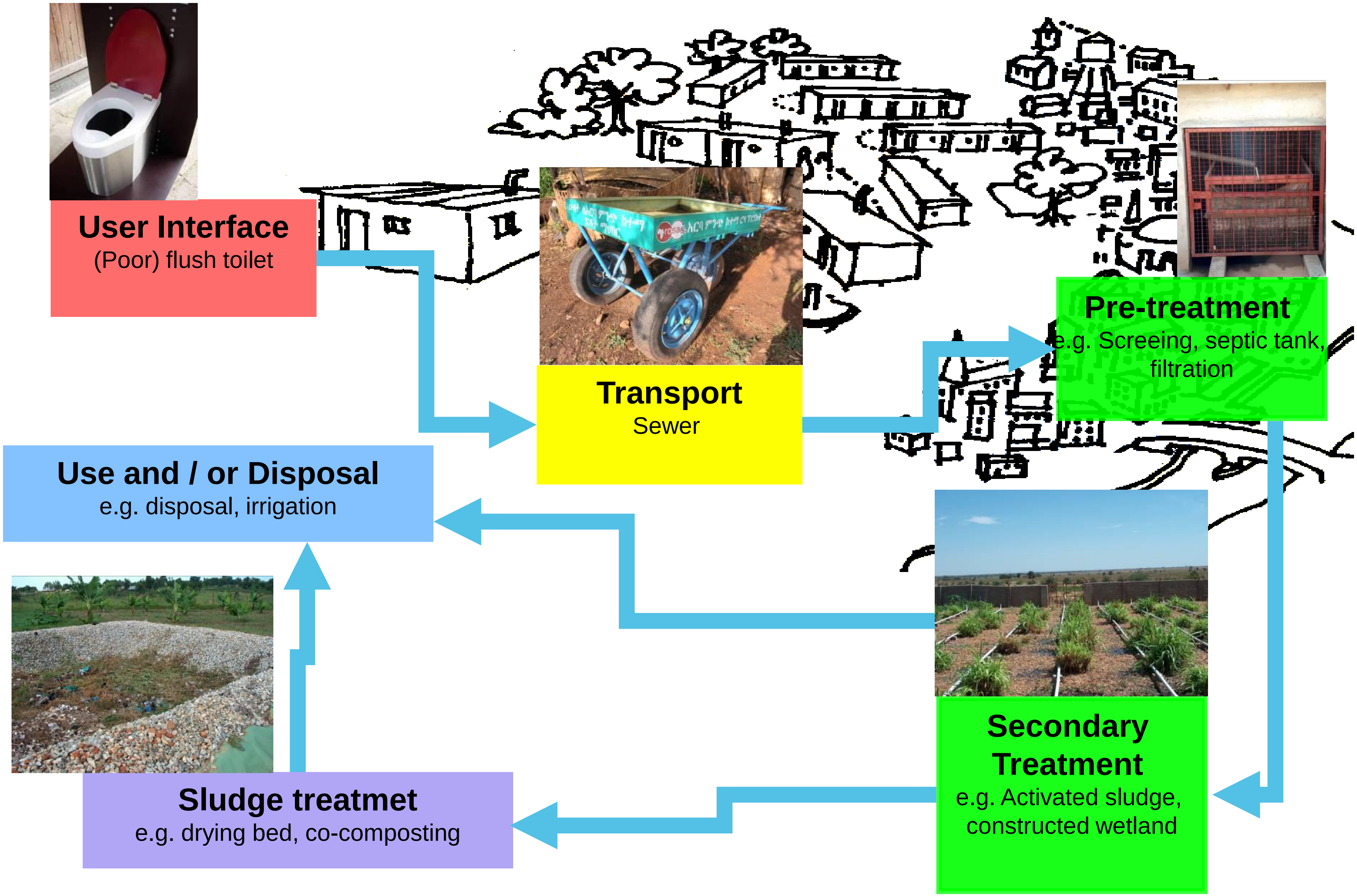

Screening

Kisoro, Uganda

Sedimentation

(e.g. septic tank)

Matany, Uganda

Pre - treatment - mechanical

Sedimentation

(e.g. sedimentation tank)

Semperit, Austria

Pre - treatment - mechanical

Filtration

Maracha, Uganda

Secondary Treatment – Biological Wastewater Treatment

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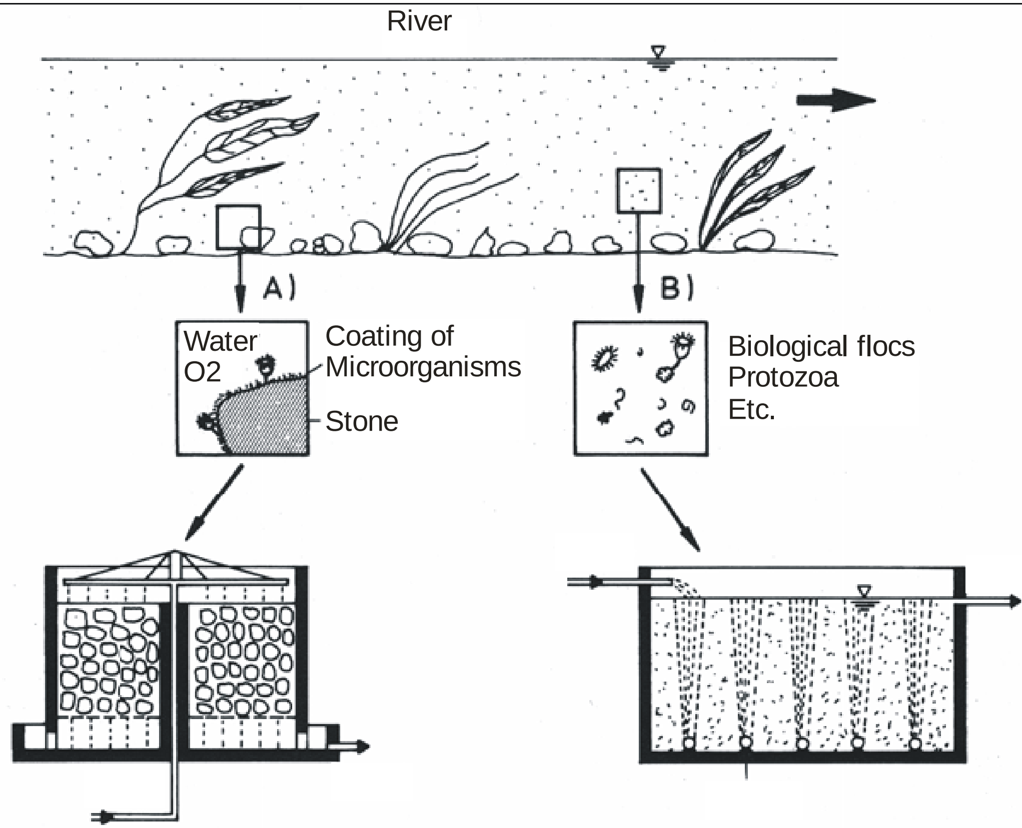
Biological aerobic Wastewater Treatment copies and intensifies the process of self-purification which takes place in natural water bodies.



Fixed Bed Reactor

Trickling filter

Constructed Wetland
Sub-surface flow

Mixed Reactor

Activated Sludge

Pond

Fluidized Bed Reactor

Constructed Wetland
Surface flow

Biological Wastewater Treatment

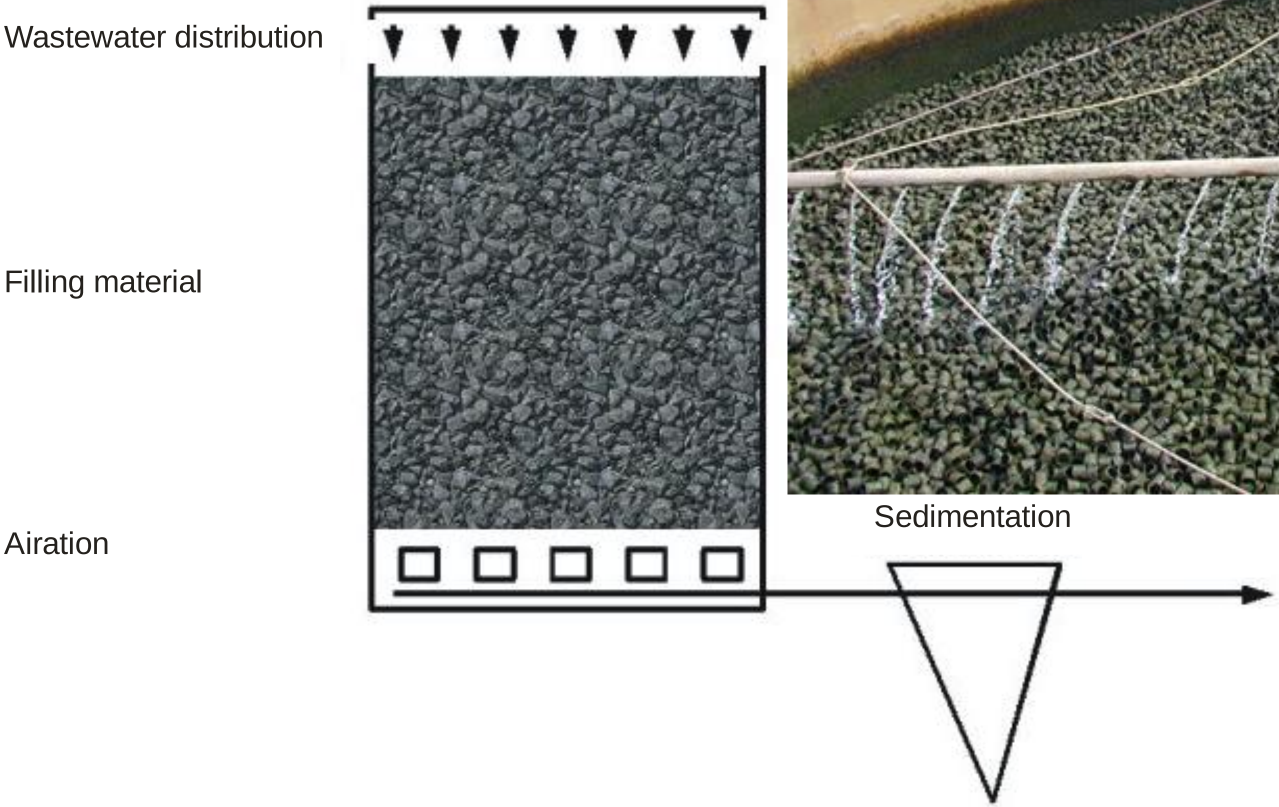
Technical Systems (Trickling Filter, Activated Sludge):

- high density of microorganisms
- low space needed
- high energy demand

Near-natural Systems (Constructed Wetlands, Ponds):

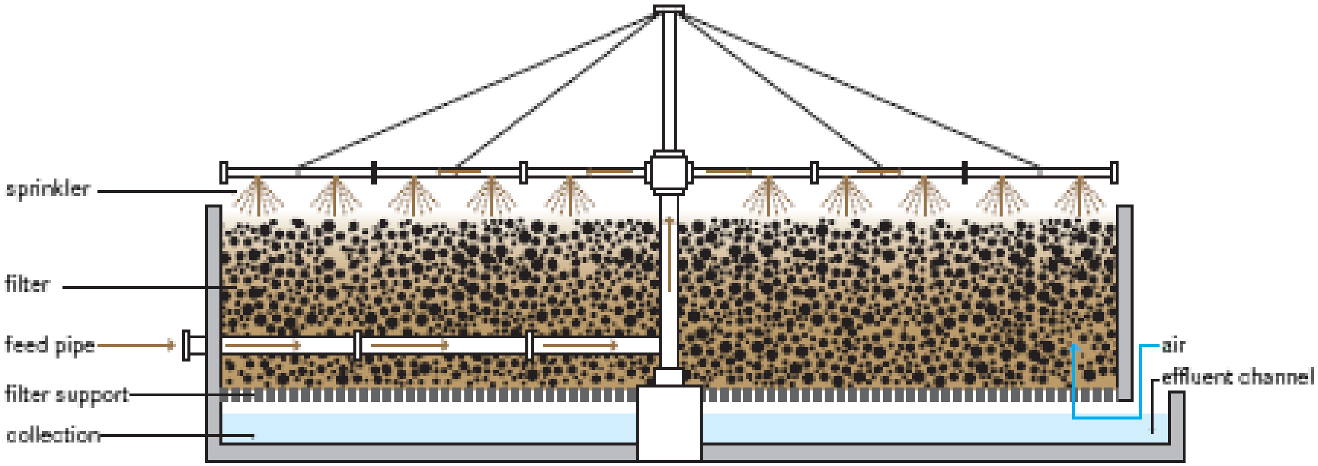
- low density of microorganisms
- high space needed
- low energy demand

Technical System - Trickling Filter



Trickling Filter

- Biological filter that operates under aerobic conditions.
- Pre – treated wastewater is ‘trickled’ or sprayed over the filter.
- Water migrates through the pores of the filter → organics are degraded by the biomass covering the filter material.



Trickling Filter - Summary

+ relatively low energy demand

+ simple to operate

+ low space requirement

- limited elimination rates for some nutrient components (especially total nitrogen)

- relatively high investment and operation cost

- constant supply of energy and wastewater required

Technical System - Activated Sludge

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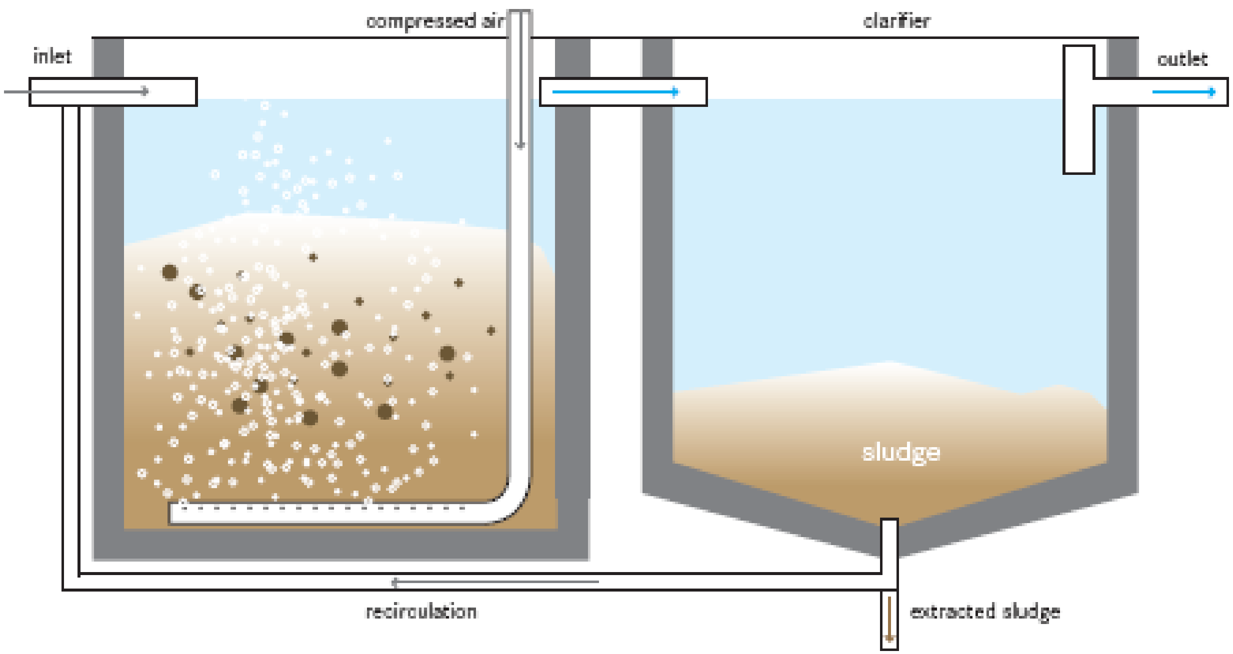
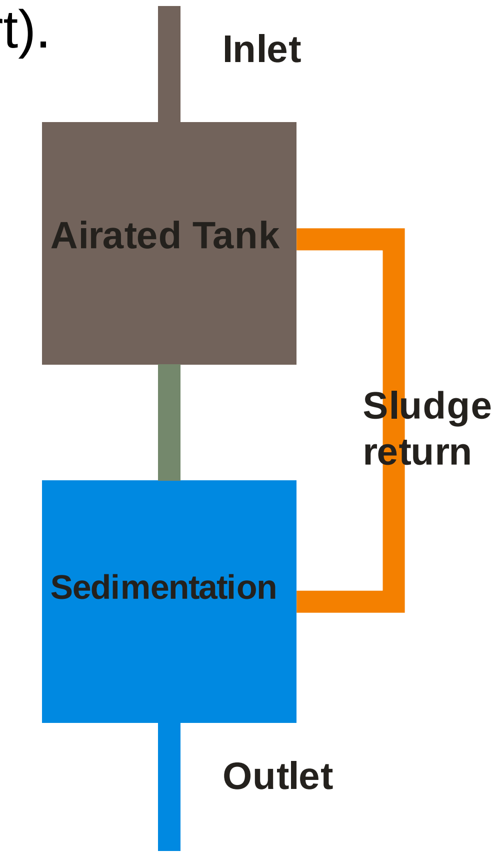
- Multi – chamber reactor unit with different designs.
- Aerated tank: aeration and mixing - aerobic microorganisms are degrading organics (main treatment step).
- Sedimentation: the mixture is transfered to a second unit – settlement of flocs (separation of solid and liquid part).





Activated Sludge

Activated Sludge - Summary

+ high purification efficiency

+ high flexibility

+ low space requirement

+ suitable for big quantities (large amounts of water)

- difficult to operate

- high capital and operation costs

- constant high energy demand

Near-natural System - Ponds (unaerated)

Inlet

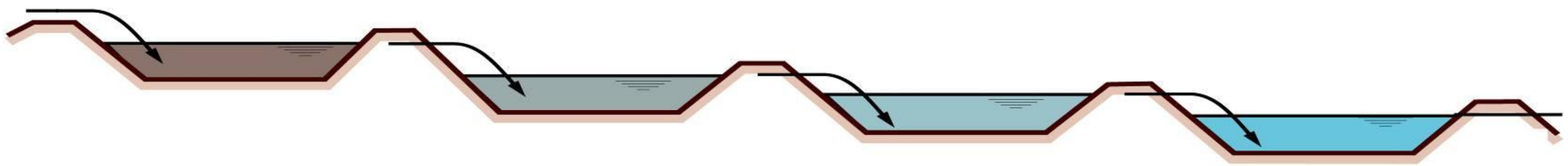
Unaerobic Pond (sedimentation)

Facultative Pond

Aerobic Pond

Outlet

Near-natural System - Ponds (unaerated)



	Anaerobic Pond	Facultative Pond	Maturation Ponds (aerobic)
Design	Deep (2-5m) and highly loaded but rather small area	Shallow (<1.5m) but large → Oxygen supply (algae, wind, artificial aeration)	Shallow (<1m) but large area
Flow	Hydraulic retention time: 1 to 3 days	Hydraulic retention time: 10 to 20 days	Hydraulic retention time: 10 days
Function	Sedimentation and anaerobic stabilisation of sludge (BOD reduction 40-50%) → **settling**	Aerobic degradation of suspended and dissolved matter (BOD reduction 50-70%) → **degradation**	Final sedimentation of suspended solids, bacteria mass and pathogens → **hygienization**

Ponds (unaerated) - Summary

+ low/no energy demand

+ low operation cost

+ simple to operate

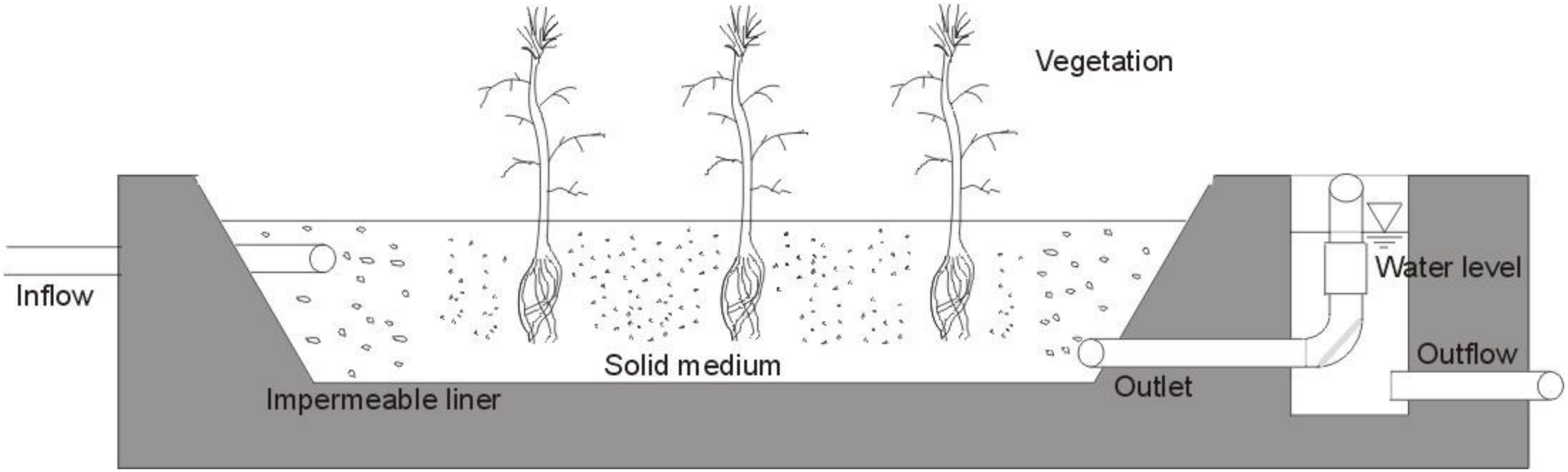
- requires a lot of space - limited by space requirement to smaller settlements (if designed to achieve at least relatively acceptable effluent qualities)

- purification efficiency low compared to other solutions

- huge quantities of sludge to be removed (every 5 – 10 years)

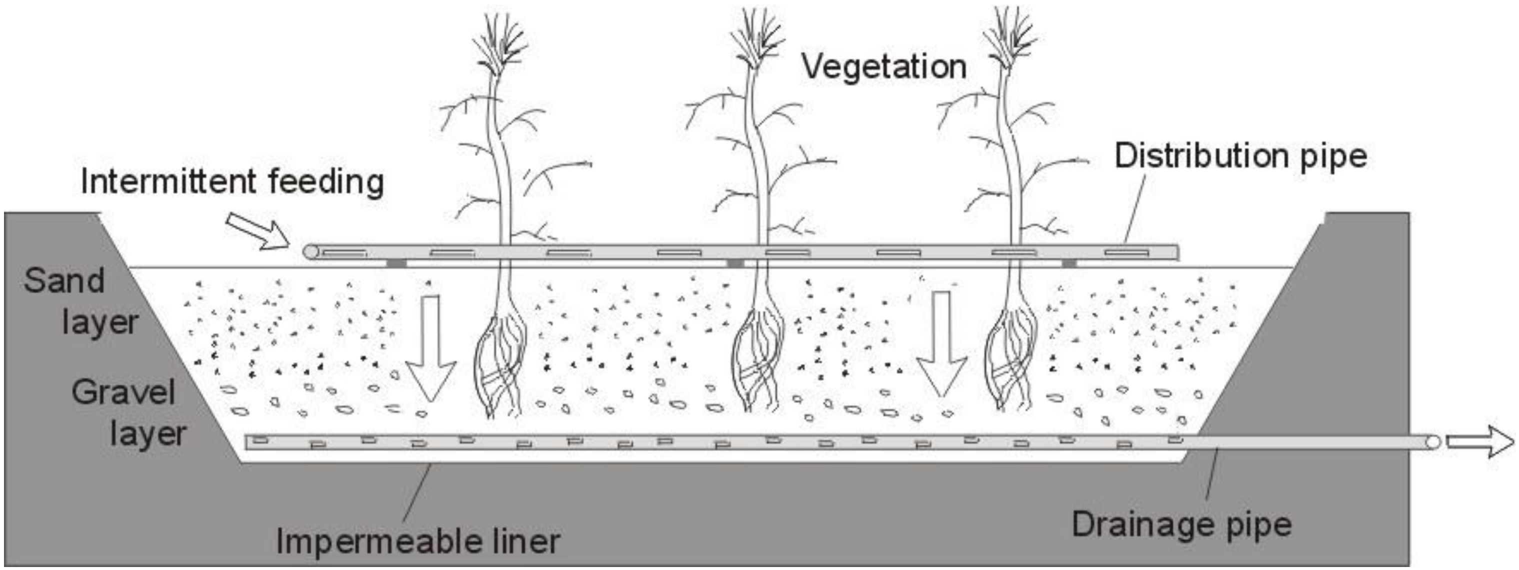
Near-natural System - Constructed Wetland

Subsurface Flow - horizontal



Constructed Wetland

Subsurface Flow - vertical



Constructed Wetland

Subsurface Flow - vertical

Constructed Wetland

Subsurface Flow - vertical

Constructed wetland - Summary

+ low/no energy demand

+ low operation cost

+ simple to operate

+ high purification efficiency for BOD and Ammonia (in case of vertical subsurface flow only)

- limited by space requirement to small settlements

- elimination of phosphorous limited

- very sensitive to overloading

Efficiency of Biological Wastewater Treatment

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	Trickling Filter	Activated Sludge	Constructed Wetlands	Ponds (unaerated)
Removal of Organic Substances (BOD_5)	>95%	>95%	>95%	85 - 95%
Removal of NH_4	99%	99%	99%	25%
Removal of NO_3	0	>70%	0	>50%
Removal of PO_4	possible by precipitation	>80% biological luxury uptake possible by precipitation	temporarily by adsorption	20%
Space needed per person equivalent	0,05-0,1m²	0,025-0,1m²	1,5-2m²	5-20m²
Energy needed per person equivalent and year	10kWh	100kWh	0-1kWh	0-1kWh

Wastewater Treatment - Cost

Investment (Eastafrican conditions):

- sewer incl. manholes: app. 50 – 100 Euros per 1 m
- wastewater treatment plant: app. 500 – 1000 Euros per 1 connected person[1]

[1]...no significant difference between technical and near-natural systems

O&M annually (Eastafrican conditions):

- sewer incl. manholes: app. 0,50 – 1,00 Euros per 1 m

- wastewater treatment plant: app. 30,- – 70,- Euros per 1 connected person[1]

[1]...higher value for technical systems due to energy demand.

Cost reduction potential - general

The cost reduction potential is generally very limited:

water borne sanitation is expensive

Cost reduction potential - sewer

- minimise diameter

  limited by flow and technical requirements for cleaning
- minimise depth

  limited by diameter and load (e.g. in roads)
- increase manhole distances

  limited by terrain and technical requirements for cleaning
- optimise routing to avoid costly surface rehabilitation

- optimised settlement planning (e.g. avoid pumping stations, short connections, ...)

Cost reduction potential – wastewater treatment

- avoid combined sewers
- reduce (organic) load (separation at source)
- plan and implement in stages (starting with lower purification efficiency but plan upgradable)

Further topics

... to be addressed when considering wastewater treatment:

- anaerobic pre-treatment (theoretical reduction of operational cost due to biogas production; however high investment cost, low efficiency in terms of effluent quality and difficult to operate)
- sludge treatment (all technologies produce sludge which requires further treatment)

Do you think you can manage a system like this?