Biogas sanitation
- concept and technology -

Appropriate sanitation for the developing world
Ås, Norway - August 2006

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A few basic findings:

- Wastewater treatment is one of the last priorities of public and private investment.
  -> nobody is interested, "arrangements" are easier
- Conventional treatment units are too expensive.
  -> difficult to demand their installation
- Conventional treatment units require skilled operators.
  -> often not performing, most of the time out of order
- Conventional treatment units operational costs are high.
  -> switched off to safe energy
- Conventional treatment units require regular maintenance.
  -> often not performing, most of the time out of order
- Conventional treatment units destroying agricultural nutrients
  -> often only end-of-pipe systems without water, energy, and nutrient recycling
- Grey water is often not considered in on-site (dry) sanitation concepts
- Nobody enjoys handling wastewater

Conclusion:

There is a technological gap between on-site dry sanitation systems and centralized highly sophisticated waste water treatment plants.

Discrepancies we do need to overcome

- The technology offered does not match with the technical skills available.
- The investment costs do not match with the possibility/ willingness to pay.
- The required input for operation (financing, time, labor, skills) do not match with the readiness to provide it.
- The discharging standards do not match with the possibility to enforce them.
- The urgency of pollution control do not match with the awareness and information levels.
- The assigned responsibility for waste water do not match with the capacity to deliver accordingly.

That is why….

….. Ecological Sanitation is an approach,

rather than a hardware package

"Washers and Wipers"

"Sitters or Squatters"

Different strokes
for
different folks

"People should not face west (east, …) when using the toilet, as that is the direction of Mecca."

International comparison of faecal production

Country	wet mass kg/cap/day	Country	wet mass kg/cap/day
China	0,26	Uganda	0,47
Europe	0,15	North America	0,15
India	0,28	The Netherlands	0,19
Kenya	0,52	Sweden	0,14
Malaysia	0,48	Peru	0,32

Source: WASTE, The Netherlands, 2006

Technology solutions / modules

1. Separated collection

„High-tech"
- Double or triple sewer piping system in households and buildings
- Vacuum toilets / vacuum sewer / urine-diversion-toilets / low flush & pour flush / incineration toilet

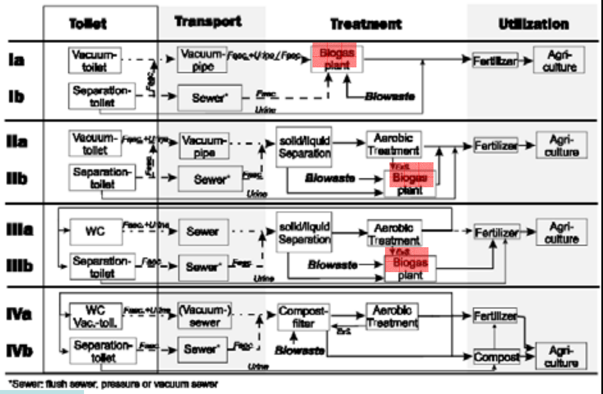
„Low-tech"
- Appropriate on-site or neighbourhood oriented sanitation systems: with urine diversion / liquid-solid separation / dehydration toilets / dry urinals / compost toilet

2. treatment
- Separating (faeces / urine vs. liquid / solid)
- Anaerobic digestion (faeces / organic waste)
- Drying (faeces / urine)
- Storage (liquids / urine)
- Composting (faeces / organic waste)
- Constructed wetlands / sand and gravel filtration / maturation ponds / membrane technology (grey water / black water) / filter bags / French drain
- Sun-UV-Radiation etc. (purified grey water)

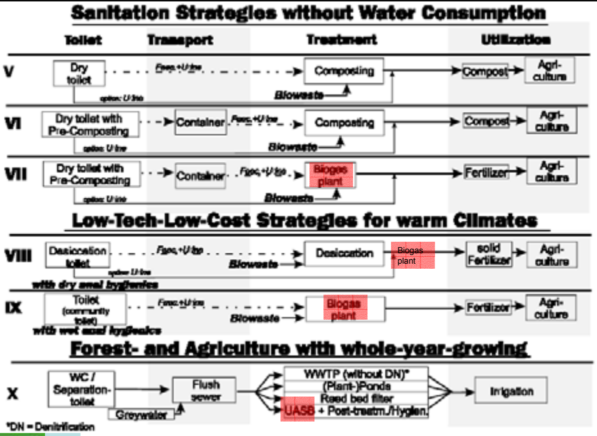
3. utilisation
- Fertilizer or soil conditioner in agriculture (faeces / urine / organic waste)
- Irrigation (grey water, rainwater)
- Groundwater recharge (purified grey water / rainwater)

Ecological Sanitation Concept

Sanitation Strategies with Water Consumption



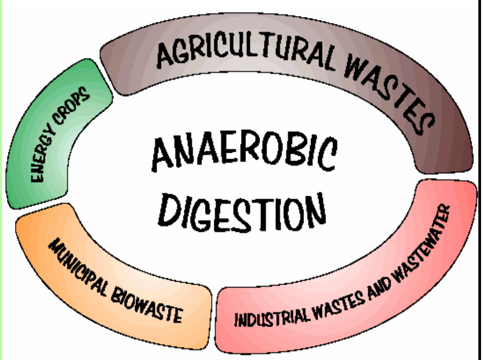
Sanitation Strategies without Water Consumption



In principle, all organic materials can ferment or be digested:

faeces from cattle, pigs and possibly from poultry and humans, organic waste, energy crops, and organic loaded wastewater.

The maximum of gas-production from a given amount of raw material depends on the type of substrate.



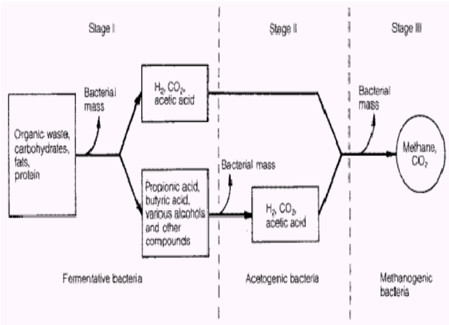
anaerobic digestion for treatment of organic material

Products put into the digester are composed mainly of carbohydrates with some lipids and proteins. The digestion has three main stages.

The first, hydrolysis, involves breaking down the large macromolecules to sugars, amino acids, and fatty acids by bacteria under aerobic conditions.

The second stage is acetogenesis, during which acetogenic bacteria convert sugars into short-chain acids, mainly acetic acid.

The third stage is methanogenesis, which is carried out by anaerobic bacteria. Here, the acids are converted into methane.



Advantages of Anaerobic Digestion Treatment (van Leir, 1998)

- **No, or very low energy demand**
- **Production of valuable energy in the form of methane**
- **Low investment costs and low space requirement**
- **Applicable at small as well as large scale**
- **Low production of excess sludge, which is well stabilized**
- **Low nitrogen and phosphorus requirements**
- **High loading capacity (5-10 times that of aerobic treatment)**
- **High treatment efficiencies**
- **Suitable for saisonal housing with long term periods without discharge of waste water**
- **Effluents contain valuable fertilizers (ammonium salts)**

Biogas sanitation

Human excreta from dry or low flush toilets and biodegradable organic fraction of household waste could enter a (domestic) anaerobic (wet or dry) digester to produce biogas.

For a biogas plant only regarded from an **energy point of view**, it is better to have some animal manure or additional feed of organic waste.

For biogas plant **as a sanitation option** it is more important to look for the sanitization of the incoming black-, brown-, or wastewater and organic wastes. Therefore the input material stays longer in the digester, and the retention time will be adopted with an optimum of sanitation degree and biogas production.

Biogas from brown water

The concentration of nitrogen in the black water cold be so high, that the digestion process could be stopped. Ammonia from the urine will be transformed by enzymes in urea, carbon dioxide and ammoniac. Urea will be toxic to the bacteria (self-intoxification).

This could be solved by solid/liquid separation (AQUATRON, filter bag, settler) or urine diversion toilet bowls and pans and only the “solid” part (faeces, sludge) are digested.

Ecological Sanitation is led by some principles, which represent the guide frame for designing

- **Decentralization:** Responsibility, Capacity, Treatment, etc.
- **Simplification:** Process, Technology, O&M,
- **Conservation: & Recycling** Water, Nutrients, Energy

1) Prevent disease: A sanitation system must be capable of destroying or isolating faecal pathogens.

2) Affordable: A sanitation system must be accessible to the consumer.

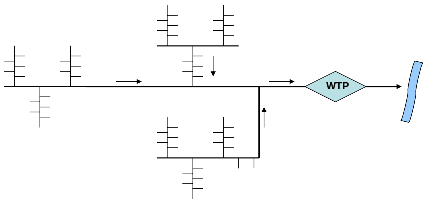
3) Acceptable : A sanitation system must be aesthetically inoffensive and consistent with socio-cultural values.

4) Simple : A sanitation system must be robust enough to be easily maintained with the available technical capacity, available institutional framework and economic resources.

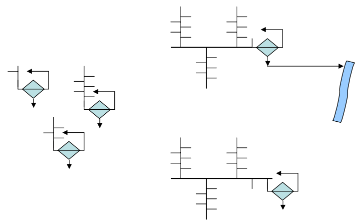
5) Protect the environment and returns nutrients: A sanitation system must prevent pollution, return nutrients to the soil, and conserve valuable water resources.

Decentralization

Centralized WW Collection and Treatment



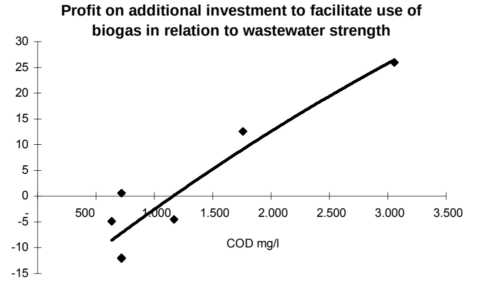
Decentralized WW Collection and Treatment



Decentralize responsibility

- Application of the principle "The polluter *pays*"
  - In industrial sector accepted
  - For domestic sector not accepted
  - A treatment unit near to the producer allows specific control

economy

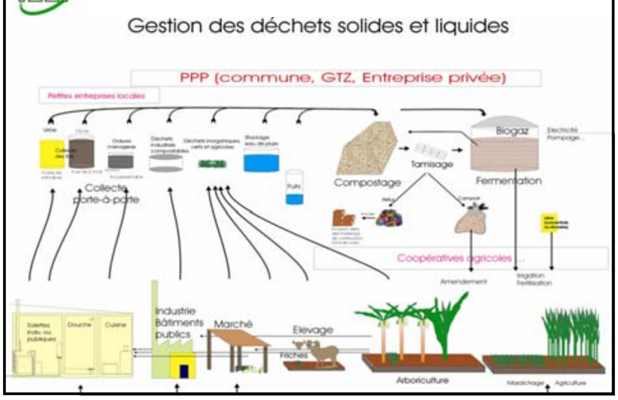


Sasse, Otterphol **1998**

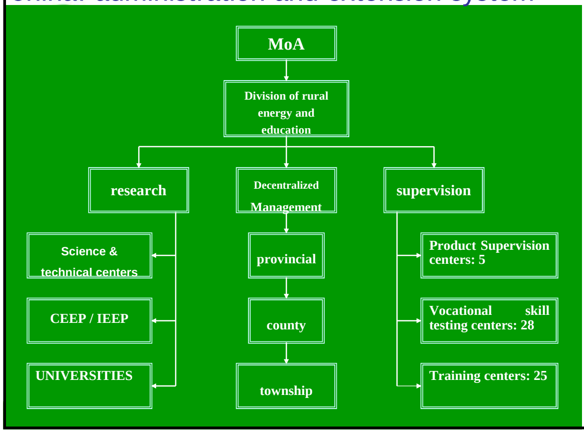
Decentralize responsibility (cont.)

- Assign responsibilities
  - Individuals (demand)
  - Builders (technical offer)
  - NGO (Awareness, Training, DEMO)
  - Research institutions (develop option)
  - Municipalities (enforcement, control)
  - Legal entities (legal provisions)

example of an community ecosan – biogas system:



China: administration and extension system

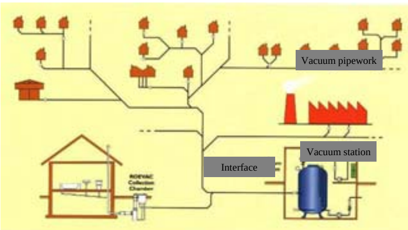


Decentralize technology

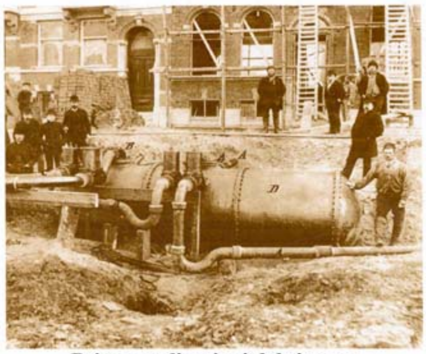
- Treatment close to where it is generated
  - Reduction of trunks and collector sewer
  - Reduction of intermediate pumping stations
  - Introduce low water sewer systems (vacuum sewer)

ROEVAC® - general description

Schematic overview

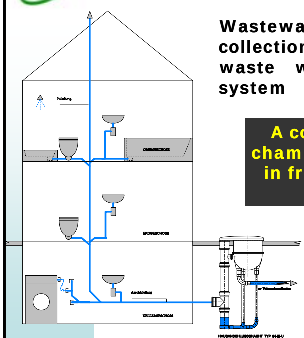


Every vacuum sewage system consists of 3 main components:
- **House collection chamber ROEVAC®** with interface unit
- **Vacuum sewer network** for the transport of sewage
- **Vacuum station** for the suction of sewage to a central point



Prime applicazioni del sistema fognatura sottovuoto
(1873, Amsterdam)

ROEVAC® - general description



Wastewater flows by gravity into the collection chamber; from there the waste water is evacuated into the system

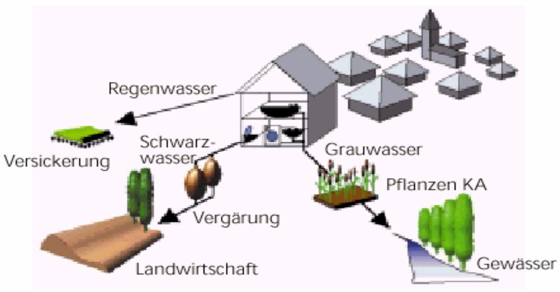
A collection - chamber is sited in front of the house

No modifications inside the house

Decentralize technology (cont.)

- Re-use close to where it is generated
  - Irrigation
  - Gardening
  - Recharge underground water
  - Use soil improver & fertilizer for agriculture

example of an "decentralized" ecosan – system:



WORLD TOILET COLLEGE

Decentralize Capacity

- Centralized design capacity
  - Vocational training
  - Training-on-job
- Decentralized implementation
  - Certified builders, architects, engineering offices
  - Service units

Simplification

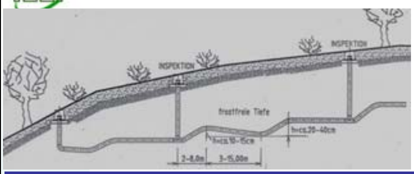
Simplification

Means LOW-TECH,
but not necessarily easy.

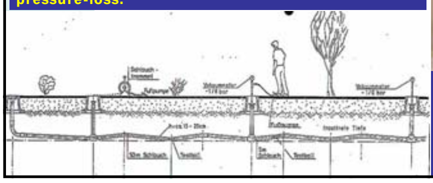
Natural processes
maybe simple from a technical point of view,
but complex from an ecological point of view.

Means CLEVER
Integrated, interdisciplinary work

Maintenance-free sewer lines



Above : a vacuum line at an inclining section. Inspection pipes for easy detection of unforeseen pressure-loss.



Above : For the case of evtl. blockage a manual interruptor and a cleaning pipe can be used. No hygienic risks!

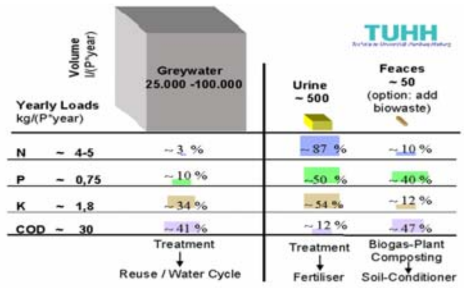
Reduce the treatment volume by limiting the catchments area through decentralization

- Less volume = easier management
- Small surfaces become available for treatment (sidewalks, private yards, parking lots, alleys, parks, etc.)
- Wastewater composition becomes more accountable
- the risk of failure is reduced (all systems fail)

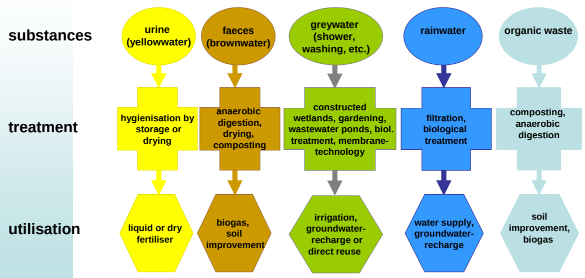
Simplification (cont.)

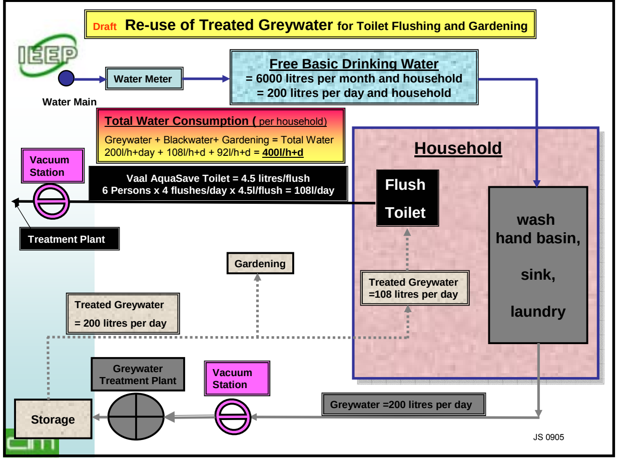
- Separation of waste water streams

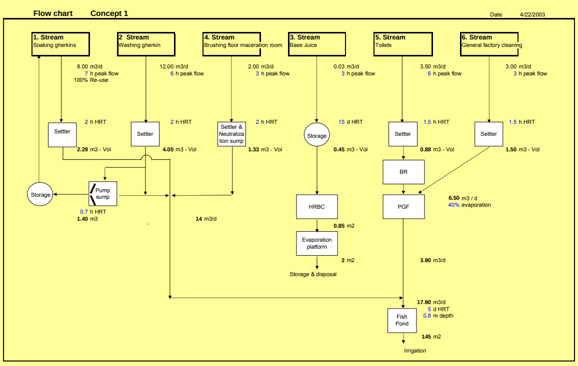
Composition of domestic wastewater



Separation of substances

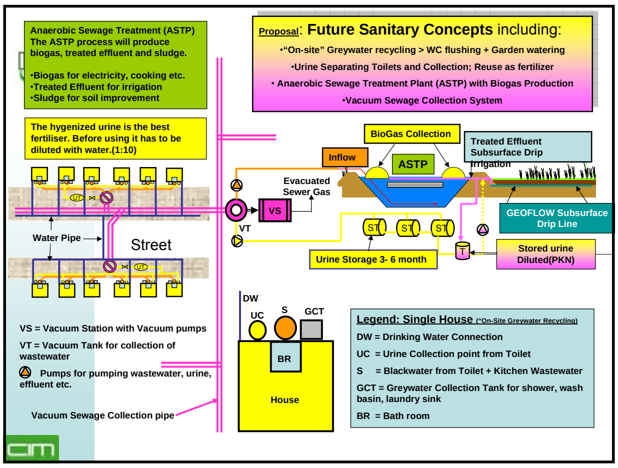






Simplification (cont.)

- Reducing water for transport of residues
  - Reduced volumes to be treated
  - Increased concentration of pollutants

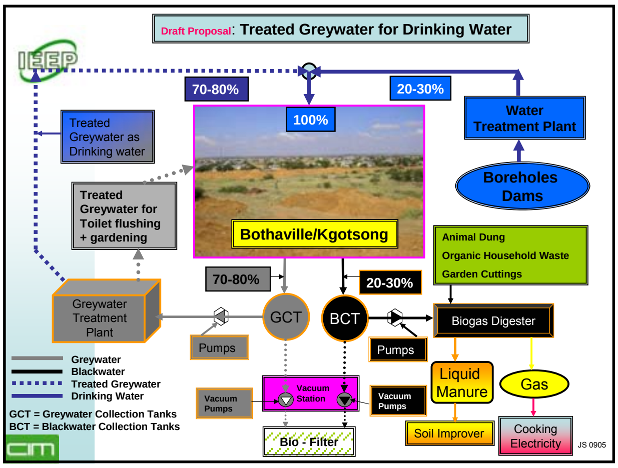


Simplification (cont.)

- Treatment until re-use is possible
  - 1st Identification of re-use options then, planning the treatment unit
    - Most pollutants are substances needed for agriculture
      - Organic
      - Phosphorus
      - Nitrogen
      - Potassium

Simplification (cont.)

•If desirable, combine treatment with other organic feedstock available



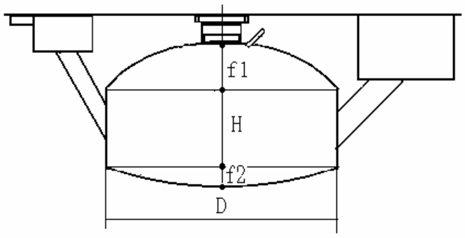
Simplification (cont.)

- Selecting the right technology
  - Priority given to anaerobic technology in warm climates (biogas sanitation)
  - Priority given to aerobic technology in cold climates (bio filter)
  - Anaerobic pre-treatment (biogas-settler)
  - Aerobic pos-treatment (trickling filter)
  - Using gravity instead of pumps
  - Avoiding valves
  - Oxygen incorporation by helophytes (ponds, wetlands)
  - Aeration by vorticity (flow aeration)
  - Opting for condominial sewer lines (small bore sewer system)
  - Integrating treatment modules in 'unused' spaces (alleys, roads, parking areas, gardens, private yards, parks, flower containers etc.)

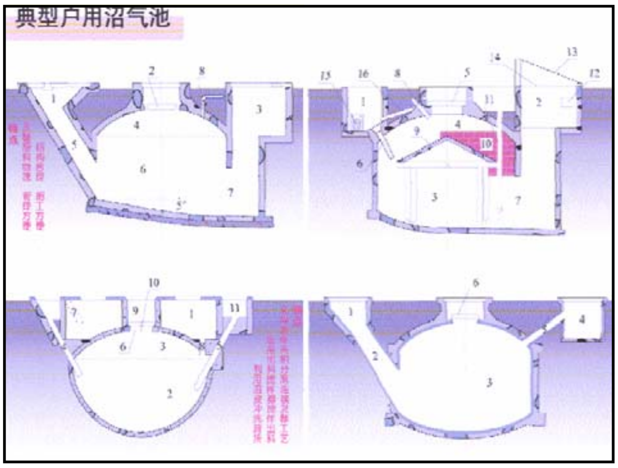
Simplification (cont.)

- Standardization
  - Assign treatment systems to specific decentralized pollution sectors
    - Identify sectors and their clusters
  - Prefabrication of modules (mass production)
    - Single House units
    - Baffle modules
    - Distribution boxes

Basic design formulas

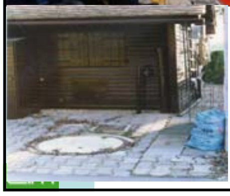


$b_1=f_1/D=1/5$; $b_2=H/D=1/2.5$; $b_3=f_2/D=1/8$



- Applied research
  - Distribution systems
  - Filter material
  - Odour reduction (EM, biofilter)
  - High ground water table solutions

Vacuum black water collection sewer application – in flooding zone



Settlement in an inundation area close to the Rhine-river, submergibility up to 5 m.

TOP: ROEVAC® Collection chamber R 65- 3”-W installed on private ground.

ROEVAC®- Collection chamber R 65 - 3”-DW, heavy duty cover.

Baffled septic tank with or without up-flow anaerobic filter has shown positive results for black water treatment in Vietnamese condition. (***Nguyen Viet Anh, Tran Duc Ha, Tran Hieu Nhue,*** *2nd international symposium on ecological sanitation, april 2003)*

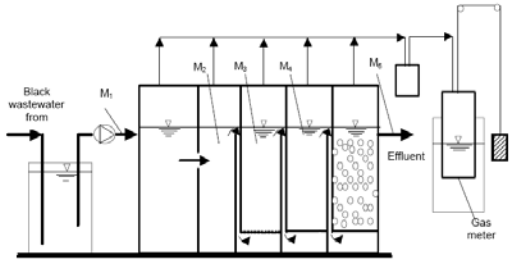


Figure 1: Baffled septic tank with anaerobic filter (BASTAF) M1, M2, M3, M4, M5: Sampling points

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Simplification (cont.)

- Including wastewater treatment unit in the planning and designing task of architects and builders
  - Design buildings taking into account the requirements of treatment units
    - Ensure correct slop to operate per gravity
    - separation of streams,
    - reduction of wastewater
    - integration in the landscape
  - Trained local craftsmen offer technology assed by certified planning units

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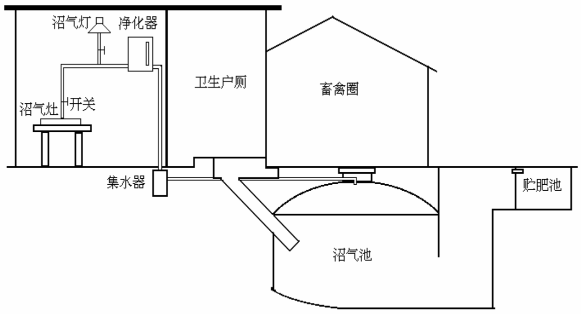
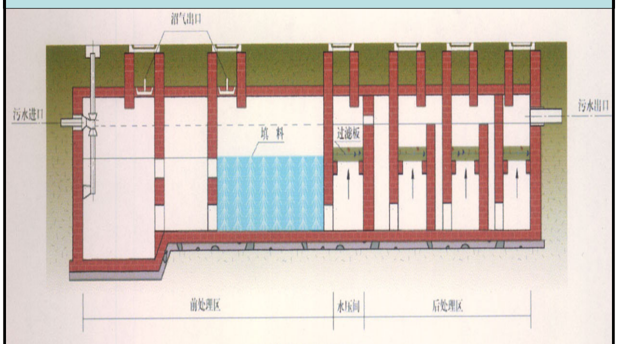
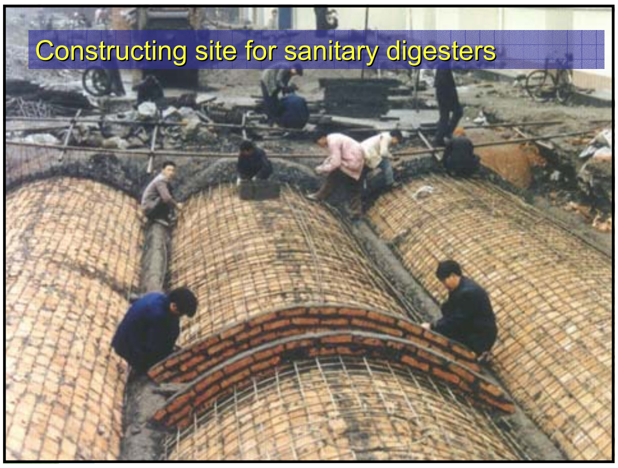
Integrating the biogas septic tank in the housing structure



Township sanitary digesters





Conservation / Recycling

- Conservation of Fossil Energies
  - Reducing electrical equipment
  - Applying anaerobic technology; using biogas
  - Selecting and reducing construction material

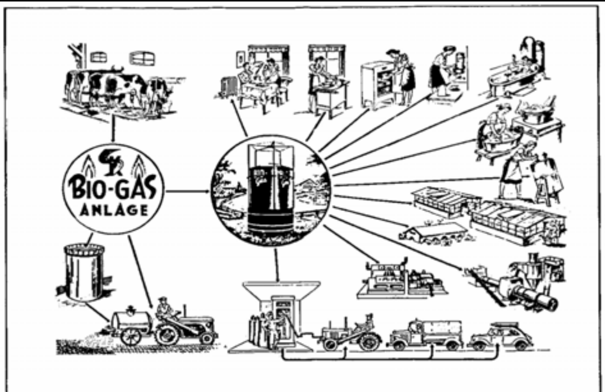


Fig.9. Alternatives of biogas utilization in the FRG in 1957
(prospectus of Seidenstücker Comp.)

Biogas potential

If the daily amount of available dung (fresh weight) is known, gas production per day will approximately correspond to the following minimum values:

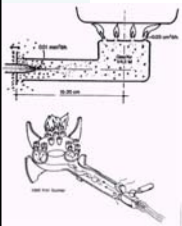
- 1 kg cattle dung 40 litre biogas
- 1 kg buffalo dung 30 litre biogas
- 1 kg pig dung 60 litre biogas
- 1 kg chicken droppings 70 litre biogas
- 1 kg human excrements 60 litres biogas

If the live weight of all animals whose dung is put into the biogas plant is known, the daily gas production will correspond approximately to the following values:

- cattle, buffalo and chicken: 1,5 litres biogas per day per 1 kg live weight

Amount cooked	Time (min)	Gas (L)
1 L water	10	40
5 L water	35	165
500 g rice	30	140
1000 g rice	37	175
350 g pulses	60	270
700 g pulses	70	315

Equipment	Amount of biogas
Household burners	200 – 450 L/h
Industrial burners	1000 – 3000 L/h
Refrigerator 100 L depending on outside temperature	30 – 75 L/h
Gas lamp, equiv. to 60 W bulb	120 – 150 L/h
Biogas/diesel engine per bhp	420 L/h
Generation 1kwh electricity biogas/diesel or gas engines	500-700 L/h

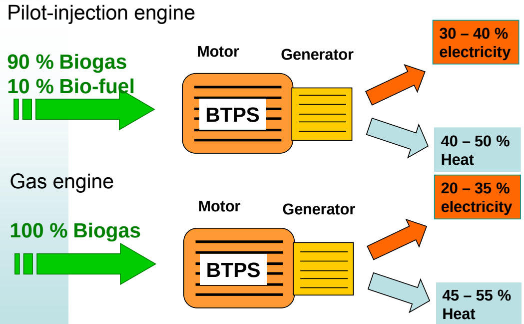


1 m3 Biogas (approx. 6 kWh/m3) is equivalent to:

- Diesel, Kerosene (approx. 12 kWh/kg) 0.5 kg
- Wood (approx. 4.5 kWh/kg) 1.3 kg
- Cow dung (approx. 5 kWh/kg dry matter) 1.2 kg
- Plant residues (approx. 4.5 kWh/kg d.m.) 1.3 kg
- Hard coal (approx. 8.5 kWh/kg) 0.7 kg
- City gas (approx. 5.3 kWh/m3) 1.1 m3
- Propane (approx. 25 kWh/m3) 0.24 m3

Sasse, India, 1988

Biogas Utilization



Biogas for combined heat and power generation (CHP)

Sterling engine:
- external combustion
- simple technology
- continuous combustion
- low noise emission

Sterling engine

WhisperGen MCHP

Technical Data:
- Electrical output 750 W
- Thermal Output 6 kW
- Energy Input 8 kW
- 1,4 m³/h Biogas (60/40)
- Pressure 20 mbarü

Biogas 'GENSET'

- reciprocating internal combustion engine,
- related to those found in trucks and buses,
- for decades provided power for off-grid applications.

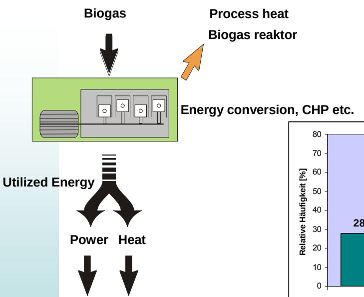
Elektro HAGL biogas GENSET company, Germany

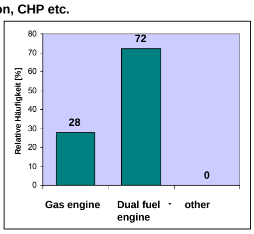
CHP – wide range scaling

- efficiencies in producing electricity range from 20-45%,
- depending largely on the size of the plants,
- range from 5-10,000 kW.

Elektro HAGL biogas GENSET company, Germany

Biogas Conversion





Energy Equivalent of Biowaste

有机垃圾所含能量

10 kg Kitchen waste
10公斤的厨余垃圾

↓

1 m³ Biogas = 0.75 m³ Natural gas
1 m³ 的有机气体= 0.75 m³天然气

↓

1 l Gasoline，1 升汽油

↓

20 km Car mileage
可供一辆轿车行驶20 km

↓

1 kg Biowaste = 2 km car mileage
1 kg的有机废物=可供一辆轿车行驶2 km

Energy Content of Biogas 沼气的内能

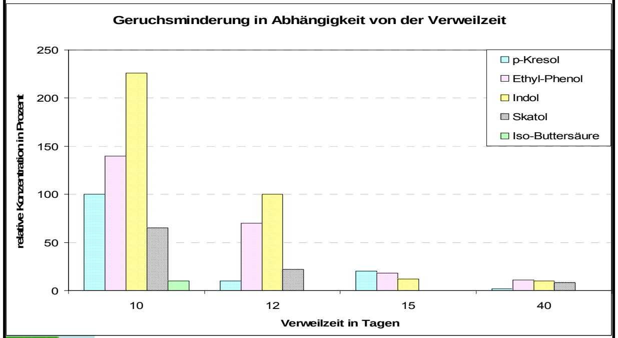
In China the rural families can cover their energy demand by 60 % from Biogas produced from their own BW
中国农村家庭所需能量的60%可由自己家庭日常生活垃圾经处理产生的甲烷提供

One family (3 persons) produces about 4 kg Biowaste a week = Energy equivalent to 8 km car mileages
一个三口之家每星期产生4kg有机垃圾，其所含能量可供一辆轿车行使8km

The overall biogas production potential from 75 mill.t of Chinese BMW is equivalent to 4.5 billion m³ natural gas

- Conservation of fresh water resources
  - Reducing water for transport (water-saving devices, water- saving attitude)
  - Substituting fresh water by treated wastewater (agriculture, cleaning)
  - Treatment of pathogens
  - Odor reduction

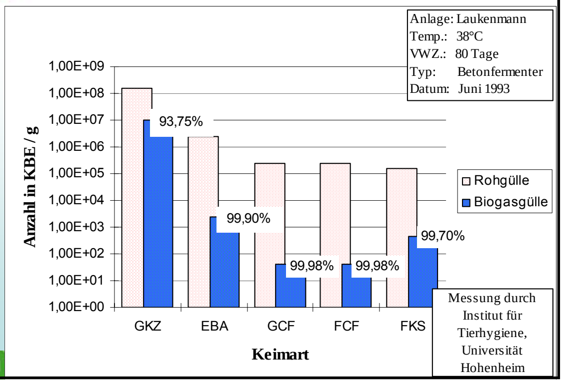
Smell reduction through digestion



Anaerobic sanitization (BRTC, China 1985)

Pathogens &parasitic ova	Thermophilic fermentation (53-55 degrees C)		Mesophilic fermentation (35-37 degrees C)		Ambient temp. fermentation (8-25 degrees C)	
	days	Fatality (100%)	days	Fatality (100%)	days	Fatality (100%)
Salmonella	1~2	100	7	100	44	100
Shigella	1	100	5	100	30	100
Poliviruses			9	100		
Colititre	2	10^{-1}~10^{-2}	21	10^{-4}	40~60	10^{-4}~10^{-5}
Schistosoma ova	Several hours	100	7	100	7~22	100
Hookworm ova	1	100	10	100	30	90
Ascaris ova	2	100	36	98.8	100	53

Reduction of pathogens



Retention time

Under plug flow conditions – without post-treatment in wetlands or polishing ponds – the usual treatment of faecal sludge – after urine separation –,

1. anaerobic psyrophilic fermentation (above 10° C and retention times of at least 40 -100 days),
2. mesophile digestion (above 30° C with retention times of at least 20 – 50 days) or
3. thermophile digestion temperature (above 55° C and about 5 – 10 days retention time),

can be considered as sufficient.

- Conservation of nutrients
  - Returning nutrients contained in the wastewater to the fields (peri-urban agriculture)

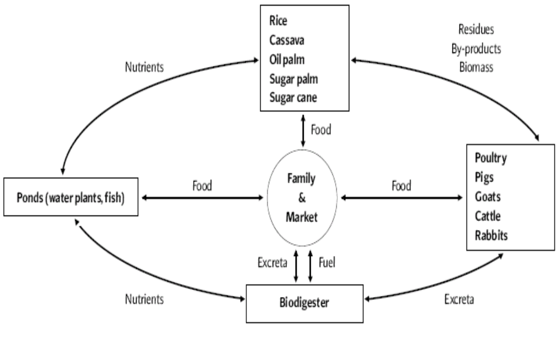


Figure 1. The integrated farming system

Recycling on household-level:

Biogas production from cattle dung and toilet waste

Use of energy and nutrient content

ecosan-example in Dhapasi, Nepal

Wastewater from Toilets
Dung from cattle

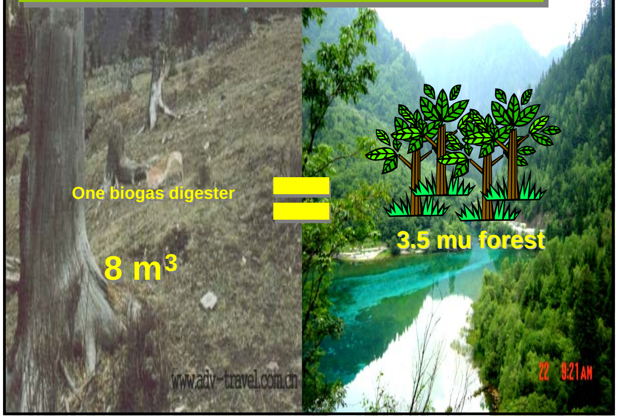
Small biogas reactor
for 1 household

Use of biogas for cooking
Use of slurry for garden fertilizing

Conservation and Recycling

- Use of the treatment products
  - **Treated wastewater** (Irrigation, water recharge, technical water, landscaping, micro- climate)
  - **Nutrients** (agriculture, horticulture, forestry, aquaculture)
  - **Biogas** (heating, electricity generation)
    Methane = greenhouse gas

Environmental benefit



Conservation and Recycling

- Locate the treatment where the products are needed
  - Public recreation areas
  - Farm land
  - Industry (co-fermentation)
- Centralized utilization of waste water, grey water, black water treatment products
  - Sludge digestion centers at focal points
    - Cogeneration
    - Compost
  - Treated wastewater pipeline
  - Urine collection centers

Summary: Source control and reuse of treated waste

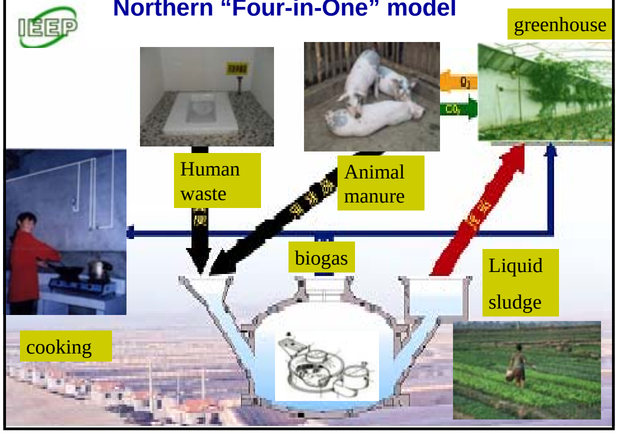
(Ralf Otterpohl, Andrea Albold and Martin Oldenburg: Differentiating Management of Water Resources and Waste in Urban Area)

1. Basic prerequisite for sanitation systems that care for the survival of our mankind, future sanitation concepts should produce a rich organic fertilizer for agriculture rather than waste.
2. One person can produce as much fertilizer as necessary for the food needed for one person (Niemczynowicz, 1997).
3. However the cycles should not be too short (industrial/energy crops first) and appropriate treatment is necessary.
4. First priority of all possible concepts is the consideration of hygienic aspects - alternative concepts can and should be better solutions in this respect, too.
5. As one of many technical solutions separated black water can be treated anaerobic in biogas plants.
6. The combination with the digestion of organic household wastes results in a mixture that is suitable for this process.
7. Separation of different qualities and their respective appropriate treatment for reuse is common in industry and is fundamental for new concepts.

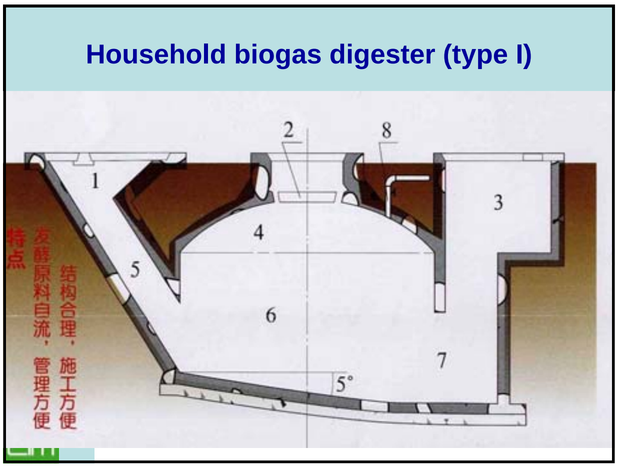
technical approaches

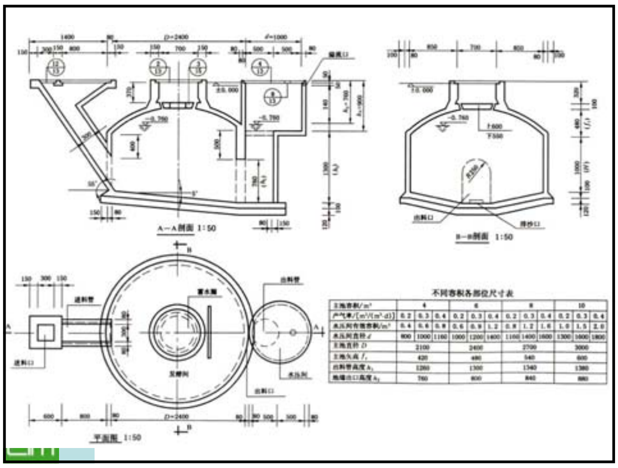
Household biogas

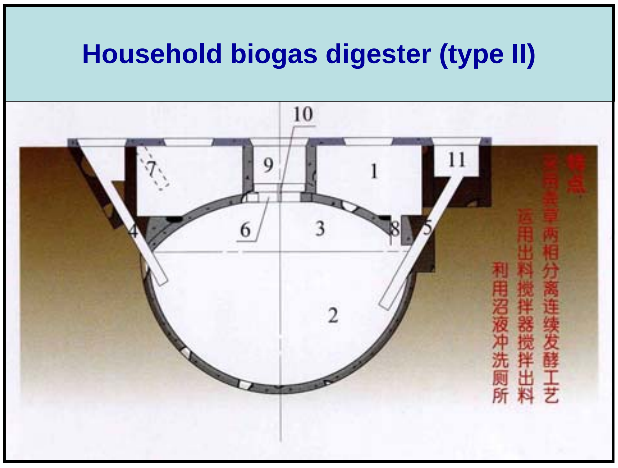
Northern “Four-in-One” model

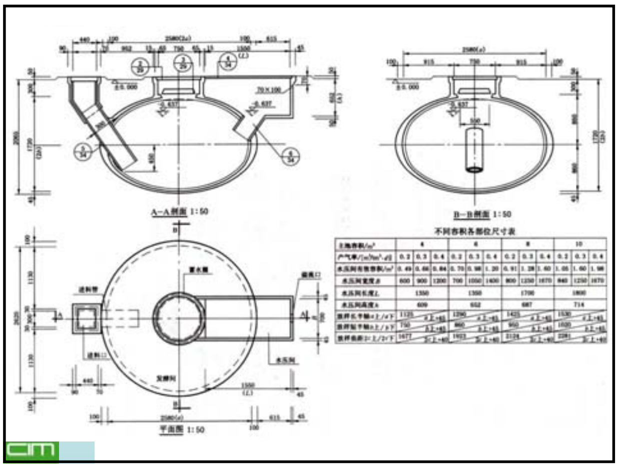



toilet
沼液冲厕器

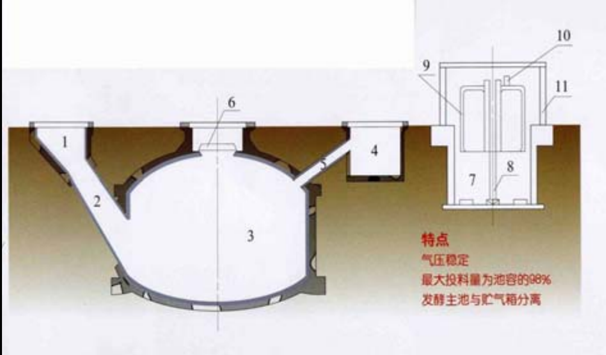

Household biogas digester (type I)
特点
发酵原料自流，管理方便
结构合理，施工方便
1
2
3
4
5
6
7
8
5°

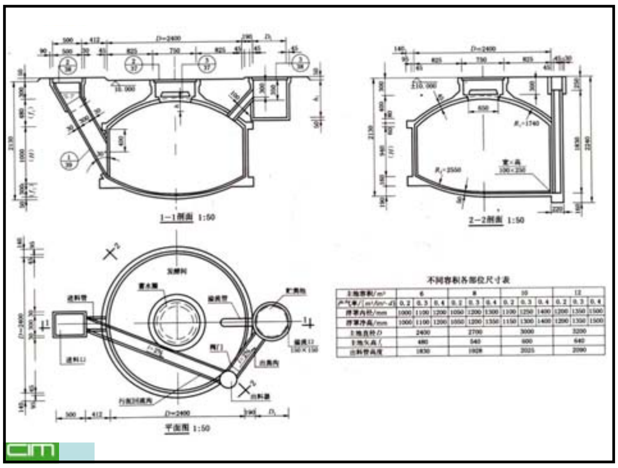


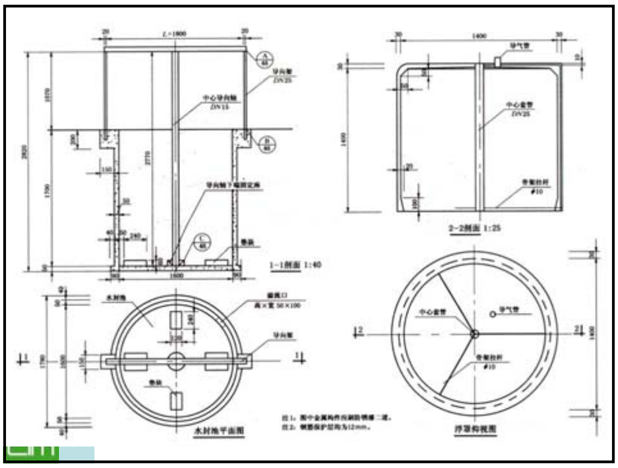

Household biogas digester (type II)
特点：
采用沼草两相分离连续发酵工艺
运用出料搅拌器搅拌出料
利用沼液冲洗厕所
1
2
3
4
5
6
7
8
9
10
11



Household biogas digester (type III)







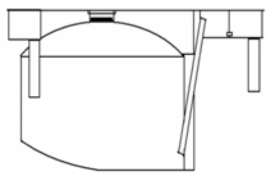
Household biogas digester (type IV)

Sanitary design details

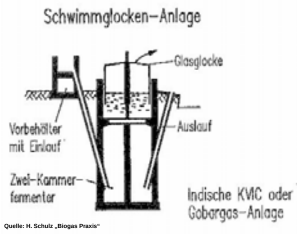
Avoiding

Sanitary design details

Sanitary design details



Floating Drum Biogas Plant



Small scale

- **well known construction**
- **easy to maintain**

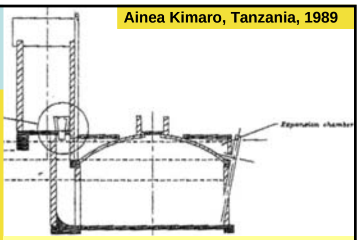
Examples

Sanitary digesters

The sanitary biogas unit

1. main planning criteria are the aimed sanitary conditions which depend on frequency of use, frequency of cleaning, and safe slurry disposal.
2. no handling of fresh human excrete; even accidental touch should be avoided
3. no access of flies to undigested excrete
4. no worms may escape from the pedestal
5. no bad odor and no indecent appearance
6. additional feeding with animal dung or kitchen waste is possible.
7. slurry should be used for fertilizing trees or shrubs but not vegetables.

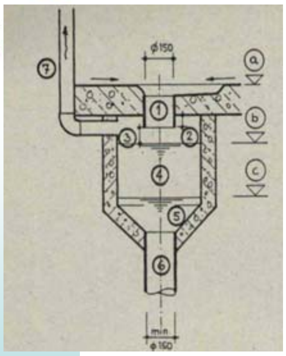
Ainea Kimaro, Tanzania, 1989



Toilets connected to a simple fixed dome biogas plant should be pedestals where a minimum of water is used for cleaning.

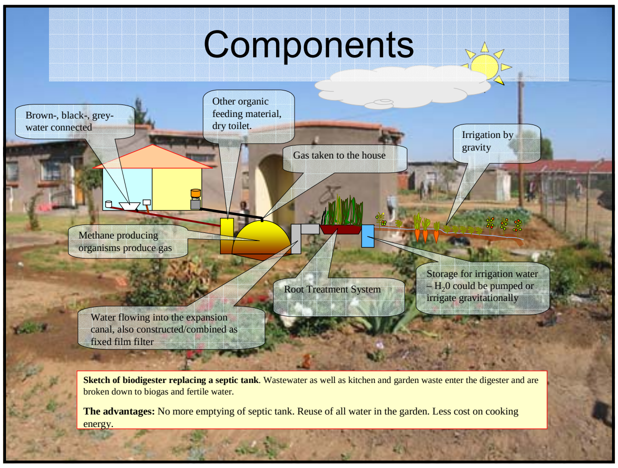
Only dry and low flush toilets are suitable for connection to biogas plants of less than 30 m3 digester volume because of the danger of diluting the slurry and thus reducing the retention time.

The toilet chamber is connected to a vent pipe which passes the roof. It is placed outside, not shaded, and is painted black as to heat up for better draft.



toilette connection to a Biodigester

(a) toilet floor;
(b) highest and
(c) lowest slurry level;
(1) inlet pipe;
(2) bottom rim of inlet pipe ;
(3) inlet piece always above highest slurry level;
(4) feeding chamber;
(5) Slope
(6) down pipe;
(7) vent pipe.



Running cost (-) or benefits (+) in Maluti per year (4 person household)

• Conventional septic tank	- 600
• Biodigester septic tank	+400
• Cheap pit latrine	- 50
• Sophisticated double vault VIP latrines	- 100
• Ecosan toilet with urine separation, utilizing compost and urine	+200
• Minimum urine separation set up, utilizing urine only	+ 30

MCK plus++ community system

The **MCK plus ++ community sanitation system** provides facilities such as bathrooms, toilets, laundry cleaning and consists of an integrated community "water point" for provision of drinking water. In addition The MCK plus +++ consists of an integrated underground wastewater treatment unit which is based on the **biogas sanitation concept and *technology***, and functions without external energy inputs

The advantages of this system are:

¨ *Low maintenance cost,* no hi-tech equipment/movable parts required

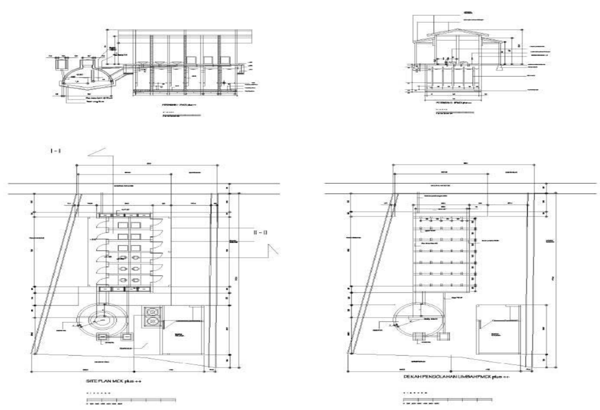
¨ *Wastewater pollution reduced by up to 90 %,* therefore reducing surface-water pollution

¨ *Ground water is not polluted,* the construction of the waste water treatment plant is waterproof and airtight

¨ *Biogas production,* provides energy for household cooking needs

¨ *Long de-sludging intervals,* de-sludging required every 2 - 3 years only

Due to these advantages MCK plus ++ is an ideal community sanitation solution for densely populated urban low income settlements where toilets and bathrooms are not available in private household.



BIOGAS DIGESTER

- Brick construction, fully water-proof and airtight plastering
- Functions as settler for “black water”
- Biogas produced consumed by households
- Connected to “Baffle Reactor”

BAFFLED REACTOR

- Simple and long lasting structure, efficient but low-cost wastewater treatment plant
- Underground construction below toilets/ bathrooms
- Based on anaerobic up-flow principles
- BOD reduction up to 90 %

BATHROOM & TOILET

- Long lasting, easy to maintain features
- Fully tiled wall and floor
- Modular design

UNIT MCK plus ++

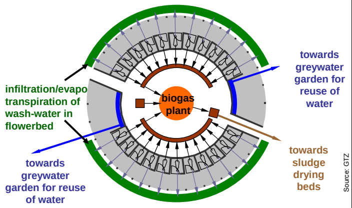
- The innovative sanitation concept consists of toilets, bathrooms, facilities for laundry cleaning and an integrated wastewater treatment system
- MCK locations are landscaped and have street access

ecosan pilot projects

Upgrading of a vocational training institute Maharashtra State, India

- 250 resident students
- Combination of 2 urine-separation double-vault vermitoilets and a common toilet block of 24 cabins linked to a biogas plant
- Reuse of showers and kitchen greywater for irrigation (after organic filtration)

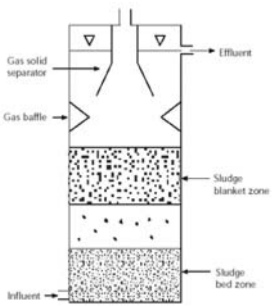
(supported by NAVSARJAN Trust, UMB, SDC and GTZ)



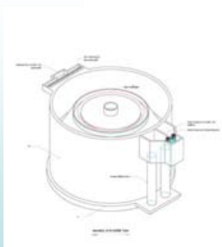
Examples

UASB systems

upflow anaerobic sludge blanket



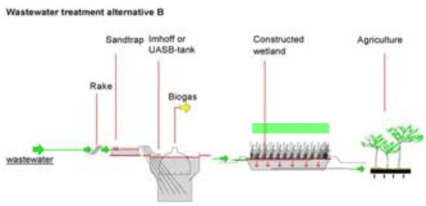
Appropriate Design and Construction of UASB-Reactors



UASB Chiang Mai University Chiang Mai / Thailand, 1990

Wastewater treatment with UASB and Wetland

- Alternative B



UASB-reactors

Units	4
Diameter	7 m
Total volume	1000 m^3

Constructed wetlands

Units	4
Length	62 m
Width	20 m
Total surface	5000 m^2

Construction phase of UASB - Biogas Plant, Thailand

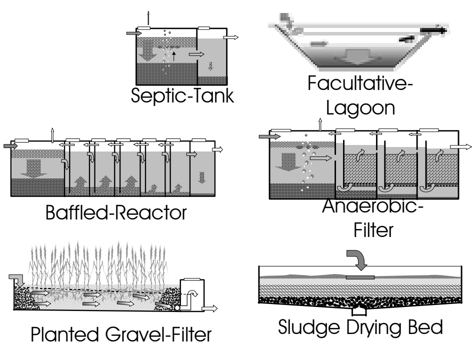
Examples

DEWATS Examples

DEWATS concept incorporates the following attributes:

- Treatment for organic wastewater from domestic and industrial sources
- Affordable prices
- Fulfillment of discharge standards
- Treatment of wastewater flows from 1-1000 m^3/d
- Tolerance to inflow fluctuation
- No dependence on energy
- Minimal maintenance
- Reliability and longevity
- Reuse of wastewater and its contents

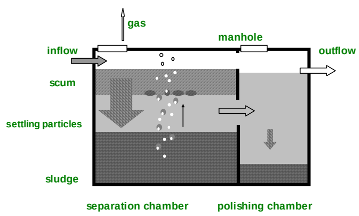
DEWATS Modules



Septic Tank

Principle of the Septic Tank

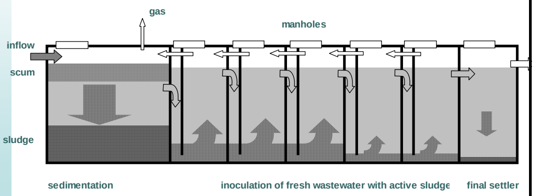
1. Sedimentation and floatation
2. Fermentation of bottom sludge

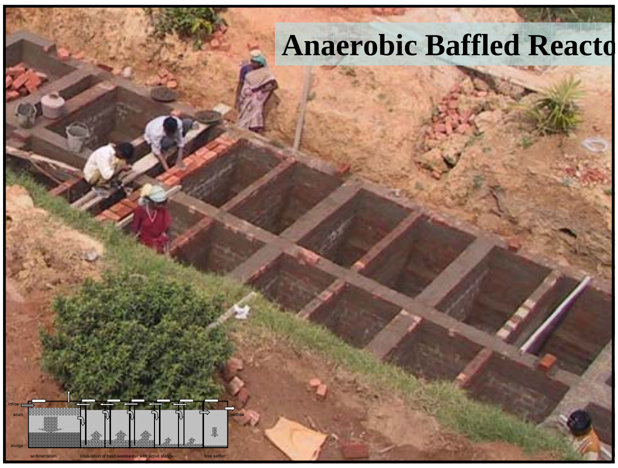


Baffled Reactor

Principle of Anaerobic Baffled Reactor

1. Sedimentation / floatation of solids
2. Anaerobic digestion of suspended and dissolved solids through sludge contact
3. Anaerobic digestion (fermentation) of bottom sludge
4. Sedimentation of mineralised (stabilised) suspended particles

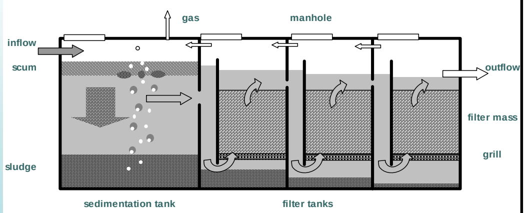




Anaerobic filter

Principle of Anaerobic Filter

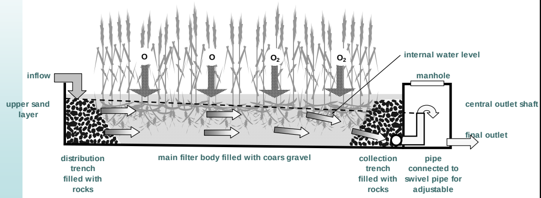
1. Sedimentation / floatation
2. Anaerobic digestion of suspended and dissolved matter inside the filter
3. Anaerobic digestion (fermentation) of bottom sludge

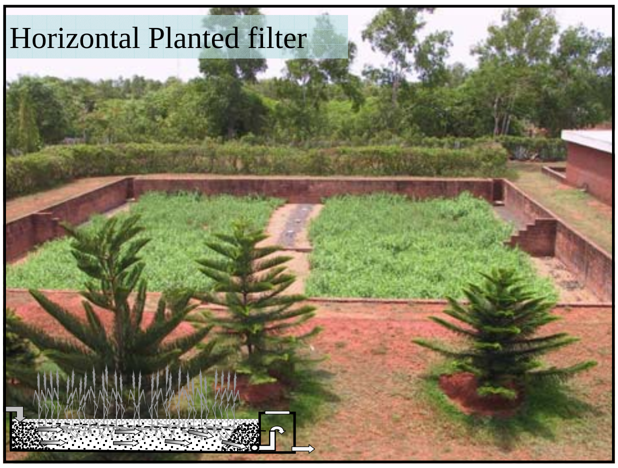


Horizontal Filter

Principle of the Horizontal Filter

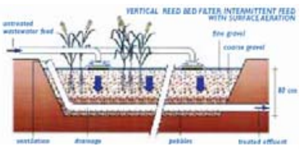
1. Continuous oxygen supply to the upper layers
2. Helophytes provide oxigen to the lower layers
3. Roots of plants provide favourable environment for bacteria diversity
4. Anaerob - facultative conditions in the lower layers





IEEP

Constructed wetlands



vertical flow

source: Cemagref

horizontal flow

source: Comtax International Ltd.

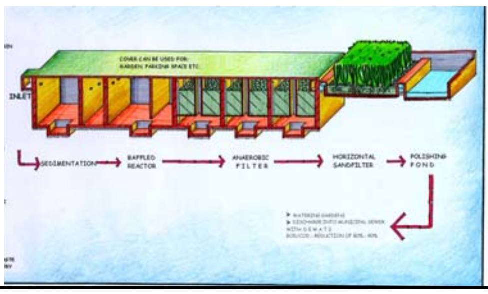
- treatment of wastewater or greywater
- effective in the removal of BOD, TSS and pathogens
- effluent can be reused
- aesthetically appealing

CIM

IEEP

DEWATS system

The right combination and dimension of the modules make DEWATS successful.



CIM

IEEP gtz – BIOMA / BRTC – BORDA - Project Team

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Comparing on 5 Models

五种模式的工 比

Chinese-German Cooperation Project

中德合作 目

Enhancing reuse options in DEWATS-projects through ecosan-approaches

通过生 生方法提升生活污水分散 氧处理系 的 源回用

CIM

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Area 1: Table 1. Characteristic of domestic wastewater
表1. 生活污水水□

Type of wastewater 污水种类	Brown water □+冲洗水	Black water □+尿+冲洗水	Kitchen wastewater (厨房污水) : Washing wastewater (洗衣污水、沐浴污水) 1 : 1	Grey + Brown	Domestic wastewater 混合污水
Quantity 水量(L/p.d)	12	30	50	62	80
COD (mg/l)	5315	3321	1614	2330	2254
BOD_5(mg/l)	2704	1407	552	969	873
NH_3-N (mg/l)	80.6	266	11.1	24.6	107

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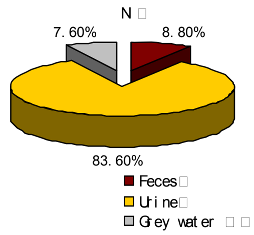

Fig 3. The contribution of different parts of domestic wastewater to nitrogen
生活污水不同部分对氮的□献

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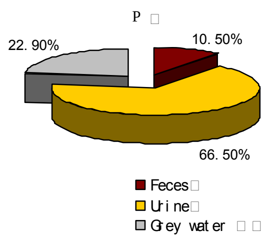

Fig 3. The contribution of different parts of domestic wastewater to phosphorus 生活污水不同部分对磷的□献

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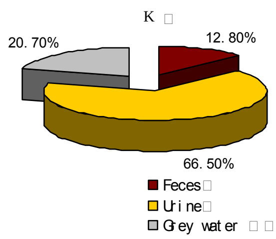

Fig 3. The contribution of different parts of domestic wastewater to kalium
生活污水不同部分对□的□献

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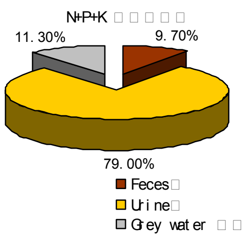

Fig 4. The contribution of different parts of domestic wastewater to N,P,K
生活污水不同部分对□□分(N、P、K)的□献

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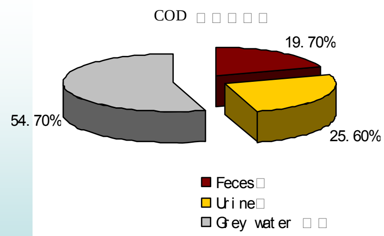

Fig 5. The contribution of different part of domestic wastewater to COD
生活污水不同部分对COD的□献

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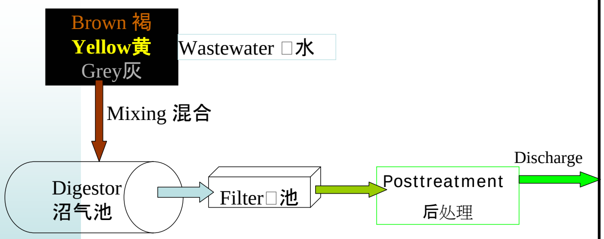
Tab.2 Nutrients and load of main components of domestic wastewater
表2 生活污水中主要成分的污染□荷

Sample 样品	Feces□	Urine尿	□+尿 Feces+ Urine	Kitchen discharge厨房出水	Washing wastewater 洗□用水
N	8.8%	83.6%	92.3%	3.7%	3.9%
P	10.5%	66.5%	77.0%	11.6%	11.3%
K	12.8%	66.5%	79.3%	15.3%	5.4%
□□分 (N+P+K)	9.7%	79%	88.7%	6.6%	4.7%
COD	19.7%	25.6%	45.3%	51.2%	3.5%

– BIOMA / BRTC – – Project Team

Model 1: Existing Layout: DEWATS-Wenjiang



模式1：已有的生活污水分散□氧处理系□

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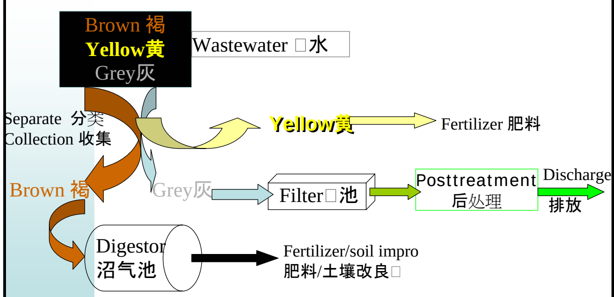
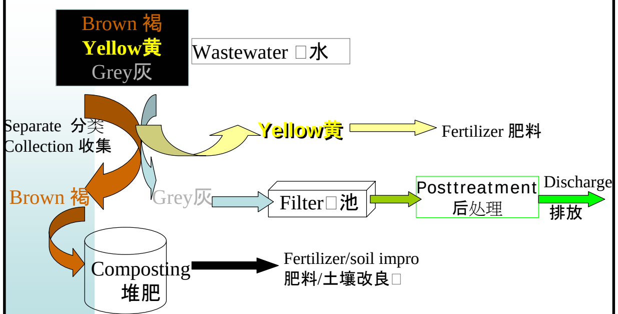
Model 2: Grey, brown and yellow water separation with biogas (flush toilet)



模式2：灰水、褐水、黄水全分离 沼气（水冲 所）

– BIOMA / BRTC – – Project Team

Model 3: Grey, faeces and urine separation (dry toilet)



模式3：灰水、褐水、黄水全分离 （旱 ）

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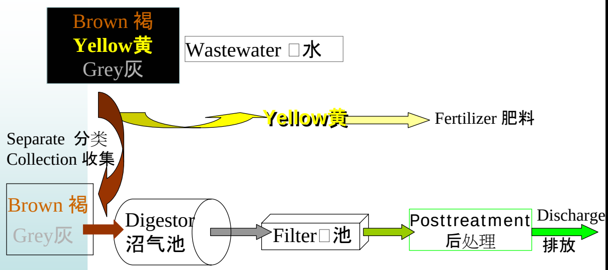
Model 4: Grey and brown & separating urine with biogas



模式4：褐水和灰水与黄水分离□沼气

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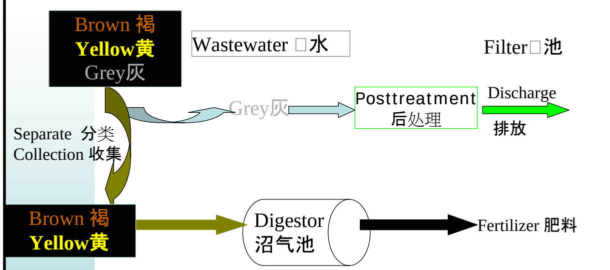
Model 5: Grey and blackwater separate



模式5：灰水与黑水分离

2.1 Base of process design (工□□□依据)

2.2.1 Quantity and characteristic of feces and urine

Faeces (□): 0.3kg/p.d (0.15L/p.d)

Urine (尿)： 1.4L/p.d

Daily domestic wastewater of each person (单位生活污水量): 80 L/p.d

Population (人口)：106 households(户)， 400 person (人)

Total quantity of domestic wastewater (生活污水□量): $32m^3/d$

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2.2.2 Loading of process design

Organic Loading of digestor and filter
□氧消化池，□池有机□荷： $0.25kgCOD/m^3.d$；

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Organic load of constructed wetland
人工湿地 有机□荷：$100kgBOD_5/10^4m^2.d$；

Ammonia nitrogen load of constructed wetland
人工湿地氨氮□荷：$20kgNH_3\text{-}N/10^4m^2.d$；

Composting HRT of faeces □堆肥周期：20天；

Storage time of urine 尿□存时□：10天。

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2.2.3 Requirement of treatment

The treated wastewater must meet <Integrated wastewater discharge standard> (GB8978-1996) No.1, viz. :

处理出水均达到中□人民共和国《污水□合排放□准》(GB8978-1996)的一□□准，即：

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COD ≤100mg/L

BOD_5 ≤20mg/L

SS ≤70mg/L

pH 6~9

Oil 动植物 油≤10mg/L

NH_3^--N≤15mg/L

Color 色度 ≤50 times 倍

PO_4^{3+}-P≤0.5mg/L

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Results

Type 类型	Digester 消化池 (m^3)	Filter □池 (m^3)	Constructed wetland 人工湿地(m^2)	Store tank for Urine 尿液□存桶 (m^3)	Composting tank 堆肥□ (m^3)
Mode 1 (WW)	250	40	1712		
Mode 2 (Br/U/G/OF)	100	130	110	5.6	
Mode 3 (dUDS/G/OF)		130	110	5.6	1.2
Mode 4 (Br+G/U)	210	20	305	5.6	
Mode 5 (BI/G/OF)	160		110		

Table 2. Volumes of DEWATS for different separations

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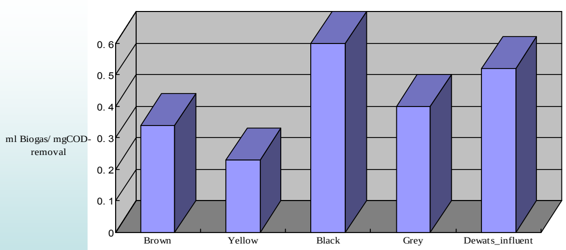


Fig. 10 Potential biogas production of different part of domestic wastewater
生活污水不同部分的□沼气潜力

Examples

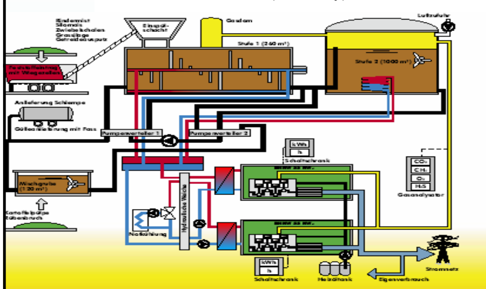
Co-Fermentation

Co-fermentation impacts (Germany

- 100 - 150 l per person per day.
- faeces, urine, organic household waste,
- bio-degradable residues from washing/cleaning (no medicine!).
- 150 Euro per year additional income by electricity selling
- economy of 1,500 Euro/person for sewage network investment.
- no need for a separate on-site wastewater treatment plant.
- wastewater from machinery/car washing should be connected to a fuel & grease flotation/decantation system and a collection tank!

Co-fermentation in farm biogas

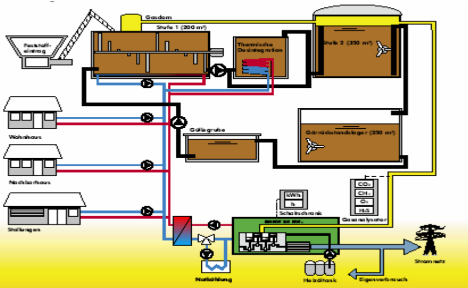
(Germany)



It should by a two step system !

If mesophile with pre- or post-treatment of the effluent (70°C; 1 h)

Co-fermentation in farm biogas

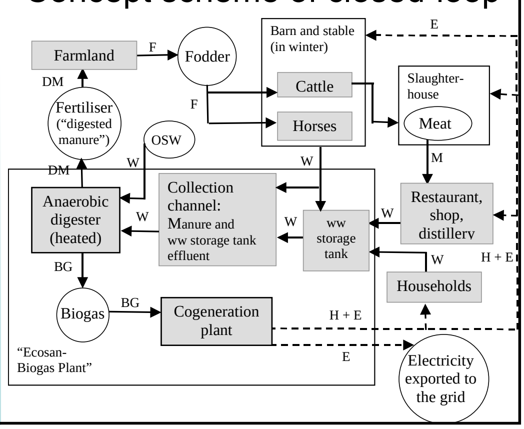


Thermophilic conditions with at least 55°C; 24 h and retention time of 20 days

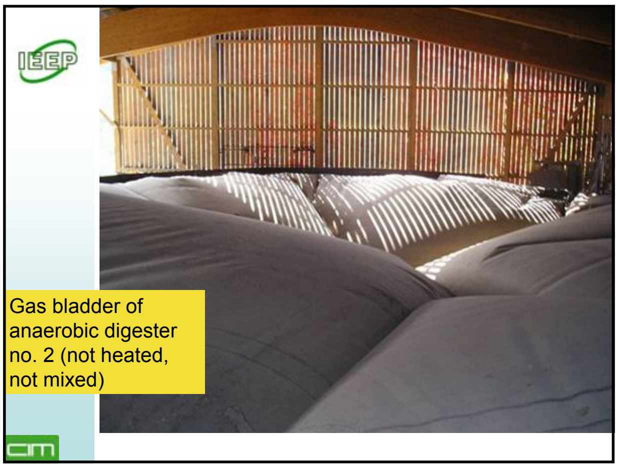
Conditions:

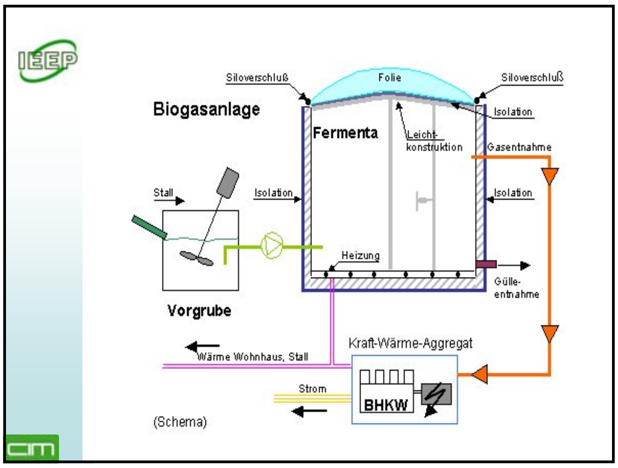
- one temperatur measurment every day, automatically registered

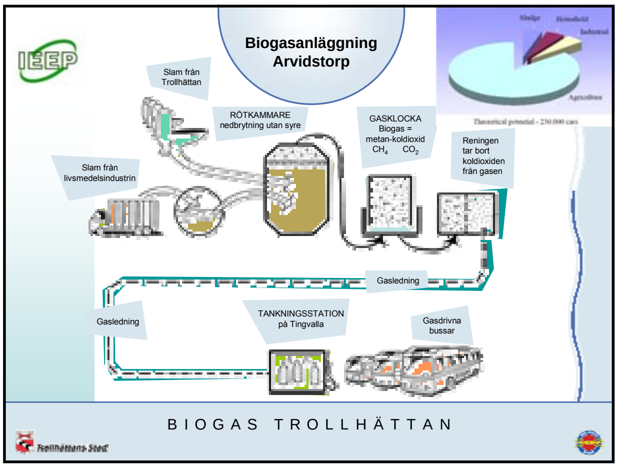
Concept scheme of closed-loop

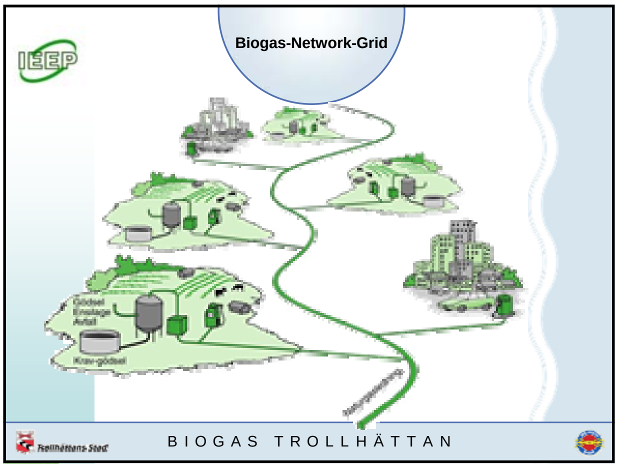


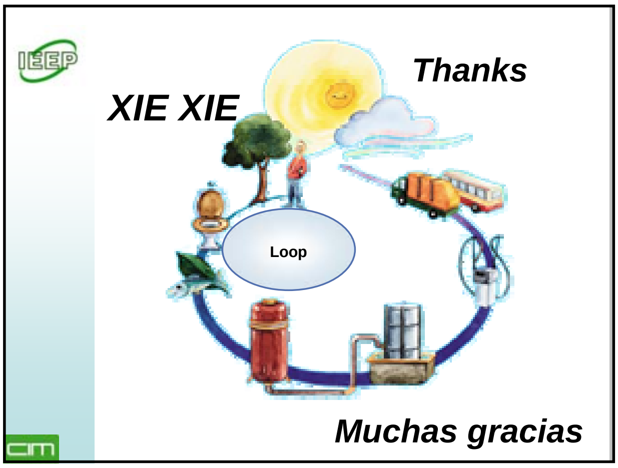

Anaerobic digester no. 1 (insulated, heated, mixed & covered)


IEEP
Gas bladder of anaerobic digester no. 2 (not heated, not mixed)
cim


IEEP
Biogasanlage
Siloverschluß
Folie
Siloverschluß
Isolation
Fermenta
Leicht-konstruktion
Gasentnahme
Stall
Isolation
Isolation
Heizung
Gülle-entnahme
Vorgrube
Kraft-Wärme-Aggregat
Wärme Wohnhaus, Stall
Strom
BHKW
(Schema)
cim


IEEP
Biogasanläggning Arvidstorp
Slam från Trollhättan
RÖTKAMMARE nedbrytning utan syre
GASKLOCKA Biogas = metan-koldioxid CH_4 CO_2
Slam från livsmedelsindustrin
Reningen tar bort koldioxiden från gasen
Gasledning
Gasledning
TANKNINGSSTATION på Tingvalla
Gasdrivna bussar
B I O G A S T R O L L H Ä T T A N


IEEP
Biogas-Network-Grid
B I O G A S T R O L L H Ä T T A N


IEEP
XIE XIE
Thanks
Loop
Muchas gracias
cim