



Introduction in the technical design for anaerobic treatment systems & DEWATS

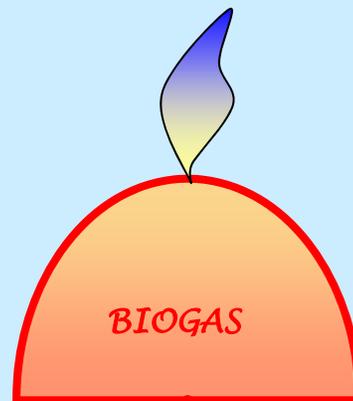
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Sanitary biogas systems

- ... are efficient, hygienic and ecologically sound wastewater treatment units with the additional benefits of energy production and an effluent of high nutrient content.
- ... can be combined with any type of (low-)flush toilet (including pour flush) and their effluent can be used directly for fertiliser application and irrigation.
- ... can be followed by constructed wetlands or other aerobic tertiary treatment to allow other forms of reuse of the effluent for car-washing, toilet flushing or outdoor cleaning purposes.
- The treatment of organic solid kitchen and garden wastes can also be integrated into the concept to increase biogas production and reduce household waste.
- Unlike septic tank systems, sanitary biogas units do not require frequent sludge removal.

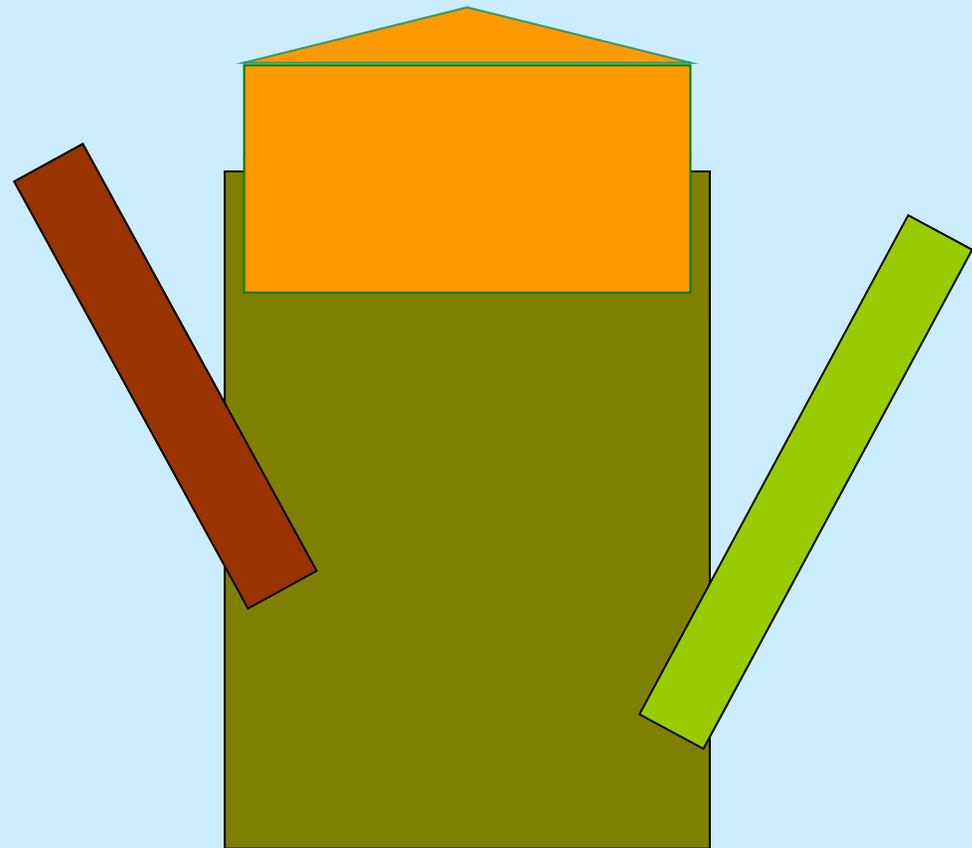
Parameters which are influencing the digestion process are

- Feeding carbon
- Mix fresh and old material inoculation
- Water physical
- Temperature conditions
- pH value milieu
- Retention time time to act



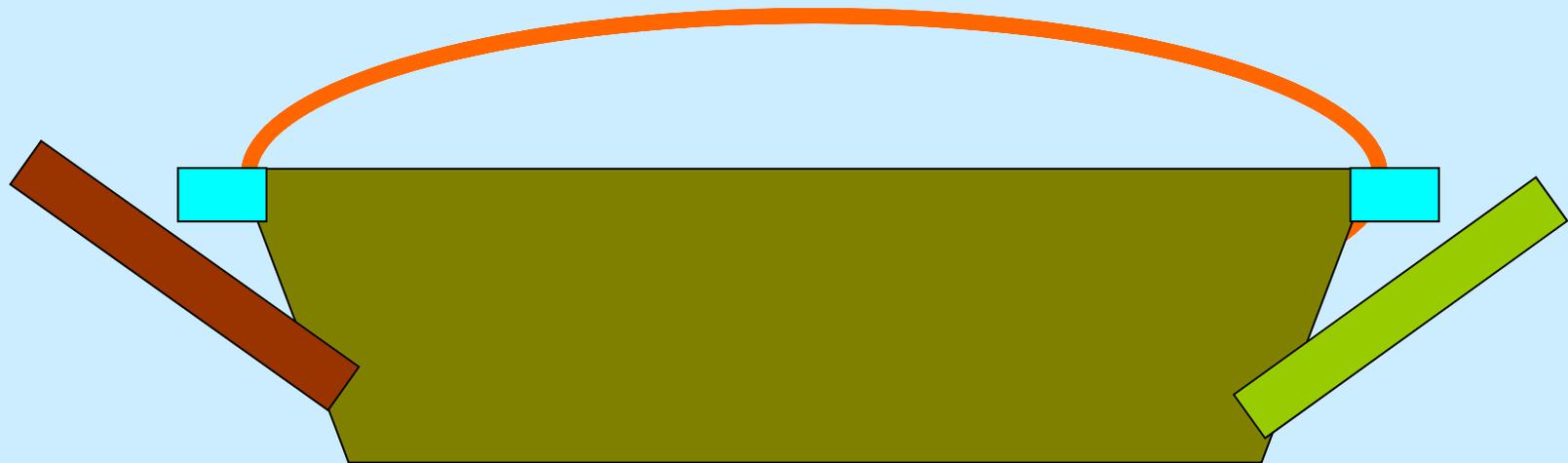
Technological alternatives

Floating drum
technology



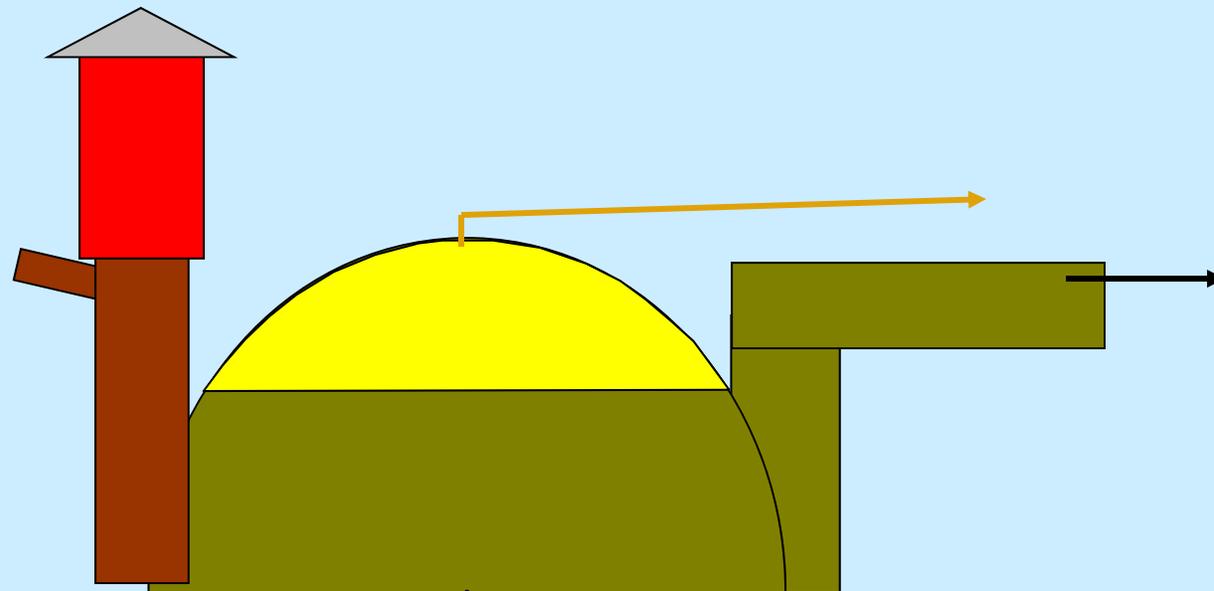
Canvas Covered Digester

For huge amounts of waste,
Canvas sealed by water canal



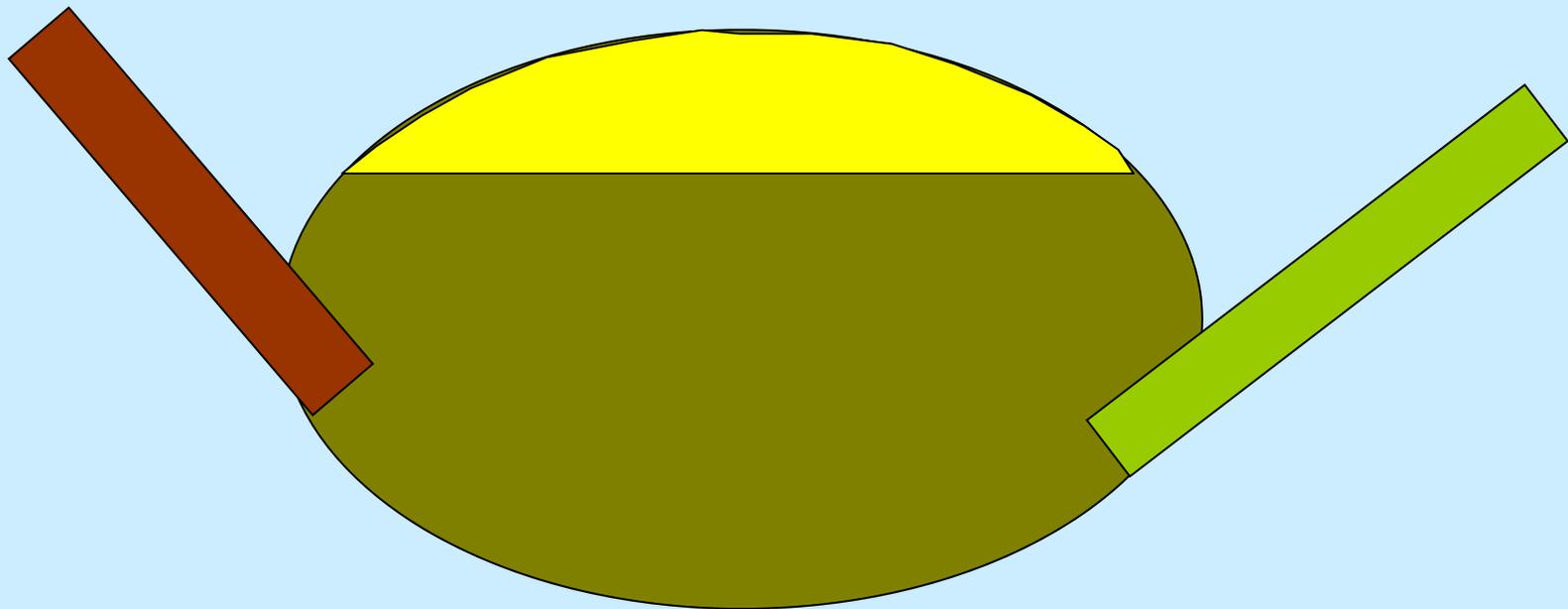
Fixed dome digester

With toilet and inlet for animal manure and wastewater



Flexi Plant

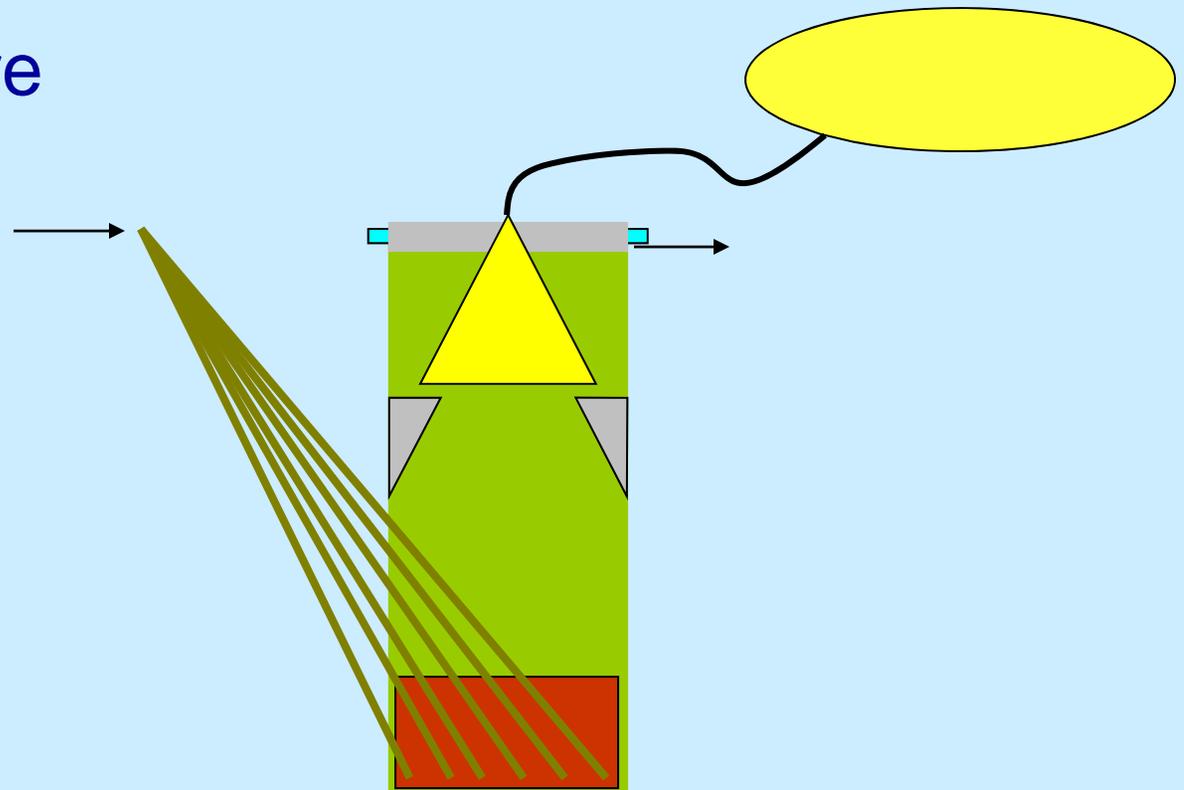
Rubber Balloon



Up flow Anaerobic Sludge Blanket (UASB)

For agro industrial
waste water

External gas store



Substrata for Digestion

Dry pit latrine waste -	Biolatrine
Flush toilet waste -	Biodigester Septic Tank
Animal waste -	Agricultural Biodigester
Agro-Industrial wastewater	High Rate Digester, short retention time (UASB)
Solid organic waste -	High Rate Digester, long retention time

System is applicable under the following conditions

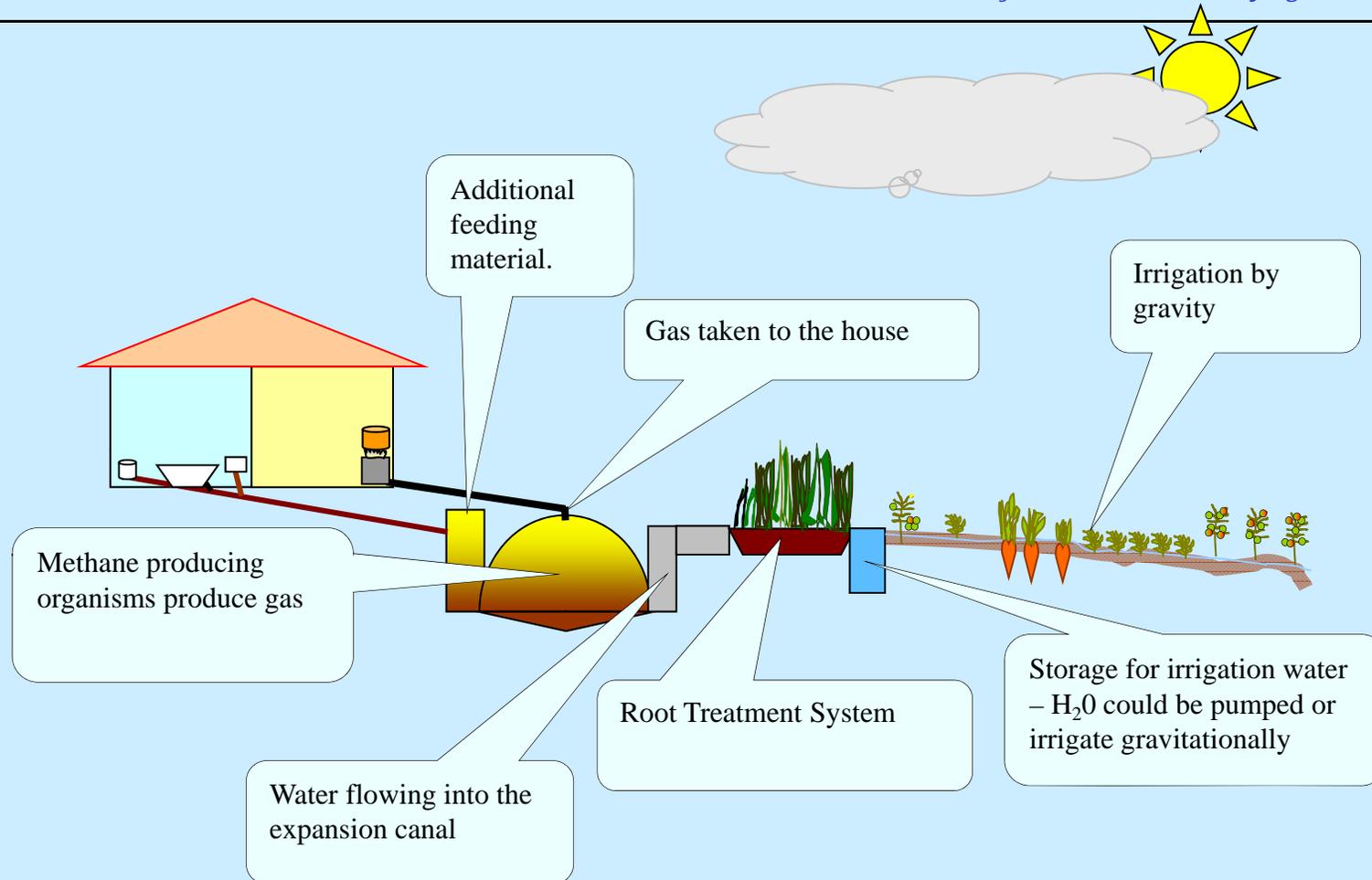
- Suitable under most conditions – floating of the facility during construction must be prevented in areas of high groundwater. Not suitable in areas of great water scarcity or rocky underground.
- Public buildings incl. schools with secured – even if limited – water supply, allowing reuse.
- Newly constructed residential areas with individual toilets attached via a small bore sewer, gravity sewer or vacuum network.
- Sanitary biogas systems should compete with costs for septic tanks.
- Community sanitation centres in permanent settlements, where residents cannot construct private toilets, due to financial, topographic or limited space conditions.
- Depending on local conditions different designs may be appropriate and could be adapted with design support from biogas technology experts.



	Advantages	Challenges
health	<ul style="list-style-type: none"> - no fly or insect breeding - hand washing facilities could be installed in the same toilet room, to use water for toilet flushing 	<ul style="list-style-type: none"> - requires post-treatment of effluent if no agricultural, gardening or landscaping use is considered
environment	<ul style="list-style-type: none"> - high retention time (treatment) of the wastewater - no smell - treatment of all domestic wastewater, including solid organic waste; no stagnant wastewater in the community - no surface or groundwater pollution - no greenhouse gas emissions produced from organic waste and wastewater when treated in sanitary biogas systems and biogas is used 	<ul style="list-style-type: none"> - requires post-treatment of effluent if no agricultural, gardening or landscaping use is considered - Clean Development Mechanism strategies could be added as financing source for dissemination programmes with cluster implementation (www.unfccc.org)
economic	<ul style="list-style-type: none"> - comparatively low investment cost, due to material savings of multi-household treatment - recovering costs by water saving and fertilizer use - recovering costs by biogas energy use 	<ul style="list-style-type: none"> - investment costs in land - covering O&M costs
social	<ul style="list-style-type: none"> - all kinds of toilets could be connected - understanding of link between sanitation and community development 	<ul style="list-style-type: none"> - users / cleaning personnel must be taught to refrain from applying bio-toxic chemical cleaners
technical	<ul style="list-style-type: none"> - can be constructed from local materials - qualified work for responsible and dedicated masons and plumbers 	<ul style="list-style-type: none"> - space requirements for facility, decision over land use - biogas facility requires training of construction and plumbing workers

Biogas septic tank

- Minimum volume: 6 m³ (5 persons or 2 m³ sewage/day)
- Each additional person or each +0,33 m³/day: + 0,25 m³ volume
- Relation chamber 1 : chamber 2 = 1:1
- Inflow : lower third part
- Outflow : bottom or middle layer outlet
- Watertight, gastight (leakage test 3% within 24 hours), biogas piping, safety
- Hydraulic compensation chamber as gasholder
- Completely mixed sludge and water
- Nearly the same hydraulic retention time for water, dissolved solids and sludge
- Kitchen waste water directly connected, without grease trap
- Emptying of accumulated bottom sludge only every 10 years
- Post-treatment only for overflow water required



Sketch of biodigester replacing a septic tank. Wastewater as well as kitchen and garden waste enter the digester and are broken down to biogas and fertile water.

The advantages: No more emptying of septic tank. Reuse of all water in the garden. Less cost on cooking energy.

Typical Example

- The following biogas digester can be used to treat domestic toilet blackwater of 50 users.
- The designed system is a fixed dome reactor with a flat bottom slab.
- The dome is constructed of brickwork ($l = 23\text{cm}$, $w = 13\text{cm}$, $h = 7\text{cm}$, tensile strength = 330kN/m^2).
- Other locally available water- and gas-tight materials with a similar tensile strength can also be applied.
- The digester receives a water-tightening plaster of 2cm thickness on the inside and outside.
- The bottom slab is constructed of 7cm thick concrete with a reinforced foundation ring.



The biogas digester has the following technical parameters:

- retention time 50 days
- digester volume 28.25 m³ net
- gas production 3.02 m³/day
- gasholder size 3.02 m³
- digester / gasholder ratio 9.3 : 1
- inner radius of hemisphere 2.46m
- lower slurry level 1.62m
- upper slurry level 1.97m

A cylindrical displacement tank was chosen:

- cylindrical unit volume 3.02m³
- radius of the tank 1.33m
- height of the overflow 0.54m
- wall and bottom slab thickness 7cm
- maximum gas pressure 0.88 m WC

Assumptions made in design:

- Average feed load per person & day 1.3 kg, 20% total solids content, 15% volatile solids
- flush water per day/person 6 litres
- average digester temperature 20°C
- total solids content of wastewater 2.3%
- volatile solids content 1.73%

Essential Design Information

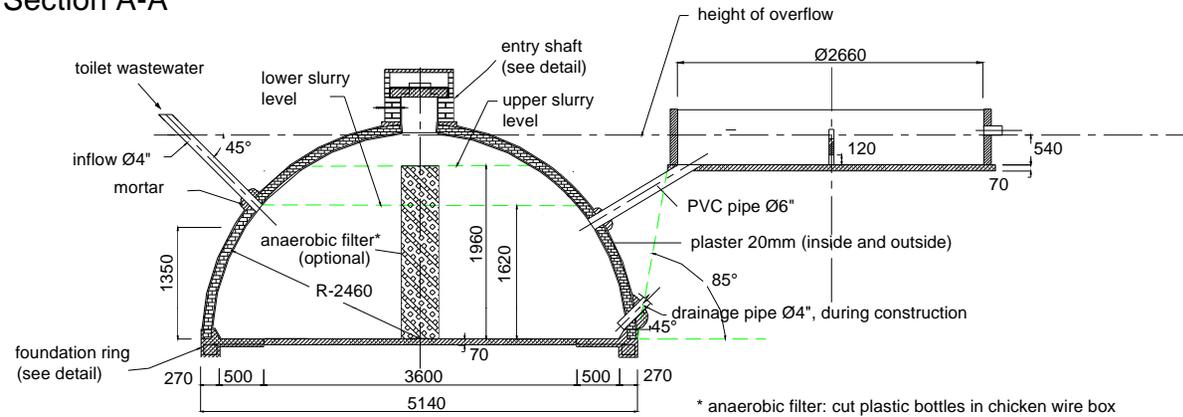
- A sanitary biogas unit must be constructed air-tight to guarantee the intended anaerobic microbiological processes. These processes minimize sludge accumulation (only 10% removable sludge compared with aerobic treatment systems) through acidification, liquefaction, and fermentation of the settled solids and the production of biogas. Up to 80% of the organic matter is converted into biogas, while a residue of organic matter is pushed out in dissolved form as effluent. Subsequently, the rate of degradation equals that of formation – eliminating the need for sludge removal.
- If biogas is to be utilised, it can be assumed that the toilet brown or black water of approximately 5 households (maximum about 30-40 litres of biogas/(person x day) are produced without adding other organic waste) are needed to cover the basic cooking needs of one family (1m³ biogas per day). Lighting (heating) with biogas lamps is feasible, but recommendable only as a secondary solution, due to increased maintenance issues and low energy use – only 3-5% of the energy content is used for light, the rest is emitted as heat.

Essential Design Information (2)

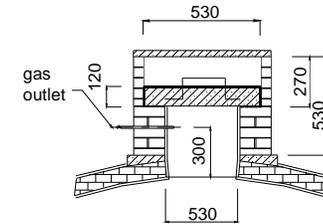
- Try to attach multiple wastewater producers, as the cost per capita decreases with the size of the treatment facility. Incurring costs are offset by the benefits from use of the gas for cooking or lighting. For volume consideration it must be considered, that it takes at least 30 days to eliminate 80% of BOD (Biological oxygen demand) from brown/black water. And pre-sanitization of black water takes at least 60 days at temperatures around 20 degrees Celsius.
- The implementing agency should complete the design, supervise the construction until completion and guarantee the proper function of the system for the time of one year.

Biogas digester

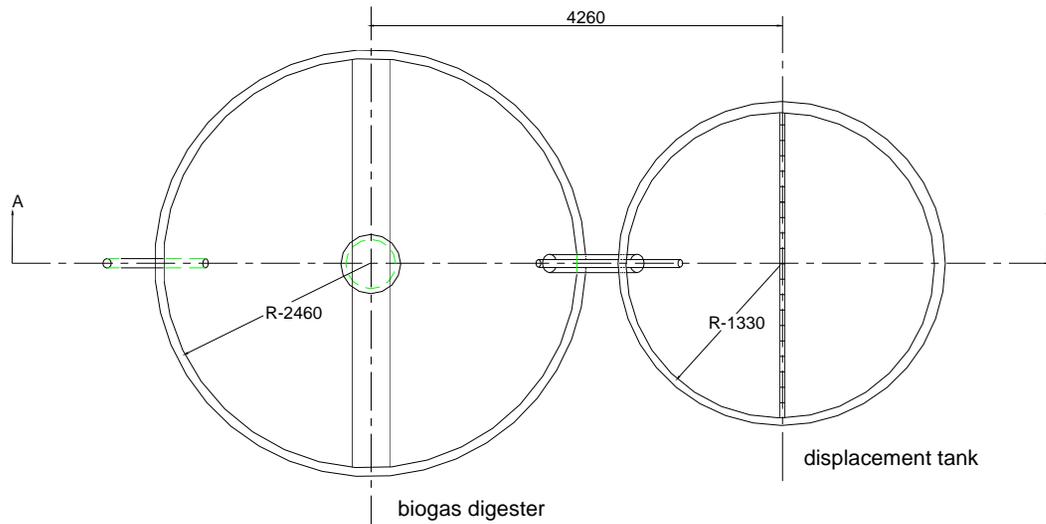
Section A-A



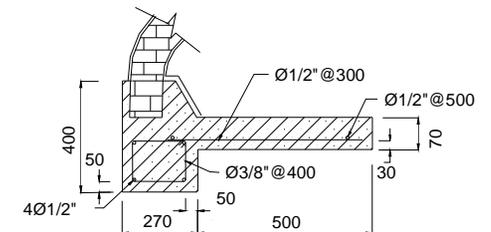
Detail: entry shaft



Plan View



Detail: Foundation



treatment of blackwater from 50 people:
digester volume - 28.25 m³
volume of displacement tank - 3.02 m³



Materials	estimated amount	Unit	Comments
Masonry, entry shaft	0.17	m ³	<p>The design should be adapted to local conditions.</p> <ul style="list-style-type: none"> • Different building materials may be more readily available and therefore more appropriate in certain locations. • Dimensions may vary due to space constraints. • Different physical conditions (soil, temperature, wastewater composition) will influence the design. • Construction and maintenance labour knowledge and capacity influence appropriate design option (prefabricated or locally constructed)
Masonry, hemisphere	2.71	m ³	
Masonry, displacement tanks	0.39	m ³	
Mortar for masonry	0.26	m ³	
Concrete, foundation	2.27	m ³	
Concrete, entry hatch	0.06	m ³	
Concrete, bottom slab, displacement tanks	0.43	m ³	
Gas-tight plaster, gasholder	0.26	m ³	
Gas-tight plaster, inner surface	43.63	m ²	
Gas-tight plaster, outer surface	47.07	m ²	
SUMMARY			
Bricks	1562	pieces	
Concrete	1218	kg	
Lime	92	kg	
Gravel	1.58	m ³	
Sand	2.15	m ³	
Inner plaster	0.87	m ³	
Outer plaster	0.94	m ³	
Ground excavation	65.25	m ³	
Inlet PVC pipe 4 inches	1.72	m	
Outlet PVC pipe 6 inches	1.68	m	
Reinforcement bars ½"	25.75	m	
Reinforcement bars ¾"	24.50	m	

	Cement	Lime	Sand	Gravel
Concrete	1	0	2	4
Plaster	1	0.25	4	0
Soft mortar	1	3	15	0
Gas-tight plaster	1	0.25	2.5	0

Operation & Maintenance

- Toilet users must be advised not to apply chemical detergents for toilet bowl cleaning, as their application kills the active bacteria in the digester – disabling the treatment process and resulting in fast sludge accumulation, which must be removed from the digester and can plug following treatment units.
- Maintenance must be carried out by trained personnel, which should be trained during the construction process.
- The trained personnel should check all control openings weekly and remove any obstructions to the regular flow.
- If biogas is utilised, storage, pipelines and appliances must be monitored regularly by trained personnel.
- User fees or communal payment models should cover maintenance costs. Additional benefits (use of irrigation water or biogas) can be awarded to the personnel.

Cross-Check – System not to be applied under the following conditions

- Users do not have water availability for low flush toilets → Dry system should be considered
- Rocky underground
- Knowledge of the system is not available and training is not possible

Up-Scaling

- The design of biogas digesters demands engineering expertise. The factors decisive for design are too complex to be expressed in simple up-scaling tables.
- Construction must be carried out by qualified masons.
- Capacity building, i.e. training for design and construction of biogas digesters is outlined in

General Spread Sheet for "Fixed Dome" Biogas Plants, Input and Treatment Data

daily flow	hours of ww flow	flow per hour	COD in g/m ³	COD / BOD ₅ ratio	liquid HRT	settleable SS / COD ratio	lowest digester temper.	ideal BOD rem rate sludge	ideal BOD rem rate liquid	total BOD rem.rate acc.to°C	BOD out	COD out	de-sludging interval
given	given	calcul.	given	given	chosen	given	given	calcul.	calcul.	calcul.	calcul.	calcul.	chosen
m ³ /d	h	m ³ /h	mg/l	mg/l / mg/l	h	mg/l / mg/l	°C	%	%	%	mg/l	mg/l	months
3	14	0,18	4.000	2,00	240	1,00	20	102%	42%	80%	394	1.089	36

for
domestic
wastewater

guiding figures=>

: 0,5

Data common for both					Ball Shaped Digester				Biogas Plant Half Round Shape				
Sludge volume	water volume	total volume	gas holder volume = VG	free distance above slurry zero line	volume of empty space above zero line	radius ball shape	actual digester radius (ball)	actual net volume of digester	volume of empty space above zero line	radius half round shape	actual digester radius (half round)	actual net volume of digester	potential biogas product.
calcul.	calcul.	calcul.	calcul.	chosen	calcul.	required	chosen	check	calcul.	required	chosen	check	calcul.
m ³	m ³	m ³	m ³	m	m ³	m	m	m ³	m ³	m	m	m ³	m ³ /d
3,58	42,9	46,4	0,75	0,25	0,43	2,26	2,25	45,66	0,54	2,85	2,85	46,45	1,00
0,0017/g BODrem				not less than 0,25									

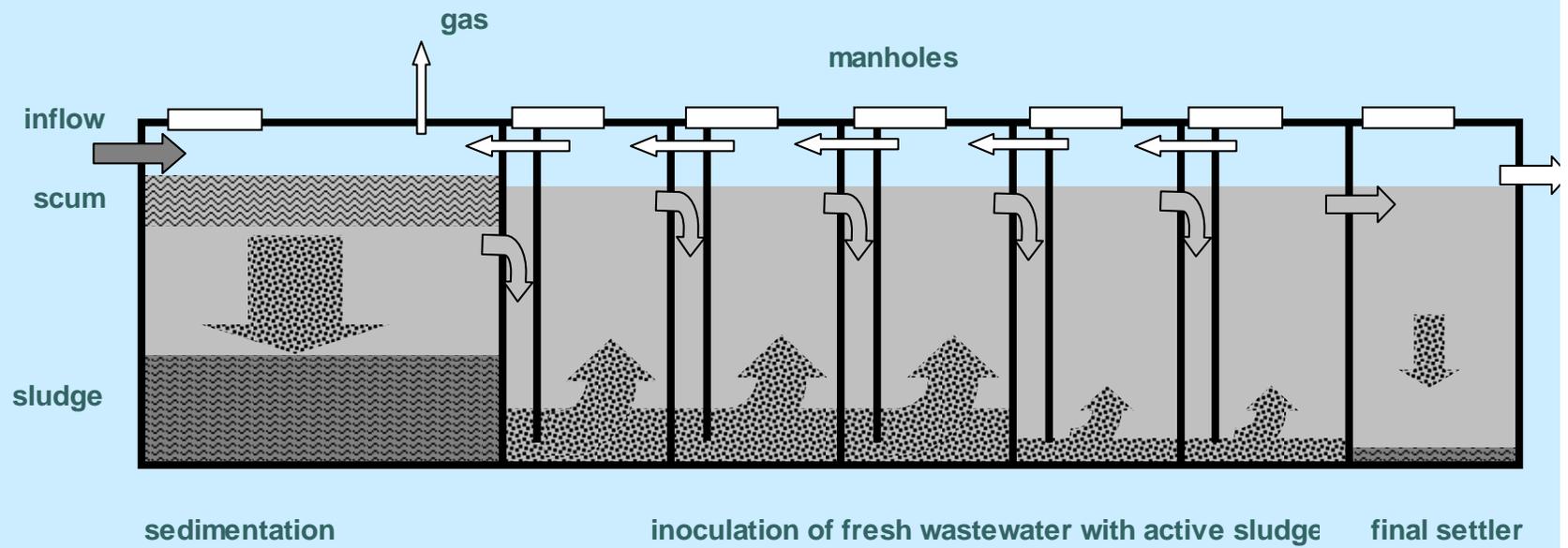
Baffled reactors

- ... also sometimes called baffled septic tanks, are efficient, hygienic and ecologically sound anaerobic treatment units for collected organic wastewater.
- ... can be combined with any type of (low-)flush toilet (including pour flush).
- Constructed out of local materials, the system provides easy maintenance, easily available spare parts and low operational costs; it does not have treatment process relevant movable parts and is not dependant on external energy inputs, like electricity.
- If the landscape is slightly sloped, water flow is caused by natural gravity, therefore no pumps are required.
- Effluent can be used for fertiliser irrigation or other forms of reuse for car-washing, toilet flushing or outdoor cleaning purposes, if followed by constructed wetlands or other aerobic tertiary treatment.
- If baffled reactors are constructed gas-tight, biogas can be collected and used

Baffled Reactor

Principle of Anaerobic Baffled Reactor

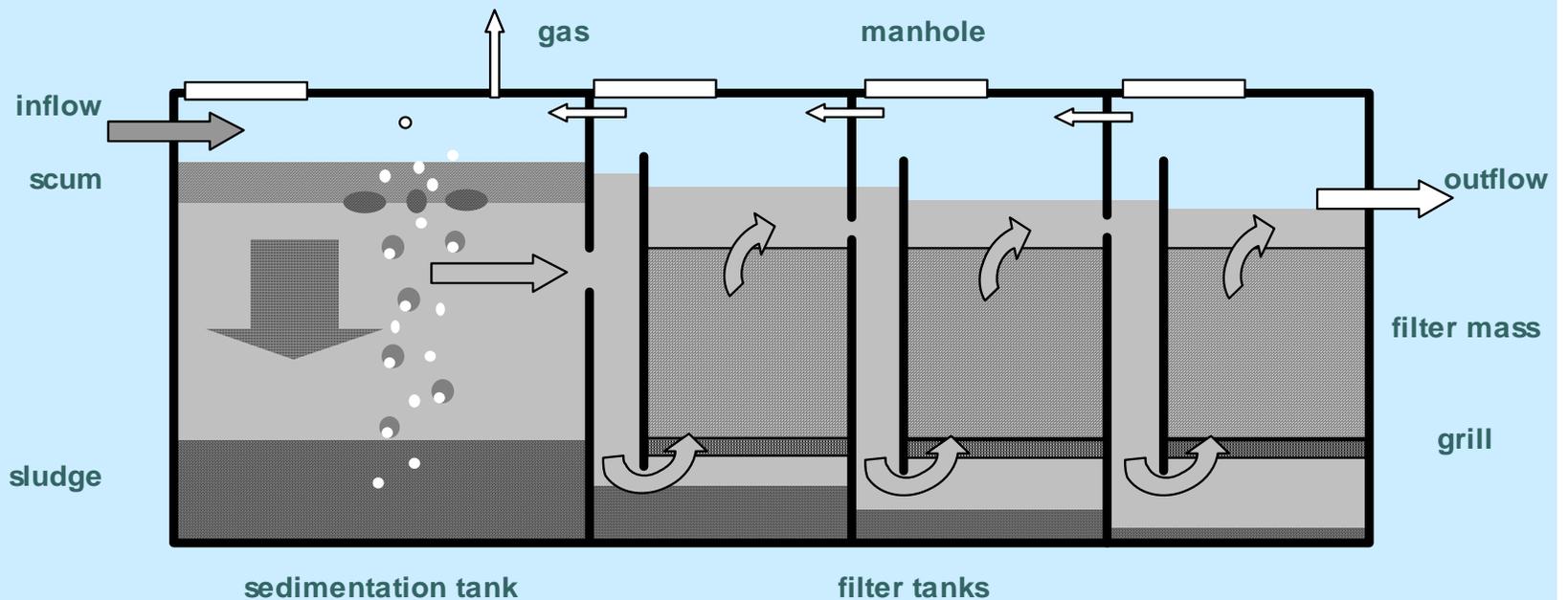
1. Sedimentation / floatation of solids
2. Anaerobic digestion of suspended and dissolved solids through sludge contact
3. Anaerobic digestion (fermentation) of bottom sludge
4. Sedimentation of mineralised (stabilised) suspended particles



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





System is applicable under the following conditions

- Suitable under most conditions – floating of the facility during construction must be prevented in areas of high groundwater. Not suitable in extremely water scarce areas without secured water supply (lack of flush water) or rocky underground.
- Public buildings incl. schools with secured – even if limited – water supply, allowing reuse.
- Newly constructed residential areas with individual toilets attached via a small bore sewer, gravity sewer or vacuum network (see appropriate chapters). Baffled reactor should compete with costs for septic tanks.
- Community sanitation centres in permanent settlements, where residents cannot construct private toilets, due to financial, topographic or limited space conditions.



	Advantages	Challenges
Health	<ul style="list-style-type: none"> - no fly or insect breeding - hand washing facilities can be installed in the same toilet room, as this used water can be used to flush the toilet pipe 	<ul style="list-style-type: none"> - requires service provision for primary settled sludge removal and treatment – location should ensure access by truck (not necessary if biogas tank or plug-flow anaerobic septic tank)
Environment	<ul style="list-style-type: none"> - high retention time (treatment) of the wastewater - no smell - treatment of all domestic wastewater, therefore no stagnant wastewater in the community - no surface or groundwater pollution 	<ul style="list-style-type: none"> - requires service provision for sludge removal and treatment (see above)
Economic	<ul style="list-style-type: none"> - recovering of costs by water saving, reuse and perhaps biogas collection and use 	<ul style="list-style-type: none"> - covering O&M costs - investment costs in land
Social	<ul style="list-style-type: none"> - all known water flush toilet systems - understanding of link between sanitation and community development 	<ul style="list-style-type: none"> - users / cleaning personnel must be taught to refrain from applying bio-toxic chemical cleaners
Technical	<ul style="list-style-type: none"> - can be constructed from local materials - qualified work for responsible and dedicated masons and plumbers - no movable parts or energy requirements - easy operation, minimal maintenance - if construction is gas-tight, biogas should be recovered and used/burnt 	<ul style="list-style-type: none"> - space requirements for facility, decision over land use - requires training of construction (and plumbing) workers

Multi compartment biogas settler (1)

- Minimum volume: at least 1,5 m deep, 0,75m weight and 1,0 m length
- Volume of the tank = sewage volume + sludge volume + volume of protection layer ($V = V1 + V2 + V3$)
 - Where $V1 = n * k * q * t1/24000$ and $V2 = a * n * k * t2 * 0,48/1000$ and $V3 = 200$ mm clear height space
 - n – number of users
 - k – modification coefficient ($n \leq 50$ $k=1$ / $50 < n \leq 200$ $k=0,95$ / $n > 200$ $k=0,9$)
 - q – per capita daily sewage quantity (l/p/d)
 - $t1$ – sewage hydraulic retention time (minimum 12 hours)
 - a – per capita daily sludge quantity (see table - l/p/d)
 - $t2$ – sludge emptying period (minimum 730 days, max. 5 years)

Multi compartment biogas settler (2)

- If 10 m³ sewage per day 2 chamber sedimentation (ratio 3 :1)
- If more than 10 m³ a 3 chamber tank system should be considered (ratio 2:1:1)
- Inflow and outflow - upper third
- Watertight, gastight (leakage test 3% within 24 hours), biogas pipe
- Extra gas storage required
- Sludge sedimentation (at least 1,50 m deep 1st chamber)
- Short hydraulic retention time for water and dissolved solids
- Long storage time for sludge and floating scums, emptying accumulated bottom sludge once every year
- Kitchen waste water directly connected, without grease trap
- Emptying of accumulated bottom sludge only every 7 years
- Post-treatment only for water required

- **sludge retention**

yearly sludge flow	sludge hydrolysis per year	Sludge removal inside tank	remaining sludge	
given	choosen	choosen	calc.	
l/year	%	y	m ³	
100,0	48	6,0		
	accumulation	degradation	reduced volume	remaining volume
year 1	100,0	0	0,0	100,0
year 2	200,0	48	48,0	152,0
year 4	352,0	48	96,0	356,0
year 4	556,0	48	169,0	487,0
year 5	687,0	48	266,9	520,2
year 6	720,2	48	329,8	490,4



- BS - Biogas Settler (minimum 10 m³)
- Waste Water Volume/day * 0,75
- Remaining sludge volume * de-sludging time
- -----
- BST - Biogas Septic Tank (minimum 6 m³ for 5 persons)
- Waste Water Volume * 1,25



Given data	200	Persons/ 24h / day
Quantity of black water	150	l/d
Quantity of grey water	350	l/d
Quantity of toilet wash water	Included in black water	l/d
Quantity of urine	Included in black water	l/d
Quantity of brown water	Included in black water	
Retention time of the water in the treatment system	18	h/d
Sludge removal period (retention time of sludge)	5	year
Sludge production per person per year	175	l/p/y
Sludge reduction percentage	48	%/year



Only blackwater	Septic Tank	Biogas Tank	Biogas Settler Tank
Water volume (m3)	33,25	54,75	20,25
Sludge volume	36,48	0	62,21
Buffering volume	-	6,85	8,25
Total volume	69,73	61,60	90,71
Efficiency	low	medium	high
Post treatment	Yes – highly needed	Yes – solid/liquid separation - gardening use	Yes – gardening use

Waste water	Septic Tank	Biogas Tank	Biogas Settler Tank
Water volume (m ³)	77,13	80	67,5
Sludge volume	36,48	0	62,21
Buffering volume	-	10	8,25
Total volume	113,61	90	129,71
Efficiency	low	medium	high
Post treatment	Yes – highly needed	Yes – solid/liquid separation - gardening use	Yes – gardening use

Typical Example

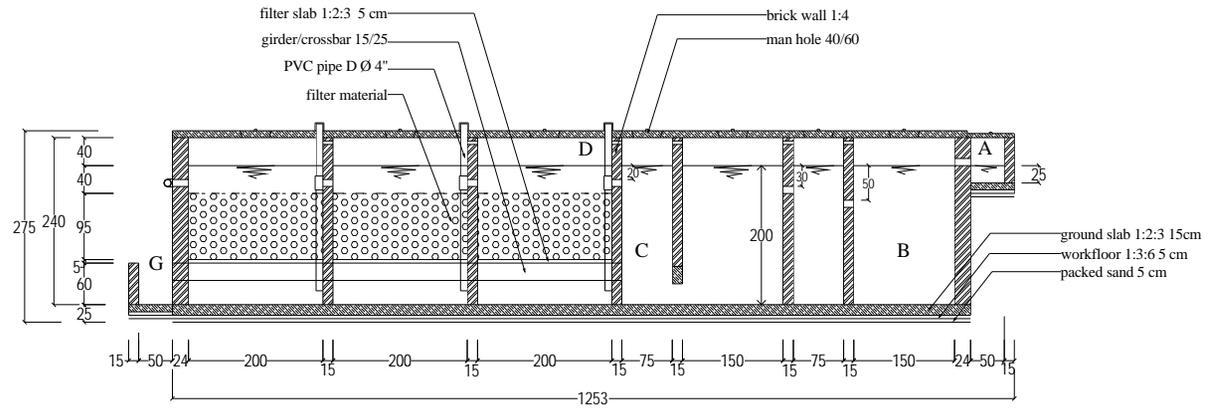
- The following plans exemplify a decentralised wastewater treatment system (DEWATS) with a combination of septic tank, baffled reactor and anaerobic baffled filter at a hospital with 50 beds.
- A sewer network collects the organic wastewater from all parts of the hospital and feeds it into the treatment inlet (A). From there the wastewater is led into a sedimentation chamber or septic tank (B), where it undergoes primary treatment. It continues into a baffled reactor (C), where the wastewater is forced to flow through collected sludge beneath the baffles and then several anaerobic filters (D). With the help of anaerobic bacteria these treatment units are able to reduce BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) by 80-90%. Finally the wastewater is lead to a constructed wetland (E) – the details of which are discussed in the appropriate technical option sheet – and final treated and/or stored in a polishing ponds (F).
- The space requirements for the construction of the anaerobic treatment units (A) through (D) amounts to approximately 60 m² and is a closed underground construction. The area above the treatment unit can either be used as construction space for the hospital or other purposes (parking lot, recreation area, etc.) as long as structural demands are met and maintenance access to the chambers can be assured.
- The time of completion of the construction is estimated at a period of 6 months. Construction Design sketches and a BOQ can be found on the following pages.
- The implementing agency should complete the design, supervise the construction until completion and guarantee the proper function of the system for the time of one year.

Typical Example

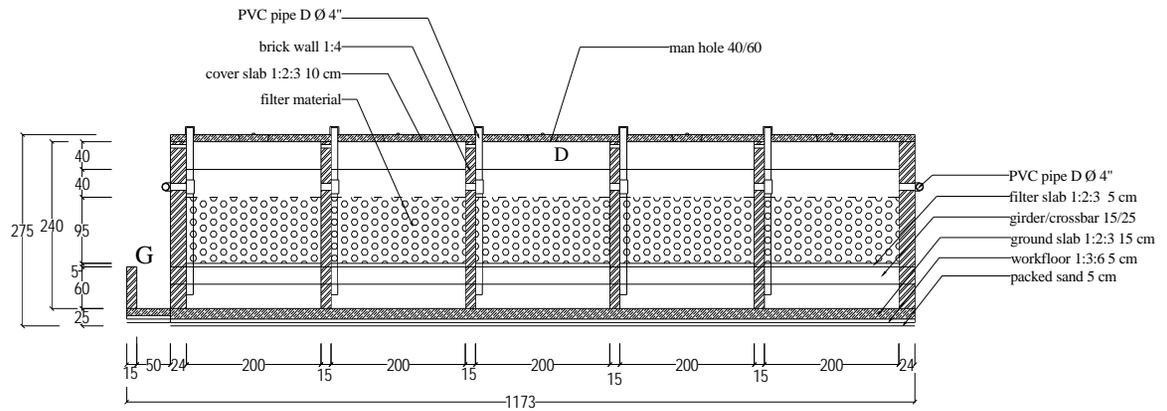
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- The implementing agency should complete the design, supervise the construction until completion and guarantee the proper function of the system for the time of one year.

Cross Section 1 -1'

- A - Treatment Inlet
- B - Sedimentation Tank / Septic Tank
- C - Baffled Reactor
- D - Anaerobic Filters
- G - Effluent Chamber

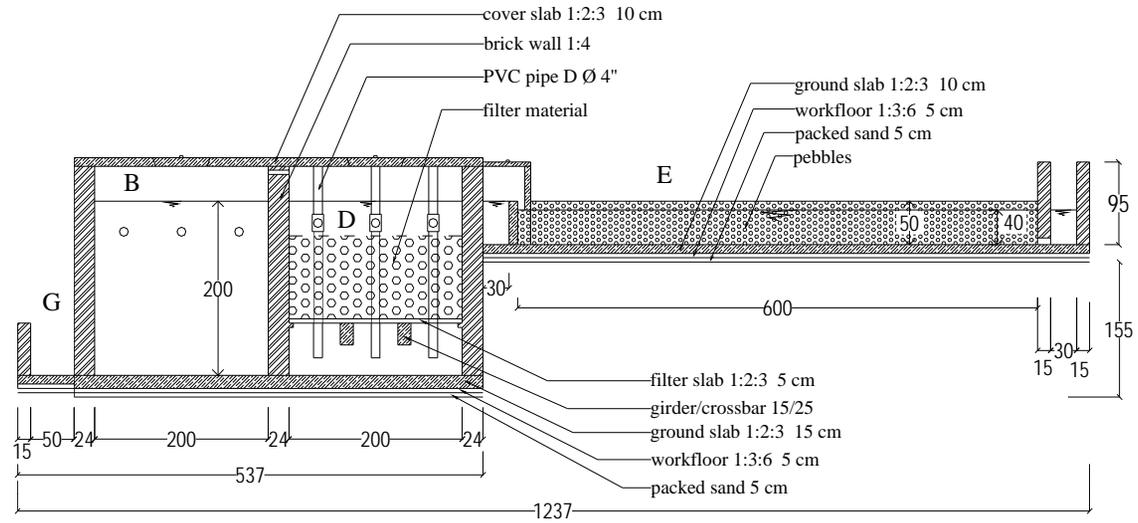


Cross Section 2 -2'

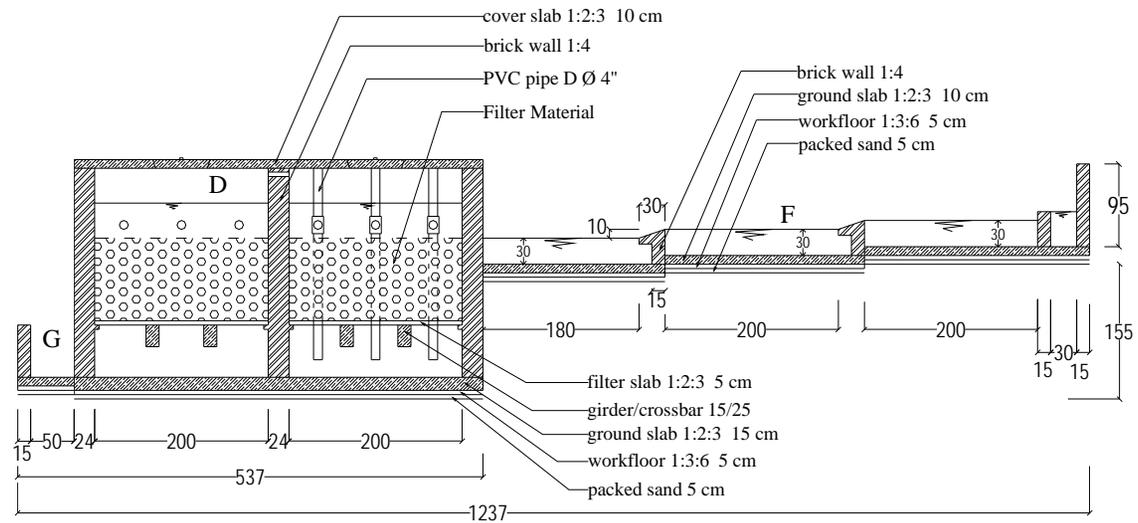


Cross Section 3 -3'

- B - Sedimentation Tank / Septic Tank
- D - Anaerobic Filters
- E - Constructed Wetland
- F - Polishing Ponds
- G - Effluent Chamber



Cross Section 4 -4'



Materials	estimated amount	Unit	Comments
Excavation			<p>The design should be adapted to local conditions.</p> <ul style="list-style-type: none"> •Different building materials may be more readily available and therefore more appropriate in certain locations. •Dimensions may vary due to space constraints. •Different physical conditions (soil, temperature, wastewater composition) will influence the design. •Construction & maintenance labour capacity influences appropriate design choice
Soil removal	213.00	m ³	
Packing of sand	7.17	m ³	
Packing of soil	30.00	m ³	
Bricklaying and plaster work			
Bricklaying 1 : 4	42.71	m ³	
Reinforced concrete 1 : 2 : 3	31.95	m ³	
Work floor 1 : 3 : 6	9.14	m ³	
Plaster work 1 : 4	286.96	m ²	
Plaster work 1 : 4	178.67	m ²	
Filter & Fittings			
Filter Material anaer. Filter	30.50	m ³	
Filter Material constr. wetland	27.00	m ³	
PVC Pipes 4"	15.00	pc.	
T-connecting/knee joint 4"	30.00	pc.	
Grass planting	54.00	m ²	

	Cement	Lime	Sand	Gravel
Concrete	1	0	2	4
Plaster	1	0.25	4	0
Soft mortar	1	3	15	0
Gas-tight plaster	1	0.25	2.5	0

The effectiveness of a baffled reactor or an anaerobic filter is greater if ...

- pre-acidification and liquefaction of organic matter has taken place in a primary treatment step. This can be achieved by pre-treatment:
 - 1) in a septic tank (two chambers), directly prior to the secondary treatment unit (as in the example)
 - 2) in a biogas settler (one chamber),
 - 3) with grease trap, settlers, sand trap and/or grid removal of solids at the household (esp. in the case of small bore sewer networks) and treatment of the organic material in a separate biogas reactor or composting unit.
- The effectiveness of the baffled reactor can be improved by adding filter material within the chambers, turning the system into an anaerobic baffled filter (also shown in the typical example). Bacteria grow on the surface of the filter material (inert natural or synthetic material with a large surface area) thereby increasing the intensive contact of bacteria and wastewater. It should be noted however that bacterial growth on the filter material can cause clogging of the filter, making removal and cleaning of the filter material necessary. If space requirements permit, a larger baffled reactor without filter material is to be preferred.

Up-Scaling

- The facility can treat any amount of wastewater greater than 1 m³/day.
- Wastewater with a higher contamination (black water or brown water) requires more chambers.
- The factors decisive for design are too complex and interrelated (peak flow, pollution load, up-flow velocity, retention time, temperature) to be expressed in simple up-scaling tables.
- The design of baffled reactors demands engineering expertise.
- Construction must be carried out by qualified masons.



General spread sheet for baffled reactor												
general data						dimensions						
avg. daily waste water flow	time of most waste water flow	COD inflow	BOD ₅ inflow	settleable SS / COD ratio	lowest digester temp.	depth at outlet	length of chambers		length of downflow shaft	width of chambers		number of upflow chambers
given	given	given	given	given	given	chosen	required	chosen	chosen	required	chosen	chosen
m ³ /day	h	mg/l	mg/l	mg/l / mg/l	°C	m	max.!	m	m	min.!	m	No.
60,00	12	1.038	474	0,43	25	2,00	0,80	0,80	0,00	6,25	6,25	8
		<i>COD/BOD ratio</i>	2,19	<i>0,35 -0,45 for domestic ww</i>					<i>min 12 cm, or 0 in case of down pipes</i>			
intermediate and secondary results												
upflow velocity <i>best below 1 m/h</i>	factors to calculate BOD removal rate of baffled reactor					BOD rem rate calcul. by factors	max peak flow per hour	actual upflow velocity	actual volume of baffled reactor	HRT in baffled tank	org. load (BOD ₅)	biogas (ass: CH ₄ 70%; 50% dissolved)
chosen	calculated according to graphs					86%	max.!	calcul.	calcul.	calcul.	calcul.	calcul.
m/h	f-overload	f-strength	f-temp	f-chamb.	f-HRT	applied	m ³ /h	m/h	m ³	h	kg/m ³ *d	m ³ /d
1	1,00	0,87	1,00	1,08	0,92	84%	5,00	1,00	80,00	30	0,71	14,42
procedure of calculation								treatment efficiency				
1. Fill in all figures in bold (until A12) 2. Check your effluent quality whether CODout or BODout is sufficient. 3. Check whether the total length of the tank suits your site. 4. If the result is not satisfying increase or reduce the number of chambers (M6) first. 5. If the result is still not satisfying increase or reduce the depth (G6).								total BOD ₅ rem.rate	COD / BOD removal factor	total COD rem.rate	COD out	BOD out
								calcul.	calcul.	calcul.	calcul.	calcul.
								%		%	mg/l	mg/l
								84%	1,04	81%	198,12	76,51

yellow cells are input data for following treatment system



General spread sheet for anaerobic filter (AF)											
general data						dimensions					
daily waste water flow	time of most waste water flow	COD inflow	BOD ₅ inflow	SS _{settl.} / COD ratio	lowest digester temper.	specific surface of filter medium	voids in filter mass	depth of filter tanks	length of each tank	number of filter tanks	width of filter tanks
given	given	given	given	given	given	given	given	chosen	chosen	chosen	chosen
m ³ /day	h	mg/l	mg/l	mg/l / mg/l	°C	m ² /m ³	%	m	m	No.	m
60,00	12	1.038	465	0,46	25	100	35%	2,00	2,00	4	6,25
		COD/BOD ₅		normal		range	range		cal.max		
		2,23		0,35-0,45 (domestic)		80 -120	30-45		2,00		
treatment data											
HRT inside AF reactor	max. velocity in filter voids	factors to calculate COD removal rate of anaerobic filter						COD removal rate	BOD ₅ removal rate	COD outflow of AF	BOD ₅ outflow of AF
check!	check !	calculated according to graphs						calcul.	calcul.	calcul.	calcul.
h	m/h	f-temp	f-load	f-strenght	f-surface	f-HRT	f-chamb.	%	%	mg/l	mg/l
27,7	1,14	1,00	1,00	0,96	1,00	0,68	1,16	76%	85%	251	71
normal	max.										
24 - 48 h	2,00										
intermediate calculations						yellow cells are input data for following treatment system					
max. peak flow per hour	BOD/COD rem. Factor AF	org.load on AF COD	filter height	net volume of filter tanks	biogas production						
calcul.	calc.	calcul.	calcul.	calcul.	calcul.						
m ³ /h	ratio	kg/m ³ *d	m	m ³	m ³ /d						
5,00	1,12	0,90	0,95	69,13	11,81						

Operation & Maintenance

- Toilet users must be advised not to apply chemical detergents for toilet bowl cleaning, as their application kills the active bacteria in the baffled reactor – disabling the treatment process and resulting in fast sludge accumulation, which must be removed from the digester and can plug following treatment units.
- Maintenance must be carried out by trained personnel, which should be trained during the construction process.
- The trained personnel should check all control openings weekly and remove any obstructions to the regular flow.
- If biogas is utilised, storage, pipelines and appliances must be monitored regularly by trained personnel.
- User fees or communal payment models should cover maintenance costs. Additional benefits (use of irrigation water or biogas) can be awarded to the personnel.

Cross-Check – System not to be applied under the following conditions

- Users do not have water availability for flush toilets
- → Dry system should be considered
- Rocky underground
- Experts to design and construct a baffled reactor are not available and training cannot be provided.

Introduction to Ecological Sanitation

USTB

University of Sci & Tech Beijing



General Info		
House holds HH (houses)	10000	
Persons per HH	5	
Discharge Rate per person + day	100	
Oil Price per barrel in USD	60	
Water Price assumed per m ³	0,06€/m ³	
Septic Tank per HH	10000	
Cost Septic Tank (see Workshop ESP)	5000000IDR	
	425,24	€
Cost Nutients per 500 persons (ESP page 11)	1.700,97	€

Septic Tank Cost		
Septic Tanks	4.252.423,88	€
Septic Tank Treatment	400.000,00	€
Cesspool Emptier	10	1.500.000,00 €
TOTAL Capital COST	6.152.423,88	€

Vacuum Sewage Installation		
HH per Collection Chamber		8
HH		10000
Collection Chambers		1250
Pipe length per person (m)		2,6
Total Pipe length (m)		130000
Households per Vacuum Station		2000
Number of Vacuum Stations		5
Cost Vacuum Sewerage System	€	4.500.000,00

Anarobic Open Pond Reactor (Biogas Digester)		
Gas Production litres per person + day	l/p+d	30
Total Gas Production per day	m ³ /d	1225
Methan Production per day	m ³ /d	735
Cost Biogas Digester	€	500.000,00
TOTAL Capital Cost €		5.000.000,00

There are really no benefits from a SEPTIC TANK System.

Groundwater Table very high in Coastal Area.

EXTRACT

Excessive nutrients released to the coastal zone from poor human waste management is the major factor causing coral reefs to be killed by algae. Coral reefs are the most nutrient-sensitive of all ecosystems. They are overgrown by algae at such low levels of nutrients that no other ecosystem would be affected. Water quality standards based on human health permit nutrient levels hundreds of times too high for corals. Much stricter, environmentally-sound, nutrient standards are needed to protect coral reefs because natural sources of nutrients are close to the limits that corals can tolerate in most reefs. A strict policy of zero waste nutrient discharge to the coastal zone is needed.

CASE STUDY (Dr. Thomas J. Goreau)

WASTE NUTRIENTS: IMPACTS ON COASTAL CORAL REEFS AND FISHERIES, AND ABATEMENT VIA LAND RECYCLING

UNITED NATIONS EXPERT MEETING ON WASTE MANAGEMENT IN SMALL ISLAND DEVELOPING STATES

Income per annum		
Methan Production per year	€	79.091,00
CDM Trading CO ² /Methan	€	56.000,00
Nutients from collected wastewater	€	170.096,96
Organic Household Waste, energie + nutrients	€	
Treated Effluent for irrigation	€	109.500,00
	€	414.687,96

Benefits of ecosan system

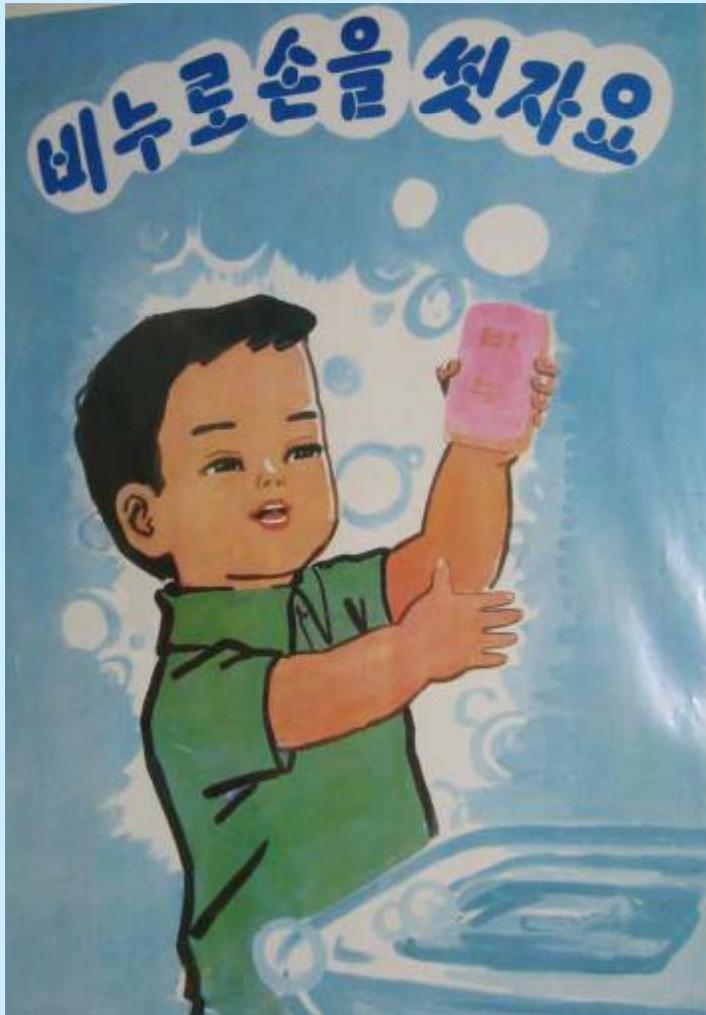
- No blockages, No Spillages, No Rodents from sewage
- Protecting the sea + the coral reefs
- Improvement of Groundwater + Health
- Creating employment + improve food production
- General Standard of living will be improved
- More sustainable
- Nutrients re-used
- Electricity produced
- Green Houses Gases reduced

Positive example

In order to act as a positive example and promote the dissemination of the achieved results, it should be decided that pilot project site should provide conditions, so that the developed system can:

- function properly and effectively,
- be operable and maintainable in a sustainable fashion (from a technical and an economic standpoint),
- improve the sanitary situation of the people living/residing in the area,
- have a long-lasting positive effect on the community,
- act as a representative model, which can be duplicated in other locations, and
- generate attention from the media and the government.

Step	Contents	Target groups	Time frame
1	Workshop for awareness building and policy change for decision makers (national, district level, local and community based) to assist with implementation of appropriate sanitation concepts, applying a household-centered, environmental approach	decision makers in politics, implementation agencies, financing partners, donors, self-help groups, community based organizations, public health officials, journalists	0.5 - 1 day
2	Training for the assessment of user needs – planning, application and analysis of surveys/seminars/workshops – and creating informed choice conditions (overview of technical solutions)	managers of implementation agencies & companies, consultants, civil constructors, community level workers, formal/informal community leaders, health care workers	1 - 2 days
3	Training in design decision making and use of implementation guidelines (toilet, collection, treatment, reuse), with focus on appropriate variations of currently common designs applied to local non-technical and technical boundary conditions	managers of implementation agencies & companies, civil constructors, vocational training experts, trainers of technical trainers, advisers of construction companies, architects, town planners, sanitary equipment & facility providers	1 - 2 day
4	Training in social and community campaigns, operation & maintenance, and technical design variations for the introduction of dry toilet systems (including one construction)	community level workers, agricultural and landscaping experts, health care workers, trainers of technical trainers, sanitary equipment & facilities providers, civil constructors, community development officers	4 - 6 days
5	Training in social and technical issues, awareness rising strategies and community building for shared community sanitation facilities	managers of implementation agencies & companies, consultants, community level workers, formal/informal community leaders, architects, health care workers, plumbers, civil constructors, community development officers	4 days
6	Introduction training for technical design, and operation & maintenance of black water, brown water, grey water and mixed sewer networks (vacuum, small bore, gravity), and water saving and reuse measures, rainwater management (plus a further accompaniment in the first project of each participant)	wastewater engineers, civil constructors, sewer equipment & facility providers, sanitation & water supply laymen, architects, town planners, agricultural and landscaping experts	5 – 8 days
7	Introduction training in design and construction of DEWATS (combined treatment with baffled reactors, anaerobic filters, constructed wetlands and polishing ponds) and reuse technology chains (1 month of on-site training, at a later time)	wastewater engineers, civil constructors, sewer equipment & facility providers, trainers of technical trainers, advisers of construction companies, household energy experts & suppliers	5 – 6 days
8	Introduction training in the design and construction of sanitary biogas systems (1 month of on-site training, at a later time)	wastewater engineers, civil constructors, trainers of technical trainers, advisers of construction companies, household energy experts & suppliers	5 – 6 days
9	Operation & maintenance, acceptance, management, evaluation and follow up of improvement activities for sanitary conditions	managers of implementation agencies & companies, consultants, community level workers, formal/informal community leaders, health care workers, sanitary equipment & facility providers, civil constructors, agricultural and landscaping experts, credit and financial support providers, journalists	2 - 3 days
10	Step by step ecological modernization and up-grading of sanitary conditions as improvement of living conditions (for on-site and off-site sanitation solutions)	decision makers in politics, implementation agencies, financing partners, donors, self-help groups, community based organizations, architects, town planners, and journalists	1 day



Thank You

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