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Biogas sanitation

„What is the connection between energy and toilets?“

partner of
sustainable sanitation alliance

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Im Auftrag des:
Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

Inputs and outputs for anaerobic digestion (anaerob = without oxygen)

Biogas
(~ 66% methane, rest CO_2)

Liquid fertiliser

(digestate with less organic matter; Not pathogen-free, but can be used as fertiliser with multi-barrier concept)

Organic waste, wastewater

Biogas reactor

4-step process
With acidogens, methanogens

Four steps of AD

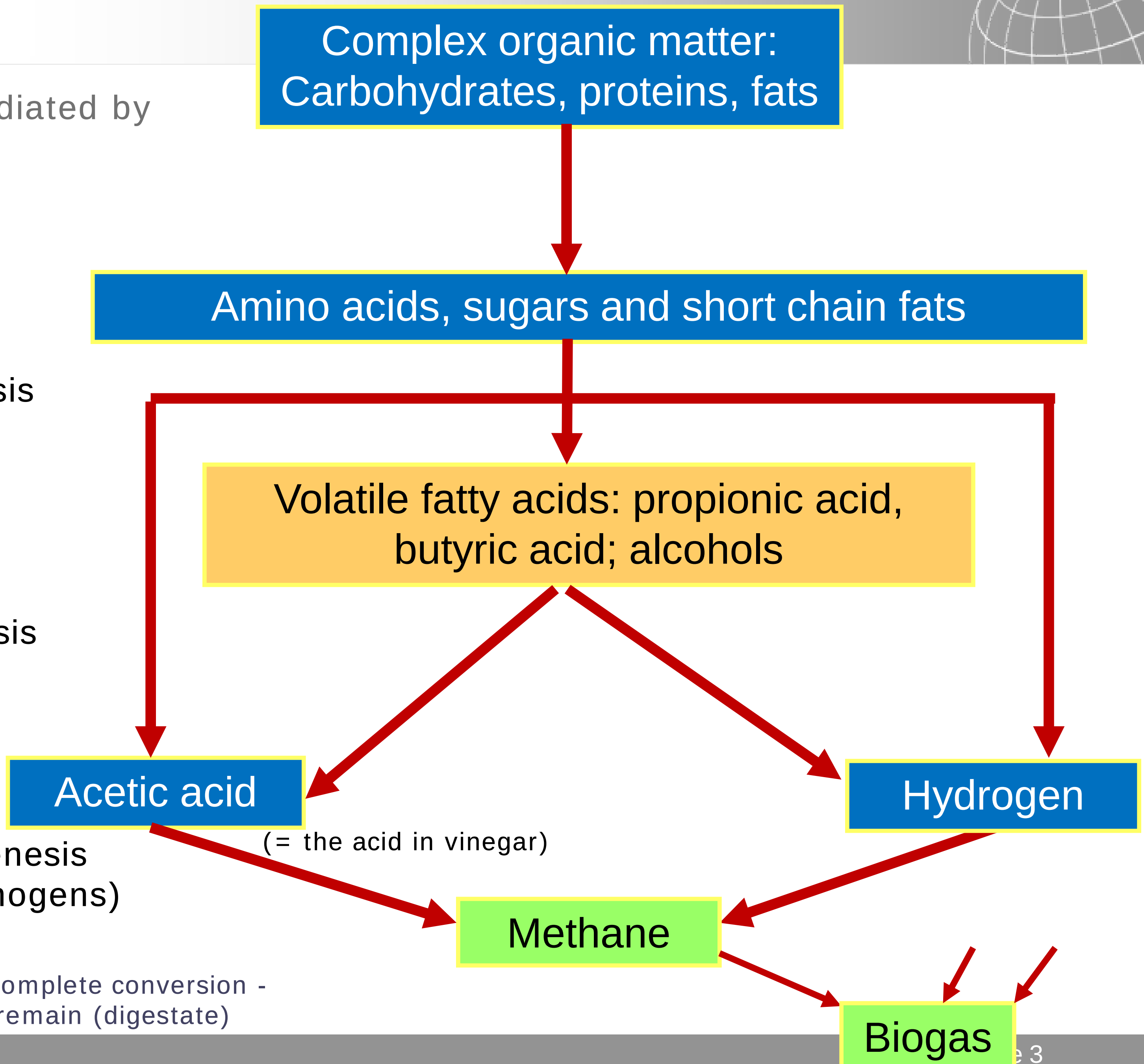
(steps 1 – 3 are mediated by bacteria)

Step 1 Hydrolysis

Step 2 Acidogenesis

Step 3 Acetogenesis

Step 4 Methanogenesis (by methanogens)



Remember: this is not a complete conversion - some organic matter will remain (digestate)

Biogas uses


Mantopi Lebofa, Lesotho, Dec. 2006

1. Cooking
2. Lighting
3. Heating
4. Electricity generation (“Combined heat and power plants” (CHP))

à If biogas is not used it should be flared because methane is a greenhouse gas (23 times more powerful than CO_2)

What is the ideal setup for biogas sanitation to be advisable?

1. Locations where lots of people come together, such as prisons, public toilets, schools
   - Or situations where animal waste is available and can be combined with human waste
2. Toilets with low amount of flush water, such as pour-flush latrines, vacuum toilets (the more concentrated the better)
3. Where the liquid effluent from the biogas reactor can be used as fertiliser
4. Where local expertise for construction, operation and maintenance is available (leading countries for biogas sanitation: China, India, Nepal, Vietnam, Rwanda, Kenya (?))

When is biogas sanitation not advisable?

- If only single households (without animal waste) are to be connected
- If a sanitation system is required that can easily be built and maintained by the users themselves
- If dry toilets are used (unless in conjunction with other waste)
- If there is no possibility to reuse or treat & discharge the digester effluent
- If there is no local biogas expertise in the country

Biogas production potential of various type of dung (excreta)

Types of dung	**Gas production* per kg dung (in m³)**
Cattle (cows and buffaloes)	**0.023 - 0.040**
Pig	**0.040 - 0.059**
Poultry (Chickens)	**0.065 - 0.116**
Human	**0.020 - 0.028**
Source: Sustainable Development Department (SD) / FAO - A system approach to biogas technology http://www.fao.org/sd/Egdirect/Egre0022.htm	

* calculated on the basis of their volatile solid content

One person produces appr. 100–200 g of faeces per day, the dry matter content of which is about 20% (up to 30%) (in other words: faeces contain 70-80% water).

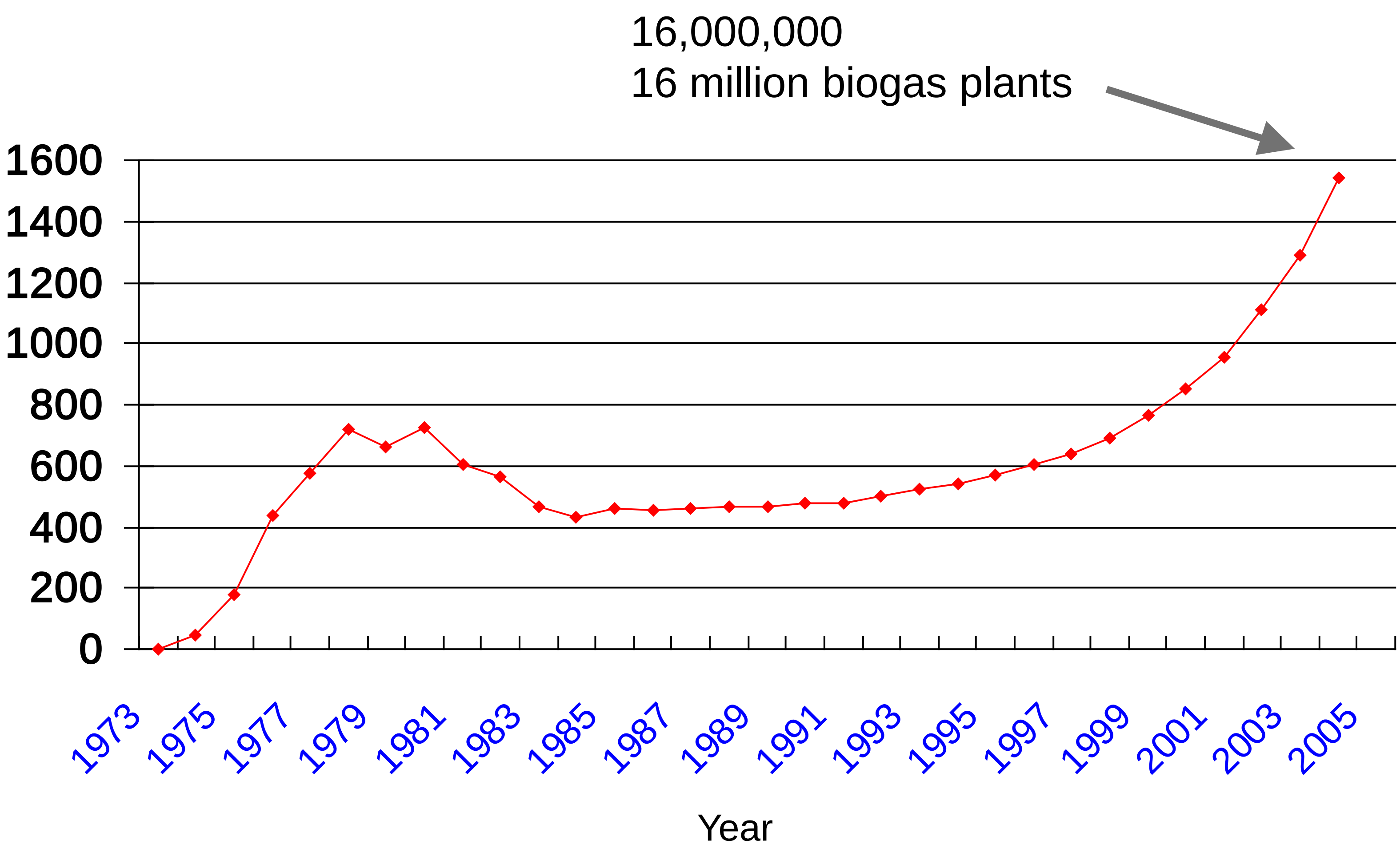
Human faeces characteristics

Volume (l*pers^{-1}*day^{-1})	**0,15**
N (g*pers^{-1}*day^{-1})	**1,5**
P (g*pers^{-1}*day^{-1})	**0,5**
Volume (l*pers^{-1}*year^{-1})	**56**
N (kg*pers^{-1}*year^{-1})	**0,6**
P (kg*pers^{-1}*year^{-1})	**0,2**
N-conc (mg/l)	**9 811**
P-conc.,(mg/l)	**3 270**
N/P-ratio	***3***
Notes	**High pathogen content. High dry mass.**

In terms of biogas production from excreta:
5 persons equal 1 pig
17 persons equal 1 cow

Sources: Folke Günther (2006) – Faeces: http://www.holon.se/folke/kurs/Distans/Ekofys/Recirk/Eng/fekalier_en.shtml
Sirkka Malkki (--) - Human faeces as a resource in agriculture http://orgprints.org/8477/01/njf4.pdf

Household biogas digester plants in China during 1973 – 2005 (total number, in 10,000)



China: Southern "Pig-Biogas-Fruit" Comprehensive utilization

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Example from Kenya (GTZ): EcoSan Promotion Project (EU-Water Facility / SIDA Co-financed)

Combined public toilet, bathrooms, digester, water kiosk - Naivasha

Bio-digester & baffle reactor - schools and prisons

Productive Sanitation: Bio-gas, fertiliser, irrigation

EcoSan Pilot Plant Kaurine Primary School (Maua District)

Sanitation facilities with up to 21 pit latrines on a school compound in a watershed area needed improvement

124 m³ Biogas plant, baffled reactors and 2x5-door poor flush toilet building

EcoSan Pilot Project
G.K. Prison in Meru

Treatment of the wastewaters of about 1,500 inmates and 350 staff Served by a 110 m³ biogas plant, baffled reactor and a 4-door UDDT EcoSan Toilet for staff

currently >100 SuSanA partners …

104 participating organisations

SuSanA partner logo
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WG 03 - renewables, climate change and groundwater

More than a quarter of the world's population has no access to electricity and rely on wood, charcoal or biomass materials for their energy needs. It is also recognised that there is a considerable overlap between regional energy scarcity, lack of sanitation and ongoing population growth. A new approach that recognises human excreta and wastewater as an important energy and nutrient resource creates new options to address this issue. In this context, integrated sustainable sanitation systems produce either biogas in anaerobic treatment processes or biomass in wastewater-fed short-rotation plantations (here groundwater protection plays an important role) which will provide renewable energy sources to cover the basic energy needs. Furthermore, by producing renewable energies and thus avoiding CO_2 emissions, these sanitation systems have the potential to alleviate climate change.

The objective of this working group is to general awareness for the energy potential of the sustainable sanitation approach and its prospective contribution to reduce dependence on imported or fossil energy sources. The working group prepares publications (fact sheet, comprehensive major publication) ideally flanked by a collection of case studies and a practical guide on how to implement sustainable sanitation solutions for energy production.

Members

gtz, BGR, BORDA, DED, IBBK, IFAD, PUVeP, Rand Water, Rotaria, SLU, TTZ, Uni Beijing, Uni Hohenheim, Uni Kwa-Zulu, Uni Xavier, WRC.

Contact of the working group is:
Christian Olt, GTZ, Germany

Own documents - 03

- Terms of Reference (PDF) - draft version
- Fact sheet on "Climate Change and Renewable Energies" (PDF) - draft version
- Fact sheet on "Groundwater Protection" (PDF)

Objective of the working group is to make clear:

- **Link** between the sanitation and renewable energies and climate change
- **Impact** of sanitation **on climate**
- **Mitigation and adaptation measures** of sustainable sanitation

SuSanA Working 2:

Sustainable sanitation and renewable energies and climate change

sustainable sanitation alliance

SuSanA fact sheet

Links between sanitation, climate change and renewable energies

08/2009 - draft

1 Introduction

There are important links between sustainable sanitation, climate change and renewable energy production. For example, sanitation systems can be designed in a way to produce renewable energy sources which in turn may mitigate climate change by reducing greenhouse gas emissions. Sanitation systems may also serve to help people adapt to climate change by reusing energy, nutrients and treated wastewater and thus substituting the use of primary resources.

This fact sheet gives an overview of the possible mitigation and adaptation measures and it explains the additional financial benefit that emission trading may bring (section 2). As one measure for mitigation it describes the possibilities to use sanitation products for renewable energy production (section 3).

2 Climate change mitigation and adaptation potential of sanitation

2.1 Greenhouse effect and responsible gases

The greenhouse effect is the phenomenon where the presence of so-called greenhouse gases (GHG) leads to a warming of the earth's surface: GHG allow solar radiation to enter the earth's atmosphere but prevent heat from escaping back to space. They absorb infrared radiation and reflect it to the earth's surface leading to a warming there.

Many human activities cause GHG emissions which drive the anthropogenic greenhouse effect. According to the Intergovernmental Panel on Climate Change the atmospheric greenhouse effect will cause a rise in the mean global temperature of between 1.1 and 6.4°C by the end of the 21st century (IPCC, 2007a), a change in rainfall patterns, a rising sea level and a weakening of sea currents which will have an additional impact on the global temperature distribution. In order to limit climate change to tolerable levels, global temperature rise has to be limited to 2°C (IPCC, 2007b). To achieve this, GHG emissions would have to be reduced by 50% by 2050 compared to the level in 1990 (IPCC, 2007c).

2.2 Relevant greenhouse gases

In the field of sanitation, the following GHG are climate relevant:

- Carbon dioxide (CO_2) is produced as a result of any fossil or non-renewable wooden biomass combustion. Similarly, the removal of organics and nutrients in wastewater treatment plants requires energy. The same holds true for the production of mineral fertilisers which is a very energy intensive process. Both the removal and the new production of nutrients for fertilisers require the consumption of fossil fuels leading directly to climate relevant CO_2 emissions. For climate protection, it is important to reduce fossil or non-renewable wooden biomass consumption.
- Methane (CH_4) is a potent greenhouse gas with a GHG potential 21 times higher than that of CO_2. In anaerobic processes, organic matter contained in domestic waste and wastewater is decomposed and biogas is formed which contains 60-70% methane. In soak pits, anaerobic ponds, septic tanks and other anaerobic treatment systems where biogas is either not collected or leaking (e.g. many UASB reactors), or even at the discharge of untreated wastewater into water bodies, anaerobic processes take place to different extents and methane is released to the atmosphere. For climate protection, wherever biogas is produced, it should be captured through a controlled anaerobic treatment and used as a renewable energy source. If the biogas cannot be used, then it has to be flared. As an alternative to a controlled anaerobic treatment, methane formation should be avoided through a low-energy aerobic treatment (e.g. dehydration, composting, constructed wetland).
- Nitrous oxide (N_2O) is the most harmful greenhouse gas with a GHG potential 310 times higher than that of CO_2. Nitrous oxide emissions occur during the denitrification process in wastewater treatment, at the disposal of nitrogenous wastewater into aquatic systems and also during mineral nitrogen fertiliser production. For climate protection, nitrogen should be recovered and reused as a fertiliser, or nitrogenous wastewater should be treated for the intended use and reused (e.g. for irrigation or groundwater recharge).

http://www.susana.org/lang-en/case-studies/technology

Links GTZ Links Info-Service

Case studies sorted by technologies:

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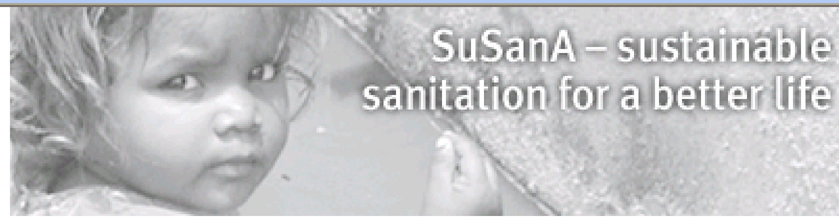

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Case studies sorted by technologies:

Anaerobic baffled reactors

Urban decentralised wastewater management, Badlapur, Maharashtra, India - draft

Biogas plants

Decentralised wastewater management at Adarsh College, Badlapur, India (PDF) - draft

Pour flush toilets with biogas plant at DSK Training Institute, Gujarat, India (PDF) - draft

Public toilet with biogas digester and water kiosk, Naivasha, Kenya (PDF) - draft

Ecological housing estate. Flintenbreite, Lübeck, Germany - draft (PDF)

Composting or composting toilets

Community-led water and ecosan programme, Shaanxi Province, China (PDF)

Urine diversion sanitation in Olympic Forest Park, Beijing, China (PDF)

Urine-diverting vacuum sanitation system, Beijing, China (PDF)

Improved traditional composting toilets with urine diversion, Leh, Jammu and Kashmir State, India (PDF) - draft

UDD toilets with reuse in allotment gardens, Cagayan de Oro, Philippines (PDF)

Summary

- Biogas sanitation is a technically proven process
- The biogas is a nice “bonus” of wastewater treatment
- Most interesting for locations where lots of people are together or in combination with animal waste treatment
- Remaining issues:
  - Pathogen removal in biogas sanitation is low à use multiple-barrier approach for reuse
  - South-South knowledge transfer urgently needed