Better use of bioenergy and plant nutrients from human waste

IV Baltic Biogas Forum

11 – 12 September 2014
Gdansk

Ruzena Svedelius AgrD
BAS-konsult
rsvedeliushotmail.com
www.biotransform.eu
0046/70 733 11 20

Human Waste (**HW**) per person and day

- **One litre urine & 200 g faeces**
- **200 – 550 litre wastewater** per person and day is “cleaned” using plenty of energy and by adding various more or less toxic chemicals
- U**nhealthy** working milieu
- L**osses** of bioenergy and nutrients
- P**olluting** environment (**N_2O etc.**)

Household waste (HHW) and human waste (HW) in Sweden

Table 1.

Solid waste	Recommendations in report "Reforsk, FoU 145, 1998" %	Treatment of household waste in 1998 %
Recycling	12	12
Incineration	6	50
Landfilling	6	38
Suitable for biological treatment	**76**	0
Liquid waste Assumption per person per year	Suitable for biological treatment	Waste water treatment in 1998
Waste water (litre)		73 000 – 100 750*
Human waste (kg)	430	
Grey water (litre)	71 000**	

* Wastewater and human waste

** Water from bathing, dishwashing and laundry.

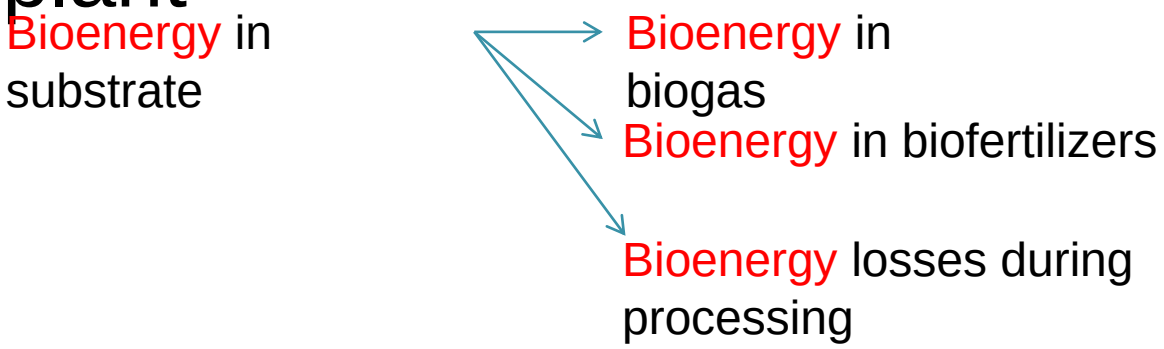
Recycling **C**loset (**RC**)

(instead of the Water Closet)

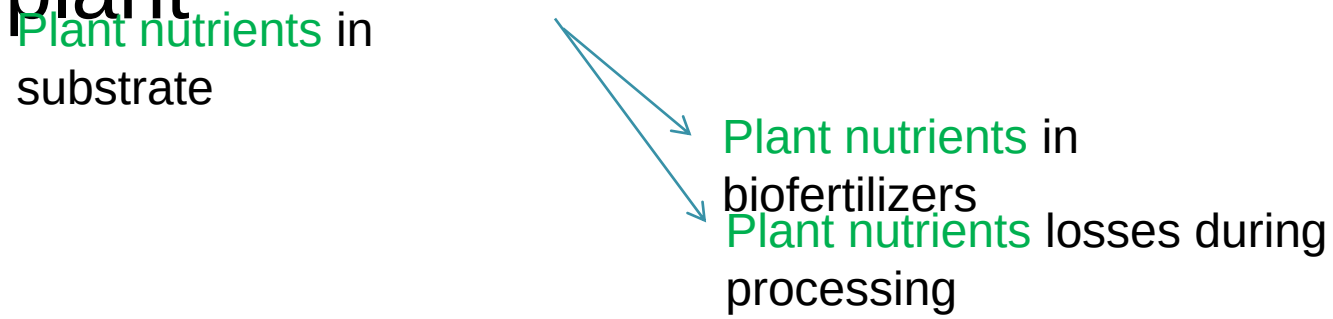
affects when used

- Directly
  - Protecting water in toilets and in WWTP
  - Reduction of drugs in waterways
  - Safer transport to biogas plants
    - Without polluting losses to environment
    - Improving of working milieu
- After treatment in local biogas plants
  - Better use of **bioenergy** as methane **in biogas** and in organic structures **in biofertilizers**
  - More efficient recycling of **plant nutrients**, thus reduction of use of artificial fertilizers

Bioenergy flow in biogas plant



Plant nutrients flow in biogas plant



The Baltic Sea

415 000 km2

← The catchment area

Countries that border on the sea: **Denmark, Estonia, Finland,** Germany, **Latvia, Lithuania, Poland,** Russia, **Sweden**

Countries that are in the drainage basin but do not border on the sea: Belarus, Czech Republic, Norway

Using RC in countries round Baltic Sea DK, SE, FI, EE, LT, LV and PL

- **65 millions** inhabitants
- **44 million tons** per year processed in Optimal Solids Anaerobic Digestion (OS-AD) in local biogas plants will give
  - **45 - 58 TWh bioenergy in biogas**
  - **65 - 78 TWh** bioenergy in biofertilizers
  - **€300,000 - €800,000 v**alue of nitrogen and phosphorus

2 kg renewable organic material (ROM) per person per day can be used as raw material in local biogas plants

Table 2.

Inhabitants	ROM (at least) tons per year	GWh Total bioenergy per year	GWh Bioenergy in biogas per year	GWh Bioenergy in biofertilizers per year	€ Value of nitrogen and phosphorus per year
1 000	730	2,2	0.7-0.9	1.0-1.2	5-7
10 000	7 300	22	7-9	10-12	50-70
100 000	73 000	220	70-90	100-120	500-700
1 000 000	**730 000**	**2 200**	**700-900**	**1 000-1 200**	**5 000-7 000**
DK 5.5 millions	4 025 000	12 100	3 850-4 950	5 500-6 600	27 500-38 500
SE 9.5 millions	6 935 000	20 900	6 650-8 550	9 500-11 400	47 500-66 500
FI 5.4 millions	3 942 000	11 880	3 780-4 860	5 400-6 480	27 000-37 800
EE 1.3 millions	949 000	2 860	910-1 170	1 300-1 560	6 500-9 100
LT 3.3 millions	2 409 000	7 260	1 540-1 980	3 300-3 960	16 500-23 100
LV 2.2 millions	1 606 000	4 840	2 310-2 970	2 200-2 640	11 000-15 400
PL 38 millions	**27 740 000**	**83 600**	**26 600-34 200**	**38 000-45 600**	**190 000-266 000**
EU 742,5 millions	542 025 000	1 633 500	519 750-668 250	742 500-891 000	3 721 500-5 197 500

Some definitions

Bio inspired by the Greek word βίος, bios, = "life"

Biomass – general: total amount or weight of living organisms in an area (such as plants, animals and birds per hectare of forest / field) or volume (eg, worms, microorganisms and roots in a cubic meter of soil).

Bioenergy / ***biofuel*** - solar energy that is biochemically bound to biological structures of plants during photosynthesis

Organic - originally from living organisms (plants, animals or microorganisms).

Organic material - every composite substance containing the element carbon (C) as a main component, it can be solid, liquid or gas and come in three types:

a) ***renewable*** organic material
b) ***synthetic*** organic material
c) ***fossil*** organic material

Anaerobic digestion

To obtain **maximum benefit**

microorganisms need

- Right substrate having all factors at optimum
- Right environment that is created with the appropriate equipment

Efficient biological conversion require

- Excellent knowledge in microbiology
- Modern logistics
- Mechanization
- Automation
- Computerization

Anaerobic digestion
Total Solids (TS) describe biogas plants

- 0.5% - 15% TS Anaerobic Digestion (AD)
- >15% TS
  - Solid-State Anaerobic Digestion (SS-AD)
  - High Solids Anaerobic Digestion (HSAD)
  - dry-AD
  - "anaerobic composting“
- Here proposed about **30% TS**
  - Optimal Solids Anaerobic Digestion (**OS-AD**)

Optimal Solids Anaerobic Digestion (OS-AD)

- Requires
  - Environment free of atmospheric oxygen
  - Substrate free of impurities
  - TS about 30%
- Other factors must be close to optimum
  - Particle size
  - C / N ratio
  - pH
  - Temperature
  - Inoculum

Local biogas plants with OS-AD

- Advantages
  - Short and fast transports of raw material
  - Local jobs
  - Better understanding of process by residents
  - Local use of biogas
  - Biofertilizers delivered to narrow producers of food
- Disadvantages
  - What do you think?

Two valuable products of OS-AD

- **Biogas** containing energy-rich methane that can be transformed to
  - Electricity & heat
  - Heat
  - Fuel for vehicles
- **Biofertilizers** - suited to cultivation - containing remaining bioenergy and all plant nutrients

Biofertilizers
important now and for future generations

- Contain organic structures with
  - **Bio**energy
  - **Plant nutrients**
- Increase amount of organic matter in cultivated soils that is positive for **soil fertility** i.e. growth of **new plant biomass** for

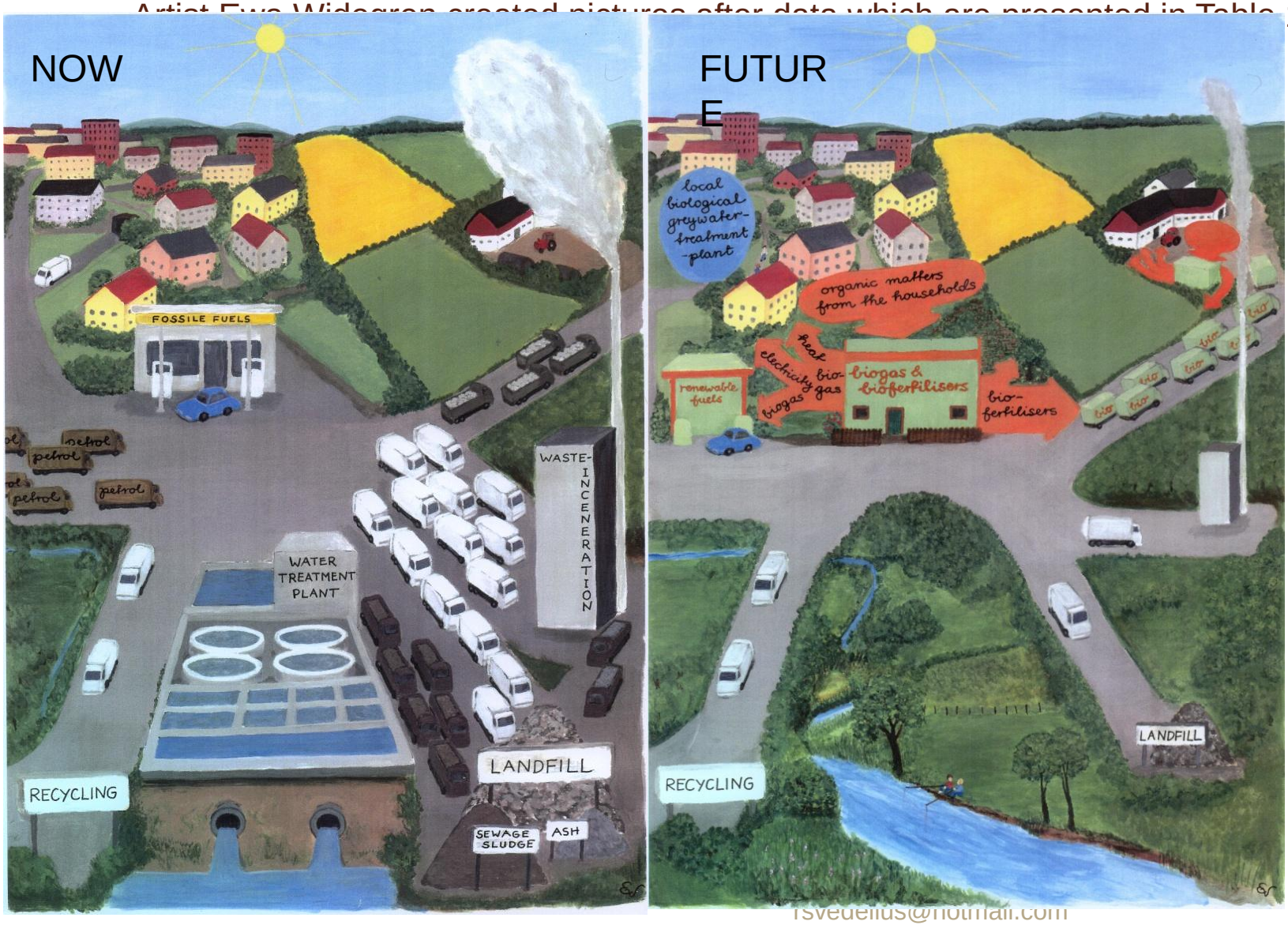
Food & **Feed** & **Fibre** & **Fuel**

Plant nutrients should be reused in biofertilizers

- All **16 chemical elements** that are *essential for plant growth and development* **should be reused**
- Here are presented only values of
  - **Nitrogen** - important for all living - that *is lost in WWTP, incineration plants, with thermal gasification and cause pollution of water and air, cause health problem when Reactive Nitrogen increases.*
  - **Phosphorus** is a finite resource that *ends up in sewage sludge and ash blended with toxic substances*

Treatment of ROM from waste now and in the future

Artist Ewa Widegren created pictures after data which are presented in Table 1.



Challenges for sustainable management of renewable organic material (ROM)

- To use **biological methods**
- To transport HW with RC and treat in biogas plants
- To adapt modern knowledge based technologies both to needs of microorganisms and to staff who handle waste and wastewater
- To create conditions under which all residents can properly handle the ROM of residues and wastes
- Cooperate with other countries
- To transform about 500 million tons ROM in EU to biogas and biofertilizers

Sustainable Biological Recycling System (SBRS) is under development

- Right collection (including RC)
- Short-distance transport
- Pre-treatment
- OS-AD will be used
  - **Biogas** to electricity and heat
  - **Biofertilizers** will meet requirements of different cultivated crops

Conclusion

- Everything that originates from plant and animal kingdom, can be transformed to valuable products
- The MSW contains more ROM than HHW because it includes ROM from restaurants, shops, farmers‘ markets, etc.
- ROM in residues from forestry, agriculture, horticulture and fishery are also suitable for co-processing in biogas plants
- Biotechnology will contribute to healthy prosperity for people throughout the globe

OUR RESPONSIBILITY

You and I can influence decisions

that result

in **more efficient resource management**

to lower costs

while reducing the negative impact on health and environment